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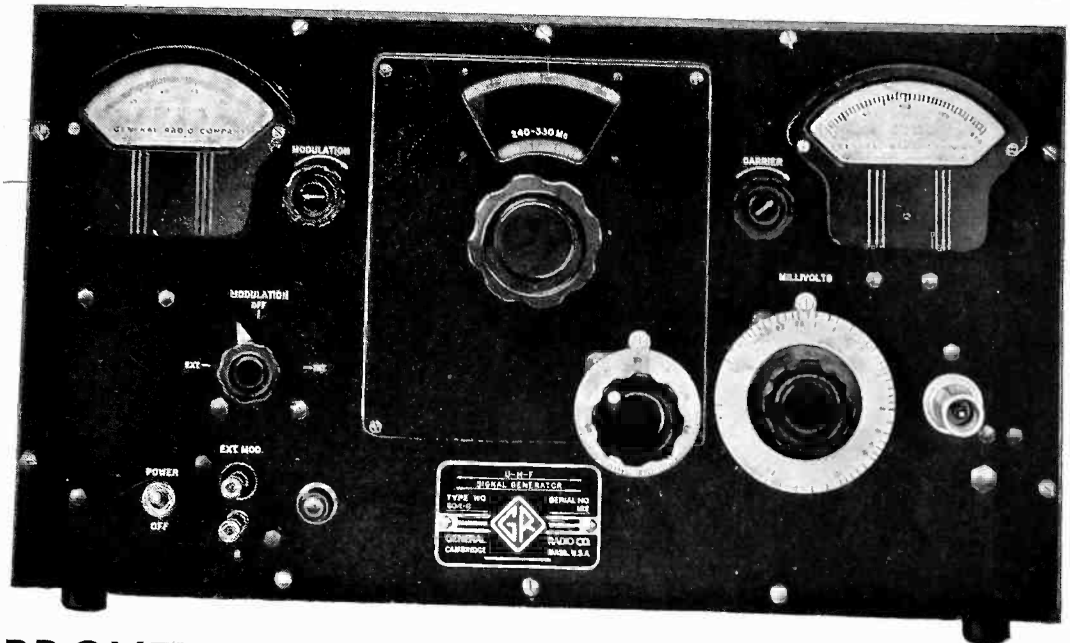
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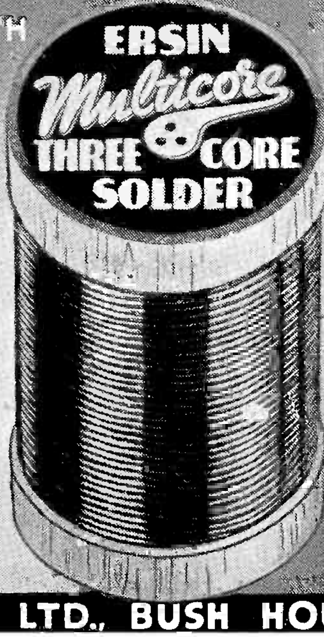
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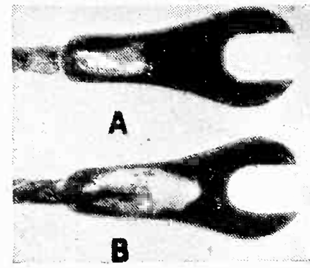
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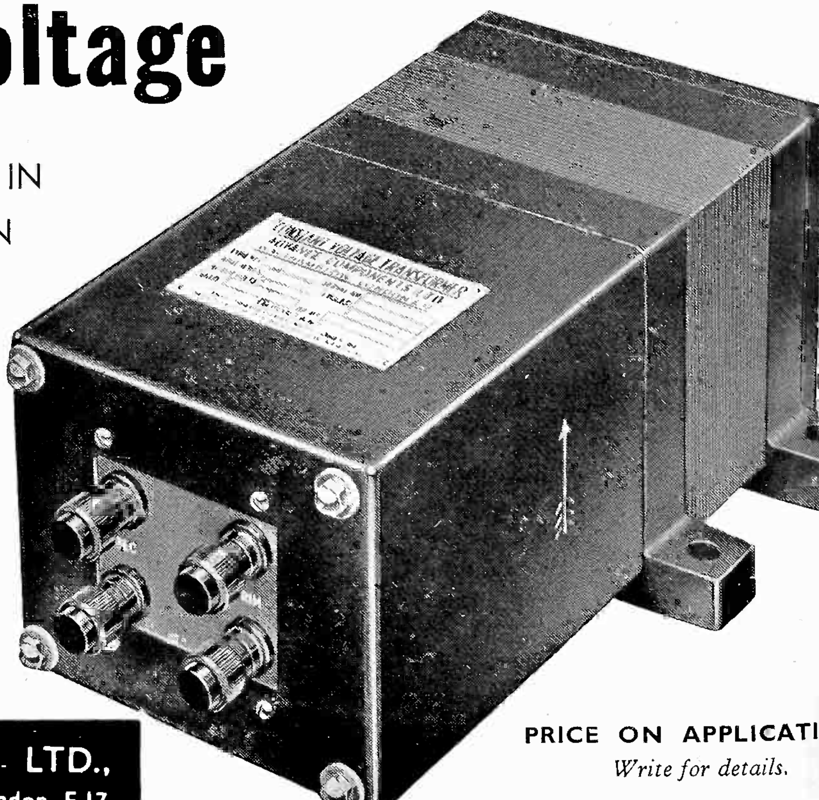

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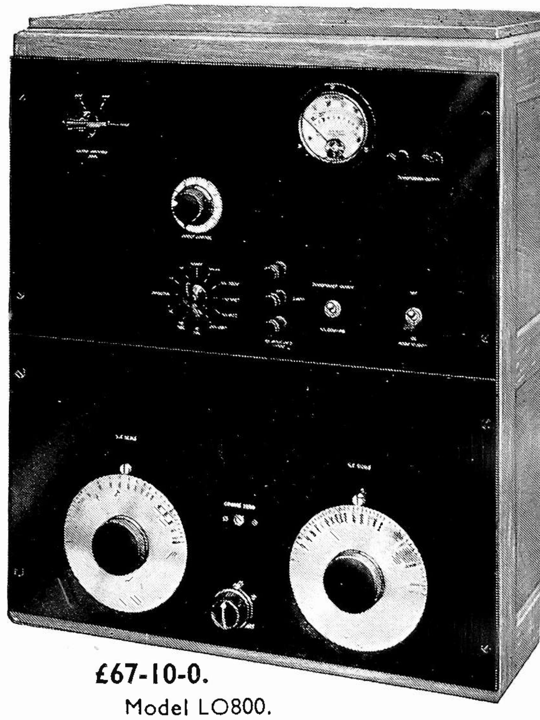

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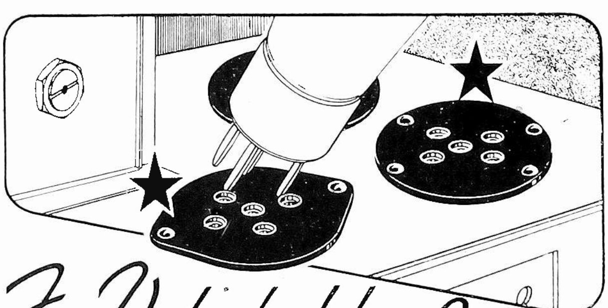

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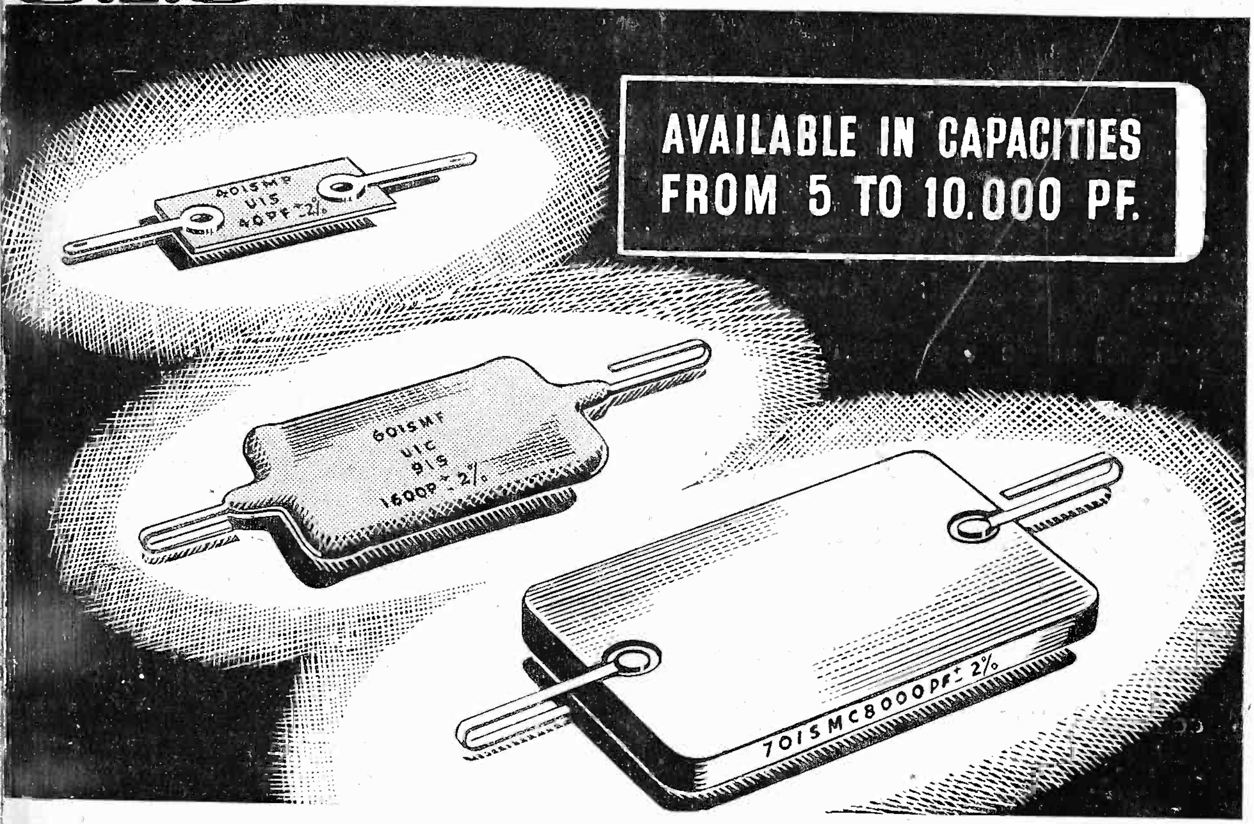

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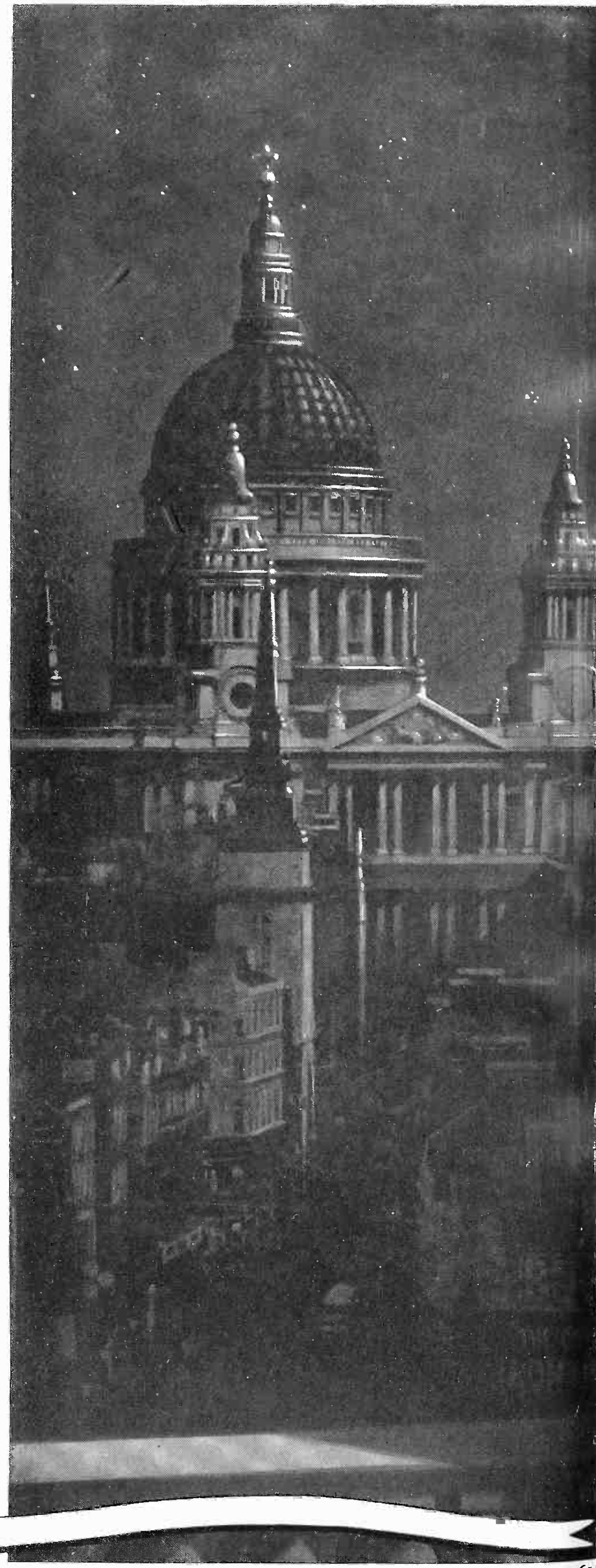


WIRELESS ENGINEER

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

VOL. XIX APRIL 1942 No. 223

Editorial

Superheterodyne Receiver Tracking

ONE of the problems of superheterodyne design is the construction of two circuits, the resonant frequencies of which shall differ by a fixed amount at all points in the tuning band. If they do this they are said to "track" exactly, but such an ideal could only be attained by very elaborate and expensive methods. In practice identical tuning condensers are employed in the two circuits and carefully ganged, but in the oscillator circuit a fixed condenser—the padding condenser—is connected in series with the variable condenser and a small trimmer condenser is connected either across the variable condenser or across the coil. The coil in the oscillator circuit has a smaller inductance than that in the signal circuit, so that the oscillator circuit has a higher resonant frequency than the signal circuit due both to reduced inductance and reduced capacitance. The problem is to choose the three variables, viz., the inductance, the padding capacitance and the trimmer capacitance so that the tracking shall be as accurate as possible, that is, so that the difference between the two frequencies shall be as constant as possible. A notable contribution to this problem was made by A. L. M. Sowerby[1] in 1932; more recently we have published two papers by Dr. M. Wald[2] on the same subject. In two recent issues of the Australian *A.W.A. Technical Review* articles have been published[3,4] entitled "Superheterodyne Tracking Charts," going into the matter very thoroughly and giving charts to simplify the rather complicated calculations.

Minimising Tuning Deviation

With the three variables it is only possible to obtain the exact value of the desired frequency difference at three points in the tuning range. Dr. Wald discussed the problem of determining the best position of these three points in the tuning range in order that the greatest deviation from the desired frequency difference might be reduced to the smallest possible value. This is obviously the best solution if equally good results are desirable over the whole range, which will normally be the case. To obtain this result it is fairly obvious that one of the three points must be at or near the middle of the range and the other two near but not at the ends of the range as shown in Fig. 1, in which the difference between the signal and heterodyne frequencies is plotted against the former. This is brought out clearly by Dr. Wald, but in some numerical examples calculated by Payne-Scott and Green, they sometimes take the two outer points at the

[1] *Wireless Engineer*, Vol. 9, p. 70.
[2] *Wireless Engineer*, March, 1940, p. 105; April, 1941, p. 146.
[3] A. L. Green, Vol. 5, p. 77.
[4] Ruby Payne-Scott and A. L. Green, Vol. 6, p. 251.

extremes of the tuning range without giving any reason. It is probable that this is often done in practice without realising that a somewhat better overall result would be obtained if the points were not taken at the extremes of the range.

An interesting point raised by Payne-Scott and Green concerns the position of the trimmer C_t; should this be connected across the variable condenser or across the coil? The alternatives are shown in Fig. 2, in which the self-capacitances of the coils are also indicated. In all his work Dr. Wald assumes that the trimmer is connected across the coil, thus adding its capacitance to that of the coil. Payne-Scott and Green point out that, although it is often convenient to do this, in some cases it leads to a greatly decreased value of the inductance and therefore of the L/C ratio of the oscillator. This is especially the case in the low-frequency band. To maintain a high value of L/C the self-capacitance of the coil itself should be kept as small as possible, and the trimmer

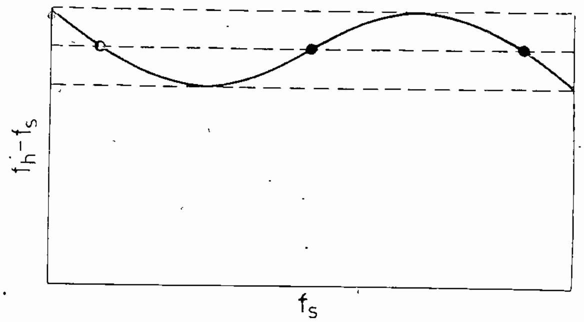


Fig. 1.

should be connected across the tuning condenser. In the short-wave band the difference is negligible; it is small in the medium-wave band, but in the long-wave band they give an actual example in which putting the trimmer across the coil reduced the value of the inductance required from 334 to 89.6 μH. This is equivalent to a reduction of the L/C ratio to 0.07 of what it would otherwise be. In an example in the medium-wave band the ratio was only reduced to 0.7 of its previous value by moving the trimmer from the variable condenser to the

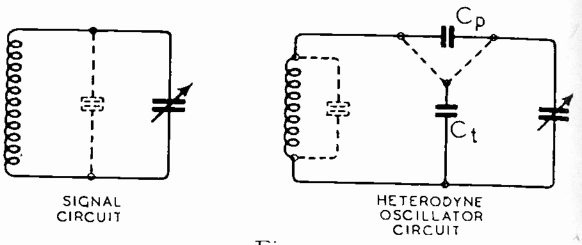


Fig. 2.

coil. This is obviously a point to be borne in mind by those concerned with superheterodyne design.

G. W. O. H.

Sir William Bragg, O.M.

THE passing of Sir William Henry Bragg, O.M., on March 12th, at the age of 79, has removed an outstanding contributor to the world of scientific research. His work in the fields of research during the past forty years has been deservedly and widely recognised. He was created a C.B.E. in 1917 for his work on submarine detection, and in 1920 he was elevated to K.B.E. He received the Order of Merit in 1931.

From 1935 to 1940 Sir William was president of the Royal Society and at the time of his death was Director of the Royal Institution.

His outstanding work was in the fields of X-ray and crystallography. Because of his extraordinarily wide outlook in all scientific matters he was an able chairman on many scientific committees. He also had an unusual aptitude for simplifying complex questions, and his lectures were models of explicitness.

His elder son, Sir Lawrence Bragg, is Cavendish Professor of Experimental Physics at Cambridge, and Chairman of the Institute of Physics.

The Retarding Field Oscillator*

By Wm. Alexander, M.Sc. (Eng.), A.M.I.E.E.

Introduction

THE classic theory postulated by Barkhausen and Kurz[1] envisages the oscillations occurring in a positive grid-negative anode triode, as an electron dance about the grid. The cathode grid accelerating field and the grid anode retarding field promote a progressive influence which causes oscillation of the electrons in the inter-electrode space. The oscillating potential produced at the valve electrodes has a periodic time which depends on the transit time of the electron between electrodes, or more exactly, between the effective or virtual positions of these electrodes, which have their effective dimensions affected by the presence of electron cushions of graded density.

Under certain restraining influences of an external circuit, Gill and Morell[2] showed that the electron oscillations could be controlled between fairly well defined limits. Thus they advanced a theory, giving an alternative mechanism for the oscillations produced, based on the work done by, and on, the electrons during their travel between the electrodes, and causing a nett flow of energy to overcome the damping factor of the tuned circuit. This led to the contention of two possible mechanisms of oscillation being accepted for some time, rather than the possibility of two modes of the same type of mechanism. Later research extended the scope of knowledge on this subject to cover electron oscillations occurring with diode and tetrode types of valves.

Hollmann[3] published results showing, under certain conditions, the simultaneous presence of B-K and G-M oscillations, as well as demonstrating, in common with other workers, that harmonics of these electron oscillations are possible. Cockburn[4] also demonstrated the presence of two oscillations of different wavelengths. He deduced theoretically, and showed by practical demonstrations, the possibility of two mechanisms operating at one and the same time; one being due to the accepted B-K mechanism, and the other due to the equivalent inductance of the electron cloud, in the valve, resonating with the geometric capacitance of the valve electrodes. Both postulates caused a good deal of comment, due to the lack of evidence that there are two different mechanisms, instead of two modes of oscillation due to the same fundamental physical cause, and having more than one degree of freedom.

McPetrie's[5] measurements, taken with a circuit where the ordinary internal valve leads are absent, made it possible to determine the true impedance of the circuits used at very high frequencies. He demonstrated that the B-K and G-M electron oscillations, occurring in a triode circuit, differ only in that one occurs below, and one above, the critical wavelength giving valve resonance.

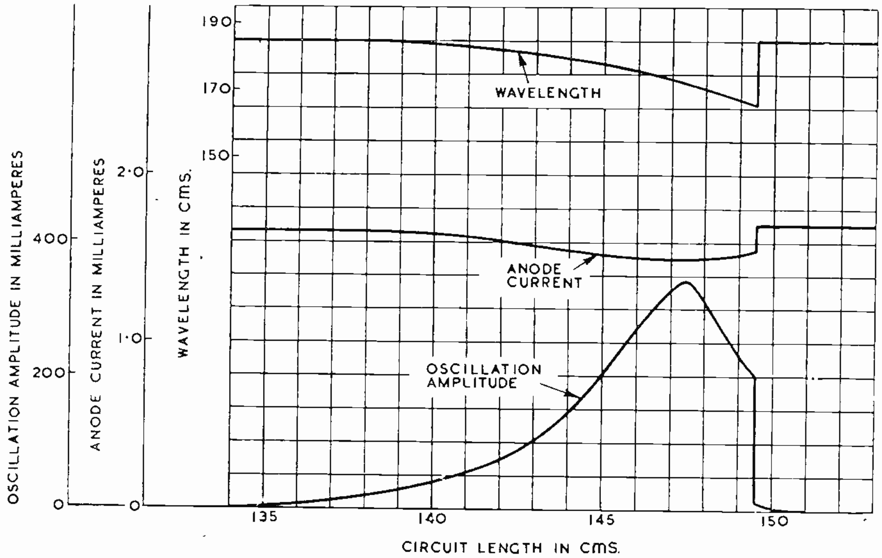
This resonance is such that the valve capacitance decreases from positive values, at wavelengths less than that corresponding to resonance, to zero near resonance. It then increases negatively as the wavelength of oscillations is further increased. The equivalent circuit of the valve was shown to be that of a negative resistance, in series with a reactance which changed sign as the frequency passed through resonance. This corresponds to the transition from the so-called B-K to G-M oscillations as the external circuit is varied in length.

Using a two electrode valve of what was named a "grid diode" type, Gill and Morell, and later Hollmann, demonstrated that the oscillations produced were of somewhat longer wavelength than those produced in the case of the triode having similar grid dimensions, and apparently no G-M oscillations were found to be present.

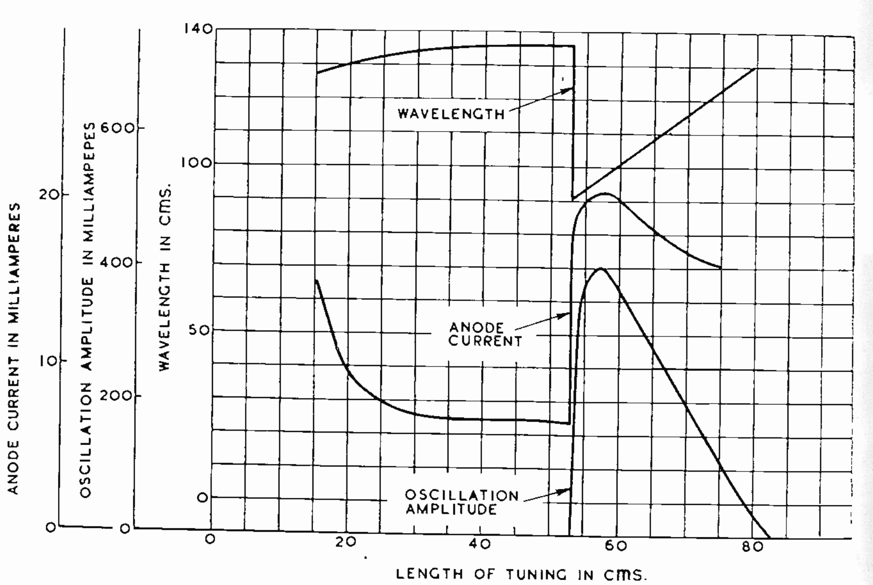
Gerber[6] in tests on electron oscillations, used a parallel wire two electrode valve, or diode, specially constructed so that these wires were an integral part of a Lecher wire system, extending on either side of the valve envelope. The nature of the oscillations

* MS. accepted by the Editor, January, 1942.

produced was identical in all respects, over a certain range of anode voltage with that of the B-K oscillations. Above this a second mode of oscillations, having a longer



wavelength, was produced. The first mode occurs in the space charge saturated region and the latter in the emission saturated region of the valve characteristic. Curves showing the results due to Gerber are reproduced in Fig. 1. A point of particular interest arising from these curves was pointed out by Megaw[7]. The variation of wavelength, and amplitude of oscillations, with circuit length occurs in the diode with lengths below the critical length; whereas in the case of the triode these variations occur with lengths above the critical length, as is apparent from the curves of Hollmann's results shown in Fig. 2.



In general, in all the investigations carried out by the various workers in this field, harmonics or oscillations of pseudo or quasi overtone frequencies have been observed with each type of oscillation.

Circuit Details

The layout of the oscillator used was quite straightforward in form. Two A.T. 40 valves, coupled in parallel, were connected to Lecher wires 75 cms. long and separated by 4.5 cms., running from the common connections to the grids, and anodes, of the valves. All battery connections were completed through chokes to prevent loading of the ultra-high-frequency circuits by the ancillary equipment. Since the electrodes connected to the Lecher wires were not at the same D.C. potential, the shorting strip for tuning the Lecher wires consisted of a low resistance vacuojunction in series with two blocking condensers having a capacit-

Fig. 1 (Left). *Gerber's curves for results obtained with the parallel wire diode.*

Fig. 2 (Below). *Example of Hollmann's results showing variation of anode current oscillation amplitude and wavelength with circuit length.*

ance sufficiently large to make the reactance negligible at these ultra high frequencies.

The valves used were chosen, from a batch, to have as nearly identical characteristics as possible. Under operation, the current, to the individual valves, was adjusted to obtain a good approximation to equal emission from the two filaments. The independent Lecher wires, which were used for measuring wavelengths, were placed at various distances from the oscillator tuning Lecher wires to observe the extent of loading, or reaction, of the wavemeter on the oscillator circuit. Throughout the tests the wavemeter Lecher wires were kept as remote as possible, to ensure that the loading was negligible.

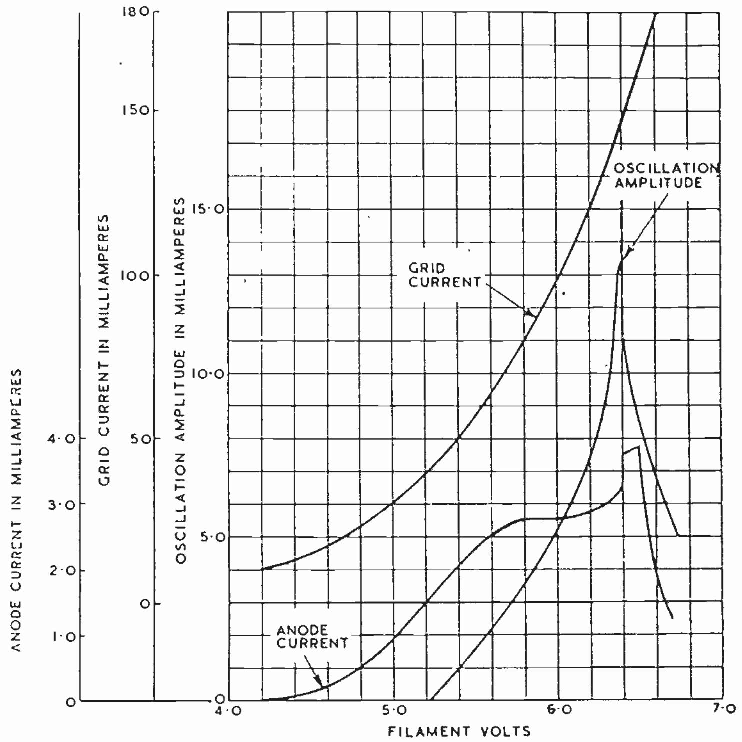


Fig. 3. *Curves showing the variation of oscillation amplitude, and that of grid and anode current with change of filament voltage.*

Experimental Results and Conclusions

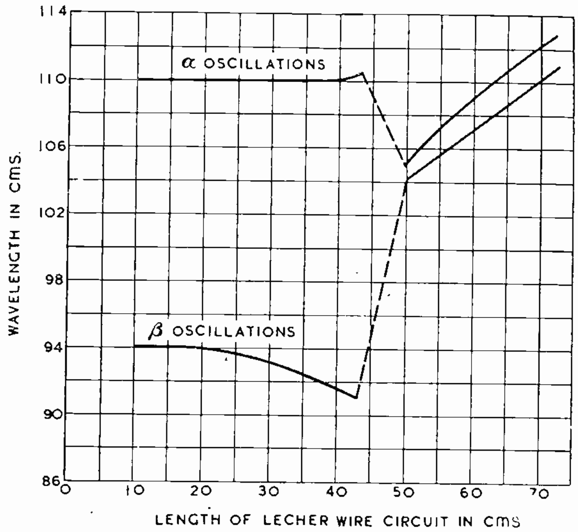
In the series of tests made the general deductions from the results, which are in agreement with those obtained previously by other investigators, are as follows.

Tuning of the Lecher wire circuit by the shorting strip shows a critical change in magnitude and frequency of the electronic oscillations. The position of the shorting strip to produce this critical change depends on, and varies with, the positive grid voltage, negative anode voltage, and filament voltage. With 100 volts positive on the grid the critical change took place at 45 cms. and at 50 volts, at 60 cms. from the valves, due to effective decrease in electrode dimensions caused by the presence of a bank of electrons. Moreover, this critical change was accompanied by the usual rapid increase in anode current. Referring to Fig. 3 of the results obtained, it is of interest to consider the following parts in detail. In this figure the variation of grid current, anode current, and oscillation amplitude with variation of filament volts is shown. The grid voltage was maintained fixed at 100 volts positive, the anode voltage at 5 volts negative, and the shorting strip set at 37 cms. from the valves. The variation of grid current, which increases at an increasing rate with filament voltage, shows the presence of emission saturation up to the larger values of filament voltage. Any further rise in filament temperature would cause a space charge saturated condition to obtain. Current of a measurable quantity commences to flow to the anode with about 4.2 volts on the filaments, and rises slowly with increase of filament volts until, at a point of inflexion in the anode current curve, occurring at about 5.2 volts, the oscillatory current commences to rise, and does so sharply, until we approach the point where emission saturation disappears.

At this point, there is a sudden and apparently complex condition which causes both the amplitude of oscillations, and the anode current, to take one of two values without any detectable change in filament conditions, or change in tuning of the external circuit. With further increase in filament volts, both the oscillatory and anode currents fall rapidly.

A series of tests was carried out at the above critical condition, the results now mentioned being the most interesting. With the filament voltage at the critical value, and grid voltage and anode voltage as above, the variation of anode current, and amplitude of oscillations, with the distance of the shorting strip from the valves are shown in Fig. 4.

The anode current decreases to a minimum, and then rises very sharply to a maximum value ; at the same position of the shorting strip a marked increase to a maximum occurs in oscillatory current. The corresponding critical length of the Lecher wire circuit was 45 cms. This is obviously due to the transition from B-K to G-M oscillations rapid change from the B-K to G-M conditions of oscillation. It is notable that the sub-maximum referred to occurs with minimum anode current. The shape of the oscillation amplitude curve previous to this is the inverse of the anode current curve. If, at the same time, we consider the wave-



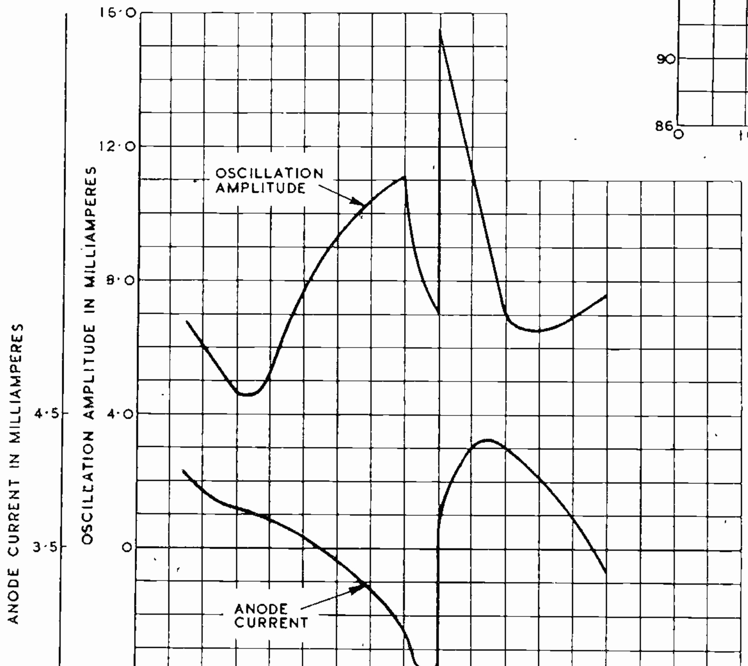


Fig. 4 (Left). *Variation of oscillation amplitude and anode current with length of tuning circuit in cms.*

Fig. 5 (Above). *Curves showing the effect of the length of tuning circuit wires on the wavelength of oscillations present.*

occurring with variation of the external tuning, and it is interesting to compare this variation with the corresponding variations in anode current, and amplitude of oscillations, shown in Hollmann's curves, Fig. 2. What is not apparent in the latter, but is very marked in Fig. 4, is the large increase of oscillation amplitude, to a sub-maximum, occurring at a low value of anode current, and rising to a peak value previous to the length of the oscillations generated, corresponding to various positions of the shorting strip (Fig. 5), it is seen that there are two discreet oscillations present of different wavelengths. These oscillations respond in different ways to variations in the distance of the shorting strip. They are described as α and β types. The α oscillations remain nearly constant in wavelength with change of circuit length, and are given, to a good degree of accuracy, by the B-K formula $\lambda = \frac{1000 d_a}{\sqrt{E_g}}$, giving a result very close to those obtained by Chapman[8] using similar types of valves. The β oscillations, however, decrease slightly, but uniformly, as the circuit length is increased. At the critical position for the shorting strip, that is when the oscillations pass from the B-K to G-M modes, there is a large increase in oscillation amplitude, together with the customary increase in anode current. Thereafter, the α and β oscillations have their wavelengths fixed according to the tuning of the external circuit, both α and β types being still detectable.

A comparison of the above results with those of Hollmann and Gerber show interesting similarities.

First, the α oscillations which are initially constant, vary in wavelength in a similar manner to those obtained by Hollmann, Fig. 2. The anode current variation with external circuit tuning is also similar. Further, as Megaw[7] points out, the variations of amplitude of oscillation and anode current are such that we have a gradual decrease in amplitude, from a sudden maximum, as the circuit length is increased. Secondly, the β oscillations, which decrease gradually at first, vary in wavelength in a manner similar to those obtained by Gerber with the parallel wire diode (see curve in Fig. 1). The same applies to the anode current variation. Moreover, from the curve in Fig. 4, the variation of oscillation amplitude shows a maximum during a minimum of anode current, which is very similar to Gerber's results, and moreover, again to quote Megaw, the variations of amplitude of oscillation, and anode current, are now a gradual decrease from a maximum as the circuit length is decreased.

Finally, it might be said that, from the comparative results obtained and the inferences drawn from these comparisons, the presence of what might be called triode type (α) and diode type (β) oscillations are simultaneously apparent in the retarding field oscillator. This is, no doubt, due to the presence of at least two degrees of freedom in the mechanism of oscillation. The critical conditions obtained might be said to be a particular case, and moreover, an interesting demonstration, covered by Hollmann's theory of "inversions"[9]. However, the exact mode of oscillation cannot be proved without further investigation, to which it is hoped to return at a future date, the present results being obtained during a very short, and hardly comprehensive, series of tests, in the nature of a laboratory demonstration.

In conclusion, I wish to commend the following graduates of Liverpool University, namely: Messrs. Maclese, Northrop and Vernon, B.Eng., for their experimental versatility, as students, in obtaining much reliable data upon part of which the foregoing results are based. My gratitude, also, is due to Prof. E. W. Marchant for his continued kindly interest and encouragement.

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Meetings in April

At the meeting of the Wireless Section of the Institution of Electrical Engineers on Wednesday, April 1st, J. E. Thwaites and F. J. M. Laver will deliver a paper on "The Technique of Frequency Measurement and its Applications to Telecommunications." The subject to be discussed at the informal meeting of the Section on Tuesday, April 14th, will be "Distortionless Detection." The opener will be A. J. Heins van der Ven.

On April 23rd, Dr. O. E. Buckley will deliver the Institution's 33rd Kelvin Lecture. His subject will be "The Future of Transoceanic Telephony."

All I.E.E. meetings now begin at 6 o'clock.

Capt. P. P. Eckersley will deliver a paper entitled "Future Development in Radio Communication" at the meeting of the British Institution of Radio Engineers on Saturday, April 18th. The meeting, which will be held at the Federation of British Industries, 21, Tothill Street, Westminster, London, S.W.1, is timed for 3 o'clock.

The Temperature Compensation of Condensers

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

(Concluded from page 111 of the March, 1942, issue)

At the conclusion of the first part of this article the author described the principle of a simple method of compensating the temperature coefficients of condensers and the application of the principle to the compensation of an air condenser of fixed value.

The method is applied to a variable air condenser in the manner depicted in Fig. 7. The fixed plates (6) of this condenser are interleaved with the moving plates (7) which are shaped to give any desired law of capacitance change. The moving plates are mounted in a conventional manner on a spindle (8) which rotates in the bearing (9). The end moving plate (10) is cut from bimetal sheet and is shaped to give the correct amount of compensation for all angular positions of the moving plate system. The bimetal plate is divided into sections by a number of saw-cuts (11) and the air gap of the condenser it forms is adjusted to the required amount by the dimension of the spacing collar (12).

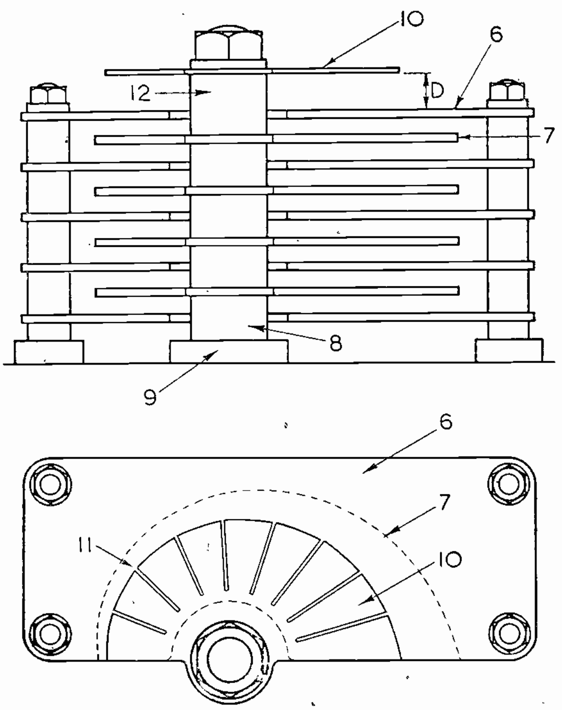

Fig. 7.

It should be noted that Thomas provides no temperature compensation for the minimum settings of his compensated variable condensers. In his third model, for example, the capacitance corresponding to any angular setting θ is given by :—

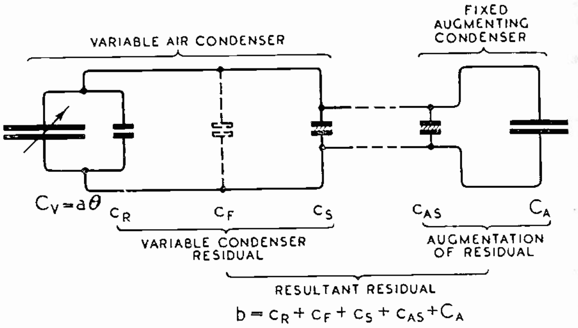

Fig. 8.

$$C = 1.21\,\theta + 47$$

whereas the compensation provided is merely proportional to θ. This may not be serious in such a rigidly constructed condenser with quartz insulation. In a more commercially constructed variable condenser, however, changes of geometry other than that of the plate systems may occur with temperature change and, more important still, quite large changes of permittivity with temperature may occur in the solid insulators of the condenser if these are of material less perfect than quartz.

The temperature coefficient of a variable condenser is, in fact, rarely constant throughout its range, as is well shown by the curves of Fig. 9. Before examining these curves it will be well to separate the various components of the capacitance of a variable condenser so that their contribution to the resultant temperature coefficient may be more readily understood.

The elements of any variable condenser may be represented as in Fig. 8. For simplicity, the condenser shown has a linear law of capacitance $C = a\theta + b$, but one of any other law may be treated similarly. For completeness the variable condenser is shown augmented by a fixed condenser, but if such is not the case the elements c_{AS} and C_A may be ignored. Using the notation of Fig. 8,

$$C = a\theta + b$$
$$= a\theta + (c_R + c_F + c_S + c_{AS} + C_A)$$

The full expression for temperature coefficient corresponding with the above formula is :—

$$\frac{\Delta C}{C} = \frac{\alpha a\theta}{a\theta + b} + \left\{\frac{\beta c_R}{a\theta+b} + 0 + \frac{\gamma c_S}{a\theta+b} + \frac{\delta c_{AS}}{a\theta+b} + \frac{\epsilon C_A}{a\theta+b}\right\} \quad \ldots \ldots (12)$$

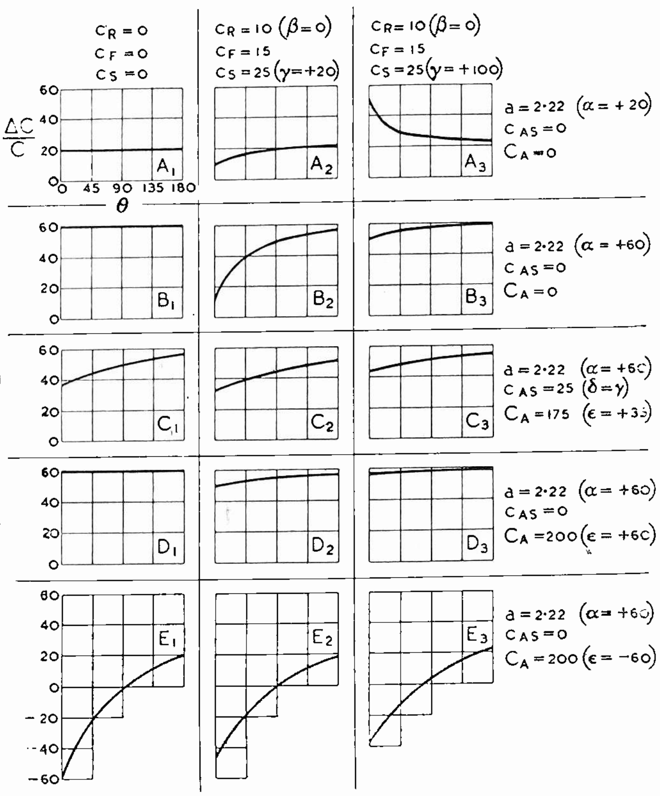

Fig. 9.

where the following are the temperature coefficients of the components :—

α = that of the variable capacitance (assumed constant for all values of θ).

β = that of the residual, c_R, of the variable capacitance (where $\theta = 0$).

γ = that of the permittivity of the solid insulating material (capacitance c_S) of the variable condenser (including terminal insulation).

δ = that of the permittivity of the solid insulating material (capacitance c_{AS}) of the fixed condenser (including terminal insulation).

ϵ = that of the air capacitance C_A of the fixed condenser or of the permittivity of the solid dielectric material if C_A is not an air condenser.

The temperature coefficient of the invariable air capacitance c_F of the structure or framework of the variable condenser may be assumed to be zero if such structure is rigid and any electrostatic shield, stout. All capacitance due to field through air dielectric other than that between the interleaved condenser plates is included in c_F.

The diversity of possible types of temperature coefficient curves which may be associated with a variable air condenser is shown in Fig. 9. These curves have been plotted from computations based on expression (12) for a variable condenser of 400 $\mu\mu$F capacitance change but having different values of residual capacitance and various kinds of solid insulation. The curves are of temperature coefficient $\frac{\Delta C}{C}$ per deg. C. in parts in a million plotted against the angular setting θ of the condenser in degrees.

Curve A_1 is that which one would naturally associate with the theoretical case of a variable air condenser having negligible residual capacitance, i.e. in which $C = a\theta$, in this case $2.22\ \theta$, and constructed throughout from metal having a temperature coefficient of linear expansion of 20×10^{-6} per deg. C. Ordinarily, however, such a condenser would have some residual capacitance and if this value $(c_R + c_F + c_S)$ is assumed to be 50 $\mu\mu$F $(C = 2.22\ \theta + 50)$ of which c_S is 25 $\mu\mu$F and is of fused silica having a temperature coefficient of permittivity of $+ 20 \times 10^{-6}$ per deg. C., the temperature coefficient curve A_2 results. If instead of silica the solid insulation c_S consists of the same amount (capacitance) of material having a temperature coefficient of permittivity of $+100 \times 10^{-6}$ per deg. C. the temperature coefficient curve A_3 is obtained.

In practice, however, the temperature coefficient of the variable portion of the capacitance of an air condenser is nearer $+ 60$ than $+ 20 \times 10^{-6}$ per deg. C. as shown in curve B_1. B_2 and B_3 are the corresponding curves for the practical cases of silica and ordinary solid insulating materials as specified for cases A_2 and A_3 respectively.

perature coefficients varying more widely than $+ 60$ to $- 60 \times 10^{-6}$ per deg. C. may be associated with the variable condensers.

Example B_2 represents the case of a really good silica insulated variable air condenser standard. Example B_3 is that of a good wavemeter condenser* and C_3 of the same condenser in which the frequency range is limited by augmentation of minimum capacitance.

The difficulty of compensating the temperature coefficient of a variable condenser by means of a single compensator is apparent from a glance at the curves of Fig. 9.

In Fig. 10 are shown (in full line) the temperature coefficient curves of four practical variable condensers. The first, B_2, is

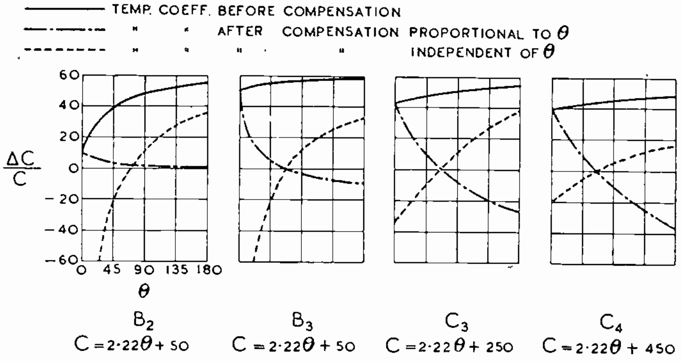

Fig. 10.

Curves B_2 are of a silica insulated condenser.

Curves B_3 are of a similar condenser but insulated with material having a higher temperature coefficient of permittivity.

Curves C_3 are for a condenser as B_3 but with a fixed air condenser in parallel.

Curves C_4 are for a condenser as C_3 but with a fixed condenser of greater value.

Curves C_1, C_2 and C_3 are of the same three variable condensers but with the value of the constant "b" augmented by a fixed air condenser of 200 $\mu\mu$F ($c_{AS} + C_A$) of normal temperature coefficient as indicated by the values of δ and ϵ.

Curves D_1, D_2 and D_3 are again of the same variable condensers but augmented by 200 $\mu\mu$F fixed condensers of mica instead of air dielectric; the mica condensers having positive temperature coefficients.

Finally, in the curves E_1, E_2 and E_3, fixed mica condensers of negative temperature coefficient are substituted for those of positive coefficient used in cases D_1, D_2 and D_3.

There are many other changes which may be made in the nature of the temperature coefficient curve of a variable condenser. The coefficient of the variable capacitance component itself may not be constant with θ; varying quantities of solid insulating material of varying temperature coefficient of permittivity may constitute c_S and c_{AS}; and fixed augmenting condensers of tem-

of a low minimum condenser with silica insulation and it is seen that this alone is amenable to approximate compensation by a method in which the amount of compensation is proportional to θ. If an appreciable quantity of solid insulating material having an appreciable temperature coefficient of permittivity is incorporated in the construction of the same condenser, it becomes impossible to compensate, even approximately, by a single type of compensator. This is illustrated by the curves of B_3, from which it is seen that a type of compensation independent of θ is particularly impracticable. The considerable augmentation of minimum capacitance of the same condenser is the case depicted in C_3. Here it is seen that the two methods, applied independently, are about equally impracticable. Still

* The curves of Figs. 9 and 10 are plotted for a condenser of linear law $C = a\theta + b$ but they are equally applicable to wavemeter condensers obeying an inverse square law $C = (a\theta + b)^{-2}$ by substituting a scale of capacitance for that of θ.

further augmentation of minimum capacitance as shown in C_4 makes possible a considerable improvement by employing a single compensator of the type independent of θ but the compensation is still very approximate only.

The author has found it necessary therefore to provide compensation in conformity with the " law " of the condenser. If, for instance, the law is that associated with a linear scale of frequency

$$C = (a\theta + b)^{-2}$$

the constant and variable terms must be treated independently and separate compensation provided. This means, of course, that a compensator as shown in Fig. 6 is provided for the compensation of the temperature coefficient of the residual or minimum capacitance of the condenser in addition to that shown in Fig. 7. The shape of the latter is not, however, designed to the same law as that which is associated with the other moving plates but tends more towards a semi-circle because of the square law connecting the deflection of the bimetal sections and their radii*. If it is found that the temperature coefficient has not been compensated exactly at all parts of the scale, appropriate adjustment may be effected by carefully bending the individual bimetal sections away from, or towards, the fixed plate in order to decrease or increase the compensation, respectively, at any corresponding section of the condenser. This operation is effected generally without appreciably affecting the calibration of the condenser.

Thus the variable condenser may be compensated exactly at its minimum setting and at all other settings, whatever the law of capacitance change. The author has compensated condensers in this manner leaving a residual temperature coefficient of only 1 or 2 parts in 10^6 per deg. C. at all scale positions. He has also employed this method to over-compensate the positive temperature coefficients of variable condensers of wavemeters, leaving negative residual coefficients of a few parts in 10^6 which in effect cancel the similarly small but positive coefficients of the inductances with which these condensers are associated.

Although the saw-cuts in the compensating plate prove extremely useful in providing varying degrees of compensation for the different portions of the variable condenser, they also serve to prevent the distortion which would otherwise occur due to the fact that the tendency to deflection is not confined to a radial direction. The saw-cuts limit the distance through which the differential expansion is effective in a circumferential direction and so limits the amount of bending in this direction. Thus the " curling " of each section of the compensating plate may be made small compared with the radial deflection, since both are proportional to the square of the free distance in the direction of the effect. For the same reason the circular compensator of Fig. 6 is shaped as shown. The saw-cuts in the compensation plate, although shown, for clarity, to be of considerable width in Fig. 7, are actually very fine so as to be negligible in comparison with the air gap distance D. In this way the slightest discontinuity of " law " is avoided.

The collective frequency compensation of the temperature coefficients of coil and condenser of the resonant circuit of a wavemeter, oscillator or master circuit of a transmitter is not a simple matter. The temperature coefficient of frequency is given by

$$\frac{\Delta f}{f} = -\frac{1}{2}\left(\frac{\Delta C}{C} + \frac{\Delta L}{L}\right) \quad .. \quad .. \quad (13)$$

and this temperature coefficient may therefore be corrected by compensating for an *effective* temperature coefficient of capacitance $\Delta C/C + \Delta L/L$.

It should be noted that although ΔL is constant for a given temperature change, the equivalent ΔC to compensate this must be proportional to C if the latter is of variable capacitance. The collective frequency compensation for temperature coefficients of a variable C and fixed L must be effected, therefore, by a method such as that of Fig. 7 in which the amount of compensation is proportional to θ.

This artifice is only possible, however, under certain well-defined conditions of temperature.

* The deflection at the free end of a cantilever strip of bimetal is proportional to the square of its length and inversely proportional to its thickness. It is, of course, proportional also to the temperature change which produces the deflection.

Such collective circuit compensation is possible only if the temperatures of the coil and condenser are always the same and, therefore, is effective only for such temperature changes as may be produced by ambient atmospheric conditions. The application of the method should be limited, therefore, to wavemeters and other circuits of low power. It is extremely unlikely that the temperature rise of the coil and condenser of a circuit due to the same oscillatory current would be equal because the power factors of coils are always, necessarily, much higher than those of condensers and their self heating therefore higher.

It is possible to compensate the temperature coefficient of inductance independently of that of the condenser by a second capacitance compensator in which

$$\frac{\Delta C_1}{C} = \frac{\Delta L}{L} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

where C_1 is the capacitance of the compensator and C the capacitance of the condenser. In such a compensator, for a given change of temperature, ΔC_1 is constant and it is seen, therefore, that the above condition (14) may be satisfied only in a circuit of fixed capacitance C and fixed inductance. The second capacitance compensator may then be situated so as to be actuated by the temperature of the coil. But this is not satisfactory because a temperature rise of the former of a coil or of the surrounding air lags behind that of the actual conductor and the compensation would therefore lag also. For this reason the temperature coefficient of inductance of the coil of an oscillatory circuit of considerable power should always be as low as possible.

It is not practicable even to attempt the independent capacitance compensation of the coil of an oscillatory circuit of considerable power if the condenser of that circuit is of variable capacitance, for in this case ΔC_1 of condition (14) must vary proportionally to C. The compensator, although situated in the intimate vicinity of the coil, would have to be of the type shown in Fig. 7, operated automatically by the rotation of the variable condenser of the circuit.

In a specially designed short wave oscillatory circuit of appreciable power in which the coil and condenser are inter-constructed it might conceivably be possible to attempt the application of collective compensation for fixed or variable capacitance conditions, provided that the thermal properties of the components were appropriately proportioned to transfer quickly to the condenser the heat generated in the coil.

If the temperature coefficient of the self-capacitance c_s of a coil is appreciable expression (13) becomes :—

$$\frac{\Delta f}{f} = -\frac{1}{2}\left(\frac{\Delta C}{C} + \frac{\Delta L}{L} + \frac{\Delta c_s}{C}\right) \quad \ldots \quad (15)$$

Δc_s is, of course, constant for a given change of temperature and because of this can be compensated only by a "fixed capacitance" type compensator, which should be fitted in the coil itself so that it may quickly attain the temperature of the insulating material, the permittivity of which is producing the temperature coefficient to be compensated.

In resonant circuits of low power the temperature coefficient of coil self-capacitance may be compensated collectively with that of the constant capacitance component of the condenser by using a single compensator of the "fixed capacitance" type since (15) may be re-written :—

$$\frac{\Delta f}{f} = -\frac{1}{2}\left(\frac{\Delta C + \Delta c_s}{C} + \frac{\Delta L}{L}\right)$$

In the case of a fixed frequency oscillator of low power ΔC, Δc_s and ΔL can all be collectively compensated by a single compensator of the "fixed capacitance" type.

The method of compensation shown in Figs. 6 and 7 has a disadvantage in that the amount of compensation, being inversely proportional to the air gap, is not independent of temperature unless that air gap is large compared with the maximum deflection likely to be experienced in practice.

This disadvantage does not seriously affect the method when applied to variable condensers because of the large area available and the large air gap permissible in consequence. The compensation of fixed condensers suffers considerably, however, as shown below :—

The deflection at the free end of a cantilever strip of bimetal is given by :

$$D = \frac{3l^2\phi T}{4d} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (16)$$

where D = deflection
l = free length
d = thickness of strip
ϕ = differential expansion coefficient
T = change of temperature

The author has found that the commercial bimetal which he has used becomes flat at a temperature of about 40 degrees C. and the above expression (16) should therefore be rewritten :

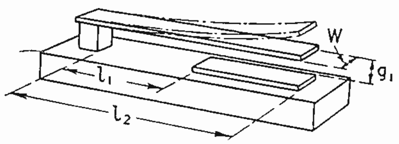

Fig. 11.

$$D = \frac{3l^2\phi(t-40)}{4d} \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

The mean dielectric gap g_{eff} is

$$g_{eff} = \frac{\int_{l_1}^{l_2} g \, . \, dl}{l_2 - l_1}$$

$$\int g \, . \, dl = \left[g_1 l + \frac{7.5 \times 10^{-4}}{3} l^3 t - \frac{0.03}{3} l^3 \right]_{l_1}^{l_2}$$

Therefore

$$g_{eff} = \frac{\left[g_1 l + 2.5 \times 10^{-4} l^3 t - 0.01\, l^3 \right]_{l_1}^{l_2}}{l_2 - l_1}$$

$$= \frac{1}{l_2 - l_1} \{ (l_2 - l_1) g_1 + 2.5 \times 10^{-4} (l_2^3 - l_1^3) t + 0.01 (l_1^3 - l_2^3) \}$$

$$= g_1 + 2.5 \times 10^{-4} \frac{l_2^3 - l_1^3}{l_2 - l_1} t + 0.01 \frac{l_1^3 - l_2^3}{l_2 - l_1} \quad \ldots \quad \ldots \quad (19)$$

The capacitance C (neglecting edge effects) for a strip width of W inch is :—

$$C = \frac{2.54\, W(l_2 - l_1)}{4\pi \frac{1}{l_2 - l_1} \{ (l_2 - l_1) g_1 + 2.5 \times 10^{-4} (l_2^3 - l_1^3) t + 0.01 (l_1^3 - l_2^3) \}}$$

$$= \frac{0.202\, W(l_2 - l_1)^2}{(l_2 - l_1) g_1 + 2.5 \times 10^{-4} (l_2^3 - l_1^3)\, t + 0.01 (l_1^3 - l_2^3)} \quad \ldots \quad \ldots \quad \ldots \quad (20)$$

Taking logarithms of both sides :—

$$\text{Log}_e C = \text{Log}_e 0.202\, W(l_2 - l_1)^2 - \log_e \{ (l_2 - l_1) g_1 + 2.5 \times 10^{-4} (l_2^3 - l_1^3) t + 0.01 (l_1^3 - l_2^3) \}$$

Differentiating :—

$$\frac{1}{C} \cdot \frac{dC}{dt} = - \frac{2.5 \times 10^{-4} (l_2^3 - l_1^3)}{(l_2 - l_1) g_1 + 2.5 \times 10^{-4} (l_2^3 - l_1^3)\, t + 0.01 (l_1^3 - l_2^3)}$$

$$\therefore \frac{dC}{dt} = - \frac{5.05 \times 10^{-5} (l_2^3 - l_1^3)(l_2 - l_1)^2 W}{\{ (l_2 - l_1) g_1 + 2.5 \times 10^{-4} (l_2^3 - l_1^3) t + 0.01 (l_1^3 - l_2^3) \}^2} \quad \ldots \quad \ldots \quad \ldots \quad (21)$$

The author has determined the coefficient ϕ and found it to be 20×10^{-6} per deg. C. The most convenient thickness of strip he has found to be 0.02 inch. Expression (17) may therefore be simplified to :—

$$D = 7.5 \times 10^{-4} l^2 (t - 40) \quad \ldots \quad (18)$$

If, between a simple strip of bimetal and the ordinary metal plate above which it is supported, as in the sketch of Fig. 11, a dielectric gap g_1 exists at a temperature of 40 degrees C., the effective dielectric gap at other temperatures is

$$g = g_1 + 7.5 \times 10^{-4} l^2 (t - 40)$$

For the purpose of a practical investigation

let $l_2 = 1$ inch and $l_1 = \frac{1}{2}$ inch

Then $g_{eff} = g_1 + 4.37 \times 10^{-4} t - 0.0175$.

and if $W = \frac{1}{4}$ inch*.

$$C = \frac{0.254}{g_1 + 4.37 \times 10^{-4} t - 0.0175}$$

* The maximum practicable width for a stable compensator is $\frac{1}{4}$ inch—above this an appreciable "curl" occurs due to the tendency for deflection at right angles to the main deflection. The consequent distortion of the bimetal introduces an uncertainty into the air gap dimension g_{eff}.

and

$$\frac{dC}{dt} = -\frac{1.105 \times 10^{-5}}{(g_1 + 4.37 \times 10^{-4}t - 0.0175)^2}$$

In Fig. 12 dC/dt is plotted for various values of g_1 and for the range of temperature likely to be experienced in ordinary practice. It will be seen that dielectric gaps of the order 0.035 inch are of no use whatever for the compensation of a temperature coefficient which is constant with temperature. Not until the dielectric gap is of the order 0.1 inch can dC/dt be said to be constant enough for this purpose.

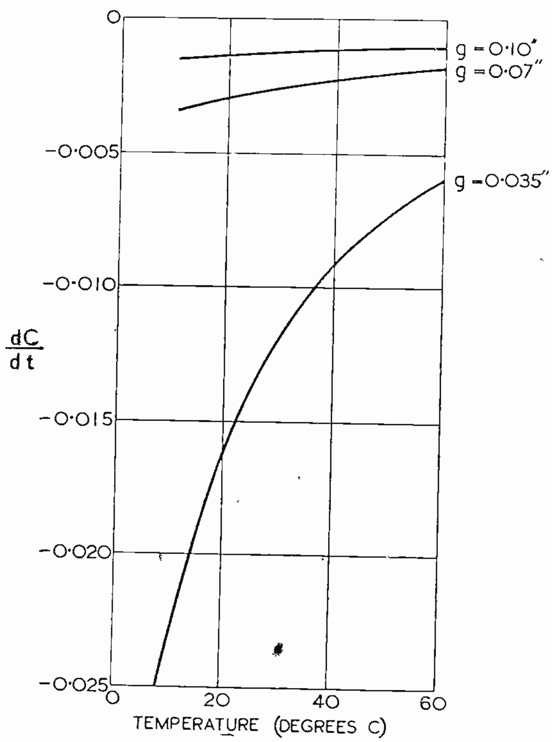

Fig. 12.

The curves of Fig. 13 show the errors which would be experienced in the temperature compensation of a 300 $\mu\mu$F condenser at temperatures of 10 deg. C. and 40 deg. C. The errors are in parts in 10^6 per deg. C. For such errors to be limited to 1 part in 10^6 or so per deg. C. it is seen that dielectric air gaps of less than 0.1 inch are impracticable. But it will be seen from the curve of Fig. 14 that a compensator with a gap of 0.1 inch will compensate a condenser of 300 $\mu\mu$F having a temperature coefficient of only 5 parts in 10^6 per deg. C.

The limitation thus imposed by the inverse law of this type of compensator is,

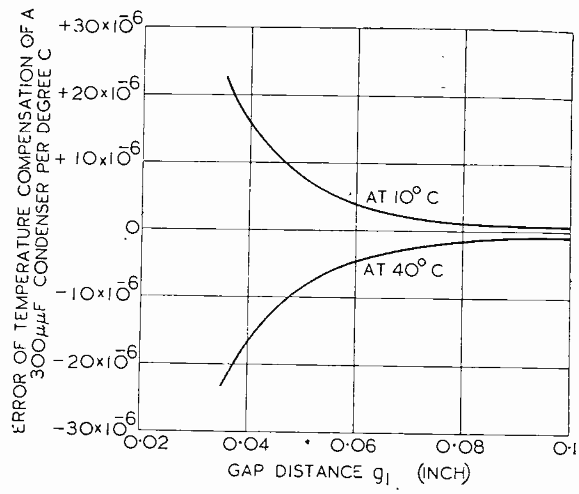

Fig. 13. *Showing the compensation errors introduced by the "inverse law" type of compensator on the principle of Fig. 11. The errors are those for a condenser of 300 $\mu\mu$F capacitance; for a condenser of any other capacitance, C, multiply the errors by 300/C.*

of course, more serious still for capacitances greater than 300 $\mu\mu$F and becomes much more serious at extremes of temperature such as are likely to be experienced in aircraft.

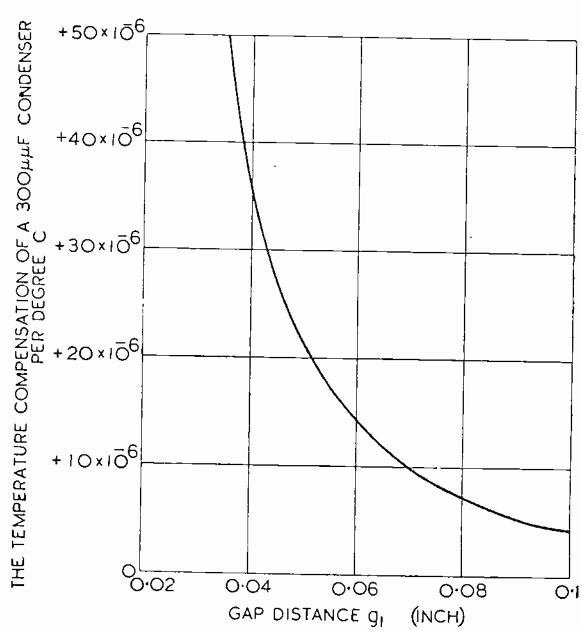

Fig. 14. *Showing the degree of temperature compensation of a 300 $\mu\mu$F condenser by the "inverse law" compensator of Fig. 11. For the degree of compensation of a condenser of any other capacitance, C, multiply by 300/C.*

It is seen, therefore, that this method of compensation possesses all the desirable features enumerated earlier in this section with the exception of feature 8 on capacitances of appreciable magnitude and of considerable temperature coefficient for wide changes of temperature.

In order to eliminate all possibility of error due to this "inverse law" method, the author has evolved a "linear law" compensator in which the same thermal property of bimetal is employed.

This in its simplest form is shown in Fig. 15. It takes the form of a parallel plate air condenser in which the capacitance between the fixed plates (16) and the lightly constructed moving plates (17) is varied by the deflection of the bimetal strip (18) to which the latter are rigidly attached. The bimetal member is securely fixed in position by attachment to the metal pillar (19). It is seen that in this compensator dC/dt is constant since ΔC is proportional to the deflection of the bimetal strip which, in turn, from (17), is proportional to Δt.

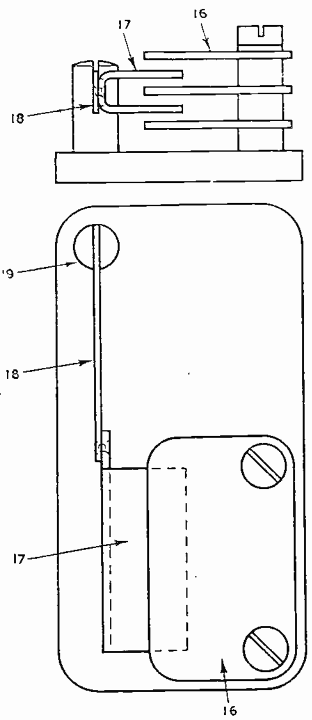

Fig. 15.

Theoretically there is no limit to the temperature coefficient which can be compensated by this device and no limit to the temperature range over which it can be employed. In practice, however, a limit is imposed by the free length of the bimetal member, the whole system becoming unstable and unwieldy if this dimension is too great.

This defect is overcome by the incorporation of a lever magnification system as shown in Fig. 16. In this compensator the air dielectric capacitance between a system of fixed plates (20) and the moving plates (21) is varied by the deflection of the bimetal member (22). The moving plates (21) are fixed to a rigid lever (24) which extends to the spindle (23) and is attached rigidly to it. The pointed levers (25) of the spindle lightly grip the bimetal and thus convert the deflectional movement of the latter into the angular motion necessary to vary the capacitance of the interleaved plate system.

The electrical circuit is obtained through the bimetal member and the spindle from the spill (27) to the moving plates—spill (28) providing the connection to the fixed plate system.

This compact compensator may be used for the complete compensation of condensers of fixed or slightly variable capacitance. It may also be used for the exact compensation of resonant circuits or oscillators in which the frequency is fixed, or variable only within narrow limits. Oscillators having a plurality of fixed frequencies may be compensated exactly by employing a compensator of this type for each frequency. The compensators may be associated with each frequency by being switched in automatically by the frequency changing switch. Thus they may be connected in circuit either independently or in parallel or series combinations as is most suited to the frequency switching scheme of the oscillator. Tempera-

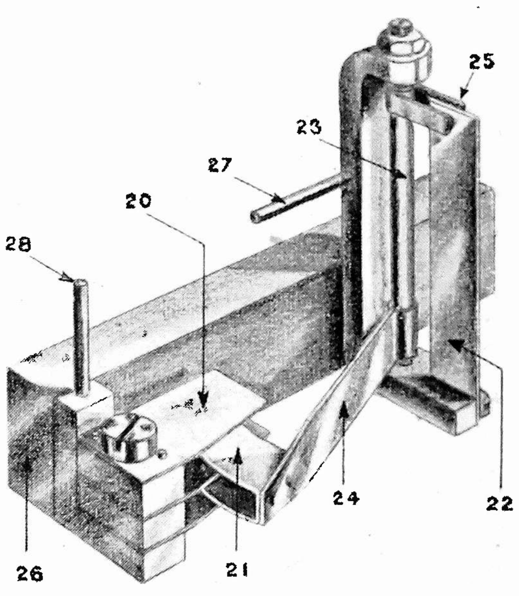

Fig. 16.

ture coefficients of either algebraic sign up to 100 or 200 parts in 10^6 per deg. C. can be compensated with ease over a very wide range of temperature. It may be seen from the sketch that the total capacitance is very small (about 2 $\mu\mu$F) and that that part of it which is due to field through solid dielectric material (the plate 26), negligible. The compensator, in fact, fully embraces all the desirable features enumerated on page 110 of the previous issue with the exception of 1 and 9. The difficulties due to these exceptions are, however, surmounted by using the linear law type compensator for the fixed or residual capacitance of a variable condenser and the inverse law type for the variable capacitance. Or the temperature coefficient may, of course, be more crudely compensated by exact compensation by the linear law compensator at some mid-scale setting, thus over compensating at the lower values and under compensating at the higher—but this is rarely possible except in condensers of very limited ranges, as has already been seen.

The algebraic sign of the temperature coefficient that is compensated by the device of Fig. 16 may be reversed by reversing the bimetal strip (22). Moreover, a groove is cut in the spindle (23) to allow the levers (25) to be adjusted in position so as to vary the effective length of the bimetal member (22). This adjustment is made to suit the degree of compensation required.

It is possible to provide for change of sign and variation of magnitude of compensation without mechanical modification in yet another type of compensator designed on the same principle. This compensator, which is shown in Fig. 17, has the appearance of a complicated piece of mechanism; this is due to the fact that it has been made universal in all respects and is subject to simplification by the omission of parts rendered superfluous by a particular application.

The capacitance of the temperature controlled variable air condenser formed by the fixed plate system (30) and the moving plate system (31) is governed by the deflection of the bimetal member (32) which is attached to the pillar (33). The mounting plate (35) is of good quality insulating material. The bimetal member (32) is so arranged that an increase of temperature deflects the moving plates (31) in a clockwise direction and so decreases the capacitance—thus compensating for a positive temperature coefficient. The amount of such decrease of capacitance for any given temperature rise is proportional to that portion of the radial dimension of the moving plate edge (36) which is embraced by the fixed plates. Thus, if the moving system is initially rotated (by turning the spindle (33) in the friction-tight bearing (34) by means of the slot (45) to the position indicated in chain dot, the temperature compensation will be only half that of the previous position. In this way the degree of compensation may

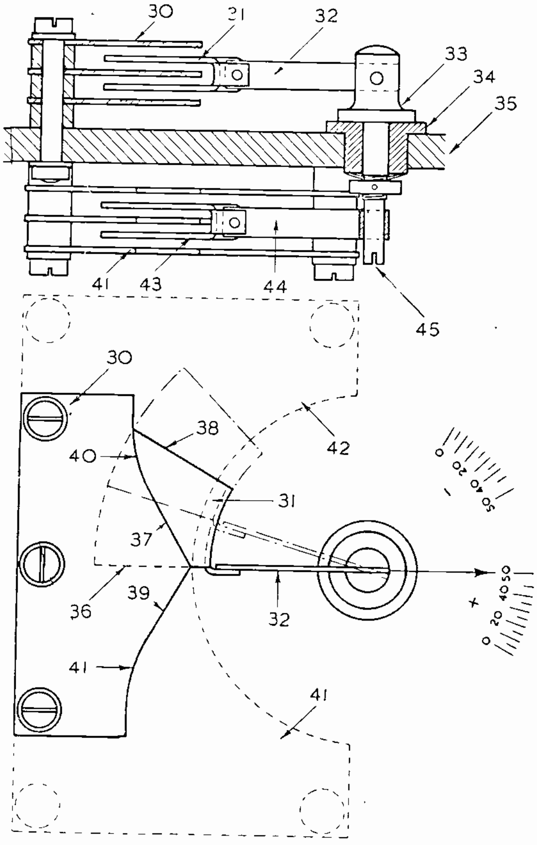

Fig. 17.

be decreased smoothly from a maximum value to zero.

If, instead of using the radial edge (36) of the moving plates in relation to the shaped edge (37) of the fixed plates, the edge (38) is used in relation to edge (39), an increase of capacitance will accompany a rise of temperature and the compensator will therefore compensate for a negative temperature coefficient. By an appropriate initial setting of the angular position of the moving plate system relative to the fixed, the amount of negative compensation also may be given any value between zero and maximum.

It will be observed that for appreciable changes of temperature a rise does not cause exactly the same change of capacitance as a fall. This departure from linearity of compensation may be arranged to be very small, however, by suitably shaping the edges (37) and (39) of the fixed plates especially at (40) where the areas involved are very small.

From the drawing it will be seen that the capacitance of the compensator is variable—depending upon the magnitude of compensation required. Because of this the calibration of a condenser, wavemeter or oscillator on which such a compensator is employed is destroyed during the process of compensation. If it is desired to avoid this, two further sets of fixed plates (41, 42) are added to the design on the reverse side of the insulating mounting plate (35) and an additional moving plate system (43), exactly similar to and angularly coincident with the first system (31), is provided and securely attached to the common spindle (33) by means of a rigid member (44) of *ordinary* metal. The additional fixed plates are connected electrically to the other fixed plate system (30) and are so shaped and arranged that the capacitance remains unaltered during the initial setting of the moving plates to any desired position.

A scale may be provided graduated in terms of the temperature coefficient compensation of a given capacitance. Such a scale is shown in Fig. 17 for the settings indicated by the arrow. The graduations in this case give the amount of positive or negative temperature compensation imparted to a condenser of 300 $\mu\mu$F in parts in 10^6 per deg. C. For a condenser of capacitance C different from 300 $\mu\mu$F the scale reading is merely multiplied by $300/C$.

It is obvious that the compensators of Figs. 15, 16 and 17 are applicable to mica condensers as well as to air condensers. There are important differences between air and mica condensers, however, which must be remembered if the compensation of the latter is undertaken. The compensation is linear for all temperatures, whereas it has been shown earlier in this article that the temperature coefficient of a mica condenser is rarely constant with temperature. A mica condenser, therefore, can be temperature compensated only for a limited and well-defined range of temperature.

In conclusion, the author would express the opinion that the problem of ensuring the frequency stability of oscillators and wavemeters has been much simplified by the introduction of this bimetal method of temperature compensation of condensers together with the method of temperature compensation of inductances described in recent issues of this journal.*

The author wishes to express his indebtedness to Messrs. H. W. Sullivan, Ltd., for their permission to publish particulars and drawings of the patented apparatus shown in Figs. 6, 7, 15, 16 and 17.

* "Recent Improvements in Air Cored Inductances." *Wireless Engineer*, January, 1941, p. 8, and February, 1941, p. 56.

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Whilst the procedure so far as ordinary domestic waste paper is well known, there are still problems that confront those who have to deal with abnormal matters of paper salvage; all such questions will readily be answered by the Waste Paper Recovery Association, 154, Fleet Street, London, E.C.4. Telephone: Central 1345.

The Industry

A PUBLICATION (No. C-111-A) recently received from Muirhead and Co., Ltd., Elmers End, Beckenham, Kent, gives illustrations and specifications of the wide range of instrument dials and control knobs made by this firm.

Londex, Ltd., 207, Anerley Road, London, S.E.20, have just issued a new list, No. 97, illustrating and describing their Synchronous Time Delay Relay PRL. The various models cover a time range of from 2 seconds to 28 days.

GOODS FOR EXPORT

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

Velocity Modulating Grids*

An Investigation of Their Action by Means of Analysis and Graphical Methods

By Rudolf Kompfner

SUMMARY.—In most publications on velocity modulation it is assumed that the distance between modulating grids is negligibly small. With distances as used in practice, however, the transit angles are quite large and a calculation of the consequences of this fact has been made, neglecting the effects of space charge. A graphical method is used to find the current and velocity distribution at the exit from the modulating grid and a particular case which has been treated by means of this method is shown. An analytical method for finding the current and velocity distributions is given under the assumption of small depth of modulation and also an estimate of the position of regions of energy transfer between modulating circuit and electron beam.

1. Introduction

THERE are few published references to the influence of the finite grid distance of a pair of modulating grids on velocity modulation [1 2 3]. The first is mainly concerned with the "signal magnifying" effect of drift-tubes, while the second demonstrates by means of a mechanical analogy the circumstances under which drift-tubes may convert D.C. energy of the electron beam into oscillating energy of the circuit. In Patent Specification No. 528041 there is a calculation of the efficiency of a device called the "Monotron" tube, and also an excellent qualitative account of the happenings between modulating grids.

It is thought, therefore, that an independent investigation of the influence of a velocity-modulating field of finite extent on the velocity and density distributions of electrons emerging from the modulating field may be useful.

2. Method of Finding Current and Velocity Distributions at the Exit Grid

Equation [5a][4] in a previous paper [5] reduces in the absence of bias, to

$$2\theta^2 = \left(\frac{2\theta}{\sqrt{M}} + \cos x\right)(y - x) - \sin y + \sin x \qquad (1)$$

It is proposed to use the same notation and symbols as in the previous paper.

Since $\theta = \dfrac{\omega d}{v_0}$,

(where $v_0 = \sqrt{\dfrac{2e}{m}E_0}$, E_0..peak A.C. voltage)

$\phi = \dfrac{\omega d}{V_0}$,

(where $V_0 = \sqrt{\dfrac{2e}{m}U_0}$, V_0..initial constant velocity)

and $\dfrac{E_0}{U_0} = M$, the "depth of modulation"

we can re-write (1) in a form of greater interest for the purpose in hand:

$$\frac{2\phi^2}{M} = \left(\frac{2\phi}{M} + \cos x\right)(y - x) - \sin y + \sin x \qquad (2)$$

ϕ can be regarded as the mean transit time

* MS. accepted by the Editor, December, 1941.

[1] Sur le tube electronique a modulation de vitesse. J. Bethénod, *Comptes Rendus*, 15th Jan., 1940, p. 105.

[2] Ballistische Modelle von Geschwindigkeits-gesteuerten Laufzeitgeräten. H. E. Hollmann, *Hochf:tech. u, Elek:akus.*, March, 1940, p. 75.

[3] British Patent Specification No. 528041.

[4] Square brackets are used for equations from the previous paper.

[5] "Transit-time Phenomena in Electronic Tubes." R. Kompfner, *Wireless Engineer*, January, 1942, Vol. XIX, No. 219, p. 2.

angle, i.e. the value of $(y - x)$ in the absence of the A.C. component of the velocity.

Equation (2) can be solved by means of the graphical representation as shown in Fig. 1 (a). By " solution " we understand a relation of the form $y = f(x)$; this has been drawn explicitly in Fig. 1 (b) directly above 1 (a). It will be noticed that the trajectories originating at or about $x = \frac{3}{2}\pi$ tend to converge in a manner reminiscent of the trajectories of electrons in space-time diagrams of drift-tubes. It can be shown that, if proper bunching or overtaking is to occur *within* the velocity-modulating grids, M would have to have a value of about 2. Nevertheless we can say quite generally that a peak or maximum in the current distribution at the second grid will occur at or about the time when the $x = \frac{3}{2}\pi$ electron passes through it.

Fig. 1 (c) shows the current distribution at the second grid, found by means of the relation $i_0 \Delta x = i_d \Delta y$. We have to plot merely the slope $\frac{dx}{dy}$ as a function of y, which gives us $i_d = i_0 \frac{dx}{dy}$, the convection current at d.

Next, we are interested in the velocity v_d of the electrons emerging from the second grid. Since the first paper [4] was written, a simpler method of representing the velocity of an electron in motion through a planar diode has been found. It consists in constructing a graph of equation [2] or [2a]. While there is not difficulty at all in taking into account the bias ratio Q, we can put $Q = 0$ in [2] for the purpose of velocity modulation and write:

$$\frac{v_d}{V_0} \cdot \frac{2\phi}{M} = \cos x - \cos y + \frac{2\phi}{M} \qquad .. \quad (3)$$

The graphical representation of (3) is shown in Fig. 1 (d) and it will be seen that it gives not only the velocity v_d of an electron passing through the grid at d, but also the velocity at any intermediate point.

The velocity distribution at d is shown in Fig. 1 (e) and is compared with a hypothetical distribution in the case of an infinitely small grid distance.

Fig. 1 (a, b, c, d, e) have been drawn for a transit angle $\phi \approx \pi/3$ (which would correspond to a frequency f of 10^9 c/s, an accele-

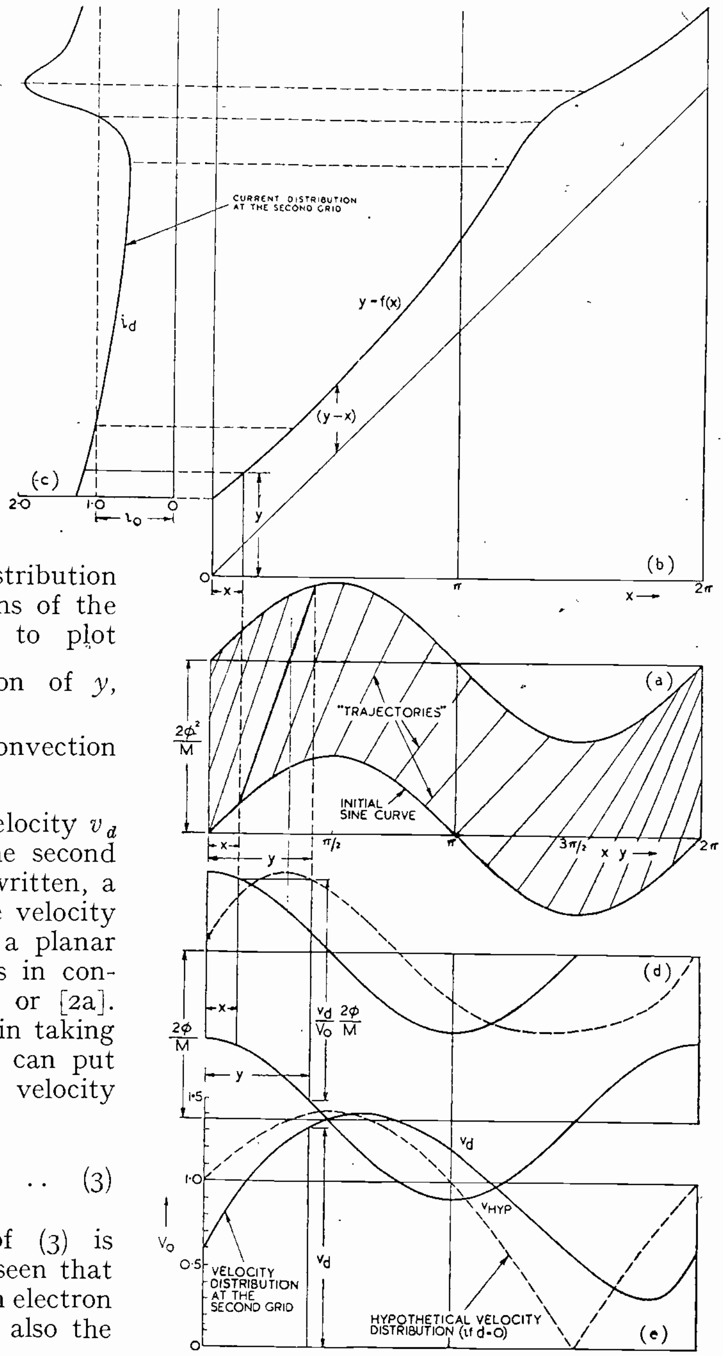

Fig. 1.

rating voltage U_0 of 2,500 volts and $d = 5$ mm) and for $M = 1$.

When ϕ is very small, an approximate derivation can be given for v_d. We make the assumption $y = x + \phi$, this neglecting the small cyclic variation in y. We have then :

$$v_d = \frac{V_0 M}{2\phi}[\cos x - \cos(x + \phi)] + V_0$$

which can be transformed into

$$v_d = \frac{V_0 M}{2} \cdot \frac{\sin \phi/2}{\phi/2} \cdot \sin(x + \phi/2) + V_0$$

This shows, as was to be expected, that an increase in ϕ will result in a decrease in the depth of velocity modulation.

3. Small-Signal Analysis

When $M \ll 1$, and ϕ not too small, we can write equation (2) without too large an error

$$\frac{2\phi^2}{M} \approx \left(\frac{2\phi}{M} + \cos x\right)(y - x)$$

and we obtain

$$y = x + \frac{\frac{2\phi^2}{M}}{\frac{2\phi}{M} + \cos x} \approx x - \frac{M}{2}\cos x + \phi \qquad \ldots \quad \ldots \quad (4)$$

To obtain the convection current distribution i_d we differentiate (4) :

$$\frac{dy}{dx} = 1 + \frac{M}{2}\sin x$$

and we can write, since $i_d = i_0 \frac{dx}{dy}$,

$$i_d \approx i_0\left(1 - \frac{M}{2}\sin x\right) \qquad \ldots \quad \ldots \quad (5)$$

which thus turns out to be independent of ϕ.

For the velocity distribution v_d we insert (4) into (3) and obtain

$$v_d = V_0 \frac{M}{2\phi}\left[\cos x - \cos\left(x - \frac{M}{2}\cos x + \phi\right)\right] + V_0 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

This can be transformed into

$$v_d = V_0[1 + A_0 + A_1 \sin(x + \alpha_1) + A_2 \sin(2x + \alpha_2)] \quad \ldots \quad \ldots \quad (7)$$

where $A_0 = -\frac{M^2}{4}\frac{\sin\phi}{\phi}$,

$$A_1 = \frac{M}{2}\frac{\sqrt{2 - 2\cos\phi}}{\phi} = \frac{M}{2}\frac{\sin\phi/2}{\phi/2}$$

$$A_2 = -\frac{M^2}{4} \cdot \frac{1}{\phi},$$

$$\alpha_1 = \tan^{-1}\frac{1 - \cos\phi}{\sin\phi} = \phi/2$$

and $\alpha_2 = \phi$.

It has to be pointed out that this transformation is only valid when ϕ is not too small ; that is to say, ϕ must be larger than M. It is not advisable to take ϕ smaller than unity.

4. Energy Exchange under "Small-Signal" Conditions

The A.C. energy W gained by all the electrons entering during one cycle is given by

$$W = \frac{2\pi\rho_0}{\omega}\int_0^{2\pi}\left(\frac{mv_d^2}{2} - \frac{mV_0^2}{2}\right)dx \qquad \ldots \quad (8)$$

where $\rho_0 = \frac{i_0}{e}$ the (constant) number of electrons entering per second.

Squaring v_d as given by (7) and neglecting terms containing powers of M higher than 2 we have :

$$v_d^2 = V_0^2\Big[1 + M\frac{\sin\phi/2}{\phi/2}\sin(x + \alpha_1) + \frac{M^2}{4}\left(\frac{\sin\phi/2}{\phi/2}\right)^2 \sin^2(x + \alpha_1) - \frac{M^2}{2}\frac{\sin\phi}{\phi} - \frac{M^2}{2\phi}\sin(2x + \alpha_2)\Big] \qquad \ldots \quad \ldots \quad (9)$$

Inserting this into (8) and carrying out the integration, we obtain :

$$W = \frac{2\pi\rho_0 V_0^2 M^2}{2\omega}\left[\frac{\pi}{4}\left(\frac{\sin\phi/2}{\phi/2}\right)^2 - \pi\frac{\sin\phi}{\phi}\right] \qquad \ldots \quad \ldots \quad (10)$$

W is wholly A.C. energy. $W_0 = i_0 U_0 \cdot \frac{2\pi}{\omega}$ (the D.C. energy expended over one cycle), and

$$\eta = \frac{W}{W_0} = \frac{\pi M^2}{2}\left[\frac{1}{4}\left(\frac{\sin\phi/2}{\phi/2}\right)^2 - \frac{\sin\phi}{\phi}\right] \qquad \ldots \quad \ldots \quad (11)$$

C

This function has been plotted on Fig. 2 and we observe that it goes through zero near $\phi = \pi, 2\pi, 3\pi$, etc., . . . and that it has negative maxima near $\phi = \frac{5}{2}\pi, \frac{9}{2}\pi$, . . . etc.

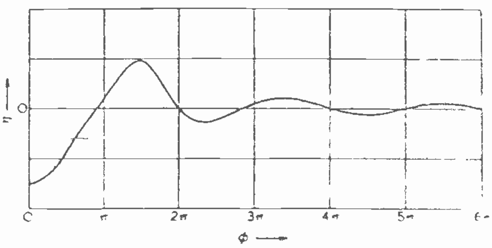

Fig. 2.

This function is obviously a rough approximation and must only be regarded as a purely qualitative expression.

It has already been pointed out by H. E. Hollmann[2], that there will be regions of transit-angles where the electrons will supply energy to the A.C. circuit, or where at least no power is consumed by the A.C. circuit in the action of impressing a velocity modulation on the electron stream, and it has been suggested that these regions will be well suited for a device acting as amplifier of very weak signals.

For Marine Operators

ORIGINALLY published in 1913 and subsequently rewritten on a number of occasions in the intervening years, a new edition—the seventh—of the "Handbook of Technical Instruction for Wireless Telegraphists," by H. M. Dowsett and L. E. Q. Walker, has been published. This textbook for the sea-going wireless operator has been completely revised and brought up-to-date, and, as Dowsett, the author of all but the first edition, states in his foreword, he has found it desirable to share the responsibility of the new edition with a second author possessing the requisite wide experience of modern marine apparatus.

The Handbook, which costs 25s., plus 9d. for postage, can be obtained from our publishers, Iliffe and Sons Ltd., Dorset House, Stamford St., London, S.E.1.

Book Received

Radio Troubleshooter's Handbook.—By Alfred A. Ghirardi. Essentially one for the service-man, this tome contains a wealth of carefully tabulated data of receivers on the American market, and servicing notes on fault finding and repair. This is the second edition of this manual, in which 386 pages are devoted to "case histories" of troubles met with during actual servicing. Pp. (8½ × 11 ins.), 710. Radio and Technical Publishing Co., 45, Astor Place, New York City, U.S.A. Price in the U.S.A., $3.50. Copies are available from A. F. Bird, 66, Chandos St., London, W.C.2, Sherratt and Hughes, 34, Cross St., Manchester, and Cornish Brothers, 39, New St., Birmingham, 2.

Wireless Patents

A Summary of Recently Accepted Specifications

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

540 071.—Utilising the cathode-heating time-lag of a valve to allow direct-current signals to be transmitted, say, over a telephone line without interfering with speech messages.

Ericsson Telephones and L. H. Drysdale. Application date 12th July, 1940.

540 193.—Connecting two amplifiers in parallel to a group of loudspeakers so that transmission is substantially unimpaired in the event of the failure of one of the amplifiers.

Standard Telephones and Cables (assignees of H. C. Curl). Convention date (U.S.A.) 18th July, 1939.

541 272.—Means for preventing overload in a push-pull pair of amplifiers with mutual cathode coupling.

Marconi's W.T. Co. and C. C. Whitehead. Application date 28th May, 1940.

541 276.—Direct-current amplifier in which a safety limit is automatically imposed on the output, particularly for secondary-emission tubes.

Scophony and S. H. M. Dodington. Application date 12th June, 1940.

AERIALS AND AERIAL SYSTEMS

539 308.—Short-wave aerial in which a number of dipoles are arranged on opposite sides of, and parallel to, an earthed supporting mast so as to minimise re-radiation.

Marconi's W.T. Co. (assignees of W. R. Koch). Convention date (U.S.A.) 31st March, 1939.

539 602.—Short-wave aerial array with progressive phase displacement for radiating a rotating field, particularly for navigational purposes.

Marconi's W.T. Co. (assignees of N. E. Lindenblad). Convention date (U.S.A.) 20th May, 1939.

539 678.—Aerial array of parallel "loops" of transmission line terminated by a surge impedance offering a constant input impedance over a wide frequency band.
H. Fletcher. Application date 1st April, 1940.

539 858.—Quarter-wave aerial with a quarter-wave base insulator, forming a readily-demountable assembly.
Marconi's W.T. Co. (assignees of G. H. Brown; J. Epstein; and R. F. Lewis). Convention date (U.S.A.) 23rd February, 1939.

DIRECTIONAL WIRELESS

540 681.—Direction-finding equipment of the switched cardioid type in which the tuning of the signal channels is stabilised by negative feed-back.
Standard Telephones and Cables and C. W. Earp. Application date 12th March, 1940.

540 828.—Modulating system for a magnetron valve generating short-wave pulsed signals, particularly for direction-finding systems.
Marconi's W.T. Co. (assignees of R. A. Braden). Convention date (U.S.A.) 29th April, 1939.

540 871.—Impedance-bridge and rotary-condenser coupling for modulating a radio-navigational beacon transmitter.
Standard Telephones and Cables (assignees of A. Alford). Convention date (U.S.A.) 3rd August, 1939.

540 897.—Intercommunication system between two or more listening posts in an aeroplane, with provision for the reception of radio-navigational signals at will.
Standard Telephones and Cables; C. W. Earp; and J. D. Holland. Application date 3rd May, 1940.

541 399.—Radio altimeter with means for securing a direct ratio between the distance to be measured and the heterodyne frequency set up between the transmitted and reflected waves.
Standard Telephones and Cables (assignees of A. Alford). Convention date (U.S.A.) 19th October, 1939.

541 427.—Directive aerial array for measuring the vertical angle of incident waves.
Marconi's W.T. Co. (assignees of DeW. R. Goddard). Convention date (U.S.A.) 29th June, 1939.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

539 655.—Anti-fading arrangements in which the receiver is automatically connected at all times to the most favourable of a number of alternative channels.
Standard Telephones and Cables (assignees of F. A. Polkinghorn and A. A. Oswald). Convention dates (U.S.A.) 23rd and 31st August, 1939.

539 661.—Valve amplifier of the cathode-ray tube type in which a focused beam is used alternately to charge and discharge an anode or target-electrode of high secondary emissivity.
International Television Corporation; P. Nagy; and M. J. Goddard. Application date 15th January, 1940.

539 802.—Multigrid amplifier in which a capacitative coupling between the anode and grid circuits is used to stabilise operation at ultra-high frequencies.
Standard Telephones and Cables and A. J. Maddock. Application date 21st March, 1940.

539 979.—Arrangement and construction of a frame aerial for use with a portable receiver inside a heavily screened vehicle, such as a steel railway car or an all-metal aeroplane.
E. F. McDonald. Convention dates (U.S.A.) 4th May, 26th June and 6th October, 1939.

540 097.—Method of winding the tuning coils of a multiple-band wireless receiver.
Johnson Laboratories Inc. (assignees of D. V. Sinninger). Convention date (U.S.A.) 26th April, 1939.

540 630.—Negative feed-back amplifier which increases stability at certain critical frequencies, particularly for use with television or multiplex signalling over coaxial transmission lines.
Standard Telephones and Cables (assignees of A. L. Stillwell). Convention date (U.S.A.) 12th October, 1939.

540 837.—Frequency-changing circuit, including a diode-pentode mixer valve for the reception of ultra-short-wave signals.
Standard Telephones and Cables and C. W. Earp. Application date 30th April, 1940.

540 839.—Balanced circuit arrangement for eliminating mutual interference and static disturbances in receiving radio telegraphy.
Standard Telephones and Cables and C. W. Earp. Application date 30th April, 1940.

540 863.—Crystal stand-by receiver for operating a relay or alarm on the receipt of a radiated carrier-wave.
Bush Radio; W. H. Harrison; H. L. Fletcher. Application date 15th May, 1940.

540 941.—Oscillation generator comprising a pair of valves with tuned anode coupling and introduces a negative feed-back to reduce the flow of grid current and increase stability.
P. B. Vanderlyn and E. L. C. White. Application date 15th February, 1940.

541 120.—Modulating a magnetron oscillator so that frequency variations are imposed free from amplitude variations, or *vice versa*.
Marconi's W.T. Co. (assignees of R. A. Braden). Convention date (U.S.A.) 24th May, 1939.

541 149.—Oscillation-generator with negative feed-back for reducing the load on the frequency-determining circuit.
Marconi's W.T. Co. (assignees of H. G. Crosby). Convention date (U.S.A.) 13th May, 1939.

541 260.—Amplifier with negative feed-back for varying gain without substantially altering the output impedance.
Standard Telephones and Cables (assignees of S. T. Meyers). Convention date (U.S.A.) 17th October, 1939.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION

539 496.—Constructing and mounting the mosaic screen in a television tube so as to reduce the effect of undesired charges induced by the scanning stream.

The Mullard Radio Valve Co. Convention date (Germany) 3rd April, 1939.

539 740.—Rotating disc and mirror-wheel scanning device in which a cylindrical lens is used to correct distortion due to the distance separating the moving and fixed slots in the path of the light ray.

Ges. zur Forderung, &c., Technischen Hochschule. Convention date (Switzerland) 14th September, 1938.

540 014.—Method of transmitting and separating the line and frame synchronising impulses used in television with interlaced scanning.

Hazeltine Corporation (assignees of H. M. Lewis). Convention date (U.S.A.) 20th March, 1939.

540 281.—Means for transmitting television signals so as to maintain a desired background of average illumination.

Marconi's W.T. Co. (assignees of R. D. Kell). Convention date (U.S.A.) 31st August, 1939.

540 371.—Means for offsetting the distorting effect of the capacity-to-ground load on a high-powered modulating valve.

Marconi's W.T. Co. (communicated by Amalgamated Wireless [Australasia]). Application date 5th February, 1940.

540 454.—Means for applying automatic gain control, with a "flat" characteristic, which approximates to the "peak" rather than to the average value of signal strength, particularly for television.

Philco Radio and Television Corporation (assignees of A. R. Applegarth, Junr.). Convention date (U.S.A.) 24th May, 1939.

540 590.—Television receiver for use with a system in which the video signals are in the form of amplitude variations, and the synchronising impulses are frequency variations of a common carrier wave.

Hazeltine Corpn. (assignees of H. A. Wheeler). Convention date (U.S.A.) 7th February, 1940.

540 739.—Method of preparing a photo-sensitive surface with a bismuth-silver-caesium coating (addition to 532 259).

Baird Television and A. Sommer. Application date 26th April, 1940.

541 005.—Amplifier circuit for separating the signals from the synchronising impulses in television reception.

Hazeltine Corpn. (assignees of H. M. Lewis). Convention date (U.S.A.) 5th October, 1938.

541 006.—Television receiver in which an amplifier stage also serves to separate the video signals from the synchronising impulses.

Hazeltine Corpn. (assignees of M. Cawein). Convention date (U.S.A.) 5th October, 1938.

541 251.—Means for automatically controlling or stabilising the frequency characteristic of a transmission line, particularly in television.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 3rd June, 1939.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

539 793.—Frequency-modulated signalling system, particularly for minimising fading in picture telegraphy.

Marconi's W.T. Co. (assignees of R. E. Mathes). Convention date (U.S.A.) 18th March, 1939.

539 948.—Multi-channel two-way carrier-wave signalling system.

Standard Telephones and Cables; F. Fairly; and R. Walsh. Application date 29th March, 1940.

540 089.—Signalling system in which the transmitted intelligence, such as speech, may, when desired, be rendered secret to an unauthorised listener.

Telephone Manufacturing Co. and L. H. Paddle. Application date 27th March, 1940.

540 232.—Generating centimetre waves by a device of the kind in which an electron stream is swept across resonant cavities formed in a conducting wall.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 19th April, 1939.

540 233.—Signalling systems in which intelligence is transmitted in the form of pulses of wave-trains of unequal duration but separated by equal intervals of time.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 19th May, 1939.

540 245.—Compensating for saturation-distortion in a modulating system in which the signal voltage is varied in amplitude during the negative part, and in relative phase-angle during a positive portion of the modulation cycle.

Marconi's W.T. Co. and T. H. Price. Application dates 3rd April and 8th August, 1940.

540 706.—Generating equipment for carrier-wave signalling over electric power mains (addition to 478 314).

E. Hallowell; Northern Utilities Trust; and Automatic Telephone and Electric Co. Application date 5th September, 1940.

540 764.—Portable radio transmitter, particularly for aircraft, with a simplified indicating system to enable it to be operated at maximum efficiency over a wide range of frequencies.

Marconi's W.T. Co.; C. S. Cockerell; and G. P. Parker. Application date 27th March, 1940.

540 773.—Capacitance tuning of the Lecher-wire system of an ultra-high-frequency radio transmitter.

Electrical Research Products, Inc. Convention date (U.S.A.) 26th July, 1939.

540 800.—Means for compensating for fading in a signalling system wherein a frequency-modulated subcarrier is superposed on a primary carrier-wave (addition to 539 793).
Marconi's W.T. Co. (assignees of J. E. Smith; J. N. Whitaker; and G. R. Clark). Convention date (U.S.A.) 27th April, 1939.

540 804.—Radio transmitter in which a modulator of the absorption type includes an impedance network giving a constant load, thereby preventing frequency and phase distortion.
Marconi's W.T. Co (assignees of D. G. C. Luck). Convention date (U.S.A.) 24th May, 1939.

540 827.—Valve-oscillator of the Barkhausen-Kurz type in which provision is made for preventing changes in frequency due to fluctuations in the supply voltage.
Marconi's W.T. Co. (assignees of R. W. George). Convention date (U.S.A.) 31st March, 1939.

540 842.—Method of coupling an ultra-short-wave generator to a transmission line, dielectric guide, or radiating horn.
Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 26th May, 1939.

540 888.—Variable-mu valve circuit for "softening" the beginning and end of the keying periods in a radio telegraphic transmitter.
Marconi's W.T. Co. and V. J. Cooper. Application date 3rd April, 1940.

540 999.—Method of measuring distances by means of reflected waves, in which the frequency of the outgoing or exploring wave is varied cyclically and produces a stationary-wave system between the source and the distant body.
The British Thomson-Houston Co. Convention date (U.S.A.) 7th September, 1939.

541 029.—Stabilised master-oscillator circuit comprising a piezo-electric crystal in series with the cathode load resistance of a valve.
R. Calvert. Application date 14th June, 1940.

541 248.—Constant-voltage transmission line for energising a series of constant-voltage repeaters.
Standard Telephones and Cables and F. Ralph. Application date 17th May, 1940.

541 271.—Velocity-modulating device for generating ultra-short waves from an electron stream which has been bunched by resonance.
The British Thomson-Houston Co. and C. C. Whitehead. Application date 28th May, 1940.

541 373.—Automatic monitoring system for the unattended repeater stations of a carrier-wave signalling system.
Standard Telephones and Cables; F. C. Wright; and S. E. Aldrick. Application date 23rd May, 1940.

541 380.—Preventing leakage of energy at the terminals of a high-frequency transmission line.
Standard Telephones and Cables and C. N. Smyth. Application date 24th May, 1940.

541 423.—Oscillation generator with negative feedback to prevent harmonic distortion and with a diode shunted across the grid to stabilise the fundamental frequency.
Standard Telephones and Cables (assignees of F. E. Terman). Convention date (U.S.A.) 16th June, 1939.

541 428.—Transmission system in which a single side-band and a carrier frequency are separately amplified and combined.
Marconi's W.T. Co. (assignees of D. Pollack). Convention date (U.S.A.) 29th June, 1939.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

539 490.—Multiple-stream electron tube in which the current in one beam is controlled by varying the current in another beam, the control being effected through the interaction of the respective space-charges.
Marconi's W.T. Co. (assignees of A. V. Haeff). Convention date (U.S.A.) 10th March, 1939.

539 662.—Photo-electric sheet-metal cathode perforated to allow light to fall in any direction on to the light-sensitive surface.
F. J. G. van den Bosch. Application date 13th February, 1940.

539 668.—Cathode-ray type of discharge tube in which the electron stream is intensity-controlled to generate a carrier-wave which is then phase-modulated by varying the effective length of the electron stream.
Marconi's W.T. Co. (assignees of H. E. Goldstine). Convention date (U.S.A.) 14th March, 1939.

540 015.—Four-electrode electronic-discharge device having a flat and fluted cathode for generating ultra-short waves at a high level of power.
Marconi's W.T. Co. (assignees of P. T. Smith and L. P. Garner. Convention date (U.S.A.) 28th February, 1939.

540 034.—Construction of cathode-ray tube, particularly for transmitting television signals with a low-velocity scanning beam.
Marconi's W.T. Co. (assignees of A. Rose). Convention date (U.S.A.) 6th June, 1939.

540 554.—Method of winding, assembling, and shaping magnetic deflecting coils for use with cathode-ray tubes.
Jefferson Electric Co. Convention date (U.S.A.) 2nd June, 1939.

540 640.—Electrode assembly of a secondary-emission amplifier with apertured target cathodes carrying progressively increasing voltages.
F. J. van den Bosch and Vacuum Science Products. Application dates 23rd February, 1940 *and 21st March,* 1941.

540 893.—Assembly and construction of the electrodes in a secondary-emission amplifier for ultra-short waves.
F. J. G. van den Bosch; F. E. Lane; H. S. Molyneux-Ffennell; and Vacuum Science Products. Application date 1st May, 1940.

540 983.—Double-diode-triode valve which functions as a degenerative diode rectifier, a triode signal amplifier, and a diode with an A.V.C. output, particularly for a superhet receiver.
Marconi's W.T. Co. (assignees of S. Hunt). Convention date (U.S.A.) 6th May, 1939.

540 989.—Magnetron type of oscillator or amplifier in which the anode surrounds the cathode and also carries a direct current for producing the magnetic control field.
Standard Telephones and Cables (assignees of R. S. Ohl). Convention date (U.S.A.) 27th September, 1939.

541 379.—Grid electrodes for high-frequency oscillators utilising a bunched stream of electrons.
Standard Telephones and Cables and R. N. Hall. Application date 24th May, 1940.

SUBSIDIARY APPARATUS AND MATERIALS

539 773.—Auxiliary magnetic circuit of the Shell type for varying the main magnetic flux through a choke, solenoid, transformer or the like.
H. Muller. Application date 22nd December, 1939.

539 812.—Multi-wave tuning dial in which a number of semi-annular scales are coaxially arranged, and are individually illuminated by lamps under the control of the wave-change switch.
Marconi's W.T. Co. and H. C. Norwood. Application date 3rd April, 1940.

539 864.—Electronic relay of the type in which the grid and anode circuits are back-coupled through a mechanically-movable vane or similar element.
A. H. Stevens (communicated by The Bristol Co.). Application date 26th March, 1940.

539 903.—Balanced-bridge circuit for measuring impedances, particularly very small capacitances and inductances.
C. G. Mayo and H. D. McD. Ellis. Application date 16th May, 1940.

539 954.—Dual heterodyne mixing circuit for measuring or supervising ultra-high frequencies.
S. R. R. Kharbanda and Pye. Application date 4th April, 1940.

540 024.—Construction of piezo-electric oscillator for use as a wave filter or coupling device for transferring a predetermined band of frequencies.
Standard Telephones and Cables (assignees of W. B. Bohannon). Convention date (U.S.A.) 8th June, 1939.

540 068.—Glow-lamp and photometric device for making local measurements of the intensity of high-frequency fields.
S. Strauss. Application date 17th June, 1940.

540 171.—Electro-mechanical vibratory system in which rigid bodies are arranged to simulate the behaviour of electrical wave-filters or networks.
Standard Telephones and Cables (assignees of R. B. Blackman and E. Lakatos). Convention date (U.S.A.) 8th March, 1939.

540 184.—Method of cutting and mounting piezo-electric crystals to prevent spurious oscillations when used in electric wave filters and in electro-mechanical vibratory systems generally.
Standard Telephones and Cables (communicated by Western Electric Co., Incorporated). Application date 7th June, 1940.

540 400.—Means for maintaining the H.T. and L.T. supplies to a diathermy oscillation-generator substantially at ground potential for H.F. currents so as to prevent undesirable radiation.
The British Thomson-Houston Co. Convention date (U.S.A.) 1st August, 1939.

540 494.—Production of high-frequency fields for heating purposes.
The British United Shoe Machinery Co. (communicated by United Shoe Machinery Corporation). Application date 17th April, 1940.

540 754.—Thermionic relay selectively responsive to the duration or repetition of an applied impulse.
Marconi's W.T. Co. (assignees of W. R. Koch). Convention date (U.S.A.) 27th May, 1939.

540 770.—Method of compensating an inductance coil in respect of variation in self-capacitance with increasing frequency.
H. W. Sullivan and W. H. F. Griffiths. Application date 1st May, 1940.

540 838.—Condenser relay device for giving an indication or sounding an alarm when the difference between two carrier-waves exceeds a predetermined value.
Standard Telephones and Cables and W. T. Frankton. Application date 30th April, 1940.

540 906.—Balanced microphone relay for automatically steering a moving body towards a distant source of sound.
W. Shaw. Application date 25th January, 1940.

541 041.—Single-valve arrangement for controlling two or more gas-filled relays in succession.
Philips Lamps. Convention date (Germany) 1st April, 1939.

541 042.—Means for stabilising the synchronisation of facsimile telegraphic recorders.
Radio Inventions Inc. (assignees of H. C. Ressler). Convention date (U.S.A.) 6th November, 1939.

541 194.—Measuring distances by the standing-wave formation produced between the distant body and a source radiating two waves of slightly different frequency.
The British Thomson-Houston Co. Convention date (U.S.A.) 29th September, 1939.

541 250.—Soldering-tag terminals for fixing small electrical components to an insulating panel.
Marconi's W.T. Co. and J. W. Graham. Application date 28th May, 1940.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of 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

925. Correction to "Transmission Theory of Plane Electromagnetic Waves" [in Free Space & in Tubes].—S. A. Schelkunoff. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, p. 603.) *See* 803 of 1938.

926. Correction to "Measurement of the Attenuation and Propagation Velocity of Electromagnetic Oscillations in Metallic Tubes."—A. Riedinger. (*Hochf:tech. u. Elek:akus.*, Oct. 1941, Vol. 58, No. 4, p. 99.)

See 356 of February. The deduction of linear detection from the linearity of the joining lines in Fig. 11 was erroneous, since every power function plotted to a logarithmic scale gives a straight line. However, this correction allows a square-law rectification to be assumed (which seems justifiable in view of the small input amplitudes) and actually improves the agreement between the experimental and calculated values (new Fig. 1). The discrepancy remaining can be attributed to the increasing skin effect at the badly conducting surface.

927. On the Eigenschwingung of the Electromagnetic Hohlraum: a Note on Resonators and Wave Guides.—M. Watanabe. (*Electrotech. Journ.* [Tokyo], Jan. 1941, Vol. 5, No. 1, pp. 7–10.)

"First the applicable limit of Bromwich's method upon resonators and wave guides of various simple forms is obtained; and then, by using these results, elliptic tubes, rectangular tubes, coaxial rectangular tubes, coaxial cylinders, and concentric spheres are investigated."

928. The Theory of Conical Electromagnetic Horns.—Sonada. (*See* 1038.)

929. General Study of Oscillating Electromagnetic Field with Curvilinear Coordinates [General Cylindrical & General Sphero-Conal Coordinate Systems: the Finding of Weber's "Electromagnetic Oscillation Vector" F (div F = div H + η div E = 0): Three Types of Polarised Field and the Principle of Superposition: etc.].—M. Ito. (*Electrotech. Journ.* [Tokyo], Nov. 1940, Vol. 4, No. 11, pp. 247–252.) For Carson, Mead, & Schelkunoff's paper, referred to here, *see* 2504 of 1936.

930. The Field-Theory Approach to Non-Uniform Transmission Lines.—S. Ramo. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, pp. 226–227: summary only.)

931. Concentric-Section Resonant Transmission Lines [New Method].—Hollingsworth. (*See* 991.)

932. Transmission-Line Vector Models [Representation of Hyperbolic Sine & Cosine of Complex Variable in terms of Difference & Sum of Two Exponential Spirals: the Making of Three-Dimensional Wire Models].—S. G. Lutz. (*Elec. Engineering*, July 1941, Vol. 60, No. 7, pp. 364–365.) Sequel to 1835 of 1941.

933. The Physics of a Transmission Line [Maxwell's Theory: Poynting's Theorem: Reaction between Electric & Magnetic Fields: Nature of Corona: Moisture Films on Insulators: etc.].—W. M. Thornton. (*Journ. I.E.E.*, Dec. 1941, Vol. 88, Part II, No. 6, pp. 561–567.)

"It is easy to accept phenomena at their face value, but it is always worth while to review them from time to time even in this very general manner if in doing so a fact or a point of view that is new to us may emerge, or an old half-forgotten theorem be restated."

934. Transmission of an Electromagnetic Wave by a Row of Equidistant Similar Plates [Action similar to Filter in Electric-Circuit Theory: Analogy to Circuit with Variable Parameters, and to General Media with Periodically Varying Refractive Index].—H. Poritsky. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 226: summary only.) For other work by the same writer *see* 2473 of 1940.

935. On the Reflection and Transmission of an Electromagnetic Wave Train of Finite Length from a Series of Parallel Layers [and the Complicated Relations of the Resultant Intensities to the Coherence Length].—Y. Nomura. (*Jap. Journ. of Phys.*, No. 1, Vol. 14, 1940/41, Abstracts p. 48.)

936. Propagation of Radiation in a Scattering and Absorbing Medium, *and* The Rôle of Absorption in Turbid Media.—E. O. Hulburt: S. Q. Duntley. (*Journ. Opt. Soc. Am.*, Dec. 1941, Vol. 31, No. 12, pp. 754–755: p. 755: summaries only.) (i) Applications are made to the brightness of clouds, etc. (ii) Oil and water emulsions: *see* also 2359 of 1941.

937. Absorption of Light and Heat Radiation by Small Spherical Particles: I—Absorption of Light by Carbon Particles [of Diameter comparable with the Wavelength].—R. Ruedy. (*Canadian Journ. of Res.*, Oct. 1941, Vol. 19, No. 10, Sec. A, pp. 117–125.)

"From Mie's classical theory . . . the expression giving the loss of light due to absorption and scattering is reduced to the formula involving only Bessel functions of orders given by half integral values. The result is used for calculating the absorption by small carbon particles. . . . When the diameter is less than 0.2μ the coefficient of absorption decreases towards the red end of the spectrum. The reverse is true for 0.3 and 0.4μ particles."

938. Pressure of Radiation on a Moving Absorbing Surface.—H. E. Ives. (*Journ. Opt. Soc. Am.*, Jan. 1942, Vol. 32, No. 1, pp. 32–34.) For a moving totally absorbing surface the value is exactly half of that for a perfect reflector: it is invariant with motion of the system source-absorber.

939. A General Law of Diminution of Light Intensity in Natural Waters, and the Percent of Diffuse Light at Different Depths.—L. V. Whitney. (*Journ. Opt. Soc. Am.*, Dec. 1941, Vol. 31, No. 12, pp. 714–722.)

940. Note on the Doppler Effect [with Useful Application in Final Adjustment of Valve-Maintained Tuning Fork to Frequency of Standard Fork].—McIlwraith. (*See* 1093.)

941. Tropospheric Reflections.—A. W. Friend. (*Proc. I.R.E.*, Aug. 1941, Vol. 29, No. 8, p. 470: summary only.) Covering much the same ground as 3220 of 1941.

942. Not One Stratosphere but Two [Temperature declines again above Tropopause in Temperate Zones, up to Second Tropopause bounding on "Pseudostratosphere"].—H. Arctowski. (*Sci. News Letter*, 29th Nov. 1941, Vol. 40, No. 22, p. 348.) *Cf.* Möller, Quéney, 637 & 639 of March.

943. Disappearance of the Tropopause during the Antarctic Winter.—A. Court. (*Science*, 12th Dec. 1941, Vol. 94, p. 550.)

944. Further Measurements of the Intensity of the Light of the Night Sky.—R. Hechtel. (*Hochf:tech. u. Elek:akus.*, Dec. 1941, Vol. 58, No. 6, pp. 153–156.)

Continuation of the work at Kochel dealt with in 1015 of 1941: between Dec. 1939 (*not* 1940 as repeatedly stated) and April 1941 the intensities in three different regions of the spectrum were measured on 61 nights by photographic photometry. The work was carried out only when there was a clear sky and no moonlight or scattered sunlight: hence the comparative paucity of material. The beginning and ending of twilight could be very clearly recognised on the records by the sharp intensity variations and by the change of the intensity ratios in *G*, *R*, and *T* (*see* previous abstract), twilight having larger ratios of *G*, and particularly *T*, to *R* than the light of the night sky ("N.H.L.", as before): this follows from the Rayleigh law of scattering. Table 1 gives 65 sets of average values of *G*, *T*, and *R* intensities, measured on an arbitrary logarithmic scale. From these values (taken over periods varying from 1 to 10½ hours) the mean values for each month were worked out and are given in Table 2, together with the number of days on which the observations were taken. They are also plotted in Fig. 1, *G*, *T*, and *R* in order downwards; at the bottom is the Herzogstand curve of mid-day values of max. electron concentration in the F_2 layer (the quantity actually plotted is twice the logarithm of the critical frequency for the ordinary ray: the logarithm of the max. concentration equals this plus a constant). The *G*, *T*, and *R* curves for the 17-month period are very similar to each other, and strongly resemble the F_2 concentration curve: "it is possible that the agreement between the curves for the N.H.L. and the max. concentration would be still better if the data for the former were more extensive. Whenever there were only a few days of observation in a month, small differences in the curves for N.H.L. and max. concentration have little significance: this applies to the position of the principal minimum, which appears in May for the N.H.L. and in June for the max. concentration. The position of the principal N.H.L. maximum cannot be defined very closely, since for Oct. 1940 and Jan. 1941 there are no data. Deviations which would seem to be real, owing to the larger number of measurements, occur in the months Dec. 1939 to Jan. 1940: here there is a small intensity increase in N.H.L. in contrast to a definite decrease in max. concentration. The same thing occurs in Nov./Dec. 1940, where there is a small rise in *G* and *T* (*R* remains constant) in contrast to a marked (16%) fall in max. concentration.

The period Dec. 1940/April 1941 shows a clear decrease, compared with the same months of the previous year, both in the N.H.L. intensity and in the max. concentration: the respective decreases are 21% (*G*), 34% (*R*), and 19% (*T*), and 30% for the max. concentration. The reason for the latter decrease is to be found in the 11-year sunspot period, and if (as is natural) a similar connection between N.H.L. and solar activity is deduced, this would mean that a part of the N.H.L. is of solar origin, presumably by way of the ionisation of the F_2 layer. No correlation with the 27-day sunspot-number curve could be established (Fig. 2), though the writer considers that the N.H.L. curves do suggest the existence of a 27-day period.

The average nightly variations of N.H.L. intensity over six three-month periods are shown in Fig. 3. In any one period the curves for *G*, *T*, and *R* are very similar, but their shapes differ in the periods belonging to different seasons: thus the Dec. 1939/Jan. 1940 curves are quite unlike those of May/July 1940, but their shape reappears in Nov. 1940/Jan. 1941. The well-known midnight intensity-maximum of the green auroral line (which is mainly responsible for the *G* intensity) "thus makes its appearance in the present records only in winter" [if this is meant to refer to the top left "*G*" curve, for instance, it is not very convincing: still less so if the bottom-but-one left curve is considered]. "It is worth noting that the critical frequency of the F_2 layer also shows a weak midnight maximum in winter (Herzogstand record for December, Fig. 4), for which no satisfactory explanation has yet been found. An interpretation of both phenomena—the seasonal variation of the nightly course of N.H.L. intensity and the midnight maximum of the F_2 critical frequency in winter—would be possible on the assumption of an auxiliary ionising agent in the form of a radiation originating in cosmic space and coming in with greater intensity from a definite direction. The possibility of such a radiation with non-uniform directional distribution has already been considered for the explanation of the diurnal variation of the cosmic rays (Kolhörster, 1620 of 1941)."

945. ON THE DIRECT AND "SUPERPROPAGATION" VELOCITIES OF SHORT WAVES [Apparent Velocity of "Long-Path" Signals Greater than That of "Short-Path" Signals, the Difference decreasing as Solar Activity increases].—N. Stoyko. (*Comptes Rendus* [Paris], 12th May 1941, Vol. 212, No. 19, pp. 784–786.)

Measurements of time signals between 1931 and 1939 gave 9410 figures for the apparent velocities, the mean values being 272 483 km/s and 283 607 km/s for the short and long paths respectively. The values for individual years all showed a greater apparent velocity for the long-path waves, but in the period 1936/39 (high solar activity) the short-path values increased and those for the long path decreased, compared with the period of low solar activity 1933/35, so that the difference was smaller in the period of greater solar activity (simple mean difference + 5 501 km/s compared with + 20 024 km/s).

"One finds that the increase of the activity of the sun (by day compared with by night, in summer compared with in winter) diminishes the height of the ionised layer, increases the angle of incidence of the waves, and consequently increases their apparent velocity: this is confirmed for the short-path propagation. The number of cases of long-path transmission increases with rising solar activity, so that the conditions of short-path and long-path propagation should approach each other. The difference between the long-path and short-path velocities ought to diminish," which fits in with the above results. But, as mentioned above, the increased solar activity does not reduce the difference only by increasing the short-path apparent velocity; it also *decreases* (and, from the figures, to a still greater extent) the long-path apparent velocity. No explanation of this is suggested. For previous work *see* 8 & 2924/5 of 1935 and 3595 of 1937.

946. HARVARD IONOSPHERE ECLIPSE EXPEDITION TO SOUTH AFRICA.—J. A. Pierce. (*Proc. I.R.E.*, Aug. 1941, Vol. 29, No. 8, p. 470: short summary only.)

"In general, the results of previous expeditions were confirmed, although the changes in the ion density of the F_2 layer were of a larger magnitude than had been reported before. Evidence was obtained of the differences in the intensity of the ionising radiation from various parts of the surface of the sun."

947. IONOSPHERIC CHARACTERISTICS AT HUANCAYO, PERU, FOR THE YEAR 1940: *and* FOR JULY/SEPTEMBER, 1941: *also* THE IONOSPHERE AT WATHEROO, WESTERN AUSTRALIA, JULY/SEPTEMBER, 1941.—R. C. Coile & others: W. C. Parkinson. (*Terr. Mag. & Atmos. Elec.*, Dec. 1941, Vol. 46, No. 4, pp. 435–442: pp. 443–446: pp. 447–450.)

948. SOME OBSERVATIONS ON INTERRUPTIONS TO RADIO COMMUNICATION OVER SHORT DISTANCES IN HIGH NORTHERN LATITUDES [Short-Wave Interruptions lasting Hours & Days in Alaska & the Yukon].—R. J. Gleason. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, p. 356: short summary only.)

949. HIGH-FREQUENCY RADIO TRANSMISSION CONDITIONS, SEPTEMBER, 1941 [including the Aurora of the 18th: Sporadic-E Reflections].—Nat. Bur. of Standards. (*Proc. I.R.E.*, Oct. 1941, Vol. 29, No. 10, pp. 563–564.)

950. ONE UNUSUAL OBSERVATION IN THE AURORAL DISPLAY OF 18TH SEPTEMBER [Streamers apparently Close Overhead], *and* OZONE ODOUR DETECTED DURING AURORAL DISPLAY.—F. C. Brown: M. E. Little. (*Science*, 12th Dec. 1941, Vol. 94, pp. 562–563: *Sci. News Letter*, 8th Nov. 1941, Vol. 40, No. 19, p. 295.)

951. THE SUNSPOT-GROUP ASSOCIATED WITH THE MAGNETIC STORM OF SEPTEMBER 18TH, 1941, *and* THE AURORA AND GEOMAGNETIC STORM OF SEPTEMBER 18TH/19TH, 1941.—R. S.

Richardson: A. G. McNish. (*Terr. Mag. & Atmos. Elec.*, Dec. 1941, Vol. 46, No. 4, pp. 459–460 : pp. 461–463.)

952. RANGES OF WIRELESS WAVES [10 kc/s to 30 Mc/s: Discussion of Curves, reproduced from National Bureau of Standards Letter Circular LC 615 of 1940, giving Predictions for 1941: Criticism of Insufficient Attention to Orientation of Communication].—H. A. Hess. (*E.T.Z.*, 23rd Oct. 1941, Vol. 62, No. 42/43, pp. 857–859.)

For the writer's paper referred to *see* 2335 of 1941: the second footnote refers to American papers on the effects of the magnetic storm of 24th March 1940 on h.t. and telephone systems—953, below.

953. PAPERS ON THE EFFECTS OF THE MAGNETIC STORM OF 24TH MARCH 1940 ON H.T. AND TELEPHONE NETWORKS, AND DATA OF BIG STORMS FROM 1859 ONWARDS.—W. F. Davidson: L. W. Germaine: A. G. McNish. (*E.T.Z.*, 30th Jan. 1941, Vol. 62, No. 5, p. 99: p. 100: p. 100: summaries only.) Referred to in 952, above: *see* also 1828 of 1941, and 15 & 1604 of same year.

954. THE SUDDEN REVERSAL IN THE MAGNETIC POLARITY OF SUNSPOTS [and the Opportunity of Research provided by the Coming Minimum in the Solar Cycle].—S. B. Nicholson. (*Science*, 7th Nov. 1941, Vol. 94, Supp. p. 10.)

955. INDUCTION MAGNETOGRAPH [and Application to Ionospheric Research].—H. Nagaoka & T. Ikebe. (*Jap. Journ. of Phys.*, No. 1, Vol. 14, 1940/41, Abstracts p. 41.) Another summary was referred to in 21 of 1940.

956. ON THE RELATIONSHIP BETWEEN THE PROPAGATION OF SHORT RADIO WAVES AND MAGNETIC ACTIVITY.—A. F. Pershin. (*Elektrosvyaz* [in Russian], No. 4, 1941, pp. 43–45.)

Some results are published of the observations made in Russia in 1938 on the propagation of day (15–25 m) and night (30–60 m) waves in a westerly (New York), easterly (Vladivostok, Khabarovsk) and southerly (Tashkent, Tbilisi) directions. The sum of the daily average amplitudes of the magnetic dip and of the horizontal and vertical components was taken as a measure of magnetic activity. The field intensity in μV/m was chosen to represent the propagation conditions. Curves showing the variation of magnetic activity (dotted line) and field intensity (thick line) are plotted. A study of these curves leads to the following conclusions:—(1) An increase in magnetic activity is nearly always accompanied by a deterioration in the propagation conditions. (2) In the majority of cases all directions are affected simultaneously. (3) On the other hand, some magnetic disturbances even of considerable intensity affect the propagation conditions only slightly or not at all. Also only some of the directions become affected. (4) During some of the strong magnetic storms a rapid increase in the field intensity was observed for a short time. (5) The easterly and westerly directions are more liable to be affected by magnetic activity than the southerly direction. (6) No variations in the propagation conditions corresponding to the 27- and 54-day periods could be observed in 1938.

To obtain a numerical relation between the propagation conditions and magnetic activity, a yearly and a few monthly correlation coefficients have been calculated for one station (RKL). Average daily field intensities and amplitude sums were used for computing the monthly coefficients, and average five-day values in the case of the yearly coefficient. The correlation coefficients for day and night are shown in Table 1. The small numerical values and the negative sign indicate respectively that there is only a slight direct relationship between the two phenomena, and that their variations are of opposite phase. A somewhat higher value of the yearly coefficient based on five-day averages indicates a better correlation, which means that there is a lag of a few days between a magnetic disturbance and the full effect on the propagation conditions.

957. GREENWICH FREQUENCY-STATISTICS [over 62 Years] OF GEOMAGNETIC DISTURBANCE: *also* COMPARISON OF LONG PERIODIC VARIATIONS IN MAGNETIC ELEMENTS AND AIR-TEMPERATURE: *and* SOME RELATIONSHIPS IN THE FIELDS OF GEOMAGNETIC STORMS.—S. Chapman: K. F. Wasserfall: B. Cynk. (*Terr. Mag. & Atmos. Elec.*, Dec. 1941, Vol. 46, No. 4, pp. 385–400: pp. 417–430: pp. 431–433.)

958. A STATISTICAL ANALYSIS OF THE EARTH'S INTERNAL MAGNETIC FIELD.—W. M. Elsasser. (*Phys. Review*, 15th Dec. 1941, Vol. 60, No. 12, pp. 876–883.)

959. "AMERICAN GEOPHYSICAL UNION, TRANSACTIONS OF 1941" [Book Review].—J. A. Fleming (Edited by). (*Terr. Mag. & Atmos. Elec.*, Dec. 1941, Vol. 46, No. 4, pp. 433–434.)

960. INTENSITY VARIATIONS OF COSMIC RAYS [including Strong Correlation with Magnetic Storms].—C. Ishii & others. (*Jap. Journ. of Phys.*, No. 1, Vol. 14, 1940/41, Abstracts p. 32.)

961. RECENT COSMIC-RAY RESEARCHES OF THE U.S. ANTARCTIC SERVICE.—S. A. Korff. (*Science*, 12th Dec. 1941, Vol. 94, pp. 549–550.)

962. ELECTRIC FIELDS [produced by Cosmic Rays] IN INTERSTELLAR SPACE.—Foster Evans. (*Phys. Review*, 15th Dec. 1941, Vol. 60, No. 12, p. 911.) Reply to Mohler's letter, 3003 of 1941.

963. ON COSMIC PARTICLES [Hitherto Overlooked Results of Existence of Diffuse Clouds of These: Secular Change of Velocity of Light, etc.].—T. Takéuchi. (*Jap. Journ. of Phys.*, No. 1, Vol. 14, 1940/41, Abstracts pp. 1–2.) *Cf.* Bessey Smith, 2337 of 1941.

964. THE PROPAGATION OF SURFACE WAVES OVER STRATIFIED AND UNEVEN GROUND [and the Derivation of a "Modified" Zenneck Wave].—J. Grosskopf. (*Hochf:tech. u. Elek:akus.*, Dec. 1941, Vol. 58, No. 6, pp. 163–171.)

After various workers had discredited the Zenneck surface waves on theoretical grounds, with Burrow's measurements on 2 m propagation over fresh water (1693 of 1937) in agreement with them, Norton showed that a splitting of the field radiated from an aerial into a space field and a surface field was quite plausible physically and was also useful for practical purposes. The Norton type of surface wave (32 & 33 of 1938) differs from Zenneck's to a not unimportant extent, and the writer therefore begins by an exposition and comparison of the two types. He sums up with the statement that the electric vector in both cases describes practically the same rotating-field ellipse: the Zenneck wave however is attenuated exponentially, and its phase velocity depends on the ground constants and is greater than the velocity of light; whereas the Norton wave at large distances from the transmitter (a condition which must be fulfilled if a comparison is to be made with the plane Zenneck wave) is attenuated in proportion to $1/r^2$ and has a phase velocity which is independent of the ground constants and is equal to c.

The writer continues: "Alpert, Migulin, & Ryasin have recently made an important contribution [the reference is to *Journ. of Phys.* [of U.S.S.R.], Vol. 4, 1941, p. 13 onwards: this is presumably a translation of the paper in Russian dealt with in 622 of March] . . . Using well-known series developments of the Sommerfeld solution they have shown on worked-out examples that the phase velocity of radio waves is (except in the close neighbourhood to the transmitter, when r is less than λ) smaller than c and that with increasing distance it very rapidly approaches c asymptotically without any dependence on the ground properties. Fig. 3, taken from this paper, shows the calculated variation of the phase velocity with distance [up to 4.5λ: $\lambda = 300$ m]: the qualitative course of the curve was confirmed by extremely careful measurements, Fig. 4 [up to 40λ: $\lambda = 127.6$–191.4 m]. Also as regards the height-dependence of the phase of the electromagnetic field good agreement between theory and experiment was found.

"In view of these results it seems no longer defensible to use the pure Zenneck wave-type in its original form as a basis for theoretical and practical considerations. On the other hand it is desirable for many purposes to be able to employ a wave similar to the Zenneck type and offering the same advantages and simplifications for the mathematical treatment of complicated problems. Now it is easy to derive from the Maxwellian equations (1) a wave form which simultaneously gives the Zenneck-Norton rotating field and has a phase velocity equal to c", by putting $H = H(y) \cdot e^{j(k_0x - \omega t)}$, where y is the height above ground. The "modified Zenneck" wave thus found has, in air, the form given by eqn. 9, fulfilling the above conditions and contained (as it must be) in the exact Norton solution eqn. 6, if these are approximated for large distances from the transmitter and not too great heights y. For under these conditions, and neglecting the term $2 \sin \psi/n\sqrt{1 - n^2}$ as small compared with unity, the sum of the two Norton fields is given by eqn. 12: putting $n^2 = k_0^2/k^2$ this reduces to eqn. 13, which yields eqn. 9 if the H_0 in this is put equal to $2\, e^{jk_0r}/r^2 \cdot k^2/k_0^2$. Here the amplitude factor, the first term of the product, expresses the surface-wave attenuation with the square of the distance, while the second term expresses the influence of the ground.

It is to be noticed that both the surface-wave and the space-wave components of the Norton "splitting" contribute to this solution, so that one can no longer really speak of a surface wave with independent physical meaning. This is already obvious from the unlimited increase of the solution for large values of y. Nevertheless the "modified Zenneck" wave can serve as the foundation for further developments provided that its limits of validity are borne in mind. The writer, accordingly, deals in section V with the propagation of the modified Zenneck wave over stratified ground, just as in a previous paper (1833 of 1941) he and Vogt dealt with the original Zenneck wave. He obtains eqn. 16, "which, except as regards the abbreviations r_1 and r_2 and as regards the left-hand side, is exactly the same expression as that obtained for the original Zenneck wave. Thus the influence of the ground on the electric rotating field is shown in a similar way with both the wave forms," and the relation $\rho' = \rho/\phi$, between the E_x/E_y ratios for stratified and homogeneous grounds, remains the same as before. The calculation of ϕ (eqn. 19) is considered on p. 167: the conclusions reached have already been compared with the experimental results (376 of February): "by careful analysis of the measured frequency-dependence of the amplitude and phase of the ratio of the axes, very many deductions as to the constitution of the ground were possible."

The writer next considers the question of the phase velocity of the original Zenneck wave over stratified ground, starting from eqn. 22 (printed "2") obtained in the previous work (1833 of 1941) for the propagation constant h over such ground. Eqn. 23 is obtained for the phase velocity: for homogeneous ground $r = 1$ and $\psi = 0$ and the phase velocity is greater than c. For five types of stratified ground (defined in the caption of Fig. 6), Fig. 7 gives the percentage deviation of the phase velocity from c as a function of frequency: it is seen that periodic fluctuations of these deviations occur, whose amplitudes and frequency depend on the thickness and conductivity of the layers: that *negative* deviations appear only when the lower layer is the more conductive (curves 4 & 5): and that the percentage deviations can attain considerable values (up to 5%). In the case of the better-conducting layers being underneath, the fluctuations are not shown in Fig. 7 because they are larger than can be dealt with by the approximate formula employed. The above behaviour of the original Zenneck wave will produce ray deflections not only at all internal inhomogeneities such as changes in the ground constants or in layer thickness, but also at surfaces which are in themselves flat; particularly for grazing incidence (*see* last paragraph of section V). Measurements over stratified ground would therefore be very suitable for a further experimental decision of the problem of the Zenneck wave.

Section VI considers the possibility of the influencing of the rotating field and of the phase velocity by curvatures of the surface. For the propagation in an axial direction over a cylindrical surface the Riemann-Weber (1927) solution gives an expression for the propagation constant h which for a very large radius is the same as that obtained by the writer for the Zenneck wave over flat ground (*see* above). For smaller radii the writer uses an approximation and gives in Fig. 8 the calculated percentage deviation from c of the phase velocity of a 30 m wave, for $\sigma = 10^8$ e.s.u. and $\epsilon = 20$, as a function of cylinder-radius values from about 10 m to 10 000 m. The phase velocity for the original Zenneck wave is seen to deviate only slightly from its value over flat earth, even at the sharpest curvatures likely to occur in practice. The same thing applies to propagation in the axial direction over a hollow cylindrical surface (Fig. 8 also). It is to be assumed that the "modified Zenneck" wave would be still less affected by curvatures. Finally, propagation over an arbitrarily curved surface is considered. The Zenneck-Rukop textbook (1925) gives the behaviour of a wave meeting a hill: for very badly conducting ground an undistorted penetration is assumed, while for very highly conducting ground a "wire"-type guiding of the surface wave is considered to occur. But diffraction and reflection effects must be added, and the writer again reproduces the diagram (Fig. 9) of the "Glider Hill" measurements of field inclination: *see* end of 1833 of 1941. The obstacle was partly penetrated, but it also exercised a considerable "guiding" action: since the conductivity was very low it may be assumed that in the case of good conductivity the latter action would predominate.

The writer proceeds to investigate to what extent an arbitrarily curved surface in this simplest case (good conductivity and not too steep slopes) may influence the propagation path. Eqn. 37 shows that the surface wave follows the behaviour of the space wave, which is known to conform to the Fermat "shortest path-time" principle. Further analysis, and the numerical example on p. 170, r-h column, lead to the conclusion that considerable ray deflections may occur even in more complicated cases where the present calculations only apply qualitatively. Such deflections cannot be neglected in the consideration of direction-finding ray variations. In many cases the Fermat principle can be used as a simple way of determining the ray path: for instance, in the case of a ray passing over a horizontal flat surface terminating in a projecting slope. The slope is first "folded down" into the horizontal position and the paths (for various directions of incidence) marked as straight lines: on returning the slope to its true position these paths remain, but their projections on the horizontal plane show changes of direction—ray deflections—at the boundary line between horizontal plane and slope.

965. THE CARTOGRAPHIC SOLUTION OF GREAT CIRCLE PROBLEMS.—A. J. Dilloway. (*Journ. Roy. Aeron. Soc.*, Jan. 1942, Vol. 46, No. 373, pp. 4–31.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

966. THE LIGHTNING DISCHARGE [Survey, with Conclusions regarding Previous Results of Norinder, McEachron, and Schonland: Wave Form of Atmospherics due to Successive Reflections from Ionosphere rather than to Current Pulsations in the Channel: etc.].—C. E. R. Bruce & R. H. Golde. (*Journ. I.E.E.*, Dec. 1941, Vol. 88, Part II, No. 6, pp. 487–505: Discussions pp. 505–520.) This is the E.R.A. Report mentioned in 2364 of 1941.

967. THE LIGHTNING-FLASH SPECTRUM.—H. Israel & K. Wurm. (*Naturwiss.*, 26th Dec. 1941, Vol. 29, No. 52, pp. 778–779.)

A particularly successful record taken on 19th July 1941 is tabulated and discussed: it was taken from the lower end of the path. The first column shows the emitting particle, the second the measured wavelength, the third the roughly estimated brightness: the remaining data, including the excitation potentials, are taken from Miss Moore's "multiplet table of astrophysical interest" (1933). The outstanding feature is the simultaneous occurrence of a strong line spectrum and a strong band spectrum. The so-called "negative" bands of nitrogen (N_2^+) which occur in this and in all the writer's records are not found in laboratory sparks in air, but are to be seen in a glow discharge through pure nitrogen at greatly reduced pressures. Various points in this and other records are discussed, such as the variation of the relative line brightnesses at different positions along the path: with regard to the special record tabulated, "it must be added that at the spot where the flash strikes the ground, 'pole-lines' of calcium appear which extend about 1.5–2 m high in the path of the flash."

The writers conclude that these results give rise to a number of questions which cannot at present be answered owing to lack of data. Moving-camera records such as those of Schonland and his colleagues have shown that the lightning stroke consists of a series of constituent phases, some of which (after-glow of the path) cannot be imitated in the laboratory. If it be assumed that the luminous phenomena in the constituent phases possess different spectra, this would perhaps yield an interpretation of the surprising spectral composition of the light from the flash.

968. "THE MECHANISM OF THE ELECTRIC SPARK" [Book Notice].—L. B. Loeb & J. M. Meek. (*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, p. 466.)

969. VOLT-TIME AREAS OF IMPULSE SPARK-OVER.—J. H. Hagenguth. (*Elec. Engineering*, July 1941, Vol. 60, No. 7, Transactions pp. 803–810.)

970. DISCUSSIONS ON "THE MEASUREMENT OF LIGHTNING VOLTAGES AND CURRENTS IN SOUTH AFRICA AND NIGERIA, 1935 TO 1937."—F. R. Perry. (*Journ. I.E.E.*, Dec. 1941, Vol. 88, Part II, No. 6, pp. 513–520 & pp. 521–524.) *See* 2996 of 1941.

971. LIGHTNING TO THE EMPIRE STATE BUILDING [1937/40 Results and Conclusions].—K. B. McEachron. (*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, Transactions pp. 885–889.)

972. THE DIRECT MEASUREMENT OF LIGHTNING CURRENT [Instruments in Empire State Building, giving Low-Magnitude, Long-Time Current Record of Each Stroke and High-

Magnitude, Short-Time Components].—J. W. Flowers. (*Journ. Franklin Inst.*, Nov. 1941, Vol. 232, No. 5, pp. 425–450.)

973. The Protection of Telecommunication Equipment against High Voltages [particularly Siemens Protectors].—F. J. Gee. (*Sci. Abstracts*, Sec. B, Nov. 1941, Vol. 44, No. 527, pp. 220–221.) *Cf.* 974/5, below, and for Müller's paper on the protection of wireless transmitting installations *see* 660 of March.

974. Development in Lightning Protection of [Sub-] Stations.—E. R. Whitehead. (*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, Transactions pp. 898–900.)

975. Lightning Protection for Electrical Plant [Survey of Various Types of Protector].—O. Naumann. (*Helios* [Leipzig], 29th June 1941, Vol 47, No. 26, pp. 825–829: in German.)

976. "Visibility in Meteorology," *and* "Meteorological Instruments" [including Radiosondes & Radio-Wave Soundings: Book Reviews].—W. E. K. Middleton. (*Journ. Roy. Aeron. Soc.*, Dec. 1941, Vol. 45, p. 378.)

977. Comparison of Methods for Computing Air-Earth Currents, *and* Radioactivity of Rocks and Ionisation-Balance of the Atmosphere.—K. L. Sherman: V. F. Hess. (*Terr. Mag. & Atmos. Elec.*, Dec. 1941, Vol. 46, No. 4, pp. 401–407: pp. 409–415.)

PROPERTIES OF CIRCUITS

978. Control Problems [Application of Operators to Linear Problems: Non-Linear Control Problems (including Liapounoff's Theorem): Laplace Transform and Hurwitz Stability Criteria: etc.].—Minorsky: Tischner. (*See* 1202/3.)

979. A Semi-Graphical [Power Circle Diagram] Method of Determining the Power Limits of an Interconnector [Compound Power-Transmitting Circuit acting as Synchronous Tie between Two Otherwise Independent A.C. Systems].—H. Rissik. (*Journ. I.E.E.*, Dec. 1941, Vol. 88, Part II, No. 6, pp. 568–588.)

980. Electrical and Mechanical Analogies [Survey].—W. P. Mason. (*Bell S. Tech. Journ.*, Oct. 1941, Vol. 20, pp. 405–414.)

981. The History of Electrical Resonance [from the Leyden Jar to "Four Sevens" Marconi Patent].—J. Blanchard. (*Bell S. Tech. Journ.*, Oct. 1941, Vol. 20, No. 4, pp. 415–433.)

982. Deionisation Considerations in a Harmonic Producer employing a Gas-Tube Switch.—Shepherd. (*See* 1146.)

983. Counter Circuits and Their Applications [Frequency-Dividing Circuits for Frequencies below 1 Mc/s, with Excellent Performance].—H. B. Deal. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 223: short summary only.)

984. Symmetrical Circuits operating at the Resonance of the Second Order.—B. N. Gorozhankin & Yu. A. Manteyfel [Manteufel]. (*Elektrosvyaz* [in Russian], No. 3, 1941, pp. 33–34.)

It has been shown by Mandelstam & Papalexi (*see* reference 1, and 1932 Abstracts, pp. 279–280) that if an e.m.f. is applied to an under-excited valve oscillator and the frequency of the e.m.f. is a multiple or nearly a multiple of the natural frequency, then oscillations may appear in the oscillator circuit ("resonance of the *n*-th order"). In practice this effect has been utilised for frequency division and in so-called "autoparametric" filters (2593 of 1935). The drawback to these systems, however, is the fact that they operate at the threshold of self-excitation. Symmetrical circuits employing two valves in push-pull, and suitable for use as autoparametric filters, are therefore considered here. One of the circuits (Fig. 1) was originally proposed by Sterky (51 of 1938) and the other (Fig. 2) by one of the authors. The operation of these circuits is discussed in detail and a report on experiments is given. It is shown that in spite of external differences the behaviour of the two circuits at second-order resonance is identical. They possess the following advantages:—the possibility of self-excitation and asynchronous excitation is excluded, greater stability at the resonance of the second order, wider band of frequencies passed, lower threshold of excitation, and quicker extinction of oscillation when the drive is removed.

985. Symposia on "Non-Linear Circuit Theory" and "Wave Filters and Other Networks" [Programme of Lectures].—(*Proc. I.R.E.*, Oct. 1941, Vol. 29, No. 10, p. 567.)

986. Author's Note and Correspondence on "The Response of Electrical Networks to Non-Sinusoidal Periodic Waves."—N. Marchand: H. Sherman. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, p. 603.) *See* 3259 of 1941. Sherman calls attention to the advantages of the "finite transform" method.

987. A Treatise on the Electric Circuits consisting of Concentrated Constants [Treatment with Advantages over Usual Method involving Solution of General Equation].—N. Yamada. (*Electrotech. Journ.* [Tokyo], Dec. 1940, Vol. 4, No. 12, pp. 263–267.)

"The characteristics of a complicated circuit can be readily deduced from that of a simple circuit, and in addition the manipulation of the circuit can be proceeded in parallel with the visualisation of the physical phenomena occurring in the circuit."

988. Transmission of an Electromagnetic Wave by a Row of Equidistant Similar Plates [Action similar to Filter: Analogy to Circuit with Variable Parameters, etc.].—Poritsky. (*See* 934.)

989. Relations between Dimension or Disposition of Electrodes and Their Electrical Equivalent Circuit Constants, in Rectangular Piezoelectric Vibrators having

LONGITUDINAL MODE OF VIBRATION [in connection with L.F. Filter-Circuit Vibrators with Deposited-Film Electrodes not covering Entire Surface].—Z. Kamayachi & T. Ishikawa. (*Electrotech. Journ.* [Tokyo], Nov. 1940, Vol. 4, No. 11, pp. 243–246.) For previous work *see* 1849 of 1941.

990. NETWORKS WITH ELECTRICAL SYMMETRY [Theorem leading to Insertion-Effects Equations & Sending-Arm Load Equation: Application to Wave-Filter & Transmission-Line Performance: etc.].—E. S. Purington. (*Proc. I.R.E.*, May 1941, Vol. 29, No. 5, p. 282: summary only.)

991. CONCENTRIC-SECTION RESONANT TRANSMISSION LINES [New Method of Shortening the Physical Length of Concentric Resonant Lines (for U.H.F. Circuit Elements) by Subdivision into Section packed One Inside the Other].—L. M. Hollingsworth. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, p. 356: summary only.)

992. NON-STATIONARY PROCESSES IN A COAXIAL CABLE.—V. N. Gorshunov. (*Elektrosvyaz* [in Russian], No. 3, 1941, pp. 45–48.)

An analysis of the processes taking place in a coaxial cable of infinite length when a unit voltage impulse is applied to it. A formula (5) is given determining the impulse voltage at a point *e* due to the unit impulse at the input. The integral in the formula is evaluated and the formula is re-written in a simplified form (13). Using this formula the building up of the voltage at the point *e* is discussed. Formulae (19) are also derived for calculating the attenuation of the cable as determined by its length. The theoretical conclusions were verified experimentally on a cable 2140 m long. A cathode-ray oscillograph was used in these experiments and some of the oscillograms are shown.

993. CORRECTION TO A FORMULA IN A PAPER ON THE INTERNAL NOISES IN A COAXIAL CABLE.—Josephs. (*Elektrosvyaz* [in Russian], No. 3, 1941, p. 76.) The original paper was in No. 8 of 1940.

994. THE INTERACTION BETWEEN TWO PARALLEL LINES WHEN THE LOADS ARE NOT MATCHED.—A. M. Zingerenko. (*Elektrosvyaz* [in Russian], No. 3, 1941, pp. 69–70: summary.)

It is stated that various cases of interference between two parallel lines such as two telephone lines, telephone and telegraph lines, power-transmission and telephone lines, etc., can be regarded as particular cases of two parallel lines with unmatched loads. Taking this general case, equations (1) determining the voltage and current in the line affected by the other are written down and their solutions are given.

995. REACTANCE NETWORKS FOR COUPLING BETWEEN UNBALANCED AND BALANCED CIRCUITS [in Cases where Isolation Transformer is Unsatisfactory owing to Charging Current across Distributed Capacitance at High Frequencies, leading to Unbalance].—S. Frankel. (*Proc. I.R.E.*, Sept. 1941, Vol. 29, No. 9, pp. 486–493.)

996. "TRANSIENTS IN ELECTRIC CIRCUITS" [Book Review].—Coulthard. (*See* 1201.)

997. THE FILTERING ACTION IN THE RECTIFICATION OF AMPLITUDE-MODULATED CARRIERS.—Buchmann. (*See* 1028.)

998. THE FULL-WAVE VOLTAGE-DOUBLING RECTIFIER CIRCUIT [for Small Receivers, C.R. Oscillographs, etc: Graphical Presentation of Analytical Results, and Comparison with Experiment: the Possible Use of Polarised Electrolytic Condensers: etc.].—D. L. Waidelich. (*Proc. I.R.E.*, Oct. 1941, Vol. 29, No. 10, pp. 554–558.) *See* also 34 of January.

999. THE CORRECTION OF TRANSFORMER FAULTS BY COMPLEX NEGATIVE FEEDBACK.—H. Oltze. (*Hochf: tech. u. Elek: akus.*, Nov. 1941, Vol. 58, No. 5, pp. 133–136.)

"For many purposes amplifiers are needed which over a wide frequency band have a constant real output resistance or an amplification independent of frequency, or both. The transformer, generally necessary in order to step down the internal resistance of the final valve to a desired value, limits by its leakage and stray inductances, and its capacitance, the frequency range over which these requirements can be fulfilled to a desired degree of accuracy. The following work investigates how far the harmful effects of the transformer on the constancy of the output resistance (*i.e.* on the reflection factor) and of the amplification can be compensated by simple means." The writer considers first an amplifier with complex voltage negative-feedback ("durchgriff correction") and then an amplifier with inductive or capacitive current negative-feedback ("slope correction").

Author's summary:—"The harmful influence of the transformer on the reflection factor and the constancy of amplification can to a great extent be compensated by complex negative feedback with simple means. The extension of the transmission range thus made possible is relatively greater, the stricter the requirements as to constancy. The relative output impedances $\mathfrak{R}_A/R_o$ [indicating the deviations of the output impedance from its required value R_o], obtaining at a definite geometrical distance from the lower or upper limiting frequency of the transformer, in the case of "durchgriff correction" or "slope correction" of the leakage inductance or capacitance are equal and reciprocal to the values obtained by correction of the stray inductance. The reflection factors reached are equal for all the types of correction considered.

"With suitably designed 'durchgriff correction' of the leakage admittance it is possible, by renouncing an optimum reflection factor, to obtain an open-circuit or working amplification which is constant over a wide range. With 'slope correction' of the leakage admittance, and also with correction of the stray inductance, the greatest constancy of the working amplification and the lowest reflection factor are obtained for the same degree of correction."

1000. AN INVESTIGATION OF [the Selectivity & Frequency Stability of] HIGH-SELECTIVITY SYSTEMS USING NEGATIVE FEEDBACK.—

A. A. Rizkin. (*Elektrosvyaz* [in Russian], No. 4, 1941, pp. 33–42.)

The use of negative feedback for raising the selectivity and frequency stability of a valve circuit is discussed. A general method based on the use of circle diagrams (Fig. 2) is proposed, and using this method the main relationships determining the operation of the system are derived. The effect of the instability of the feedback circuit on the selectivity of the system is also investigated. Systems using ordinary *LC* oscillating circuits (Fig. 3) and *RC* circuits only (Fig. 4) are then considered, and it is shown that both types have identical resonance curves. In conclusion a description is given of a two-stage amplifier for use as a high-stability audio-frequency oscillator. Performance data and a circuit diagram (Fig. 6) showing the values of the components are included.

1001. THE DESIGN OF FEEDBACK AMPLIFIER SYSTEMS.—F. E. Terman. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, p. 361: summary only.)

1002. CALCULATION AND DESIGN OF RESISTANCE-COUPLED AMPLIFIERS USING PENTODE TUBES.—F. E. Terman & others. (*Sci. Abstracts*, Sec. B, Nov. 1941, Vol. 44, No. 527, p. 227.) A summary was dealt with in 325 of 1941.

1003. THE SIGNIFICANCE OF THE GRID/ANODE CAPACITANCE FOR TELEPHONE LINE AMPLIFIERS.—M. Kluge. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 126–128.)

Since the introduction of the screen-grid valve the grid/anode capacitance has lost the importance which it previously had in the design of selective h.f. amplifiers. On the other hand it is perhaps not sufficiently realised that in the a.f. amplifiers of long-distance cables this capacitance plays an important rôle, one which is in fact decisive in determining the most important working properties. The practical significance of this point is here investigated, with special reference to the completeness of distortion-correction and matching, and the necessary accuracy with which the various circuit components must be manufactured in order that good results may be obtained. Thus in the neutralised triode amplifier of Fig. 1 the input capacitance must be kept within ± 3% if the frequency-equalisation is to be kept within ± 0.03 neper. But about a half of this capacitance is made up of the self-capacitances of transformer, leads, sockets, and the grid/cathode gap, and it must therefore vary by a good deal more than 3%. This problem is considered in detail, and it is shown that by departing from strict neutralisation the input capacitance can be made to reach the value necessary for equalisation, and that the employment of negative capacitances allows a lower total capacitance, and thereby higher amplification and distortion-correction, to be obtained.

1004. ON THE REDUCTION TO A MINIMUM OF FREQUENCY-PHASE DISTORTIONS IN AMPLIFIERS.—V. G. Vol'pyan. (*Elektrosvyaz* [in Russian], No. 3, 1941, pp. 15–32.)

It is well known that the frequency and phase characteristics of a circuit bear a definite relationship. Nevertheless in designing amplifiers it is usual to consider the two characteristics separately, with the result that it is difficult to obtain a simultaneous improvement in both. Accordingly, a new method is proposed which is based on the use of so-called "imaginary frequency characteristics" unifying the conceptions of the frequency and phase characteristics. From a study of these characteristics, conditions are derived for obtaining the minimum distortion at low and high frequencies. The application of these conditions to the design of amplifiers is then discussed, and amplifying stages without as well as with various correcting circuits for low and high frequencies are considered.

1005. AMPLIFIER RESPONSE TO SQUARE WAVES.—R. K. Crooks. (*Proc. I.R.E.*, March 1941, Vol. 29, No. 3, p. 142: summary only.)

1006. RELAXATION RESPONSE OF VIDEO AMPLIFIERS.—Huggins. (*See* 1102.)

1007. A STABILISED NEON-TUBE DIRECT-COUPLED AMPLIFIER [with Degenerative Cathode Resistor].—Huggins. (*See* 1147.)

1008. IN-PHASE AMPLIFIER: DESIGNING A NON-PHASE-REVERSING STAGE [for Vision-Frequency Amplifiers, Pulse Generators, etc.].—R. C. Whitehead. (*Wireless World*, Feb. 1942, Vol. 48, No. 2, pp. 40–41.)

1009. A COMPARISON BETWEEN TWO SYSTEMS FOR TWO-WAY HIGH-FREQUENCY AMPLIFICATION [for Multi-Channel Carrier Telephony: Comparison between Two Parallel Branches, each with a One-Directional Amplifier, and System with Common Amplifier connected across the Two Branches].—E. V. Zelyakh. (*Elektrosvyaz* [in Russian], No. 4, 1941, pp. 67–76.)

TRANSMISSION

1010. A VELOCITY-MODULATED GENERATOR WITH ONE CAVITY RESONATOR.—J. J. Müller & E. Rostas. (*E.T.Z.*, 23rd Oct. 1941, Vol. 62, No. 42/43, pp. 871–872.) Another summary of the paper dealt with in 406 of February.

1011. DEVICE FOR THE GENERATION OF ULTRA-SHORT WAVES [Current of Air, carrying Metallic Dust, led between Spark-Gap Electrodes]. — F. Vilbig. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, p. 148.) D.R.P. 706 698.

1012. ARRANGEMENT FOR THE GENERATION OF ULTRA-SHORT WAVES BY FREQUENCY-MULTIPLICATION WITH ELECTRON-MULTIPLIERS.—W. Engbert. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, p. 148.) D.R.P. 706 660, assigned to Telefunken.

1013. ON ULTRA-SHORT-WAVE QUARTZ CRYSTAL VIBRATORS [*e.g.* 1.8 m Fundamental].—Kamayachi & Watanabe. (*See* 1121.)

1014. A 112-MC. EMERGENCY TRANSMITTER: A CORRECTION, AND THE ANSWER TO A QUESTION [regarding Use of the Oscillator to excite a Type 815, giving a Stabilised Master-Oscillator Power-Amplifier Transmitter].—G. Grammer. (*QST*, Jan. 1942, Vol. 26, No. 1, p. 8.) *See* 681 of March.

1015. AN INDUCTIVELY COUPLED FREQUENCY MODULATOR [Method of introducing Variable Reactance by Inductive Coupling, without Use of Phase-Shifting Circuits required by Usual Reactance-Valve Methods: giving a F.M. Oscillator with More Power Output & able to operate on Higher Fundamental Frequency].—B. E. Montgomery. (*Proc. I.R.E.*, Oct. 1941, Vol. 29, No. 10, pp. 559–563.)

1016. A NEW FREQUENCY-MODULATION TRANSMITTER [with New Amplifier Circuit permitting Simple Design & Economy in Valves].—N. C. Olmstead & A. A. Skene. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 226: short summary only.)

1017. FACTORS ENCOUNTERED IN FREQUENCY-MODULATED-SIDEBAND LIMITATION.—H. J. Scott & L. J. Black. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, p. 359: summary only.)

1018. PHASE DISTORTION IN FREQUENCY-MODULATION SYSTEMS [Development of Physical Approach giving Simple Method of Solution].—N. I. Korman. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 225: summary only.)

1019. MODULATION AND DEMODULATION METHOD USING CONDENSERS OF PERIODICALLY VARYING CAPACITANCE.—T. Tomituka. (*Sci. Abstracts*, Sec. B, Nov. 1941, Vol. 44, No. 527, p. 227: reference only.)

1020. EXTENSION OF THE BARKHAUSEN SELF-OSCILLATION FORMULA.—Y. Ito. (*Hochf: tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 124–126.)

An extract from a series of researches at the Japanese Naval Research Establishment, started in 1929. For the investigation of the generation of oscillations it is customary to use differential equations, but on the assumption that an oscillation is actually present the Barkhausen formula $0 = -\mathfrak{R} + D + 1/S\,\mathfrak{R}_a$ can be employed, not only to give the condition for the existence of oscillations but also to give a clear idea concerning building-up and decay, so long as the oscillations are sinusoidal. The simplicity of the formula allows a good insight into the phenomena to be obtained. For non-sinusoidal oscillations it can be taken to apply only to the fundamental, and here its four constants are more or less influenced by the harmonics.

The formula is ordinarily used for the excitation of a triode, but the writer applies it to various other types of circuit by altering the significance of the four constants. Thus the unchanged formula applies to the "anode-dynatron" (as the writer calls the ordinary dynatron, to distinguish it from the special "grid-dynatron" circuit dealt with in 1931 Abstracts, p. 386 and back reference) by altering the definition of the back-coupling factor $\mathfrak{R}$ and making S, previously the triode slope, stand for the dynatron "durchgriff," while D, previously the triode "durchgriff," represents the dynatron slope. "A similar equation can be derived for the grid-dynatron" [*loc. cit.*]. The above are all examples of "parallel" oscillation: for "series" oscillation, as in an arc or in a buzzer or hummer circuit, the general formula is $K = D\mathfrak{R} + 1/S$.

"Very interesting is the application of the Barkhausen formula to the problem of the generation of polyphase oscillations [3513 of 1938]. Here again one must distinguish between parallel and series connections. Fig. 3 [ring oscillator] shows a general circuit for the generation of [polyphase] parallel oscillations with triodes. For a symmetrical arrangement a general equation (4) is obtained": this is in the form of the Barkhausen formula, and reduces to eqns. 5, 6 and 7 for single-phase, two-phase (parallel and series), and three-phase (parallel, right-rotating, and left-rotating) oscillations respectively. Eqn. 4 can also be applied to the multi-slit magnetron (467 of 1939: *see* also 3162 of 1938) and to series-oscillations with gas-filled valves; and it can be extended to cover the "electron-dance" type ("B-K" oscillations: *see*, for example, Möller, 1930 Abstracts, pp. 627–628).

1021. THE TRANSMITTER AMPLIFIER WITH COMPLEX EXTERNAL RESISTANCE.—H. Rothe. (*Hochf: tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 139–141.)

For previous work *see* 1918 & 3111 of 1939 and 3053 of 1941. "The calculation of the power which an amplifier valve can deliver to an external resistance is directly possible if the accompanying modulation of the valve characteristic field can be determined. In the following pages we will consider the modulation relations of a transmitter amplifier whose anode circuit contains an oscillatory circuit consisting of a parallel connection of L, C, and R_p, and therefore representing an appreciable resistance only for a frequency band lying on both sides of the resonance frequency ω_r. If the control grid is supplied with a sinusoidal voltage whose frequency ω nearly coincides with the resonance frequency ω_r, the anode alternating voltage will also be purely sinusoidal, since the resonance circuit represents a practical short-circuit for any harmonics which occur. With the help of this special condition it is possible to determine the modulation of the characteristic field not only for the case of resonance, when the frequency of the grid alternating voltage agrees with ω_r, but also when this frequency is departed from. The power derivable from the valve is then of practical importance for all transmitters, but especially for television transmitters, in which very wide frequency bands have to be transmitted."

The idealised case of a linear characteristic field is first considered: the anode-current/anode-voltage characteristics are taken as parallel and equidistant straight lines. On a first assumption that the modulation of the characteristic field consists in an anode current flowing throughout a whole alternating period (current-flow angle $\theta = 180°$), eqns. 4 and 5 are obtained, respectively, for the amplitude u_a of the anode alternating voltage and for the a.c. power delivered to the resonance circuit. The magnitude of $\cos^2\phi'$, and therefore of the power, decreases with increasing detuning from resonance, but to a smaller extent the smaller the ratio R_i/R_p: this is the well-known influence of "pseudo-damping" by the internal resistance of the valve. If, on the other hand, the anode current is assumed to flow during a part only of the period, the amplitude u_a of the anode alternating voltage is then given by eqn. 7, involving θ as well as cos ϕ'. θ can be obtained from the operating data with the help of eqn. 8, but since this also involves the still unknown u_a the calculation can only be carried out by a step-by-step approximation. For screen-grid valves, however, particularly pentodes, the anode retroaction u_a/μ and the other term (anode d.c. voltage divided by μ) can in general be neglected, so that eqn. 8 for θ no longer involves the unknown u_a, and the calculation can be made directly without step-by-step approximation: in the above, μ is the amplification factor between anode and control grid.

But the characteristics of actual valves differ very considerably from the parallel straight lines assumed above, and to obtain a more exact value for the available output the modulation characteristic must be constructed graphically on the actual characteristic field. The procedure is described in section 2: with practice it can be carried out quite quickly, and the three diagrams of Fig. 1 show the results for a pentode, the resonance resistance being chosen at $R_p = 3$ kilohms. Thus the bottom diagram shows the anode-voltage/grid-voltage field, with 5 modulation curves superposed, each with a different relative detuning v/d (tan ϕ) ranging from 0 to 1.73: these curves are true ellipses, whereas in the diagram above this (anode-voltage/anode-current field) they are distorted ellipses. The table at the end of the paper gives the anode alternating voltages u_a, and the delivered powers, determined from these curves, for these five values of detuning. For zero detuning the output is 32 watts, rising to 33 for a detuning of 0.268 because the fundamental wave corresponding to the asymmetrical current in Fig. 2 increases, while cos ϕ' is still practically equal to unity. As the detuning is increased to 0.577 ($\phi = 30°$) and beyond, the fundamental continues to increase because of the increase in the anode peak current, but the power decreases (to 29 watts and on down to 13 watts) because of the decrease in $\cos^2 \phi'$. The above increase of the anode peak current with increasing detuning is the more pronounced, the smaller the internal resistance R_i of the valve: consequently the half-value width of the amplifier resonance curve is the greater, the smaller R_i is. This increase of the peak current, and also of the fundamental-wave amplitude, with increasing detuning furnishes a clear interpretation of this so-called pseudo-damping effect.

RECEPTION

1022. Intermediate-Frequency Values for Frequency-Modulated-Wave Receivers [Types of Spurious Responses to which F.M. Receivers are Liable: Influence of I.F. on Spurious Responses, and on Selectivity (No Influence if Q is proportioned to the I.F. employed) & Stability].—D. E. Foster & J. A. Rankin. (*Proc. I.R.E.*, Oct. 1941, Vol. 29, No. 10, pp. 546–551.)

"For receivers designed to operate on weak signals, where spurious responses are unlikely, a relatively low i.f. of 4.3 or 5.38 Mc/s is preferable. However, for a considerable part of the service area, where signal intensities are high and spurious responses likely, high sensitivity is not required and an i.f. of 8.26 or even 11.45 Mc/s has much to recommend it. Where a receiver is designed to operate over a wide range of signal intensities, it may be preferable to use a relatively high i.f. value to minimise spurious responses, using impedance distribution or neutralisation principles, and if necessary an additional stage to obtain the required high gain with stability."

1023. Problems encountered in Frequency-Modulation Receiver Design, *and* Reception of Frequency-Modulation Signals.—J. D. Reid: J. M. Pettit. (*Proc. I.R.E.*, May 1941, Vol. 29, No. 5, p. 284: p. 288: summaries only.)

1024 Factory Alignment Equipment for Frequency-Modulation Receivers [for Rapid Alignment and Quantitative Check on Sensitivity & Fidelity].—H. E. Rice. (*Proc. I.R.E.*, Oct. 1941, Vol. 29, No. 10, pp. 551–554.) From the Stromberg-Carlson Company.

1025. Receivers for 112-Mc. Emergency Work: Super-Regenerative and Superheterodyne Receivers with Standard Tubes.—B. Goodman. (*QST*, Jan. 1942, Vol. 26, No. 1, pp. 18–25 and 80, 82.)

1026. Super-Regenerative Receiver for Ultra-Short Waves [Receiving Aerial, or Its Reflector, periodically Detuned by (*e.g.*) a Condenser-Microphone Arrangement: Receiving Valve thus made to swing about Oscillation Threshold].—D. K. Fritz. (*Hochf: tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, p. 150.) D.R.P. 705 319, assigned to Telefunken.

1027. Modulation and Demodulation Method using Condensers of Periodically Varying Capacitance.—T. Tomituka. (*Sci. Abstracts*, Sec. B, Nov. 1941, Vol. 44, No. 527, p. 227: reference only.)

1028. The Filtering Action in the Rectification of Amplitude-Modulated Carriers [in Wireless or Wire Broadcasting Reception].—E. Buchmann. (*T.F.T.*, April 1941, Vol. 30, No. 4, pp. 116–118.)

The great increase in the selectivity of a filter when it is combined with a rectifier has long been known and has often been dealt with in the literature (the few references given range from Aiken in 1931 to Moebes, 997 of 1940), but the calculations have been rather complicated and not very illuminating. "The present paper gives a clear treatment which is accurate to a good approximation."

Author's summary:—"In the demodulation of a carrier which is filtered out from a number of carriers, the rectifier has an effect which considerably raises the selectivity. If, for instance, the wanted carrier bears to the unwanted carrier a ratio whose logarithm is b, the logarithm of the ratio of the wanted modulation to the unwanted modulation, after rectification, is about twice as great, on the assumption that b is greater than 2 nepers. The exact value depends on the form of the rectifier characteristic. With a square-law rectifier, for instance, the attenuation is just twice as large; with linear rectification the doubled attenuation has a supplement of 0.7 neper. These calculations were confirmed by measurements [including some on a "People's" receiver with wire-broadcasting unit], and practical use has been made of them for the design of filters."

1029. Spurious Signals [Experiences with Two Crystal Receivers on Separate but Adjacent Aerials: Two-Way Conversation by speaking into Telephones, when Both Sets are receiving Carrier Wave from Near-By Station].—A. E. Burns: A. F. Eastman & L. F. C. Horle. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 230.) Prompted by the paper dealt with in 692 of 1941.

1030. Sensitivity in Visual Reception and Instrument Observation. — K. Fränz. (*Hochf:tech u. Elek:akus.*, Oct. 1941, Vol. 58, No. 4, pp. 95–99.)

In his summary the writer begins: "The ratio of signal voltage to noise voltage, as usually measured, forms no useful quantitative measure of the readability of signals in recorded or instrument-observation reception. For the interference does not depend on the mean pointer-deflection, corresponding to the average noise, on which the usual measurements are based: it depends on the pointer fluctuation, due to the noise, about its mean position . . ."

The paper itself begins with more general considerations. "As is well known, the unavoidable noise of a receiver constitutes a lower limit for the reception of weak signals. As a measure of the readability of a signal the custom has been exclusively to take the ratio of the mean values of signal voltage plus noise voltage to noise voltage. This ratio is easily measured, and undoubtedly good reception is associated with a large quotient and poorer reception with a small quotient. But if it is desired to receive the same signal on two different receivers, it can no longer be maintained that the relation of signal voltage to noise voltage is a quantitative measure of comparison, unless the spectral distribution of the noise energy is the same in the two receivers, so that the noise voltages differ in their magnitudes, their effective values, but in no other respect. This used often to be the case in communication reception," where it was common practice to fix the pass-band of all receivers to the minimum compatible with the signal spectrum likely to be received. Now, however, it is becoming a common practice to provide commercial receivers with band widths which can be varied between wide limits, and the question arises how to compare the sensitivities of receivers whose noises display pronounced differences in spectral distribution. Tests on the readability of signals through atmospheric noises (Dannehl & Kotowski, 2678 of 1938) and on intelligibility (Fletcher, 2398 of 1938) have already shown that these values depend on the receiver band width in a way different from that in which the effective noise value depends. "In the present work we will deal with the relations obtaining in recorded reception and in instrument observation, where these relations depend very little on physiological effects and are therefore calculable."

"That the average deflection of the pointer by the noise has nothing to do with the sensitivity is most obviously seen in the target-flight (homing) receiver, where the noise deflects the pointer with equal probability to left and right, so that however great the noise may be the mean deflection remains zero. When Morse signals are being received the mean deflection due to noise can be allowed for by a zero shift of the scale. What do cause trouble are the pointer fluctuations about its middle position. We shall therefore regard the mean fluctuation of the pointer, $\bar{\bar{x}}$, produced by the noise, as a quantitative measure of the interference: it is defined by eqn. 1, where $x(t)$ represents the deflection at time t. If $x(t)$ were a current, $\bar{x}$ would be its d.c. component and $\bar{\bar{x}}$ the effective value of the a.c. component. We must now calculate this mean fluctuation: the same problem has already presented itself in another connection in acoustics. Thiede [2690 of 1936] has shown, theoretically and experimentally, that the mean relative fluctuation of the output of a quadratic rectifier is inversely proportional to the square root of the band width of the preceding amplifier," and this result applies to the present case of a square-law indicating instrument: *see* the last two columns of the paper (where, incidentally, two numerical errors in Thiede's paper are mentioned). The present writer reaches the result by a different line of argument, and confirms it by a second treatment making use of the energy-spectrum triangular diagram of Fig. 2. For an instrument showing the actual value (such as can be realised with a linear rectifier) the case is little different (Fig. 3): the writer has already shown (3027 of 1941) that the spectrum is again approximately triangular, but that it changes only its base, and not its height, in proportion to the amplifier band width. The relative fluctuation is again inversely proportional to the square root of the amplifier band width, but the amount is only half as large as with quadratic rectification.

Instead of, as hitherto, attributing to the instrument an approximate band width of its own, the writer now develops a more exact treatment by considering its actual pass curve, for the various frequencies, corresponding to the time constants. In the case of $\Delta_\omega \delta \gg 1$, the relative fluctuation is given approximately by $\bar{\bar{x}} / \bar{x} = 1 / \sqrt{2\delta\Delta_\nu}$: this case must predominate in practice, since the time constants of the instrument are often greater than 0.1 second and the band widths greater than 10 c/s. For linear rectification $\bar{\bar{x}} / \bar{x} = 1/\sqrt{8\delta\Delta_\nu}$ (which conforms with the comparison at the end of the preceding paragraph).

The corresponding approximate formulae for the *absolute* fluctuations, eqns. 4 and 6, show that for a quadratic rectifier a change in band width Δ produces a change of absolute fluctuation directly proportional to the square root of Δ, since $\bar{v}_1^2$, the square of the input voltage, is proportional to Δ: while for a linear rectifier the absolute fluctuation does not depend at all on the band width. Thus with a linear rectifier nothing is gained in sensitivity by narrowing the band width so long as the latter is still large in comparison with the reciprocal of the time constant; while with a square-law rectifier, under the same limitation, for constant readability of signals the signal carrier should be reduced only in proportion to the fourth root of the band width, since the d.c. produced by the signal is proportional to the square of the carrier voltage.

The writer continues : " The qualitative correctness of the formulae can easily be shown experimentally with a logarithmic Neumann recorder [*cf.* Grosskopf & Vogt, 2046 of 1941] which on account of its logarithmic characteristic records the relative fluctuation of the receiver output. Fig. 4 shows the noise of an ordinary receiver, for band widths $\Delta_\nu = 10$ kc/s and $\Delta_\nu = 200$ c/s. The mean noise level has decreased to a seventh to correspond to the [fifty-fold] reduction in band width, while the relative fluctuation has increased on the same grounds. To show that there was no question of over-control, the volume control was adjusted so that with the large band width the same average output was obtained as with the narrow band width. Further, Fig. 5 gives the records of a signal with a ratio of 2 : 1 for the quotient mean-signal-plus-noise voltage by noise voltage, for the same two large and small band widths. For the large band width the readability is considerably better, though it is true that the signal voltage required to produce the constant signal/noise ratio was seven times larger."

1031. THE FULL-WAVE VOLTAGE-DOUBLING RECTIFIER CIRCUIT [for Small Receivers, etc.].—Waidelich. (*See* 998.)

1032. INTERMEDIATE-FREQUENCY TRANSFORMER DESIGN AND CONSTRUCTION.—F. J. Frater. (*Proc. I.R.E.*, May 1941, Vol. 29, No. 5, pp. 288–289 : summary only.)

1033. ANOTHER VIEWPOINT AND THE NOISE OF VALVE OSCILLATORS [contributing to the Noise from First Converter Valve].—Seki. (*See* 1067.)

1034. CURING INSTABILITY : CAUSES OF UNWANTED OSCILLATION IN BROADCAST RECEIVERS.—J. Gibbons. (*Wireless World*, Feb. 1942, Vol. 48, No. 2, pp. 48–49.)

1035. THE DESIGN AND EXPERIMENTAL VERIFICATION OF AUTOMATIC FREQUENCY CONTROL.—N. I. Chistyakov. (*Elektrosvyaz* [in Russian], No. 4, 1941, pp. 23–32.)

The automatic frequency control of the beating oscillator in a receiver is discussed. The type considered is that in which the anode circuit of the regulator valve is connected in parallel with the tuned circuit of the oscillator (Fig. 1). The operation of the regulator is discussed and experimental curves confirming the discussion are given. The discriminator is of the type using two inductively coupled tuned circuits (Fig. 5), and in view of a previous investigation by the author (126 of 1939) the discussion in the present paper is limited to the effect of de-tuning the two circuits. Experimental curves are given. The operation of the system as a whole is then discussed and illustrated by experimental curves. The maximum permissible frequency deviation is established, and suggestions are made regarding design procedure.

1036. SHORT-WAVE SPREAD-BAND RECEIVER CIRCUITS.—D. E. Foster & G. Mountjoy. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, pp. 223–224 : short summary only.)

1037. NEW CONSTRUCTIONAL IDEAS IN THE NEW GERMAN RECEIVERS FOR EXPORT, 1941/42.—R. Wigand. (*Helios* [Leipzig], 12th Oct. 1941, Vol. 47, No. 41, Supp. pp. 1295–1297 : in German.)

Improvement by diagonal position of h.f. iron screen : improved fixing of h.f. iron cores and condensers : midget receiver design : etc. *See* also pp. 1297–1310.

AERIALS AND AERIAL SYSTEMS

1038. THE THEORY OF CONICAL ELECTROMAGNETIC HORNS [Equations of Possible Waves inside Horn and of Radiated Waves from It].—S. Sonada. (*Electrotech. Journ.* [Tokyo], Jan. 1941, Vol. 5, No. 1, p. 16.) For the writer's previous work *see* 4275 of 1939 and 1745, 1886, & 3833 of 1940.

1039. ABNORMAL RADIATION OF ELECTRIC WAVES [44 cm] FROM PARALLEL-WIRE CIRCUIT [Length of Pair rather greater than $\lambda/2$, Spacing 1.5 cm, Far End Closed : Max. Radiation (and Electric Vector) in Direction Perpendicular to Plane of Wires : " Coil-Antenna Type " Radiation (in Plane containing Wires) Too Small to be Detected].—K. Okabe, M. Hishida, & K. Mori. (*Electrotech. Journ.* [Tokyo], Dec. 1940, Vol. 4, No. 12, pp. 274–275) " In the case of open terminal, the results were different."

1040. HEAT-TREATED TELEVISION [Picture-Wave Aerial enclosed in Electrically Heated Box with Sound-Wave Aerial on Top (and Reflector Rod serving also as Lightning Conductor to protect Tower & Relay Equipment) : for relaying from Schenectady to Helderberg Station].—(*Gen. Elec. Review*, Dec. 1941, Vol. 44, No. 12, p. 696.)

1041. A TURNSTILE ANTENNA FOR ULTRA-HIGH-FREQUENCY BROADCASTING.—G. H. Brown & J. Epstein. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 221 : summary only.) Developed from the original " turnstile " (2595 of 1936), for greater suitability for service on the top of high structures.

1042. ULTRA-HIGH-FREQUENCY LOOP ANTENNAS FOR FREQUENCY-MODULATION BROADCASTING.—A. Alford, A. G. Kandoian, & R. A. Hampshire. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, pp. 220–221 : summary only.) For previous work *see* 3011 of 1940.

1043. ULTRA-HIGH-FREQUENCY ANTENNAS AND LINES [developed for C.A.A. for Instrument Landing : chiefly Miniature Type : including Crossed Half-Wave Dipoles for Intense High-Angle Radiation].—A. Alford. (*Proc. I.R.E.*, May 1941, Vol. 29, No. 5, pp. 283–284 : summary only.)

1044. Antennas for the Civil Aeronautics Authority Transoceanic Communication Systems.—S. Pickles. (*Proc. I.R.E.*, March 1941, Vol. 29, No. 3, p. 142 : summary only.)

1045. Impedance Measurements on Aircraft Aerials [by R. F. Bridge & by Bridged-T Measuring Set, as contrasted to Usual Substitution Method].—F. Ireland & P. Holmes. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, p. 358 : short summary only.)

1046. A Device for the Direct Measurement of the Travelling-Wave Coefficient in Feeders.—A. A. Pistol'kors & M. S. Neyman. (*Elektrosvyaz* [in Russian], No. 4, 1941, pp. 9–15.)

In an h.f. feeder, the coefficient k serves as a measure of the deviation from pure travelling-wave operation. It is equal to $(1-p)/(1+p)$, where p is the reflection coefficient determining the ratio of the reflected and direct waves. The measurement of k can therefore be reduced to the measurement of p, and the apparatus used for this purpose must respond to electromagnetic waves propagating in its vicinity, and discriminate between the two waves. It is shown that a loop formed by two parallel conductors of length l, loaded by resistances R_1 and R_2 at the ends (Fig. 2), satisfies these conditions ; that is, if it is placed alongside the feeder, and R_1 and R_2 are made equal to the characteristic impedance of the transmission line formed by the conductors l, the currents (or voltages) induced in the resistances will correspond respectively to the amplitudes of the two waves. By picking up these currents and feeding them to a logometer with a suitable scale (Fig. 5), direct readings of k can be obtained. It is shown that the operation of this apparatus, called the "feeder reflectometer," is independent of the power and length of the waves, and of the distribution of the nodes and antinodes in the feeder. Moreover, experiments have shown that cables of any length can be used for connecting the logometer, and the apparatus is therefore suitable for remote measurements.

1047. On Choosing the Type of Short-Wave Transmitting Aerial.—L. A. Kopytin. (*Elektrosvyaz* [in Russian], No. 4, 1941, pp. 6–8.)

For the previous correspondence *see* 441 of February : also *Elektrosvyaz*, No. 3, 1941, pp. 73–74. Concluding this discussion, the standpoint of the Commissariat of Communications is expounded briefly as follows :—Insufficient information is as yet available on the operation of dipole and rhombic aerials under working conditions. The waveband of a rhombic aerial should not be unduly extended and several aerials with overlapping wavebands should preferably be used. The erection of multi-dipole aerials with 48 + 48 or more dipoles should be continued where greater gain is required. Until sufficient information is accumulated great care should be exercised in replacing the existing multi-dipole aerials by the rhombic type.

1048. Discussion on "Radiation from Rhombic Antennas" [Equation for Gain requires a Correction Factor which is "by No Means Negligible": Implications of This Result : an Equation for Radiation Resistance of Rhombic Aerial in Free Space, with Simple Practical Approximate Formula].—D. Foster : L. Lewin. (*Proc. I.R.E.*, Sept. 1941, Vol. 29, No. 9, p. 523.) For Foster's paper *see* 119 of 1938.

1049. Theory of Antennas of Arbitrary Size and Shape [starting with Maxwell's Equations and assuming Conical Conductors].—S. A. Schelkunoff. (*Proc. I.R.E.*, Sept. 1941, Vol. 29, No. 9, pp. 493–521.)

"Finally, our method turns out to be consistent with a physical picture which is rather attractive to the engineer. Let us suppose that a wire is energised at the centre. A spherical wave emerging from the generator is guided by the antenna until it reaches the limit of the 'antenna region,' that is, the sphere passing through the ends of the antenna ; there, some of the energy passes into the outer space and some is reflected back, a situation existing when one transmission line is joined to another. We may also think of the wire as the wall of an electric horn with an aperture so wide that one can hardly see the horn itself. In fact, the mathematical analysis used by us is precisely the analysis appropriate to wave guides and electric horns. We end up with a picture of the antenna as a transmission line (Fig. 2) whose output impedance Z_t represents the end effect. The real part R_t of Z_t represents radiation and should properly be called the 'radiation resistance'; it is the resistance of the outer space as seen from the ends of the antenna. Unfortunately, this name has been generally given to a quantity which turns out to be equal to K^2/R_t." For corrections *see* issue for November, No. 11, p. 603.

1050. Antenna Problems [Summaries of Papers in Special Issue of *Telefunken-Mitteilungen*, No. 83, Vol. 21, 1940].—W. Moser, W. Berndt, H. Brückmann, K. Schlayer, K. Fränz, & W. Jachnow. (*E.T.Z.*, 13th March 1941, Vol. 62, No. 11, pp. 296–297.)

Berndt deals with the possibilities of improving anti-fading vertical aerials : a high characteristic impedance, a low radiation resistance, and a small distance from top of aerial to current node are desirable. A special circular array around a central radiator is also discussed (*cf.* 139 of 1939). Brückmann gives a calculation technique for "aerials, particularly self-oscillating masts," which is comparatively simple and which in spite of many approximations gives results, for aerials whose thickness compared with height is appreciable, which are in good agreement with practical results: the method is based on line theory extended for the purpose. The influence of the design of the top and footing of the mast, of its mechanical construction, etc., is examined, and a mathematical appendix deals with natural and resonance waves. Schlayer considers directive systems for broadcast waves, particularly those with two vertical radiators, the second either fed or radiation-coupled. Numerous tables and curves are given, and various practical conclusions are reached. Fränz's paper on the improvement of transmission efficiency by the use of directive arrays was dealt with in 2699 of 1941. Jachnow's paper on the theory of long-wire transmitting aerials, particularly with progressive waves, includes a comparison of the rhombus aerial with the fir-tree type: it appears to cover much the same ground as the papers dealt with in 585 of 1940 and 2407 of 1941.

1051. THE RELATIONSHIP BETWEEN THE DIRECTIONAL CHARACTERISTIC OF A LINEAR CONDUCTOR AND THE DISTRIBUTION OF THE CURRENT IN IT.—I. I. Vol'man. (*Elektrosvyaz* [in Russian], No. 4, 1941, pp. 46–54.)

A vertical radiator of a given height (Fig. 1) is considered: it is required to determine the phases and amplitudes of the current in it necessary for producing a specified directional characteristic. Reference is made to the methods proposed by Wolff (2963 of 1937) and Pistol'kors (2766 and 3563 of 1939) and it is pointed out that in using these methods the height of the radiator cannot be fixed in advance. It is, therefore, suggested that use should be made of the integral equation (1) derived by Ramm (*Scientific-Technical Symposium on Elec. Communications*, No. 3, 1937) in which the required relationship is given. Methods are indicated for solving the equation and the solution obtained is verified in the case of a half-wave dipole. A complete identity is obtained between the known current distribution in the dipole and that derived by the methods proposed.

1052. OPTIMUM CURRENT DISTRIBUTIONS ON VERTICAL ANTENNAS.—L. La Paz & G. A. Miller. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 225: long summary.)

1053. THE DETERMINATION OF FIELD-STRENGTH PATTERNS OF ANTENNA SYSTEMS BY GRAPHICAL METHODS [and Their Advantages over Analytical Methods].—E. A. Yunker. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, p. 360: summary only.)

1054. A MECHANICAL CALCULATOR FOR DIRECTIONAL ANTENNA PATTERNS, *and* HORIZONTAL-POLAR-PATTERN CALCULATOR FOR DIRECTIONAL BROADCAST ANTENNAS.—W. G. Hutton: F. A. Everest & W. A. Pritchett. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 224: June 1941, No. 6, pp. 355–356: summaries only.)

1055. BROADCAST ANTENNA MEASUREMENTS.—B. Akerman. (*Proc. I.R.E.*, Aug. 1941, Vol. 29, No. 8, p. 470: summary only.)

1056. THE ERECTION OF POLES FOR OVERHEAD LINES IN REGIONS WHERE THE SUBSOIL IS PERMANENTLY FROZEN.—E. L. Kretovich. (*Elektrosvyaz* [in Russian], No. 3, 1941, pp. 71–72.)

1057. DISCUSSION ON "PRACTICAL ASPECTS OF EARTHING".—E. Fawssett & others. (*Journ. I.E.E.*, Dec. 1941, Vol. 88, Part II, No. 6, pp. 600–608.) *See* 765 of 1941.

VALVES AND THERMIONICS

1058. LOCK-IN TUBES FOR THE ULTRA-HIGH FREQUENCIES: NEW SPECIAL TUBES FOR THE RANGE ABOVE 200 Mc/s [Types 1201, 1203, 1204, 1291, & 1293].—Hygrade Sylvania. (*QST*, Jan. 1942, Vol. 26, No. 1, pp. 17 and 54, 56.) Also the 7W7 pentode, as amplifier up to 200 Mc/s, and higher as mixer.

1059. HIGH-FREQUENCY TUBE PHENOMENA [and the Proper Design of U.H.F. Valves: Advantages of the "Lock-In" Type: etc.].—M. A. Acheson. (*Proc. I.R.E.*, Aug. 1941, Vol. 29, No. 8, p. 472: summary only.) From the Hygrade-Sylvania laboratories.

1060. NEW SMALL ULTRA-HIGH-FREQUENCY RECEIVING TUBES, *and* THE DESIGN AND DEVELOPMENT OF THREE NEW ULTRA-HIGH-FREQUENCY TRANSMITTING TUBES [RCA-815, 826, & 829].—L. B. Curtis: C. E. Haller. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 222: p. 224: summaries only.)

1061. THREE NEW ULTRA-HIGH-FREQUENCY TRIODES [Types GL-8002 (& 8002-R with Fin Cooler), GL-889 (& 889-R), and GL-880 (with Re-entrant Anode to reduce Lead Length)].—K. C. DeWalt. (*Proc. I.R.E.*, Sept. 1941, Vol. 29, No. 9, pp. 475–480.) Plate dissipations range from 1.2 to 20 kw.

1062. THEORY OF RADIAL DIRECT-CURRENT SPACE-CHARGE FLOW BETWEEN CONCENTRIC CYLINDERS [and Simple Form of Equations by using Special Parameter measuring Transit Time].—W. G. Dow & A. B. Bronwell. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 223: summary only.)

1063. VOLTAGE-CONTROLLED ELECTRON MULTIPLIERS, *and* THE BEHAVIOUR OF ELECTROSTATIC ELECTRON MULTIPLIERS AS A FUNCTION OF FREQUENCY.—B. J. Thompson: L. Malter. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, p. 583–587: pp. 587–598.) Summaries were dealt with in 1899 & 1900 of 1941.

1064. THE ORBITAL-BEAM SECONDARY-ELECTRON MULTIPLIER FOR ULTRA-HIGH-FREQUENCY AMPLIFICATION.—H. M. Wagner & W. R. Ferris. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, pp. 598–602.) Already dealt with in 446 of February.

1065. SECONDARY-EMISSION OUTPUT FROM SILVER-MAGNESIUM ALLOYS: PRELIMINARY COMMUNICATION.—J. Friedheim & J. G. Weiss. (*Naturwiss.*, 26th Dec. 1941, Vol. 29, No. 52, p. 777.)

"Prompted by the information reported in the Italian patent No. 372 631 on the secondary-emission output of films of silver-magnesium alloy [*cf.* also Zworykin & others, 3346 of 1941], the writers have investigated silver-magnesium alloys having various proportions of the components and subjected to various pre-treatments. The alloys were melted either in a protecting gas (argon) or in a furnace under potassium or sodium chloride. It was found that an alloy of 3% magnesium and 97% silver could under certain conditions be made to yield extremely high outputs, up to a factor of 16, while alloys of other proportions also gave good outputs. The alloys were rolled out in the cold to plates about 0.2 mm thick, which after their surfaces had been scraped were introduced into the experimental tube. They were then heated to about 450°, on which the vacuum temporarily deteriorated to 7×10^{-5} mm from its stationary value (measured by an ionisation manometer) of 1×10^{-6} mm. After about 30 minutes of heating the output rose from δ = about 2 to $\delta_{max} = 14$–16, for a primary-electron energy of 500 volts. The measured values remained generally constant during a three-hours' loading. Fig. 1 [with a maximum at 500 v] shows an example of an output curve obtained from measurements with a testing tube in which special precautions were observed to prevent the hot cathode from having any influence on the bombarded electrode. So far no evidence has been found of any inertia suggesting the presence of a Malter effect."

1066. THE TRANSMITTER AMPLIFIER WITH COMPLEX EXTERNAL RESISTANCE [with Special Application to Wide-Band Television Transmitters].—Rothe. (*See* 1021.)

1067. ANOTHER VIEWPOINT AND THE NOISE OF VALVE OSCILLATORS.—H. Seki. (*Electrotech. Journ.* [Tokyo], Jan. 1941, Vol. 5, No. 1, pp. 18–19.)

"There are some cases where the noise from the first converter tube becomes important, *e.g.* in field-strength measuring sets. This noise is partly due to the converter tube and partly to the oscillator tube, the latter not being known till now."

Valve oscillations are not free oscillations but forced oscillations represented by an equation such as $\ddot{x} + af(x)\dot{x} + x \neq 0$. Noise current will always exist in an oscillator valve except for an instant before it reaches a steady-state condition, passing through the point of zero damping constant. No oscillations can exist near the immediate frequency of the fundamental. Calculation of thermal and shot noise in the oscillator circuit.

1068. A METHOD FOR CALCULATING THE PERFORMANCE OF SELF-BIASED PLATE-MODULATED AMPLIFIERS, *and* A MECHANICAL DEVICE TO AID IN THE CALCULATION OF CLASS B AND C POWER-TUBE PERFORMANCE.—R. I. Sarbacher. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, pp. 358–359: p. 359: summaries only.)

1069. THE SELECTION OF TRANSMITTING TUBES, *and* THE SELECTION OF MODULATOR TUBES [Desirability of Reduction in Number of Types: with Five Suitably Selected Types, Efficient & Economical Transmitters between 25 & 4000 W can be designed].—P. J. Arnaud. (*Proc. I.R.E.*, Sept. 1941, Vol. 29, No. 9, p. 525: p. 525: summaries only.)

1070. THE EFFECTS OF CONTACT POTENTIALS ON THE CHARACTERISTICS OF VACUUM TUBES.—G. D. O'Neill. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 226: May 1941, No. 5, p. 286: summaries only.)

1071. ANISOTROPY OF THE ELECTRONIC WORK FUNCTION OF METALS [Observed Differences of ϕ for Different Crystal Faces explained on Basis of Wigner-Bardeen Picture (Work Function as Sum of Volume & Double-Layer Contributions): Good Agreement with Experimental Results].—R. Smoluchowski. (*Phys. Review*, 1st Nov. 1941, Vol. 60, No. 9, pp. 661–674.) *See* 3038 of 1936 & back reference, and 2712 of 1941.

1072. STRESS DISTRIBUTIONS IN METAL-SEALED GLASSES.—M. Kanno. (*Electrotech. Journ.* [Tokyo], Nov. 1940, Vol. 4, No. 11, pp. 258–259.)

1073. GRAPHICAL REPRESENTATION FOR A CONDITION TO SELECT A STEM GLASS [so that Stress Conditions shall be Suitable for Metal/Glass Seal to be used as Stem of Valve].—M. Kanno. (*Electrotech. Journ.* [Tokyo], Dec. 1940, Vol. 4, No. 12, p. 276.)

DIRECTIONAL WIRELESS

1074. GONIOMETER FOR SHORT AND ULTRA-SHORT WAVES.—K. G. Holsten & W. Schätzel. (*Hochf:tech. u. Elek:akus.*, Oct. 1941, Vol. 58, No. 4, p. 104.)

A Lorenz patent, No. 704 176. For such wavelengths the field and exploring coils must be wound with spaced turns. To give a continuous course of the field during rotation, in spite of this, the turns of one coil are inclined at an angle to those of the other coil (Fig. 13).

1075. DEVELOPMENT OF AN ULTRA-HIGH-FREQUENCY AURAL RADIO RANGE [for C.A.A.].—J. C. Hromada. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, p. 357: summary only.)

"It is shown conclusively that a radio range operating on 125 Mc/s and using pure horizontal polarisation is superior to any of the other u.h.f. facilities previously developed."

1076. "AUTOMATIC" AIRCRAFT NAVIGATION: DUAL DIRECTION FINDERS [Adoption in U.S.A.].—C. A. A: McGillivray. (*Wireless World*, Feb. 1942, Vol. 48, No. 2, p. 38.) *Cf.* McGillivray, 1013 of 1939.

1077. THE RADIO SYSTEM OF A MODERN AIR TRANSPORT, *and* AVIATION RADIO IN THE UNITED STATES.—A. E. Abel & others: P. J. Noizeux. (*Proc. I.R.E.*, Sept. 1941, Vol. 29, No. 9, p. 524: p. 525: summaries only.) From the Bendix Radio Corporation and Transradio Internacional.

1078. SENSITIVITY IN VISUAL RECEPTION AND INSTRUMENT OBSERVATION [as in Target-Flight Receivers].—Fränz. (*See* 1030.)

1079. CONTROL OF NIGHT ERROR IN AIRPLANE DIRECTION FINDING.—H. Busignies. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 222: summary only.) *See* also 3044 of 1940 and 1911 of 1941, and 1080, below.

1080. Wireless Position-Finding by the Phase-Measurement Method [Survey].—E. Kramar. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 128–133.)

Fundamentally, all d.f. methods depend on one of three processes: determination of the reception minimum, comparison of amplitudes, or measurement of phase. In contrast to the first two, the last method is little known in Germany, although other countries have worked in this field for a long time. The writer therefore surveys the various schemes suggested and developed, starting with the direct-reading direction finder of Lévy (1926) and the Busignies "radio-compass," the latter in its later development (*see*, for example, 1079, above) coming into use in the French Air Force and in various other countries. The great advantage of such devices is that not merely instantaneous values (minima, for instance) are made use of, as in rotating frame systems with cathode-ray indication, but the whole current-surface of the ground wave is utilised in the phasemeter, so that interference has little effect if the moving system is suitably designed in size and damping. The disadvantage (particularly for aircraft) is the mechanical one of a frame revolving at 15 r.p.s. A "radio-compass" weighs 28 kg, of which 6.8 kg are taken up by the frame with its drive and generator.

The obvious next step was, therefore, to transfer the application of the principle to the transmitting end, thus obtaining a rotating beacon system having simple receiving apparatus on board the aircraft and yet free from the limitations of rotating beacons based on minimum-determinations or field-strength comparisons: for these, even when direct-reading and thus able to use high speeds of rotation, are still inferior as regards interference to the phase-measuring devices, whose continuous deflection depends on the comparison of current-surfaces. As examples of these the writer takes the two Swedish "Aga-Baltic-Radio" systems with fixed crossed loops and a vertical aerial at the transmitter, and a single aerial at the receiver. The first of these systems (Figs. 4 & 5) transmits two h.f. carriers, a rotating-field one and a pulsating-field one: the second system (Figs. 7 & 6) does the same job with a single h.f. carrier having two i.f. carriers superposed on it. "It is not known whether the firm Aga-Baltic ever developed this proposal": the priority date is 1931. The solution given by Okada (reference "7": "unluckily only in Japanese with a short English summary"—but *cf.* 1003 of 1938) was very similar, but used Adcock aerials for radiating the rotating field, and a thyratron circuit for phase-measurement. The much earlier patent of Electrical Research Products in 1929 is illustrated (as regards the transmitting end) in Fig. 9: it depends on the separation of the two sidebands and the radiation of one from fixed crossed loops and of the other from a vertical aerial: the writer criticises this system as too difficult from the receiving standpoint.

Finally, a U.S.A. patent of 1932 (Philpott) is discussed (Figs. 10 & 11: combination of two crossed-loop systems with a common vertical aerial: double phasemeter—"synchroscope"—with pointers crossing on map of locality, to give position): a 1936 Standard Telephones & Cables patent is mentioned, dealing with the rendering useless, except to the "interested parties," of phase-rotating-beacon signals, including u.s.w. types: and an R.C.A. patent of 1938 is outlined, in which a vertically polarised field is used for the deflection of a cathode ray and a horizontally polarised field for its brightness control. This arrangement does, it is true, give a phase relation, but only an instantaneous value of the horizontally polarised oscillation is utilised, and the system must therefore be excluded from the true phase-measuring class (*see* above): it is worth mentioning, however, because the employment of the two polarisations does offer possibilities.

1081. The Propagation of Surface Waves over Stratified and Uneven Ground [including Results applying to Direction Finding].—Grosskopf. (*See* 964.)

1082. The Cartographic Solution of Great Circle Problems.—A. J. Dilloway. (*Journ. Roy. Aeron. Soc.*, Jan. 1942, Vol. 46, No. 373, pp. 4–31.)

ACOUSTICS AND AUDIO-FREQUENCIES

1083. The Employment of Different Types of Microphone in German Broadcasting.—W. Reichardt. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 136–139.)

Increasing use of directional microphones, particularly of the "kidney"-diagram type: reduced use of the figure-of-eight type (even for face-to-face dialogues the spherical-diagram type can replace it, except when a loudspeaker has to be in the same room, when the zero-reception line of the figure-of-eight type is useful to avoid retroaction): the latest "kidney" condenser-microphone (Fig. 1) with Cardan suspension and a switch for converting to the spherical diagram: swivelling microphone with parabolic reflector (80 cm diameter) for motor races, march-past ceremonies, etc.: microphones for noisy surroundings, especially the hand instrument (Fig. 3) with two piezoelectric cells spaced 8 cm and switched either in parallel with opposed polarity, giving a pressure-gradient action suitable for use in the spherical wave-field close to the mouth (a hinged chin-rest is provided), or in series so that the polarities are added, giving a pure pressure-type microphone with spherical characteristic: inconspicuous microphones for interviews, etc., such as the wristlet type of Fig. 4 and the buttonhole instrument (both piezoelectric): the "swan-neck" microphone. The objection to condenser and crystal microphones, that they have to be kept close to the first amplifier stage, has led to attempts to develop a satisfactory moving-coil instrument which could have a low resistance and could be connected to the amplifier by a twin lead of length up to 100 metres. It would be considerably less sensitive, and there are difficulties regarding directional characteristic and frequency-dependence: the German industry has, however, succeeded in producing an instrument which satisfies the highest requirements (it will be reported on in a later paper). But the moving-coil principle is unsuitable for general and varied applications, and the types described will retain their importance for a long time.

1084. A METHOD OF ABSOLUTE AMPLITUDE MEASUREMENT OF ROCHELLE SALT VIBRATORS [under Actual Operating Conditions, using Inouye's Method of measuring Minute Capacitance-Changes: Resulting Amplitude/Frequency Curve].—T. Kashimoto & T. Tsumura. (*Electrotech. Journ.* [Tokyo], Dec. 1940, Vol. 4, No. 12, p. 275.)

1085. THE DIELECTRIC CONSTANTS OF A ROCHELLE SALT CRYSTAL [Temperature & Orientation Characteristics of Dielectric Constant, at 2000 & 100 kc/s].—N. Takagi & T. Nakayama. (*Electrotech. Journ.* [Tokyo], Dec. 1940, Vol. 4, No. 12, pp. 275–276.)

1086. CONN CHROMATIC STROBOSCOPE AS AN AUDIO-FREQUENCY METER [with Application to Visual Observation of Frequency-Deviation of 60 c/s Line and Measurement of Turntable "Wow," etc.].—F. A. Lidbury. (*Proc. I.R.E.*, May 1941, Vol. 29, No. 5, pp. 282–283: summary only.)

1087. A METHOD OF CHANGING THE FREQUENCY OF A COMPLEX WAVE [with Applications to A.F Wave-Analyser (extending the Range), Electronic Musical Instruments, & possibly in Transmission of Intelligence].—E. L. Kent. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 225: short summary only.) For other work by this writer *see* 1458 of 1940.

1088. PROGRAMME-OPERATED LEVEL-GOVERNING AMPLIFIER [Western Electric 1126A Amplifier].—Black & Norman. (*See* 1189.)

1089. AN OBJECTIVE NOISE-METER READING IN PHONS FOR SUSTAINED NOISES, WITH SPECIAL REFERENCE TO ENGINEERING PLANT.—A. J. King & others. (*Journ. I.E.E.*, June 1941, Vol. 88, Part II, No. 3, pp. 163–176: Discussions pp. 176–182, and in Dec. issue, No. 6, pp. 610–612.) A summary was referred to in 800 of 1941.

1090. ELECTRICAL AND MECHANICAL ANALOGIES [Survey].—W. P. Mason. (*Bell S. Tech. Journ.*, Oct. 1941, Vol. 20, No. 4, pp. 405–414.)

1091. HOW SHOULD ACOUSTICAL PHENOMENA BE REPRESENTED PHYSICALLY?—P. Jacquinot & R. Guillien. (*Comptes Rendus* [Paris], 24th March 1941, Vol. 212, No. 12, pp. 475–478.)

An energy/frequency curve derived from an acoustic analyser ceases to represent the acoustic phenomena properly when the equivalent Fourier series contains frequencies N or frequency differences ΔN inferior to ΔN_0, on which the resolving power of the analyser depends: such is the case for a mixture of two sounds whose frequencies differ by less than ΔN_0, or for a sound modulated at a frequency less than ΔN_0. Consideration of the two main types of analyser, the "sweep" (exploring-note) type and the "synoptic" type with a large number of resonators, leads to the conclusion that an acoustical phenomenon should be represented by three coordinates N, I (readings of the analyser) and t (time), yielding a characteristic surface S: it is easy to imagine an apparatus which would give such a surface directly. The suggestion and its implications are discussed further.

1092. ELECTRICAL ANALYSER FOR LOW-FREQUENCY VIBRATION [in 10–300 c/s Range].—Kobayashi & Endo. (*See* 1267.)

1093. NOTE ON THE DOPPLER EFFECT [with Useful Application in Final Adjustment of Valve-Maintained Tuning Fork to Frequency of Standard Fork].—C. G. McIlwraith. (*Review Scient. Instr.*, Dec. 1941, Vol. 12, No. 12, p. 612.)

It is easy to get the two forks within a few c/s of each other, as evidenced by slow beats, but difficult (except by trial & error) to determine which fork is the higher in frequency. If the forks are placed on opposite sides of the room and the observer walks quickly towards one fork, the apparent beat rate *rises* if that fork is the higher in frequency.

1094. METHOD OF NOISE GENERATION [for Testing Purposes: Generator using Gas-Filled Discharge Tube: Stable Operation, Large Output, Wide Frequency Band].—T. Hayashi & M. Endo. (*Electrotech. Journ.* [Tokyo], Nov. 1940, Vol. 4, No. 11, p. 258.) *Cf.* Peterson, 1476 of 1940: *also* Weber, 4338 of 1940.

1095. ON THE VIBRATION OF METALLIC DISCS BY THE RHYTHMIC SUBLIMATION [Mary Waller's Solid CO_2 Method extended to Solid Iodine & Camphor: etc.].—T. Okaya & T. Tobiisi. (*Jap. Journ. of Phys.*, No. 1, Vol. 14, 1940/41, Abstracts p. 7.) *See* 3401 of 1941.

1096. ACTUAL RESEARCH ON DIRECT-READING DEPTH-METER AT SHIOGAMA HARBOUR [Modulated-Frequency Principle, measuring "Depths as Shallow as 15 cm"].—S. Matsuo. (*Electrotech. Journ.* [Tokyo], Nov. 1940, Vol. 4, No. 11, pp. 255–257.) *See* 1061 of 1939: and *cf.* Beard, 3238 of 1938.

1097. ON THE SUPERSONIC WAVE GENERATOR [and Methods of Increasing the Output of Quartz Generators: Max. Ratio Output/Anode-Input 0.29 at 530 kc/s].—K. Yosioka. (*Jap. Journ. of Phys.*, No. 1, Vol. 14, 1940/41, Abstracts p. 4.)

1098. HEARING IN THE RAT AT HIGH FREQUENCIES [Most Audible Frequency about 40 kc/s: Limit probably above That of Bats].—J. Gould & C. Morgan. (*Science*, 15th Aug. 1941, Vol. 94, p. 168.)

PHOTOTELEGRAPHY AND TELEVISION

1099. TELEVISION IN FRANCE [Recent Demonstration & Plans].—(*Wireless World*, Feb. 1942, Vol. 48, No. 2, p. 38: paragraph only.)

1100. PROGRAMME ASPECTS IN TELEVISION BROADCASTING, *and* TECHNICAL FEATURES OF TELEVISION TRANSMISSION AND RECEPTION.—W. C. Eddy: A. H. Brolly. (*Proc. I.R.E.*, May 1941, Vol. 29, No. 5, p. 283: p. 283: summaries only.)

1101. Non-Stationary Processes in a Coaxial Cable.—Gorshunov. (*See* 992.)

1102. Relaxation Response of Video Amplifiers [Previous Treatments by replacing Square Wave by Fourier Series are unsuitable for L.F. Square Waves, where Many Harmonics must be included in Fourier Series: Treatment starting from Fundamental Differential Equation].—W. H. Huggins. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, p. 357: summary only.)

1103. Television—The Scanning Process [Analysis as a Two-Dimensional Fourier Series of Terms correlated to Frequency Components of Transmitted Signal: Relationship between Scanning Process & Reproduction of Detail: the Two Main Types of Impairment: Over-All Impairments ("Stroboscopic Flicker," etc.) due to Intermittency: etc.].—P. Metz. (*Proc. I.R.E.*, Oct. 1941, Vol. 29, No. 10, pp. 529–537.)

1104. Measurement, Analysis, Synthesis, and Evaluation of the Square-Wave Response of Television Apparatus.—R. D. Kell, A. V. Bedford, & others. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 224: summary only.)

1105. The Transmitter Amplifier with Complex External Resistance [with Special Application to Wide-Band Television Transmitters].—Rothe. (*See* 1021.)

1106. Measurement of the Slope and Duration of Television Synchronising Impulses.—R. A. Monfort & F. J. Somers. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, p. 358: summary only.)

1107. Heat-Treated Television [Picture-Wave Aerial enclosed in Electrically Heated Box].—(*See* 1040.)

1108. Orthicon Portable Television Equipment.—M. A. Trainer. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 229: summary only.)

1109. The Relative Sensitivities of Television Pick-Up Tubes, Photographic Film, and the Human Eye.—A. Rose. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 227: summary only.)

1110. Behaviour of the Foreign Metal Particles in the Composite Photocathode: Parts I and II.—S. Asao. (*Jap. Journ. of Phys.*, No. 1, Vol. 14, 1940/41, p. 39: p. 39.) *See* also 2467 of 1941.

1111. Studies on the Photoconductivity of Semiconducting Layers composed of Some Heavy-Metal Sulphide or Selenide: I and II [Cadmium Selenide, Thallous Sulphide: Relation between Spectral Sensitivity & Light Absorption: between Grain Size & Sensitivity].—C. Asai. (*Jap. Journ. of Phys.*, No. 1, Vol. 14, 1940/41, Abstracts p. 54: p. 54.)

1112. Photoelectric Properties of Bismuth [Work Function Values all between 4.22 & 4.25 eV: α 0.03–01 as Large as for Sodium: etc.].—H. Jupnik. (*Phys. Review*, 15th Dec. 1941, Vol. 60, No. 12, pp. 884–889.) For Weber & Eisele's work *see* 485 of February.

MEASUREMENTS AND STANDARDS

1113. Ultra-High-Frequency Oscillator Type 757-A [with Lead-Screw Drive to Piston: Output 4 W at 400 Mc/s, Lower but Still Considerable Output at 600 Mc/s].—General Radio. (*Review Scient. Instr.*, Dec. 1941, Vol. 12, No. 12, p. 614.)

1114. Impedance Measurements at Frequencies from 1 to 100 Megacycles.—R. F. Field. (*Proc. I.R.E.*, May 1941, Vol. 29, No. 5, p. 289: summary only.)

"Resistance standards can be built giving an error of only 2.5% at 100 Mc/s", whereas the best capacitance standards at present give about 10% with 100 $\mu\mu$F at 60 Mc/s.

1115. Impedance Measurements over a Wide Frequency Range [and in particular a "Susceptance-Variation" Circuit (for Dielectric Investigation) for Frequencies 0.5–100 Mc/s: Results on Polystyrene, etc.].—L. E. Packard. (*Proc. I.R.E.*, Aug. 1941, Vol. 29, No. 8, p. 472: summary only.)

1116. Extending the Range of Q-Meter Measurements to Higher Frequencies [up to 150 Mc/s].—C. J. Franks. (*Proc. I.R.E.*, Aug. 1941, Vol. 29, No. 8, pp. 471–472: short summary only.) From the Boonton Radio laboratories.

1117. Voltmeter for High Frequencies [Oscillatory-Circuit Condenser with Transparent Dielectric whose Heating-Up by Dielectric Losses produces Strains measurable by Polarised Light].—H. Straubel. (*Hochf:tech. u. Elek:akus.*, Oct. 1941, Vol. 58, No. 4, p. 104.) D.R.P. 704 178. *Cf.* 1553 of 1938.

1118. An Exploring-Head Voltmeter for Ultra-Short Waves [Compact Diode Voltmeter, Mains-Driven: Input Impedance over 50 Kilohms up to 30 Mc/s, about 500 Ohms at 1000 Mc/s: Accurate within 5% up to 500 Mc/s].—Rohde & Schwarz Laboratories. (*Helios* [Leipzig], 28th Sept. 1941, Vol. 47, No. 39, Supp. pp. 1230–1232: in German, French & Spanish.)

1119. A Frequency-Modulation Station Monitor [Development of General Electric Company's Design].—H. R. Summerhayes, Jr. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, pp. 228–229: summary only.) *Cf.* 178 of January.

1120. The Megacycle Meter [Form of "Grid-Dip" Meter designed for Frequencies 10–400 Mc/s: Application to Alignment of U.H.F. Superheterodyne Receivers and to Locating of Parasitic Oscillations].—J. Minter. (*Proc. I.R.E.*, Aug. 1941, Vol. 29, No. 8, p. 472: summary only.)

1121. On Ultra-Short-Wave Quartz Crystal Vibrators [*e.g.* 1.8 m Fundamental, oscillating easily in Pierce Circuit: Temperature Coefficient only 1×10^{-6} compared with -4 to 7×10^{-5}/°C of Tourmalin.]—Z. Kamayachi & H. Watanabe. (*Electrotech. Journ.* [Tokyo], Jan. 1941, Vol. 5, No. 1, pp. 19–20.)

For the 1.8 m wavelength the plate had diameter 12 mm, thickness 0.015 mm, and θ about 138°. Optical devices were used for the selection and preparation of the crystal.

1122. Relations between Dimension or Disposition of Electrodes and Their Electrical Equivalent Circuit Constants, in Rectangular Piezoelectric Vibrators having Longitudinal Mode of Vibration.—Kamayachi & Ishikawa. (*See* 989.)

1123. Piezoelectric Excitability of Thickness Vibration [Theoretical Method of finding the Excitation Strength of the Three Modes of Thickness Vibration, with Example: Usefulness proved in Researches on Rochelle Salt Plates].—N. Takagi. (*Electrotech. Journ.* [Tokyo], Jan. 1941, Vol. 5, No. 1, p. 18.)

1124. Researches on Rochelle Salt Crystals.—Kashimoto & Tsumura: Takagi & Nakayama. (*See* 1084 & 1085.)

1125. Frequency Standards for High Frequencies [based on Tuning-Fork Oscillator].—R. P. McLoughlin. (*Proc.I.R.E.*, Sept. 1941, Vol. 29, No. 9, pp. 525–526: summary only.)

1126. An Investigation of [the Selectivity & Frequency Stability of] High-Selectivity Circuits using Negative Feedback.—Rizkin. (*See* 1000.)

1127. An Improved Frequency Meter for Commercial Power Frequencies [Advantages of Iron-Core Cross-Coil Design].—K. J. Knudsen. (*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, Transactions pp. 866–868.)

1128. A Single-Stage Valve Voltmeter without Energy Consumption, for D.C. & A.C. (up to 10 kc/s) Voltages to 400 V.—(*Helios* [Leipzig], 29th June 1941, Vol. 47, No. 26, pp. 834–836: in French.) Made by a Berlin firm.

1129. The Determination of Magnitude and Phase Angle of Electrical Quantities [as in Measurement of Capacitance & Power Factor of Imperfect Condensers, etc: Three-Voltmeter Method (taking advantage of Valve-Voltmeter Qualities) modified by Balancing-Out of One Component].—E. A. Walker. (*Elec. Engineering*, Aug. 1941, Vol. 60, No. 8, Transactions pp. 837–839.)

1130. Measurement of High Insulation Resistance with Valve Electrometer [instead of Quadrant Electrometer: Apparatus for Currents 10^{-7} to 10^{-14} A: Results on Amber, Quartz, etc.].—T. Akahira & M. Kamazawa. (*Jap. Journ. of Phys.*, No. 1, Vol. 14, 1940/41, Abstracts p. 40.)

1131. The Absolute Measurement of Electrical Resistance by a Method using the Average Electromotive Force of a Commutating Generator [having an Extremely Flat Maximum of Mutual Inductance].—H. R. Nettleton & E. G. Balls. (*Proc. Phys. Soc.*, 1st Jan. 1942, Vol. 54, Part 1, No. 301, pp. 27–46.)

1132. The Measurement of Small Alternating Current Powers [Survey].—J. Bubert. (*E.T.Z.*, 23rd Oct. 1941, Vol. 62, No. 42/43, p. 867: summary only.)

1133. The Photocell Compensator in Measuring Technique [Survey, with 11 Literature References].—H. Bleckwenn. (*E.T.Z.*, 13th March 1941, Vol. 62, No. 11, pp. 292–294.)

Particularly valuable applications of this instrument (*see*, for example, Hunsinger, 3195 of 1941) are to the measurement of temperature in metallurgical research and to p_H measurement. It also presents great advantages in telemetering, allowing the distance to be increased considerably. In the recording of h.f. currents, a thermo-converter delivers only a few milliwatts, but the interposition of a photocell compensator allows even rapidly varying h.f. currents to be recorded by an inkwriter taking 30 milliwatts. Such an arrangement can be used for monitoring the field strengths of transmitting stations. Also, in recording field strengths over large distances a logarithmic scale is often desirable: this can be obtained by recording the control voltage of an exponential (variable-mu) valve.

1134. Magnetic [Saturation] Amplifiers for Measuring and Control Technique.—W. Geyger. (*E.T.Z.*, 23rd Oct. & 6th Nov. 1941, Vol. 62, Nos. 42/43 & 44/45, pp. 849–853 & 891–898.) Already dealt with in 2857 of 1941.

1135. Formulas for the Inductance of Rectangular Tubular Conductors, *and* Self-Geometric Mean Distances of Stranded Conductors.—T. J. Higgins: O. P. Doria. (*Elec. Engineering*, Nov. 1941, Vol. 60, No. 11, p. 553—summary only: pp. 564–565.)

SUBSIDIARY APPARATUS AND MATERIALS

1136. Kerr-Effect Oscillograph with Two-Coordinate Deflection [Application of Low Relaxation Time (10^{-10} s) of Kerr Effect to Observation of Very Rapid Oscillatory Processes: Sensitivity increases with Bias Voltage: etc.].—Eder. (*E.T.Z.*, 23rd Oct. 1941, Vol. 62, No. 42/43, p. 867.) Summary of the paper referred to in 1725 of 1941.

1137. A New Cathode-Ray Oscillograph for the Wire-Broadcasting Service.—Eisele. (*See* 1187.)

1138. A Ten-Megacycle Oscilloscope [with Hard-Valve Sweep Circuit (continuously adjustable from 20 c/s to 1 Mc/s): Identical Amplifiers for Sweep & Test Circuits, having Their First Stages as " Probes " (in Small

Aluminium Shields) on Shielded Cords: etc.].—Edson. (*Bell Lab. Record*, Dec. 1941, Vol. 20, No. 4, pp. 95–98.)

1139. RECORDING OF HIGH-SPEED TRANSIENT [Non-Recurrent] PHENOMENA BY MEANS OF A SEALED-OFF CATHODE-RAY TUBE [Experiments in improving Standard Tube to give Photographic Records at Max. Spot Speeds up to about 1000 km/s].—Fujitaka & others. (*Electrotech. Journ.* [Tokyo], Jan. 1941, Vol. 5, No. 1, pp. 15–16.)

1140. BLACKOUT-PANEL OSCILLOGRAPH [for Use, if necessary, in Total Darkness: Scales, etc., in Luminous Paint giving Same Colour & Intensity of Glow as the C.R. Tube Trace].—DuMont Laboratories. (*Gen. Elec. Review*, Nov. 1941, Vol. 44, No. 11, p. 638.)

1141. A CATHODE-RAY OSCILLOGRAPH WITH ROTATING-DRUM CAMERA.—Downie. (*Elec. Engineering*, Nov. 1941, Vol. 60, No. 11, Transactions pp. 984–986.)

1142. SOME SIMPLIFIED METHODS OF DETERMINING THE OPTICAL CHARACTERISTICS OF ELECTRON LENSES [Three Calculation Procedures & an Experimental Method: New Graphical Representation of Complete Solution of Lens Equation, revealing Properties previously Unrecognised: Design Procedure for C.R. Tubes].—Spangenberg & Field. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 228: summary only.) *Cf.* Sándor, von Ardenne, 504 & 515 of February.

1143. THE CATHODO-LUMINESCENCE OF LUMINESCENT MAGNESIUM SILICATES AND SOME RELATED MAGNESIUM MINERALS [Remarkably Intense Red Luminescence by Addition of Manganese: etc.], *and* ON THE FLUORESCENCE SPECTRUM AND COMPOSITION OF SCAPOLITE.—Iwase. (*Jap. Journ. of Phys.*, No. 1, Vol. 14, 1940/41, Abstracts pp. 54–55: p. 55.)

1144. RESEARCHES ON THE PHOTOGRAPHIC RECORDING OF X-RAY SCREEN IMAGES [including the Optimum Combination of Film & Fluorescent Screen, After-Glow, etc.].—Stanford. (*Sci. Abstracts*, Sec. B, Nov. 1941, Vol. 44, No. 527, pp. 225–226.)

1145. PAPER ON THE DEVELOPMENT OF TIME BASES.—Puckle. (*Electrician*, 13th Feb. 1942, Vol. 128, pp. 127–128.) Summary of I.E.E. paper.

1146. DEIONISATION CONSIDERATIONS IN A HARMONIC PRODUCER EMPLOYING A GAS-TUBE SWITCH [Experimental Investigation of Thyratron as High-Frequency Switch up to Several Hundred Kilocycles per Second, with Special Grid-Potential Conditions: Incomplete Deionisation, but Normal Switching Behaviour].—Shepherd. (*Proc. I.R.E.*, April 1941, Vol. 29, No. 4, p. 228: short summary only.)

1147. A STABILISED NEON-TUBE DIRECT-COUPLED AMPLIFIER [particularly for Cathode-Ray Oscillography: with Degenerative Cathode Resistor].—Huggins. (*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, p. 437.)

1148. ALLOYS FOR VACUUM-TIGHT SEALS [with Data & Manufacturers' Names, etc.].—Winckelmann. (*Helios* [Leipzig], 28th Sept. 1941, Vol. 47, No. 39, pp. 1212–1217: in German, French & Spanish.)

1149. STRESS DISTRIBUTIONS IN METAL-SEALED GLASSES, *and* SELECTION OF STEM GLASS.—Kanno. (*See* 1072 & 1073.)

1150 VAPOUR TRAP AND VACUUM GAUGE [Trap made from Thermos Bottle: Geissler-Tube Gauge with Fluorescent Coating, indicating down to 10^{-5} mm Hg].—Moriya. (*Electrotech. Journ.* [Tokyo], Nov. 1940, Vol. 4, No. 11, p. 259.)

1151. THE DETERMINATION OF OPERATING DATA AND ALLOWABLE RATINGS OF VACUUM-TUBE RECTIFIERS [Formulae & Graph for Calculation of Peak Current, Inverse Voltage, & Plate Dissipation, in order to determine Permissible Limits of Operation: Extension to Half-Wave Condenser Input & Polyphase Choke Input].—Frommer. (*Proc. I.R.E.*, Sept. 1941, Vol. 29, No. 9, pp. 481–485.)

1152. EFFECT OF ADMIXTURE OF SILVER ON THE RECTIFYING PROPERTIES OF Cu/Cu_2O CELLS.—Dixit. (*Sci. Abstracts*, Sec. B, Nov. 1941, Vol. 44, No. 527, p. 216.)

1153. CURRENT RATING AND LIFE OF COLD-CATHODE TUBES [acting as Relay, Rectifier, Voltage-Regulator, etc: Application of Townes's Conclusions on Low-Voltage Cathode-Sputtering].—Rockwood. (*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, Transactions pp. 901–903.) *See*, for example, 4167 of 1939 (Ingram): for Townes's paper *see* 815 of March.

1154. AN ELECTROMAGNETIC VOLTAGE STABILISER.—Shevchuk. (*Elektrosvyaz* [in Russian], No. 3, 1941, pp. 7–15.)

A complete investigation has been made of the Friedlander-type voltage stabiliser for voltages applied to small loads. The operation is discussed and the fundamental relationships between the magnetic fluxes, voltages, and ampere-turns are derived. Methods are proposed for design. Manufacturing details of 25, 40 and 180 VA stabilisers built in the laboratory are given, and their performance is illustrated by a number of curves and oscillograms. The accuracy of stabilisation is discussed, and in conclusion a circuit (Fig. 13) is briefly described for obtaining stabilised rectified voltage from a double-diode rectifier valve and a special transformer-stabiliser.

1155. A VALVE-VOLTMETER RELAY OF UNLIMITED SENSITIVITY [for Voltage Stabilisation].—Orlov & Pirogov. (*Elektrosyaz* [in Russian], No. 4, 1941, pp. 16–22.)

A valve-voltmeter relay for stabilising voltages is described. It consists essentially of two rectifier valves whose characteristics have different slopes. The valves are connected in a compensating circuit, *i.e.* with terminals of the same sign in opposition (Fig. 1). The absolute difference between the two rectified voltages so obtained is used for controlling the servo-motor of the regulating equipment. The relay can easily be adjusted for any desired voltage value, and sharply reacts to any change in this value. The circuit diagram of a relay on this principle is given, together with a short specification of the components. Constructional details are discussed, and methods are described for adjusting and testing the relay. This stabiliser is now in production, its sensitivity being of the order of 0.35–0.4%.

1156. Constant Voltage Supply: a Circuit combining Partial Stabilisation of A.C. Input with Full Stabilisation of D.C. Output.—Ledward. (*Wireless World*, Feb. 1942, Vol. 48, No. 2, pp. 33–35.) Using a neon lamp and heavy-current, steep slope valves of Harries tetrode type. For a correction to Fig. 4 *see* March issue, p. 67.

1157. A New Mercury Rheostatic Element for Regulation and Control [the "Mercurystat": Power Amplification of Order of 100 000 obtainable].—Oplinger. (*Elec. Engineering*, Aug. 1941, Vol. 60, No. 8, Transactions pp. 846–849.) "In most applications it is difficult to justify the use of tubes or rotating amplifiers."

1158. Vibrators and Vibrator-Operated Power Supplies.—Nace. (*Proc. I.R.E.*, Aug. 1941, Vol. 29, No. 8, pp. 470–471: summary only.) "As evidence of their practicability it was stated that some of the airlines are beginning to accept such power supplies."

1159. Power Supply for Emergency Equipment: Building Vibrator-Type Supplies for 300 Volt 100 Milliampere Output.—Grammer. (*QST*, Jan. 1942, Vol. 26, No. 1, pp. 9–14 and 54.) In connection with 681, 816, & 883 of March (*see* also 1014, above).

1160. Lead-Cadmium Accumulators with Low Spontaneous Discharge.—von Thyssen-Bornemisza. (*Zeitschr. V.D.I.*, 13th Dec. 1941, Vol. 85, No. 49/50, p. 963.)

1161. Application of Conducting Rubber to the Shielding of Flexible Leads [for High Frequencies].—Peterson & Lewis. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, p. 358: summary only.)

1162. On a Method giving a Reduction of the Losses by Brush Discharge in Electrostatic Machines [van de Graaf Generators, etc: Max. Potential about Doubled by Use of Metallic Toroidal Ring].—Yadoff & Platoff. (*Comptes Rendus* [Paris], 21st April 1941, Vol. 212, No. 16, pp. 671–674.)

1163. Atmospheric Variations and Apparatus Flashover.—McAuley. (*Elec. Engineering*, July 1941, Vol. 60, No. 7, Transactions pp. 798–803.) *Cf.* Tenney, 595 of February.

1164. High-Voltage D.C. Flash-Over of Solid Insulators in Compressed Nitrogen.—Trump & Andrias. (*Elec. Engineering*, Nov. 1941, Vol. 60, No. 11, Transactions pp. 986–990.)

1165. Effects of Corona and Spark-Over in Freon [Non-Inflammable Gas with Dielectric Strength about 3 Times that of Air at Same Pressure], *and* High-Pressure Gas [Nitrogen & Freon] as a Dielectric.—De Wolf: Nonken. (*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, pp. 435–436: pp. 446–447—summary only.) *See* also 233 of January.

1166. On the Possibility of the Replacement of Oil Insulation in H.T. Installations by Gases or Mixtures of Gases and Vapours [particularly CCl_4 & CCl_2F_2].—Drigo & Drigo. (*E.T.Z.*, 23rd Oct. 1941, Vol. 62, No. 42/43, pp. 865–866: summary only.)

1167. High-Frequency Dielectric Loss Angles of Various Solid Insulating Materials at Low Temperatures [$-150°$ to $+100°$C: Apparatus: Curves for Steatite, Mycalex, etc.].—Okazaki & Otuka. (*Electrotech. Journ.* [Tokyo], Jan. 1941, Vol. 5, No. 1, p. 15.) Using the method dealt with in 1532 of 1940.

1168. Dielectric Loss Measurements of Liquid and Semi-Solid Insulating Materials at High Frequencies [up to 40 Mc/s].—Okazaki & Yamamoto. (*Electrotech. Journ.* [Tokyo], Jan. 1941, Vol. 5, No. 1, p. 19.) Using the equipment dealt with in 4506 of 1938.

1169. Temperature Characteristics of Dielectric Losses at High Frequencies [100 kc/s to 10 Mc/s: Porcelain, Bakelite, Quartz, Mica, & Ambroid: Effect of Moisture: etc.].—Tsumita. (*Jap. Journ. of Phys.*, No. 1, Vol. 14, 1940/41, Abstracts p. 42.)

1170. Some Measurements on the Validity of the Principle of Superposition in Solid Dielectrics [Frequency-Dependences of Conductance & Capacitance of Carnauba-Wax Condenser, measured between 20 c/s & 20 Mc/s, establish Validity].—Silva & Gross. (*Phys. Review*, 1st Nov. 1941, Vol. 60, No. 9, pp. 684–687.) Leading out of Gross's work, 2539 of 1941.

1171. The Basis for the Non-Destructive Testing of Insulation [Correlation between Dielectric Strength and L.F. Interfacial Polarisation: New Method of Measurement].—Field. (*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, Transactions pp. 890–895.)

1172. Factors influencing the Mechanical Strength of Cellulose Insulation.—Clark. (*Elec. Engineering*, July 1941, Vol. 60, No. 7, Transactions pp. 778–783.)

1173. Temperature-Compensating Capacitors [Sealed Mica Condensers Type "K" for correcting Temperature Coefficient of Inductances].—Aerovox. (*Review Scient. Instr.*, Dec. 1941, Vol. 12, No. 12, pp. 615–616.) "It is possible to obtain oscillator frequency stability [in radio transmitters] comparable to that obtained with quartz crystals", with saving of space and weight.

1174. Recovering Boric Acid in Manufacture of Electrical Capacitors.—McCrea. (*Elec. Engineering*, Aug. 1941, Vol. 60, No. 8, p. 417.)

1175. High-Frequency Iron Cores [of All Dimensions & Shapes, Special or Standard].—Crowley & Company. (*Review Scient. Instr.*, Dec. 1941, Vol. 12, No. 12, pp. 613–614.)

1176. Magnetic Moments at High Frequencies [calculated for Conducting, Permeable Spheres & Cylinders in Oscillating Magnetic Field, as Functions of Conductivity, Permeability, Cross-Sectional Radius, & Wavelength: Electric Moment of Conducting Sphere in Oscillating Electric Field: Application to Effect of Particle Size on Effective Permeability of Magnetic Powders].—Page. (*Phys. Review*, 1st Nov. 1941, Vol. 60, No. 9, pp. 675–684.)

1177. The Shielding of Permanent Magnets from Transient Magnetic Fields [by Use of New High-Speed Copper-Plating Process].—Wey. (*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, Transactions pp. 875–877.)

1178. The Radio Alarm for Civilian Defence.—Van Dyck & Deal. (*See* 1213.)

STATIONS, DESIGN AND OPERATION

1179. Practical Engineering Aspects of Frequency-Modulation Broadcasting [with Special Reference to the Paxton & Mount Washington Stations].—de Mars. (*Proc. I.R.E.*, Sept. 1941, Vol. 29, No. 9, p. 525: summary only.)

1180. A Commercial 50-Kilowatt Frequency-Modulation Broadcast Transmitting Station [as installed (with Dummy Aerials) at the Helderberg Station, W2XOY].—Thomas & Williamson. (*Proc. I.R.E.*, Oct. 1941, Vol. 29, No. 10, pp. 537–545.)

1181. Frequency Modulation for Communication Purposes [including Police & Military Uses].—Budelman. (*Proc. I.R.E.*, Aug. 1941, Vol. 29, No. 8, p. 471: summary only.)

1182. Frequency Modulation in Railway Signalling [at Shell-Loading Plant].—(*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 13: paragraph only.)

1183. A Frequency-Modulation Station Monitor.—Summerhayes. (*See* 1119.)

1184. The Communication Facilities of the U.S. Forest Service.—Simson. (*Elec. Engineering*, Nov. 1941, Vol. 60, No. 11, Transactions pp. 971–976.) *See* also 543 of February.

1185. Some Problems in Railway-Train Telephony.—Herrmann. (*Hochf:tech. u. Elek: akus.*, Nov. 1941, Vol. 58, No. 5, pp. 114–118.)

Author's summary:—"The task of transmitting communication between a fixed and a moving station is performed in train telephony by supplying the energy to a pair of conductors in the bunch of overhead lines running parallel to the track. The station in the train is coupled capacitively to this pair by a wire stretched over the roof. Coupling attenuation and line attenuation vary, in opposite senses, with the frequency. The total attenuation [eqn. 9] is smallest at the frequency for which the line attenuation of the half section between two fixed stations amounts to 2 nepers [but the maximum for the best frequency is flat: *see* bottom of p. 117, l-h column] . . . At 100 kc/s the distance between the fixed station and the station coupled to the overhead lines may be 130 km. The operating attenuation would then fluctuate between 4.5 and 9.5 nepers, and with an aerial power of 10 watts this would allow receiving levels to be attained which in the most unfavourable conditions would still be 2 nepers above the background of telegraphy and broadcasting." The system actually in action and tested, working on 75 kc/s with an aerial power not much over 1 watt, is occasionally subject to severe interference. The advantage, in increasing signal strength, of frequent earthings along the course of the pair of lines is discussed at the end of section 1a.

1186. On the Reconstruction and Development of Wire Broadcasting in Towns.—Vaks. (*Elektrosvyaz* [in Russian], No. 3, 1941, pp. 4–6.)

It is considered that wire broadcasting should become predominant in towns, and the requirements necessary for ensuring service of high quality and reliability are discussed.

1187. A New Cathode-Ray Oscillograph for the Wire-Broadcasting Service [Type A40, Portable: Sensitivity 50 mV_{eff}, Frequency Range 30 c/s up to or over 1 Mc/s: Adjustable Time-Base Frequency 30 c/s up to or over 300 kc/s: Input Circuit symmetrical to Earth, with Sensitivity Adjustment: etc.].—Eisele. (*T.F.T.*, April 1941, Vol. 30, No. 4, pp. 108–115.)

1188. Radio Broadcasting in Canada.—Frigon. (*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, Transactions pp. 896–898.)

1189. Programme-Operated Level-Governing Amplifier [General Considerations (Peak Choppers inferior to Peak Limiters): Requirements of the Latter: the Western Electric 1126A Amplifier].—Black & Norman. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, pp. 573–578.)

GENERAL PHYSICAL ARTICLES

1190. THE ELECTRIC MOMENT OF A HIGHLY CONDUCTING SPHERE IN AN OSCILLATING ELECTRIC FIELD.—Page. (*See* 1176.)

1191. AN APPROXIMATE SOLUTION FOR THE DISTRIBUTION OF TEMPERATURE OR POTENTIAL WITH CYLINDRICAL ISOTHERMAL OR EQUIPOTENTIAL SURFACES [Use of Dipoles or Source-Sink Combinations to give Approx. Solution of Laplace's Equation].—Whitehead. (*Proc. Phys. Soc.*, 1st Jan. 1942, Vol. 54, Part 1, No. 301, pp. 63–65.)

1192. NOTE ON ELECTRIC AND MAGNETIC DIMENSIONS [particularly of K and μ, and the Derivation of the Inverse-Square Laws of Force].—Yarnold. (*Proc. Phys. Soc.*, 1st Jan. 1942, Vol. 54, Part 1, No. 301, pp. 46–49.)

Prompted by the discordant views of Brown and Duncanson (2893/4 of 1941). In the Discussion (pp. 49–50) S. Gill points out the advantages of taking as fundamentals length, time, electric charge, and magnetic pole-strength. *See* also 1193, below.

1193. DIMENSIONS OF PHYSICAL QUANTITIES.—Wilson: Burmiston Brown. (*Phil. Mag.*, Jan. 1942, Vol. 33, No. 216, pp. 26–33.) Criticism of Brown's paper, 2893 of 1941: *see* also 1192, above.

MISCELLANEOUS

1194. "STATISTICAL PROCEDURES AND THEIR MATHEMATICAL BASES" [Book Review].—Peters & van Voorhis. (*Nature*, 7th Feb. 1942, Vol. 149, p. 151.)

1195. "AN ENGINEER'S MANUAL OF STATISTICAL METHODS" [Book Review], *and* THE TECHNIQUE OF QUALITY CONTROL [Extract from Above Book].—Simon. (*Gen. Elec. Review*, Nov. 1941, Vol. 44, No. 11, p. 642: *Engineer*, 30th Jan. 1942, Vol. 173, pp. 100–102.)

1196. THE LIMITING FORM OF POISSON'S DISTRIBUTION.—Gumbel. (*Phys. Review*, 1st Nov. 1941, Vol. 60, No. 9, p. 689.)

1197. NUMERICAL DIFFERENTIATION NEAR THE LIMITS OF A DIFFERENCE TABLE.—Bickley & Miller. (*Phil. Mag.*, Jan. 1942, Vol. 33, No. 216, pp. 1–14.)

1198. THE CONSTANTS OF STRAIGHT-LINE LAWS [Correspondence].—Freeman. (*Engineering*, 16th Jan. 1942, Vol. 153, p. 54.) *See* 563 of February.

1199. METHODS OF FINDING THE EQUATIONS OF CURVES [Reference to a General Method].—Tobin: Barnes. (*Engineering*, 2nd Jan. 1942, Vol. 153, p. 15.) Prompted by 296 of January.

1200. ON CERTAIN EXPANSIONS OF THE SOLUTIONS OF MATHIEU'S DIFFERENTIAL EQUATION [including a More General Expansion containing an Arbitrary Parameter whose Suitable Choice may be useful for Computing, by improving Convergence].—Erdélyi. (*Proc. Cambridge Phil. Soc.*, Jan. 1942, Vol. 38, Part 1, pp. 28–33.)

1201. "TRANSIENTS IN ELECTRIC CIRCUITS" [and the Use of the Operational Calculus: Book Review].—Coulthard. (*Electrician*, 30th Jan. 1942, Vol. 128, p. 64.) For previous work by the writer *see* 2595 of 1939.

1202. CONTROL PROBLEMS [Application of Operators to Linear Control Problems: General Properties of Linear Systems acted on by Linear Controls: Stability of Controlled Systems: Non-Linear Control Problems (including Liapounoff's Theorem)].—Minorsky. (*Journ. Franklin Inst.*, Nov. & Dec. 1941, Vol. 232, Nos. 5 & 6, pp. 451–487 & 519–551.)

Practically all existing control systems belong to the linear class dealt with in the first three parts of the paper. "Part IV deals with non-linear control systems. Although the intrinsic difficulties of this particular field have retarded considerably the advent of these non-linear methods, it is thought that its potential possibilities may be of a sufficient interest to warrant at least a rather superficial review here." *Cf.* 1203, below.

1203. THE REPRESENTAITON OF CONTROL PROCESSES [in Linearly Functioning Electrical & Mechanical Systems: Use of Laplace Transformation & Hurwitz Stability Criteria].—Tischner. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 145–148.) Independent of, but covering the same ground as, Grünwald's work dealt with in 670 of March. *Cf.* also Minorsky, 1202, above.

1204. MAGNETIC AMPLIFIERS FOR MEASURING AND CONTROL TECHNIQUE.—Geyger. (*See* 1134.)

1205. A NEW MERCURY RHEOSTATIC ELEMENT FOR REGULATION AND CONTROL [the "Mercury-stat"].—Oplinger. (*See* 1157.)

1206. THE USE OF AN AMPLIDYNE-CONTROLLED MOTOR IN SAW-MILLS, *and* IN STRIP GRINDING AND POLISHING.—La Roque: Murrah. (*Gen. Elec. Review*, Nov. 1941, Vol. 44, No. 11, pp. 619–620: pp. 625–627.)

1207. THE PHOTOCELL COMPENSATOR IN MEASURING TECHNIQUE [for Industrial Supervision & Control of Temperature, p_H Measurement, etc.].—Bleckwenn. (*See* 1133.)

1208. THERMOSTATS EMPLOYING EXTERNAL SURFACE CONTROL [for Scientific or Industrial Plant].—Hopper. (*Proc. Phys. Soc.*, 1st Jan. 1942, Vol. 54, Part 1, No. 301, pp. 55–62.)

1209. LINE-ECONOMISING "COORDINATE CONNECTION" ("K CONNECTION") FOR REMOTE CONTROL AND TELEMETERING.—Stark. (*E.T.Z.*, 11th Sept. 1941, Vol. 62, No. 37, pp. 775–778.)

1210. FREQUENCY MODULATION APPLIED TO TELEGRAPH LINES [to avoid Troubles in Carrier-Current Systems due to Sharp Weather Changes].—Western Union. (*Science*, 12th Dec. 1941, Vol. 94, Supp. p. 10.)

1211. Carrier Current Communication: "Wired Wireless" over High-Voltage Power Lines.—Forrest. (*Wireless World*, Feb. 1942, Vol. 48, No. 2, pp. 26–29.)

1212. Terminal Equipment for the L1 Carrier System [New Coaxial System giving 480 Channels: Stevens-Point/Minneapolis].—Crane. (*Bell Lab. Record*, Dec. 1941, Vol. 20, No. 4, pp. 99–104.)

1213. The Radio Alarm for Civilian Defence [operated from Standard Broadcasting Station, by Inaudible 24 & 36 c/s Signals: Tuned-Reed Receiving Relays].—Van Dyck & Deal. (*Proc. I.R.E.*, Oct. 1941, Vol. 29, No. 10, p. 566—two summaries.) *See* also 3561 of 1941; for various R.C.A. devices *see* 4313 of 1938 & back references, and 1977 of 1941.

1214. A Method of Changing the Frequency of a Complex Wave [with Possible Application to Transmission of Intelligence].—Kent. (*See* 1087.)

1215. The Interaction between Two Parallel Lines when the Loads are Not Matched [in connection with Interference between Power Lines & Communication Lines, etc.].—Zingerenko. (*See* 994.)

1216. The Interference with Communication Lines due to the Equalising Voltage between Compound Rectifiers at Railway Substations, *and* The Determination of the Interfering Current, affecting a Two-Wire Telephone Line, in the Contact Network of an Electric Railway fed from Mercury Rectifiers.—Solov'ev: Mikhaylov. (*Elektrosvyaz* [in Russian], No. 3, 1941, pp. 49–68: No. 4, 1941, pp. 77–88.)

1217. Civilian Communications under Wartime Conditions [Report on Visit to London: Criticisms (Lack of Self-Powered Equipments, etc.)]—Leonard. (*Proc. I.R.E.*, Oct. 1941, Vol. 29, No. 10, p. 567: summary only.) *Cf.*, for example, *QST*, Jan. 1942, Vol. 26, No. 1, pp. 7–8 and Inset (Editorials).

1218. "How Inventors Can Aid National Defence" [Book Notice].—U.S. Department of Commerce. (*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, p. 466.)

1219. Use of Science and Scientific Workers in the War.—Association of Scientific Workers. (*Nature*, 31st Jan. 1942, Vol. 149, pp. 130–132.)

1220. The Industry in Wartime: Annual Report of the Radio Manufacturers' Association.—(*Wireless World*, Feb. 1942, Vol. 48, No. 2, pp. 29–30.)

1221. Method in Invention [and the Use of the "Change of Position Operator," "Addition, Combination, Increased-Function, & Omission Operators"].—Turnbull. (*Distribution of Electricity*, Jan. 1942, Vol. 14, No. 145, pp. 514–515 and 520.) Continued from a previous issue.

1222. Cooperation between Instrument Makers and Instrument Users [Correspondence].—Marsh. (*Journ. of Scient. Instr.*, Feb. 1942, Vol. 19, No. 2, p. 31.) Prompted by Marsh's article, 589 of February.

1223. "Modern Assembly Processes: Their Development and Control" [Jointing Methods (Riveting, Soldering, etc.): Book Review].—Miller. (*Nature*, 13th Dec. 1941, Vol. 148, p. 711.) "The wisdom of Chapter 14, 'Testing, Inspection, and Trouble Hunting,' is worth every penny of the book's purchase price."

1224. High-Production High-Economy Methods for Metal Parts: Part III—Stampings, Formed and Drawn Parts, Soldering and Brazing, Powder Metallurgy.—Basch. (*Gen. Elec. Review*, Dec. 1941, Vol. 44, No. 12, pp. 685–695.) Final part of the series referred to in 594 of February.

1225. "Gears for Clockwork Mechanisms: War Emergency British Standard 978" [Book Notice].—(*Journ. of Scient. Instr.*, Jan. 1942, Vol. 19, No. 1, p. 15.)

1226. "A Dictionary of Electrical Terms, including Electrical Communication: Fourth Edition" [Book Review].—Roget. (*Engineering*, 26th Dec. 1941, Vol. 152, pp. 507–508.)

1227. The Correction by Scientists of Manuscripts for the Press.—Potter. (*Science*, 7th Nov. 1941, Vol. 94, pp. 438–439.)

1228. The History of Electrical Resonance [from the Leyden Jar to "Four Sevens" Marconi Patent].—Blanchard. (*Bell S. Tech. Journ.*, Oct. 1941, Vol. 20, No. 4, pp. 415–433.)

1229. Atmospheric Variations and Apparatus Flashover.—McAuley. (*Elec. Engineering*, July 1941, Vol. 60, No. 7, Transactions pp. 798–803.) *Cf.* Tenney, 595 of February.

1230. Future Sources of Power [Survey leading to Conclusion of Importance of Photosynthesis].—Furnas. (*Science*, 7th Nov. 1941, Vol. 94, pp. 425–428.) For an abridged version see *Engineering*, 2nd Jan. 1942, p. 4.

1231. Present Position of Research into the Effect of Commercial Currents on Vital Organs [and the Problem of Resuscitation].—Alvensleben. (*E.T.Z.*, 14th Aug. 1941, Vol. 62, No. 33, pp. 706–709.)

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