2/6

THE WIRELESS ENGINEER

The Journal of Radio Research & Progress

Vol. XIX MARCH 1942 No. 222

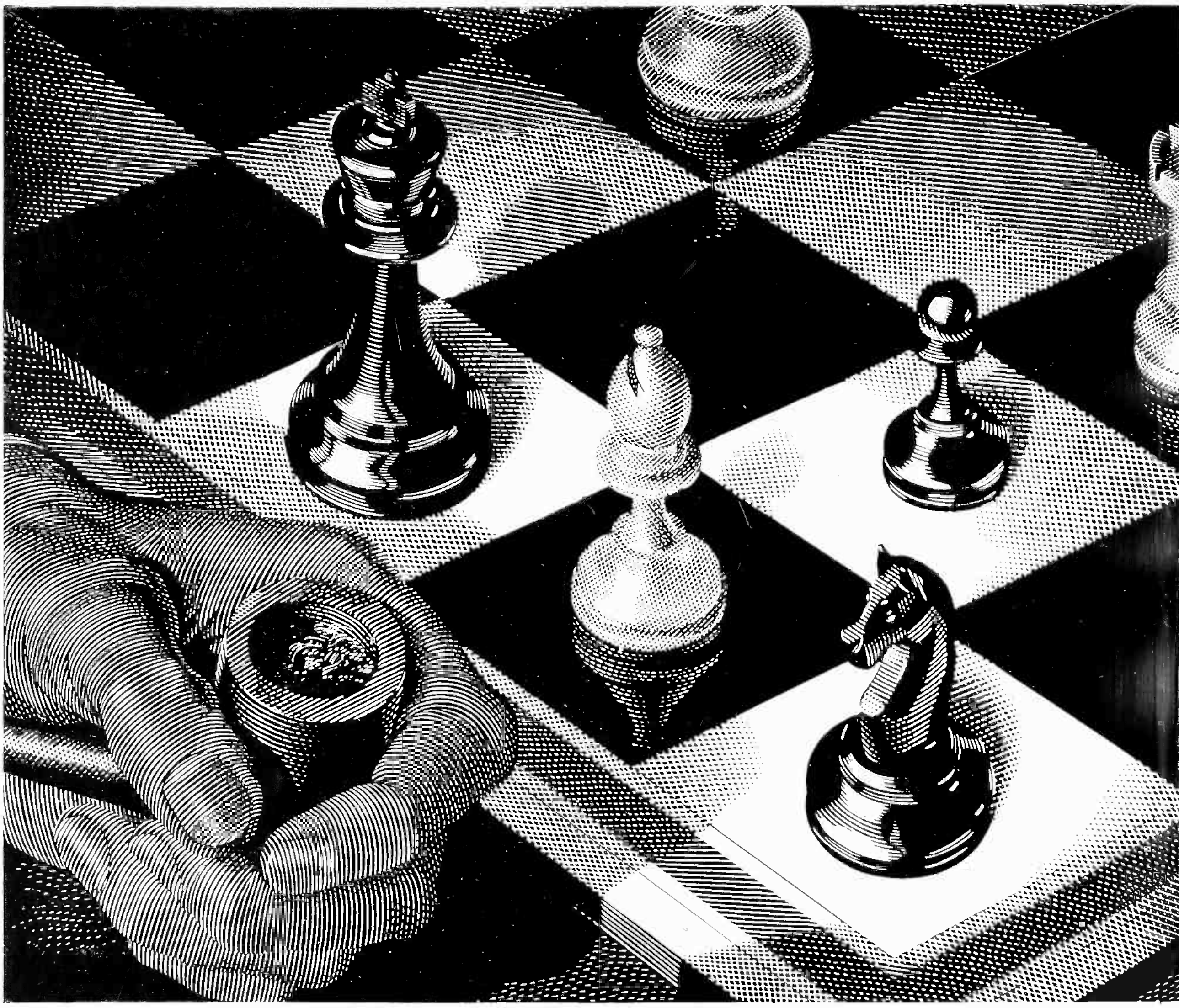
CONTENTS

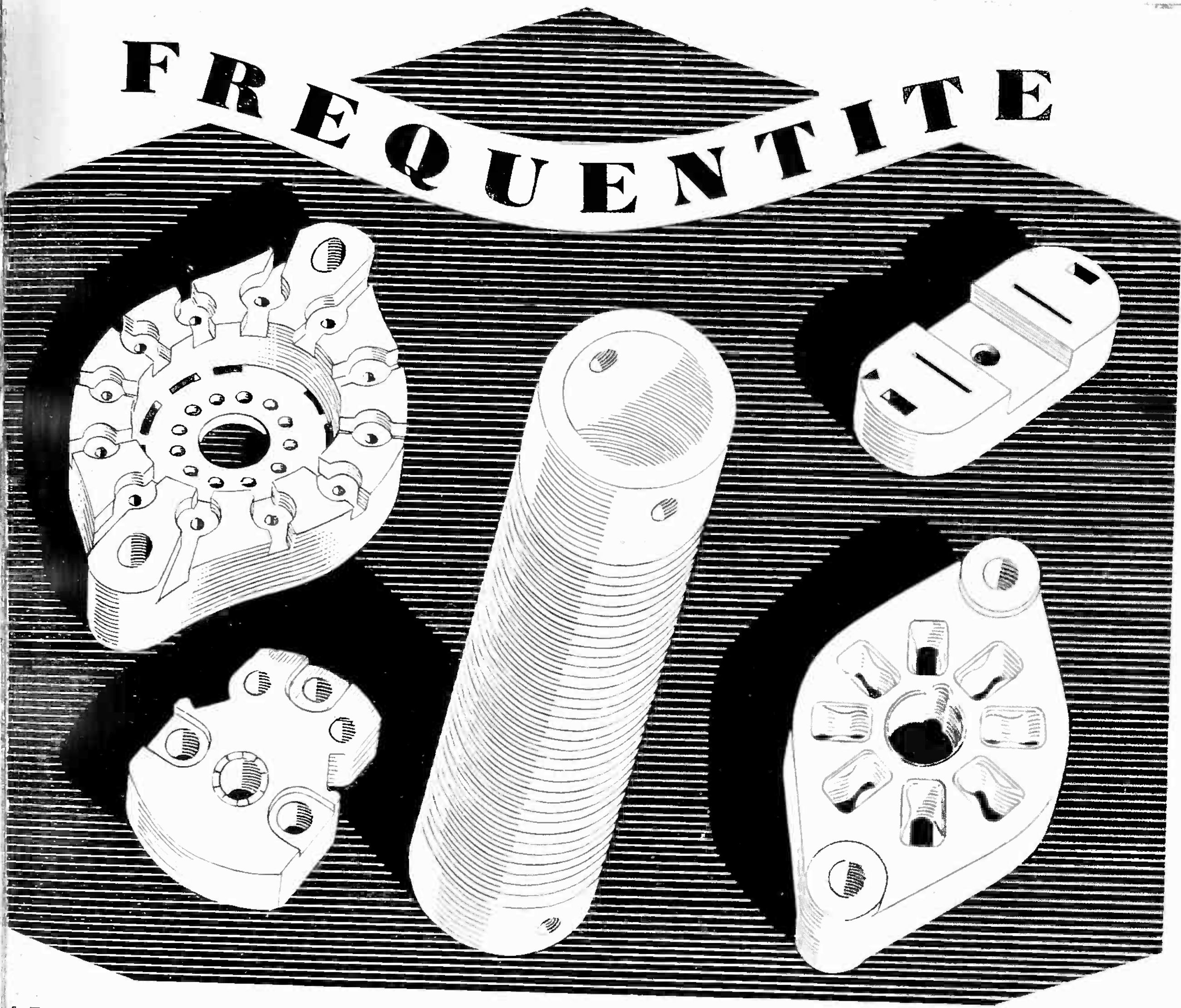
Published on the first of each month.

SUBSCRIPTIONS (Home and Abroad):
One Year 32/-, 6 Months 16/-

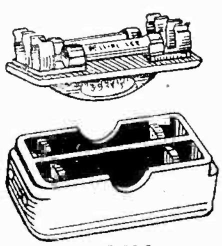
Telephone: Waterloo 3333 (35 lines).
Telegrams: Experiwyr Sedist London.

ILIFFE & SONS LTD. DORSET HOUSE STAMFORD ST. LONDON S.E.1




FREQUENTITE

Links in the chain of Success



MAIN BASEBOARD FUSEHOLDER

Moulded in X20 HD Bakelite. When in use, it is impossible to touch fuses; when cover is withdrawn, fuses are accessible, and disconnected from circuit. May be mounted on panel or baseboard with back or front connections. Standard with two 1¼" one amp. fuses, or as required. For 250 volts, available with anti-vibration springs.

Other Belling-Lee Activities.

Fuses 60 m/a. up to 300 amps. Fuseholders, valveholders up to 12,000 volts. Terminals up to 100 amps. Plugs and sockets and couplings up to 10-way. Screened rooms and cabinets, anti-interference aerials, dipoles and speciality feeders.

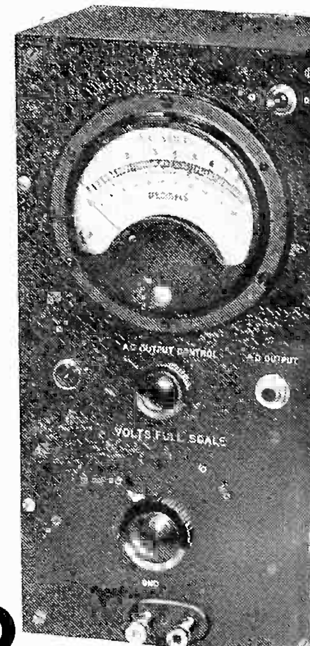
BELLING & LEE LTD

CAMBRIDGE ARTERIAL ROAD, ENFIELD, MIDDX.

G.P. 2835

BALLANTIN

IMMEDIATE DELIVERY



With the recently announced DECADE AMPLIFIER Model 220 and Multipliers 402-A & B the Model 300 Sensitive Electronic Voltmeter now covers the extraordinary range of from **30 microvolts to 10,000 volts.**

For VIBRATION studies, DYNAMIC BALANCING and acoustic measurements in AIRCRAFT PRODUCTION, etc., VIBRATION PICK-UP VP-5 and SOUND-METER attachment 400 are available.

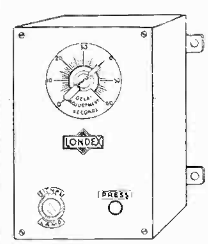
Send for details of this outstanding equipment and of other items from the ranges of Clough-Brengle, Ferris, Boonton and Hewlett-Packard.

LELAND INSTRUMENTS LTD

43, Mecklenburgh Square,
Telephone : TERminus 5

CLOUGH-BRENGLE • BOONTON • FERRIS • BALLANTINE • HEWLETT

LONDEX for RELAYS



Synchronous Time Delay Relay PRL

For A.C. or D.C., silent and reliab
2 VA coil consumption, from 2-6 volts, tested to 2,000 volts. U mounted and in cast-iron casin Also Time Lag Relays. High Sen tive Relays, Synchronous Proce Timers, and Complete Contr Plants.

Apply for leaflet SPN/WE.

LONDEX LT

Manufacturers of Relays.
Anerley Works, 207, Anerley
London, S.E.20.
Telephone : Sydenham 6258 & 6

MELTON METALLURGICAL LABORATORI LT

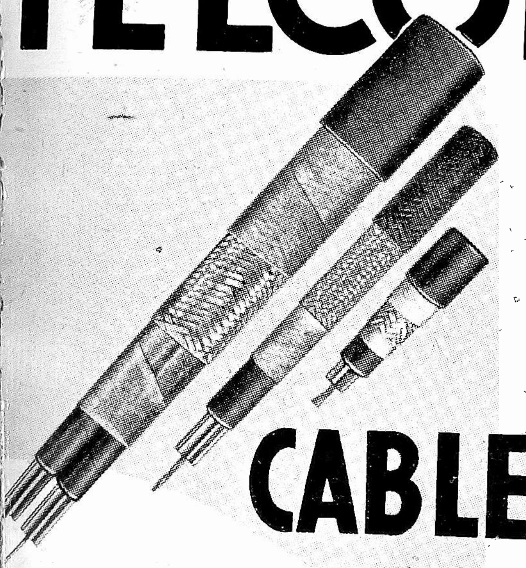
LIQUID SILVER for metallising CERAMIC, MICA, QUARTZ, or GLASS, Low Melting-point SOLDER from 70°C. or to specification. Non-Corrosive Liquid FLUX for all electrical or radio purposes

PRE-WAR DELIVERIES

OVERSEAS ENQUIRIES INVITED

IPSWICH RD. TRADING ESTATE, SLOUGH, BUCKS. *Phone : Slough 2099*

TELCON



CABLES

for

IGH FREQUENCY TRANSMISSION AND RECEPTION

•

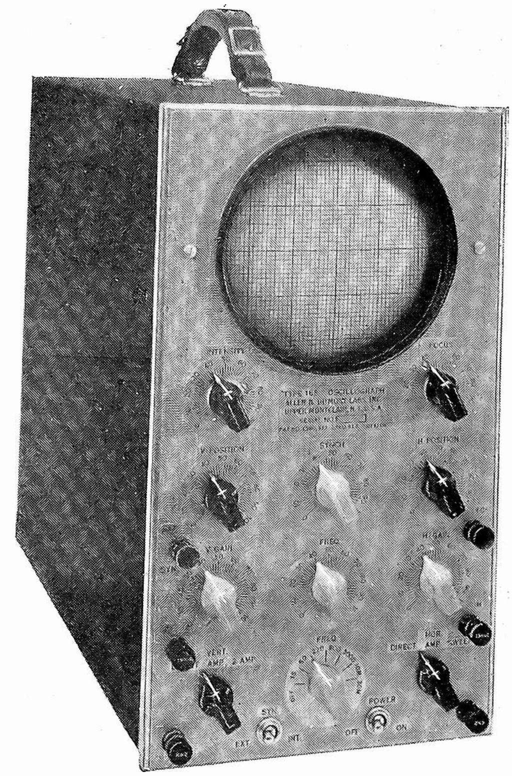
ull particulars of this and other
ELCON PRODUCTS
ill be furnished on request

•

THE ELEGRAPH CONSTRUCTION MAINTENANCE CO. LTD.

FOUNDED 1864

Head Office: **22, OLD BROAD ST., E.C.2.**
Telephone: LONdon Wall 3141
Temporary Address: BLACKSTONE, REDHILL, SURREY.
Redhill 1056



OSCILLOGRAPHS?

We have a Complete Range and invite your enquiries

For nearly Ten Years, The ALLEN B. DUMONT LABORATORIES HAVE PIONEERED in the manufacture of Cathode-Ray Tubes and Cathode-Ray Oscillographs, introducing the first commercial cathode-ray oscillograph assembly on the market, and continuing their leadership right through to the present day.

We have represented this pioneer firm for many years. Their range is a very complete one. Deliveries can be made very promptly. Prices are extremely favourable and quality and performance throughout is of an exceptionally high order of merit.

The new DUMONT Catalogue "B"—68 Pages—will gladly be despatched to you on request. Please state your requirements as fully as possible.

Illustrated is our most popular model, Type 168. This is an exceptionally flexible and useful assembly, employing a 5-inch DuMont Cathode-Ray Tube. Hundreds are in use in the U.K. alone—All 100 per cent. engaged "on Service."

CLAUDE LYONS, LTD

LIVERPOOL, 3,
AND LONDON, W.1.

C.R

Printed in England for the Publishers, Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1, by The Cornwall Press Ltd., Paris Garden, Stamford Street, London, S.E.1.

THE
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 MARCH 1942 No. 222

Editorial

Electromagnetic Waves in Rectangular Metal Tubes

THE consideration of apparently complex phenomena can often be simplified by resolution into two or more components. A well-known example is the amplitude-modulated wave, which, by resolution into carrier-wave and side-bands, is made amenable to treatment by simple alternating current formulae. In a recent number[1] of the *Journal of the Institution of Electrical Engineers*, the propagation of waves along metal tubes of rectangular cross-section is treated by John Kemp in a very interesting manner. The method had already been suggested and discussed at some length by Brillouin[2] and subsequently discussed by Page and Adams[3] and by Chu and Barrow[4], but Kemp confines himself mainly to the calculation of attenuation. The idea is to reduce the problem to that of the simple telephone transmission line and thus calculate the attenuation from the well-known formulae. There are various types of waves that can be propagated along metal tubes, but only one type lends itself to this simplification, and that is the type known as the *H* wave, in which there is a magnetic field in the direction of propagation. We discussed these various types in the Editorial of June, 1936, and the wave studied in detail by Kemp is that shown in Fig. 5, except that the tube is rectangular and not circular, as there shown. This simplifies the problem, as can be seen from Fig. 1, which shows the rectangular metal tube of depth *a* and width *b*. The electric field is assumed to be vertical, ending on charges on the inside of the metal tube. We have only shown the electric field where it is a maximum at two points half a wavelength apart; between these points it will vary sinusoidally, going through zero midway between them. The electric field also varies sinusoidally across the tube, being almost zero at the side walls and a maximum at the centre. The magnetic field is horizontal. The transverse magnetic field is a maximum where the electric field is a maximum. Where the electric field is zero the magnetic field is longitudinal, being zero at the centre and reaching a maximum value at the side walls.

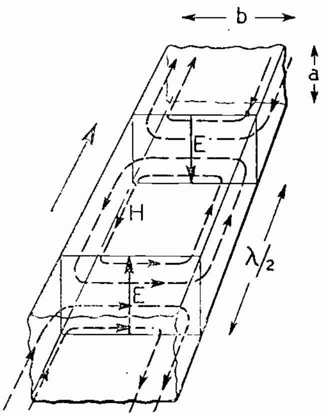


Fig. 1.

There is a minimum frequency f_0 below

[1] Vol. 88, Part III, Sept., 1941, p. 213.
[2] *Revue Générale*, 1936, 40, p. 227.
[3] *Physical Review*, 1937, 52, p. 647.
[4] *Proc. Inst. of R.E.*, 1938, 26, p. 1520.

which transmission does not take place; this is given by the formula $f_0 = \frac{v_1}{2b}$ where v_1 is the velocity—not of the wave along the tube, but in free space filled with the same dielectric; in air $v_1 = 3 \times 10^{10}$ cm/sec., and the maximum-possible free-space wave-length is therefore $2b$. We shall refer to f_0 as the cut-off frequency. Having thus seen the nature of the electromagnetic wave inside the tube we now turn to the novel way of regarding the problem. The top and bottom of the tube are assumed to be cut into a number of parallel zigzag paths as shown in Fig. 2, thus forming a number of transmission lines. The sides are pictured as a number of slabs which act as reflectors to the zigzag transmission lines. It will be seen that every part of the top and bottom is associated with two of the zigzag lines in such a way that the transverse components of the line currents neutralise each other whereas the longitudinal components are additive. It might be objected that if the wave follows this zigzag path its velocity along the tube will be less than that of the original wave, but it is just this point that brings out clearly some of the peculiarities of the original wave. The angle θ that the zigzag path makes with the side walls cannot be chosen at random; it depends on the frequency in such a way that $\sin\theta = f_0/f$ where f_0 is the cut-off frequency. If $f = f_0$ the angle is 90 degrees and there is no transmission along the tube.

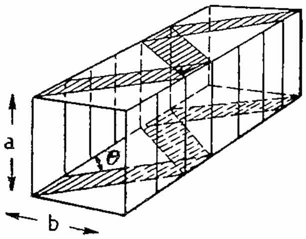


Fig. 2.

Phase Velocity and Energy Velocity

We must distinguish between two different velocities along the tube, viz., the phase velocity and the energy velocity. The latter corresponds to the group velocity when a wave passes through the Heaviside layer. If the energy follows the zigzag path *acd* (Fig. 3a) at a velocity v_1, its velocity along the tube will be

$$v_1 \frac{ab}{ac} = v_1 \cos\theta = v_1\sqrt{1 - \sin^2\theta} = v_1\sqrt{1 - \frac{f_0^2}{f^2}}.$$

If the frequency f is very high compared with the cut-off frequency f_0, the energy velocity approaches that in free space, but as f approaches f_0 the energy velocity approaches zero.

Fig. 3b shows the crests of waves (full lines) falling on the side wall and being reflected; the dotted lines represent the crests of reflected waves. In one cycle the crest *abcd* moves to *efgh*, and during the same interval the crest *mcgn* moves to *pbfq*. The crest of the resultant interference pattern originally at c will move parallel to the wall to f during the interval. Hence the phase velocity will be given by $v_1 \frac{cf}{\lambda_1}$ but since $cf = bg \tan\theta$ and $\lambda_1 = bg \sin\theta$ this is equal to $v_1/\cos\theta$ that is to

$$\frac{v_1}{\sqrt{1 - \frac{f_0^2}{f^2}}}.$$

We see then that as the frequency approaches the cut-off frequency, the energy velocity

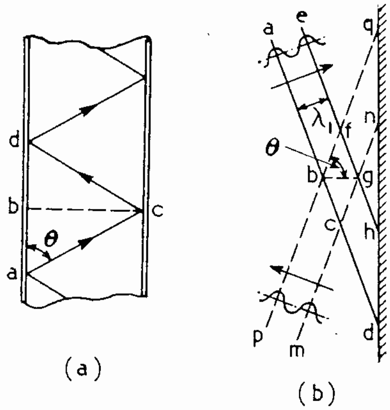


Fig. 3.

becomes a small fraction of the free space velocity whilst the phase velocity becomes a multiple of the free space velocity, the ratio being the same in each case.

Calculation of Attenuation

In the paper to which we have referred, Kemp uses this method to calculate the attenuation of the wave along the tube and obtains results in strict agreement with those obtained by more elaborate means by other investigators.

For a line consisting of two flat parallel strips with guard strips on either side, it is easy to see that for unit length

$$L_1 = \frac{\mu_1 a}{w_1} \text{ henries}$$

and $$C_1 = \frac{w_1 \kappa_1}{a} \text{ farads}$$

where w_1 is the width of the strips, a their distance apart, μ_1 the permeability of the medium in henries per cm cube and κ_1 its permittivity in farads per cm cube. To find the resistance it must be remembered that owing to skin effect the current is confined to a very thin layer of the inside of the tube; its equivalent thickness is $1/\sqrt{\pi\mu_2 f\sigma_2}$ where σ_2 is the conductivity of the material of the tube. This gives for the resistance of unit length of the line, $R_1 = \frac{1}{w_1}\sqrt{\frac{4\pi f\mu_2}{\sigma_2}}$.

If in the usual approximate formula for the attenuation constant, viz.:

$$\alpha = \frac{R}{2}\sqrt{\frac{C}{L}} + \frac{G}{2}\sqrt{\frac{L}{C}}$$

we assume that the dielectric leakance G is negligible, and substitute the above values for R, C and L we obtain the formula,

$$\alpha_1 = \frac{K}{2a\sqrt{b \sin\theta}}$$

where $$K = \sqrt{\frac{2\pi\mu_2}{\sigma_2 v_1 \mu_1^2}}.$$

This is the attenuation constant for the zigzag line excluding losses occurring at reflection; these we must now determine. We picture the zig-zag lines as being continued as ideal lines of zero resistance into the slab material, which replaces the dielectric.[5] R and C are negligible, and the propagation constant reduces to

$$\sqrt{j\omega L_2 G_2} = \alpha + j\beta$$

where $$\alpha = \beta = \sqrt{\pi f \mu_2 \sigma_2}.$$

The wave only penetrates the slab to a very small depth before being completely extinguished.

The zigzag line has an approximate surge impedance

$$Z_1 = \sqrt{\frac{L_1}{C_1}} = \frac{a}{w_1}\sqrt{\frac{\mu_1}{\kappa_1}} = \frac{a}{\sin\theta}\sqrt{\frac{\mu_1}{\kappa_1}}.$$

[5] Howe. *Journal I.E.E.*, 1916, 54, p. 473.

For the surge impedance of the fictitious line into the slab we have

$$Z_2 = \sqrt{\frac{j\omega L_2}{G_2}} = a\sqrt{\frac{j\omega\mu_2}{\sigma_2}}.$$

We have here assumed that the slabs are made with a width of 1 cm, in which case the width of the zigzag lines will be $\sin\theta$.

When waves travelling along a line 1 arrive at a junction with a line 2 the ratio of the energy entering the second line—in our case the slab—to that arriving at the junction is equal to the real part of

$\frac{4u}{(1+u)^2}$ where $u = Z_1/Z_2$. In the present case

$$u = \frac{1}{\sin\theta}\sqrt{\frac{\mu_1\sigma_2}{j\omega\mu_2\kappa_1}}$$

$$= (1 - j) \cdot \frac{1}{\sin\theta} \cdot \sqrt{\frac{\mu_1\sigma_2}{2\omega\mu_2\kappa_1}}.$$

If expressed as a loss of current or voltage the ratio will be approximately a half of this value, and since u is very large compared with unity, we can put

$$\frac{2u}{(1+u)^2} = \frac{2}{u} = (1 + j)\sin\theta\sqrt{\frac{2\omega\mu_2\kappa_1}{\mu_1\sigma_2}}$$

the real part of which is equal to $K\sqrt{\frac{\sin\theta}{b}}$.

The length of the zigzag line from side to side is $b/\sin\theta$. If the loss occurring on reflection at the side be spread over this length, the attenuation per cm will be increased by $K\left(\frac{\sin\theta}{b}\right)^{3/2}$, giving a total attenuation per cm of

$$\frac{K}{2a\sqrt{b\sin\theta}} + K\left(\frac{\sin\theta}{b}\right)^{3/2}.$$

This is for unit length of the zigzag line. For the attenuation per cm of the tube length this must be divided by $\cos\theta$ giving finally

$$\alpha = \frac{K}{\cos\theta}\left[\frac{1}{2a\sqrt{b\sin\theta}} + \left(\frac{\sin\theta}{b}\right)^{3/2}\right].$$

Putting

$$\sin\theta = \frac{f_0}{f} = \frac{v_1}{2bf} = \frac{1}{2bf\sqrt{(\mu_1\kappa_1)}} = \nu$$

this may be written

$$\alpha = \frac{K}{\sqrt{1-\nu^2}} \cdot \frac{1}{b^{3/2}}\left[\frac{b}{2a\nu^{\frac{1}{2}}} + \nu^{3/2}\right].$$

K involves only μ_1, μ_2, κ_1 and σ_2, i.e. the properties of the materials of which the line is constructed. ν involves b, μ_1 and κ_1 and is also inversely proportional to the frequency.

In any actual case the medium and walls will be non-magnetic and the medium will probably be air. In this case $1/\sqrt{(\mu_1\kappa_1)} = 3 \times 10^{10}$ cm per second, $\sin\theta = \nu = \frac{3 \times 10^{10}}{2bf}$, and K reduces to $\sqrt{1/(60\sigma_2)}$.

On the other hand, if any material medium is used as the dielectric in the tube the losses in it will probably not be negligible and the second term of the ordinary attenuation formula will have to be taken into account. We shall then have

$$\frac{G_1}{2}\sqrt{\frac{L_1}{C_1}} = \frac{\sigma_1}{2}\sqrt{\frac{\mu_1}{\kappa_1}} = \frac{\omega \tan\delta}{2v_1}$$

where δ is the loss angle of the dielectric and $\tan\delta = \sigma_1/(\omega\kappa_1)$. Putting $\omega = 2\pi f$ and $v_1 = 2\,bf\nu$, this becomes $\pi\tan\delta/(2b\nu)$, which is the additional attenuation per cm of the zigzag line. The additional attenuation per cm of tube length is therefore equal to this divided by $\cos\theta$, that is, by $\sqrt{1-\nu^2}$. Adding this to the value found above for the attenuation, we have

$$\alpha = \frac{1}{\sqrt{1-\nu^2}}\left[\frac{K}{2a\sqrt{b\nu}} + K\left(\frac{\nu}{b}\right)^{3/2} + \frac{\pi\tan\delta}{2b\nu}\right]$$

the first term representing the loss in the top and bottom of the tube, the second that in the side walls and the third that in the dielectric inside the tube. Although not a very simple formula, it enables the attenuation to be calculated in a few minutes for any given set of conditions, and it has been obtained entirely by application of the ordinary telephone transmission formula.

G. W. O. H.

Testing Radio Components*

"Ageing" and Tropical Humidity Tests

By Philip R. Coursey, B.Sc., M.I.E.E., F.Inst.P.

THE proper testing of radio components is a subject of great importance at the present time. It always has been one of interest both to the user and to the manufacturer of them, not only from the view-point of methods of test but also from that of the apparatus best suited for effecting such tests. At the present time, however, we are vitally concerned not only with normal measurements and tests but also with special tests to determine the long time performance of the components in both normal atmospheric and also in special working conditions such as those met in the tropics.

The various types of tests that may normally be applied to radio components are classified in Fig. 1. All of these can relate to mechanical and/or electrical tests, the former covering dimensions and quality determinations, wear and corrosion tests, etc., for all parts that have a static function only ; and the latter covering all forms of electrical measurements made on the article to determine its properties and the manner in which they change with time or environment.

The majority of the Class I electrical tests can be covered by well-known standard test equipment although difficulties often arise where the highest frequencies are involved and in adapting test methods from the laboratory to the mass-production requirements of the factory and to their use by less skilled personnel. Fundamentally these are all proof tests made on every component.

Class II and Class III tests may in some instances serve as proof or acceptance tests applicable to every component ; but in the majority of cases their nature is such that

* Notes based upon the opening remarks at an Informal Discussion on this subject held by the Wireless Section of the Institution of Electrical Engineers on November 25th, 1941.

they can serve as type tests applied only to samples selected from a production batch.

Class II tests include primarily prolonged performance life tests or "ageing" tests made in the Laboratory on samples drawn from the factory production—or during investigations to determine the suitability of any given component for the proposed duty. This class covers type tests under working conditions—electrical and/or mechanical. These tests are fundamentally not acceptance tests on account of the time required for their completion. Their function is primarily one of checking for maintenance of quality of manufacture; and the collection of data for design.

The tests on a component included in (A(i)) comprise the idling or storage tests which consist of the measurement of the properties of the component—mechanical and/or electrical—such as dimensions, strength, appearance, colour, or its electrical properties such as voltage and internal resistance (for batteries); characteristics (for valves); surface or body leakage (for insulators); inductance, self capacitance, "Q" (for coils); capacitance, leakage and power factor (for condensers), etc. These measurements are taken at intervals over the desired test period which may be months or years. Those included in (A(ii)) comprise similar measurements made at intervals

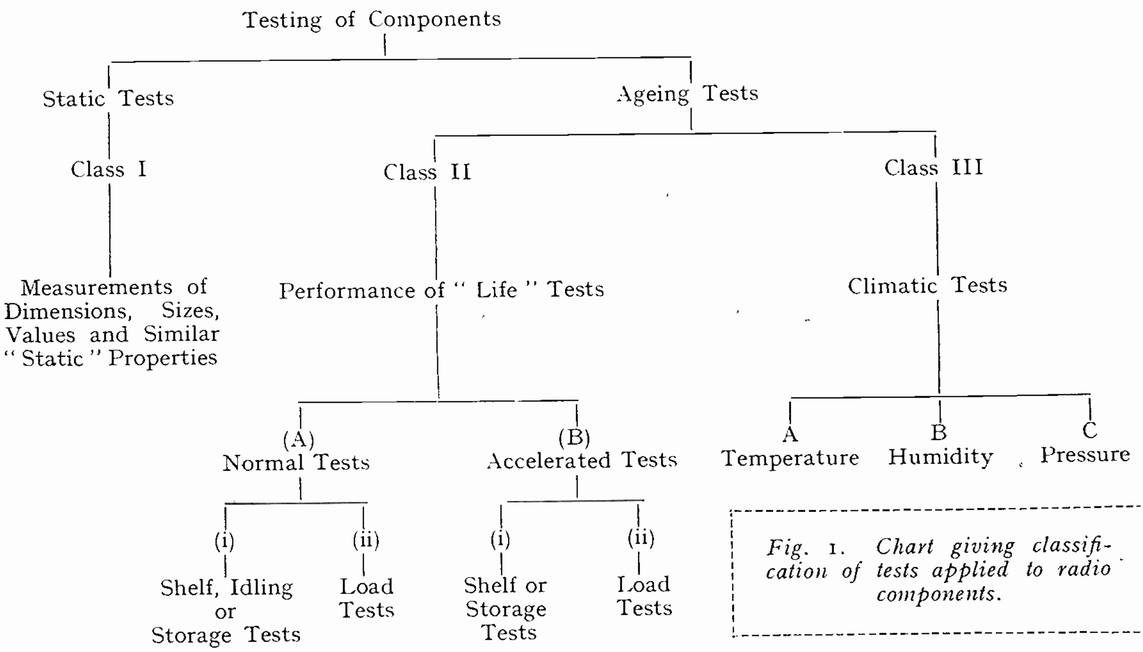


Fig. 1. Chart giving classification of tests applied to radio components.

Tests of this character fall fundamentally into two groups designated A and B in Fig. 1, viz. :—

(A) Tests run at normal operating conditions and generally also at room temperatures; and

(B) Accelerated tests designed primarily to determine the performance of the components as in (A) but accelerated in some way so as to determine a probable "life" in a shorter time than normal.

Both of these are subdivisible into "shelf" and load tests as indicated in the diagram.

over periods of months or years, while the components under test are subjected during those periods to some form of operating or load test. For example, valves run at normal operating voltages have their characteristics measured at intervals, condensers run under working applied voltages have their capacitance, insulation and other properties measured at intervals; springs such as for switches, etc. are measured for resilience at intervals while being subjected to intermittent bending or flexing movements; variable resistances (volume controls) are tested for value at intervals during a wear test in which they are rotated backwards and forwards by a mechanical drive, etc.

Groups B (i) and B (ii) cover an exactly similar series of tests made at periodic intervals during th test while the components are subjected to some acceleration of the test—such for example as by making the tests at higher than normal operating temperatures ; at over-voltages, at higher than rated frequency, etc.

Accelerated ageing tests included in this class are some of the most difficult to carry out—not because of any inherent difficulty in making the tests themselves, but because of the uncertainty that always arises in translating the results of any accelerated test into its equivalent under non-accelerated or normal operating conditions. In general the fixing of suitable accelerating conditions for any given test on any specified component can be done only after considerable practical experience in carrying out such tests under various known conditions and of correlating the results so obtained with similar long period life (or group A) tests on samples of the same batch of articles. Often they are carried out in ovens or rooms kept at an elevated temperature by thermostatically controlled heaters.

Class III tests may be regarded as a special form of Class II ageing tests, but may be separated therefrom for two reasons :—

(a) because they represent working conditions best classed as "atmospheric" to distinguish them from the "electrical" and "mechanical" ones envisaged in Class II—conditions which, while they may be repeated periodically, are not usually continuously applied ; and

(b) because they can readily be used as type acceptance tests.

This separation enables them to be considered separately and more completely apart from the other considerations involved in Class (I) and Class (II) tests.

The importance of tests of this class as a means of determining the design of, and for assessing the suitability of any given component for its proposed duty cannot be overestimated. Water, both as liquid and in its less tangible form as moisture vapour, is a great enemy of all electrical components—and more especially so of radio components. The essential need for adequate protection against the effects of moisture in order to maintain the components—and therefore the complete apparatus containing them—in good working order has by no means been fully or widely recognised, a fact which has undoubtedly led in many cases to the widespread use of unsuitable components resulting in early and unnecessary failures.

The manner in which any given component or apparatus is liable to be affected by moisture and heat (that is, whether its function will merely be impaired, and the degree of such impairment ; or whether it will be completely destroyed by entry of moisture), and the extent to which the proper functioning of the complete apparatus (of which the component forms a part) will be interfered with by the impairment above mentioned, and (most important of all) the conditions of use of the apparatus or component (e.g. as part of apparatus to be used indoors in this country, to be used in the field, or in aircraft, or in the tropics, etc.) all control vitally the degree of humidity resistance that is necessary in the particular component.

It has in consequence been usual to make tests under "tropical conditions" with various combinations of heat and humidity, frequently with cyclic changes of temperature in order to simulate normal day-to-day atmospheric changes.

Were it possible to make every component able easily to withstand the most severe working conditions, only one test, and that the most stringent one, would be required. Such however is not the case, and specially severe tests are sometimes needed to cater for exceptionally severe conditions of use, or more generally for apparatus whose functioning is most liable to be upset by any deterioration in quality.

These two grades of "tropical" test are best met by carrying on the tests for different durations—a short test of a few cycles of temperature and humidity to cover normal uses, and a long test of a much larger number of similar cycles of temperature and humidity to cover those specially important applications where no sensible impairment of properties can be tolerated. Different testing authorities have specified different temperatures and humidities for these tests but all agree in having a cycle of temperatures so that humidity increases to 100 per cent.

so that free condensation occurs as the temperature is lowered in a closed space containing the articles steeped in moisture vapour.

One of the earliest of these tests specified by the International Electrotechnical Commission for tests on radio apparatus and components has been widely used in many European countries. It makes use of steam injection to provide the humid atmosphere in the closed testing space (Fig. 2). The

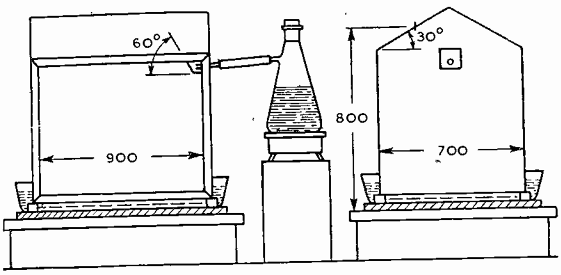


Fig. 2. *Schematic diagram of humidity test apparatus as recommended by the I.E.C.*

test method most generally employed in this country based on the specification K110, published by H.M. Stationery Office, does not lay down specifically whether the humid atmosphere is provided by steam injection into the enclosure or by evaporation from the surface of a water bath contained in it. In practice these two methods do not give the same results, although it is difficult to see why this should be so if the relative humidity is the same in both cases. There is, however, greater difficulty in securing the same degree of humidity with the water evaporation method as has been demonstrated by the Electrical Research Association.†

The steam injection method is the more severe, as may be seen for example by the test results set out in Table I which represents tests made by the two methods on a number of samples of insulating material. The much greater deterioration in insulation with the steam method is apparent. The steam has more heat to give up to the article when it condenses on its surface than is the case where moisture vapour from an evaporating water bath is used, and in some instances this causes more damage to the article than occurs in the other method. Taken all round, however, the steam injection method wins on the score of consistency in test results particularly as between one test apparatus and another, and this method has therefore more to recommend it than the other.

The most essential feature of all tropical tests, however, lies in the interpretation of the test results. If the articles are subjected to test while too much condensed moisture remains upon them, some quite erroneous conclusions may be drawn as to the effect of the moisture upon the article itself. The main surface water needs to be rmoved, but this removal must be carried out in a standardised manner—such for example as subjection to a defined air stream

† See Technical Report No. A/T57 issued by the British Electrical and Allied Industries Research Association.

TABLE I

COMPARISON OF STEAM INJECTION AND WATER EVAPORATION METHODS FOR K110 TESTS

Apparatus	Test	Insulation in Megohms				
Steam Injection	Initial Values	22,600	24,700	13,700	22,400	22,750
	After Heat Cycle	14,040	12,700	5,200	16,500	19,700
	After first Humidity Cycle	8,580	—	0.1	12,250	19,810
	After second Humidity Cycle	0.1	11,650	< 0.1	8,175	381
Water Evaporation	Initial Values	15,720	16,780	34,700	11,320	21,700
	After Heat Cycle	15,280	19,630	22,680	5,200	13,700
	After first Humidity Cycle	13,920	19,400	20,600	8,050	19,100
	After second Humidity Cycle	16,800	22,600	24,800	9,300	24,800

for a specified time in order to obtain consistent and comparable results. Complete or nearly complete recovery of the initial properties after the completion of the

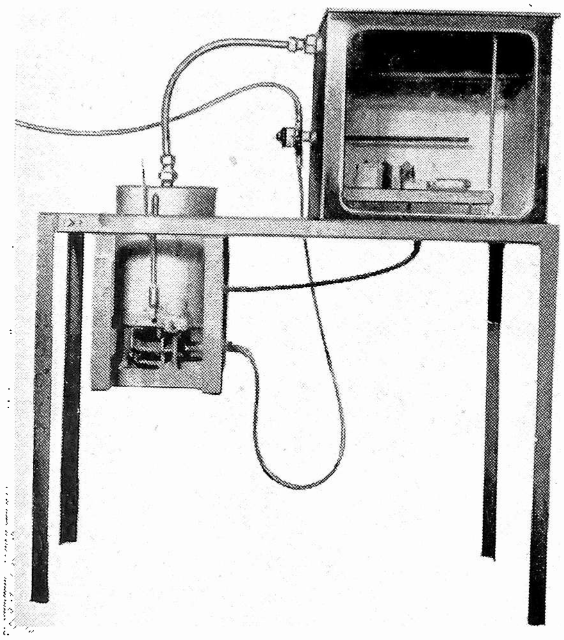


Fig. 3. *One form of enclosure for tropical humidity tests using the steam-injection method. The thermometer can be seen hanging down inside the glass panel, whilst the horizontal arm of the thermostat control is visible against the back of the cabinet.*

tropical tests even if apparent "failure" occurs during the test itself may in fact imply a more reliable article than one which "passes" the test against a defined datum line, but nevertheless has been subject to permanent deterioration as a result of the test. The permissible lack of recovery of initial properties must be quantitatively defined for each article, and this should be done both for the normal test with, say, two humidity cycles, and for the special test with, say, twenty humidity cycles.

It may be pointed out also that this type of test can be employed as an ageing type test falling into Class II B of Fig. 1. For this purpose no set number of humidity cycles is defined, but the test is continued indefinitely (with removal of the article at intervals from the test enclosure, to enable its properties to be measured) and the number of humidity cycles that it withstands before a defined degree of deterioration occurs, used as a gauge of its "life." No article or material is perfect, so that failure will ultimately occur in all cases. This application of the test however must be reserved for research purposes, and must never be used as a form of acceptance test.

Correspondence

"Current Induced in an External Circuit."

To the Editor, The Wireless Engineer.

SIR,—I wish to correct an unfortunate mistake which I have made in the paper "Current Induced in an External Circuit by Electrons Moving Between Two Plane Electrodes," published in the February issue of *The Wireless Engineer.*

I omitted to denote by appropriate symbols two points in Fig. 1, one lying between E and D, and the other between G and C. These points are both at a distance $\frac{2\theta}{\sqrt{M}}(y-x)$ from E and G respectively and they should be denoted E' and G'. The text at the foot of the column which contains Fig. 1 should then read: . . . "Next we draw a line corresponding to the term $\frac{2\theta}{\sqrt{M}}(y-x)$ which gives us the point E'; that is, we add the slope $\frac{2\theta}{\sqrt{M}}$ to the slope $(-\cos y)$. Actually $GG' = EE'$. Finally we draw a parabola based on the line BE' . . ."

Birmingham. R. KOMPFNER.

The Industry

WIRES with coverings of special heat-resisting rubber are being produced under the name of "Hamofil" by Hammans Industries, Limited, 5, Regent Parade, Brighton Road, Sutton, Surrey. Details are available in leaflet form.

Taylor Electrical Instruments, Ltd., whose instrument sales department is now at 148a, High Street, Slough, Bucks, have just issued a leaflet giving revised prices of their products.

British Insulated Cables, Ltd., Prescot, Lancs., have issued a folder giving details of their oil-resisting, rubber, bitumen and adhesive jointing tapes.

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.

The Temperature Compensation of Condensers*

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

SUMMARY.—The temperature coefficients of paper, mica, ceramic and air condensers are discussed quantitatively and the recent improvement in the thermal behaviour of mica condensers is given. A self-compensating air condenser is described and an experimental example given. Formulae are developed for self compensating condensers.

A method of temperature compensating variable air condensers is described and criticised.

The composite ceramic temperature compensating condenser and its application is described and the method criticised.

These criticisms lead to the enumeration of the desirable features to be aimed at in methods of compensation of temperature coefficients of capacitance of condensers and which are attained in novel methods in which bimetal is employed—methods which are then described.

The first of these is a simple one and may be applied to air condensers both variable and fixed. This, however, is shown mathematically to be prone to errors owing to its dependence upon the inverse law connecting capacitance with gap distance in a parallel plate condenser. Such errors are, however, eliminated in another type of bimetal compensator operating in conformity with a linear law. A compact commercial type of temperature compensator is described—this being suitable for the compensation of large temperature coefficients of any condensers (without mechanical modification) throughout a very wide range of temperature such as would be experienced in tropical climates or in aircraft. Finally a universal temperature compensator is described—a design which is readily adjusted to give compensation of any magnitude of either algebraic sign, without change of circuit capacitance, which introduces no losses and which is unaffected by humidity.

In the early days of electrical communication engineering condensers almost invariably were of the paraffined paper dielectric type. These were used for such purposes as the construction of artificial lines, signalling condensers, and were even used as standards. In those days telephony was in its infancy and telegraphy was therefore predominant; because of this the measurement of capacitance was effected by the direct current method of "throws" using a ballistic galvanometer and the accuracy therefore limited to 1 or 2 per cent. It was not unnatural, therefore, that no serious attempts were made to improve the temperature coefficient of capacitance of these paper condensers which was of the order -400 parts in 10^6 per deg. C. and, of course, very dependent upon temperature because of the low melting point of paraffin. Nor is it surprising that to-day commercial paper condensers have temperature coefficients up to $-2{,}000$ parts in 10^6 per deg. C. because it soon became evident, with the rapid growth of telephony and with the greater use of alternating current bridge methods of capacitance measurement, that condensers of better quality could be made by employing mica as the dielectric. Mica condensers had lower power factors, lower temperature coefficients and greater stability for both long and short periods. It was at first found a little difficult to obtain a high insulation resistance[1] in mica condensers and so the paper condenser was still used at very low frequencies for some time. Eventually, however, the mica condenser was used for all frequencies where good quality and permanence were required, and the paper condenser discarded.

The temperature coefficients of capacitance of early mica condensers even of standard quality were not, however, very low and were certainly not predeterminable. They were within the limits ± 150 parts in 10^6. To-day the very best mica condensers have temperature coefficients within the limits ± 10 parts in 10^6 per deg. C. The modern

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

[1] The product of capacitance and insulation resistance of the best quality paraffined paper condensers used in submarine cable circuits had been > 20 M$\Omega.\mu$F.

methods of construction which have effected this improvement have also improved the power factors of these condensers and their stability of value. The author has found with long experience in the design of such mica standards that the temperature coefficient of capacitance may usually be regarded as a criterion of power factor and permanence of value over long periods. Not without reason, because the elimination of much of the paraffin with which the condenser is "laid" cannot but improve all three of these qualities.

It is easily seen, however, that a temperature coefficient as low as 10 parts in 10^6 per deg. C. is not obtained merely by squeezing the paraffin from between the interleaved foil conductors and sheets of dielectric. The temperature coefficient of a built-up solid dielectric condenser is given by

$$\frac{\Delta C}{C} = 2\alpha - \gamma + \sigma \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where α = temperature coefficient of linear expansion of the foil conductors

γ = temperature coefficient of linear expansion of the dielectric material

σ = temperature coefficient of permittivity of the dielectric.

In the case of a mica and foil condenser 2α may vary from 35 to 45 according to the conductor used. γ is 3 and is therefore almost negligible in its effect upon the temperature coefficient of the condenser, while σ is probably between 20 and 40. Thus it is seen that the temperature coefficient of the condenser with all air and paraffin excluded should theoretically be of the order $+ 70 \times 10^{-6}$ per deg. C. This is only true, however, if the pressure with which the interleaved conductor foils and dielectric sheets are clamped is constant with temperature. It is quite possible for a *well-made* mica condenser to have a temperature coefficient of $- 70 \times 10^{-6}$ per deg. C. Only by such artifices as the manufacturer may devise can the temperature coefficient be controlled within limits finer than $\pm 70 \times 10^{-6}$.

Highly negative temperature coefficients are usually due to the inclusion of paraffin between the conductors and dielectric sheets and such coefficients are therefore very dependent upon temperature, changing rapidly as the temperature approaches 50 deg. C. in the vicinity of the melting point of the paraffin. Moreover, highly negative coefficients are never cyclic if the condensers which bear them are subjected to appreciably high temperatures. High-power factor and lack of permanence of capacitance with age are also attributable to residual paraffin and are therefore to be found in condensers having negative temperature coefficients of appreciable magnitude.

One might, in passing, observe the difficulty of controlling the temperature coefficient of a paper condenser. Both γ and σ of expression (1) are very high and variable —being dependent upon temperature—because the paper serves principally as a vehicle for the paraffin, which is the predominant dielectric.

Although mica condensers of capacitances greater than, say, 0.001 μF are now available with cyclic temperature coefficients $< 10 \times 10^{-6}$ per deg. C. over the range 0 deg.–35 deg. C. and with comparable stability it is only with great difficulty that mica condensers of lower capacitance are produced with the same high quality. Mica condensers may be, and are, produced which have very low temperature coefficients over given well-defined ranges of temperature but, in general, the coefficients of these small condensers are not linear over wide ranges and often a reversal of algebraic sign occurs. The temperature coefficients of mica condensers of any capacitance are rarely constant over an appreciable range of temperatures. The curves of Fig. 1 show the temperature coefficients of typical mica condensers of exceptional quality and it will be observed that all the curves exhibit a strong tendency to become increasingly negative as the temperature approaches the melting point of paraffin. Curve 1 should, of course, be the aim of the designer but is not always possible with condensers of large values. Generally there is a tendency to curve 2 for condensers of large value (0.1 μF) and a tendency to curve 3 in those of small values (0.001 μF).

Fortunately the temperature coefficients of these condensers are fairly constant throughout the range of temperature experienced in the laboratory under temperate conditions and it is only under tropical or sub-tropical conditions that a large change occurs.

The author would give a word of warning

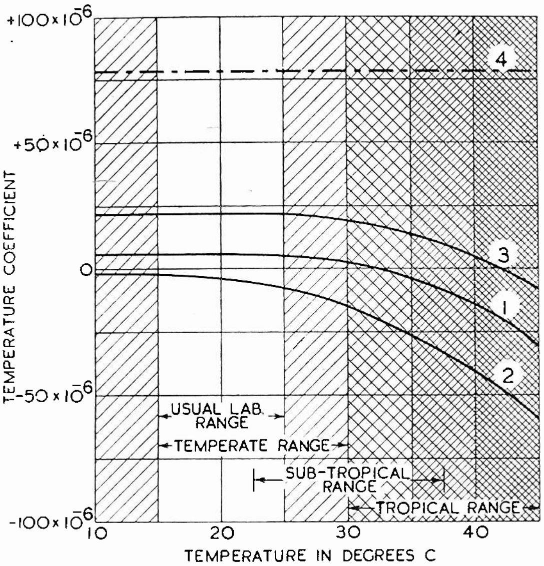


Fig. 1. *The variations of temperature coefficients of good mica condensers with temperature.*

to user and manufacturer alike on the temperature coefficient measurement of mica condensers. A temperature coefficient judged from capacitance values measured at two temperatures only may be very misleading, for in such a measurement excursions are always made into high temperatures in order to obtain (it is thought) a sufficiently large capacitance change for accurate determination. The single value of temperature coefficient determined in this way, although flattering the condenser at high temperatures, often leads to an under-estimation of stability over a more reasonable temperature range.

Corresponding with the curves of Fig. 1 the curves of actual capacitance change are given in Fig. 2. It is seen that from measurements at 20 deg. C. and 43 deg. C. condenser 1 might easily be thought to have zero temperature coefficient throughout the range. From measurements at similar temperatures the temperature coefficient of condenser 2 might be judged to be much worse than is the case at the more usual range of laboratory temperatures.

It is possible, by building a condenser with mica sheets on which silver is fired to form the conductor, to obtain a temperature coefficient which is constant but unfortunately the magnitude of the coefficient is often unexpectedly high, as is shown by the curves 4 of Figs. 1 and 2. Moreover, the behaviour of such condensers is usually non-cyclic with temperature.

It is of interest to note that the broken-line curve 5 of Fig. 2 shows the change of capacitance with temperature experienced in a good paper condenser or a poor mica condenser.

As the lower capacitance values are approached, mica condensers, even those of the best quality, exhibit a tendency to non-cyclic temperature coefficient and a corresponding tendency to change of capacitance value with age. It is fortunate that this falling off of quality occurs at values where the substitution of air dielectric becomes practicable. Fixed value air condensers, being purely mechanical structures, generally have temperature coefficients both cyclic and constant throughout all reasonable temperatures.

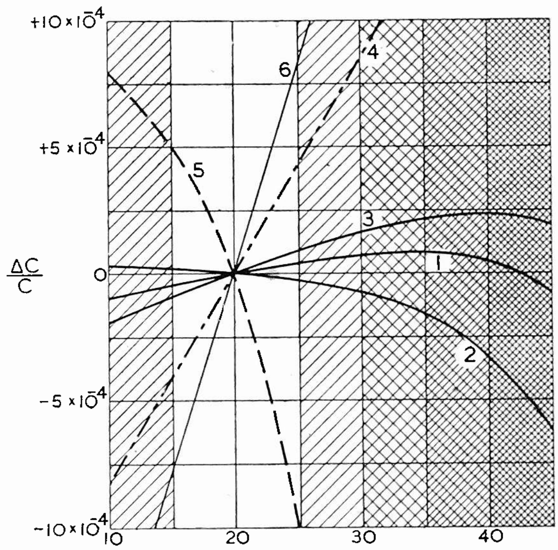


Fig. 2. *The variation of capacitance of good mica condensers with temperature (the curves are of condensers which are similarly numbered in Fig. 1).*

Before proceeding to deal with condensers of air dielectric more fully, however, mention should be made of those in which the conductor is deposited on a ceramic dielectric of good quality. Such condensers are better than commercial mica condensers, although still very inferior to the best mica condensers which have been considered in the foregoing. Their temperature coefficients are fairly cyclic but of high value—of the order $+ 150 \times 10^{-6}$ per deg. C. The capacitance change of these condensers with temperature is shown by curve 6 of Fig. 2. Apart from its high temperature coefficient, however, the capacitance of the ceramic condenser has a tendency to dependence upon humidity, for the permittivity of ceramics is not constant for relative percentage humidities higher than 70 or 80 per cent.

Another disadvantage of the ceramic condenser is the impossibility of adjusting its value accurately to a given or nominal value—a disadvantage which it shares with the deposited ceramic inductance coil.

For low capacitance values the air dielectric condenser is the most stable, but, although the thermal behaviour is usually cyclic, its temperature coefficient may be as high as $+ 100 \times 10^{-6}$ per deg. C.

The temperature coefficient of a condenser built up with solid dielectric material has been given by (1) as :—

$$\frac{\Delta C}{C} = 2\alpha - \gamma + \sigma$$

That of the air condenser of conventional interleaved flat-plate design is given by a similar expression except that term γ is now governed by the spacing collars instead of by the dielectric itself. Thus in a condenser constructed throughout from one material only

$$\frac{\Delta C}{C} = 2\alpha - \alpha + \sigma$$

$$= \alpha + \sigma \qquad \ldots \quad \ldots \quad \ldots \quad (2)$$

where σ is the temperature coefficient of permittivity of air.

The permittivity of air (at N.T.P.) is approximately 1.0006 times that of vacuum. Obviously the permittivity of vacuum cannot alter with temperature. It is equally obvious therefore that it is only the difference between 1.0006 and unity which is the variable portion of the permittivity of air. This difference will be proportional to the density of the air.

Now, from Charles's law, the coefficient of expansion of all gases is 0.003665 per deg. C. at constant pressure. The temperature coefficient of density must therefore be $- 0.003665$ and the temperature coefficient of permittivity of air at N.T.P. is therefore given by :—

$$\sigma = - 0.003665 \, (1.0006 - 1)$$

$$\doteqdot - 2 \times 10^{-6} \text{ per deg. C.}$$

The temperature coefficient of an air condenser is always *less*[2] by approximately 2 parts in a million than that due to the structure itself if the pressure is allowed to remain constant with change of temperature.

The permittivity of air also increases proportionally to atmospheric pressure—it is proportional to absolute pressure and it is seen therefore that the pressure coefficient of permittivity at a normal pressure of 760 mm of mercury is 0.79 parts in 10^{-6} per mm.

The variation of capacitance due to a reasonable maximum variation of atmospheric pressure of ± 1 inch of mercury is seen therefore to be $\pm 20 \times 10^{-6}$—a change such as would be produced by a temperature change of ± 10 deg. C.

Variation of both atmospheric pressure and ambient air temperature may therefore be said to be of equal importance to the stability of capacitance of an *unsealed* air condenser.

The permittivity of air is also dependent upon the percentage relative humidity and this is in turn, within a given period, dependent upon changes of temperature either due to natural or to artificial heating. Unfortunately, however, great changes of natural atmospheric humidity occur, due to causes other than changes of ambient air temperature and humidity and temperature co-

---

[2] Thomas states (" Theory and Design of Valve Oscillators " by H. A. Thomas, pp. 153–154) " . . . it can be shown that the temperature coefficient of capacitance of an air condenser is always *greater* by 2.15 parts in 1 million than the coefficient of the same condenser if the air dielectric were replaced by a vacuum."

The italics have been introduced by the present author to emphasise his disagreement on the question of algebraic sign. He would also point out that the exact figure of $- 2.15 \times 10^{-6}$ for the temperature coefficient of permittivity of air holds only at a temperature of 0 deg. C.—it naturally decreases as the temperature is raised owing to the decrease of air density (at constant pressure). For the more usual range of temperature experienced in practice the figure of $- 2 \times 10^{-6}$ is more correct and is certainly as close an approximation as can be applied usefully to condenser problems.

efficients of permittivity of air cannot be combined and compensated collectively.

It would seem, therefore, that in order to eliminate or reduce the effects of varying atmospheric pressure and humidity the air condenser should be sealed in an air-tight chamber. Such sealing should also have the effect of eliminating the temperature coefficient of the air dielectric since the mass of air contained within the sealed chamber could not be changed by temperature and the density would thus remain unaltered.

If further explanation of this is needed it may be given by considering a combination of the effects of Boyle's and Charles's laws. If the mass, and therefore the density, of the (dry) air dielectric is allowed to change by the removal of the sealing chamber, then for a given increase of temperature, at constant pressure, the capacitance of the condenser will decrease by an amount which is governed solely by the temperature coefficient of expansion of the air. This amount would be exactly compensated by the increase of capacitance produced by the greater mass of air which would be contained in a volume equivalent to that of the sealing chamber, at a pressure equivalent to that which would have been produced in that chamber by the higher temperature.

It is seen, however, that air contributes little to the temperature coefficient of a condenser even if it forms most of the dielectric of that condenser. From (2) it would seem that the temperature coefficient of an air condenser must be of the same order as the temperature coefficient of linear expansion of the metal from which it is constructed.

The author carefully constructed an air condenser from brass throughout, plates, spacing collars, and supporting collars and the whole mounted on a robust brass casting. One set of plates was insulated by small pieces of silica. The temperature coefficient of capacitance of this condenser was found to be $+ 12.5 \times 10^{-6}$ per deg. C., whereas from (2) it should have been $+ 16.9 \times 10^{-6}$. It was thought that a degree of compensation had been unwittingly introduced by using different brasses for plates and collars. The author therefore constructed another condenser from more dissimilar materials.

Two copper discs 2 inches in diameter were interleaved between three square copper plates. The discs and plates were 0.104in. thick and all dielectric air gaps were 0.052in. The plates of both systems were spaced by collars of duralumin. The temperature coefficient of capacitance of a condenser built from dissimilar materials is given by:

$$\frac{\Delta C}{C} = 2\,\alpha - \frac{\beta B - \alpha A}{B - A} - 2 \qquad \ldots \quad (3)$$

(which becomes simply $\alpha - 2$ for a condenser constructed throughout from one material).

where A = thickness of plates of material having a temperature coefficient α

B = thickness of spacing collars of material having a temperature coefficient β.

The temperature coefficient of the condenser described should therefore have been

$$\frac{\Delta C}{C} = (33.6 - 30.3 - 2) \times 10^{-6}$$
$$= 1.3 \times 10^{-6} \text{ per deg. C.}$$

For the temperature coefficient of such a condenser to be zero

$$(2\alpha - 2)(B - A) = \beta B - \alpha A$$

Therefore

$$B = \frac{\alpha - 2}{2\alpha - 2 - \beta} \cdot A \qquad \ldots \quad \ldots \quad (4)$$

Having decided upon a dimension for the plate thickness A and found dimension B from (4) the resulting air gap will not necessarily be convenient. Since the dielectric gap distance is the dimension which principally governs the capacitance stability of the condenser it is necessary to determine one of the dimensions A or B in terms of the gap distance G.

$$B - A = 2G$$

From (4),

$$(2\alpha - 2 - \beta)\, B - (\alpha - 2)\, A = 0$$

Multiplying the first expression by $(\alpha - 2)$,

$$(\alpha - 2)\, B - (\alpha - 2)\, A = (\alpha - 2)\, 2G$$

Subtracting,

$$(\alpha - \beta)\, B = -2\,(\alpha - 2)\, G$$

Therefore, for zero temperature coefficient,

$$B = -\frac{2(\alpha - 2)}{\alpha - \beta} \cdot G \qquad \ldots \quad \ldots \quad (5)$$

and $A = B - 2G \qquad \ldots \quad \ldots \quad \ldots \quad (6)$

The mean of several measurements of temperature coefficient of the condenser in question was $+ 4.5 \times 10^{-6}$ per deg. C. and should have been $+ 1.3 \times 10^{-6}$ from expression (3). The discrepancy between measured and calculated coefficients is not great, but there was a certain degree of instability and non-cyclic behaviour which, in the author's opinion, was due principally to the fact that the duralumin spacing collars and the copper plates which they spaced were clamped between nuts on a *brass* bolt or stem—due in fact to the differential expansion between collars (plus plates) and bolt.

The author suggests, therefore, that a really stable and temperature coefficientless fixed condenser may be possible, if, after satisfying condition (5), equalisation of expansions of bolts and members clamped by them is effected in the following manner.

A sectional sketch of the two plate systems of a condenser and the clamping stems is given in Fig. 3. The plates and the top mounting plate are of "*a*" material, the spacing collars of "*b*" material and the stems of "*d*" material. Both systems are insulated by washers of "*e*" material.

If n = number of dielectric gaps

δ = coefficient of expansion of d material

ϵ = coefficient of expansion of e material

α and β are coefficients used previously and A, B, E, F are the dimensions shown on the sketch,

then for System 1,

$$\epsilon E + (\tfrac{1}{2}n + 2)\beta B + (\tfrac{1}{2}n + 1)\alpha A = \delta\{E + (\tfrac{1}{2}n + 2)B + (\tfrac{1}{2}n + 1)A\}$$

$$\therefore E = \frac{(\tfrac{1}{2}n + 2)(\delta - \beta)B + (\tfrac{1}{2}n + 1)(\delta - \alpha)A}{\epsilon - \delta} \quad \ldots \quad \ldots \quad (7)$$

System 2 is then built up to be similar to System 1 in respect of the total amounts of a, b, d and e material as shown in Fig. 3 and it remains only to find the dimension F of a collar of b material in order to effect expansion equalisation on this stem also :—

$$F = (\tfrac{1}{2}n + 2)B - \{\tfrac{1}{2}nB + (B - A)\}$$
$$= B + A \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

By using copper for the a material, duralumin for b, brass for d and pyrex for e the scheme should be practicable, the dimension E being altered to suit the number of dielectric gaps required. After having determined one or two convenient thicknesses of insulating washer in this way the effective area of the plates may be varied to give a range of values of capacitance.

But the temperature coefficients of fixed air condensers—even those of otherwise good quality—may be as high as $+ 30$ or $+ 40 \times 10^{-6}$ per deg. C. The coefficients of variable air condensers may be, and often are, much higher still. Coefficients of $+ 60 \times 10^{-6}$ per deg. C. are quite usual even in best quality variable air condensers and the author remembers measuring the temperature coefficient of an expensive quartz insulated standard of well-known make to be $+ 120 \times 10^{-6}$ per deg. C.

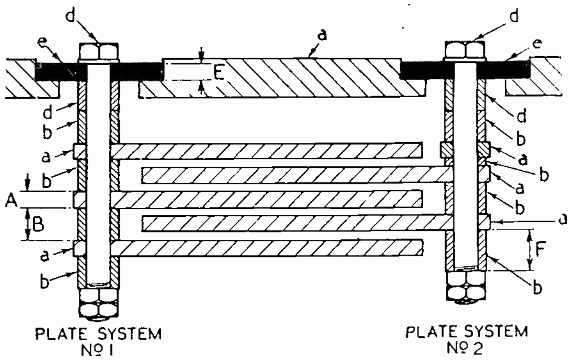


Fig. 3.

The causes of such unexpectedly high temperature coefficients of variable air condensers have been investigated fully by Thomas[3]. It is the intention of the present author to deal only with the compensation of temperature coefficient. The reader must, however, be ever mindful of the fact that before any method of temperature compensation can be efficacious the condenser to which it is applied *must* be cyclic in behaviour with thermal changes and must be stable at any given temperature—stable to a degree at least comparable with the temperature coefficient desired ultimately.

Thomas[4] has designed several types of variable air condenser of the conventional rotating plate type in which an ingenious method of temperature compensation is employed. The principle of this method is

[3] "Theory and Design of Valve Oscillators," by H. A. Thomas, pp. 154–182.

[4] *loc. cit.* pp. 228–241.

based upon the inverse law connecting the capacitance between two flat parallel plates and their distance apart, because of which the capacitance of a parallel plate condenser

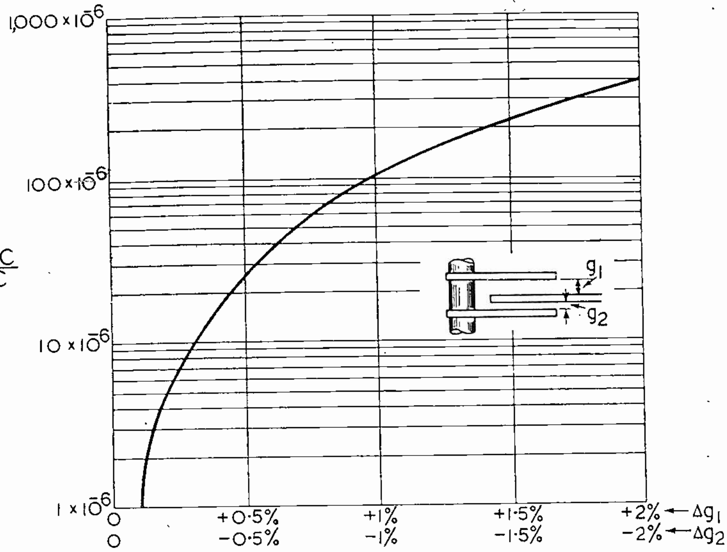


Fig. 4.

of more than one dielectric gap is changed by the relative displacement of the sets of plates in a direction normal to the plate surfaces.

Let g_1 and g_2 be the distances of the dielectric gaps between a moving plate and adjacent upper and lower fixed plates respectively, then the capacitance of this element of the plate assemblage is proportional to

$$\frac{1}{g_1} + \frac{1}{g_2}$$

$$C \propto \frac{g_1 + g_2}{g_1 g_2} \text{ but } g_1 + g_2 \text{ is constant}$$

and therefore

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

The curve of Fig. 4 shows, for various axial displacements of the moving plates of a variable air condenser from their exact mid-positions, the consequent increase of the reciprocal of the product of the gaps, $1/g_1g_2$, to which the resultant capacitance is proportional.

Thomas, in his designs, arranges that one set of plates is moved axially relative to the other by the differential thermal expansion of dissimilar materials which determine the relative positions of the two sets of plates. But the differential expansion between such suitable metals as, say, brass (18.9×10^{-6}) and steel (11.6×10^{-6}) is only of the order 30×10^{-6} inch per four-inch-length per deg. C. This will give an axial displacement of one set of plates of but 0.05 per cent. per deg. C. if the dielectric gaps $g_1 = g_2 = 0.06$ inch. From Fig. 4 it is seen that a gap displacement of this order will produce a capacitance change of less than 1×10^{-6} whereas the temperature coefficients such displacements are required to compensate may be as much as fifty times this amount. It is obvious, therefore, that a means of magnifying the effect of such small displacements must be employed.

The curves of Fig. 5 show how an *initial* axial displacement of one set of plates relative to the other produces this desired magnification. Curve 0 shows that when g_1

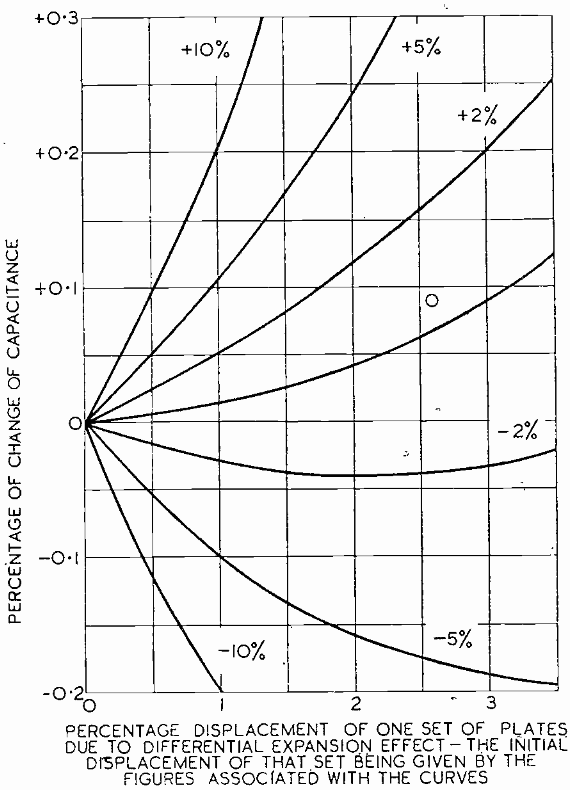


Fig. 5.

is set initially to equality with g_2 a 1 per cent. displacement of one plate system, due to the differential expansion effect, produces only 0.01 per cent. capacitance change. If, however, the systems are displaced relatively by 5 per cent. of g_2 (curve -5 per cent.) then the same differential expansion produces a 0.1 per cent. diminution of capacitance. This is of the right order of capacitance compensation required for a temperature rise of 20 deg. C.—the temperature increase which effects a 1 per cent. axial displacement.

This is the method which Thomas has employed in the construction of condensers in which, in order to use conveniently shorter differentially expanding members, he employs an even greater initial relative displacement of the two plate systems, amounting to 16.7 per cent. ($g_1 = 2g_2$).

The first of these[5] is an ambitious model which has proved to be sensibly independent of temperature—the residual temperature coefficient being of the order 1×10^{-6} per deg. C. The designer is to be congratulated upon this design which is, however, too costly to be commercial.

The second model[6] is still costly and of very special construction although more practicable than the first. Its residual temperature coefficient is of the order 4×10^{-6} per deg. C. but this figure, like that of the first model, is obtained only for slow changes of ambient temperature.

The present author, however, cannot wholly agree with the principle of compensation employed in these condensers because of its possible effect upon the permanence of calibration over long periods. The same method of initial plate displacement used to magnify the effect of differential expansion also magnifies the change of calibration due to unwanted air gap changes, which may be due to bearing wear, plate ageing or other mechanical changes with age. Moreover, such initial displacement magnifies greatly the departures from the design law of capacitance change of the condenser due to plate wobble and other causes.

Attention was first drawn to the *necessity for gap equalisation* in this journal[7] by the present author, when Fig. 5 of the present article was indeed used for that purpose.

The author feels that at least the initial displacement should be limited to a lower order than 16.7 per cent. by using a greater amount of differential expansion—especially in attempting to apply the principle to condensers of lesser mechanical perfection.

In passing it may be of interest to remind the reader that the present author designed a series-gap Precision Variable Air Condenser[8] of exceptional stability in order to eliminate entirely the instability caused by small axial displacements of plates.

In this condenser the dielectric gaps g_1, g_2, on either side of a moving plate, are electrically in series, so that, their reactances being added arithmetically, the resultant capacitance of the combination will be, for any given scale setting, inversely proportional to the sum of the two gaps.

If C_1 is capacitance of dielectric gap g_1

C_2 is capacitance of dielectric gap g_2

and C is the resultant of the two gaps in series

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

Therefore $C \propto \dfrac{1}{g_1 + g_2}$

which remains constant irrespective of unwanted air gap changes provided that adjacent fixed plates are of opposite potentials and that the moving plates are insulated from both fixed plate systems. One essential feature of such a condenser is that the moving plates must be appreciably thicker than $g_1 + g_2$ if a reasonable capacitance range is to be obtained.

Thomas has constructed yet another compensated variable condenser[9] which, although involving special construction, is of smaller dimensions and more practicable than the others. The author favours this model since the compensation, although following

[5] *loc. cit.* p. 228. [6] *loc. cit.* p. 232.

[7] "The Accuracy and Calibration Permanence of Variable Air Condensers for Precision Wavemeters." *Experimental Wireless* (now *Wireless Engineer*), Jan. and Feb. 1928.

[8] "The Accuracy and Calibration Permanence of Variable Air Condensers for Precision Wavemeters." Part 2 *Experimental Wireless* (now *Wireless Engineer*), Feb. 1928, and "Further Notes on the Calibration Permanence and Overall Accuracy of the Series-gap Precision Variable Air Condenser." *Experimental Wireless* (now *Wireless Engineer*), Jan. and Feb. 1929.

[9] "Theory and Design of Valve Oscillators," by H. A. Thomas, p. 235.

the same principle, is effected by the displacement of only one plate and this in an air gap especially enlarged for the purpose—thus largely overcoming the author's objections. Moreover, this model is provided with an adjustment enabling the temperature coefficient to be varied at will throughout wide limits, leaving a residual coefficient of the order 5×10^{-6} per deg. C.

The temperature coefficient of this model, once adjusted, is much more independent of rate of change of temperature than is the case with the others because of its better thermal proportioning. The capacitance range of this condenser is 47 to 265 $\mu\mu$F.

Another method of compensating the temperature coefficient of an air condenser is to connect in parallel with it a composite dielectric ceramic condenser which has a coefficient of reverse sign from that of the air condenser. Such a commercial compensator[10] has been constructed very cleverly so that suitable proportions of ceramics having temperature coefficients of permittivity of opposite algebraic sign may be selected by adjustment to produce any temperature coefficient between $+ 50 \times 10^{-6}$ and $- 500 \times 10^{-6}$ per deg. C. It is built from two ceramic insulators; one, Calit, having a temperature coefficient of $+ 140 \times 10^{-6}$ and the other, Condensa *C*, having a coefficient of $- 700 \times 10^{-6}$. These are arranged to form a small condenser the dielectric of which, although of constant total capacitance, comprises varying proportions of the two materials. The two materials are very different in permittivity (that of Calit being 6.5 and that of Condensa *C*, 80) so that their dielectric thicknesses have to be proportional to these figures.

In order to compensate for the temperature coefficient η of a condenser of capacitance C_1 the temperature coefficient τ of such a compensator (of capacitance C_2) must be adjusted to be

$$\tau = -\frac{C_1}{C_2} \times \eta \qquad \ldots \quad \ldots \quad \ldots \quad (9)$$

Since the maximum negative value of τ is limited (by the temperature coefficient of permittivity of Condensa *C*) to $- 500 \times 10^{-6}$ per deg. C., it follows that the capacitance of compensator required is :—

$$C_2 = -\frac{\eta C_1}{\tau} \qquad \ldots \quad \ldots \quad \ldots \quad (10)$$

$$= \frac{\eta C_1}{500}$$

The value of the ceramic compensator for the compensation of good quality *air* condensers is doubtful, especially at the lower frequencies, since it must always introduce a large quantity of solid insulating material. The proportion of the total capacitance of the completely compensated condenser which is solid ceramic material is given by :—

$$\frac{C_2}{C_1 + C_2} = \frac{\eta}{\eta - \tau} \qquad \ldots \quad \ldots \quad \ldots \quad (11)$$

and the power factor of the *air* condenser therefore can be only

$$\frac{\eta - \tau}{\eta}$$

better than that of the ceramic material itself.[11]

For a temperature coefficient of, say, $+ 50 \times 10^{-6}$ per deg. C. it is seen from (10) that the capacitance of ceramic material which must be introduced is no less than one-tenth of that of the air condenser which it is required to compensate. It is seen also (from 11) that the resultant power factor of the compensated condenser will be as much as 1/11 of that of the ceramic material Condensa *C*. The power factor of this material is of the order 20×10^{-4} at frequencies of the order 1 Mc/s but the effect of atmospheric humidities of over 70 per cent. must become increasingly important as the frequency is reduced until it must seriously augment this figure at frequencies within the telephonic range. It is, of course, for this reason that ceramics are essentially radio frequency insulators.

But at *all* frequencies there is another serious disadvantage with the introduction of such a large amount of ceramic material into the circuit of an air condenser. The permittivity of a ceramic insulator increases with excessive humidity and so will increase the capacitance of the condenser across which it is connected by

$$\frac{\eta}{\eta - \tau}$$

[10] By the United Insulator Co., Ltd.

[11] The reader is referred to "The Losses in Variable Air Condensers," by the present author. *Wireless Engineer*, March, 1931.

of the amount of such increase. This increase cannot be compensated and produces an increasing instability of capacitance as the relative humidity rises above 70 per cent.—probably becoming very serious above 80 per cent. or so.

This particular ceramic compensator is protected from the effects of excessive humidity by a complete coating of varnish or lacquer. Even so, the protective coating ceases to be entirely efficacious when the humidity rises above 80 per cent. Changes of atmospheric humidity accompany changes of ambient temperature and therefore give the effect of *apparent* over-compensation, but no readjustment can be made to satisfy this condition because humidity may also vary without temperature change and also because changes of humidity below 60 per cent. or so cannot affect the permittivity of the ceramic material.

Unlike the Thomas method of compensation, the principle of which may be applied with equal success to both fixed and variable condensers, the ceramic compensator can be applied only to condensers of fixed capacitance if complete compensation is required.

It may be applied with efficacy to a variable condenser if, by accident or by design, the temperature coefficient of such condenser at any setting is inversely proportional to the capacitance at that setting—an extremely unusual law. A variable condenser of limited range, i.e. in which the minimum capacitance is augmented to a considerable extent, may be compensated for the mid-capacitance setting and this will give approximate compensation at all other settings.

Having examined two methods of temperature compensation and discovered some disadvantages of both, perhaps it will be well to enumerate some desirable features required of any ideal method.

1. The method should be equally applicable to air condensers of both variable and fixed capacitance.

2. It should be equally applicable to condensers of all types ; not necessarily confined to those of the more conventional parallel plate type and preferably not even confined to those having air dielectric.

3. It should not depend upon the inequality of air gaps of a parallel plate condenser.

4. It should not appreciably increase the power factor of the condenser nor cause the capacitance to vary with excessive atmospheric humidity, i.e. it should not appreciably augment the quantity of solid insulating material in the electric field of the condenser.

5. If the method is dependent upon an added device such device should be preferably of negligible capacitance (so as not to disturb appreciably the law of the condenser) or, if the capacitance is appreciable, it should be sensibly constant irrespective of any adjustment which may be provided for magnitude of temperature compensation.

6. It should not necessitate the mechanical modification of existing designs.

7. It should not appreciably increase the cost of a condenser in which it is incorporated.

8. The compensation afforded should be independent of temperature.

9. The compensation provided for a variable air condenser should be capable of independent adjustment for different scale settings.

Thomas's method, while possessing features 1, 4, 5 and 8, does not possess features 2, 3, 6 and 7. The ceramic compensator on the other hand possesses features 2, 3, 6, 7 and 8 but not 1, 4 and 5. Neither possess feature 9.

The author has devised a compensator depending upon a principle which, while entirely different from either of the above, combines the advantages of both. The principle is that of the incorporation in the design of the condenser of an element, the capacitance of which is varied by the temperature actuated deflection of a bimetal member. The bimetal from which this member is constructed is that which is now commonly employed for the manufacture of commercial thermostatic devices and consists of two sheets of dissimilar metals bonded together throughout their entire area. The metals are chosen for their appreciably different temperature coefficients of expansion—one of them usually having an exceptionally low temperature coefficient.

Consequent upon this inequality of temperature coefficient there is, upon heating, an appreciable deflection of a strip of bimetal in the direction of the metal having the lower temperature coefficient and it is this deflection which is used to decrease (or increase if necessary) the capacitance of an element of the condenser.

The deflection and force exerted due to temperature change depend on the strength and uniformity of the bond between the metals, the method and uniformity of treatment during manufacture and the physical properties of the component metals. If the change in shape of a piece of bimetal due to

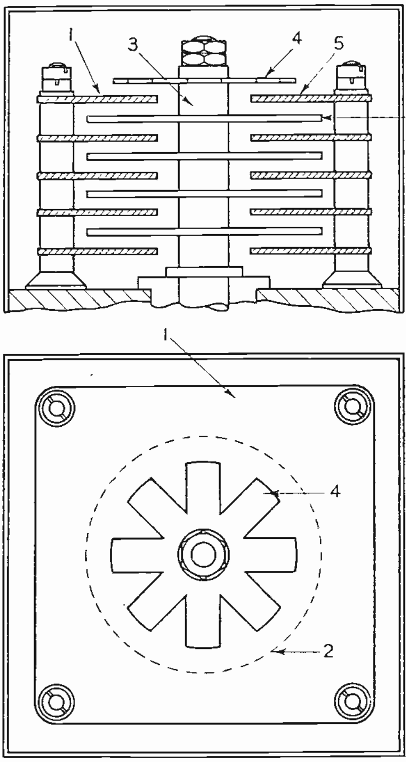


Fig. 6.

either temperature or load does not strain some part of the metal beyond its elastic limit there can, of course, be no *permanent* change in the deflection or behaviour of the piece. Hence the calibration, once it is made to embrace the compensating element, is as permanent as that of the condenser itself.

The drawing of Fig. 6 shows the application of the principle to a fixed air condenser, the temperature coefficient of which it is required to compensate. The square plates 1 form the low potential system of this condenser and the discs 2 are mounted on the central pillar to form the high potential plate system. The bimetal disc 4, shaped as shown, forms with the end plate 1 a condenser element the capacitance of which is variable with temperature to an extent which is governed by adjusting the dimension of the air gap 5 by altering the thickness of the spacing collar 3 or by a screw thread device on the central spindle. Thus the capacitance change with temperature of this element may be adjusted to be equal to that due to the temperature coefficient of the main condenser while its algebraic sign is made opposite to that of the temperature coefficient by appropriately selecting the direction of deflection of the member 4. It will be seen that this method of compensation introduces no extra solid dielectric material into the condenser and that no structural alteration is involved.

(*To be concluded.*)

March Meetings

At the ordinary meeting of the Institution of Electrical Engineers to be held on Thursday, March 19th, a critical review of education and training for engineers will be presented by Dr. A. P. M. Fleming, C.B.E., M.Sc., on behalf of the Education and Training and Personnel Sub-Committee of the Institution's Post-War Planning Committee.

At the monthly meeting of the Wireless Section of the I.E.E. arranged for Wednesday, March 4th, Mr. S. Hill, M.Eng., will give a paper on "Public Address Systems." The discussion on the frequency stability of tuned circuits at the informal meeting of the Wireless Section on Tuesday, March 10th, will be under three headings :—(*a*) raw materials, (*b*) components, and (*c*) complete assembly, which will be opened respectively by Messrs. G. P. Britton, A. H. Cooper, B.Sc., and C. W. Eggleton. All I.E.E. meetings held in London now begin at 6 p.m.

Mr. N. Partridge, B.Sc., A.M.I.E.E., is to give a paper on "Harmonic Distortion in Audio-Frequency Transformers" at the meeting of the British Institution of Radio Engineers at 3 p.m. on Saturday, March 7th, at 21, Tothill Street, Westminster, S.W.1.

Manuscripts & Waste Paper

It has occasionally been stressed that manuscripts submitted for publication in *The Wireless Engineer* should be written on one side of the paper only, and if typewritten should be with double-line spacing. Whilst it might appear to be contrary to the national save-paper campaign to continue this practice at the present time, it should be pointed out that it is essential to do so, especially in mathematical articles, in order to ensure that errors do not creep in whilst the type is being set. There is, however, no objection to writing on paper which has already been used on one side, provided that the obsolete matter on the reverse side has been clearly cancelled.

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

539 360.—Thermionic amplifier with negative feed-back combined with means to stabilise gain control.

Standard Telephones and Cables; A. H. Roche; and A. J. Buxton. Application date 5th March, 1940.

539 833.—Construction of pole piece to minimise distortion in a sound reproducer of the telegraphone type.

Electrical Research Products Inc. Convention date (U.S.A.) 13th July, 1939.

539 859.—Amplifying circuit designed to offset automatically the effect of variations in load impedance, for instance the loudspeaker load on a wired-wireless relay system.

A. H. Cooper. Application date 24th February, 1940.

DIRECTIONAL WIRELESS

539 224.—Remote control of moving craft by means of a radiated beam which is variable in direction and wavelength and steers the craft through selective relays.

G. W. Walton. Application date 27th November, 1939.

539 505.—Radio blind-landing system for aircraft in which means are provided for indicating the glide path, the runway guide-path and the direction of the radio beacon.

Marconi's W.T. Co. (assignees of D. S. Bond). Convention date (U.S.A.) 12th April, 1939.

539 686.—Short-wave system in which a tank circuit is coupled to a radiating and reflector combination to secure a desired directional effect.

Standard Telephones and Cables (assignees of R. J. Kirchner). Convention date (U.S.A.) 2nd June, 1939.

539 817.—Compass of the earth-inductor type for indicating when a vessel or craft changes its direction.

Scophony; G. Wikkenhauser; and P. L. F. Jones. Application date 23rd February, 1940.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*).

539 233.—Click stop device for a so-called spot-wave selector for tuning a wireless receiver or transmitter.

Marconi's W.T. Co.; F. E. Baum; and T. N. D. Phillips. Application date 30th January, 1940.

539 254.—Demodulating frequency-modulated signals by passing them through a push-pull pair of gas-filled valves arranged as a relaxation relay.

Marconi's W.T. Co. (assignees of G. R. Clark). Convention date (U.S.A.) 22nd May, 1939.

539 289.—Epicyclic gear device for combined coarse and fine tuning in a wireless receiver.

Marconi's W.T. Co. and G. Payne. Application date 3rd April, 1940.

539 370.—Means for stabilising the current taken by the dial-illuminating lamp in a set which is adapted to be fed either from alternating or direct current supply mains.

The General Electric Co. and A. J. Biggs. Application dates 20th March and 10th May, 1940.

539 596.—Valve circuit with negative admittance, particularly adapted for rectifying heavily-modulated carrier waves.

Standard Telephones and Cables. Convention date (U.S.A.) 30th June, 1939.

539 603.—Automatic biasing arrangement for an oscillator or amplifier wherein a gas-filled discharge tube is utilised to give a voltage drop which is independent of the current taken.

Amalgamated Wireless (Australasia). Convention date (Australia) 19th May, 1939.

539 630.—Amplifying system in which automatic gain control is made to operate between two predetermined limits, the rate of increase at the lower limit being controlled by a circuit with a relatively long time constant.

C. G. Mayo and H. D. McD. Ellis. Application date 30th May, 1940.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION.

538 931.—Receiver for television or facsimile signals in which a local oscillator is used to minimise the "streak effects" due to fading.

Marconi's W.T. Co. (assignees of J. E. Smith). Convention date (U.S.A.) 20th April, 1939.

538 947.—Television system with means for grading the contrast between elementary picture areas, and for introducing certain desirable and deliberate distortion effects.

Hazeltine Corpn. (assignees of J. C. Wilson). Convention dates (U.S.A.) 14th and 27th January, 1939.

539 198.—Stabilizing the operation of an oscillation generator for transmitting frequency-modulated signals, particularly for television.
W. S. Percival. Application date 29th February, 1940.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*).

538 898.—Control gear for adjusting the tuning, say, of a radio transmitter to one or other of a number of predetermined frequencies.
Marconi's W.T. Co. and H. J. H. Wassell. Application date 3rd April, 1940.

538 982.—Push-pull modulating circuit for equalising the load on, and thereby increasing the efficiency of, the output valves of a radio transmitter.
" Le Transformateur " and M. Nikis. Convention dates (France) 30th April, 1938, and 25th April, 1939.

539 033.—Remote control over a single pair of wires of the voltages fed to a radio transmitter from sources of different polarity.
Standard Telephones and Cables and E. A. H. Bowsher. Application date 23rd February, 1940.

539 082.—Negative feed-back circuit comprising a Wheatstone Bridge arrangement with a piezo-electric element for stabilising the frequency of a valve oscillator. (Addition to 510 379.)
Standard Telephones and Cables (assignees of L. A. Meacham). Convention date (U.S.A.) 24th June, 1939.

539 562.—Carrier-wave transmission system comprising a number of parallel quadripole channels with predetermined time-delay characteristics.
Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 5th May, 1939.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

538 753.—Method of preparing the photo-sensitive mosaic screens used in television transmitting tubes of the so-called camera type.
Standard Telephones and Cables (assignees of T. T. Goldsmith, Jr.). Convention date (U.S.A.) 7th November, 1938.

538 760.—An amplifier of the electron-multiplier type in which focusing or control rods or grids are interposed between successive target electrodes.
Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 11th February, 1939.

539 122.—Arrangement and assembly of the magnetic deflecting coils of a cathode-ray tube designed to produce a more uniform field.
Jefferson Electric Co. Convention date (U.S.A.), 2nd June, 1939.

539 315.—Electronic-discharge tube wherein a number of anodes are arranged as a segmented ring on to which a rotating radial beam of electrons is focused to function, for instance, as a distributing switch.
Electrical Research Products. Convention date (U.S.A.) 27th May, 1939.

539 419.—Television tube in which the angle of incidence of a scanning stream of electrons is kept substantially uniform at all points on the mosaic screen.
W. S. Brown. Application date 5th February, 1940.

539 422.—Electron tubes of the klystron or velocity-modulated type adapted to produce and control electron streams of high intensity.
Standard Telephones and Cables and J. H. Fremlin. Application date 6th February, 1940.

SUBSIDIARY APPARATUS AND MATERIALS

538 521.—Remote radio-control system depending on an impulse code which is not easily deciphered and used for directing aircraft or other mobile vehicles.
Marconi's W.T. Co. (assignees of D. G. C. Luck). Convention date (U.S.A.) 31st January, 1939.

538 541.—Method of supporting and fitting electrodes to piezo-electric crystal oscillators.
Standard Telephones and Cables (assignees of Le Matériel Téléphonique, Soc. Anon.). Convention date (France) 2nd August, 1939.

538 674.—Crystal-controlled oscillation generator in which a single valve is used to develop a number of different carrier frequencies.
The General Electric Co. and R. S. Rivlin. Application date 1st April, 1940.

538 989.—Elastic suspension or support for a piezo-electric crystal operating as a frequency oscillator of high precision.
Fabrica Italiana Magneti Narelli. Convention date (Italy) 22nd February, 1939.

539 047.—Method of grinding a piezo-electric crystal intended to oscillate at a frequency determined by its thickness.
Marconi's W.T. Co. (assignees of S. A. Bokovoy). Convention date (U.S.A.), 29th April, 1939.

539 094.—Synchronising system in which one moving element supplies power to a second moving element in accordance with the relative phase conditions.
Marconi's W.T. Co. (assignees of M. Artzt). Convention date (U.S.A.) 21st June, 1939.

539 194.—Quarter-wave resonant line device for coupling circuits of different impedances, over a wide range of frequency, without introducing losses.
Marconi's W.T. Co. (assignees of G. H. Brown). Convention date (U.S.A.) 28th February, 1939.

539 511.—Construction of an impedance line which, when once calibrated, remains of constant value and cannot be tampered with.
Reliance Electrical Wire Co. and K. Konstantinowsky. Application date 11th January, 1940.

539 627.—Reflecting arrangement to broaden the resonance curve of a piezo-electric crystal used for supersonic light-modulation.
Scophony and S. H. M. Dodington. Application date 27th May, 1940.

Abstracts and References

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

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

615. THE NUMERICAL SOLUTION OF A TYPE OF EQUATION [tan $x = xf(x)$: including Equations relating to Electrical Waves on a Sphere, etc.].—Plummer. (*See* 890.)

616. PROPAGATION OF ELECTROMAGNETIC WAVES IN A SPACE CHARGE ROTATING IN A MAGNETIC FIELD.—Blewett & Ramo. (*See* 676.)

617. REFRACTIVE INDEXES OF GASES AT HIGH RADIO FREQUENCIES [58 Mc/s: by Standing-Wave Method using Gas-Tight Concentric-Tube Lecher Circuit: Values for Dry Air & Water Vapour, at 100° C and 76 cm Hg].—F. J. Kerr. (*Nature*, 20th Dec. 1941, Vol. 148, pp. 751–752.)

The figure for water vapour ($\mu = 1.0030_1 \pm 0.00007$) is found to agree with that (1.0060) given by Tregidga (2355 of 1940) for 42 Mc/s, 99.8° C and 76 cm Hg. "The important part played by the water vapour in the atmosphere in the propagation of ultra-short waves can be seen from these results."

618. STEADY-STATE ANALYSIS OF MULTICONDUCTOR TRANSMISSION LINES [starting from Maxwell Field Equations: Slightly Dissipative Case of Good Conductors in Good Dielectrics can be regarded as Slight Perturbation of Ideal Case (where alone Telegraphist's Equations are Rigorously Valid): Solution by Laplacian Transformation & Matrix Notation: Symmetrical Cases of Cables & Transposed Open Lines: etc.].—L. A. Pipes. (*Journ. Applied Phys.*, Nov. 1941, Vol. 12, No. 11, pp. 782–799.) *See* also 619, below.

619. AN OPERATIONAL TREATMENT OF ELECTROMAGNETIC WAVES ALONG WIRES [Two Parallel Wires: Rigorous Solution of Dissipation-less Case, & Solution of Case of Finite Conductivity as Perturbation of Ideal Case: Deformation of Front of Initially Rectangular Wave by Skin Effect: etc.].—L. A. Pipes. (*Journ. Applied Phys.*, Nov. 1941, Vol. 12, No. 11, pp. 800–810.) *See* also 618, above.

620. THE ENERGY PROPAGATION ALONG LINES WITH EXPONENTIALLY VARYING CHARACTERISTIC IMPEDANCE.—A. A. W. Ruhrmann. (*Hochf: tech. u. Elek:akus.*, Sept. 1941, Vol. 58, No. 3, pp. 61–69.)

A preliminary communication, from the Telefunken transmitter laboratories. "In the field of the theory of energy propagation along lines and their quasi-stationary equivalent structures, very fruitful work has been done recently (Smith, 1372 of 1939: Meinke, 1853 of 1941). High-frequency technique in particular, in its striving to make practical use of shorter and shorter waves, has prompted the more exact analysis of all physical processes. The present work deals with a special type of line which up to the present has attained no practical importance [but *cf.*, for example, Burrows, Wheeler, 1453, 1454 of 1939, and Volpert, 3835 of 1940]. But as wavelengths grow shorter the constructional difficulties decrease, so that there is nothing to stand in the way of its application. The results now given not only enable the design calculations of special line structures to be made but also allow the effect of variations of characteristic impedance, due to the construction, to be estimated and allowed for."

Author's summary :—"In the first part of the paper the differential equation of the loss-free line with varying characteristic impedance is integrated for the case of an exponential variation. After the introduction of the phase ζ of the characteristic impedance as the determining parameter, the current and voltage distributions of the infinitely long, the open-circuited, and the short-circuited line are investigated and presented fully. Further, the equations for the behaviour of the input impedance as a function of the line length are given for these three cases. Termination by a pure reactance is seen to be related to these cases [" Figs. 4 & 5 show that for $\mu > 0$ the ' length variation ' by variation of a capacitive terminating resistance is more effective than by an inductive termination. For $\mu < 0$ the reverse is the case." For the definition of μ *see* below]. For loading by arbitrary complex terminating resistances, the equations for current and voltage are brought into the form of the generalised four-terminal-network equations (eqn. 39). The discussion of the input resistance is not, however, possible with the help of these equations because of their complicated form.

" In the second part a circle diagram [*cf.* Schmidt, 1933 Abstracts, p. 222] is obtained for arbitrary complex terminations, which allows the variation of the input resistance of the line with the terminating resistance, or with length of line, to be determined graphically. A practical example illustrates the use of this diagram " : it is required to find the frequency characteristic of the input resistance of a line of length 1.5 m with a gradient constant of $\mu = 1.074$/m in the wavelength range 1–10 m, the line being loaded with a series connection of a frequency-independent ohmic resistance and a condenser, of given values. The logarithmic gradient constant μ mentioned above is taken from the exponential-variation equation 4, $\phi(x) = e^{\mu x}$, where x is the distance from the beginning of the line.

The results are finally seen in Fig. 8, in which the curve R_a represents the real component and the curve X_a the imaginary component of the input resistance as functions of λ_o (the zero subscript indicates, throughout the paper, a value referring to a corresponding *homogeneous* line). The accompanying ellipse A and straight line B show the behaviour in the case of a reflection-free termination of the line by an impedance $Z_e e^{j\zeta}$. " The representation allows it to be seen how well, with comparatively simple means, a reflection-free termination can be built up, almost up to the limiting wavelength " [the " limiting wavelength," in this case 11.7 m ($\lambda_{ogr} = 4\pi/\mu$), is the wavelength at the boundary between the two zones implicit in eqn. 8 : only when γ' and γ'' are complex is the energy propagated in wave form. Eqn. 7 shows that the wavelength on the line with exponential characteristic is always greater than on the homogeneous line, and it is infinitely great at the limiting wavelength].

621. THE SKIN EFFECT IN CYLINDRICAL CONDUCTORS, ESPECIALLY OF ELLIPTICAL CROSS SECTION [Strict Mathematical Treatment, prefaced by Short Survey of Previous Limited Treatments & Approximations: Formulae also applicable to Thin Rectangular Sections (Bands, etc.)].—J. Fischer. (*Physik. Zeitschr.*, Oct. 1941, Vol. 42, No. 19/20, pp. 327–336.)

622. AN INVESTIGATION OF THE PHASE STRUCTURE OF AN ELECTROMAGNETIC FIELD AND OF THE VELOCITY OF RADIO WAVES.—Ya. A. Al'pert, V. V. Migulin, & P. A. Ryazin. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 7–36.)

For previous work *see* 1405, 1893, and 1894 of 1940. The object of this investigation was (a) to obtain reliable experimental data relating to the phase structure of the electromagnetic field of radio waves excited by a radiator located on the earth's surface, and (b) to compare these data with calculations based on Sommerfeld's equation (1). The propagation of medium waves for short distances (of the order of 10 km) over land and sea was investigated, using various methods based on the interference theory as expounded by Mandelstam & Papalexi. A detailed report on these experiments is given together with a theoretical discussion. The main conclusions reached are as follows :—(1) The phase velocity of radio waves propagating over a flat and uniform surface is not constant but varies, never exceeding c, as follows : (a) in the near zone, *i.e.* within a radius of $(3–4)\lambda$, it varies very rapidly, decreasing with the distance from the radiator : (b), in the intermediate zone, it increases continuously ; the limits of this zone depend on the electric constants of the surface, in the case of land surfaces it extends from $(4–5)\lambda$ to $(50–60)\lambda$: (c) in the distant zone, *i.e.* from $(50–60)\lambda$, the phase velocity approaches c asymptotically.

(2) The effect of the earth's surface on the phase structure of the field does not extend beyond a height of $(4–5)\lambda$ (a balloon was used for these experiments).

(3) In the case of a non-uniform surface the phase structure is distorted owing to diffraction phenomena. (4) A strict interpretation of Sommerfeld's equation is confirmed experimentally. On the other hand, experimental results are in contradiction with Zenneck's theory of non-uniform plane waves and Sommerfeld's theory of " surface " waves.

623. THE HEIGHT-GAIN FACTOR AND PHASE RELATIONS OF ULTRA-SHORT WAVES.—B. A. Vvedenski [Wwedensky]. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 37–43.)

Formulae 1–6 for determining the effect of the height-gain factor on the diffraction field of ultra-short waves, derived by the author in 1936 (*see* 34 of 1938 and back refs.) are quoted, and it is shown that these formulae are similar to those derived by Eckersley & Millington (3835 of 1938). It is pointed out however that the " method of phase integrals " adopted by the latter authors is rather artificial and necessitates a number of simplifications which are not always justifiable. The same criticism applies to the propagation curves for u.s.w. published by Eckersley (1660 of 1937) and it is pointed out that they may lead to completely wrong conclusions if certain considerations are not borne in mind. Formulae are also derived for determining the phase angle of a diffraction field.

624. MEASUREMENT AND AUTOMATIC REGISTRATION OF LARGE DIFFERENCES OF PHASE ANGLES.—E. Ya. Shchegolev [Schegolev]. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 44–54.)

The interference method proposed by Mandelstam & Papalexi is based on measurements of the phase difference between two beams when these have a whole-number frequency relationship (usually 3 : 2). These differences may reach large values (500 000° when distances of the order of 50 km are measured).

It is therefore desirable to use apparatus which would register automatically the phase differences and also indicate the sign of the change. Such a phasemeter should satisfy a number of special requirements which preclude the use of existing types. Accordingly several new arrangements, some of them utilising existing phasemeters, have been developed, and these are described in detail.

625. A Particular Type of Interference Apparatus for determining the Phase Distribution of an Electromagnetic Field.—V. I. Yuzvinski. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 55–60.)

Systems based on the interference theory of Mandelstam & Papalexi and applicable to a number of practical purposes are discussed. It is suggested that in the receiving equipment of these systems use should be made of the "consecutive" and "double" heterodyning described in a separate paper (626, below). This would enable superheterodyne reception to be employed, with a resulting increase in the range of operation. The phase relationships in the systems under consideration are fully discussed.

626. On Methods for receiving Radio Waves and maintaining Constant the Phase Relationships.—V. I. Yuzvinski. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 61–68.)

See also 625, above. In phase measurements of an electromagnetic field it is essential to keep constant the phase difference between the input and output of a radio receiver. This condition is not fulfilled in an ordinary superheterodyne receiver, where the phase of the output depends on the arbitrary phase of the beating oscillator. Accordingly a method of "consecutive" heterodyning is proposed in which the same oscillator is used for beating the incoming oscillations and then, after intermediate-frequency amplification, for restoring the original frequency. When the incoming oscillations have to be compared with local oscillations of the same frequency a method of "double" heterodyning can be used. In this method the two trains of oscillations are made to beat with the same oscillator and the required comparison is made after i.f. amplication. The above methods are somewhat modified when the incoming and output frequencies or the incoming and local frequencies are not equal but in a ratio represented by whole numbers. The theory of the proposed methods is discussed.

627. Is Sharp Phase Selectivity Possible?—G. Gorelik. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 69–71.)

It is pointed out that the usual argument against the practicability of sharp phase selectivity is in fact only a statement that a linear system cannot possess such selectivity with regard to an external sinusoidal force. An example is then discussed in which the receiver is a linear circuit with a resistance $R(t)$ varying sinusoidally about a positive average value $\bar{R}$, and the signal generator is a non-linear system similar to the receiving circuit but with a negative $\bar{R}$. It is shown that under these conditions the phase selectivity of the receiver can be made as sharp as desired.

628. The Assimilation of Electromagnetic Reflection and Refraction Theory with the Physical Phenomena.—O. Schriever. (*Ann. der Physik*, 29th Oct. 1941, Vol. 40, No. 6, pp. 448–462.)

From the Telefunken Works. "Attenuation in space has hitherto been allowed for in the electromagnetic theory of reflection and refraction by substituting the 'complex index of refraction' for the 'real' index. It will be shown in what follows that such a procedure is inadequate, and that in particular it is not in agreement with the actual processes when the incidence is oblique. With this object, the theory is derived anew from predominantly physical viewpoints." The formulae in the group on p. 460 are obtained, giving the intensities with which the secondary (reflected and refracted) rays leave the surface of demarcation, in terms of the incident intensity. The new point about them is the appearance of the real (geometrical) refractive index $\mathfrak{n}$ together with the complex index n ["it is physically meaningless to write the law of refraction with a complex refractive index: what determines the refracted direction is the quotient of the real components of the complex wave-number (p. 449). A distinction between propagation-direction and attenuation-direction contradicts the processes of nature. In addition to the real refraction of direction there occurs also a complex intensity-refraction. Consequently in the intensity formulae for oblique incidence the real and the complex refractive indices occur together"]. If these two indices are put equal to one another (absence of conductivity), the formulae of the old theory are obtained directly. On the other hand, for vertical incidence the geometrical refractive index drops out of all the formulae, so that the laws for loss-free dielectrics acquire general validity by the mere use of the complex refractive index in place of the real index: this, the only case where this happens, is because only intensity-refraction is present: as soon as oblique incidence introduces direction-refraction, the geometrical index must also come in.

In wireless technique, either vertical or horizontal dipoles are chiefly encountered: they are seldom sloping. For these two special cases the formulae become greatly simplified (p. 461: vertical polarisation, top group: horizontal, lower group). "The values obtained by these formulae for the reflection coefficients of the ground differ only slightly (up to a few per cent) from those obtained by the usual formulae." For other recent work by the same writer *see* 2 of 1941 and 375 of February.

629. "The Behaviour of Slow Electrons in Gases" [including the Mechanism of the Luxembourg Effect: Book Notice].—R. H. Healey & J. W. Reed. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 4.) *See* 16 of January.

630. Maintaining Short-Wave Communication: Range of Frequencies necessary throughout a Complete Sunspot Cycle.—T. W. Bennington. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, pp. 2–4.)

631. A Remarkable Group of Ionospheric Disturbances of Sudden Onset [27th Feb./3rd March, 1941: shown by Instantaneous & Sharp Improvement in Propagation of Very Long (10 000 m) Waves as indicated on Atmospherics Recording Equipment: followed by Magnetic Storm].—R. Bureau. (*Comptes Rendus* [Paris], 31st March 1941, Vol. 212, No. 13, pp. 561–563.)

Each daily diagram shows, in addition to the atmospherics trace on 10 km, the simultaneous trace on 25 km, which illustrates one of the characteristics of the phenomenon, the property of disappearing on wavelengths over 17 km. The sudden rises of the 10 km curve are among the most violent ever recorded. Further records showed that on 5 km the improvement of propagation appeared also, but less vigorously than on 10 km: and that on 2000 m there was no improvement and no fade-out. The magnetic storm broke out about 39 hours after the first peak, "A," and 36 hours after the violent disturbance "C." "This interval corresponds very well with the difference in time applying to two radiations coming from the same solar source, the one ultra-violet and the other corpuscular."

632. Sunspots may cause Delayed Radio Black-out [New Evidence of Slow (1200 m.p.s.) Particles affecting E Layer One Day after Fast Particles affect F Layer].—H. T. Stetson. (*Sci. News Letter*, 1st Nov. 1941, Vol. 40, No. 18, p. 282.) *See* also 10 of 1941 and back reference.

633. Coefficients of Absorption of Air in the Ultra-Violet [using a Source with Continuous Spectrum: Complete Table from 1898 to 4260 AU].—A. Vassy. (*Comptes Rendus* [Paris], 17th March 1941, Vol. 212, No. 11, pp. 439–441.) Enabling the spectral energy distribution of the solar radiation reaching different heights in the atmosphere to be calculated.

634. Space Motions of Solar Prominences.—(*Nature*, 27th Dec. 1941, Vol. 148, p. 786: summary only.)

635. Daily Variations in the Heat of the Sun [and the Consequent Up-&-Down Movement of the Tropopause, & Its Results].—H. Arctowski. (*Science*, 21st Nov. 1941, Vol. 94, Supp. p. 8: *Sci. News Letter*, 22nd Nov. 1941, Vol. 40, No. 21, p. 324.)

636. "On the Correlation between the Geopotential of the Tropopause and the Temperature of the Middle Troposphere" [Book Review].—E. Björkdal. (*Gerlands Beiträge z. Geophysik*, No. 1/2, Vol. 58, 1941, pp. 215–216.)

637. The Thermal Radiation of Water Vapour in the Atmosphere [including Conclusions regarding the Formation of the Tropopause (& the Part played by a "Haze" Layer) and the Lack of Isothermy in the Stratosphere (Decrease of the Order of 0.3°/100 m): etc.].—F. Möller. (*Gerlands Beiträge z. Geophysik*, No. 1/2, Vol. 58, 1941, pp. 11–67.)

638. On the Slope of the Surfaces of Second-Order Discontinuities in the Atmosphere [Characterised by Continuity of ρ, X', Y', Z', but by Discontinuity of Their First-Order Partial Derivatives: the Tropopause as Such a Surface].—L. Cagniard. (*Comptes Rendus* [Paris], 3rd March 1941, Vol. 212, No. 9, pp. 360–363.)

639. Study of the Atmospheric Perturbations in the Neighbourhood of Lyons [based on 206 Daily Radiosonde Ascents (Nov. 1939/June 1940), of which 112 reached a Height of 15 km].—P. Quéney. (*Comptes Rendus* [Paris], 24th March 1941, Vol. 212, No. 12, pp. 500–502.)

"In the high layers, the results already known are confirmed, the only special result to report being the behaviour of the variation of temperature as a function of altitude: amplitude practically constant in the troposphere, diminishing at the passage into the stratosphere . . ." Another point of interest in these Lyons results was that in 79 cases there was one very distinct tropopause, while in 78 other cases the tropopause was succeeded by a zone of temperature inversion, itself bordered above by a second surface of discontinuity: the vertical temperature-gradient, practically uniform in the troposphere and in the stratosphere, was also practically uniform in this inversion zone (gradient 4.4°/km, thickness of zone 1.5 km). This second type of result predominated during tropical phases of the perturbations: during the corresponding days a layer of cirrus was nearly always observed. Sudden changes of the wind, at the passage through the tropopause, were specially frequent in the second group of ascents, and occurred also at the upper discontinuity: the wind was almost always stronger in the inversion zone, generally exceeding 100 km/h. Other results are given.

640. The Emission Bands of Ozone in the Spectrum of the Night Sky, *and* On the Variations of the Atmospheric Ozone [and Their Origin].—G. Déjardin: A. & E. Vassy. (*Comptes Rendus* [Paris], 13th Jan. 1941, Vol. 212, No. 2, pp. 95–98: pp. 98–100.) For the second part of the Vassy paper see *ibid.*, 24th February, No. 8, pp. 301–303.

641. Remarks on the Spectra of Phosphorescence of Nitrogen and Their Interpretation [including the Rôle played in the Upper Atmosphere].—R. L. Herman. (*Comptes Rendus* [Paris], 20th Jan. 1941, Vol. 212, No. 3, pp. 120–123.)

642. Mesotron Variation with Upper-Air Temperatures [Correlation of Mesotron Intensity at Ground Level with Radiosonde Temperature Data].—V. F. Hess & F. A. Benedetto. (*Phys. Review*, 15th Oct. 1941, Vol. 60, No. 8, pp. 610–611.)

643. Cosmic Rays and the Magnetic Disturbance of Sept. 18th, 1941.—V. F. Hess & E. B. Berry. (*Phys. Review*, 15th Nov. 1941, Vol. 60, No. 10, p. 746.)

"Compared with the aurora of Jan. 25/26th, 1938, the above cosmic-ray fluctuations are less pronounced, and this is in accordance with the belief that, if electronic ring currents at distances of several earth's radii around the globe cause a diminution of incoming particles, then the radii of these currents may differ considerably from storm to storm or even during a storm." *See* also 2220 of 1938, 1341 of 1940, and 642, above.

644. Hypothesis as to the Origin of Cosmic Rays, and the Experimental Testing of It in India and Elsewhere [Five-Band Hypothesis].—R. A. Millikan & others. (*Science*, 10th Oct. 1941, Vol. 94, pp. 335–336.)

645. On the Protonic Nature of the Primary Cosmic Radiation.—G. Cocconi. (*Phys. Review*, 1st Oct. 1941, Vol. 60, No. 7, pp. 532–533.)

"It must therefore be considered that the primary protons produce the mesotrons in the atmosphere and furthermore, directly as well as indirectly by means of processes now unknown, the photons and the electrons which are responsible for the large showers and the components called residue by us."

646. Positive Excess in Mesotron Spectrum [Improved Repetition of Rossi's Experiment gives Conclusive Proof of Positive Excess].—G. Bernardini & others. (*Phys. Review*, 1st Oct. 1941, Vol. 60, No. 7, pp. 535–536.)

647. The Energy Spectrum of the Primary Cosmic Rays [Calculated Curve based on Results of Bowen, Millikan, & Neher: Sudden Cut-Off at Low Energy End (probably due to Blocking Effect of Solar Magnetic Field): etc.].—H. C. Shan. (*Phys. Review*, 15th Oct. 1941, Vol. 60, No. 8, p. 614.)

648. On the Validity of the Huyghens-Fresnel Principle [Extension to Thermal Waves: Treatment applicable to Other Damped Waves (Electromagnetic, Light Waves in Absorbing Media, etc.)].—R. Potier. (*Comptes Rendus* [Paris], 10th Feb. 1941, Vol. 212, No. 6, pp. 229–231.)

649. Reflection of Longitudinal Waves in Liquids: Conversion into Transverse Waves.—R. Lucas. (*Comptes Rendus* [Paris], 20th Jan. 1941, Vol. 212, No. 3, pp. 118–119.)

650. The Polarisation of Atmospheric Haze.—H. Neuberger: G. M. Byram. (*Science*, 21st Nov. 1941, Vol. 94, pp. 485–486.) Comments on Byram's paper referred to in 2961 of 1941.

651. The Brewsterian Angle and Refractive Indices.—A. H. Pfund. (*Journ. Opt. Soc. Am.*, Nov. 1941, Vol. 31, No. 11, pp. 679–682.)

The poor definition of the Brewsterian angle, rendering it unsuitable as a reliable basis for evaluating the refractive index, is avoided by making the incident plane-polarised light vibrate in a direction making only a few degrees with the plane of incidence: the angular change ϕ in R, on passing through the Brewsterian angle, is then large.

652. A New Method of Measuring the Velocity of Light [Kerr Cell, Two Paths, & Photocell Arrangement with Cathode-Ray Oscillograph having Circular Time Base rotating at 10^6 r.p.s.].—A. Niini. (*Ann. Ac. Scientiarum Fennicae*, Ser. A, Vol. 55, 1940, No. 2, pp. 3–7: in German.)

653. "Waves: a Mathematical Account of the Common Types of Wave Motion" [Book Review].—C. A. Coulson. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, p. 503.)

654. The Dispersion and Absorption of Sound in Clouds.—Oswatitsch. (*See* 764.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

655. Atmospherics during the Sudden Ionospheric Disturbances of 27th Feb./3rd March, 1941.—Bureau. (*See* 631.)

656. Initial Processes in Lichtenberg Figures [Previous Results have always represented a Rather Advanced Stage: Study of the Initial Processes, by reducing Surge Period to 10^{-7}–10^{-8}s: Results in Air & Other Gases].—W. Rogowski, O. Martin, & H. Thielen. (*Arch. f. Elektrot.*, 25th Aug. 1941, Vol. 35, No. 7, pp. 424–430.)

"The negative figure begins in avalanche form at preferred points on the cathode. Neighbouring avalanches show very clearly the mutual repulsion due to similar charge. The discharge has a stratified constitution. The positive figures are formed later . . ." It is nowadays assumed that the positive figure is produced by an electron making for the positive electrode and producing an electron avalanche which advances towards the anode, and it had been hoped in these experiments to obtain records of channels which ended before reaching the anode. No success was obtained: perhaps even these very short surges were still too long.

657. Pulses in Negative Point-to-Plane Corona [Trichel Pulses].—L. B. Loeb & others. (*Phys. Review*, 15th Nov. 1941, Vol. 60, No. 10, pp. 714–722.) *See* Trichel, 1188 of 1939.

658. Methods for the Measurement of the Thunderstorm Electric Field at the Occurrence of Lightning Discharges [Comparison of the Earth Plate, Aerial, & Point-Discharge-Mast Methods: Advantages of the Last Method: etc.]—H. Wichmann. (*Gerlands Beiträge z. Geophysik*, No. 1/2, Vol. 58, 1941, pp. 95–111.)

659. Instrument warns Pilot if Too Close to Lightning [Neon Tube Device].—C. M. Foust & others. (*Sci. News Letter*, 1st Nov. 1941, Vol. 40, No. 18, p. 280.)

660. The Protection of Low-Power Wireless Transmitting Installations against Surges.—G. Müller. (*E.T.Z.*, 11th Sept. 1941, Vol. 62, No. 37, pp. 769–773.)

"Most transmitting installations up to 1.5 kw in power are to-day without any reliable, automatically acting protection against over-voltages," although power installations and (to a certain degree) communication networks are suitably protected against lightning surges and over-voltages, while for receiving installations good reliable devices are well known. Transmitting stations are particularly vulnerable on account of their often high, exposed situations, the space they cover, and so on; yet the custom is merely to shut down the transmitter and earth the aerial during thunderstorms; at most, some sort of protection is provided by spark-gaps of various types. Protecting chokes are seldom provided except to carry away static charges. Protecting arrangements of the "Peters circuit" type, with bridge connections and safety gaps, are only applicable when there is a transmission line from transmitter to aerial: this is not the case for the small and medium-power transmitters which are so numerous in commerce, aviation, police systems, etc. The writer therefore considers the protection of such stations, ending his paper with some results of practical experience from 1939 onwards.

To replace the direct earthing of the aerial, the protecting device must act automatically and must afford at least as much protection as a direct earth: the current from a direct flash must be broken immediately: the detuning and added damping of the h.f. circuit must be as small as possible, the temperature-dependence of the arrester must not exceed that of other components, for fear of frequency fluctuations: for telegraphic installations the conducting time, on the occurrence of a surge, should be shorter than the shortest signal to be transmitted, or a distortion to the signal caused by a surge during traffic should be recognisable as such as easily as possible. Consideration of the electrical relations of a transmitting aerial and of the usual commercial arresters, in sections 2 and 3, and of the matching of arrester and aerial to give a high measure of protection, in section 4, leads to the conclusion that an arrester suitably selected (as regards low self-capacity, low coefficient ρ, and high exponent n: section 3) from the various commercial types is quite suitable for the present purpose. Thus completely successful results over two years were obtained with arresters of the type shown in Fig. 7, designed for a nominal voltage of 1.2 kv and a striking voltage of 5.4 kv. Since the test voltage of the transmitter was over 10 kv, the high striking voltage did not matter. The static capacitance of the arrester was 22 pF, and with attention to correct mounting the total capacitance was kept down to about 30 pF. Further data and particulars as to performance are given. Satisfactory results have been obtained at frequencies up to and over 3 Mc/s: "for this, the arrester must always be designed on the lines of h.f. technique. To get the best protective effect, the aerial should have a high characteristic impedance: this can be attained by increasing the length up to the working wave and by decreasing the wire diameter to a limiting value." In all the above it is assumed that the arrester is connected at a point close to the transmitter, and that current and voltage there are both greater than zero.

661. On the Methods of Measurement of Atmospheric Electricity: II—The Counting of the Condensation Nuclei [and the (sometimes) 74% Discrepancy between the Two Usual Methods: Impossibility of Reliable Determination at Present].—H. Israël & M. Krestan. (*Gerlands Beiträge z. Geophysik*, No. 1/2, Vol. 58, 1941, pp. 73–94.)

662. "Aerologische Beobachtungen mit Radiosonden in Sommer 1937 in Spitzbergen und in Petsamo", *and* "Der Strahlungsfehler der finnischen Radiosonde" [Book Reviews].—M. Tommila & N. Raunio: V. Väisälä. (*Gerlands Beiträge z. Geophysik*, No. 1/2, Vol. 58, 1941, pp. 210–211: pp. 211–213.)

PROPERTIES OF CIRCUITS

663. Small Oscillations of a Pendulum whose Point of Suspension is endowed with a Periodic Vertical Movement.—M. Parodi. (*Comptes Rendus* [Paris], 13th Jan. 1941, Vol. 212, No. 2, pp. 69–71.) Leading to an equation of the type investigated by Barrow, Smith & Baumann, 2543 of 1936. For further work, on two coupled pendulums, see *ibid.*, 27th January, No. 4, pp. 144–146.

664. The Energy Relationships in Oscillating Systems, and the Parameters of Radiating Systems.—Kessenikh. (*See* 705.)

665. A Variable-Phase Transformer and Its Use as an A.C. Interference Eliminator [primarily to eliminate 60 c/s Hum induced in Input Leads of High-Gain Amplifier employed in an A.C. Induction Flow Meter for Electrolytes, but with Many Other Applications].—A. Kolin. (*Review Scient. Instr.*, Nov. 1941, Vol. 12, No. 11, p. 555.)

666. Cathode Phase Inversion [and Its Application, particularly to C.R. Oscillography: including a Modified Circuit for Ease of Attenuation].—O. H. Schmitt. (*Review Scient. Instr.*, Nov. 1941, Vol. 12, No. 11, pp. 548–551.)

For this amplifier circuit and its scientific and commercial applications *see* 2024, 2488, & 3734 of 1938: 895 of 1940 (Rahm): and 2503 of 1941 (Geohagen). For other work by the same writer *see* also 1603 of 1938 and 1206 of 1939.

667. Radiotron 13 W 6V6-G Amplifier Circuit A 504 [Max. Power Output increased by Class AB_1 Operation: Circuit for Constant Current Drain: Characteristics].—(*Sci. Abstracts*, Sec. B, Oct. 1941, Vol. 44, No. 526, p. 207.)

668. On the Output Resistance of Amplifiers with Negative Feedback [and the Development of a Special Circuit].—H. Böhme & E. Koch. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 107–109.)

Authors' summary:—"The way in which the amplification factor and the internal resistance are influenced in various negative-feedback connections is investigated. Independent adjustment of the two quantities is only possible by the simultaneous use of current and voltage feedbacks [and in amplifiers that, if electronic ring currents at distances of several earth's radii around the globe cause a diminution of incoming particles, then the radii of these currents may differ considerably from storm to storm or even during a storm." *See* also 2220 of 1938, 1341 of 1940, and 642, above.

644. HYPOTHESIS AS TO THE ORIGIN OF COSMIC RAYS, AND THE EXPERIMENTAL TESTING OF IT IN INDIA AND ELSEWHERE [Five-Band Hypothesis].—R. A. Millikan & others. (*Science*, 10th Oct. 1941, Vol. 94, pp. 335–336.)

645. ON THE PROTONIC NATURE OF THE PRIMARY COSMIC RADIATION.—G. Cocconi. (*Phys. Review*, 1st Oct. 1941, Vol. 60, No. 7, pp. 532–533.)

"It must therefore be considered that the primary protons produce the mesotrons in the atmosphere and furthermore, directly as well as indirectly by means of processes now unknown, the photons and the electrons which are responsible for the large showers and the components called residue by us."

646. POSITIVE EXCESS IN MESOTRON SPECTRUM [Improved Repetition of Rossi's Experiment gives Conclusive Proof of Positive Excess].—G. Bernardini & others. (*Phys. Review*, 1st Oct. 1941, Vol. 60, No. 7, pp. 535–536.)

647. THE ENERGY SPECTRUM OF THE PRIMARY COSMIC RAYS [Calculated Curve based on Results of Bowen, Millikan, & Neher: Sudden Cut-Off at Low Energy End (probably due to Blocking Effect of Solar Magnetic Field): etc.].—H. C. Shang. (*Phys. Review*, 15th Oct. 1941, Vol. 60, No. 8, p. 614.)

648. ON THE VALIDITY OF THE HUYGHENS-FRESNEL PRINCIPLE [Extension to Thermal Waves: Treatment applicable to Other Damped Waves (Electromagnetic, Light Waves in Absorbing Media, etc.)].—R. Potier. (*Comptes Rendus* [Paris], 10th Feb. 1941, Vol. 212, No. 6, pp. 229–231.)

649. REFLECTION OF LONGITUDINAL WAVES IN LIQUIDS: CONVERSION INTO TRANSVERSE WAVES.—R. Lucas. (*Comptes Rendus* [Paris], 20th Jan. 1941, Vol. 212, No. 3, pp. 118–119.)

650. THE POLARISATION OF ATMOSPHERIC HAZE.—H. Neuberger: G. M. Byram. (*Science*, 21st Nov. 1941, Vol. 94, pp. 485–486.) Comments on Byram's paper referred to in 2961 of 1941.

651. THE BREWSTERIAN ANGLE AND REFRACTIVE INDICES.—A. H. Pfund. (*Journ. Opt. Soc. Am.*, Nov. 1941, Vol. 31, No. 11, pp. 679–682.)

The poor definition of the Brewsterian angle, rendering it unsuitable as a reliable basis for evaluating the refractive index, is avoided by making the incident plane-polarised light vibrate in a direction making only a few degrees with the plane of incidence: the angular change ϕ in R, on passing through the Brewsterian angle, is then large.

652. A NEW METHOD OF MEASURING THE VELOCITY OF LIGHT [Kerr Cell, Two Paths, & Photocell Arrangement with Cathode-Ray Oscillograph having Circular Time Base rotating at 10^6 r.p.s.].—A. Niini. (*Ann. Ac. Scientiarum Fennicae*, Ser. A, Vol. 55, 1940, No. 2, pp. 3–7: in German.)

653. "WAVES: A MATHEMATICAL ACCOUNT OF THE COMMON TYPES OF WAVE MOTION" [Book Review].—C. A. Coulson. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, p. 503.)

654. THE DISPERSION AND ABSORPTION OF SOUND IN CLOUDS.—Oswatitsch. (*See* 764.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

655. ATMOSPHERICS DURING THE SUDDEN IONOSPHERIC DISTURBANCES OF 27th FEB./3rd MARCH, 1941.—Bureau. (*See* 631.)

656. INITIAL PROCESSES IN LICHTENBERG FIGURES [Previous Results have always represented a Rather Advanced Stage: Study of the Initial Processes, by reducing Surge Period to 10^{-7}–10^{-8}s: Results in Air & Other Gases].—W. Rogowski, O. Martin, & H. Thielen. (*Arch. f. Elektrot.*, 25th Aug. 1941, Vol. 35, No. 7, pp. 424–430.)

"The negative figure begins in avalanche form at preferred points on the cathode. Neighbouring avalanches show very clearly the mutual repulsion due to similar charge. The discharge has a stratified constitution. The positive figures are formed later . . ." It is nowadays assumed that the positive figure is produced by an electron making for the positive electrode and producing an electron avalanche which advances towards the anode, and it had been hoped in these experiments to obtain records of channels which ended before reaching the anode. No success was obtained: perhaps even these very short surges were still too long.

657. PULSES IN NEGATIVE POINT-TO-PLANE CORONA [Trichel Pulses].—L. B. Loeb & others. (*Phys. Review*, 15th Nov. 1941, Vol. 60, No. 10, pp. 714–722.) *See* Trichel, 1188 of 1939.

658. METHODS FOR THE MEASUREMENT OF THE THUNDERSTORM ELECTRIC FIELD AT THE OCCURRENCE OF LIGHTNING DISCHARGES [Comparison of the Earth Plate, Aerial, & Point-Discharge-Mast Methods: Advantages of the Last Method: etc.]—H. Wichmann. (*Gerlands Beiträge z. Geophysik*, No. 1/2, Vol. 58, 1941, pp. 95–111.)

659. INSTRUMENT WARNS PILOT IF TOO CLOSE TO LIGHTNING [Neon Tube Device].—C. M. Foust & others. (*Sci. News Letter*, 1st Nov. 1941, Vol. 40, No. 18, p. 280.)

660. THE PROTECTION OF LOW-POWER WIRELESS TRANSMITTING INSTALLATIONS AGAINST SURGES.—G. Müller. (*E.T.Z.*, 11th Sept. 1941, Vol. 62, No. 37, pp. 769–773.)

"Most transmitting installations up to 1.5 kw in power are to-day without any reliable, automatically acting protection against over-voltages," although power installations and (to a certain degree) communication networks are suitably protected against lightning surges and over-voltages, while for receiving installations good reliable devices are well known. Transmitting stations are particularly vulnerable on account of their often high, exposed situations, the space they cover, and so on; yet the custom is merely to shut down the transmitter and earth the aerial during thunderstorms; at most, some sort of protection is provided by spark-gaps of various types. Protecting chokes are seldom provided except to carry away static charges. Protecting arrangements of the "Peters circuit" type, with bridge connections and safety gaps, are only applicable when there is a transmission line from transmitter to aerial: this is not the case for the small and medium-power transmitters which are so numerous in commerce, aviation, police systems, etc. The writer therefore considers the protection of such stations, ending his paper with some results of practical experience from 1939 onwards.

To replace the direct earthing of the aerial, the protecting device must act automatically and must afford at least as much protection as a direct earth: the current from a direct flash must be broken immediately: the detuning and added damping of the h.f. circuit must be as small as possible, the temperature-dependence of the arrester must not exceed that of other components, for fear of frequency fluctuations: for telegraphic installations the conducting time, on the occurrence of a surge, should be shorter than the shortest signal to be transmitted, or a distortion to the signal caused by a surge during traffic should be recognisable as such as easily as possible. Consideration of the electrical relations of a transmitting aerial and of the usual commercial arresters, in sections 2 and 3, and of the matching of arrester and aerial to give a high measure of protection, in section 4, leads to the conclusion that an arrester suitably selected (as regards low self-capacity, low coefficient ρ, and high exponent n: section 3) from the various commercial types is quite suitable for the present purpose. Thus completely successful results over two years were obtained with arresters of the type shown in Fig. 7, designed for a nominal voltage of 1.2 kv and a striking voltage of 5.4 kv. Since the test voltage of the transmitter was over 10 kv, the high striking voltage did not matter. The static capacitance of the arrester was 22 pF, and with attention to correct mounting the total capacitance was kept down to about 30 pF. Further data and particulars as to performance are given. Satisfactory results have been obtained at frequencies up to and over 3 Mc/s: "for this, the arrester must always be designed on the lines of h.f. technique. To get the best protective effect, the aerial should have a high characteristic impedance: this can be attained by increasing the length up to the working wave and by decreasing the wire diameter to a limiting value." In all the above it is assumed that the arrester is connected at a point close to the transmitter, and that current and voltage there are both greater than zero.

661. On the Methods of Measurement of Atmospheric Electricity: II—The Counting of the Condensation Nuclei [and the (sometimes) 74% Discrepancy between the Two Usual Methods: Impossibility of Reliable Determination at Present].—H. Israël & M. Krestan. (*Gerlands Beiträge z. Geophysik*, No. 1/2, Vol. 58, 1941, pp. 73–94.)

662. "Aerologische Beobachtungen mit Radiosonden in Sommer 1937 in Spitzbergen und in Petsamo", *and* "Der Strahlungsfehler der finnischen Radiosonde" [Book Reviews].—M. Tommila & N. Raunio: V. Väisälä. (*Gerlands Beiträge z. Geophysik*, No. 1/2, Vol. 58, 1941, pp. 210–211: pp. 211–213.)

PROPERTIES OF CIRCUITS

663. Small Oscillations of a Pendulum whose Point of Suspension is endowed with a Periodic Vertical Movement.—M. Parodi. (*Comptes Rendus* [Paris], 13th Jan. 1941, Vol. 212, No. 2, pp. 69–71.) Leading to an equation of the type investigated by Barrow, Smith & Baumann, 2543 of 1936. For further work, on two coupled pendulums, see *ibid.*, 27th January, No. 4, pp. 144–146.

664. The Energy Relationships in Oscillating Systems, and the Parameters of Radiating Systems.—Kessenikh. (*See* 705.)

665. A Variable-Phase Transformer and Its Use as an A.C. Interference Eliminator [primarily to eliminate 60 c/s Hum induced in Input Leads of High-Gain Amplifier employed in an A.C. Induction Flow Meter for Electrolytes, but with Many Other Applications].—A. Kolin. (*Review Scient. Instr.*, Nov. 1941, Vol. 12, No. 11, p. 555.)

666. Cathode Phase Inversion [and Its Application, particularly to C.R. Oscillography: including a Modified Circuit for Ease of Attenuation].—O. H. Schmitt. (*Review Scient. Instr.*, Nov. 1941, Vol. 12, No. 11, pp. 548–551.)

For this amplifier circuit and its scientific and commercial applications *see* 2024, 2488, & 3734 of 1938: 895 of 1940 (Rahm): and 2503 of 1941 (Geohagen). For other work by the same writer *see* also 1603 of 1938 and 1206 of 1939.

667. Radiotron 13 W 6V6-G Amplifier Circuit A 504 [Max. Power Output increased by Class AB_1 Operation: Circuit for Constant Current Drain: Characteristics].—(*Sci. Abstracts*, Sec. B, Oct. 1941, Vol. 44, No. 526, p. 207.)

668. On the Output Resistance of Amplifiers with Negative Feedback [and the Development of a Special Circuit].—H. Böhme & E. Koch. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 107–109.)

Authors' summary:—"The way in which the amplification factor and the internal resistance are influenced in various negative-feedback connections is investigated. Independent adjustment of the two quantities is only possible by the simultaneous use of current and voltage feedbacks [and in amplifiers with severe matching requirements, such as the line amplifiers of modern transmission systems, the power of varying the internal resistance without affecting the degree of negative feedback is very desirable]. In Black's bridge connection the value of the internal resistance is not affected by the feedback [Fig. 1: but owing to the bridge circuit it is also impossible to vary the internal resistance at will: a special circuit with a differential transformer, also due to Black (Fig. 2), gives independent control of both quantities, but only for high values of negative feedback]. By a suitable choice of current and voltage feedbacks in a parallel circuit [due to Koch: Fig. 4] it has been successfully arranged that the desired internal-resistance variations can be obtained without altering the amplification [and without the requirement that the feedback should be large]. The behaviour of this circuit is investigated also for complex feedback paths," by which the internal resistance can be given a definite desired frequency dependence.

669. Four-Circuit High-Frequency Filter Circuits with Four-Humped "Levelled" Resonance Curves.—Sommer. (*See* 695.)

670. The Laplace Transformation as a Method of Solution for Balancing Processes in Linear Networks, and Its Application to Automatic Regulation.—E. Grünwald. (*Arch. f. Elektrot.*, 25th Aug. 1941, Vol. 35, No. 7, pp. 379–400.)

Author's summary:—"After a short discussion about the Laplace transformation and the usefulness of its application to the problems of automatic regulation [*cf.* Artus, 401 of February], appropriate calculating methods are developed. In particular the fundamental equations are obtained for disturbances from the initial steady régime; these equations quite generally permit the characteristic behaviour of a regulating system to be determined. The treatment of special examples, in the shape of a speed governor and a voltage regulator, includes among other things a way of avoiding the solution of equations of high order, by the use of harmonic analysis, and an approximation method based on the consideration only of the most important partial solutions. Finally, the development of a regulating system for a [voltage] regulation of prescribed characteristics is given."

671. Matrices, Tensors, or Dyadics for Studying Electrical Networks? [Comparison of the Three Methods, leading to Choice of Matrix Method as the Most Useful].—M. B. Reed. (*Journ. Applied Phys.*, Nov. 1941, Vol. 12, No. 11, pp. 773–779.)

672. The Relationship between the Components of a "Fraser" Artificial Line for Duplex Balance.—P. A. Naumov. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 53–56.)

673. The Skin Effect in Cylindrical Conductors, especially of Elliptical Cross Section.—Fischer. (*See* 621.)

TRANSMISSION

674. On the Theory of the Klystron.—V. P. Gulyaev. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 100–105.)

It is pointed out that the theory of the klystron is not yet sufficiently elaborated and that in particular very little is known regarding the effect of the klystron parameters on the operating conditions necessary for the excitation of oscillations. It is also observed that the dielectric constant, and therefore the capacity, of the catcher in the klystron is periodically varied by the electrons reaching it, and that therefore the operation of the apparatus can be treated from the standpoint of the parametric excitation of oscillations as proposed by Mandelstam & Papalexi. In the subsequent discussion from this standpoint, conditions necessary for the excitation of oscillations are established, the phase relationships are determined, and methods are indicated for calculating the final amplitude of oscillations. The optimum operating conditions are also discussed. A footnote states that Kalinin's new work (1637 of 1941) does not contradict these results.

675. The Oscillation Regions of the Multi-Slit Magnetron.—O. Döhler & G. Lüders. (*Hochf.tech. u. Elek:akus.*, Oct. 1941, Vol. 58, No. 4, pp. 73–80.)

The slit-anode magnetron gives three kinds of oscillation, the Habann (negative-resistance) type; the "higher order" or "rotating-field" type (*see* 1370 & 2597 of 1935), with frequency *inversely* proportional to the magnetic field strength; and the "transit-time" type, with oscillation periods of the same order as the electron transit times, so that the oscillations are of the order n, where $n\,(=\omega_e/w_s)$ is about equal to or less than unity (ω_e is the angular velocity of the electrons, $e\mathfrak{H}/2m$, and ω_s that of the oscillations themselves). The present paper deals with the oscillation regions of the last type only, for magnetrons with two, four, six, and eight slits: questions of energy and efficiency are not dealt with, being reserved for a later work. Calculated values of n, based on H. G. Möller's "ring-current" theory (63 of 1937 and back ref.) which was developed for the four-slit magnetron by J. Möller (2954 of 1940), are obtained for all four types of magnetron, in each case for the four possible modes of excitation. Thus the original theory, applied to the two-slit magnetron, indicates that oscillations should occur for $n = 1.0$ (Barkhausen or "rolling-circle" excitation [*cf.* 1319 of 1937]: $\bar{\epsilon}$ is in phase with the anode voltage: for $\bar{\epsilon}$ *see* eqn. 8 in the discussion of Möller's "ring-current"); for $n = 0.33$ ("landing-current" excitation: $\bar{\epsilon}$ displaced by 180° with respect to the anode voltage: this mode also occurs in the simple diode with no magnetic field): for $n = 0.25$ ("influence-current" excitation: $\bar{\epsilon}$ displaced by 90°); and for $n = 0.22$. Further development of the theory, however (section IVa) shows that the condition $n = 1.0$ (which actually gives no oscillations in practice) should be replaced by $n = 0.57$ for the two-slit magnetron.

The writers then compare (table on p. 80) their theoretical results with measurements carried out by themselves and also, where possible, with the published results of other workers. For the two-slit magnetron their experimental values are 0.56, 0.35, 0.26, and 0.21 which agree well with the above calculated values and with the 0.54 and 0.33 found by Herriger & Hülster (3721 of 1936). Similarly consistent results are obtained for the four-, six-, and eight-slit magnetrons, the only serious discrepancy being with the six-slit type, where the writers' calculated and measured largest values of n are 0.80 and 0.78, whereas Herriger & Hülster (1319 of 1937) found 1.3: this difference is difficult to explain, but it is mentioned that these workers also measured the efficiency and gave $n = 0.80$ for the optimum energy condition.

Finally, the writers state [but this is not clear] that the table shows that with an increasing number of slits the oscillation regions occur at lower values of n: from this it is deduced (from considerations of back-heating) that larger anode radii can be used, and the tube loading thus increased.

676. Propagation of Electromagnetic Waves in a Space Charge rotating in a Magnetic Field [Theoretical & Experimental Investigation: the Possibilities of a Magnetron-Type Tube as a Reactance Tube at Ultra-High Frequencies: Need for Further Study to determine Structure combining High Theoretical Reactance with Lowest Possible Losses].—J. P. Blewett & S. Ramo. (*Journn. Applied Phys.*, Dec. 1941, Vol. 12, No. 12, pp. 856–859.) A summary, under a different title, was dealt with in 2670 of 1941.

677. Magnetrons with Grids [for Amplitude Modulation].—L. Müller. (*Hochf:tech. u. Elek:akus.*, Oct. 1941, Vol. 58, No. 4, pp. 81–95.)

The choice of frequency modulation for magnetrons, in preference to amplitude modulation, is largely influenced by the following defects in existing methods of carrying out the latter: a 100% modulation is impossible because even smaller depths of modulation make the oscillations break off, the h.f. current does not vary linearly with the modulating voltage, and the amplitude modulation is accompanied by an unwanted frequency modulation. In such existing methods the modulation is either direct, by voltage variations at the anode segments or at electrodes introduced specially for modulating purposes (six literature or patent references are given); or indirect, by influencing the h.f. energy in the oscillatory circuit or in the radiation field of the transmitter (six more references). "The indirect methods give, to some extent, good physical results, but involve more expenditure in apparatus and are not always practicable. It is therefore attempted in the present work to develop a satisfactory, simple method for the amplitude modulation of a magnetron": that is, a modulation, exerted on electrodes in the magnetron, which will be sufficiently free from the above defects.

Since the anode-voltage modulation procedure is the simplest of all, it should not be abandoned in favour of another method until its unsatisfactoriness has been definitely proved: until, for example, it has been established that even with the most careful selection of working conditions this method cannot, even at some sacrifice of efficiency, be made to give a satisfactory modulation. The writer therefore begins with a systematic experimental investigation of this point. It involves in the first place the measurement of output power: since the modulation properties of a magnetron vary within wide limits with the external resistance of the oscillatory circuit, generally valid modulation characteristics can be obtained only with power-measuring devices whose resistance remains constant for all values of load; incandescent lamps, for example, cannot be used. The characteristics are only of practical value when they correspond to (more or less) optimum power-output conditions for the magnetron, so that the procedure used must allow the best matching of the measuring device to the internal resistance of the magnetron. The thermojunction device employed by the writer (Figs. 1 & 2) enables currents and powers between 0.1 and 1.4 A and 0.3 and 4.8 W to be measured practically without error at a wavelength of 150 cm, and at 50 cm with about − 10% error. Frequency variations not less than about 5‰ were measured by a Lecher system: smaller variations required the use of a heterodyning method developed from the simple one given by Mulert (1934 Abstracts, p. 149): in its perfected form this technique allowed a frequency change of as little as 0.05‰ to be detected, and was applicable to wavelengths down to 30 cm.

The systematic investigation of anode-voltage modulation, for the transit-time type of oscillation of the second and higher orders (wavelengths 110 and 225 cm), showed that even the most careful choice of working conditions failed to improve the modulation characteristic to any great extent: the "best possible" characteristics are seen in Figs. 6 and 7, and the "smallest possible" frequency variation was found to be 0.25‰ per 1% of modulation. First-order oscillations (50 cm), obtained with the magnetic field oblique to the filament, gave the "best possible" characteristics of Figs. 10 and 11 by the careful choice of magnetic field strength and angle, and also of emission: as regards linearity they are worse than those for the higher-order oscillations, but the more important "depth of modulation attainable" is very much better (up to 90%) and the "smallest possible" frequency variation is only 0.036‰ per 1% modulation. This improved behaviour with the first-order oscillations is explained in the final paragraph of section C.

It was therefore decided to develop a "grid magnetron" with a particular eye on the oscillations of second and higher orders for which the anode-voltage modulation had been found so unsatisfactory. It was desired to design such a tube so that its efficiency should be almost as high as that of the grid-less type. This would be accomplished if the grid took on the potential which would exist, in the grid-less type, at the exact spot where the grid is introduced ("equipotential grid") But in practice the least possible taking-up of current by the grid is desired; that is, the grid should be at as low a potential as possible; at the smallest possible distance, in fact, from the cathode. Investigation of such "near-to-cathode," not-equipotential grids showed that a magnetron with such a grid has a definite value of penetration with severe matching requirements, such as the line amplifiers of modern transmission systems, the power of varying the internal resistance without affecting the degree of negative feedback is very desirable]. In Black's bridge connection the value of the internal resistance is not affected by the feedback [Fig. 1: but owing to the bridge circuit it is also impossible to vary the internal resistance at will: a special circuit with a differential transformer, also due to Black (Fig. 2), gives independent control of both quantities, but only for high values of negative feedback]. By a suitable choice of current and voltage feedbacks in a parallel circuit [due to Koch: Fig. 4] it has been successfully arranged that the desired internal-resistance variations can be obtained without altering the amplification [and without the requirement that the feedback should be large]. The behaviour of this circuit is investigated also for complex feedback paths," by which the internal resistance can be given a definite desired frequency dependence.

669. FOUR-CIRCUIT HIGH-FREQUENCY FILTER CIRCUITS WITH FOUR-HUMPED "LEVELLED" RESONANCE CURVES.—Sommer. (*See* 695.)

670. THE LAPLACE TRANSFORMATION AS A METHOD OF SOLUTION FOR BALANCING PROCESSES IN LINEAR NETWORKS, AND ITS APPLICATION TO AUTOMATIC REGULATION.—E. Grünwald. (*Arch. f. Elektrot.*, 25th Aug. 1941, Vol. 35, No. 7, pp. 379–400.)

Author's summary:—"After a short discussion about the Laplace transformation and the usefulness of its application to the problems of automatic regulation [*cf.* Artus, 401 of February], appropriate calculating methods are developed. In particular the fundamental equations are obtained for disturbances from the initial steady régime; these equations quite generally permit the characteristic behaviour of a regulating system to be determined. The treatment of special examples, in the shape of a speed governor and a voltage regulator, includes among other things a way of avoiding the solution of equations of high order, by the use of harmonic analysis, and an approximation method based on the consideration only of the most important partial solutions. Finally, the development of a regulating system for a [voltage] regulation of prescribed characteristics is given."

671. MATRICES, TENSORS, OR DYADICS FOR STUDYING ELECTRICAL NETWORKS? [Comparison of the Three Methods, leading to Choice of Matrix Method as the Most Useful].—M. B. Reed. (*Journ. Applied Phys.*, Nov. 1941, Vol. 12, No. 11, pp. 773–779.)

672. THE RELATIONSHIP BETWEEN THE COMPONENTS OF A "FRASER" ARTIFICIAL LINE FOR DUPLEX BALANCE.—P. A. Naumov. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 53–56.)

673. THE SKIN EFFECT IN CYLINDRICAL CONDUCTORS, ESPECIALLY OF ELLIPTICAL CROSS SECTION.—Fischer. (*See* 621.)

TRANSMISSION

674. ON THE THEORY OF THE KLYSTRON.—V. P. Gulyaev. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 100–105.)

It is pointed out that the theory of the klystron is not yet sufficiently elaborated and that in particular very little is known regarding the effect of the klystron parameters on the operating conditions necessary for the excitation of oscillations. It is also observed that the dielectric constant, and therefore the capacity, of the catcher in the klystron is periodically varied by the electrons reaching it, and that therefore the operation of the apparatus can be treated from the standpoint of the parametric excitation of oscillations as proposed by Mandelstam & Papalexi. In the subsequent discussion from this standpoint, conditions necessary for the excitation of oscillations are established, the phase relationships are determined, and methods are indicated for calculating the final amplitude of oscillations. The optimum operating conditions are also discussed. A footnote states that Kalinin's new work (1637 of 1941) does not contradict these results.

675. THE OSCILLATION REGIONS OF THE MULTI-SLIT MAGNETRON.—O. Döhler & G. Lüders. (*Hochf.tech. u. Elek:akus.*, Oct. 1941, Vol. 58, No. 4, pp. 73–80.)

The slit-anode magnetron gives three kinds of oscillation, the Habann (negative-resistance) type; the "higher order" or "rotating-field" type (*see* 1370 & 2597 of 1935), with frequency *inversely* proportional to the magnetic field strength; and the "transit-time" type, with oscillation periods of the same order as the electron transit times, so that the oscillations are of the order n, where $n\,(=\omega_e/\omega_s)$ is about equal to or less than unity (ω_e is the angular velocity of the electrons, $e\mathfrak{H}/2m$, and ω_s that of the oscillations themselves). The present paper deals with the oscillation regions of the last type only, for magnetrons with two, four, six, and eight slits: questions of energy and efficiency are not dealt with, being reserved for a later work. Calculated values of n, based on H. G. Möller's "ring-current" theory (63 of 1937 and back ref.) which was developed for the four-slit magnetron by J. Möller (2954 of 1940), are obtained for all four types of magnetron, in each case for the four possible modes of excitation. Thus the original theory, applied to the two-slit magnetron, indicates that oscillations should occur for $n = 1.0$ (Barkhausen or "rolling-circle" excitation [*cf.* 1319 of 1937]: $\bar{\epsilon}$ is in phase with the anode voltage: for $\bar{\epsilon}$ *see* eqn. 8 in the discussion of Möller's "ring-current"); for $n = 0.33$ ("landing-current" excitation: $\bar{\epsilon}$ displaced by 180° with respect to the anode voltage: this mode also occurs in the simple diode with no magnetic field): for $n = 0.25$ ("influence-current" excitation: $\bar{\epsilon}$ displaced by 90°); and for $n = 0.22$. Further development of the theory, however (section IVa) shows that the condition $n = 1.0$ (which actually gives no oscillations in practice) should be replaced by $n = 0.57$ for the two-slit magnetron.

The writers then compare (table on p. 80) their theoretical results with measurements carried out by themselves and also, where possible, with the published results of other workers. For the two-slit magnetron their experimental values are 0.56, 0.35, 0.26, and 0.21 which agree well with the above calculated values and with the 0.54 and 0.33 found by Herriger & Hülster (3721 of 1936). Similarly consistent results are obtained for the four-, six-, and eight-slit magnetrons, the only serious discrepancy being with the six-slit type, where the writers' calculated and measured largest values of n are 0.80 and 0.78, whereas Herriger & Hülster (1319 of 1937) found 1.3 : this difference is difficult to explain, but it is mentioned that these workers also measured the efficiency and gave $n = 0.80$ for the optimum energy condition.

Finally, the writers state [but this is not clear] that the table shows that with an increasing number of slits the oscillation regions occur at lower values of n : from this it is deduced (from considerations of back-heating) that larger anode radii can be used, and the tube loading thus increased.

676. Propagation of Electromagnetic Waves in a Space Charge rotating in a Magnetic Field [Theoretical & Experimental Investigation : the Possibilities of a Magnetron-Type Tube as a Reactance Tube at Ultra-High Frequencies : Need for Further Study to determine Structure combining High Theoretical Reactance with Lowest Possible Losses].—J. P. Blewett & S. Ramo. (*Journ. Applied Phys.*, Dec. 1941, Vol. 12, No. 12, pp. 856–859.) A summary, under a different title, was dealt with in 2670 of 1941.

677. Magnetrons with Grids [for Amplitude Modulation].—L. Müller. (*Hochf:tech. u. Elek:akus.*, Oct. 1941, Vol. 58, No. 4, pp. 81–95.)

The choice of frequency modulation for magnetrons, in preference to amplitude modulation, is largely influenced by the following defects in existing methods of carrying out the latter : a 100% modulation is impossible because even smaller depths of modulation make the oscillations break off, the h.f. current does not vary linearly with the modulating voltage, and the amplitude modulation is accompanied by an unwanted frequency modulation. In such existing methods the modulation is either direct, by voltage variations at the anode segments or at electrodes introduced specially for modulating purposes (six literature or patent references are given) ; or indirect, by influencing the h.f. energy in the oscillatory circuit or in the radiation field of the transmitter (six more references). "The indirect methods give, to some extent, good physical results, but involve more expenditure in apparatus and are not always practicable. It is therefore attempted in the present work to develop a satisfactory, simple method for the amplitude modulation of a magnetron" : that is, a modulation, exerted on electrodes in the magnetron, which will be sufficiently free from the above defects.

Since the anode-voltage modulation procedure is the simplest of all, it should not be abandoned in favour of another method until its unsatisfactoriness has been definitely proved : until, for example, it has been established that even with the most careful selection of working conditions this method cannot, even at some sacrifice of efficiency, be made to give a satisfactory modulation. The writer therefore begins with a systematic experimental investigation of this point. It involves in the first place the measurement of output power : since the modulation properties of a magnetron vary within wide limits with the external resistance of the oscillatory circuit, generally valid modulation characteristics can be obtained only with power-measuring devices whose resistance remains constant for all values of load ; incandescent lamps, for example, cannot be used. The characteristics are only of practical value when they correspond to (more or less) optimum power-output conditions for the magnetron, so that the procedure used must allow the best matching of the measuring device to the internal resistance of the magnetron. The thermojunction device employed by the writer (Figs. 1 & 2) enables currents and powers between 0.1 and 1.4 A and 0.3 and 4.8 W to be measured practically without error at a wavelength of 150 cm, and at 50 cm with about − 10% error. Frequency variations not less than about 5‰ were measured by a Lecher system : smaller variations required the use of a heterodyning method developed from the simple one given by Mulert (1934 Abstracts, p. 149) : in its perfected form this technique allowed a frequency change of as little as 0.05‰ to be detected, and was applicable to wavelengths down to 30 cm.

The systematic investigation of anode-voltage modulation, for the transit-time type of oscillation of the second and higher orders (wavelengths 110 and 225 cm), showed that even the most careful choice of working conditions failed to improve the modulation characteristic to any great extent : the "best possible" characteristics are seen in Figs. 6 and 7, and the "smallest possible" frequency variation was found to be 0.25‰ per 1% of modulation. First-order oscillations (50 cm), obtained with the magnetic field oblique to the filament, gave the "best possible" characteristics of Figs. 10 and 11 by the careful choice of magnetic field strength and angle, and also of emission : as regards linearity they are worse than those for the higher-order oscillations, but the more important "depth of modulation attainable" is very much better (up to 90%) and the "smallest possible" frequency variation is only 0.036‰ per 1% modulation. This improved behaviour with the first-order oscillations is explained in the final paragraph of section C.

It was therefore decided to develop a "grid magnetron" with a particular eye on the oscillations of second and higher orders for which the anode-voltage modulation had been found so unsatisfactory. It was desired to design such a tube so that its efficiency should be almost as high as that of the grid-less type. This would be accomplished if the grid took on the potential which would exist, in the grid-less type, at the exact spot where the grid is introduced ("equipotential grid") But in practice the least possible taking-up of current by the grid is desired ; that is, the grid should be at as low a potential as possible ; at the smallest possible distance, in fact, from the cathode. Investigation of such "near-to-cathode," not-equipotential grids showed that a magnetron with such a grid has a definite value of penetration coefficient (" Durchgriff ") for which the maximum efficiency occurs exactly when the grid potential is zero (Figs. 16 & 17). For a grid pitch giving a " durchgriff " smaller than this critical value the grid bias must be made positive if the efficiency is to be maintained approximately. Only a slightly greater efficiency can be obtained by using a " durchgriff " slightly higher, combined with a negative bias. The value of the " critical durchgriff " increases with the ratio grid-radius/anode-radius, and these values, and the grid voltages necessary for complete control (h.f. power = 0), are given in the table on p. 90 for four different values of this ratio. For optimum designs of a four-slit magnetron and a two-slit magnetron, the variation of efficiency with the order of the oscillation is examined : as the order increases, the efficiency of the grid magnetron rises steadily towards that of the grid-less tube, the difference being only 22% for $n = 2$ and 15% for $n = 15$, whereas with the first-order oscillation (for which the tube is not designed, and which is seriously distorted by the grid) the efficiency is only one-fifth of that of the grid-less tube.

For true " guiding-path " oscillations (high-order oscillations) the grid magnetron will give 100% and almost linear modulation. For second-order oscillations (mixed " rolling-circle " and " guiding-path " oscillations : *cf.* Herriger & Hülster, 1319 of 1937) the modulation characteristic shows some points of instability ; but even here a nearly linear modulation up to 95–100% can be obtained by the use of a continuously varying grid pitch and an anode system mounted obliquely to the magnetic field. The frequency variation is of about the same order as with anode-voltage modulation (*see* above) but its amount can be divided by about 100 by simultaneous modulation on grid and on anode. The grid magnetron gave no signs of back-heating up to an anode voltage of 2000 v, and only slight signs at higher voltages. The necessary modulating energy is small.

678. Contribution to the Theory of the Sidebands in Frequency Modulation.—T. Vellat. (*E.N.T.*, July 1941, Vol. 18, No. 7, pp. 149–155.)

From the Telefunken laboratories. One well-known difference between frequency and amplitude modulations is that in the latter the amplitude of the carrier oscillation is independent of the modulation and is constant, whereas in the former it is proportional to the Bessel function of zero order : $A\omega = I | J_o(x) |$, and $J_o(x)$ has null points, so that for certain values of the modulation index x (frequency-deviation / modulating-frequency) the carrier frequency vanishes. Recent measurements published in American literature indicate that frequency-modulated oscillations show a further fundamental difference from those which are amplitude-modulated : in the latter, whatever the curve-form of the modulation, the sideband oscillations are symmetrical to the carrier frequency in amplitude and phase, while in frequency modulation frequency spectra may occur which are asymmetrical in respect to amplitude : the only reference given is to Kroger, Trevor, & Smith's paper, 4080 of 1940. It is this new experimental result that the present writer investigates analytically.

He first gives the theoretical basis for the amplitude symmetry of the amplitude-modulated wave, and then shows (directly from eqn. 1) that a sinusoidally frequency-modulated wave also gives amplitude symmetry with respect to the carrier frequency (eqn. 8). Then, representing the modulation function to be transmitted by the function $M(t)$ with the time-period $2\pi(\omega_N)$, the real Fourier analysis of this function gives eqn. 9 containing a constant term a_o, which signifies that the shaded surfaces above and below the time axis in Fig. 2 (representing the modulation function in its most general form) are unequal in area. This a_o is seen also in eqn. 10 for the frequency-modulated wave, derived from eqn. 9, and its influence is seen directly : the carrier frequency ω_t is displaced by an amount a_o : the frequency no longer swings about ω_t but about $\omega_t + a_o$: a receiver would be best tuned at $\omega_t + a_o$. But a_o alters with the modulation function $M(t)$: in particular, in the modulation pauses the function $M(t)$, and consequently a_o, becomes zero, so that a correct tuning of the receiver would be impossible. The subsequent investigation of eqn. 10 assumes that a_o is zero, so that the shaded areas above and below the time axis are equally large. Just as, previously, x represented the modulation index of the wave frequency-modulated by the low sinusoidal frequency ω_N, so x_n now represents the modulation index of the harmonic $n \cdot \omega_N$. Then eqns. 14a and 14b are obtained for the amplitudes of the sideband with the frequency $\omega_t + k\omega_N$ and of that with the frequency $\omega_t - k\omega_N$, respectively, where $k = n_1 + 2n_2 + 3n_3 + \ldots \infty n_\infty$. That these two expressions need not be equal is more easily seen if the simplest case is taken, when only x_1 and x_2 are present : the equations then reduce to eqns. 15 and 15a.

The next step is to assume that in these last two equations the phase angles are both zero ; that is, that $\phi_1 = 0$ and $\phi_2 = 0$: this means that the modulation function $M(t)$ takes the form $M(t) = a_1 \cos \omega_N t + a_2 \cos 2\omega_N t$ (Fig. 3). On this assumption, the amplitude of the first sideband above the carrier frequency is given by eqn. 16a, that of the first sideband below the carrier by eqn. 16b : it is seen that $A_{\omega_t + \omega_N}$ and $A_{\omega_t - \omega_N}$ are different. Similarly, it is shown that the amplitudes of the second sidebands, namely $A_{\omega_t + 2\omega_N}$ and $A_{\omega_t - 2\omega_N}$, are different. But on another assumption, that $\phi_1 = 0$ and $\phi_2 = \pi/2$, meaning that the modulation function takes the form $M(t) = a_1 \cos \omega_N t + b_2 \sin 2\omega_N t$ (Fig. 4), it is found that the amplitudes of the first sidebands are equal, and those of the second sidebands also equal : or generally, that $A_{\omega_t + k\omega_N} = A_{\omega_t - k\omega_N}$, so that the sideband spectrum is symmetrical. The above is based on the previous assumption of only two sidebands (only x_1 and x_2 present—*see* above), and the condition for sideband symmetry is seen from Fig. 4 to be that the modulation function should be radially symmetrical for the points P or Q. But an obvious deduction is that quite generally (that is, even when higher harmonics are present) the sideband spectrum will be symmetrical in amplitude with respect to the carrier frequency provided that the modulation function has radial symmetry (as in Fig. 5) : for this, the condition to be fulfilled is that $\phi_1, \phi_3, \phi_5 \ldots = 0$, and $\phi_2, \phi_4, \phi_6 \ldots = \pm\pi/2$. "An exact, physically clear foundation for the occurrence of asymmetrical sidebands in frequency modulation is not known to the writer," but in his last paragraphs he attempts a superficial explanation based on the vector diagram of Fig. 7.

679. Oscillation Processes in Periodic Phase-Manipulation.—G. Hässler. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 109–112.)

"The increased use of phase and frequency modulation prompts the consideration of the oscillatory processes occurring at the output of a frequency-selective transmission system whose input is subjected to an alternating voltage changing its phase suddenly backwards and forwards between two values. The following treatment is limited to the simplest case of such a process, where the alternating voltage changes from one phase position to the other periodically, in equal spaces of time. Even though this simplest assumption may not cover all practical possibilities, at any rate the results obtained give considerable information on the fundamental behaviour of a transmission system under phase-manipulation."

The input is subjected to an alternating voltage, of frequency ω, which at time intervals $\tau = \pi/\Omega$ periodically takes on the alternate phase values $\phi = \phi_o$ and $\phi = 0$ (keying ratio 1 : 1 with keying frequency Ω). The frequency spectrum of this process is found by Fourier analysis to be given by eqn. 5, containing the carrier ω with the sidebands $\omega \pm \Omega$, $\omega \pm 3\Omega$, ... The amplitude distribution is given by eqn. 6, and is represented in Fig. 1 for the cases $\phi_o = 45°$, $90°$, $135°$, and $180°$. It is seen that phase-manipulation produces a wide sideband spectrum, in which the carrier amplitude becomes smaller and smaller in comparison with the sideband amplitudes as the keying-angle becomes larger: at 180° the carrier amplitude is zero. The individual frequencies of this spectrum undergo different amounts of phase displacement and attenuation on passing over a frequency-selective path. On the assumption (holding with good approximation for the pass region of the usual filter arrangements) of a phase angle altering linearly with the frequency, there occurs a phase displacement of the carrier frequency and of the keying process, with respect to the original state, which is of no importance for the investigation. In what follows, therefore, the phase rotation by the transmission path is neglected and only the frequency-dependent attenuation of the component oscillations is considered. The carrier wave ω passes without weakening (output voltage = input voltage) while the output voltage of any other frequency ν bears a ratio μ_ν to the input voltage. There appears, therefore, at the output of the system a "distorted" process given by eqn. 7.

Of the many possible types of transmission-path characteristic only one or two important ones are selected for consideration. In view of the desire to use the smallest possible frequency band, the most important of all is one which passes only the carrier and the two first-order sidebands $\omega + \Omega$ and $\omega - \Omega$. Assuming an attenuation curve symmetrical to the carrier ($\mu_{\omega + \Omega} = \mu_{\omega - \Omega} = \mu$) eqn. 7 simplifies in this case to the three terms seen at the end of p. 110. The vector representation shown in Fig. 2 makes it clear that the resulting oscillation vector undergoes an amplitude modulation and a phase modulation. The course of the amplitude on the assumption of $\mu = 1$ (undamped sideband transmission), is seen in the curves of Fig. 3, and that of the phase in Fig. 4, for the same keying angles (ϕ_o) as taken in Fig. 1. It is found that as a result of the phase jump at the input there occurs at the output a phase modulation which is practically sinusoidal at small keying angles, and an additional amplitude modulation which increases with the keying angle. At 180° a beat effect occurs (corresponding to a two-sideband transmission with suppressed carrier) in which the amplitude falls to zero and a phase change of 180° takes place at the null point: true phase modulation no longer occurs. If the passage of the sidebands is not undamped ($\mu < 1$), both the phase and amplitude modulations are reduced. Eqns. 8 & 9 show that a decrease of μ has the same effect as a decrease in tan $\phi_o/2$: the attenuation of the sidebands is equivalent in its effect to a reduction in the keying angle.

The course of the instantaneous frequency at the output of the transmission path is of interest, since the phase modulation has also a frequency modulation as a consequence. The deviation $\Delta\omega$ of the instantaneous frequency from the carrier frequency, when $\mu = 1$, is given by eqn. 10a: it is proportional to the keying frequency Ω, and the course of the ratio $\Delta\omega/\Omega$, as a function of Ωt, is shown in Fig. 5 for $\phi_o = 45°$, $90°$, and $135°$. It is seen that at each phase jump at the input of the transmission system there occurs at its output a transitory frequency change whose sign corresponds to the direction of the phase jump and whose magnitude corresponds to the size of the keying angle.

If the transmission system is given a definite band width, the more sidebands will succeed in passing, the lower the keying speed: thus the highest possible keying frequency is that which allows just the first-order sidebands to pass, as dealt with above. Consideration of keying frequencies of 1/3rd and 1/5th the max. frequency leads to the phase and frequency curves of Figs. 6 & 7, on the assumption of the unweakened transmission of the resulting sidebands ($\Omega \pm \omega$ and $\omega \pm 3\Omega$ in the first case and $\Omega \pm \omega$, $\omega \pm 3\Omega$, and $\omega \pm 5\Omega$ in the second). These curves show that (apart from the swings of phase and frequency about the final values, produced by the higher sidebands) for a fixed band width in the transmission system the steepness of the phase variation, and the magnitude of the frequency deviation, resulting from the influence of the higher sidebands depends only to a slight degree on the keying speed. It is deduced that this result applies with good approximation to the case where the sideband attenuation through the system is *not* zero, and experiments have confirmed this. Fig. 6 also shows that the building-up time τ for the new phase condition is also practically independent of the keying speed, being equal to the length of a half-period of the max. keying frequency. Since this max. frequency is equal to half the band width, the law that the building-up time is equal to the reciprocal of the band width is seen to apply also to phase manipulation.

680. On the Influencing of a Discharge Plasma by an Electrically Controlled Grid [and the Effect of the Curvature of the Grid Wires].—W. O. Schumann. (*Arch. f. Elektrot.*, 25th Aug. 1941, Vol. 35, No. 7, pp. 437–444.)

The work described in Part I dates from 1937: the grids described by Kobel and Lüdi (1157 of 1937 and back reference) are not considered, "since their action depends on special subsidiary effects." For Schumann's other recent work *see* 2685 of 1941 and Sichling's paper dealt with in 111 of January, which also gives other references; for similar work on inert-gas plasmas *see* Leimberger, 410 of February.

"If one brings into the plasma of a vacuum-discharge arc a grid which is given a more negative potential than that possessed by the plasma at the locality of the grid, this grid attracts positive ions from the plasma and repels the negative electrons. This withdrawal of positive ions alters the composition of the plasma in the plane of the grid, so that the arc current diminishes or may be extinguished. In order to affect the plasma as strongly as possible it is therefore necessary to shape the grid in such a way that it deionises the plasma as effectively as possible. This is best accomplished by grids composed of elements with sufficiently sharp curvature, since with these an increased applied potential will cause the greatest increase in the quantity of ions withdrawn." Part I. deals with this point on the lines of the Langmuir/Mott-Smith theory for concentric electrodes; "in all cases one arrives in practice at wires of 0.1 mm radius and less, and at meshes of about 10 per cm upwards. Only if considerably higher potentials are allowed, or plasmas of unusually low density are worked with, can coarser grids be used. But the higher potentials increase the danger of disintegration and of back-discharge at the grid . . ." Similar considerations apply to electrodes of shapes other than cylindrical: in all cases it is a matter of sufficient curvature—for instance, of the edges of the holes, in grids in the form of perforated sheet.

The formulae used in Part I apply only to the stationary régime: the relations obtaining when the grid potential rises very quickly are quite different, since the positive ions can, owing to their large mass, be considered as stationary during the potential rise; or, if potential pulses follow one another in succession, as moving towards the electrode with a constant average velocity. "Only if the influencing electrode has such a potential course relative to the plasma that the potential integral over a period is equal to zero, does no impulse effect occur on the positive ions (we neglect, here, the periodic positive condition of the anode at the extinction of current. How far this may give an average impulse to the ions will depend on whether or not large positive anode-falls occur. They should, however, only appear at extremely high frequencies)". The more recent work of Part II therefore considers the action of potential impulses acting on a cylindrical electrode. A wire of radius ρ is supposed to lie inside a plasma of radius R (very large compared with ρ) and to be given a sudden potential negative to the plasma, so that before the electrons begin to move a charge-free electrostatic field exists between ρ and R. As a result of this field the electrons then begin to move outwards, leaving a positive-ion layer of radius s round the wire; outside this layer an electrostatic charge-free field exists (Fig. 1 and adjacent text).

"From eqns. 3 and 4 it follows that oscillations of the electron block will make their appearance; *i.e.*, the thickness of the ionic layer fluctuates rhythmically . . . The ratio s/ρ for maximum layer thickness is about twice the value of s/ρ for the stationary final state . . . To determine the frequency of these oscillations, the equation $\int^{v} ds/v = t$ must be integrated and reversed. It is found to be dependent on amplitude. To a first approximation it can be calculated, for small amplitudes, by supposing small oscillations to be superposed on a stationary régime." Two resonant points are found. The first of these, a parallel-resonance frequency, is given by $\omega_p = \sqrt{pe/\Delta m}$, and is equal to Langmuir's spontaneous natural frequency of a plasma: "for normal mercury-vapour plasma it corresponds to a wavelength in the region of 30 cm" [*cf.* same writer, 2685 of 1941: "of the order of 10^{10} per sec."]. The second, a series-resonance frequency, is given by

$$w_s = w_p \sqrt{\log_e s_e/\rho / \log_e R/\rho},$$

and is thus equal to the natural frequency ω_R obtained on p. 443 as the natural frequency for maximum layer-oscillation: "at this frequency the electron block swings in resonance and its oscillation amplitude is at its greatest." The two resonant frequencies can be considered as those of a series connection of the layer capacitance with a combination in parallel of the geometrical plasma capacitance and the plasma inductance due to electron inertia. "The whole circuit is capacitive at low frequencies, becomes inductive as ω_s is passed through, and again capacitive as ω_p is exceeded. ω_s is the frequency of free oscillation on the application of a potential impulse, whereas a current impulse produces ω_p."

681. A 112-Mc. Emergency Transmitter: Portable Oscillator and Modulator for Vibrator Plate Supply.—G. Grammer. (*QST*, Dec. 1941, Vol. 25, No. 12, pp. 14–19 and 68..72.) *See* also 883, below.

682. A Mobile Transmitter for 2½ Metres.—V. Chambers. (*QST*, Nov. 1941, Vol. 25, No. 11, pp. 36–38 and 84, 86.)

683. A Low-*C* Electron-Coupled Oscillator [Variable Frequency, with High Frequency Stability].—E. O. Seiler. (*QST*, Nov. 1941, Vol. 25, No. 11, pp. 26–27 and 78.) Prompted by Roberts's paper (3380 of 1940) on the limits of inherent frequency stability.

684. Variable Crystal Frequency with a Type 815 Locked Oscillator [3.5 Mc/s Output Frequency varied 7–10 kc/s].—(*QST*, Nov. 1941, Vol. 25, No. 11, pp. 53–54.)

685. Cutting Bias Supply Size and Cost [Unorthodox Circuit saving 50 lb in a One-Kilowatt Transmitter].—J. D. Blitch. (*QST*, Dec. 1941, Vol. 25, No. 12, pp. 29–30 and 72, 74.)

686. "LEARNING MORSE: NINTH EDITION" [Book Notice].—(*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 12.)

687. THE DEVELOPMENT OF MODULATORS FOR CARRIER-FREQUENCY COMMUNICATION TECHNIQUE [Wire & Wireless: particularly the Latest Cu_2O Ring Modulators].—O. Henkler. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 112–114.)

In order to suppress some of the disturbing modulation products, and to increase the efficiency, the simple non-linear circuit for frequency transposition has in modern practice been replaced by push-pull or double-push-pull circuits. Of these, the simplest and most convenient is the ring modulator, which has the advantage of particularly good efficiency and also the useful property that the modulation products appearing at one of the three pairs of terminals (carrier, signal, and output circuits) are absent at both the other two. The enormous saving in space attained by the introduction of the copper-oxide rectifier is seen in the photographs: the right-hand ring modulator in Fig. 3 is a double-push-pull circuit with four non-linear circuits, using the 7 mm type of rectifier and applicable to frequencies from the lowest a.f. up to several Mc/s: while the valve modulator of Fig. 1 has only one non-linear circuit. The 20 mm copper-oxide rectifier seen in the middle of Fig. 2 has been largely superseded by the 7 mm type, which has the added advantage of being sealed up in a ceramic tube.

The copper-oxide rectifier has a comparatively large capacitance, and for that reason was at first used only for the modulation of low frequencies: but calculation and experiment showed that the capacitance did no harm even at high frequencies. The damping at 1 Mc/s is only about 0.3–0.5 neper higher than in the a.f. range: this is because the capacitance as well as the ohmic resistance varies non-linearly with the applied voltage, and thus contributes to the modulation. A ring modulator made from such rectifiers has a non-linear-distortion factor satisfying the requirements of a modern carrier system, and requires a carrier power of only about 1 mw instead of the hundred-times greater value needed by the older types. *Cf.* "Varistors as Modulators", *Bell Lab. Record*, Dec. 1941, Vol. 20, No. 4, p. 105.

RECEPTION

688. TWO U.H.F. RECEIVERS USING THE 9000 SERIES TUBES: A 112 & 224 Mc/s SUPER-REGENERATIVE AND A 112 Mc/s TUNED-R.F. RECEIVER.—B. Goodman. (*QST*, Nov. 1941, Vol. 25, No. 11, pp. 10–14 and 62, 64.) Following on 110 of January.

689. AN EXPERIMENTAL 112-Mc. RECEIVER: OVERCOMING THE FAULTS OF THE SUPER-REGENERATIVE RECEIVER [Superheterodyne with Super-Regenerative Final Detector].—J. W. Brannin. (*QST*, Dec. 1941, Vol. 25, No. 12, pp. 36–38 and 78, 80.)

690. A COMPACT RECEIVER FOR 112 Mc. [primarily for Car Dashboard Mounting].—V. Chambers. (*QST*, Dec. 1941, Vol. 25, No. 12, pp. 31–33 and 49.)

691. RECEIVERS MAINTAINING CONSTANT PHASE RELATIONSHIPS: "CONSECUTIVE" AND "DOUBLE" HETERODYNING. — Yuzvinski. (*See* 625 & 626.)

692. IS SHARP PHASE SELECTIVITY POSSIBLE?—Gorelik. (*See* 627.)

693. ON THE THEORY OF DIODE DETECTION.—V. A. Lazarev. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 106–112.)

It is pointed out that although a large number of papers have been published on the subject, no exact theory of diode detection is available. This is due to the fact that in theoretical discussions it is usual to simplify greatly the rectifier circuit, with the result that in conclusions reached the effect of some circuit element or other is completely neglected. A stricter theory is therefore presented which, although not free from certain assumptions, corresponds (it is claimed) more fully to the physical processes taking place in the detector.

The cases of modulated and unmodulated oscillations are considered separately, and non-linear differential equations 9 and 10 respectively are derived to represent the detection process. Methods are indicated for integrating eqn. 9, and therefore eqn. 10, which is a particular case of that equation. The discussion is illustrated by a concrete example.

694. VALVE NOISE AND RESISTANCE NOISE.—F. Borgnis. (*E.T.Z.*, 21st Aug. 1941, Vol. 62, No. 34, pp. 727–729.)

A short survey, leading to equations for the mean valve-noise current (eqn. 1: a "weakening factor" F must be introduced here for space-charge-limited conditions); for the mean resistance-noise voltage (eqn. 2: at a room temperature of 293° K, and measuring the resistance in kilohms and the band width in kilocycles/second, this reduces to $0.126\sqrt{R\Delta f}$ μV); and for the conversion from mean current to mean voltage and *vice versa*. Finally, for circuits with complex resistances eqn. 7 is obtained for the square of the mean noise voltage: applying this to a low-damping oscillatory circuit (Fig. 2) followed by an amplifier whose band width is large compared with the resonance width of the circuit, it can be reduced to an approximate value kT/C, where k is the Boltzmann constant. Hence the mean noise voltage itself, for the assumed room temperature of 293° K, is given approximately as $63/\sqrt{C}$ μV when C is measured in picofarads: so that a short-wave oscillatory circuit with $C = 10$ pF would have a mean noise voltage of 20 μV. The above approximation becomes $0.16\sqrt{R_{res}\Delta f_H}$ μV when $1/C$ is replaced by the half-value width (in kc/s) of the oscillatory-circuit resonance curve and the resonance resistance (in kilohms).

695. FOUR-CIRCUIT HIGH-FREQUENCY FILTER CIRCUITS WITH FOUR-HUMPED, "LEVELLED" RESONANCE CURVES.—J. Sommer. (*E.N.T.*, Aug. 1941, Vol. 18, No. 8, pp. 178–193.)

By coupling two or more oscillatory circuits a filter is obtained having a resonance curve with several humps and combining a heightened selectivity with a wider pass-band. In broadcast receivers the habit has been to make up a four-circuit filter from two two-circuit, two-humped filters, the selectivity being increased by connecting the two *similar* filters in series, with a valve between them. The writer now examines the question whether such four-circuit filters cannot better be composed of two two-circuit filters of *different* electrical dimensions.

Author's summary :—" A four-circuit filter with ' levelled ' transmission curve is investigated [by ' levelled ' (geebnete) is meant that the humps are all equally high and the troughs all equally deep : Figs. 2 & 3]. The locus curve of the transmission factor [reciprocal of the amplification] $\ddot{u} = 1/\mathfrak{V}$ of a four-circuit filter is the complex parabola $\ddot{u} = \ddot{u}_o (F_o + jF_1\Omega - F_2\Omega^2 - j\Omega^3 + \Omega^4)$ of the fourth degree [provided only symmetrical filters are considered, and these are the only ones of interest, since asymmetry produces distortion]. For the special case of the ' levelled ' resonance curve, the form factors F_0, F_1, and F_2 must bear a special relation to one another. With the help of the Tschebyscheff function $T_8 = \cos(8 \text{ arc} \cos \Omega/\Omega_g)$ [which passes exactly 8 times, within the region $x = +1$ to $x = -1$, from the value $T = +1$ to the value $T = -1$, and which thus corresponds to a four-hump resonance curve], this relation is determined [eqn. 24, where A stands for $1 - 2F_2$, so that the equation involves all three form factors]. Further, it is shown what connection exists between these form factors, the ' ripple ' of the transmission curve in the pass band [measured by the " hump attenuation " b_H, eqns. 32 & 35], and the ' standardised ' limiting detuning Ω_g " [defined as lying at the point where, for the last time, the transmission curve passes through the same value as at the middle of the pass band : *see* Fig. 3. Eqn. 36 gives $\Omega_g = \pm \sqrt{F_2 - 0.5}$. The curves of Fig. 10 give the three form factors and the cut-off frequency Ω_g as functions of the " ripple," represented by the " hump attenuation " b_H].

" The design of a four-circuit filter with a ' levelled ' resonance curve, made up from two [different] two-circuit band filters [Fig. 13], is examined, and also that of a four-circuit filter made up from four separate circuits [Fig. 14 : two main reasons are given against the simple series connection of four coupled circuits shown in Fig. 12, and the combination seen in Fig. 14 requires, therefore, two additional valves] . . . The calculation shows that the ratio of the time constants of the two two-circuit filters is independent of the ' ripple ' of the resonance curve. A comparison is then made of a four-circuit filter of this type with a filter having the same number of circuits but made up from two *equal* two-circuit filters [same connections as in Fig. 13, but different values]. It is found that for an equal ' ripple ' in the resonance curve, and equal selectivity, the filter with the four-circuit arrangement [giving the four "levelled" humps] can transmit a wider frequency band. For an i.f. filter, for example, a higher selectivity can be attained without decreasing the band width in the pass region, provided that coils of higher quality [*e.g.* $\rho = 600$] than are usual today are available. While, therefore, with two-circuit filters even the existing values of quality factor cannot be utilised fully, the development of still higher values is desirable for the sake of the four-circuit filter with ' levelled ' resonance curve.

" Finally, the detuning angle [difference in angle between the amplified output voltages at the middle of the band and at a detuning Ω] of the four-circuit filter with ' levelled ' four-hump curve is found and compared with the phase behaviour of a filter composed of two equal two-circuit filters. The former filter, in contrast to the latter, shows an almost linear phase characteristic in the pass band " [Fig. 25].

696. A VARIABLE-PHASE TRANSFORMER AND ITS USE AS AN A.C. INTERFERENCE ELIMINATOR [primarily to eliminate 60 c/s Hum].—Kolin. (*See* 665.)

697. STATIC ELECTRICITY AND ITS EFFECT ON CAR RADIO PERFORMANCE [Interference Not Due to Spark Discharges but to Action of Sharply Varying Electrostatic Fields : Different Sensitivities of Different Types of Aerial : Preventive Action of Conductive Powder introduced into Inner Tube : Application of Results to Industry : etc.].—S. M. Cadwell, N. E. Handel, & G. L. Benson. (*News Edition, Am. Chem. Soc.*, 25th Oct. 1941, Vol. 19, No. 20, pp. 1130–1141.) *See* also *Scient. American*, Nov. 1941, p. 274, *and* Bartholomew, Beach, *Elec. Engineering*, Aug. 1941, Vol. 60, No. 8, pp. 415–416.

698. HIGH FIDELITY [as regards Frequency Range] NOT WANTED.—E. La Prade. (*Sci. News Letter*, 1st Nov. 1941, Vol. 40, No. 18, p. 286.) Based on S. E. Gill's survey : but high fidelity as regards contrast range, studio acoustics, balance & perspective would be more acceptable.

699. TONE CONTROL BY NEGATIVE FEEDBACK [Circuit giving Exceptionally Wide Range].—W. Moody. (*QST*, Dec. 1941, Vol. 25, No. 12, pp. 48–49.)

700. " THE RADIOTRON DESIGNER'S HANDBOOK " [Book Review].—F. Langford Smith. (*QST*, Dec. 1941, Vol. 25, No. 12, p. 80.)

701. AN " ALL-DRY " PORTABLE : FURTHER NOTES ON THE DESIGN OF A " PERSONAL " HEADPHONE SET [using Two Valves Type N 14, with Filaments in Series off 3 V Cell, and 9 V for Anodes].—S. W. Amos. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 21.) Sequel to 2695 of 1941.

702. PORTABLE H.T. BATTERIES : RECENT IMPROVEMENTS IN VOLUMETRIC EFFICIENCY.—H. F. French. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 9.) Based on French's paper, 3306 of 1941.

703. MORE MEANING IN YOUR SIGNAL REPORTS [Conversion and Interpretation of Signal-Strength Reports based on the " S-Meter " embodied in Various Types of Communications Receivers].—S. G. Taylor. (*QST*, Nov. 1941, Vol. 25, No. 11, pp. 30–33 and 78 . . 82.)

AERIALS AND AERIAL SYSTEMS

704. An Operational Treatment of Electromagnetic Waves along Wires.—Pipes. (*See* 619.)

705. The Energy Relationships in Oscillating Systems, and the Parameters of Radiating Systems.—V. N. Kessenikh. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 77–100.)

In studying radiating systems it is usual to replace them either by systems with a limited number of degrees of freedom or by systems with an infinite number of degrees of freedom but limited in space. In both cases the radiating system is assumed to have the parameters of the systems replacing it, and a definite value of total energy is ascribed to it. Considerable difficulties arise, however, from the fact that (a) a radiating system is in continuous interaction with the field set up by it, and (b) the amount of energy in the field is indefinitely large, depending on the "history" of the system. Accordingly, a theoretical investigation is presented, the main objects of which are, first, to ascertain whether it is possible to divide the total energy of a radiating system into the definite finite energy of the system itself and an indefinitely large radiated energy of the field, and second, to modify the parameters of oscillating systems so as to make them applicable to the case of a radiating system.

The investigation starts with a study of one of the simplest "dissipating" systems, namely a two-terminal network connected in series with a source of sinusoidal e.m.f. and a load. This is followed by an examination of the four-terminal network. A mechanical radiator (conical loudspeaker) is then considered, and finally electromagnetic radiation from a single wire and a spherical radiator is considered.

The conception of the "energy reserve" of a system, *i.e.* of the energy given out by a system when it is disconnected from the source of supply, is used throughout, and it is shown that the division of the total energy of a system referred to above is possible. To characterise the intensity and duration of transient processes in radiating systems, a conception of a "generalised time constant" is introduced, which in simple cases is reduced to the usual time constant or to the inverse value of the damping coefficient.

706. The Protection of Low-Power Wireless Transmitting Installations against Lightning.—Müller. (*See* 660.)

707. The Measurement of Earth Contact Resistances.—Schmidt. (*See* 787.)

708. Sag Tension Calculations for Overhead Line Conductors [with Allowance for Windage & Ice Weight].—J. McCombe. (*Distribution of Electricity*, Jan. 1942, Vol. 14, No. 145, pp. 503–507.)

709. A Multi-Band End-Fed Antenna [Arrangement of Multiple Feeders for maintaining Feeder Balance when using "Zepp" Aerial for Multi-Band Work].—S. L. Seaton. (*QST*, Nov. 1941, Vol. 25, No. 11, pp. 52–53.)

710. A Coupling Unit for Continuous Antenna Rotation: Simple and Effective System for Rotary Beams.—E. L. Plotts. (*QST*, Nov. 1941, Vol. 25, No. 11, pp. 15–16.)

VALVES AND THERMIONICS

711. On the Theory of the Klystron.—Gulyaev. (*See* 674.)

712. The Oscillation Regions of the Multi-Slit Magnetron, *and* Magnetrons with Grids.—Döhler & Lüders: Müller. (*See* 675 & 677.)

713. Valve Noise and Resistance Noise.—Borgnis. (*See* 694.)

714. The Shot Effect in a Saturated Diode [Equivalence of Campbell's & Schottky's Theorems].—N. R. Campbell & V. J. Francis. (*Phil. Mag.*, Dec. 1941, Vol. 32, No. 215, pp. 496–504.)

Removal of restrictions (infinitely small transit time, all impedances lumped) from 3354 of 1941. "The treatment of any discharge device other than a saturated diode requires the introduction of additional physical hypotheses. There appears to be no doubt that, if the same hypothesis is associated with each theorem, the result will again be the same . . ."

715. Temperature Distribution in Vacuum-Tube Coolers with Forced Air Cooling [Derivation of Law for Application to Establishment of Permissible Power Dissipation in Various Conditions of Heat Generation and Cooling]. — I. E. Mouromtseff. (*Journ. Applied Phys.*, June 1941, Vol. 12, No. 6, pp. 491–497.)

716. Dynamic Characteristics and Non-Linear-Distortion Factors of Amplifier Valves with Complex Load [and the Development of the Most General Expression for the "Klirr" Factor, from which the Known Formulae can be derived as Special Cases].—H. Holzwarth. (*E.N.T.*, Sept. 1941, Vol. 18, No. 9, pp. 195–203.)

"The static relation $I_a = f(U_g, U_a)$ . . . (eqn. 1), which fully describes the electrical working of a valve for amplifying purposes, is represented by a surface in space with the coordinate axes I_a, U_g, and U_a. For a real external resistance R_a the dynamic characteristic is the line of intersection of the characteristic surface of eqn. 1 with the working surface, which according to the relation $\Delta U_a = -R_a \Delta I_a$ is represented by a plane completely independent of the form of the characteristic surface and parallel to the U_g axis. Thus eqn. 1 always allows the equation of the dynamic characteristic for a real external resistance to be obtained in closed form. Complex external resistances produce the following complications: (1) the three variables I_a, U_g, and U_a are supplemented by the time t as a parameter, and (2) there is no longer a defined working surface independent of the characteristic surface. The dynamic characteristic is now a closed line on the characteristic surface, whose projections on the coordinate planes are curves resembling ellipses (Fig. 1). The deviations from a true ellipse depend on the non-linearity of eqn. 1, that is on the characteristic surface. Analysis yields differential equations whose solution is not possible in practice. The graphical method of determining the working curve [Kammerloher (the reference given is incomplete, but *see* also 1932 Abstracts, pp. 43–44, and 1068 of 1935) and Preisman, 3616 of 1937 and 438 of 1938] leads to usable results only for large non-linearities. But in communications technique it is just the *almost* linear behaviour which is of importance, so that the graphical method is generally inadequate. With the theory now available for quasi-linear networks (Feldtkeller & Wolman, 1931 Abstracts, p. 611) it is possible to calculate small distortions provided that one of the quantities S, D, or R_i in the characteristic field is constant. In the present paper we set ourselves to obtain, for any arbitrary form of eqn. 1, the equation of the dynamic characteristic; applying, for this purpose, the symbolic treatment so far as it is applicable to non-linear problems." The treatment is based on the fact that the relation of eqn. 1 can be represented, in the neighbourhood of the working point, with sufficient accuracy by the double power series

$$\Delta I_a = S\Delta U_g + G\Delta U_a + \tfrac{1}{2} S_g \Delta U_g^2 + \tfrac{1}{2} G_a \Delta U_a^2 + G_g \Delta U_g \Delta U_a + \ldots,$$

where the first symbol in each term on the right represents the partial derivatives of the current I_a with respect to the grid voltage U_g and the anode voltage U_a.

In this way the writer obtains eqn. 20, "the most general law for the 'klirr' factor of an amplifier valve having an arbitrary 'discharge law' [eqn. 1] and loaded with an arbitrary external resistance. For the magnitude of the 'klirr' factor the sign of the imaginary component of the external resistance is thus of no importance, since X_1 occurs only in the squared form; the important point is the fact that the term $\sqrt{r^2 + t^2}$ in the numerator depends only on the behaviour of the external resistance with respect to the fundamental oscillation." Application of eqn. 20 to the case of the "classic single-grid valve" (for which the "Durchgriff" $1/\mu$ can be regarded, in the first approximation, as constant) leads to the simple formula of eqn. 34, already arrived at by Feldtkeller & Wolman (*loc. cit.*) by regarding the valve as a quasi-linear network. The question of how far this approximation leads to satisfactory results is discussed in section 4. Application of eqn. 20 to the "classical pentode" (with negligibly small anode retroaction) leads to the well-known approximate formula which gives the current 'klirr' factor as independent of the external resistance, as a result of the infinite internal resistance. The practical use of the above work is illustrated by the calculation of the frequency characteristics of the distortion in a stage having a transformer with leakage in the anode circuit, and in a stage having a load resistance with a capacitive shunt.

717. ALTERNATIVE VALVES [Note on Tabulated List & Its Use], *and* THE VALVE REPLACEMENT MANUAL [Book Review].—(*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 11: p. 22.)

DIRECTIONAL WIRELESS

718. PAPERS ON PHASE-DIFFERENCE MEASUREMENTS IN THE INTERFERENCE METHOD [of Distance Determination, etc.].—Al'pert, Wwedensky, Schegolev, & others. (*See* 622/627.)

719. RADIO-LOCATION METHODS ON THE RE-RADIATION PRINCIPLE.—T. Elmquist: H. Gutton. (*Hochf:tech. u. Elek:akus.*, Sept. 1941, Vol. 58, No. 3, pp. 71–72: p. 72.)

(I) The cathode ray is deflected in synchronism with the movements of the scanning beam (along two coordinates) and is modulated in brightness by the re-radiated signals. (II) A beat method in which the minimum is read for two neighbouring modulating frequencies in succession.

720. PULSE DIRECTION-FINDING RECEIVER [for Aural Reception, the Pulse is prolonged in the A.F. Stages of the Receiver so as to produce an Easily Audible Note].—G. Ulbricht. (*Hochf:tech. u. Elek:akus.*, Sept. 1941, Vol. 58, No. 3, p. 71.) A Telefunken patent, DRP 702 609.

721. AZIMUTH INDICATOR FOR FLYING FIELDS [for Rapid (Five Seconds) D.F. on Regular Communication Transmission from Aircraft: Ten-Frequency Receiver (2–7 Mc/s Band) with Cathode-Ray Tube & Loudspeaker, connected to System of Five Vertical Dipoles (Centre & Corners of Square)].—H. T. Budenbom. (*Bell Lab. Record*, Nov. 1941, Vol. 20, No. 3, pp. 58–61.)

ACOUSTICS AND AUDIO-FREQUENCIES

722. THE STEREOPHONIC SOUND FILM SYSTEM: GENERAL THEORY: *also* MECHANICAL AND OPTICAL EQUIPMENT FOR THE STEREOPHONIC SOUND FILM SYSTEM: *and* STEREOPHONIC SOUND FILM SYSTEM: PRE- AND POST-EQUALISATION OF COMPANDOR SYSTEMS.—H. Fletcher: E. C. Wente & others: J. C. Steinberg. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 89–99: pp. 100–106: pp. 107–114.)

723. "FANTASOUND"—STEREOPHONIC SOUND EFFECTS IN WALT DISNEY'S FILM "FANTASIA" [including the Volume-Expansion System retained in the Non-Stereophonic "Vitasound" System].—(*Wireless World*, Nov. 1941, Vol. 47, No. 11, pp. 276–278.)

In this country a combined single sound track, for standard equipment, is in use. For previous references *see* 1917 of 1941: also *Electronics*, March 1941, Vol. 14, No. 3, pp. 18–21.

724. "SONOVOX": SOUND EFFECTS WITH ELECTRO-ACOUSTIC "VOCAL CORDS" [Required Characteristic Noise Current generated at Steady Level and then Voice-Modulated by Device with Pads against Sides of Throat: demonstrated in "The Reluctant Dragon"—G. M. Wright. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 13.) *Cf.* Firestone, 1477 of 1940.

725. "PHYSIK UND TECHNIK DES TONFILMS" [Book Review].—H. Lichte & A. Narath. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, p. 48.)

726. PHASE DISTORTION IN ELECTROACOUSTIC SYSTEMS [Phase Characteristics of Commercial Microphones compared with That of Standard Condenser Microphone: "Close-Up" Phase Characteristics of Various Loudspeakers].—F. M. Wiener. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 115–123.)

727. A LOW-FREQUENCY HORN OF SMALL DIMENSIONS [folded so as to utilise Wall & Floor Reflections to improve Impedance Match at Mouth: Console-Size Unit for Corner of Room, Frequency 40–400 c/s, Good Efficiency].—P. W. Klipsch. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 137–144.)

When this "woofer" is combined with a high-frequency unit, "guests are inclined to compare the performance with their recollections of original renditions rather than with other reproducing systems."

728. ON THE SOLUTION OF SECOND-ORDER DIFFERENTIAL EQUATIONS SATISFYING BOUNDARY CONDITIONS [Sound Distribution in front of Spherical Concave Reflector].—Morgans. (*See* 891.)

729. ERRORS IN LIGHT-BAND WIDTH MEASUREMENTS ON PHONOGRAPH RECORDS [Buchmann & Meyer Method: Exact Computation of Two Factors originally only Approximations: Curves of Corrections].—R. Bierl. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, p. 190.) Summary, from *Akust. Zeitschr.*, Vol. 5, 1940, pp. 145–147. For recent work on this method *see* 137 of January and back reference.

730. A THEORY OF "TRACING DISTORTION" IN SOUND REPRODUCTION FROM PHONOGRAPH RECORDS.—W. D. Lewis & F. V. Hunt. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 348–365.)

731. LINEAR AND NON-LINEAR DISTORTION IN GRAMOPHONE DISC PROCESSES [Recording & Reproducing].—G. Guttwein. (*E.T.Z.*, 28th Aug. 1941, Vol. 62, No. 35, pp. 745–746: long summary, from *Akust. Zeitschr.*, Vol. 5, 1940, p. 330 onwards.)

732. QUESTIONNAIRE ON CHOICE BETWEEN VERTICAL AND LATERAL RECORDINGS FOR BROADCAST TRANSCRIPTIONS.—U.S. National Association of Broadcasters. (*Wireless World*, Dec. 1941, Vol. 47, No. 12, p. 312.)

733. NOTES ON PHONOGRAPH PICK-UPS FOR LATERAL-CUT RECORDS.—L. Fleming. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 366–373.)

734. NEW R.C.A. RECORD CHANGER [with Tandem Tone-Arm having Two Pick-Up Heads, for playing Upper & Lower Sides].—(*Wireless World*, Dec. 1941, Vol. 47, No. 12, p. 304.) For up to 15 records.

735. GRAMOPHONE NEEDLE WITH LARGE, ROUNDED SAPPHIRE TIP REDUCES NEEDLE SCRATCH AND PROLONGS RECORD LIFE.—(*Sci. News Letter*, 11th Oct. 1941, Vol. 40, No. 15, p. 238.) Riding always on well-formed top of groove: "to appear on 1942 models of a well-known maker."

736. "DIE ELEKTROAKUSTISCHEN WANDLER" [Converters (Electrodynamic, Electromagnetic, Magnetostrictive, Dielectric, & Piezoelectric Types), Mathematical Theory, Comparisons, etc: Book Review].—H. Hecht. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, p. 47.)

737. SCALE DISTORTION: IS IT REALLY DISTORTION? THE CASE FOR FREQUENCY CORRECTION [Fallacy of Prevailing Idea that Scale Distortion, due to Uncorrected Amplifier, is responsible for Loudspeaker Output being Satisfactory only at Full Orchestral Volume: Some Consequences].—A. S. Evans. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, pp. 5–6.) *Cf.* February issue, pp. 45–46.

738. PORTABLE BROADCAST AMPLIFIER [for Remote Broadcasts: Weight under 15 lb: 80 db Gain].—I. R. Wolfe. (*Communications*, Aug. 1941, Vol. 21, No. 8, pp. 12 and 32, 33.)

739. "ADD-A-UNIT" AMPLIFIERS [*e.g.* Power Supply, Mixer, Equaliser, Power Amplifier, Monitor, & Pre-Amplifier Equipment with Scope for Extension].—H. Paro. (*Communications*, Sept. 1941, Vol. 21, No. 9, pp. 14 and 16, 34, 35.)

740. AUTOMATIC CIRCUIT FOR DETERMINING LOAD CHARACTERISTICS [primarily for Large Number of Quickly Succeeding Characteristics needed for Compandor Design (Transmission at 16 Loads measured in 1¼ Minutes)].—D. Robertson. (*Bell Lab. Record*, Oct. 1941, Vol. 20, No. 2, pp. 30–34.)

741. AUTOMATIC MEASUREMENT OF CROSSTALK AT CARRIER FREQUENCIES [Equipment drawing Complete Curve (30–150 kc/s) in a Few Minutes].—E. P. Felch. (*Bell Lab. Record*, Nov. 1941, Vol. 20, No. 3, pp. 62–67.) Or a curve, comparable to one plotted from 40 individual measurements, in 40 seconds.

742. STEADY-STATE ANALYSIS OF MULTICONDUCTOR TRANSMISSION LINES.—Pipes. (*See* 618.)

743. METHODS FOR MEASURING THE PERFORMANCE OF HEARING AIDS [by placing the Microphone in Known Sound Field & measuring Output of Receiver when terminated in Appropriate Impedance (Closed Cavity, for Air-Conduction Receiver: Artificial Mastoid, for Bone-Conduction Type)].—F. F. Romanow. (*Bell Tel. System Tech. Pub.*, Monograph B–1314, 27 pp.) To appear in *Journ. Acous. Soc. Am.*

744. ON THE STUDY AND DETECTION OF INFRA-SONIC WAVES BY SPECIAL SENSITIVE FLAMES [including Scientific & Practical Applications].—E. Esclangon. (*Comptes Rendus* [Paris], 5th Feb. 1941, Vol. 212, No. 5, pp. 181–186.)

deviations from a true ellipse depend on the non-linearity of eqn. 1, that is on the characteristic surface. Analysis yields differential equations whose solution is not possible in practice. The graphical method of determining the working curve [Kammerloher (the reference given is incomplete, but *see* also 1932 Abstracts, pp. 43–44, and 1068 of 1935) and Preisman, 3616 of 1937 and 438 of 1938] leads to usable results only for large non-linearities. But in communications technique it is just the *almost* linear behaviour which is of importance, so that the graphical method is generally inadequate. With the theory now available for quasi-linear networks (Feldtkeller & Wolman, 1931 Abstracts, p. 611) it is possible to calculate small distortions provided that one of the quantities S, D, or R_i in the characteristic field is constant. In the present paper we set ourselves to obtain, for any arbitrary form of eqn. 1, the equation of the dynamic characteristic; applying, for this purpose, the symbolic treatment so far as it is applicable to non-linear problems." The treatment is based on the fact that the relation of eqn. 1 can be represented, in the neighbourhood of the working point, with sufficient accuracy by the double power series

$$\Delta I_a = S\Delta U_g + G\Delta U_a + \tfrac{1}{2} S_g \Delta U_g^2 + \tfrac{1}{2} G_a \Delta U_a^2 + G_g \Delta U_g \Delta U_a + \ldots,$$

where the first symbol in each term on the right represents the partial derivatives of the current I_a with respect to the grid voltage U_g and the anode voltage U_a.

In this way the writer obtains eqn. 20, " the most general law for the ' klirr ' factor of an amplifier valve having an arbitrary ' discharge law ' [eqn. 1] and loaded with an arbitrary external resistance. For the magnitude of the ' klirr ' factor the sign of the imaginary component of the external resistance is thus of no importance, since X_1 occurs only in the squared form; the important point is the fact that the term $\sqrt{r^2 + t^2}$ in the numerator depends only on the behaviour of the external resistance with respect to the fundamental oscillation." Application of eqn. 20 to the case of the " classic single-grid valve " (for which the " Durchgriff " $1/\mu$ can be regarded, in the first approximation, as constant) leads to the simple formula of eqn. 34, already arrived at by Feldtkeller & Wolman (*loc. cit.*) by regarding the valve as a quasi-linear network. The question of how far this approximation leads to satisfactory results is discussed in section 4. Application of eqn. 20 to the " classical pentode " (with negligibly small anode retroaction) leads to the well-known approximate formula which gives the current ' klirr ' factor as independent of the external resistance, as a result of the infinite internal resistance. The practical use of the above work is illustrated by the calculation of the frequency characteristics of the distortion in a stage having a transformer with leakage in the anode circuit, and in a stage having a load resistance with a capacitive shunt.

717. ALTERNATIVE VALVES [Note on Tabulated List & Its Use], *and* THE VALVE REPLACEMENT MANUAL [Book Review].—(*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 11: p. 22.)

DIRECTIONAL WIRELESS

718. PAPERS ON PHASE-DIFFERENCE MEASUREMENTS IN THE INTERFERENCE METHOD [of Distance Determination, etc.].—Al'pert, Wwedensky, Schegolev, & others. (*See* 622/627.)

719. RADIO-LOCATION METHODS ON THE RE-RADIATION PRINCIPLE.—T. Elmquist: H. Gutton. (*Hochf:tech. u. Elek:akus.*, Sept. 1941, Vol. 58, No. 3, pp. 71–72: p. 72.)

(I) The cathode ray is deflected in synchronism with the movements of the scanning beam (along two coordinates) and is modulated in brightness by the re-radiated signals. (II) A beat method in which the minimum is read for two neighbouring modulating frequencies in succession.

720. PULSE DIRECTION-FINDING RECEIVER [for Aural Reception, the Pulse is prolonged in the A.F. Stages of the Receiver so as to produce an Easily Audible Note].—G. Ulbricht. (*Hochf:tech. u. Elek:akus.*, Sept. 1941, Vol. 58, No. 3, p. 71.) A Telefunken patent, DRP 702 609.

721. AZIMUTH INDICATOR FOR FLYING FIELDS [for Rapid (Five Seconds) D.F. on Regular Communication Transmission from Aircraft: Ten-Frequency Receiver (2–7 Mc/s Band) with Cathode-Ray Tube & Loudspeaker, connected to System of Five Vertical Dipoles (Centre & Corners of Square)].—H. T. Budenbom. (*Bell Lab. Record*, Nov. 1941, Vol. 20, No. 3, pp. 58–61.)

ACOUSTICS AND AUDIO-FREQUENCIES

722. THE STEREOPHONIC SOUND FILM SYSTEM: GENERAL THEORY: *also* MECHANICAL AND OPTICAL EQUIPMENT FOR THE STEREOPHONIC SOUND FILM SYSTEM: *and* STEREOPHONIC SOUND FILM SYSTEM: PRE- AND POST-EQUALISATION OF COMPANDOR SYSTEMS.—H. Fletcher: E. C. Wente & others: J. C. Steinberg. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 89–99: pp. 100–106: pp. 107–114.)

723. " FANTASOUND "—STEREOPHONIC SOUND EFFECTS IN WALT DISNEY'S FILM " FANTASIA " [including the Volume-Expansion System retained in the Non-Stereophonic " Vitasound " System].—(*Wireless World*, Nov. 1941, Vol. 47, No. 11, pp. 276–278.)

In this country a combined single sound track, for standard equipment, is in use. For previous references *see* 1917 of 1941: also *Electronics*, March 1941, Vol. 14, No. 3, pp. 18–21.

724. " SONOVOX ": SOUND EFFECTS WITH ELECTRO-ACOUSTIC " VOCAL CORDS " [Required Characteristic Noise Current generated at Steady Level and then Voice-Modulated by Device with Pads against Sides of Throat: demonstrated in " The Reluctant Dragon "]—G. M. Wright. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 13.) *Cf.* Firestone, 1477 of 1940.

725. "PHYSIK UND TECHNIK DES TONFILMS" [Book Review].—H. Lichte & A. Narath. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, p. 48.)

726. PHASE DISTORTION IN ELECTROACOUSTIC SYSTEMS [Phase Characteristics of Commercial Microphones compared with That of Standard Condenser Microphone: "Close-Up" Phase Characteristics of Various Loudspeakers].—F. M. Wiener. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 115–123.)

727. A LOW-FREQUENCY HORN OF SMALL DIMENSIONS [folded so as to utilise Wall & Floor Reflections to improve Impedance Match at Mouth: Console-Size Unit for Corner of Room, Frequency 40–400 c/s, Good Efficiency].—P. W. Klipsch. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 137–144.)

When this "woofer" is combined with a high-frequency unit, "guests are inclined to compare the performance with their recollections of original renditions rather than with other reproducing systems."

728. ON THE SOLUTION OF SECOND-ORDER DIFFERENTIAL EQUATIONS SATISFYING BOUNDARY CONDITIONS [Sound Distribution in front of Spherical Concave Reflector].—Morgans. (*See* 891.)

729. ERRORS IN LIGHT-BAND WIDTH MEASUREMENTS ON PHONOGRAPH RECORDS [Buchmann & Meyer Method: Exact Computation of Two Factors originally only Approximations: Curves of Corrections].—R. Bierl. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, p. 190.) Summary, from *Akust. Zeitschr.*, Vol. 5, 1940, pp. 145–147. For recent work on this method *see* 137 of January and back reference.

730. A THEORY OF "TRACING DISTORTION" IN SOUND REPRODUCTION FROM PHONOGRAPH RECORDS.—W. D. Lewis & F. V. Hunt. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 348–365.)

731. LINEAR AND NON-LINEAR DISTORTION IN GRAMOPHONE DISC PROCESSES [Recording & Reproducing].—G. Guttwein. (*E.T.Z.*, 28th Aug. 1941, Vol. 62, No. 35, pp. 745–746: long summary, from *Akust. Zeitschr.*, Vol. 5, 1940, p. 330 onwards.)

732. QUESTIONNAIRE ON CHOICE BETWEEN VERTICAL AND LATERAL RECORDINGS FOR BROADCAST TRANSCRIPTIONS.—U.S. National Association of Broadcasters. (*Wireless World*, Dec. 1941, Vol. 47, No. 12, p. 312.)

733. NOTES ON PHONOGRAPH PICK-UPS FOR LATERAL-CUT RECORDS.—L. Fleming. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 366–373.)

734. NEW R.C.A. RECORD CHANGER [with Tandem Tone-Arm having Two Pick-Up Heads, for playing Upper & Lower Sides].—(*Wireless World*, Dec. 1941, Vol. 47, No. 12, p. 304.) For up to 15 records.

735. GRAMOPHONE NEEDLE WITH LARGE, ROUNDED SAPPHIRE TIP REDUCES NEEDLE SCRATCH AND PROLONGS RECORD LIFE.—(*Sci. News Letter*, 11th Oct. 1941, Vol. 40, No. 15, p. 238.) Riding always on well-formed top of groove: "to appear on 1942 models of a well-known maker."

736. "DIE ELEKTROAKUSTISCHEN WANDLER" [Converters (Electrodynamic, Electromagnetic, Magnetostrictive, Dielectric, & Piezoelectric Types), Mathematical Theory, Comparisons, etc: Book Review].—H. Hecht. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, p. 47.)

737. SCALE DISTORTION: IS IT REALLY DISTORTION? THE CASE FOR FREQUENCY CORRECTION [Fallacy of Prevailing Idea that Scale Distortion, due to Uncorrected Amplifier, is responsible for Loudspeaker Output being Satisfactory only at Full Orchestral Volume: Some Consequences].—A. S. Evans. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, pp. 5–6.) *Cf.* February issue, pp. 45–46.

738. PORTABLE BROADCAST AMPLIFIER [for Remote Broadcasts: Weight under 15 lb: 80 db Gain].—I. R. Wolfe. (*Communications*, Aug. 1941, Vol. 21, No. 8, pp. 12 and 32, 33.)

739. "ADD-A-UNIT" AMPLIFIERS [*e.g.* Power Supply, Mixer, Equaliser, Power Amplifier, Monitor, & Pre-Amplifier Equipment with Scope for Extension].—H. Paro. (*Communications*, Sept. 1941, Vol. 21, No. 9, pp. 14 and 16, 34, 35.)

740. AUTOMATIC CIRCUIT FOR DETERMINING LOAD CHARACTERISTICS [primarily for Large Number of Quickly Succeeding Characteristics needed for Compandor Design (Transmission at 16 Loads measured in 1¼ Minutes)].—D. Robertson. (*Bell Lab. Record*, Oct. 1941, Vol. 20, No. 2, pp. 30–34.)

741. AUTOMATIC MEASUREMENT OF CROSSTALK AT CARRIER FREQUENCIES [Equipment drawing Complete Curve (30–150 kc/s) in a Few Minutes].—E. P. Felch. (*Bell Lab. Record*, Nov. 1941, Vol. 20, No. 3, pp. 62–67.) Or a curve, comparable to one plotted from 40 individual measurements, in 40 seconds.

742. STEADY-STATE ANALYSIS OF MULTICONDUCTOR TRANSMISSION LINES.—Pipes. (*See* 618.)

743. METHODS FOR MEASURING THE PERFORMANCE OF HEARING AIDS [by placing the Microphone in Known Sound Field & measuring Output of Receiver when terminated in Appropriate Impedance (Closed Cavity, for Air-Conduction Receiver: Artificial Mastoid, for Bone-Conduction Type)].—F. F. Romanow. (*Bell Tel. System Tech. Pub.*, Monograph B–1314, 27 pp.) To appear in *Journ. Acous. Soc. Am.*

744. ON THE STUDY AND DETECTION OF INFRA-SONIC WAVES BY SPECIAL SENSITIVE FLAMES [including Scientific & Practical Applications].—E. Esclangon. (*Comptes Rendus* [Paris], 5th Feb. 1941, Vol. 212, No. 5, pp. 181–186.)

745. A CONTINUOUSLY VARIABLE ACOUSTIC IMPEDANCE.—E. C. Jordan. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, p. 8.) Arising out of the work dealt with in 2702 of 1941.

746. MEASUREMENT OF ACOUSTICAL IMPEDANCES [by measuring the Electrical Impedance of Loudspeakers under Different Air Loads: Results on Treetax, Felt, & Helmholtz Resonator].—Chandra Kanta. (*Indian Journ. of Sci.*, June 1941, Vol. 15, Part 3, pp. 161–171.)

747. MEASUREMENT OF COEFFICIENT OF REFLECTION AND PHASE FOR SOUND WAVES [Theory & Practice of Method: Results for Various Materials at 1200 c/s: No Significant Absorption-Coeff./Phase-Change Relation: Phase Change, in Assembly of Capillary Tubes, greater than Pi].—C. Kanta. (*Sci. Abstracts*, Sec. B, Oct. 1941, Vol. 44, No. 526, pp. 204–205.)

748. A RE-EXAMINATION OF THE "NOISE REDUCTION COEFFICIENT" [accepted as Average of Absorption Coefficients at 256, 512, 1024, & 2048 c/s: Need for Consideration also of 4096 c/s (particularly in Office Quieting) and of 128 c/s in Factories with Heavy Machinery: etc.].—J. S. Parkinson & W. A. Jack. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 163–169.)

749. FREQUENCY DISTRIBUTION OF NORMAL MODES [Maa's Formula for Rectangular Enclosure verified & extended to Other Shapes: Calculation of Resonance Response & Rate of Decay in Cylinder].—G. M. Roe. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 1–7.)

750. THE FLUTTER ECHOES [excited by Short Sound Pulses (Footsteps, Voices, etc.) between Parallel Walls: Treatment by Techniques of Geometrical Acoustics ("Normal Modes") & Physical Acoustics ("Standing-Wave Patterns")].—D. Y. Maa. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 170–178.)

751. FREQUENCY BRIDGE [using Wien Resistance-Capacitance Network: Small & Light: No Valves: 100–12 100 c/s].—Muirhead & Company. (*Journ. of Scient. Instr.*, Jan. 1942, Vol. 19, No. 1, p. 13.)

752. A BRIDGE METHOD FOR DETERMINING THE FREQUENCY OF AN ALTERNATING CURRENT IN THE AUDIO-FREQUENCY RANGE [New Bridge with Adjustment Characteristic of the Parabolic Form $f = a\sqrt{x}$: Advantages].—L. M. Chatterjee. (*Current Science*, Bangalore, Aug. 1941, Vol. 10, No. 8, pp. 363–364.)

753. CORRIGENDA: FURTHER APPLICATIONS OF OUR DIRECT-READING PITCH AND INTENSITY RECORDER.—J. Obata & R. Kobayashi. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, p. 449.) *See* 4324 of 1940: for later work *see* 2742 of 1941.

754. MEASUREMENTS OF ORCHESTRAL PITCH.—O. J. Murphy. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 395–398.) Already dealt with in 1402 of 1941.

755. AN ELECTRICAL TUNING-NOTE GENERATOR [for the Standard 440 c/s].—H. J. von Braunmühl & O. Schubert. (*Zeitschr. V.D.I.*, 13th Dec. 1941, Vol. 85, No. 49/50: summary, from *Akust. Zeitschr.*, No. 5, Vol. 6, 1941, pp. 299–303.)

Since musicians find that a pure note is unsuitable for tuning purposes, and since a tuning fork is the simplest means of producing an approximately constant frequency, the portable generator takes the form of an amplifying valve controlled by a tuning fork and feeding a loudspeaker. Volume is up to 100 phons at 1 metre: the mains-driven instrument is ready for use 1 minute after plugging-in: the frequency drift over several hours of working and for temperature fluctuations between 10° and 30° amounts to ± 0.15 c/s: the total weight is about 17 lb.

756. THE PROBLEM OF A STRINGING SCALE FOR SMALL VERTICAL PIANOFORTES.—W. B. White. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 409–411.)

757. MEASUREMENT OF THE LOGARITHMIC DECREMENT, DUE TO INTERNAL FRICTION, OF VARIOUS WOODS [at 10–800 c/s].—E. Rohloff & W. Lawrynowicz. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 22, 1941, pp. 110–111.)

758. PHYSICAL PROPERTIES OF WOOD FOR VIOLIN CONSTRUCTION.—R. B. Abbott & G. H. Purcell. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 54–55.)

759. IMPROVED TECHNIQUES IN THE STUDY OF VIOLINS.—R. B. Watson & others. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 399–402.)

760. END CORRECTIONS OF ORGAN PIPES.—A. T. Jones. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 387–394.)

761. TONE SPECTRUM OF A SILBERMANN ORGAN [Date 1731, compared with That of an Organ with Quality considered Ideal around 1900].—W. Lottermoser. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 189–190: summary, from *Akust. Zeitschr.*, Vol. 5, 1940, pp. 324–330.)

762. TRENDS IN ACCEPTABLE TONE QUALITY AS EVIDENCED IN MODERN MUSICAL INSTRUMENTS, *and* MASKING EFFECTS IN PRACTICAL INSTRUMENTATION AND ORCHESTRATION.—A. Pepinsky. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 403–404: pp. 405–408.)

763. "MUSICAL ACOUSTICS" [Book Review].—C. A. Culver. (*Journ. Applied Phys.*, Nov. 1941, Vol. 12, No. 11, p. 770.)

764. THE DISPERSION AND ABSORPTION OF SOUND IN CLOUDS [Mathematical Investigation].—Kl. Oswatitsch. (*Physik. Zeitschr.*, 20th Nov. 1941, Vol. 42, No. 21/22, pp. 365–378.)

Author's summary:—" At sufficiently low acoustic frequencies the water vapour in clouds, or fog droplets, can be condensed and evaporated in considerable quantities. This leads to dispersion and absorption phenomena. Whereas the region of dispersion for clouds lies always below the range of audibility, the absorption region for clouds rich in water, composed of small drops, reaches into the low audible frequencies. This agrees with the known strong absorption of thunder." For these low audible frequencies the propagation velocity is not altered appreciably. The same results apply to ice-containing clouds. In the supplementary section 3 the writer, by calculating the temperature jump at the surface of a condensing water-drop, considers how correct it is to put the droplet temperature at the water surface equal to the immediate contiguous air layer: he also considers the correctness of regarding the drop-condensation as a quasi-stationary process.

765. Ultrasonic Absorption and Velocity Measurements in Numerous Liquids.—G. W. Willard. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 438–448.) A summary was referred to in 3475 of 1940.

766. An Explanation of the Diminished Acoustic Velocity in Fluids at High Frequencies [and the Different Thermodynamic Actions at "Ultrasonic" & "Hypersonic" Frequencies].—B. V. R. Rao & D. S. S. Ramaiya. (*Phys. Review*, 15th Oct. 1941, Vol. 60, No. 8, p. 615.)

767. The Temperature and Frequency Effects on Ultrasonic Velocities in Carbon Dioxide: *also* The Origin of the Absorption of Ultrasonic Waves in Liquids: *and* The Absorption of Ultrasonic Waves in Highly Viscous Liquids.—C. J. Overbeck & H. C. Kendall: K. F. Herzfeld: J. L. Hunter. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 26–32: pp. 33–35: pp. 36–40.)

768. Sound Velocities in Gases under Different Pressures.—R. C. Colwell & L. H. Gibson. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 436–437.) Using the method of 1115 of 1941.

769. On the Mechanical Behaviour of Liquids under High-Frequency Oscillations: Corrections.—I. Osida. (*Proc. Phys.-Math. Soc. Japan*, Aug. 1941, Vol. 23, No. 8, p. 667.) *See* 2755 of 1941.

770. Heat-Conduction Effects in Sound Emission [when Medium receiving the Sound & impeding the Motions of Source is a Gas: Reduction in Total Amount of Sound Energy Radiated: etc.].—R. S. Alleman. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 23–25.) The theoretical results were applied in the paper dealt with in 1563 of 1939.

771. On the Influence of Supersonic Waves on the Speed of Attacking Reactions on Copper [exposed to Iodine Vapour or H_2S: Definite Speeding-Up].—J. A. Hedvall & O. Jönsson. (*Naturwiss.*, 28th Nov. 1941, Vol. 29, No. 48, pp. 726–727.)

772. Supersonic Methods for studying the Properties of Tempered Steel and determining Internal Defects of Metallic Articles.—Sokolov. (*See* 904.)

773. "Waves: a Mathematical Account of the Common Types of Wave Motion" [Book Review].—C. A. Coulson. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, p. 503.)

PHOTOTELEGRAPHY AND TELEVISION

774. New Television Development: Use of Colour Technique and Stereoscopic Relief.—J. L. Baird. (*Electrician*, 26th Dec. 1941, Vol. 127, p. 359.) Account of a demonstration to the technical Press. *See* also *Wireless World*, Feb. 1942, pp. 31–32.

775. The Brightness Scale of Exterior Scenes and the Computation of Correct Photographic Exposure [with Measurements on Max. & Min. Brightness of 126 Scenes of Wide Variety of Types].—L. A. Jones & H. R. Condit. (*Journ. Opt. Soc. Am.*, Nov. 1941, Vol. 31, No. 11, pp. 651–678.)

776. Etching Glass Surfaces reduces Reflection [Hydrofluoric-Acid-Vapour Technique for Television C.R. Tubes, Framed Pictures, etc.].—F. H. Nicoll. (*Scient. American*, Dec. 1941, Vol. 165, No. 6, p. 335.) From the R.C.A. laboratories. *See* also *Sci. News Letter*, 1st Nov. 1941, Vol. 40, No. 18, pp. 275–276: *also* Abstracts 3656/8 of 1940 and 1439 of 1941.

777. Modulation Capability of Zinc-Oxide Phosphors.—J. Wolf. (*E.N.T.*, Sept. 1941, Vol. 18, No. 9, pp. 204–217.)

In cathode-ray tubes used for the reception of television the most important qualities of the fluorescent screen (apart from its life) are the luminous output and the physiological merit of its colour. In a tube for transmitting purposes, on the other hand, the vitally important quality is the shortness of persistence. The ideal screen, with an emission completed free from after-glow and inertia (*i.e.* a purely fluorescent emission) is at present unattainable. The nearest approach is the zinc-oxide screen, in general use today for fluorescent-screen scanning.

Author's summary:—"The frequency characteristic of the modulation capability of zinc-oxide screens in television scanning tubes is investigated up to a frequency of 12 Mc/s. The light spot is sharply concentrated and, in order to avoid over-loading the phosphor, is moved raster-wise over the screen. The luminous modulation is obtained by superposing a constant h.f. voltage on a fixed d.c. voltage on the Wehnelt cylinder. From a knowledge of the luminous characteristic it is possible to calculate, from the values of these two voltages, the degree of light modulation to be expected from an inertia-less phosphor ('100% modulation capability.') The *actual* degree of light modulation is obtained from measurements of the ratios of the alternating light to the steady light, and a comparison of the measured results with the calculated values gives the value of the modulation capability at any particular test frequency.

" Up to frequencies of about 20–40 kc/s (depending on the quality of the ray focusing obtainable with the particular tube employed, and on the value of the screen-loading) a 100% modulation capability is reached; at 12 Mc/s it has fallen to 10%. A comparative test on a ZnS-ZnS/CdS mixed phosphor showed a drop to 3% at 12 Mc/s.

" The influence of the electron-lens voltage (and therefore of the spot size) upon the modulation capability and steady luminous output was investigated with an electrostatically focused tube. The behaviour observed in the two related quantities is traced to questions of energy density and consequent local screen temperatures. Decrease of steady light and shortening of persistence-time are the result of an increase of energy density due to improved focusing. The influence of spot diameter on the modulation capability is greatest at the highest frequencies; any desired high modulation capability can, at the cost of shortened life for the phosphor, be obtained if the excitation density is sufficiently increased.

" The behaviour of the modulation capability and steady light, immediately after the switching-on of the anode voltage and up to the attainment of a constant light-emission condition (a period of about 20 minutes) is attributed to the temperature rise in the screen. The higher the temperature to which the screen can be raised by the electron-ray excitation, the greater the gain in modulation capability. A supplementary heating of the screen increases the modulation capability, with a simultaneous diminution of steady-light output [a raising of the temperature from 35°C to 100°C caused the steady light to fall to 84% of its original value, while the ratio alternating-light/steady-light increased to 128%, for 4.1 and 11·6 Mc/s. " The fact that such a small temperature change should produce so large an effect on the modulation capability is astonishing, since the instantaneous temperatures of the excited light centres must probably reach several hundred degrees." At 150°C the steady light fell to only 52%, but the alternating-light/steady-light ratio only increased to 154% (for 4.1 Mc/s) and 168% (for 11.6 Mc/s)—so that apparently conditions are not so favourable at the higher temperature. In any case the tests were of a rather provisional nature, and further research is needed, with tubes having their screens thermally insulated from the glass bulb].

" To sum up, it may be said that a maximum modulation capability of the zinc-oxide screen is attained by the best possible focusing of the ray and by the greatest application of energy—that is, highest density of excitation—compatible with a reasonable life for the phosphor."

778. An Automatic Recorder of Spectral Sensitivity of Photoelectric Surfaces [Adaptation of Hardy-Type Spectrophotometer: Investigated Surface converts Monochromatic Beam (of Gradually Varying Wavelength) into Variations of Light Intensities emitted by Source of Constant Spectral Distribution].—J. T. Tykociner & L. R. Bloom. (*Journ. Opt. Soc. Am.*, Nov. 1941, Vol. 31, No. 11, pp. 689–692.)

779. Photoelectrically Sensitive Semiconductors and Resistances in Electrical Oscillatory Circuits [including the Development of a Selenium-Cell Circuit giving Unusually High Sensitivity to Light].—F. Goos. (*Ann. der Physik*, 29th Oct. 1941, Vol. 40, No. 6, pp. 425–447.)

Further development of the work dealt with in 4588 of 1939. The previous results are generalised and extended, and expressed quantitatively both graphically and numerically. Conclusions are thus arrived at which lead to further knowledge of the physical nature not only of semiconductors (of which the selenium cell is merely one example) but also of materials with almost entirely dielectric properties, particularly phosphors. The special high-sensitivity selenium-cell circuit (Fig. 13) is one in which the cell is connected in series with the oscillatory-circuit inductance. A Thallofide cell is also investigated: under certain conditions the " anomalous dielectric-constant effect " (decrease of dielectric constant under illumination), already found with phosphors (*see* footnote reference, and 2714 of 1940 and 2468 of 1941), is also evident in this cell: in both cases this hitherto unexplained phenomenon is now clarified.

MEASUREMENTS AND STANDARDS

780. A Method for the Measurement of Impedance by means of Lecher Wires [depending on Measurement of Currents flowing in Bridge across Far End & in Sliding Bridge: Theory, yielding Relation between Ratio of Currents & Distance Apart: Application to Measurements (at 224 cm Wavelength) on Thermal Detectors for R.F. Current Meters].—H. T. Flint & G. Williams. (*Phil. Mag.*, Dec. 1941, Vol. 32, No. 215, pp. 489–495.)

781. Investigation on Diodes for the Comparative Measurement of Voltages in the Decimetric-Wave Band.—G. Möhring. (*Hochf:tech. u. Elek:akus.*, Sept. 1941, Vol. 58, No. 3, pp. 57–61.)

An absolute voltage measurement is difficult to carry out in this waveband on account of the resistances of the leads and transit-time effects. But if the frequency can be kept constant, a relative measurement is often all that is needed: for example in resistance-measurement by the resonance method, where only the ratio of two voltages is required. For such measurements the only thing necessary to know is the characteristic curve of the measuring device. This can be determined by some form of calibration, for instance a calibration at low frequency of the diode employed, a calibration with a thermojunction (Strutt & Knoll, 4067 of 1939), or with the help of the known voltage distribution along a line (Lange, 3039 of 1941), and so on. Or the process of calibration can be omitted and the measurement based on a theoretical form for the characteristic. In this case the characteristic is generally taken to follow the square law; this is possible if the working region is sufficiently restricted (Kaufmann, 2443 of 1939). The present paper investigates the useful limits of a diode employed in this last manner: the over-control error is treated according to the laws which hold at low frequencies. This is easily accomplished by working in the initial-current part of the curve, where, moreover, the greatest sensitivity can be obtained.

Author's summary :—" Starting from the exponential characteristic of a diode in the initial-current region, the error is calculated with which an applied voltage would be wrongly estimated if that characteristic were assumed to be quadratic over a certain portion. The error in comparative voltage measurements arising from the use of the square law is calculated and displayed in curves [for instance, Figs. 4 & 5 show the percentage errors in the measurement of resistances by resonance-curve methods, the former by the " half-value width " technique (detuning until the resonance voltage drops to $1/\sqrt{2}$ of its full value), the latter by the resonance-peaks method, using a known resistance for substitution]. The calculated error is extremely well confirmed by measurements on resistances at a wavelength of 54 cm [using a diode particularly suitable for the decimetric-wave region, with a current increasing exponentially up to about 10 μA]. The influence of leads and of transit-time angle is investigated and [the latter] is found to be negligible for anode/cathode distances of 0·17 mm [Fig. 7, where results with diodes in which this gap was 0·17, 0·5, and 1·0 mm are compared]. Thus it is found that a comparative voltage measurement in the decimetric-wave region can be carried out without error, and without calibration, on the assumption of a square law, provided the control is kept sufficiently small (about 10% of the steady current) and diodes with small transit-time angles are used."

782. A Modern Vacuum-Tube Voltmeter for D.C., A.C., and R.F. Measurements [up to or over 120 Mc/s].—C. B. De Soto. (*QST*, Dec. 1941, Vol. 25, No. 12, pp. 40–44 and 90..96.)

783. A.C. Instrument Test Panel [to supply Current & Voltage for Calibration of Voltmeters & Ammeters].—Salford Electrical Instruments. (*Journ. of Scient. Instr.*, Jan. 1942, Vol. 19, No. 1, pp. 12–13.)

784. The Decade Calibrator: an Inexpensive Frequency Checker [100–1000 kc/s Oscillator Combination with Provision for Tone Modulation].—R. B. Jeffrey. (*QST*, Oct. 1941, Vol. 25, No. 10, pp. 23–25 and 94..98.)

785. The A.C. Dielectric-Loss and Power-Factor Method for Field Investigation of Electrical Insulation.—F. C. Doble. (*Elec. Engineering*, Oct. 1941, Vol. 60, No. 10, Transactions pp. 934–939.)

786. D.C. Valve Voltmeter: a Low-Range Instrument of High Input Resistance [suitable for Measurements on Detectors, A.V.C., Grid Bias, Condenser Insulation Resistance, etc.].—(*Wireless World*, Jan. 1942, Vol. 48, No. 1, pp. 17–19.)

787. The Measurement of Earth Contact Resistances.—H. J. Schmidt. (*E.N.T.*, Aug. 1941, Vol. 18, No. 8, pp. 173–178.)

Author's summary :—" The earthing-measuring bridges of Stössel and of L. M. Ericsson are described. While the Stössel bridge has been used for earthing measurements, the Ericsson bridge has been neglected, although it has advantages over the other. One of these bridges has now been brought into use by the German P.O. The relations in this bridge, *i.e.* the magnitude and phase of the currents and voltages, are investigated mathematically and discussed with the help of graphical representations. It is then shown how the procedure can be extended so as to measure the real and imaginary components of complex earthing resistances. The capacitive component is in general so small that it can be neglected, especially as its value decreases with increasing frequency, so that for high-frequencies and surge currents (lightning) it is without effect."

788. The Variation of the Specific Resistance of Platinum with Wire-Diameter [Reuter's Large Increase due to Systematic Error associated with Microscopic Method of measuring Diameter: New Results].—E. Moser. (*Ann. der Physik*, 18th Aug. 1941, Vol. 40, No. 2, pp. 121–130.)

789. "Metallische Werkstoffe für Thermoelemente" [Book Review].—A. Schulze. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 22, 1941, p. 138.)

790. "Advanced Electrical Measurements" [Book Review].—W. C. Michels. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, p. 492.)

791. Names of Electrical Units [in E.S.U. System: Avoidance of Cacophonous Names such as " Statcoulombs," by Use of " Franklin " as Unit of Charge, yielding Centimetre-Second-Franklin System].—E. A. Guggenheim, A. C. Egerton. (*Nature*, 20th Dec. 1941, Vol. 148, p. 751.)

792. Committee for Units and Dimensions: Provisional Definitions and Formulae for Electric-Field and Magnetic Quantities.—A.E.F. (*E.T.Z.*, 4th & 11th Sept. 1941, Vol. 62, Nos. 36 & 37, pp. 765–768 & 781–783.)

SUBSIDIARY APPARATUS AND MATERIALS

793. New Oscilloscope: an Aid to Good Resistance Welding [Magnetic Oscilloscope, unaffected by the Stray Fields liable to upset Cathode-Ray Instruments: High-Speed Response (about 1/3000 Second: Sturdy & Light].—Levoy & Schermerhorn. (*Gen. Elec. Review*, July 1941, Vol. 44, No. 7, pp. 391–395.)

794. The Garceau Chronograph [*e.g.* with Four Fixed Styluses marking on Dry Electrically Sensitive Paper Tape moving at 3 cm/s].—(*Review Scient. Instr.*, Nov. 1941, Vol. 12, No. 11, p. 559.)

795. DISTRIBUTION OF ENERGY AMONG THE CATHODE RAYS OF A GLOW DISCHARGE [Practically Homogeneous at Low Pressures & High Voltages (Useful Source of Electrons for High-Speed C.R. Tubes, etc.): Wide Range of Energies at Higher Pressures & Lower Voltages: etc.].—Chaudhri. (*Nature*, 13th Dec. 1941, Vol. 148, pp. 727–728.)

796. AN ELECTRON GUN GIVING A 1.3-AMPERE RAY FOR 1–2 HOURS, OR 0·5 AMPERE (500 VOLTS ON ANODE) FOR LONG PERIODS.—Paul. (*Zeitschr. f. Phys.*, 15th Aug. 1941, Vol. 117, No. 11/12, pp. 776–777.) In a paper on an atomic beam apparatus for spectrum analysis.

797. A DISCUSSION OF THE FUNDAMENTAL LIMIT OF PERFORMANCE OF AN ELECTRON MICROSCOPE [and the Diffusion of Image of Geometrical Point by Diffraction Defect].—Hillier. (*Phys. Review*, 15th Nov. 1941, Vol. 60, No. 10, pp. 743–745.)

"If a 10% change in intensity is the minimum change that can be detected in the electron image by means of a photographic emulsion, it is shown that a single atomic nucleus can produce a discernible image only if it is of atomic number greater than 25": etc.

798. THE PHASE-CONTRAST METHOD AND ITS APPLICATION IN [Optical] MICROSCOPY [for Improvement in Image Contrast].—Köhler & Loos. (*Sci. Abstracts*, Sec. A, Oct. 1941, Vol. 44, No. 526, p. 311.)

799. ELECTRONIC VACUUM CAMERA [for Study of Tarnish, Polish, Lubrication, Corrosion, etc: using 40 kV Electron Beam].—Johnson. (*Journ. Applied Phys.*, June 1941, Vol. 12. No. 6, p. 509: paragraph only.)

800. "ELECTRONENGERÄTE, PRINCIPIEN UND SYSTEMATIK" [Electron-Optical Apparatus: Book Review].—Brüche & Recknagel. (*E.N.T.*, Sept. 1941, Vol. 18, No. 9, pp. 217–218.)

801. CATHODE PHASE INVERSION [and Its Application, particularly to C.R. Oscillography].—Schmitt. (*See* 666.)

802. MODULATION CAPABILITY OF ZINC-OXIDE PHOSPHORS.—Wolf. (*See* 777.)

803. PHOTOELECTRICALLY SENSITIVE SEMICONDUCTORS AND RESISTANCES IN ELECTRICAL OSCILLATORY CIRCUITS [with Conclusions regarding the Behaviour of Phosphors, etc.].—Goos. (*See* 779.)

804. STUDIES ON LUMINESCENT MATERIALS: III—PHOTOCONDUCTIVITY AND THE MOLECULAR VIBRATION STRUCTURE OF FLUORESCENCE SPECTRA OF THE ZnS CRYSTAL PHOSPHORS.—Uehara. (*Sci. Abstracts*, Sec. A, Oct. 1941, Vol. 44, No. 526, p. 308.) For Parts I & II *see* 525 of 1941.

805. "PHYSIK UND TECHNISCHE ANWENDUNGEN DER LUMINESZENZ" [Book Reviews].—Riehl. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 22, 1941, pp. 138–139: *Naturwiss.*, 5th Dec. 1941, Vol. 29, No. 49, p. 743.) For examples of the writer's work *see* 1580 of 1940 and back references.

806. FILM-CONTRACTION ERRORS IN LATTICE-SPACING MEASUREMENTS [with Information on Effects of Humidity, etc., on Length of Film].—Hume-Rothery & others. (*Journ. of Scient. Instr.*, Dec. 1941, Vol. 18, No. 12, pp. 239–240.)

807. A HIGH-VACUUM VALVE [without Sylphon Bellows].—Cowie & Green. (*Review Scient. Instr.*, Nov. 1941, Vol. 12, No. 11, p. 556.)

808. DESIGN AND PERFORMANCE OF A PROTON ACCELERATOR [up to 400 kV] FOR QUANTITATIVE IRRADIATION OF LIVING MATTER.—Scott & Haskins. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 466–471.)

809. PRODUCTION OF LARGE ION CURRENTS: II [With Suitable Parameters, Probability of Ionisation is So Great that Number of Ions generated per Electron exceeds Unity: etc.].—Korsunsky & Shavlo. (*Journ. of Phys.* [of USSR], No. 4/5, Vol. 3, 1940, pp. 385–392: in English). For I *see* 531 of 1941.

810. ELECTROSTATIC GENERATOR FOR NUCLEAR RESEARCH AT M.I.T., *and* AN APPARATUS FOR THE TRANSMUTATION OF ATOMIC NUCLEI [Ion Tube with 1.25 MV Accelerating Voltage, Earthed Transmutation Chamber].—Van Atta & others: Heijn & Bouwers. (*Review Scient. Instr.*, Nov. 1941, Vol. 12, No. 11, pp. 534–545: *Philips Tech. Review*, Feb. 1941, Vol. 6, No. 2, pp. 46–53.) With some results.

811. THE BREAKDOWN OF COMPRESSED GAS WHEN ROTATING ELECTRODES ARE USED.—Rzyankin. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 72–76.)

An experimental investigation in connection with the development of electrostatic high-voltage generators in which the electrodes rotate at high speed in a compressed gas or vapour. It appears that under these conditions the breakdown voltage of the gas increases almost linearly with pressure, which differs considerably from the results observed with stationary electrodes.

812. ON THE PENETRATION OF THE INERT GASES INTO METALS [in a Glow Discharge: Extension of the Work of Alterthum & others (2583 of 1938) on "Clean-Up" Action].—Bartholomeyczyk & others. (*Zeitschr. f. Phys.*, 15th July 1941, Vol. 117, No. 9/10, pp. 651–656.)

813. INITIAL PROCESSES IN LICHTENBERG FIGURES, *and* PULSES IN NEGATIVE POINT-TO-PLANE CORONA.—Rogowski & others: Loeb & others. (*See* 656 & 657.)

814. THE GLOW DISCHARGE FROM WIRES IN A CYLINDRICAL FIELD [50 c/s, up to about 70 kV].—Faulhaber. (*Arch. f. Elektrot.*, 25th Aug. 1941, Vol. 35, No. 7, pp. 431–436.)

The glow discharge in the positive half-wave (current from wire to cylinder) set in rather earlier than in the negative half-wave. As the voltage was increased, the mean value of the current of the positive half-wave was at first always greater than that of the negative: after a certain voltage and up to just before breakdown, this relation was reversed. Breakdown itself occurred in the positive half-wave. Finally, the $u = f(i)$ characteristic was obtained with a c.r. oscillograph.

815. Theory of Cathode Sputtering in Low-Voltage Glow Discharges [with Expression for Total Rate of Sputtering].—Townes. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, p. 171: summary only.)

816. Vibrator Power Supplies [for Mobile Transmitters & Receivers: General Considerations].—Goodman. (*QST*, Nov. 1941, Vol. 25, No. 11, pp. 44–46 and 96, 98.)

817. A Direct-Current Supply Apparatus with Stabilised Voltage [Type GM 4 560: Voltage continuously variable between 150 & 300 V: Max. Current 100 mA: Mains Fluctuation of 5% causes Output Voltage Variation less than 0.004%: Internal Impedance below 10 Ohms under Most Conditions, below 4 Ohms always].—Lindenhovius & Rinia. (*Philips Tech. Review*, Feb. 1941, Vol. 6, No. 2, pp. 54–61.)

Apart from a short description of the final commercial apparatus, the paper is devoted to the step-by-step development of the highly effective circuit adopted, containing two triodes, a neon tube, and a bridge circuit. Starting from a simple one-triode arrangement, it is shown how each step improves the performance of the whole. The commercial model of the apparatus weighs about 19 kg, including the comparison battery, usually lasting a year.

818. An Inexpensive Automatic Line-Voltage Regulator.—Taylor. (*QST*, Oct. 1941, Vol. 25, No. 10, pp. 26–29.)

819. Storage-Battery Eliminator for Electrometer Tubes [replacing Accumulators for Filament Supply: a High-Vacuum Valve Circuit].—Anderson & others. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 511–512.)

820. The Calculation of Battery-Charging Rectifiers with Automatic Current Regulation [Simple Approximate Analytical Expressions derived for the Transcendental Relations in Theory of Rectifiers with Anode Inductances: for Practical Use: Comparison with Graphical Results].—Thièl. (*E.T.Z.*, 25th Sept. 1941, Vol. 62, No. 38/39, pp. 791–795.)

821. On the Influencing of a Discharge Plasma by an Electrically Controlled Grid.—Schumann. (*See* 680.)

822. The Ignition Characteristic of Ionic Converters, and the Influence on It of the Grid-Circuit Resistance, *and* The Ignition of the Hot-Cathode Converter as a Function of the Grid-Circuit Resistance.—Kirschstein: Adam. (*Wiss. Veröff. a. d. Siemens-Werken*, No. 3, Vol. 18, 1939, pp. 82–93: 25th April 1941, Vol. 20, No. 1, pp. 28–39.)

The first paper surveys existing theories and then describes an investigation of the dependence of the ignition point on the grid-circuit resistance and the consequent displacement of the characteristic. It brings out a serious discrepancy between theory and experiment. The second writer sets himself to explain this discrepancy (the experimentally found displacement of characteristic by an amount greater than that accounted for by the voltage drop due to the initial current flowing to the grid) and formulates a new theory which is satisfactorily confirmed by measurements on a triode with inert-gas filling and an almost plane electrode system: he shows that the use of d.c. voltage is essential for measuring purposes.

823. Hot-Cathode Rectifiers [New Series of Sealed-Off Steel-Tank Mercury-Vapour Rectifiers for 3- or 6-Phase Operation, for 40–500 A, 35–220 V: Life up to 25 000 Hours (Indirectly Heated Cathode): Compact & Efficient Design].—Geyer. (*E.T.Z.*, 11th Sept. 1941, Vol. 62, No. 37, pp. 774–775.)

824. A Rectifier for Small Telephone Exchanges [Selenium Type, for Battery Maintenance without Supervision].—Klinkhamer. (*Philips Tech. Review*, Feb. 1941, Vol. 6, No. 2, pp. 39–45.)

825. Selenium Rectifier Characteristics, Applications, and Design Factors.—Clarke. (*Elec. Communication*, No. 1, Vol. 20, 1941, pp. 47–66.)

826. Measurements on Selenium Rectifiers and Barrier-Layer Cells: an Experimental Contribution to the Schottky Boundary-Layer Theory.—Schmidt. (*Zeitschr. f. Phys.*, 15th Aug. 1941, Vol. 117, No. 11/12, pp. 754–773.)

The cuprous-oxide rectifier has already been shown to be typical of the "exhaustion boundary layer" of Schottky's theory, but on the basis of existing measurements on selenium rectifiers Schottky at first classified these latter rectifiers as belonging to a "reserve boundary layer" type. The writer's new results, however, show that for the selenium rectifier also a barrier layer in the "exhaustion" region can be assumed, the observed deviations from the ideal type of "exhaustion" rectifier being attributable to field-emission effects at the metal/semiconductor boundary (*cf.* Schottky's latest work, 2828 of 1941). Since the field-emission effects are strongly influenced by the local field, formed at the metal/semiconductor boundary in proportion to the electronic impoverishment at the boundary, it is to be expected that selenium rectifiers with such metallic electrodes as produce only slight boundary-impoverishment (*i.e.* metals with small deficiency-electron work function, such as bismuth and gold) would be least subject to the disturbing influences of field emission, and would therefore approach most closely to the "ideal" type: this is found to be the case (*see*, for example, Fig. 8). In contrast to the cuprous-oxide rectifier, the selenium rectifier fulfils comparatively well the assumptions of the homogeneous-boundary-layer theory of Schottky. The rectifying mechanism is therefore not bound up with the existence of an inhomogeneous disturbance - point distribution (" chemical barrier layer ") or even with the formation of heterogeneous selenide layers: a unipolar conductivity is called into being, when a current passes, by a purely electronic boundary-impoverishment (" physical barrier layer ").

827. PAPER ON THE GROWTH OF CHEMICAL COMPOUNDS ON A Cu SINGLE CRYSTAL [Studied by Electron Diffraction: including Structures of Cu_2O & Cu_2S Films].—Usmani. (*Phil. Mag.*, Aug. 1941, Vol. 32, No. 211, pp. 89–105.)

828. ELECTRICAL CONDUCTIVITY OF SEMICONDUCTORS WITH AN IONIC LATTICE IN STRONG FIELDS [and the Contrast with That of Semiconductors with an Atomic Lattice].—Davydov & Shmushkevitch. (*Journ. of Phys.* [of USSR], No. 4/5, Vol. 3, 1940, pp. 359–377: in English.)

829. ELECTRICAL CHARACTERISTICS OF ALKALINE COUNTER-E.M.F. CELLS. — Piontkovski. (*Elektrosvyaz* [in Russian], No. 12, 1940, pp. 77–81.) *Cf.* Catt, 215 of January.

830. SALVING ACCUMULATORS: REGENERATION OF SULPHATED CELLS [Bennett-Cole Method].—Hickling. (*Wireless World*, Dec. 1941, Vol. 47, No. 12, p. 317.)

831. PORTABLE H.T. BATTERIES: RECENT IMPROVEMENTS IN VOLUMETRIC EFFICIENCY.—French. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 9.) Based on French's paper, 3306 of 1941.

832. CEMENTING BAKELITE [" Ardux," New Adhesive for Use with Articles of Cured Synthetic Resin].—(*Wireless World*, Jan. 1942, p. 6.)

833. TEMPERATURE [& Frequency] DEPENDENCE OF YOUNG'S MODULUS AND INTERNAL FRICTION OF LUCITE AND KAROLITH [Vibrational Measurements at Frequencies around 50 kc/s].—Rinehart. (*Journ. Applied. Phys.*, Nov. 1941, Vol. 12, No. 11, pp. 811–816.)

The processes accounting for the internal frictional losses " are apparently closely connected with the plasticity and dielectric properties of the material, and more experimental data would be helpful in arriving at a satisfactory theory ": hence this investigation of two thermoplastic plastics.

834. A NEW SERIES OF THERMOPLASTIC POLYMERISED MATERIALS [Tenaplas K & L].—(*Electrician*, 26th Dec. 1941, Vol. 127, p. 362.) The " L " type is used chiefly for h.f. cables.

835. CONTRIBUTION TO OUR KNOWLEDGE OF THE MECHANISM OF THERMAL POLYMERISATION OF STYROL [including New Results with Monochlorbenzol as Solvent: No Chemical Participation of This Solvent, in Contrast to Carbon Tetrachloride]. — Breitenbach. (*Naturwiss.*, 21st Nov. 1941, Vol. 29, No. 47, p. 708.) For an omitted caption *see* issue for 26th December, p. 784.

836. THE THEORY OF DIELECTRIC LOSS IN POLAR POLYMERS: *also* DEPENDENCE OF DIELECTRIC LOSS ON MOLECULAR WEIGHT IN THE SYSTEM POLYVINYL - CHLORIDE DIPHENYL: *and* THE RELATION OF DIELECTRIC PROPERTIES OF STRUCTURE OF LINEAR POLYAMIDES AND POLYESTERS.—Kirkwood: Fuoss: Yager & Baker. (*Elec. Engineering*, Oct. 1941, Vol. 60, No. 10, p. 516: p. 516: p. 517: summaries only.)

837. EXPERIMENTS ON THE FLOW OF PLASTIC MASSES FROM NON-CENTRAL ORIFICES [with View to Elimination of Defects of Usual Central-Orifice Extrusion].—Unckel. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 22, 1941, pp. 105–110.)

838. THE BEHAVIOUR OF CELLULOSE TRIACETATE [particularly under the Action of Heat].—Kroker & Becker. (*E.T.Z.*, 9th Oct. 1941, Vol. 62, No. 40/41, pp. 825–829.)

839. IMPROVED CERAMIC DIELECTRIC MATERIALS [Survey, with Particular Attention to Steatites (Dielectric Properties superior to Those of Fused Quartz): Cordierite Ceramics & Their Special Advantages: Titanium-Dioxide Ceramics].—Rigterink. (*Review Scient. Instr.*, Nov. 1941, Vol. 12, No. 11, pp. 527–534.) From the Bell Telephone laboratories.

840. THE FUSING OF QUARTZ GLASS [Technique for Large-Scale Drawing of Tubes].—Hänlein. (*Zeitschr. V.D.I.*, 13th Dec. 1941, Vol. 85, No. 49/50, pp. 958–959: summary, from *Zeitschr. f. tech. Phys.*, Vol. 21, 1940, p. 97 onwards.)

841. DISCUSSION ON " THE PERFORMANCE OF GLASS INSULATORS, AND COMPARISONS WITH PORCELAIN " [E.R.A. Report U/T16]. — (*Journ. I.E.E.*, Aug. 1941, Vol. 88, Part II, No. 4, p. 372.) *See* 875 of 1941.

842. DIELECTRIC PROPERTIES OF GLASS CLOTH IN COMPRESSED GASES [Measurements at 50 c/s]. —Wul & others. (*Journ. of Phys.* [of USSR], No. 4/5, Vol. 3, 1940, pp. 321–326: in English.)

843. NATURAL AMBER AND MOULDED AMBER, WITH SPECIAL REFERENCE TO THEIR INSULATING QUALITIES IN DRY AND MOIST AIR [Both Kinds are Imperfect Insulators in Moist Air, and are Hygroscopic: etc.].—Walter. (*Ann. der Physik*, 18th Aug. 1941, Vol. 40, No. 2, pp. 154–164.) Arising out of the experiments dealt with in 613 of 1941.

844. ELECTRICAL PROPERTIES OF NEOPRENE COMPOSITIONS.—Yerzley. (*Journ. Franklin Inst.*, Oct. 1941, Vol. 232, No. 4, p. 364: summary only.)

845. EXPERIENCES WITH INSULATING VARNISHES WITH SYNTHETIC RESIN BASES.—Burmeister. (*E.T.Z.*, 9th Oct. 1941, Vol. 62, No. 40/41, pp. 843–844: summary only.)

846. INVESTIGATIONS ON ENAMELLED WIRES FOR COMMUNICATIONS TECHNIQUE [Comparison with Silk & Cotton Coverings: Various Types of Enamel and Their Physical Properties: Full Account of Test Methods & Devices, Electrical & Mechanical].—Wolff & Pohler. (*E.N.T.*, July 1941, Vol. 18, No. 7, pp. 156–171.)

847. PAPER DIELECTRICS CONTAINING CHLORINATED IMPREGNANTS: DETERIORATION IN D.C. FIELDS.—McLean & others. (*Elec. Engineering*, Oct. 1941, Vol. 60, No. 10, p. 516: summary only.)

848. INSULATING PAPER [Effects of Contamination, etc.].—Finch. (*Bell Lab. Record*, Aug. 1941, Vol. 19, No. 12, pp. 371–373.)

849. ON THE DIELECTRIC CONSTANT OF HETEROGENEOUS MIXTURES [and the Erroneous Results obtained by Use of Lorentz-Lorenz Formula in calculating ϵ for Compact State from Measurements in Powdered State: Tests on Pure Dry Iron Powder].—Guillien. (*Comptes Rendus* [Paris], 17th March 1941, Vol. 212, No. 11, pp. 437–439.)

850. ON THE THEORY OF RESIDUAL PHENOMENA IN DIELECTRICS [Establishment of Complete Expression for Current in Condenser under Various Potential Conditions].—Gross. (*Sci. Abstracts*, Sec. B, Oct. 1941, Vol. 44, No. 526, p. 190.) *See* also 1602 of 1940 and 2539 of 1941.

851. DETERMINATION OF THE RESIDUAL CURRENT OF AN IONISATION CHAMBER AND THE TRUE CONDUCTIVITY OF DIELECTRIC LIQUIDS [shielded from Cosmic Radiation & Radioactive Phenomena].—Rogozinski. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, pp. 148–149.)

852. ON THE ELECTRICAL BREAKDOWN OF INSULATING CRYSTALS.—Worobjew [Vorobjev]. (*Journ. of Phys.* [of USSR], No. 2, Vol. 3, 1940, pp. 73–80: in German.)

Experimental investigation on alkali-halide crystals, from which it is concluded that "the electrical strength of solid dielectrics represents a definite physical characteristic of the material which is determined according to law by the chemical composition and the structure of the dielectric, but not by small disturbances of this structure caused by a plastic deformation, the introduction of small admixtures, or by temperature changes. The electrical strength of solid dielectrics is determined not merely by the magnitude of the binding energy of the electrons in the lattice (as explained in the existing breakdown theories) but also by the binding energy of the particles constituting the lattice of the dielectric. The electrical strength increases with an increase of the binding energy of the most loosely bound electrons and with an increase of the lattice energy."

853. THE ELECTRICAL STRENGTH OF GASES [with Complete Molecules: Comparisons of Strength, Ionisation Potential, & Molecular Weight for Various Gases].—Bonch-Bruevich & others. (*Journ. of Phys.* [of USSR], No. 4/5, Vol. 3, 1940, pp. 327–332: in English.)

854. RESEARCH ON THE ESTABLISHMENT OF THE LAW OF THE DISSIPATION OF ELECTRICITY IN THE AIR.—Yadoff. (*Comptes Rendus* [Paris], 13th Jan. 1941, Vol. 212, No. 2, pp. 73–75.)

855. READING LIST ON RADIO-FREQUENCY INSULATION, 1931 TO DATE.—(*Science Library Bibliogr. Series*, No. 557, 1941, 2 pp.)

856. THE EVAPORATION OF MOLTEN METALS FROM HOT FILAMENTS [in Preparation of Mirrors, Thermocouples, High Resistances, etc: Investigation on Best Filament Materials for Evaporation of Twenty Seven Metals].—Caldwell. (*Journ. Applied Phys.*, Nov. 1941, Vol. 12, No. 11, pp. 779–781.)

857. RAW MATERIALS: ALTERNATIVES ADOPTED BY R.C.A.—R.C.A. Laboratories. (*Wireless World*, Dec. 1941, Vol. 47, No. 12, p. 312.)

858. PRECISION THERMOSTAT CONTROL [carrying up to 10 mA].—Steiner. (*Journ. of Scient. Instr.*, Jan. 1942, Vol. 19, No. 1, p. 14.)

859. A WELL-TESTED COUNTER MECHANISM [for Impulses from Counter Tubes, etc: and the Advantages over Photographic Recording]. —Kolhörster & Lange. (*Physik. Zeitschr.*, Oct. 1941, Vol. 42, No. 19/20, pp. 341–343.)

860. CONTRIBUTION TO OUR KNOWLEDGE OF FRICTION [and the Electrical Conductivity of Sliding Contacts], *and* SURFACE CONTACTS UNDER HIGH PRESSURES.—Holm: Müller-Hillebrand. (*Wiss. Veröff. a. d. Siemens-Werken*, 25th April 1941, Vol. 20, No. 1, pp. 68–84: pp. 85–103.)

861. THE CONTROL OF CONTACT PRESSURES [*e.g.* in Mass-Produced Receiver Mains-Switch: Testing Device].—Werner. (*Philips Tech. Review*, Feb. 1941, Vol. 6, No. 2, pp. 61–62.)

862. A NEW POTENTIOMETER FOR COMMUNICATIONS TECHNIQUE [Rotating Type, with Special Device giving Vibration-Proof Contact without Wear on Wire].—(*E.T.Z.*, 14th Aug. 1941, Vol. 62, No. 33, pp. 715–716.)

863. LAMINATED SHIM [giving Right Thickness to obtain "Snug" Fit by peeling-off Layers of 2–3 Thousandths of an Inch].—(*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, p. 515.)

864. MULTICORE SOLDER WITH ERSIN FLUX.—(*Journ. of Scient. Instr.*, Jan. 1942, Vol. 19, No. 1, p. 15.)

865. "ELECTROMAGNETIC DEVICES" [Fundamental Principles & Practical Details of Magnet-Operated Devices: Book Review].—Roters. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 502–503.)

866. NON-MAGNETIC STEELS.—Riedrich. (*E.T.Z.*, 9th Oct. 1941, Vol. 62, No. 40/41, p. 844: summary only.)

867. On a New Magneto-Caloric Effect [Periodic Heating & Cooling of a Ferromagnetic Single Crystal at Low Temperatures, during Its Rotation in a Strong Magnetic Field].—Akulov & Kirensky. (*Journ. of Phys.* [of USSR], No. 1, Vol. 3, 1940, pp. 31–34: in German.)

868. Magnetic Penetration [Further Experimental Investigation of View that Magnetisation of Ferromagnetic Material is initiated at Surface & penetrates by means of Chain-like Effect].—Wall. (*Engineer*, 12th Sept. 1941, Vol. 172, pp. 166–167.)

869. The Temperature Dependence of the Magnetic Anisotropy of Cobalt Single Crystals [Support for Bloch-Gentile Model against That of Van Vleck], *and* On the Quantum Theory of Magnetostriction of Ferromagnetic Single Crystals.—Vonsovsky. (*Journ. of Phys.* [of USSR], No. 2, Vol. 3, 1940, pp. 83–93: No. 3, pp. 181–190: in English.)

870. Torque on Silicon-Iron Crystal in a Magnetic Field [Apparently Anomalous Behaviour (Definite Value of Field producing a Maximum Torque) & Its Explanation].—Bozorth & Williams. (*Bell Lab. Record*, Oct. 1941, Vol. 20, No. 2, p. 52.)

871. The Dependence of the Initial Susceptibility and of the Coercive Force of Ferromagnetic Crystals on the Temperature.—Dekhtjar & Andriushin. (*Journ. of Phys.* [of USSR], No. 6, Vol. 3, 1940, pp. 487–492: in English.) Translation of the Russian paper referred to in 2869 of 1941.

872. Magnetisation in Crystalline Media [and the Adequacy of Weber's Theory].—Peddie. (*Phil. Mag.*, Sept. 1941, Vol. 32, No. 212, pp. 225–238.)

873. Statistics of the Two-Dimensional Ferromagnet: Parts I and II.—Kramers & Wannier. (*Phys. Review*, 1st Aug. 1941, Vol. 60, No. 3, pp. 252–262 & 263–276.)

874. Statistical Computation of Magnetic Susceptibility.—Kaner. (*Journ. of Phys.* [of USSR), No. 3, Vol. 3, 1940, pp. 153–164: in English.) The original Russian version was dealt with in 587 of 1941.

875. Statistical Theory of Binary Alloys: II—Application to Ferromagnetism.—Takagi. (*Proc. Phys.-Math. Soc. Japan*, July 1941, Vol. 23, No. 7, pp. 553–567: in English.) For Part I *see* 2863 of 1941.

876. A Preliminary X-Ray Study of Binary Alloys of Platinum with Cobalt, Molybdenum, and Tungsten [and the Formation of the Superlattice responsible for the Superlative Remanence & Coercivity reported by Jellinghaus].—Hultgren & Jaffee. (*Journ. Applied Phys.*, June 1941, Vol. 12, No. 6, pp. 501–502.) *See* 1976 of 1936.

877. Equilibrium Relations in the Solid State of the Iron-Cobalt System.—Ellis & Greiner. (*Bell S. Tech. Journ.*, July 1941, Vol. 20, No. 3, p. 360: summary only.)

878. Magnetic Studies of Solid Solutions: II—The Properties of Quenched Copper-Iron Alloys.—Bitter & others. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, pp. 134–138.) For I *see* 1642 of 1940.

879. Absolute Saturation Magnetisation of Nickel-Antimony and Nickel-Tantalum Alloys [and a Summary of Previous Data on Ferromagnetic Binary Alloys].—Rado & Kaufmann. (*Phys. Review*, 15th Aug. 1941, Vol. 60, No. 4, pp. 336–339.)

880. Remarks on the Volume Magnetostriction of Nickel [Extension of Theory (1509 of 1941) to Nickel].—Smoluchowski. (*Phys. Review*, 1st Aug. 1941, Vol. 60, No. 3, pp. 249–251.)

STATIONS, DESIGN AND OPERATION

881. The Eckersley Plan: Suggestions for a Post-War Broadcasting Service [" Wire Britain for Sound & Vision, but preserve Some Short-, Medium-, & Long-Wave Stations " (for Liberty to hear across Frontiers)].—Eckersley. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, pp. 7–8.) For an Editorial *see* p. 1, and for correspondence *see* February issue, pp. 46–47.

882. " The Power behind the Microphone " [Book Review].—Eckersley. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 12.)

883. 112-Megacycle Emergency Gear: an Outline of Requirements and Recommendations of Standardisation.—Grammer. (*QST*, Dec. 1941, Vol. 25, No. 12, pp. 9–13 and 66.) *See* also 681, above, and *Wireless World*, Feb. 1942, p. 37.

884. One Shack—Nine Bands: 1.75 to 400 Mc/s at W2TY [in Small Attic Space].—MacDonald. (*QST*, Dec. 1941, Vol. 25, No. 12, pp. 39 and 86.)

885. A Soldier's Portable: Midget Station to fit in an Army Foot Locker [and to stand up to the " Baggage Smashers "].—Roof. (*QST*, Nov. 1941, Vol. 25, No. 11, pp. 22–25 and 74, 76.)

886. The Protection of Low-Power Wireless Transmitting Installations against Surges.—Müller. (*See* 660.)

GENERAL PHYSICAL ARTICLES

887. Attempt at a Synthesis between Wave Mechanics and Corpuscular Mechanics: Second Communication.—Planck. (*Ann. der Physik*, 23rd Nov. 1941, Vol. 40, No. 7, pp. 481–492.)

888. The Microcoulomb Experiment [Résumé of Work on Charges carried by Minute Solid Particles in Gases].—Ehrenhaft. (*Nature*, 3rd Jan. 1942, Vol. 149, p. 25: summary only.) For recent work *see* 18 of January.

889. Electrical Conductivity Mechanism and Superconductivity of Metals [Survey, including Much of the Writer's Own Work].—Justi. (*E.T.Z.*, 21st & 28th Aug. 1941, Vol. 62, Nos. 34 & 35, pp. 721–725 & 741–745.)

MISCELLANEOUS

890. The Numerical Solution of a Type of Equation [tan $x = xf(x)$: including Equations relating to Electrical Waves on a Sphere, Sound Waves in a Sphere, Vibrations of a Rod, etc.].—Plummer. (*Phil. Mag.*, Dec. 1941, Vol. 32, No. 215, pp. 505–512.)

891. On the Solution of Second Order Differential Equations satisfying Boundary Conditions [primarily in considering Sound Distribution in front of Spherical Concave Reflector, but applicable also to Electrostatic Problems, etc.]—Morgans. (*Phil. Mag.*, Dec. 1941, Vol. 32, No. 215, pp. 483–488.)

892. Matrices, Tensors, or Dyadics for Studying Electrical Networks ?—Reed. (*See* 671.)

893. Automatic Regulation Systems and Their Treatment with the Help of the Laplace Transformation.—Grünwald. (*See* 670.)

894. Some Properties of a Composite, Bivariate Distribution in which the Means of the Component Normal Distributions are Linearly Related [in Applications of Physical Sciences to Industrial Problems].—Charnley. (*Canadian Journ. of Res.*, Dec. 1941, Vol. 19, No. 12, Sec. A, pp. 139–151.)

895. The Imaginary in Mathematics [Correspondence on "j" or $\sqrt{-1}$: Caspar Wessel's Original Postulates: etc.].—Campbell & others. (*Electrician*, 16th Jan. 1942, Vol. 128, pp. 38–39.) Continued from previous issues.

896. On Algebraic Lamé Functions *and* Note on Heine's Integral Representation of Associated Legendre Functions.—Erdélyi. (*Phil. Mag.*, Oct. 1941, Vol. 32, No. 213, pp. 358–350: pp. 351–352.) *See* also 4478 of 1940.

897. On the Analytical Functions with Several Variables: V—The Cauchy Integral.—Oka. (*Jap. Journ. of Mathematics*, Aug. 1941, Vol. 17, No. 4, pp. 523–531: in French.)

898. "Mathematical Tables" [including Large Section on Hyperbolic Functions: Binomial Coefficients, Elliptic Integrals, etc: Book Review].—Dwight. (*Journ. Franklin Inst.*, Oct. 1941, Vol. 232, No. 4, pp. 392–393.)

899. On the Theory of Non-Linear Direction Displacements.—Mikami. (*Jap. Journ. of Mathematics*, Aug. 1941, Vol. 17, No. 4, pp. 541–568: in English.)

900. The World mapped in Complementary Segments [with "Equal Area" Projection].—Dufton. (*Phil. Mag.*, Nov. 1941, Vol. 32, No. 214, pp. 436 and Map.) It is added that for certain purposes an oblique projection may be preferred to a presentation symmetrical with respect to the equator.

901. Application of Autoabsorption [in Excited Gases] in Long Tubes to the Observation of Radiations of Feeble Intensity in the Neighbourhood of Intense Rays.—Jacquinot. (*Comptes Rendus* [Paris], 31st March 1941, Vol. 212, No. 13, pp. 537–540.)

902. On the Energy Consumption in the Separation of Isotopes [likely in the Future to become Important for Technical Purposes].—Houtermans. (*Ann. der Physik*, 23rd Nov. 1941, Vol. 40, No. 7, pp. 493–508.) From the von Ardenne laboratories.

903. On the Study and Detection of Infra-Sonic Waves by Special Sensitive Flames [including Scientific & Practical Applications].—Esclagon. (*Comptes Rendus* [Paris], 5th Feb. 1941, Vol. 212, No. 5, pp. 181–186.)

904. Ultra-Acoustical [Supersonic] Methods for studying the Properties of Tempered Steel and determining Internal Defects of Metallic Articles.—Sokolov. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 160–169.)

The theory of the following methods is discussed and the necessary apparatus described:—(1) Determination of internal defects. Oscillations of the order of 6×10^6 c/s are generated by a crystal plate excited by an oscillator, and passed through the article under investigation. On the opposite side of the article is mounted another crystal plate which receives these oscillations and transmits them to a suitable amplifier. From a study of the received oscillations it is possible to detect the presence of any flaws in the article such as cracks, foreign bodies, etc. (2) Obtaining a television image of the internal defect. The "electrical" image of the defect on the receiving crystal plate is converted by means of a television transmitter and receiver into a visible image. (3) Measuring the depth of the tempered layer. Use is made of the reflection of oscillations from the tempered layer. A number of photographs relating to the above methods are included.

905. Determination of the Static and Dynamic Constants [of Materials under Test, *e.g.* by Induced Vibrations] by means of Response Curves.—Bernhard. (*Journ. Applied Phys.*, Dec. 1941, Vol. 12, No. 12, pp. 866–874.)

906. Superconducting Compounds with Very High Critical Temperatures: NbH and NbN [15° and 20.4° Absolute: and the Possibility of Use for obtaining Very Strong Magnetic Fields].—Aschermann & others. (*Physik. Zeitschr.*, 20th Nov. 1941, Vol. 42, No. 21/22, p. 349–360.)

907. ANGLO-AMERICAN COOPERATION IN SCIENTIFIC RESEARCH. — Conant. (*Nature*, 3rd Jan. 1942, Vol. 149, pp. 10–12.) *See* also p. 17 (message from Association of Scientific Workers).

908. SCIENCE AND NATIONAL DEFENCE.—Bush. (*Journ. Applied Phys.*, Dec. 1941, Vol. 12, No. 12, pp. 823–826.) Address by the Director of the O.S.R.D.

909. RECENT AMERICAN DEVELOPMENTS IN EXPERIMENTAL PHYSICS.—Overbeck. (*Journ. of Scient. Instr.*, Jan. 1942, Vol. 19, No. 1, pp. 1–11.)

910. "MITTEILUNGEN AUS DER FORSCHUNGSANSTALT DER DEUTSCHEN REICHSPOST: BAND V" [to June 1940: Book Review].—(*E.N.T.*, Sept. 1941, Vol. 18, No. 9, p. 218.)

911. FOUNDATION OF THE GERMAN STATE SOCIETY FOR DOCUMENTATION.—(*E.N.T.*, July 1941, Vol. 18, No. 7, p. 155.)

912. TRAINING OF WIRELESS ENGINEERS.—Dalton. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 16.) "In practice, the [properly trained] radio man could eat the electrical engineer's subject and then carry on with his own." For previous correspondence *see* 305 of January, and for criticisms (of two very different types) *see* February issue, p. 47.

913. CONDITIONS FOR AMATEUR LICENCES [after the War: Allocation of Micro-Waves?].—Dean. (*Wireless World*, Jan. 1942, p. 16.)

914. "THE POWER BEHIND THE MICROPHONE" [Book Review].—Eckersley. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 12.)

915. ON THE METHOD OF PROSPECTING FOR GEOLOGICAL STRATA BY THE PENETRATING [Telluric] RADIATIONS. — Rothé. (*Comptes Rendus* [Paris], 10th Feb. 1941, Vol. 212, No. 6, pp. 212–215.)

916. SOME NEW PHYSICAL METHODS APPLIED TO THE PROBLEM OF THE RATIONAL LOCATION OF OIL WELLS.—Dorfman & Sergeyev. (*Journ. of Phys.* [of USSR], No. 4/5, Vol. 3, 1940, pp. 393–400: in English.)

917. THE SHORT-WAVE [and Ultra-Short-Wave] CONDENSER FIELD [Experimental Investigation].—Swaminathan. (*Indian Journ. of Phys.*, Aug. 1941, Vol. 15, Part 4, pp. 307–316.)

The method of mapping employed was based on the use of small neon bulbs: different pressures in different bulbs make them ignite at different field intensities, so that different parts of the field can be examined at the same time. The presence of a bulb does not affect the field materially: the plate current of the valves producing the field showed no appreciable variation when a bulb was introduced. In addition to the field plotting, heating effects were noted: for instance, a test with a liquid in a tube surrounded by low-melting-point wax showed that by a suitable choice of wavelength the liquid could be heated without the wax being melted. Effects on emulsions and on colloidal particles were also demonstrated. The optimum heating effect and its dependence on wavelength and on the specific resistance and dielectric constant of the solution was investigated. "If the frequency is so low that the induced charges build up equilibrium in a small part of each cycle, then there will be idle time within the cycle, without heating. If, on the other hand, the resistance is too high (too few ions), the ions cannot build up the equivalent induced charge within a half-cycle, and the energy used, or the heating, will be less than the maximum. Finally there will be one concentration for any given frequency in which the time period will be just sufficient to cause the ionic motion to be continuous during the entire period, and this will correspond to the maximum heat for that frequency."

918. THE DIELECTRIC BEHAVIOUR OF INHOMOGENEOUS SUBSTANCES, PARTICULARLY BIOLOGICAL BODIES, AT VARIOUS TEMPERATURES AND FREQUENCIES.—Schwan. (*Ann. der Physik*, 23rd Nov. 1941, Vol. 40, No. 7, pp. 509–528.)

The wavelength-dependence of the electrical constants of such substances is explicable either by the Maxwell-Wagner (inhomogeneity) theory or by the Debye (polar-molecule) mechanism. Experimental investigations hitherto have failed to decide between the two theories. The present discussion shows that the behaviour of the conductivity and of the dielectric constant (but especially the latter) as regards temperature-dependence at various wavelengths should be very different according to the two theories, and should form a quantitative basis for a decision. A number of literature references are given.

919. MECHANISM OF THE ACTION OF IONISING RAYS ON BIOLOGICAL ELEMENTARY UNITS [Survey, with Many Literature References].—Riehl & others. (*Naturwiss.*, 17th Oct. 1941, Vol. 29, No. 42/43, pp. 625–639.)

920. PHYSIOLOGICAL EFFECTS OF ULTRA-SHORT-WAVE RADIATION [and Lakhovsky's Researches].—Walker. (*Wireless World*, Jan. 1942, Vol. 48, No. 1, p. 16.) Prompted by 339 of January. For some of Lakhovsky's work *see* 1934 Abstracts, p. 110: 632 of 1935: and 2617 of 1939.

921. NEW OSCILLOSCOPE: AN AID TO GOOD RESISTANCE WELDING.—Levoy & Schermerhorn. (*See* 793.)

922. ETCHING GLASS SURFACES REDUCES REFLECTION [for Television C.R. Tubes, Framed Pictures, etc.].—Nicoll. (*See* 776.)

923. AN AUTOMATIC RECORDER OF SPECTRAL SENSITIVITY OF PHOTOELECTRIC SURFACES.—Tykociner & Bloom. (*See* 778.)

924. AN A.C. INDUCTION METER FOR MEASURING THE RATE OF FLOW OF ELECTROLYTES THROUGH A CONDUIT.—Kolin. (In paper dealt with in 665, above.)