2/6

WIRELESS ENGINEER

The Journal of Radio Research & Progress

Vol. XIX MAY 1942 No. 224

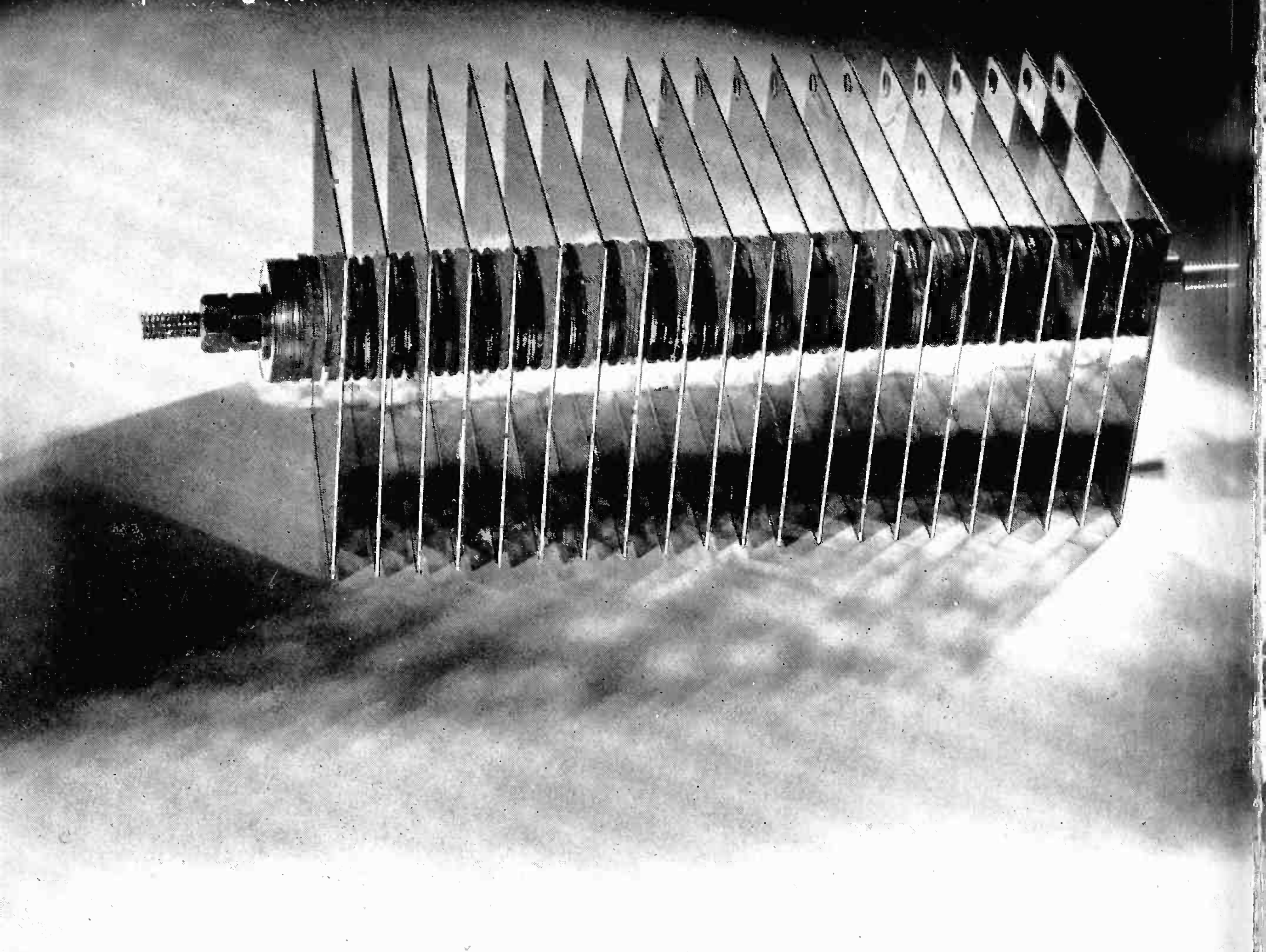
CONTENTS

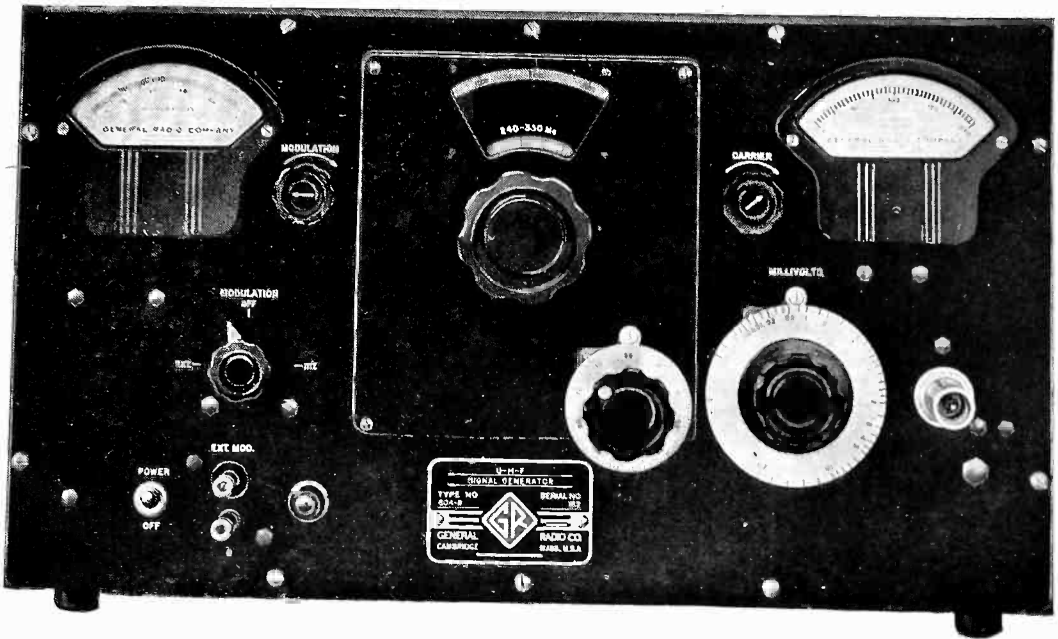
Published on the first of each month
SUBSCRIPTIONS (Home and Abroad)
One Year 32/- 6 Months 16/-

Telephone:
Waterloo 3333 (35 lines)

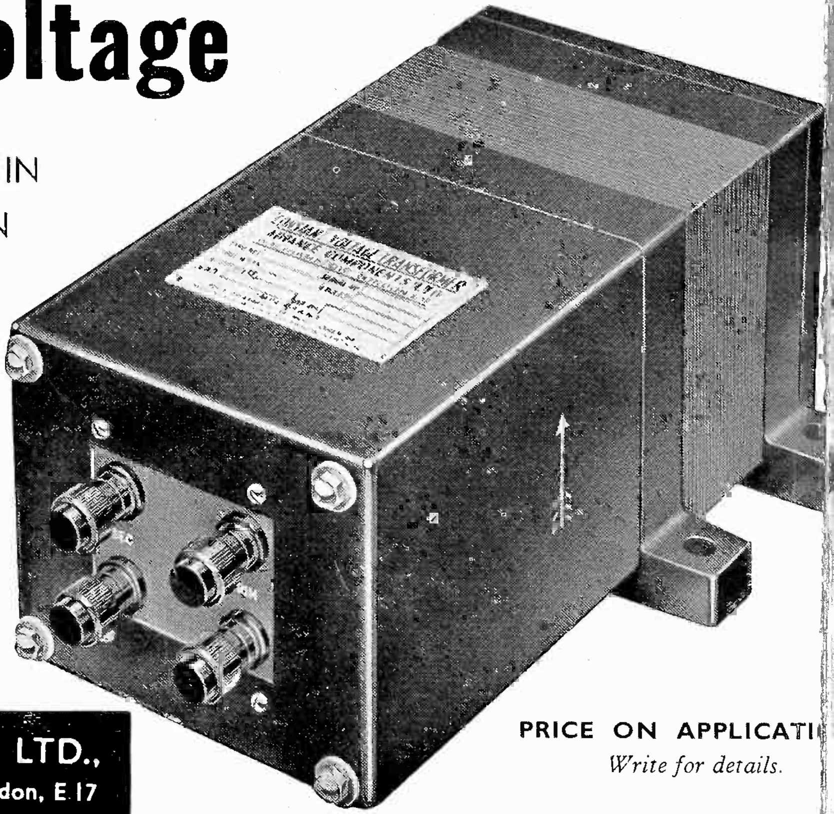
Telegrams:
Experiwyr Sedist London

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




MODULATION
240-330 Mc
CARRIER
MILLIVOLTS
MODULATION OFF
EXT MOD.
POWER
OFF
U-H-F SIGNAL GENERATOR
TYPE NO 804-B
SERIAL NO
GENERAL RADIO CO.
CAMBRIDGE MASS. U.S.A.

Constant Voltage



A NEW 'ADVANCE' IN TRANSFORMER DESIGN

Line voltage variations of $\pm 15\%$ reduced to $\pm 1\%$

Stabilize your Electrical Instruments by using an "ADVANCE" Constant Voltage Transformer

TYPICAL SPECIFICATION

Input Voltage:	190-260 v. 50 c.
Output Voltage:	230 v. ± 1%.
Max. load:	150 watts.

Input power factor over 90%.

ADVANCE COMPONENTS LTD.,
Back Rd., Shernhall St., Walthamstow, London, E 17
Telephone: Larkswood 4366-7

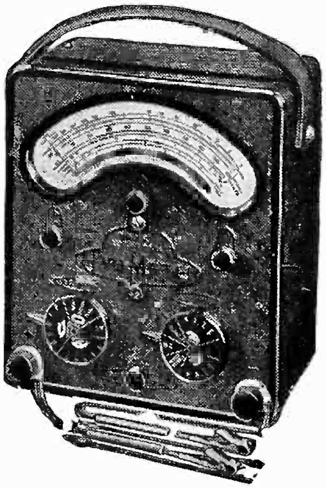
PRICE ON APPLICATI
Write for details.

'AVO'

Regd. Trade Mark.

PRECISION TESTING INSTRUMENTS

British Made



The MODEL 7 *46-Range Universal* AVOMETER

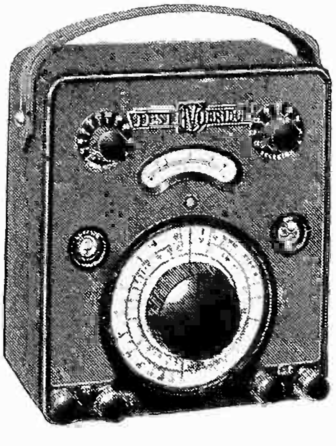
Electrical Measuring Instrument

A self-contained, precision moving-coil instrument, conforming to B.S. 1st Grade accuracy requirements. Has 46 ranges, providing for measuring A.C. & D.C. volts, A.C. & D.C. amperes, resistance, capacity, audio-frequency power output and decibels. Direct readings. No external shunts or series resistances. Provided with automatic compensation for errors arising from variations in temperature, and is protected by an automatic cut-out against damage through overload.

Also available:—

Model 7 Resistance Range Extension Unit (for measurements down to 1/100th ohm).

The 40-range Universal AvoMeter
The Universal AvoMinor
etc., etc.



THE 'AV TEST BRIDGE

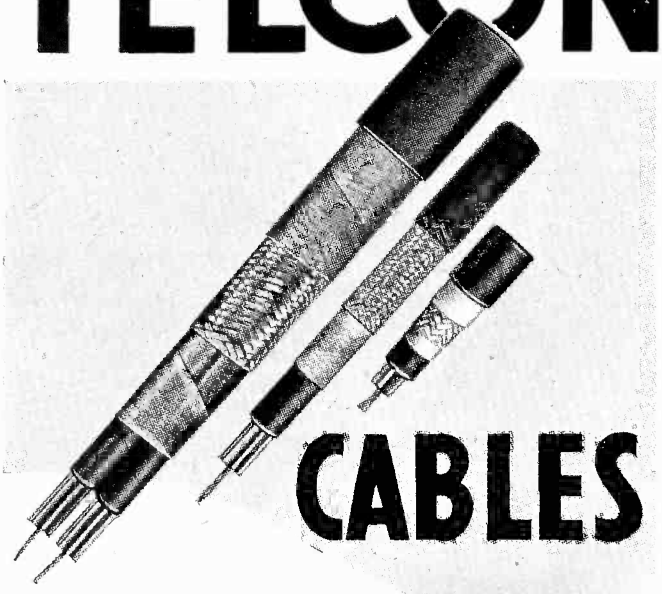
A self-contained 50-cycles measuring bridge of except accuracy and utility. Provides for the direct measure of all normal sizes of condensers and resistances. Accu except at the extreme ends of the range, is **better than** Facilities are also provided for condenser power factor mea ments and leakage tests. Inductances from 0.1 Henry upv can be checked against external standards. It may als employed as a highly efficient valve voltmeter indicato the measurement of both audio and radio frequency volt

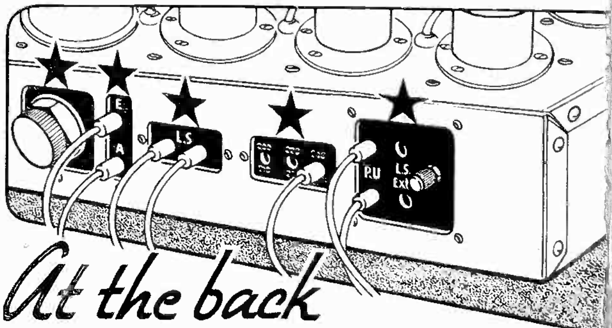
CAPACITY: Range C.1—·000005 μF to ·005 μ
Range C.2—·0005 μF to ·5 μ
Range C.3—·05 μF to 50· μ

RESISTANCES Range R.1— 5 ohms to 5,000 o
Range R.2— 500 ohms to 500,000 o
Range R.3—50,000 ohms to 50 mego

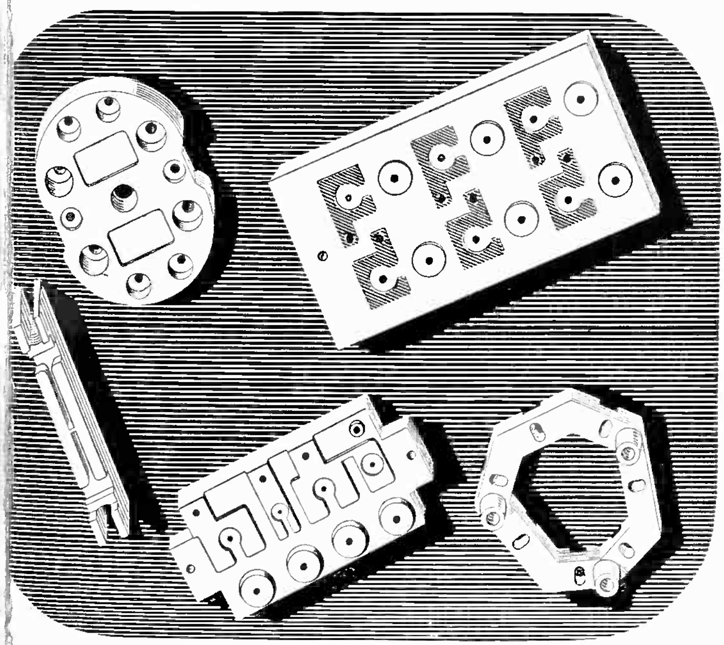
● **Write for fully descriptive literature and current prices.**

Sole Proprietors and Manufacturers:—
THE AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO. LTD., Winder House, Douglas Street, London, S.W.1. *Phone: Victoria 34*




E
A
L.S.
P.U
L.S.
Ext

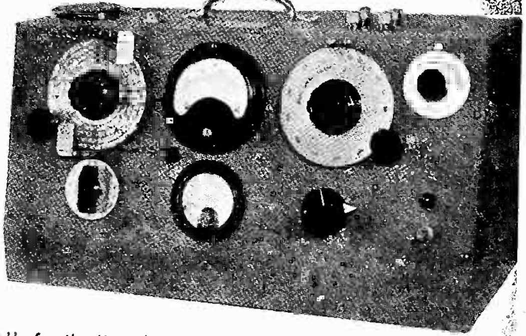

VALVE VOLTMETER
TYPE T.F.428 No2339
MARCONI-EKCO INSTRUMENTS LTD
LONDON
MAINS
OFF
ON
SET ZERO
RANGE MULTIPLIER



BOONTON

the famous

"Q" METER



A most versatile Laboratory instrument with applications in every branch of the Radio and Electrical Industries.

Measures "Q" of coils directly without calculation, Power factors of condensers, dielectrics, insulating materials, waxes, oils, yarns, etc. Direct calibration of oscillator and built-in Standard Condenser.

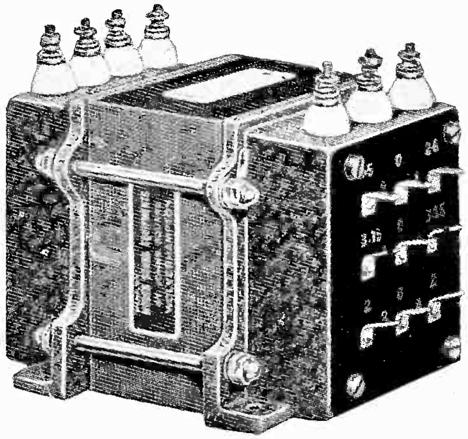
Send for details of this outstanding instrument and of other items available from the ranges of Ferris, Clough-Brengle, Ballantine and Hewlett-Packard equipment.

LELAND INSTRUMENTS LTD 43 MECKLENBURGH SQ. LONDON. W.C.1
TELEPHONE: TERMINUS 5689

CLOUGH-BRENGLE • BOONTON • FERRIS • BALLANTINE • HEWLETT-PACKARD

Play safe . . . In equipment where you can't afford a breakdown use Woden Transformers. They have done — and are doing — yeoman service in much vital equipment up and down the country.

Woden make stripped, fully shrouded and special types from 10 VA—10 KVA.

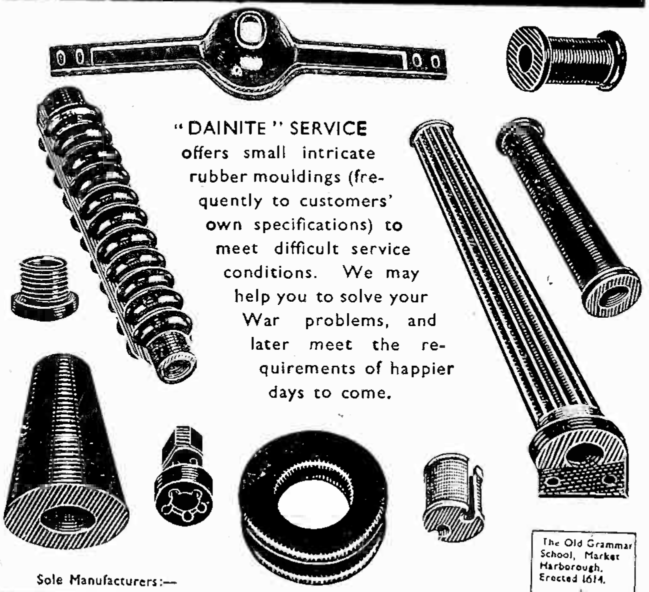


WODEN TRANSFORMER C
Thornley St., Wolverhampt
Tel.: Wolverhampton 22829

MAKERS OF TRANSFORMERS, POWER PACKS, & SPECIAL RECEIVING & TRANSMITTING APPARA

Dainite

MOULDED RUBBER PARTS



"DAINITE" SERVICE offers small intricate rubber mouldings (frequently to customers' own specifications) to meet difficult service conditions. We may help you to solve your War problems, and later meet the requirements of happier days to come.

Sole Manufacturers:—

THE HARBORO' RUBBER CO., LTD.
MARKET HARBOROUGH

The Old Grammar School, Market Harborough. Erected 1614.

LEWIS'S SCIENTIFIC LENDING LIBRARY

ELECTRICAL & RADIO ENGINEERING TEXTBOOKS & WORKS OF REFERENCE

New Works and New Editions can be had from the Library immediately on publication.

ANNUAL SUBSCRIPTION from ONE GUINEA

Prospectus on Application

H. K. LEWIS & Co. Ltd.
136 Gower Street, London, W.C.1
Telephone: EUSton 4282 (5 lines)

We specialise in

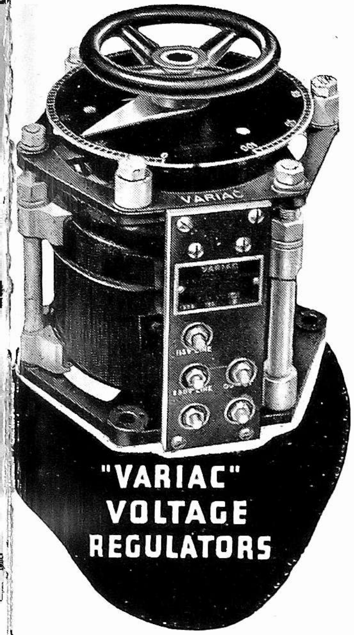
MIDGET SHORT WAVE VALVE
AND
GASDISCHARGETUBE

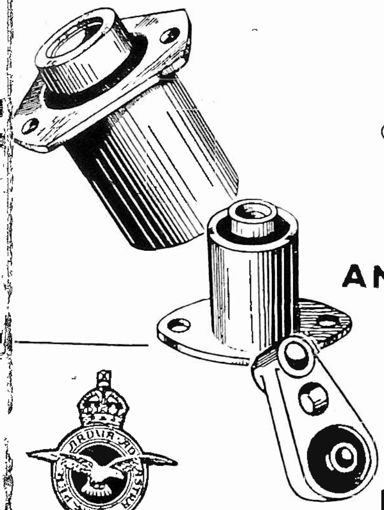
HIVAC
THE SCIENTIFIC VALVE
BRITISH MADE

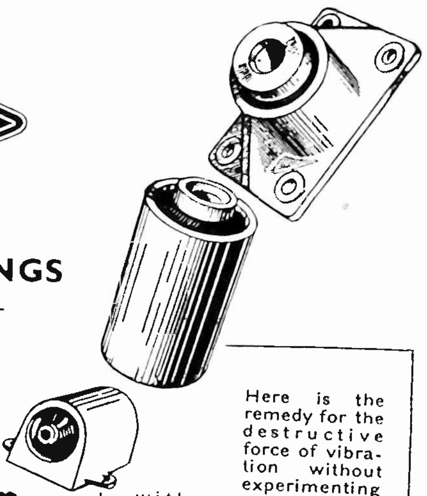
Telephone: HARROW 0895

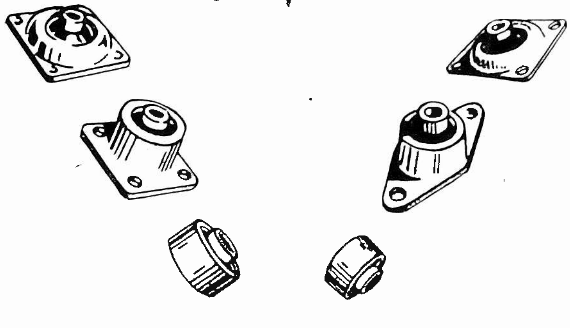
All enquiries should be addressed to:

HIVAC LIMITE
Greenhill Crescent,
Harrow-on-the-Hill, Mdd


VARIAC
"VARIAC" VOLTAGE REGULATORS







The Pioneers of Low Loss Ceramics

MANUFACTURERS OF:—

CERAMIC TRIMMER CONDENSERS
SILVERED MICA CONDENSERS
SILVERED CERAMIC CONDENSERS

CONTRACTORS TO G.P.O. & GOVERNMENT DEPARTMENTS

ON A.I.D. APPROVED LIST

U.I.C

UNITED INSULATOR Cº LTD

12-20, LAYSTALL STREET, LONDON, E.C.1.
'Phone: TERminus 7383.
'Grams: CALANEL, SMITH, LONDON.

MELTON METALLURGICAL LABORATORIES LTD

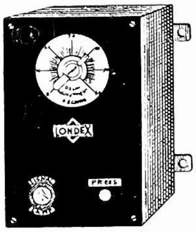
LIQUID SILVER for metallising CERAMIC, MICA, QUARTZ, or GLASS, Low Melting-point SOLDER from 70°C. or to specification. Non-Corrosive Liquid FLUX for all electrical or radio purposes

PRE-WAR DELIVERIES

OVERSEAS ENQUIRIES INVITED

IPSWICH RD. TRADING ESTATE,
SLOUGH, BUCKS. *Phone: Slough 20992*

LONDEX for RELAYS



Synchronous Time Delay Relay PRL

For A.C. or D.C., silent and reliable. 2 VA coil consumption, from 2-600 volts, tested to 2,000 volts. Unmounted and in cast-iron casing. Also Time Lag Relays. High Sensitive Relays, Synchronous Process Timers, and Complete Control Plants.
Apply for leaflet SPN/WE.

LONDEX LT
Manufacturers of Relays.
Anerley Works, 207, Anerley Rd
London, S.E.20.
Telephone: Sydenham 6258 & 6259

SUPPLIERS OF:
BERYLLIUM OXIDE, NITRATE X-RAY TUBE WINDOWS
BUYERS OF:
TUNGSTEN AND MOLYBDENUM SCRAP.
BRITISH UNICORN LTD.,
122, LONDON WALL, LONDON, E.C.2.

LARGE DEPT. FOR WIRELESS BOOKS.

FOYLES

BOOKSELLERS TO THE WORLD—NEW AND SECONDHAND BOOKS ON EVERY SUBJECT.
Catalogues Free. **Books Bought.**
113-125, CHARING CROSS ROAD, LONDON, W.C.2.
Tel.: GERrard 5660 (16 lines). Open 9 a.m.—6 p.m., including Saturday

Q.C.C

Piezo QUARTZ CRYSTALS
for all applications.
Full details on request.

QUARTZ CRYSTAL CO., LTD.,
(Phone: MALden 0334.) **63-71, Kingston Rd., New Malden, SURREY.**

TANNOY

Specialists in Sound Amplifying Equipment, Microphones, Power Amplifiers, Loudspeakers, etc.
Also makers of Scientific Instruments.
TANNOY PRODUCTS (Guy R. Fountain Ltd.) W. NORWOOD, S.E.


ERSIN
Multicore
THREE CORE
SOLDER

WIDE-RANGE TRANSFORMERS

TYPES D-106 and D-139

FOR MODERN COMMUNICATIONS EQUIPMENT.

- FREQUENCY CHARACTERISTICS.

Practically linear from the lower audio frequencies to over 100 Kc/s.
(See representative curves)

- IMPEDANCE RATIOS.

Many impedance ratios are available, from 1 : 1 to 500 : 1.

- POWER.

Types D-139 will handle up to one watt AC power above 40 c.p.s. Types D-106 are designed as input and interstage transformers where the power is negligible.

- SCREENING.

All types double screened against electromagnetic and electrostatic interference.

- DIMENSIONS.

$2\frac{5}{8}'' \times 3\frac{1}{2}'' \times 3''$ high overall.

- WEIGHT $2\frac{1}{2}$ lb.

Full information is given in Bulletin B-538-A which will gladly be sent on request.

MUIRHEAD

MUIRHEAD & CO. LTD., ELMERS END, BECKENHAM, KENT. BECKENHAM 0041-0

FOR OVER 60 YEARS DESIGNERS & MAKERS OF PRECISION INSTRUMEN

C.R.C.

BRITISH BSR THROUGHOUT

HETERODYNE OSCILLATOR

with exclusive B.S.R. features

Never has a commercial Oscillator been produced with such a performance irrespective of price. Built to retain its superlative performance indefinitely.

8 Watts with under 1% total Harmonic distortion.

2-$5\frac{1}{2}''$ dia. Nickel Dials with slow motion.

4 Output Impedances selected by switch.

Multi-range Rectifier Output meter.

All stages checked by milli-ammeter.

Hum Content less than 0·16%.

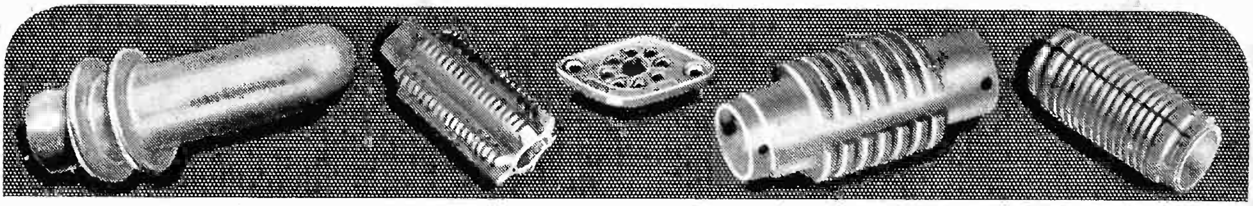
Alternative R.C. Output down to 5 c.p.s.

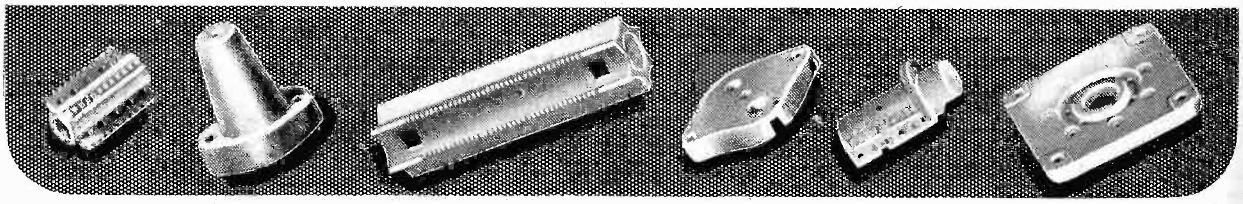
Output within ± 0·5db. 20 to 15,000 c.p.s.

110/200/250 volts, 50 cycles.

£67-10-0.
Model LO800.

BIRMINGHAM SOUND REPRODUCERS LTD.,
CLAREMONT WORKS, OLD HILL, STAFFS. *'Phone : Cradley Heath 6212/3.* *'Grams : Electronic, Old Hill.*





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.

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 MAY 1942 No. 224

Editorial

The Polar Diagram of a Simple Broadside Array

IN this number we publish an article on "Extended Aerial Systems" by E. Green, of the Marconi Company, and this editorial note was suggested by that article, to which it may be regarded as an introduction or supplement. If an even number of plain vertical aerials are erected in a row, half a wavelength apart, and energised in phase, it is fairly obvious that the end-on radiation will be zero, and the broadside radiation a maximum, but it is not so easy to say at once in which other directions the radiation will be zero or a secondary maximum. Fig. 1 (a) shows an array of six aerials; in a direction making an angle θ with the normal to the line of the array the effects of the individual aerials will arrive with a phase difference of 180° sin θ. Calling this phase difference ϕ, it is obvious that if $\phi = 60°$, the fields at a distant point due to the six aerials will be represented by the vector diagram in Fig. 1 (b), the resultant of which is zero. Similarly if $\phi = 120°$ the fields will be represented by Fig. 1 (c), the resultant of which is zero. If there were eight aerials the corresponding values of ϕ would be 45°, 90°, and 135°; in general, with n aerials, the radiation will be zero when $\phi = \frac{\pi}{n} \times$ an even number. In Fig. 1, for 180° sin θ to be 60° or 120°, sin θ must

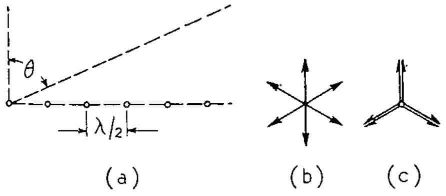


Fig. 1.

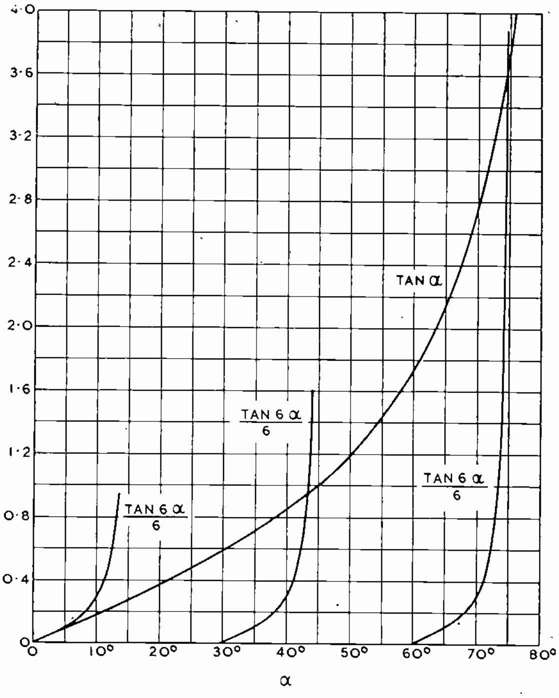


Fig. 2.

be $\frac{1}{3}$ or $\frac{2}{3}$, and therefore θ must be 19° 28′ or 41° 49′. These then are the directions in which the radiation is zero. The directions in which the secondary maxima occur cannot be determined so simply. As Mr. Green shows, if n equal vectors differ in phase by an angle ϕ, the ratio of the resultant to their sum is $\frac{\sin n(\phi/2)}{n \sin(\phi/2)}$, a formula which will be very familiar to anyone who has calculated the e.m.f. induced in alternator windings.

This then is the ratio of the field in any direction to that normal to the line of the array, since in the latter direction the vectors are in phase and can be simply added. Putting $\phi/2 = \alpha$, we wish to find the values of α for which $\sin n\alpha/\sin \alpha$ is a maximum.

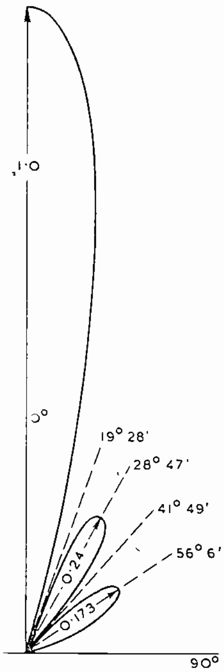


Fig. 3.

$$\text{If} \quad \frac{d}{d\alpha}\left(\frac{\sin n\alpha}{\sin \alpha}\right) = 0,$$

$$n \sin \alpha \cos n\alpha - \sin n\alpha \cos \alpha = 0$$

$$\text{and} \quad \tan \alpha = \frac{\tan n\alpha.}{n}$$

In Fig. 2 we have plotted $\tan \alpha$ and the positive branches of $\frac{\tan 6\alpha}{6}$. These intersect when $\alpha = 43^\circ\,23'$ and when $\alpha = 74^\circ\,34'$; the corresponding values of ϕ are 84° 46′ and 149° 8′, and $\sin \theta = \frac{\phi}{180} = 0.48$ and 0.83. The corresponding values of θ are 28° 47′ and 56° 6′; these then are the directions of the secondary maxima. The magnitudes of these maxima are

$$\frac{\sin(43^\circ\,23' \times 6)}{6 \sin 43^\circ\,23'} = 0.24 \quad \text{for } \theta = 28^\circ\,47'$$

$$\text{and} \quad \frac{\sin(74^\circ\,34' \times 6)}{6 \sin 74^\circ\,34'} = 0.173 \text{ for } \theta = 56^\circ\,6'.$$

The directions of the zeros and maxima and the magnitudes of the latter are shown in Fig. 3 for this simple example of six aerials with $\lambda/2$ spacing. The more general case is fully discussed in Mr. Green's article.

G. W. O. H.

The Frequency Spectrum

WE wish to draw special attention to the letter from Mr. B. C. Fleming-Williams which will be found on p. 200. In it he proposes a rational system of nomenclature for the whole range of frequencies from a few cycles per second up to and beyond the frequencies of luminous waves. Like the expression of gain in bels and decibels, it is based on powers of ten, all frequencies between say 10^5 and 10^6 being in Band 5. Ordinary power frequencies and bass notes are in Band 1 since they lie between 10^1 and 10^2, whereas, as Mr. Fleming-Williams points out, luminous waves are in Band 14. There might be some uncertainty as to whether a wave in the *exact middle* of Band 3 would be one with a frequency of 5,500 or of $10^{3.5}$, which is only 3,163 cycles per second, but this is a minor detail. The adoption of the suggestion would certainly simplify the specification of the frequencies employed in the many and ever-increasing applications of electromagnetic waves. It will be interesting to see how the suggestion appeals to our readers.

Extended Aerial Systems*

Calculating the Polar Diagrams

By E. Green

(Marconi's Wireless Telegraph Co., Ltd., Research and Development Department)

IN *Wireless Engineer* for October 1927, a simple vector method of calculating the polar diagrams of many aerial systems was given. In this the separate radiators were replaced by a uniform sheet of electromagnetic wave energy. Originally it was proposed to put the individual radiators at small distances apart compared with the wavelength, and this approximation was legitimate. Mr. C. S. Franklin, however, generalised the method to deal with uniformly spaced aerials with any spacing factor. This showed that for broadside arrays, with the aerials excited in phase, the spacing between adjacent aerials could be increased to half a wavelength without serious change in the polar diagrams, while for end-fire arrays, the spacing could be quarter wavelength. This was one of the factors which led to the adoption of the original beam aerial system. Although past history, it seems worth while to recall this solution, as it is not generally known, and may have other applications.

Consider " n " aerials, each with equal current, uniformly spaced " $k\lambda$ " apart in a straight line as shown in Fig. 1, and with a uniform phase advance between consecutive aerials of " ϕ_0 " along the line from A to B. At any distant point " P " each aerial will produce the same field strength, and the resultant field will be the vector sum of the individual amplitudes taking account of the resultant difference of phase. This phase difference " ϕ " will be the same for consecutive aerials along the line, and will depend on ϕ_0, the spacing " $k\lambda$ " and the direction of P relative to the line of aerials. The vector diagram for the field at the point P is shown in Fig. 2. The unit vectors LM, MN, etc., represent the contribution of individual aerials, with constant phase

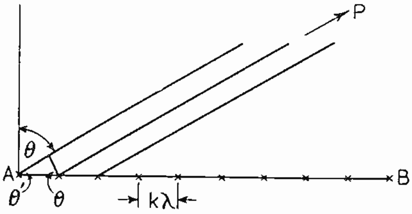


Fig. 1.

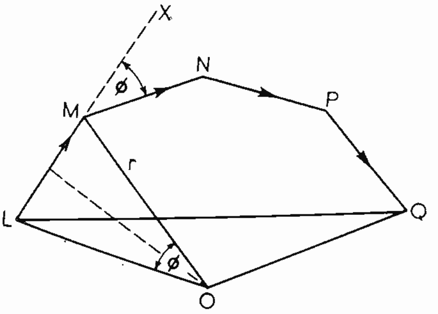


Fig. 2.

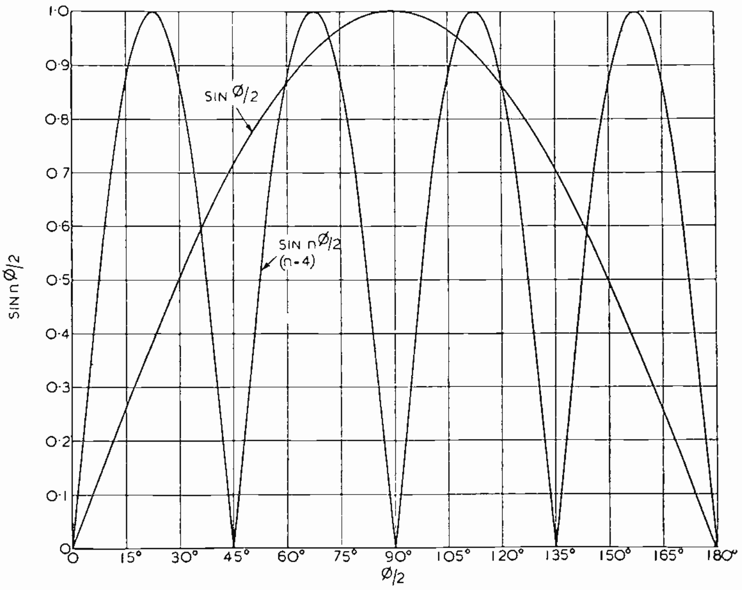


Fig. 3.

---

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

difference, ϕ, while LQ, the line joining the extremities, is the resultant field strength. The unit vectors form the consecutive sides of a regular polygonal figure, and there will be a centre O equi-distant from L, M, N, etc. The maximum field strength possible occurs when the unit vectors are in phase. Taking this as a standard we can find the strength at the point P.

Let "r" = radius of circle

Then $L\hat{O}M = N\hat{M}X = \phi$

$$LM = 2\,r \sin\frac{\phi}{2}$$

Hence maximum field strength $= 2\,nr \sin\frac{\phi}{2}$

Also $L\hat{O}Q = n\phi$

Resultant field strength at

$$P = LQ = 2\,r \sin\frac{n\phi}{2}$$

$$\frac{\text{Field at } P}{\text{Maximum field}} = \frac{2\,r \sin\frac{n\phi}{2}}{2\,n\,r \sin\frac{\phi}{2}} = \frac{\sin\frac{n\phi}{2}}{n \sin\frac{\phi}{2}} \qquad \ldots \quad \ldots \quad (1)$$

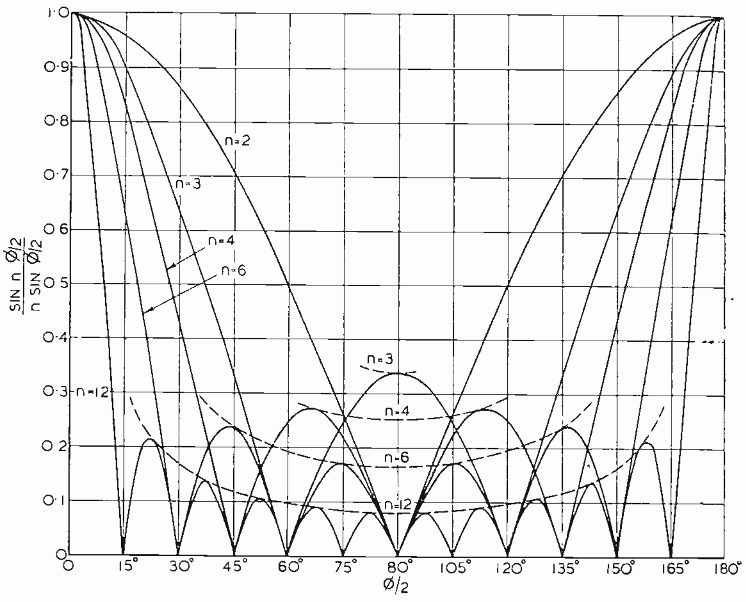


Fig. 4. *Curves of* $\dfrac{\sin n\frac{\phi}{2}}{n \sin\frac{\phi}{2}}$ *for* $n = 2, 3, 4, 6$ *and* 12.

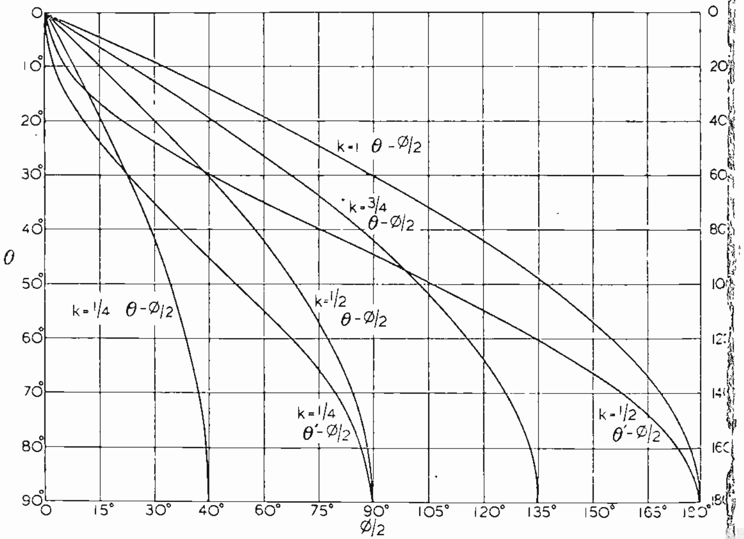


Fig. 5.

This gives the general form of the polar curve. Both numerator and denominator are varying sinusoidally as θ increases, but at different speeds, the numerator going through "n" complete periods while the denominator goes through one. Fig. 3 shows $\sin\frac{\phi}{2}$ and $\sin\frac{n\phi}{2}$ plotted separately for $n = 4$. [For convenience both halves of the sine curve are plotted above the line] while Fig. 4 shows the resultant curve. Where $\frac{\phi}{2} = 0, \pi, 2\pi$, etc., the separate curves pass through zero, and their ratio is a maximum. These points constitute main maxima on the resultant curve. At other points where $\frac{n\phi}{2} = \pi,\ 2\pi$, etc., the numerator passes through zero alone, so that the resultant curve passes through zero. In between these points where $\frac{n\phi}{2} = \frac{3\pi}{2}, \frac{5\pi}{2}, \frac{11\pi}{2}$, etc., there are subsidiary maxima which decrease towards a value of $\frac{1}{n}$ of the main maxima at the mid point.

In the case of $n = 4$, the maxima at

$\frac{n\phi}{2} = \frac{\pi}{2}, \frac{7\pi}{2}, \frac{9\pi}{2}$ are absorbed in the main maxima. (The general form for the absorbed maxima is $\frac{n\phi}{2} = mn\pi \pm \frac{\pi}{2}$ where " m " has the integral values 0, 1, 2, 3, etc.). There are $(n - 2)$ subsidiary maxima between the main peaks. As usual consecutive maxima are of opposite sign indicating a reversal of phase. In Fig. 4 are also shown the curves

$$\frac{\sin \frac{n\phi}{2}}{n \sin \frac{\phi}{2}}$$

for $n = 2$, 3, 6 and 12 for $\frac{\phi}{2}$ between 0 and π. For larger values of $\frac{\phi}{2}$ the curve repeats itself.

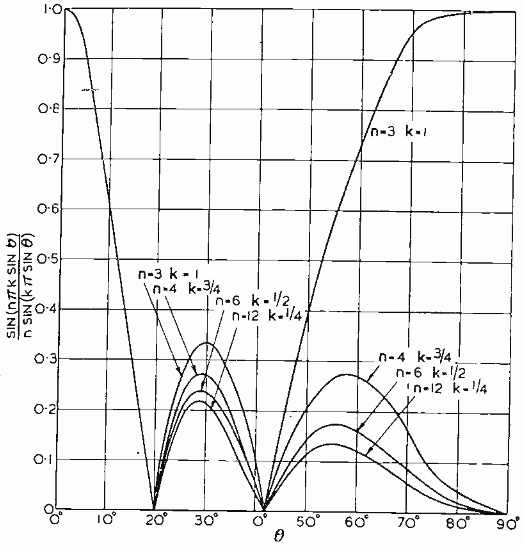


Fig. 6. *Details of polar curves for 3 aerials, 1λ spacing; 4 aerials, ¾λ spacing; 6 aerials, ½λ spacing and 12 aerials, ¼λ spacing. n = number of aerials; $k\lambda$ = spacing.*

Particular Cases

(1) *Broadside Array*

In this the elements are set in a straight line and the currents are equal and all in phase ($\phi_0 = 0$). Measure the direction θ of P from the line perpendicular to the array. Then $\phi = 2\pi k \sin \theta$

$$\frac{\phi}{2} = k\pi \sin \theta \qquad \ldots \quad \ldots \quad \ldots \quad (2)$$

and

$$\frac{\text{Field at } P}{\text{Maximum field}} = \frac{\sin (nk\pi \sin \theta)}{n \sin k\pi \sin \theta} \qquad \ldots \quad (3)$$

To determine what happens as the spacing is varied plot $\frac{\phi}{2}$ against θ as shown in Fig. 5 immediately below Fig. 4 for various values of k (¼, ½, ¾, 1, etc.). Then for any particular spacing we can take a series of values of θ, read first the corresponding values of $\frac{\phi}{2}$, and thence determine the intensity, but we can see the general trend without plotting the complete curves. As the spacing increases the main loop gets sharper, and the number of side loops increases, but these are of steadily decreasing intensity for values of k less than ½.

If " k " is increased beyond this the outer side loops slowly increase in size, but it is not until k approaches 1 that a second main loop appears. This implies a large loss of energy in the desired main loop. All the more so because $\frac{\phi}{2}$ is only varying slowly with θ. When $k = 2$ a third main loop will appear at $\theta = 30$ deg. It is clear that up to $k = \frac{1}{2}$ the improvement in diagram is marked, but the total length of the aerial is increasing. The more practical case to

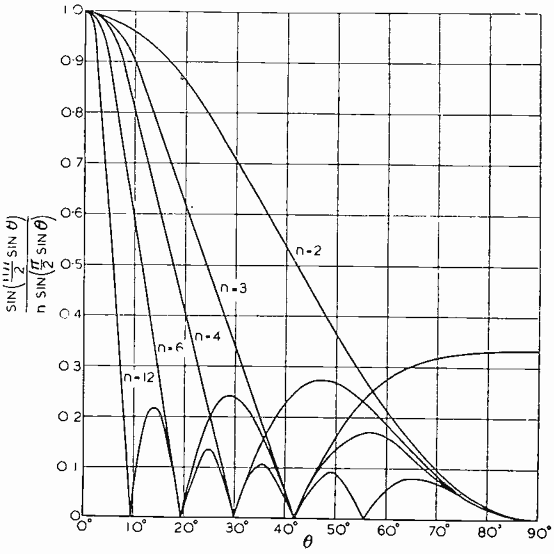


Fig. 7. *Details of polar curves for 2, 3, 4, 6 and 12 aerials, all at ½λ spacing. n = number of aerials; $k\lambda$ = spacing.*

determine is what is the minimum number of aerials required in a given extent of front to produce the best polar curve. From the curves we can readily compare, 12 aerials at $\frac{1}{4}\lambda$ spacing, 6 at $\frac{1}{2}\lambda$, 4 at $\frac{3}{4}\lambda$ and 3 at 1λ spacing. This has been done in Fig. 6. The main loop is practically the same in each case and the side loops have only increased a little up to $k = \frac{1}{2}$. The increase is more marked at $k = \frac{3}{4}$ and the second main loop containing most of the energy appears when $k = 1$.

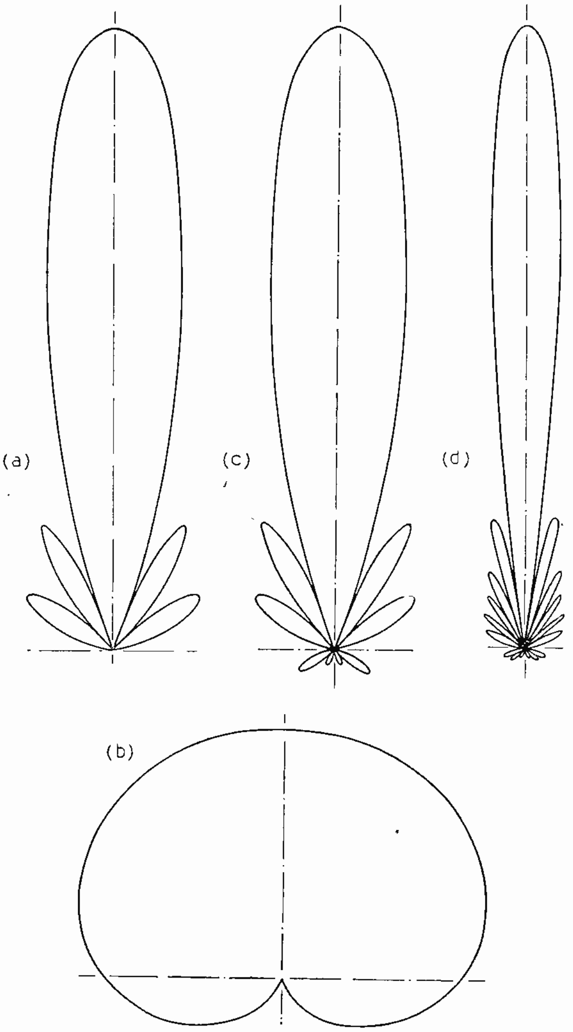


Fig. 8. (*a*) *Broadside array without reflector (front half of diagram only). 6 aerials, $\frac{1}{2}\lambda$ spacing.*
(*b*) *Single aerial and reflector, $\frac{1}{4}\lambda$ spacing.*
(*c*) *Broadside array with reflector. 6 aerials, $\frac{1}{2}\lambda$ spacing.*
(*d*) *Broadside array with reflector. 12 aerials, $\frac{1}{2}\lambda$ spacing.*

If we never make k greater than $\frac{1}{2}$ we shall be safe from bad effects even when there is some degree of misphasing as may arise in practice. This rule was adopted for the arrays in the original beam system.

In Fig. 7 the curves for 2, 3, 4, 6 and 12 aerials at $\frac{1}{2}\lambda$ spacing have been derived from Figs. 4 and 5. These can, of course, be plotted in normal polar form.

For the single broadside array all four quadrants are identical. In most cases, however, there will be a reflector situated $\frac{1}{4}\lambda$ behind the main array. For this we must multiply the polar curve by that for a pair of aerials at $\frac{1}{4}\lambda$ spacing and phased to give a minimum behind. Fig. 8(a), is the polar curve for 6 aerials at $\frac{1}{2}\lambda$ spacing (half only), 8(b) is for two aerials $\frac{1}{4}\lambda$ spacing, and 8(c) for the aerial and reflector combined. Fig. 8(d), is the polar curve for 12 aerials at $\frac{1}{2}\lambda$ spacing with reflector.

(2) *End Fire Arrays*

In these the elements are set in a line, but the currents are phased so as to produce maximum intensity in the line of the array.

In Fig. 1, if the radiation is to be a maximum in the direction AB, then the currents in consecutive aerials must lag by $2\ k\pi$ as we proceed from A to B. It is convenient to measure the angle from the line of maximum radiation. If this angle is θ' then the

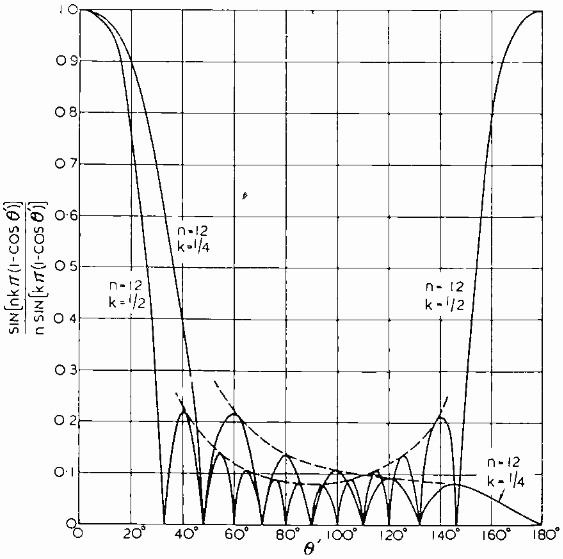


Fig. 9. *Details of polar diagrams of extended aerial systems; end fire arrays.* n = *number of aerials,* $k\lambda$ = *spacing.*

total phase difference ϕ between the consecutive elements of intensity in this direction will be

$$2\pi k - 2\pi k \cos\theta' = 2\pi k(1 - \cos\theta')$$

$$\frac{\phi}{2} = k\pi(1 - \cos\theta') \qquad .. \qquad .. \qquad (4)$$

$$\frac{\text{Field at } P}{\text{Maximum Field}} = \frac{\sin[nk\pi(1 - \cos\theta')]}{n \sin[k\pi(1 - \cos\theta')]} \qquad (5)$$

In this case we must take θ' from 0 to 180 deg., during which $(1 - \cos\theta')$ increases from 0 to 2 and $\frac{\phi}{2}$ from 0 to $2\,k\pi$. In Fig. 5, $\frac{\phi}{2}$ has been plotted against θ' for $k = \frac{1}{4}$ and $\frac{1}{2}$ and in the same way as before we can derive the curves for various numbers of aerials with these spacings.

It will be seen that for good single ended radiation "k" should not be much greater than $\frac{1}{4}$, and that it becomes double ended when $k = \frac{1}{2}$. Fig. 9 shows the form of the curves for 12 aerials at $\frac{1}{4}\lambda$ and $\frac{1}{2}\lambda$ spacing, while Fig. 10 gives the former in polar form.

The main loop is much broader than that of the broadside array of the same length shown in Fig. 8(c). But the end fire array gives concentration in both horizontal and vertical planes, while the broadside array only gives concentration in the plane of its extension. If concentration is required in the vertical plane the aerial must be extended in that plane. It is no part of this paper to discuss the relative gain of different types of aerial, but rather to point out the flexibility of the formulae developed.

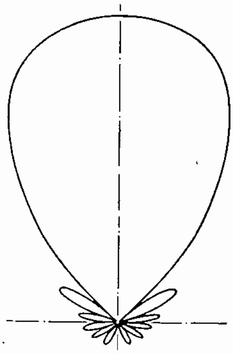


Fig. 10. *End fire array. 12 aerials, $\frac{1}{4}\lambda$ spacing.*

Correspondence

Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain

The Temperature Compensation of Condensers.

To the Editor, " Wireless Engineer."

SIR,—The subject discussed in the article by Mr. Griffiths in the March issue of *Wireless Engineer* is an extremely important one, as the magnitude of the capacitance changes that occur in various forms of condensers is certainly not recognised as fully as it should be by many users of those condensers. So often is it thought that air condensers in particular, both fixed and variable *must* be good standards of capacitance, that it should be helpful to many (even if a shock to them also) to have the detailed analysis given in the article.

I agree fully with Mr. Griffiths in his dislike of the use of ceramic elements to compensate the temperature coefficient of air condensers. I do so, however, for the following further reason that the compensation cannot be a constant one. Since the coefficient α (in equation 2) is necessarily positive and in consequence the temperature coefficient of most air condensers is positive also; compensation by a ceramic element requires the use of a material with a negative coefficient of capacitance. Ceramic materials that have this property derive it from their rutile constituent. Unfortunately, however, the permittivity of rutile varies considerably with frequency as also does its dissipation factor ($\tan\delta$) both rising considerably in the audio frequency range.* The extent of the compensation therefore will be a function of frequency. The resultant " compensated " air condenser will, in consequence, have a capacitance value and a temperature coefficient both of which will depend upon the frequency of measurement. While such changes may be tolerated in certain types of condensers, intended for radio uses, they are most undesirable in air dielectric condensers which are so widely recognised as being substantially constant in value as regards different frequencies. I consider that this feature is of almost greater importance than those quoted in the article.

In mentioning paper dielectric condensers, the author refers only to " paraffin " as the impregnant. He is doubtless well aware that other materials are very commonly used to-day. The temperature coefficient of these condensers is a function of the impregnant and to an extent also of the mechanical form given to the condenser. By the use of different materials both positive and negative coefficients have been obtained, but their value depends upon the temperature range selected since $\Delta C/1°\text{C}$. is a function of the temperature.

I do not feel entirely in agreement with the author's general statement on page 104 that the

---

*A single exception to this generalisation has only been available from German sources.

permittivity of ceramics is dependent upon the humidity. I would prefer to regard the effects of humidity as of a more extraneous nature concerned with the electrodes, as all the ceramic materials used as dielectrics show entire absence of water penetration. Some of them, however, do readily condense surface films of moisture, so that for all applications requiring stability of performance it is essential to protect them completely from all contact with moist air. This cannot be done by the varnish coating mentioned on page 110. Manufacturers of these condensers never intend that coating to provide more than a measure of protection against the smaller humidity changes, and employ complete hermetic sealing in an external ceramic casing where stability is required under all conditions. This construction is applicable to fixed condensers only and is not readily adaptable to adjustable ones (e.g. "trimmer" condensers) which from their construction are even more liable to be affected by moist atmospheres than are fixed capacitance ones.

I should be interested to know why the author states on page 104 that ceramic condensers are *impossible* to adjust accurately to a given capacitance. Such a procedure is a general one even on a mass production basis, often to an accuracy of 0.2 $\mu\mu$F. Many users in fact ask for still closer tolerances but the methods of accurate measurement under defined conditions impose greater limitations than does the actual adjustment itself.

Liss, Hants. PHILIP R. COURSEY

To the Editor, "Wireless Engineer"

SIR,—In the article "The Temperature Compensation of Condensers" by W. H. F. Griffiths, in your March issue, the author states that "a disadvantage of the ceramic condenser is the impossibility of adjusting its value accurately to a given or nominal value. . . ." This is apt to give a misleading impression of the value of this product.

It is suggested that the ceramic condenser does not suffer this disadvantage as its value can be adjusted to a given nominal value, within the normal capacitance range of the dielectric material, just as accurately as any mica condenser.

Is it not a matter of common knowledge that the accuracy to which either mica or ceramic condensers can be adjusted, for special applications, is dependent upon the accuracy with which measurement can be made and is this not governed by the accuracy of the calibrations of test equipment normally available from authorative sources which are not usually closer than ± 0.1 or ± 0.2 $\mu\mu$F?

The minimum commercial tolerance applicable to ceramic condensers, for radio use, within the capacitance range 0.0001 μF to 0.001 μF is ± 1 per cent., this is the same as for metallised mica condensers for the same application and within the same range. For special applications the closest tolerance required on mica condensers of 0.001 μF nominal capacitance is ± 0.1 per cent., similarly for special applications, this tolerance is as practical on a ceramic condenser of the same nominal value. Such a tolerance is not as fine as that normally employed for laboratory standard condensers where a tolerance of ± 0.02 per cent. or ± 0.01 per cent. is the minimum, however, these tolerances are usually applied to values in the region of 0.01 μF and the condensers are normally made up of a number of sections in parallel. If a similar method is adopted using ceramic elements it follows that a comparable tolerance should be obtainable if desired.

London, W.3. S. TINCKHAM

The Frequency Spectrum.

To the Editor, "Wireless Engineer"

SIR,—When speaking in general terms of a radio transmission it was at one time sufficient to say that it was on "a long wavelength" if it was on more than about 1,000 metres, on a "medium wavelength" if it was between about 1,000 and 200 metres, and anything other than this was just "short."

In recent times commercially used wavelengths have tended to become shorter and shorter, or putting it in a more convenient way, the frequencies have tended to become higher and, as a result, various qualifications of the terms "short wave" and "high frequency" have come into use. These, however, through lack of definition have become almost meaningless. Thus to some people "ultra high frequency" may mean 50 Mc/s, to others it may suggest 500 Mc/s or even more. It therefore seems high time that a more rational system was introduced.

In seeking such a system, it occurred to me that the whole frequency spectrum should be divided up into a number of bands which might be defined in the following manner.

If a frequency is expressed in cycles per second, it will lie in a band whose number is equal to the characteristic of the logarithm (to base 10) of that frequency. Putting this in another way, the band number may be found by expressing a frequency as a number between 1 and 10 multiplied by a power of ten. Then the band number is given by that power of ten.

The following table shows the application of the system.

Band No.	Frequency Band In Cycles per Sec.	Approximate Equivalent Nomenclature on Present System	
0	1–10		
1	10–100	Bass Register	Audio Frequencies
2	100–1,000	Middle Register	
3	1,000–10,000	Top or Treble Register	
4	10–100 k	Long-wave band.	
5	100–1,000 k	Medium-wave band.	
6	1–10 M	Short-wave Band.	
7	10–100 M	V.H.F.	
8	100–1,000 M	U.H.F.	
9	1,000–10,000 M	Micro-wave or Cm-wave Band.	
10	10,000–100,000 M	Millimetre-wave Band.	

Of course the present terminology does not exactly correspond to the individual band numbers. The use of band numbers is most convenient when discussing circuits in a general way. Thus, for example, one might say that most broadcast receivers have an I.F. amplifier working in the middle of band 5, whereas for television receivers working in band 7, the I.F. usually works in band 6.

The system can be extended widely, for instance, electric power is usually transmitted in band 1, whereas an etheric disturbance in the middle of band 14 is visible to the human eye!

London, N.W.3. B. C. FLEMING-WILLIAMS

Humidity Testing of Components.

To the Editor, "Wireless Engineer"

SIR,—I should like to comment on two articles in your March number.

Mr. Coursey, in his article on "The Testing of Radio Components," raises the question of tropical tests, and concludes that the steam injection method has "more to recommend it" than the water evaporation method. However, I feel that the idea of blowing steam on to radio components is unjustified from the viewpoint of simulating even the most extreme tropical conditions. Also, in the absence of experimental evidence to the contrary, the steam test is unlikely to be the equivalent of an accelerated ageing test at 100 per cent. relative humidity, just as in mechanical engineering there is no definite correlation between the fatigue resistance and tensile strength of materials.

Mr. Lethersich has shown (E.R.A. Report Ref. A/T60) that the unreliability of the water evaporation method is due to the water temperature being less than that of the oven atmosphere because of vapour condensation on the walls and leakage into the outer atmosphere. I suggest that these difficulties are readily overcome by adapting the oven to the type of object it is meant to test.

The small dimensions of most radio components hardly justify the expanse of the usual commercial humidity chamber which is the root of the trouble. Hence I have constructed a small tinned container (12in. dia. × 18in. height) with a removable lid and perforated tray inserts arranged in tiers to accommodate the test components.

The "chamber" is covered at the bottom with water and is almost completely immersed in an external water bath, with the top projecting into the atmosphere to allow a thermometer to be inserted. Temperature is obtained by varying the water bath temperature.

Since the internal "chamber temperature" was found practically to coincide with that of the well-stirred water bath, the method ensures a high and controllable chamber temperature (up to 90 deg.) and there is good reason to believe a R.H. well above 90 per cent. We suggest that this is a more rational approach to the problem than the rather doubtful steam method.

Referring to Mr. Griffiths' article on the "Temperature Compensation of Condensers" and in particular to the statement at the beginning of p. 104, I would point out that ceramic condensers can, theoretically, be made with any desired temperature coefficient between -740×10^{-6} and $+140 \times 10^{-6}$ by the suitable choice and blend of materials, but owing to the necessity for limiting the number of such materials, the range is, in practice, restricted to those materials which find the greatest use, viz.:

-700 to -740×10^{-6} (e.g. Conda C)
-340 to -380×10^{-6} (e.g. Conda N)
$+30$ to $+50 \times 10^{-6}$ (e.g. Tempa S)
$+120$ to $+160 \times 10^{-6}$ (e.g. Calit).

I would also draw attention to the fact that the capacitance of ceramic condensers may be readily adjusted to any degree of accuracy desired, ± 0.4 $\mu\mu$F being a practical limit in mass production.

A correction must also be added to Mr. Griffiths' statement that "the capacitance of the ceramic condenser has a tendency to dependence on humidity." While it must be admitted that, ordinarily, the surface leakage resistance and not the permittivity deteriorates with rising humidity, this is readily overcome where necessary by enamelling or otherwise treating the surface. In this way complete protection can be obtained.

In discussing air dielectric condensers, Mr. Griffiths has omitted Dr. Thomas's findings relating to the effect of assembly strain on temperature coefficient. Such strains are practically inevitable in any but high grade laboratory condensers, and should therefore be remembered in interpreting Mr. Griffiths' expressions for $\frac{\Delta C}{C}$.

N. WESTCOMBE

United Insulator Co., Ltd.

P. K. Turner

It is with regret that we record the death of Philip Keston Turner, at the early age of 53, on March 16th. For a short time prior to 1925 he was editor of *Wireless Engineer*, which was then known as *Experimental Wireless & Wireless Engineer* He was also the first editor of our contemporary, *The Wireless Trader*. "P.K.," as he was known among his many friends in the industry, was associated in recent years with H. A. Hartley in the development of the high-quality moving-coil loudspeaker which bore their two names.

May Meetings

THE last meeting of the Wireless Section of the I.E.E. for the 1941–42 season will be held at 6 o'clock on Wednesday, May 6th, when a discussion on "Post War Planning in Radio Communication" will be opened by Col. Sir A. Stanley Angwin, D.S.O., M.C., B.Sc. (Eng.), Post Office Engineer-in-Chief, and Mr. H. Bishop, C.B.E., B.Sc. (Eng.), chairman of the Section.

The Annual General Meeting of the Institution, which Corporate Members and Associates only are allowed to attend, will be held on May 7th at 6 o'clock. As it was not possible for all those who wished to speak in the discussion on Dr. A. P. M. Fleming's paper "A Critical Review of Education and Training for Engineers" to do so when the paper was presented on March 19th, arrangements have been made for the discussion to be continued on May 7th at approximately 6.30, following the annual meeting.

The next meeting of the British Institution of Radio Engineers will be held at the Federation of British Industries, 21, Tothill Street, London, S.W.1, on Friday, May 29th, at 6.30, when a paper will be read by Mr. O. S. Puckle, A.M.I.E.E. This meeting will be preceded by the annual meeting of the Institution.

Eddy Current Tuning*

By C. C. Eaglesfield

SUMMARY.—The effect on the magnification of a circuit of eddy current tuning is considered. In particular the case of a single layer solenoid with a metal cylinder inserted axially is treated, and formulae are given for design. Experimental results show that the formulae are reasonably accurate.

CONTENTS

1. Introduction

BY eddy current tuning is meant the adjustment of the resonant frequency of a circuit by varying the inductance of part of the circuit by coupling a cylinder, disc, ring, etc. of non-magnetic conductive material to it. This method of tuning is of course very well known, and is a useful device for many applications: for instance, in amplifiers designed for a wide frequency band when the parallel capacitance must be kept to a minimum, or at high frequencies where suitable variable condensers are not available, and the losses in available dust-iron cores are too great.

This method of tuning is often called slug tuning: this term will be used for convenience.

Slug tuning suffers from two defects. Firstly, the frequency range that can be obtained in practice is limited, and secondly, losses are introduced as the slug is inserted.

The limited frequency range is due to the difficulty of obtaining sufficiently tight coupling between the coil and the slug with a convenient mechanical arrangement; and also stray inductance in series with the slugged coil has a great effect on the frequency range. Stray series inductance is analogous to stray parallel capacitance in the case of parallel variable condenser tuning.

The losses occur from two causes. As the slug is inserted, the coil inductance is reduced, but its resistance increases since the frequency is increased. In addition resistance is transferred from the resistance of the slug. As a result the magnification of the coil is reduced at the high-frequency end of the range; magnification being defined as the ratio of reactance to resistance.

The comparison between parallel capacitance tuning and slug tuning depends of course on the criterion adopted. If the circuit impedance is the criterion then slug tuning gives a higher impedance than capacitance tuning at the low frequency end of the range, but a lower impedance at the high frequency end. The variation of impedance is much greater with slug tuning than with capacitance tuning.

The method of treatment is to consider the slug as a single turn coil inductively coupled to the main coil. It is assumed that the effect of capacitance between the main coil and the slug is negligible.

In all that follows the capacitance is taken as constant. Consequently the frequency will vary with changes in the size and position of the slug. The ratio of the frequency when the slug is coupled to the coil, to the frequency when the slug is removed (designated as "α") is taken as the main parameter of the circuit.

It will be shown that to a first approximation the variation in magnification of the circuit is a function only of "α," and the conductivity of the slug material, and is independent of the geometry of the slug and the percentage of stray inductance. For a given slug material the variation in magnification is a function only of "α."

The particular case of a cylindrical slug moved axially inside a single layer solenoid of solid wire is treated in some detail. This is probably the most important practical design. Formulae are deduced for the magnification without the slug, the variation

---

* MS. accepted by the Editor, March 1942.

of magnification against "α," and the maximum value of "α," the results being expressed in the form of curves.

This is the complete information required for design purposes.

Experimental results show that the accuracy of the formulae is quite adequate for design.

2. List of Symbols

L_a	Inductance of the coil without the slug.
L_b	Inductance of the slug.
L_c	Stray inductance in series with the coil.
L'_a	Effective inductance of the coil when slugged.
M	Mutual inductance between coil and slug.
r_a	Series resistance of the coil without the slug.
r_b	Series resistance of the slug.
r_c	Series resistance of the stray inductance.
r'_a	Effective resistance of the coil when slugged.
Q_a	Magnification of the coil without the slug.
Q_b	Magnification of the slug.
Q_0	Magnification of the coil (without slug) together with the stray inductance.
Q_c	Magnification of the stray inductance.
Q	Effective magnification.
α	Ratio of the frequency to the frequency without the slug.
α_m	Maximum value of α when the slug is fully in.
γ	Ratio of stray inductance to coil inductance.
F_1	Function involved in the formula for inductance of a straight circular wire.
K	Function involved in the formula for inductance of a solenoid (Nagaoka's constant).
F_2	Function involved in the formula for magnification of a solenoid.
D	Diameter of the coil (over the turns).
D'	Diameter of the slug.
d	Diameter of the wire.
t	Equal to $\frac{1}{2}(D - D')$.
β	Equal to t/D.
l	Length of the coil (or straight wire).
l'	Length of the slug inside the coil.
N	Number of turns on the coil.

3. Elementary Circuit

Consider the circuit of Fig. 1. L_a and L_b are the inductance of the coil and the slug respectively. Their resistances are $r_a\sqrt{\alpha}$ and $r_b\sqrt{\alpha}$ respectively. The reason for the factor $\sqrt{\alpha}$ is that it is shown in a succeeding section that the resistance of a coil varies as $\sqrt{f}$. The resistances are r_a and r_b when $\alpha = 1$, corresponding to the frequency f_0 when the slug is removed.

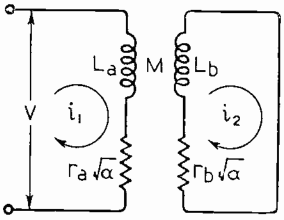


Fig. 1.

The equations are

$$V = (r_a\sqrt{\alpha} + j\omega L_a)i_1 - j\omega M i_2$$
$$O = (r_b\sqrt{\alpha} + j\omega L_b)i_2 - j\omega M i_1$$

Substituting for i_2 from the second equation in the first equation :

$$\begin{aligned} Z &= \frac{V}{i_1} = r_a\sqrt{\alpha} + j\omega L_a \\ &\quad + \omega^2 M^2/(r_b\sqrt{\alpha} + j\omega L_b) \\ &= r_a\sqrt{\alpha} + \frac{\omega^2 M^2 r_b\sqrt{\alpha}}{\alpha r_b{}^2 + \omega^2 L_b{}^2} \\ &\quad + j\omega L_a - \frac{j\omega L_b \omega^2 M^2}{\alpha r_b{}^2 + \omega^2 L_b{}^2} \\ &= r_a\sqrt{\alpha} + (M/L_b)^2 r_b\sqrt{\alpha} \\ &\quad + j\omega L_a - j\omega L_b(M/L_b)^2 \end{aligned}$$

taking $\omega L_b \gg r_b$.

i.e. $Z = r'_a + j\omega L'_a$

where

$$\begin{aligned} r'_a &= \sqrt{\alpha}[r_a + (M/L_b)^2 r_b] \\ L'_a &= L_a - M^2/L_b \qquad \ldots \qquad \ldots \qquad (1) \end{aligned}$$

4. Effect of Stray Inductance

Consider Fig. 2, where the stray inductance L_c with its resistance $r_c\sqrt{\alpha}$ has been added.

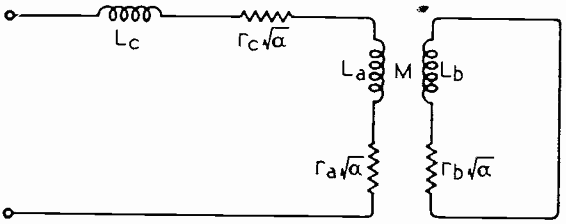


Fig. 2.

By the results of the previous section, this can be replaced by Fig. 3 where L'_a and r'_a are given by equation 1.

The frequency ratio for constant tuning capacitance is given by :

$$\alpha^2 = \frac{L_c + L_a}{L_c + L'_a} \quad \cdots \quad (2)$$

$$= \frac{L_c + L_a}{L_c + L_a - M^2/L_b}$$

$$\text{or} \quad 1/\alpha^2 = 1 - \frac{M^2}{L_b(L_c + L_a)} \quad \cdots \quad (3)$$

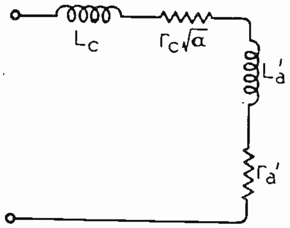


Fig. 3.

The magnification for $\alpha = 1$ (frequency f_0) is given by Q_0 where

$$Q_0 = \frac{\omega_0(L_c + L_a)}{r_c + r_a} \quad \cdots \quad (4)$$

The magnification at "α" (frequency f) is given by Q where

$$Q = \frac{\omega(L_c + L'_a)}{r_c\sqrt{\alpha} + r'_a}$$

$$= \frac{\omega(L_c + L_a)}{\alpha^2(r_c\sqrt{\alpha} + r'_a)} \qquad \text{by 2.}$$

$$= Q_0 \frac{\omega}{\omega_0} \frac{1}{\alpha^2} \frac{(r_c + r_a)}{r_c\sqrt{\alpha} + r'_a} \qquad \text{by 4.}$$

$$= \frac{Q_0}{\alpha\sqrt{\alpha}} \frac{r_c + r_a}{r_c + r_a + (M/L_b)^2 r_b} \qquad \text{by 1.}$$

$$= \frac{Q_0}{\alpha\sqrt{\alpha}} \frac{1}{1 + (M/L_b)^2 \dfrac{r_b}{r_c + r_a}}$$

$$= \frac{Q_0}{\alpha\sqrt{\alpha}} \frac{1}{1 + \dfrac{L_c + L_a}{L_b} \dfrac{r_b}{r_c + r_a}(1 - 1/\alpha^2)} \qquad \text{by 3.}$$

$$= \frac{Q_0}{\alpha\sqrt{\alpha}} \frac{1}{1 + (1 - 1/\alpha^2)Q_0/Q_b}$$

and finally

$$Q/Q_0 = \frac{\sqrt{\alpha}}{\alpha^2 + (\alpha^2 - 1)Q_0/Q_b} \quad \cdots \quad (5)$$

Now equation 5 gives Q/Q_0 in terms of α and Q_0/Q_b. If the stray inductance were zero Q_0/Q_b would be replaced by Q_a/Q_b For this particular case, equation 5 reduces to :—

$$Q/Q_a = \frac{\sqrt{\alpha}}{\alpha^2 + (\alpha^2 - 1)Q_a/Q_b} \quad \cdots \quad (6)$$

It may be noted in either of equations 5 or 6 that if $Q_b = \infty$, i.e., if the slug has no losses, the reduction in Q is simply that due to the reduction in inductance of the primary coil, while its resistance increases as $\sqrt{f}$.

5. Magnification of a Straight Circular Conductor

To use equation 5 the values of various magnifications must be known. Consider the simplest case, a straight circular conductor. The stray inductance can be approximated by this case.

Let l = length of conductor in cms.
d = diameter of conductor in cms.
ρ = resistivity.
L = inductance at high frequency per cm.
r = resistance at high frequency per cm.

ρ, r, L are in absolute E.M. units.

Expressions are known for L and r :—

$$* \; L = 2[\log_\epsilon 4l/d - 1] \quad \cdots \quad (7)$$

$$r = 2.04 \frac{\sqrt{f\rho}}{d} \quad \cdots \quad (8)$$

Equation 8 is the limiting form that a more complicated expression assumes for high values of skin factor.

$$\text{Thus} \quad Q = L\omega/r$$

$$= \frac{2F_1 \, 2\pi f}{2.04\sqrt{f\rho}/d}$$

$$= 6.15 F_1 d\sqrt{f/\rho} \quad \cdots \quad (9)$$

$$\text{where} \quad F_1 = \log_\epsilon 4l/d - 1 \quad \cdots \quad (10)$$

If the material is copper, $\rho = 1{,}700$ and equation 9 becomes

$$Q = 150 \; F_1 d\sqrt{f} \quad \cdots \quad (11)$$

where "f" is in Mc/s.

A curve of F_1 against l/d is given in Fig. 4.

The inductance of the straight conductor can be obtained directly from Fig. 4 and equation 7.

$$\text{Thus} \quad L = 2lF_1 \text{ absolute units}$$

$$= 2lF_1 \times 10^{-3}\mu\text{H} \quad \cdots \quad (12)$$

---

* For a derivation of this formula, see *Electric and Magnetic Fields*, by S. S. Attwood (Chapman and Hall). Section 191. It is assumed that the conductor is in free space, and the effect of the terminal connections, that is of the conductors leading into and out of the conductor under consideration, is neglected. For a practical case, therefore, the formula can be used as an approximation.

6. Magnification of a Single Layer Solenoid

Now take the magnification of the coil. Only the case of a circular solenoid consisting of a single layer winding of solid wire will be considered. This is the most probable case for high frequencies.

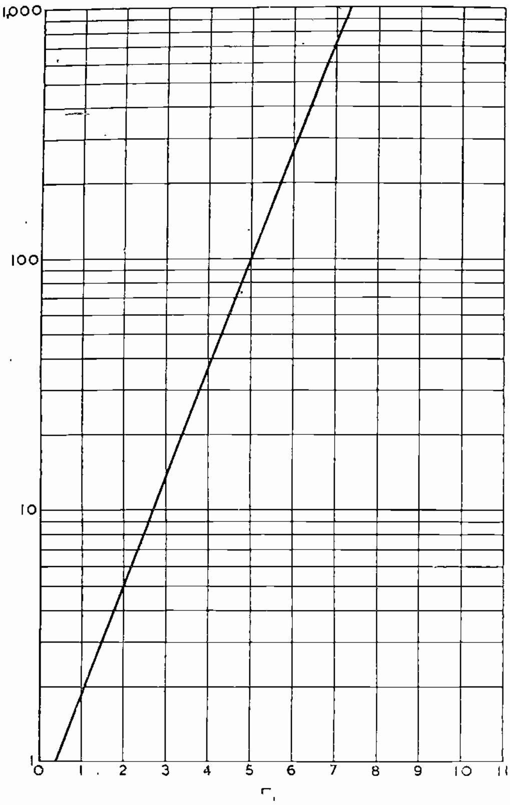


Fig. 4. *Curve of* $F_1 = \log_\epsilon 4l/d - 1$.

The dimensions are given in Fig. 5.

The inductance can be written :—

$$L = (\pi^2 D^2 N^2/l)K \text{ absolute units} \quad .. \quad (13)$$

where " K " is a function of l/D calculated by Nagaoka. A curve of " K " is given in Fig. 6.

Using Butterworth's results on the resistance of coils, it can be shown that when the frequency is so high that the skin factor is large, the resistance of the coil is the resistance of the wire considered straight multiplied by the factor :—

$$1 + 2(Nd/l)^2.$$

(Nd/l) is, of course, the pitch ratio. The length of wire is $N\pi D$ approximately. Thus using equation 8 for the resistance per cm. of straight wire, the resistance of the coil is r where

$$r = N\pi D \times (2.04\sqrt{f\rho}/d) \times [1 + 2(Nd/l)^2]$$

Using equation 13 :—

$$Q = L\omega/r$$

$$= \frac{(\pi^2 D^2 N^2/l)K \,.\, 2\pi f}{N\pi D(2.04\sqrt{f\rho}/d) \times [1 + 2(Nd/l)^2]}$$

$$= \frac{2\pi^2}{2.04} D\sqrt{f/\rho}\, K \frac{Nd/l}{1 + 2(Nd/l)^2} \quad (14)$$

In equation 14 we can write

$$\frac{Nd/l}{1 + 2(Nd/l)^2} = R \quad .. \quad .. \quad .. \quad (15)$$

R is a maximum when $Nd/l = 1/\sqrt{2}$

and $R_{\max} = 0.355$

Thus $R = 0.355\, R/R_{\max}$

$= 0.355\, F_2$

where $F_2 = R/R_{\max}$ .. .. (16)

F_2 is given in the curve in Fig. 6.

Equation 14 becomes

$$Q = 3.42\, D\sqrt{f/\rho} K F_2 \quad .. \quad .. \quad (17)$$

Taking the wire as copper $\rho = 1{,}700$ and

$$Q = 83 D\sqrt{f} K F_2 (f \text{ in Mc/s}) \quad .. \quad (18)$$

Note that when $l = D$ and $Nd/l = 0.71$, $K = 0.688$ and $F_2 = 1$

and $Q = 57\, D\sqrt{f}$ .. .. .. (19)

Now equation 18 has been derived on the assumption that the skin factor was high. Also no allowance has been made for losses in the insulation, either of the coil former or of the covering of the wire. It is not therefore surprising that it is found experimentally that equation 18 gives results that are too high except for self-supporting coils of uncovered wire.

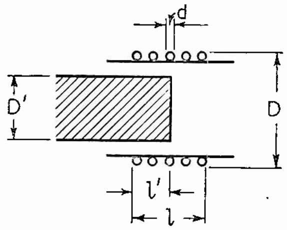


Fig. 5.

A useful empirical formula is obtained by reducing the constant in equation 18.

i.e. $Q = 58\, D\sqrt{f} K F_2$ .. .. (20)

It is found experimentally that equation 20 fits the usual type of coil used at frequencies between one and twenty Mc/s within a few per cent., that is to say, coils made from silk or cotton covered wire on a paxolin or similar former. A different value of the constant may be appropriate for higher frequencies.

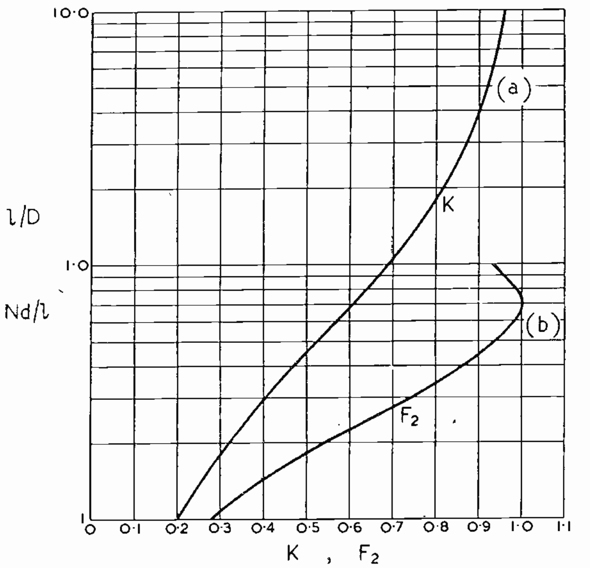


Fig. 6. *(a) Curve of K (Nagaoka's constant) against l/D. (b) Curve of* F_2 *against Nd/l.*

7. Magnification of a Slug

A slug of the form shown in Fig. 5 will be considered; whether the slug is a solid cylinder or a hollow cylinder is immaterial, since the current will flow only in the curved surface—that is provided the tube thickness is greater than the penetration depth.

It seems reasonable to assume that the current flows only in that part of the slug which is actually inside the coil. Thus the effective length of the slug is as marked in Fig. 5.

Thus the slug is to be considered as a single turn solenoid of length l' diameter D' and $Nd/l = 1$.

From equation 18

$$Q = 83\,D'\sqrt{f}K \,.\, 0.92$$

$$= 76\,D'\sqrt{f}K \text{(for a copper slug)} \qquad (21)$$

Equation 21 is not likely to suffer from the same inaccuracy as equation 18, since there are no dielectric losses (the loss in the coil-former being allocated to the coil).

8. Frequency Ratio due to the Slug.

The frequency ratio can be approximately calculated very simply when the slug is fully inserted inside the coil (i.e., when $l' = l$ in Fig. 5). Unfortunately it is a very difficult matter to calculate the frequency ratio when the slug is only partly inserted.

For an infinitely long solenoid, the inductance is proportional to the area of cross-section of the coil. When the slug is present, since the penetration of flux inside the metal is negligible, the effective area is the area between the turns and the slug.

$$\text{Thus} \quad L'_a/L_a = \frac{\frac{1}{4}\pi(D^2 - D'^2)}{\frac{1}{4}\pi D^2}$$

$$= \frac{D^2 - (D - 2t)^2}{D^2}$$

$$= 4(t/D) - 4(t/D)^2$$

$$= 4\beta(1 - \beta) \qquad \ldots \quad (22)$$

$$\text{where} \qquad \beta = t/D \qquad \ldots \quad \ldots \quad (23)$$

From equation 2,

$$\alpha_m^2 = \frac{L_c + L_a}{L_c + L'_a} \quad \text{where } \alpha_m \text{ is the maximum frequency ratio}$$

$$= \frac{L_c/L_a + 1}{L_c/L_a + L'_a/L_a}$$

$$= \frac{\gamma + 1}{\gamma + 4\beta(1 - \beta)} \qquad \ldots \quad \ldots \quad (24)$$

$$\text{where} \quad \gamma = L_c/L_a \qquad \ldots \quad \ldots \quad \ldots \quad (25)$$

"γ" is the stray inductance ratio. In Fig. 7 are given curves of α_m against β for several values of γ.

9. Variation of Magnification due to the Slug

The data is now available for inserting in equation 5 the appropriate values of Q_0 and Q_b. Q_a, the magnification of the coil, can be calculated from equation 20, and Q_c, the magnification of the stray inductance from equation 11, assuming that the stray inductance is a straight conductor.

Then Q_0 is given by

$$Q_0 = \omega(L_a + L_c)/(r_a + r_c)$$

$$= Q_a \frac{1 + \gamma}{1 + \gamma Q_a/Q_c} \qquad \ldots \quad \ldots \quad (26)$$

Q_b the magnification of the slug, is given by equation 21.

Inserting these values in equation 5 we get Q/Q_0 against α; since α_m is found from equation 24, the extent of the curve is determined.

Approximate Treatment.—There is a difficulty about the treatment just outlined. Q_b is a function of the effective length of the slug, i.e. of the length of the slug inserted in the coil. But it has only been practicable to calculate α for full insertion. Thus we can only calculate Q/Q_0 exactly for the one case—full insertion.

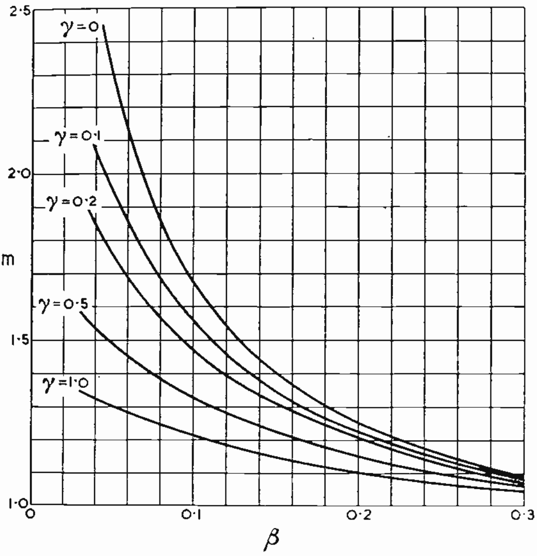


Fig. 7. *Curves of α_m against β for several values of γ.*

One way out of this difficulty is to assume that the effective length of the slug (for calculation of Q_b) is always the same, and equal to the length of the coil. This will give the correct value of Q as α approaches α_m, but an optimistic value of Q for small values of α. However, in practice, one is most interested in the worst value of Q, which occurs for $\alpha = \alpha_m$ so that no great harm will be done by this approximation.

Equation 26 shows that for small values of the stray inductance ratio γ and for Q_a/Q_c not greatly different from unity, Q_0 will be approximately equal to Q_a.

It is thus justifiable to use equation 6 rather than equation 5.

We have from equations 20 and 21

$$Q_a/Q_b = \frac{58\, D\sqrt{f} K F_2}{76\, D'\sqrt{f} K'}$$

for copper throughout and $\alpha = \alpha_m$. Since then the effective length of the slug is to be taken as the length of the coil, K is approximately the same for coil and slug. Suppose the turns for the coil have optimum spacing, then $F_2 = 1$.

$$\text{Thus} \quad Q_a/Q_b = 0.76\, D/D' \qquad \ldots \quad (27a)$$

Similarly for a coil of copper wire and a brass slug (since ρ for brass $= 8{,}000$):

$$Q_a/Q_b = 1.65\, D/D' \qquad \ldots \quad \ldots \quad (27b)$$

Finally, the approximate equations for Q are

$$Q = \frac{Q_a\sqrt{\alpha}}{\alpha^2 + 0.76\,(\alpha^2 - 1)D/D'} \text{ (copper slug)} \qquad \ldots \quad \ldots \quad (28a)$$

$$Q = \frac{Q_a\sqrt{\alpha}}{\alpha^2 + 1.65\,(\alpha^2 - 1)D/D'} \text{ (brass slug)} \qquad \ldots \quad \ldots \quad (28b)$$

10. Experimental Results

Coil No. 1.

The dimensions of this coil and slug were as follows (see Fig. 5).

D	l	d	N	D'	t
cms. 0.963	cms. 1.0	cms. 0.02	cms. 27	cms. 0.795	cms. 0.084

The inductance was $L_a = 4.4\ \mu$H.

The stray inductance was $L_c = 0.15\ \mu$H approximately,

$$\text{Thus} \quad \gamma = L_c/L_a = 0.033$$
$$\beta = t/D = 0.088$$

From equation 24:

$$\alpha_m{}^2 = \frac{\gamma + 1}{\gamma + 4\beta(1 - \beta)}$$

i.e. $\alpha_m = 1.71$.

The measured change of frequency was from 8.0—13.0 Mc/s.

i.e. $\alpha_m = 1.63$.

Thus equation 24 gives a somewhat high value of α_m.

The magnification was measured on a Boonton Q meter for various amounts of entry of the slug. In the table Q/Q_0 is compared with that calculated by equation 28a and 28b (γ being small enough to take $Q_0 = Q_a$).

From Table I, the measured Q_a (without slug) was 110 at 8 Mc/s.

Calculating Q_a, $l/D = 1.04$
and $K = 0.7$ from Fig. 6.
also $Nd/l = 0.54$
and $F_2 = 0.96$ from Fig. 6.
Thus $Q_a = 58\,D\sqrt{f}KF_2$ from equation 20.

$$= 58 \times 0.96\sqrt{8} \times 0.7 \times 0.96$$

$$= 106 \text{ at 8 Mc/s.}$$

Thus with this coil there is good agreement between calculation and measurement of Q_a and Q/Q_0, the agreement in Q/Q_0 being better for full insertion of the slug than for partial insertion.

The calculated value of α_m is higher than the measured value.

Coil No. 2.

The particulars of this coil are shown in the table at the top of the next column.

D	l	d	N	D'	t	β
0.985	0.7	0.04	15	0.795	0.095	0.096

L_a	L_c	γ	Nd/l	F_2	l/D	K
1.87	0.15	0.08	0.86	0.97	0.71	0.61

From equation 24

$$\alpha_m = 1.60$$

The measured frequency change was from 15–23.5 Mc/s.

$$\text{i.e., } \alpha_m = 1.57$$

Again the calculated value of α is too large, but the discrepancy is smaller this time.

With this coil we will check the magnification of the stray inductance. It consisted of 14.5 cms. of 1 mm. wire.

Thus $l/d = 145$ and $F_1 = 5.4$ from Fig. 4.

From equation 11

$$Q_c = 150\,d\sqrt{f}F_1$$

$$= 150 \times 0.1\sqrt{15} \times 5.4$$

$$= 314 \text{ at 15 Mc/s.}$$

TABLE I

	Copper Slug				Brass Slug		
f (Mc/s)	α	Q	Q/Q_0	Q/Q_0 (equation 28a)	Q	Q/Q_0	Q/Q_0 (equation 28b)
8.0	1.0	110	1.0	1.0	110	1.0	1.0
9.0	1.13	70	0.64	0.69	58	0.53	0.59
10.0	1.25	55	0.50	0.54	44	0.40	0.42
11.0	1.38	45	0.41	0.43	35	0.32	0.32
12.0	1.50	39	0.35	0.36	30	0.27	0.26
13.0	1.63	35	0.32	0.31	26	0.24	0.22

TABLE 2

	Copper Slug				Brass Slug		
f (Mc/s)	α	Q	Q/Q_0	Q/Q_0 (calculated)	Q	Q/Q_0	Q/Q_0 (calculated)
15.0	1	130	1.0	1.0	130	1	1.0
15.5	1.03				100	0.77	0.86
16.0	1.07	90	0.69	0.80	81	0.62	0.71
17.0	1.13	76	0.58	0.69			
17.3	1.15				64	0.49	0.54
18.5	1.23	67	0.52	0.56			
19.6	1.31				50	0.38	0.36
20.0	1.34	61	0.47	0.46			
23.5	1.57	50	0.38	0.33	40	0.31	0.23

also $Q_a = 58 D\sqrt{f}KF_2$

$$= 58 \times 0.98 \times 15 \times 0.61 \times 0.97$$

$$= 131 \text{ at } 15 \text{ Mc/s.}$$

From equation 26

$$Q_0 = Q_a \frac{1 + \gamma}{1 + \gamma Q_a/Q_c}$$

$$= 137$$

The measured value of Q_0 was 130.

Table 2 shows measured values of Q and values calculated from equations 28a and 28b.

Table 2 shows that equation 28 again gives results for Q that are too high when the slug is partially inserted, and too low when it is fully inserted.

Coil 1 with various slug diameters.

The frequency ratio α_m was measured for several diameters of slug fully inserted in Coil 1. It was noted incidentally that eccentricity of the slug in the coil made a negligible difference to the effect of the slug. The results are given in Table 3, and compared with the value given by equation 24.

TABLE 3

D	D'	β	α_m	γ	α_m (calculated)
0.963	0.319	0.335	1.04	0.033	1.05
0.963	0.499	0.241	1.12	0.033	1.16
0.963	0.700	0.136	1.35	0.033	1.44
0.963	0.795	0.088	1.63	0.033	1.71

From Table 3 it appears that equation 24 gives a value of α_m that is some 5 per cent. high.

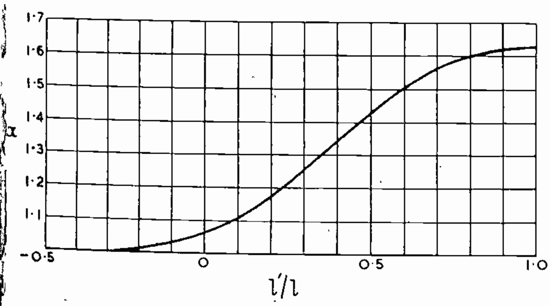


Fig. 8. *Curve of α against l′/l for coil No. 1.*

Frequency ratio against slug insertion.

Measurements were made of the frequency change produced by various lengths (l') of slug insertion in Coil 1. α is plotted against l'/l in Fig. 8. The measurement was approximate only. For this experiment

$$\beta = 0.088$$
$$l/D = 1.04$$
$$\gamma = 0.033$$
$$f_0 = 8 \text{ Mc/s.}$$

It is possible that different values of β and l/D would give a different shape to the curve, but probably Fig. 8 is typical.

Book Received

Automatic Record Changers and Recorders.—By John F. Rider. This volume is intended to give the service-man at once general and specific facts about the record changers and recorders on the American market. Although no effort is made to cover the theory of mechanics, every effort has been made to provide all the essential data, including numerous illustrations and diagrams, needed by the service-man, who, as the author states, is "through no fault of his own now surrounded with pawls and cams and gears." The fundamental principles of motors and drivers, recorders and phonographs and automatic record changers are dealt with in the first sixty pages, whilst the remaining pages are occupied by manufacturers' service data. Pp. (8½ × 11 ins.) 744. John F. Rider, Publisher, Inc., 404, Fourth Avenue, New York, U.S.A. Price in the U.S.A., $6.00.

Paper Salvage

WHERE an appreciable quantity of paper or paper board that has been impregnated or otherwise treated for electrical work is available for salvage and there is some doubt as to its suitability for repulping, the problem should be referred to the Waste Paper Recovery Association, 154, Fleet Street, London, E.C.4 (Telephone: Central 1345). Where it is thought necessary a sample of the material should be sent.

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.

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

541 493.—Balanced bridge circuit for comparing the relative intensities of two sounds, particularly for training in the use of sound-ranging equipment.

Marconi's W.T. Co.; P. R. Berkeley; and A. G. Berkeley. Application date 28*th May*, 1940.

AERIALS AND AERIAL SYSTEMS

541 593.—Aerial systems for transmitting overlapping beams so as to mark out a clear-cut guide path for navigational purposes.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 18*th August*, 1939.

541 867.—Multi-band wireless set fed by a pair of crossed frame aerials, one for short-wave and the other for long-wave reception.

Philco Radio and Television Corpn. (assignees of D. Grimes). Convention date (U.S.A.) 3*rd June*, 1939.

541 870.—Impedance-matching or transformer device for a short-wave aerial required to operate over a wide band of frequencies.

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

541 881.—Combined reflecting and refracting aerial system for short-wave transmission and reception.

L. Lipcsey and J. Bittera. Application date 11*th June*, 1940.

541 905.—Construction of electrostatically-shielded frame aerial suitable for mounting inside a receiver.

Philco Radio and Television Corp. (assignees of W. H. Grimditch). Convention date (U.S.A.) 5*th June*, 1939.

541 986.—Coupling means comprising negative feed-back for interconnecting two transmission lines.

Standard Telephones and Cables (assignees of S. Doba, Junr.). Convention date (U.S.A.) 10*th November*, 1939.

542 035.—Transmission line terminating circuit comprising a pair of push-pull valves with a common cathode load.

Baird Television and E. D. McConnell. Application date 21*st June*, 1940.

DIRECTIONAL WIRELESS

541 657.—Switching arrangement for ascertaining the "sense" of direction in a radiogoniometer coupling between fixed aerials say of the Adcock type.

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

541 669.—Means for "steering" the maximum lobe of a short-wave directional aerial system.

Standard Telephones and Cables (assignees of R. K. Potter). Convention date (U.S.A.) 2*nd August*, 1939.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*).

541 956.—Construction of electrostatically-screened radio-frequency transformer.

Marconi's W.T. Co.; C. S. Cockerell; J. D. Brailsford; and M. H. Cufflin. Application date 23*rd February*, 1940.

542 023.—Means for reducing distortion in systems in which signals reach their destination over a number of paths of different lengths.

Marconi's W.T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.) 16*th June*, 1939.

542 030.—Automatic gain control voltage derived from a pentode arranged to function as a cathode-loaded detector.

Philco Radio and Television Corpn. (assignees of C. Travis). Convention date (U.S.A.) 17*th June*, 1939.

542 077.—Coupling circuit which discriminates against interfering signals of given amplitude and duration or steepness of wave-front.

Philco Radio and Television Corpn. (assignees of A. P. Montgomery). Convention date (U.S.A.) 13*th May*, 1939.

542 130.—Means for screening the mains transformer of the power-pack from a frame aerial when both are housed in the same cabinet.

Philco Radio and Television Corpn. (assignees of A. C. Miller.) Convention date (U.S.A.) 5*th June*, 1939.

542 147.—Distortionless combination of a super-regenerative valve, adjusted to the "logarithmic" mode of operation, and a low-frequency amplifier, preferably of the pentode type.

Standard Telephones and Cables and W. A Montgomery. Application date 25*th June*, 1940.

542 151.—Phase-balancing method for eliminating the effect of mains-supply ripple in an amplifier of the electron multiplier type.

Vacuum-Science Products and H. S. Molyneux-Ffennell. Application date 26*th June*, 1940.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception.

541 531.—Means for producing from a time-base circuit the high voltages required for operating a cathode-ray tube.
Marconi's W.T. Co.; R. J. Kemp; and S. W. H. W. Falloon. Application date 28th May, 1940.

541 860.—Means for scanning the screen say of a television transmitter tube when the surface to be scanned is displaced from the axis of the gun.
W. S. Brown. Application date 5th February, 1940.

542 032.—Arrangement for "linearising" a saw-tooth oscillation supplied to the magnetic deflecting coils of a cathode-ray tube.
Marconi's W.T. Co. (assignees of W. A. Tolson). Convention date (U.S.A.) 30th June, 1939.

542 092.—Stabilizing the grid-bias of the gas-filled discharge valve of a time-base circuit, so that changes in the amplitude do not affect the repetition-frequency of the sweep-voltage.
The General Electric Co. and D. Midgley. Application date 27th August, 1940.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television).

541 495.—Means for maintaining a substantially-constant percentage modulation in radio transmission.
Marconi's W.T. Co. (assignees of H. J. Schrader; B. W. Robins; and J. McC. Brumbrugh). Convention date (U.S.A.) 29th June, 1939.

541 529.—Feed-back circuit in discharge apparatus for generating ultra-short waves by means of a "bunched" stream of electrons.
Standard Telephones and Cables and W. T. Gibson. Application date 28th May, 1940.

541 532.—Crystal circuit for monitoring the frequency output of a radio transmitter.
Marconi's W.T. Co.; F. C. Chamberlaine; and D. Fairweather. Application date 28th May, 1940.

541 535.—Spark-gap circuit for generating and propagating continuous waves of the order of millimetres.
Standard Telephones and Cables (assignees of R. S. Ohl). Convention dates (U.S.A.) 14th and 20th June, 1939.

541 553.—Carrier-wave signalling over electric supply mains, particularly for controlling street lights and for giving public warnings.
Automatic Telephone and Electric Co. and J. F. Mackenzie. Application date 30th May, 1940.

541 604.—Generating ultra-short waves by means of a diode valve with a critical electron-transit time.
Standard Telephones and Cables (assignees of F. B. Llewellyn). Convention date (U.S.A.) 17th February, 1940.

541 631.—Generating ultra-short waves from an electron stream by a method in which groups of electrons are caused to travel at different velocities across the stream.
Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 15th June, 1939.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

541 477.—Discharge tube for generating ultra-short waves by the passage of an electron stream through a resonance chamber.
Marconi's W.T. Co. (assignees of A. V. Haeff). Convention date (U.S.A.) 2nd February, 1939.

541 704.—Electron-beam device for controlling the phase of an alternating current for measuring, testing or signalling purposes.
Standard Telephones and Cables (assignees of F. Gray). Convention date (U.S.A.) 18th November, 1939.

541 739.—Method of producing a photo-sensitive surface for photo-electric cells of the selenium type.
G. A. Veszi. Application date 16th July, 1940.

541 794.—Arrangement of a screening grid or shield for a photo-electric cell.
Baird Television and G. A. R. Tomes. Application date 14th June, 1940.

541 933.—Electrode arrangement of a discharge tube for "bunching" an electron stream by resonant action.
W. E. Benham. Application date 21st May, 1940.

542 104.—Means for avoiding the undesirable effects of static charges which are liable to be set up along the glass walls of a cathode-ray tube.
The British Thomson-Houston Co. Convention date (U.S.A.) 27th October, 1939.

SUBSIDIARY APPARATUS AND MATERIALS

541 489.—Circuit arrangement for operating an electron-discharge tube requiring a pre-heating current.
The British Thomson-Houston Co. Convention date (U.S.A.) 27th May, 1939.

541 623.—Means for "bunching" a stream of electrons in an electron-discharge device of the velocity-modulation type.
Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 29th July, 1939.

541 661.—Indicating the amplitude of high-frequency currents by a hot-wire filament connecting two points of different phase in the circuit under test.
Standard Telephones and Cables and C. N. Smyth. Application date 4th June, 1940.

541 927.—Circuit in which a square-law rectifier is coupled through a second rectifier to a filter with a prolonged time-constant for developing a gain-control voltage.
O. K. Kolb (communicated by Electrical Fono-Films Co., Akt.). Application date 7th October, 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

1279. Limiting Waves and Scattering in Wireless Propagation [and the Collaboration of the F Layer in Scattered-Wave Transmissions].—B. Beckmann, W. Menzel, & F. Vilbig. (*T.F.T.*, Feb. 1941, Vol. 30, No. 2, pp. 43–52.)

For a shortened version *see* Beckmann, *Funktech. Monatshefte*, June 1941, No. 6, pp. 81–87. "We have already pointed out the great importance of scattered radiation in previous papers [2650 & 3877 of 1939], in connection with observations made in the course of our ionospheric measurements. Recently we have carried out continuous field-strength recordings of various stations. The results of these completely confirm the conclusions arrived at in the above papers on the basis of echo measurements" [*cf.* also penultimate paragraph, 1004 of 1941: *also* 2964 of 1941 and back reference]. Since, apart from disturbances and special anomalies, the ordinary disappearance and reappearance of the space wave are approximately symmetrical (in point of time) with the position of the sun, the writers refer to these phenomena as the "setting" and "rising" of the space wave. "From the examples of 'settings' given in Fig. 7 [London, Rome, Oslo, Moscow: Aug./Oct. 1940] it may be assumed that after a 'setting' the station is inaudible . . . On occasion, however, a weak field strength is observed which makes reception of a kind possible. It is two or three orders of magnitude weaker than before the 'setting.' Such a case is seen in Fig. 8" and is a result of scattering at ion clouds in the E region, only noticeable when the F radiation has "set" and no longer masks the effect.

The writers then come to the crux of their investigation. "After the 'setting' of the London 25 m transmission, the London 19 m wave could almost always be heard at great strength right up to the end of the observation period, after midnight: the aural quality of the transmission differed in no way from the previous 25 m transmission. Secondly, the Zeesen 19 m transmission, which according to Table 1 and Fig. 6 should not have been audible in Munich, was frequently received there at very loud strength. It showed no evening 'setting,' but was on many occasions audible to the end of the observation period. Both these results appear to contradict the limiting-wave theory. For the Zeesen transmitter, Munich came within the skip zone throughout the observation period, and the London 19 m wave should have become not audible there (or at any rate not audible at the great strength actually found) even *before* the 'setting' of the London 25 m wave. This great strength contradicts the explanation by scattered radiation as given in the previous chapter." and the behaviour of these London waves is discussed with the help of Figs. 10 & 11. As a result (particularly of the observation that the times of transition from normal fading to scattered radiation agree approximately with the times of ordinary "setting" on the other occasions, about equal in number) the mechanism shown in Fig. 13 is deduced: when, after sunset, the F ionisation falls below the limiting value for distant reception by direct reflection, the transmission is not interrupted, because the direct rays are replaced by the rays deflected by E-region scattering and falling more obliquely on the F layer: after reflection there they are (according to the diagram) again deflected by the E-region ionic clouds, this time downwards to earth.

The fact that such clouds do not on all occasions bring about the collaboration of the F layer, but often act by themselves to produce only the weak scattered radiation, probably depends on conditions of the degree of ionisation, position and dimensions of the clouds, and absorption conditions. That the F layer does play a part in the strong scattering-type transmissions is supported by two other effects, the frequent alternation between scattered radiation and normal fading, and the increase in scattered radiation before the beginning of the normal fading: these points are discussed in the r-h column of p. 51. The results obtained with the London waves were found also with the other stations.

The second result contradicting the "limiting-wave" picture was mentioned above—the strong Zeesen 19 m signals at Munich. This effect is discussed with the help of the records of Fig. 15, and explained as a result of the same scattering effect. The average value of the typical scattered-radiation Zeesen signals (record "a") is of the same order as for London. Record "d" shows a rarely occurring short-time transition from scattering to normal fading, at 19.00: probably the second evening maximum of F-layer ionisation was particularly high that day. Record "f" shows that for the Zeesen station (as already found for London) the scattered radiation reaches a minimum about midnight.

The writers end by stressing the false results which the "limiting-wave" theory by itself may lead to: "radio weather" must take into account also the strength of the scattered radiation, which in 50% of these observations replaced the ordinary "setting." Researches with high-power pulses over great distances are projected, together with observations of the scattering in various directions with respect to the transmitter. The connection with long-distance u.s.w. transmissions has already been pointed out by the writers (*see*, for example, 3877 of 1939).

1280. Measurements of the Angle of Arrival in the Short-Wave Band [of European Stations: particularly at Times of "Layer Dissolution"].—J. Grosskopf & K. Vogt. (*T.F.T.*, Jan. 1941, Vol. 30, No. 1, pp. 19–22.)

"In previous work [the reference given is to this paper itself: presumably the one intended is that dealt with in 2047 of 1941] we have made use of the particularly simple propagation conditions in the short-wave band at the period of layer 'setting' [*see* Beckmann & others, 1279, above] for the investigation of the polarisation of the last-vanishing extra-ordinary component of the radiation, and its possible dependence on direction. We have already pointed out in that paper that the measurement of the angles of arrival should also be undertaken during that time. The advantages of this method of measuring at the moment of layer dissolution over the pulse method have already been pointed out in that paper": the pulse method has the advantage that one can select one's moment, but the need for pulse transmitters raises difficulties in investigating the effects of direction, distance, and frequency: for other disadvantages *see* later in this abstract.

"The arrangement of the measuring aerials (1 and 2) and a calibrating transmitting aerial S is seen in Fig. 2. The phase difference of the voltages excited in the two aerials was measured with a phase-meter described in a previous paper [2048 of 1941]. The amplitudes and phase were continuously registered by a triple recorder [referred to in 2047 of 1941]. The base d of the aerials had an average length of 60 metres." The calibration of the equipment is described: originally the transmitting aerial was in a line with the two receiving aerials, but this arrangement would be sound only on the assumption that the phase velocity over the earth's surface was equal to the velocity of light, and the writers "have established by experiment that the phase velocity over ground of finite conductivity, in the wave band 20–30 m, is about 1 to 2% lower than the velocity of light" [*cf.* Al'pert & others, 622 of March]. This discrepancy leads to serious errors, particularly for small angles of arrival: for an average value of 20° the measured angles were 20–30% too high. The calibrating aerial was therefore changed to the position shown, at a distance of 60 metres from the mid-point of the line joining to two receiving aerials, and at right angles to this line. The laying of the cables from the receiving aerials seriously affected the phase readings: this action was compensated by counterpoises (3 radiators each 3 m long) under the aerials. The azimuthal direction of the in-coming wave was measured by a direction-finding instrument (Patent Application of 5.9.1940) working on the phase-measuring principle and giving results in good agreement with the calculated azimuths. This device will be reported on in a later paper."

Figs. 2 & 3 show examples of the behaviour of the angles of arrival, and of the effective layer heights calculated from these by the simple formula $H = \frac{1}{2}D \tan \alpha$, during the "setting" of the 25 m and 31 m waves of the Moscow, and the 30 m wave of the Daventry, telephony transmissions (measurements taken near Berlin). The curves show clearly the increase of the arrival angles and layer height with increasing dissolution of the layer. Fig. 4 shows some angles of arrival of Moscow and Daventry waves between 9.5 and 15.3 Mc/s, measured during normal transmission periods: the average value for Moscow is about 20°, for Daventry about 25°.' No frequency-dependence within this wave range could be established from the data available. "In combination with the previous investigations on the polarisation conditions [*loc. cit.*], the angle measurement show that the measured dissolution processes occur in the F layer."

The writers point out that on many days no well-defined "layer setting" occurs such as is necessary for a perfectly reliable measurement of arrival angles: the "setting" is masked by absorption processes, presumably in lower layers. In attempting to take measurements during ordinary times, it is often necessary to decide, from comparisons of the amplitude courses and phase behaviour, whether only one ray is being received or several coming in at different angles. In the latter case a close measurement is generally impossible, for although the measured angles may on occasions merely swing between the values corresponding to the various rays (as shown in the calculated curves of Figs. 5 & 6: an actual saw-tooth phase curve corresponding to that of Fig. 5 is seen in the Daventry record of Fig. 8 and still better in the

Moscow-Daventry records, Fig. 9), on other occasions much more violent, unreal fluctuations will occur, as seen in the record of Fig. 7. The calculated curve forms of Fig. 6 have been reproduced in many records. An example of a completely constant phase curve resulting from the presence of one wave only is seen in Fig. 10, taken during a fade produced by absorption, so that there was no change in the layer height.

It is concluded that really reliable measurements of arrival angles during normal times can only be obtained by the use of a Musa aerial system. Finally, the writers mention that neither with European nor North American stations could they find the "jumps" of arrival angles between discrete values, found by Schüttlöffel & G. Vogt (1003 [and 1293] of 1941): "we must conclude from this that sudden changes between different transmission paths do not occur, a conclusion which is also to be expected from echo observations."

1281. The Phase Velocity of Short Waves over Ground of Finite Conductivity.—Grosskopf & Vogt. (In paper dealt with in 1280, above.)

1282. Approximate Formulae for Functions expressed as Definite Integrals [in Theory of Absorption of Radiation in an Exponential Atmosphere: Approx. Formulae in form of Index-Sums, including Application to Integral considered by Appleton (395 of 1938) and to Multiple Scattering of Light in Plane-Stratified Atmosphere (Hammad & Chapman, 3456 of 1939)].—A. Majid Mian & S. Chapman. (*Phil. Mag.*, Feb. 1942, Vol. 33, No. 217, pp. 115–130.)

1283. The Extreme Ultra-Violet Radiation from the Day and Night Sky [Pic du Midi Results during the Yearly Ozone-Minimum].—A. Dauvillier. (*Comptes Rendus* [Paris], 4th June 1941, Vol. 212, No. 22, pp. 958–960.)

The writer has developed, for photon-counters, semi-transparent cathodes of Cu$_2$S, Au, Mg, etc., which operate by transmission and are particularly sensitive: for Cu$_2$S the range of sensitivity is $2000 < \lambda < 2300$, for magnesium hydride $3000 < \lambda < 5000$, while for magnesium treated with oxygen it is $2500 < \lambda < 7000$, a range which approaches that of the caesium-oxide cathodes of photoelectric technique: "this remarkable fact may perhaps help to explain the rôle of magnesium in chlorophyll assimilation (λ 6800 AU). There is here a new method for the study of the chemistry of thin films." The counters were made to control, through a thyratron, a Richard anemocinemograph [*see* Lugeon & Gurtzman, 1933 Abstracts, pp. 457–458]; the equipment, portable and mains-driven, gave completely unattended operation over any periods and should have many applications, such as in atmospheric ozone registration, in ultra-violet dosage in medicine, etc.

With the highly selective Cu$_2$S counter, exposed to the whole of a clear mid-day sky for a total of 16 hours, no luminous radiation was detected of the same order (as regards pulse frequency) as the cosmic rays. The existence, in the light of the night sky, of an u.v. radiation at the limit of the atmospheric ozone transmission (2863 AU) has already been reported: using a gold-hydride cathode (max. sensitivity at 2700 AU) this radiation was recorded from twilight to dawn, from a very clear September sky. Its minimum intensity was three times that of the cosmic rays, which gave one pulse per minute per cm^2 of cathode. It had a decided maximum, almost doubling its intensity at 0^h or 1^h (local solar time). This night minimum is comparable with that observed around midnight in the ionisation of the ionosphere. Records taken at Bagnères (560 m compared with the 2875 m of the Pic) at about the same date showed a radiation only half as strong and with a less pronounced maximum.

A very pronounced phenomenon was that while the u.v. dawn did not begin till half an hour before sunrise, that is, much later than the visible dawn, the end of the u.v. twilight did not occur till an hour after sunset, that is, in full night. This dissymmetry shows that an intense radiation occurs as a result of a phosphorescence of the ionosphere, excited by solar u.v. ($2863 < \lambda < 2950$), and is capable of persisting for half an hour after its excitation. A phosphorescence persisting for more than an hour had already been observed at Meudon (4th June 1940) in a wider region of the spectrum ($2863 < \lambda < 3500$), with a copper-hydride cathode.

1284. Spectrophotometry of the Night Sky [and Comparison with Light of Andromeda Nebula].—H. W. Babcock & J. J. Johnson. —(*Nature*, 24th Jan. 1942, Vol. 149, p. 114: summary only.)

1285. Downward Radiation of the Earth's Atmosphere [Contrast between Observations at Bombay (Damp Climate) & Poona (Dry): Annual Variation of Sky Radiation depends mainly on Annual Variation of Vapour Pressure, Not of Temperature: etc.].—R. Narayanaswami. (*Nature*, 7th March 1942, Vol. 149, pp. 279–280: summary only.)

1286. Radio Reception [throughout India] during the Magnetic Storm and Ionospheric Disturbance from 17th September to 20th September 1941 [and Pulse Observations at Todapur, near Delhi].—K. Venkataraman. (*Current Science* [Bangalore], Dec. 1941, Vol. 10, No. 12, pp. 517–518.)

"There appears to be no coincidence between the most intense period of the magnetic storm and the period of greatest disturbance of the ionosphere . ." This result is compared with those of the magnetic storms of March 1940 and March 1941. Observations on Indian regional short-wave stations indicate either that the effect of the magnetic storm on the F-layer critical frequency was not marked at the low latitudes of Trichinopoly and Madras, or else that though the storm may have had its normal effect, the lowered value of the critical frequency was still high enough not to disturb the regional service from Madras. Pulse observations showed that the disappearance of echoes on 7.2 Mc/s during the fade-out period was entirely due to the increased absorption in the newly-formed layer below the E region, the F$_2$-layer ionisation and height being practically unchanged.

1287. Great Sunspot of September 1941.—H. W. Newton. (*Nature*, 21st Feb. 1942, Vol. 149, p. 223: summary only.) *Cf.* 643 of March and 949/951 of April, and 1286, above.

1288. On Yule's Method of investigating Periodicities of Disturbed Series. The Motion of a Pendulum in a Turbulent Fluid.—T. E. W. Schumann. (*Phil. Mag.*, Feb. 1942, Vol. 33, No. 217, pp. 138–150.)

Yule's work (which he applied, among other things, to the analysis of sunspot numbers) was later extended by Walker (1931 Abstracts, p. 456) and others, " but thus far only the case where the disturbances are entirely random has been dealt with, and if any fundamental advance is to be made on Yule's original research, it becomes imperative to deal with the more general case of disturbances which are interrelated. The object of this paper, then, is to discuss the general case of disturbed harmonic motion, when the time series constituting the disturbances is not entirely haphazard, but shows finite coefficients of auto-correlation for finite time-lags."

1289. Solar Radiation and Atmospheric Temperature [and the Existence of Two Tropopauses].—H. Arctowski. (*Nature*, 7th March 1942, Vol. 149, p. 276.) *See* also 635 of March and 942 of April.

1290. On the Evolution and the Concerted Movements of the Solar Prominences [and the Correlation of the Corresponding " Filaments " with the Sunspot Regions].—L. d'Azambuja. (*Comptes Rendus* [Paris], 30th June 1941, Vol. 212, No. 26, pp. 1128–1131.). *See* also Vol. 211, 1940, p. 424.

1291. A Monochromatic Filter specially suitable for Solar Researches [Combination of Quartz & Polaroid: enabling Cinematography of Prominences & Chromosphere to be carried out even through Cirrus & Dust Clouds].—B. Lyot. (*Comptes Rendus* [Paris], 16th June 1941, Vol. 212, No. 24, pp. 1013–1017.)

1292. A Remarkable Green Line Source [Laboratory Results].—J. Kaplan. (*Nature*, 7th March 1942, Vol. 149, p. 273.)

" One conclusion is already tempting, namely that the catalytic effect of the walls of the tube for the destruction of active nitrogen has in some way been removed and the tube behaves effectively as if it had *no walls*. The large intensities of the two most striking components of the auroral spectrum, the green line and the auroral bands, lend considerable weight to this conclusion, because both ions and metastable atoms are effectively quenched at walls."

1293. Surge Propagation [Methods involving Simple Mathematical Treatment & Graphical Representation].—T. F. Wall. (*Engineering*, 20th Feb. & 6th March 1942, Vol. 153, pp. 141–143 & 181–182.) With illustrations taken from the E.R.A. Report referred to in 2999 of 1941: concluded in issue of 13th March.

1294. Data Sheets on the H.F. Characteristic Impedance of Transmission Lines and on the Resonant Length of the Capacity-Loaded Quarter-Wave Transmission Line.—(*See* 1314.)

1295. Interference Phenomena with a Moving Medium: II [Amplitudes remain Same on Both Sides of Jet (exciting Mercury-Surface Ripples) in spite of Great Relative Velocity of Jet & Mercury ($v/c = 0.585$)].—H. E. Ives & G. R. Stilwell. (*Journ. Opt. Soc. Am.*, Jan. 1942, Vol. 32, No. 1, pp. 25–31.) For I *see* 1305 of 1941: *see* also 938 of April.

1296. Waves and Tidal Streams.—P. J. H. Unna. (*Nature*, 21st Feb. 1942, Vol. 149, pp. 219–220.)

1297. Influence of the Wave-Source Area on the Amplitude of Soil Vibrations, *and* The Choice of the Depth of the Source and Receiver of Waves propagating in the Soil.—D. Barkan. (*Journ. of Tech. Phys.* [in Russian], No. 11, Vol. 11, 1941, pp. 1014–1019: pp. 1020–1028.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

1298. Methods for the Statistical Recording of Electromagnetic Interference.—Carbenay. (*See* 1336.)

1299. Sudden " Jumps " in the Atmospheric-Electric Field, and Atmospheric Discharges [Investigation (Not Limited to Thunderstorm Days) using the Photocell-Compensator (1133 of April) as Recorder].—H. Israel. (*Naturwiss.*, 30th Jan. 1942, Vol. 30, No. 5/6, pp. 85–87.)

(i) In addition to the unrest practically always present to a greater or smaller extent, sudden aperiodic field-strength " jumps " occur only in squally or thundery weather: the relation between these and lightning flashes and invisible discharges is discussed briefly.

(ii) These sudden changes, as seen in the records, are of two distinct types, " single " and " double ": no certain explanation can yet be given, but it is possible that the " single " type is due to discharges within the clouds and the " double " to discharges to earth.

(iii) A very special phenomenon is illustrated in Fig. 2, occurring during thunderstorms and less frequently during squalls: this is a series of rhythmically recurring " jumps," always apparently on the " negative " side of the record, following each other at regular intervals varying (on different occasions) between 8 and 10 seconds, and always of the order of 200 volts/meter: in no case was any thunder heard. This phenomenon, evidently associated with some unknown rhythm or pulsation in the clouds, requires explanation either through observation or by theory. For previous work *see* 364 of February.

1300. The Measurement of Lightning Voltages and Currents in Nigeria: Part 2—1938 to 1939 [including Suggestions for Future

Investigations].—F. R. Perry & others. (*Nature*, 14th Feb. 1942, Vol. 149, pp. 198–199: summary only.)

For Part I *see* 2996 of 1941. "Pronounced double pulses were obtained in certain oscillographic records of lightning voltages, and the suggestion is made that these are dependent on the current pulses in the main return lightning stroke, as was the opinion of Malan & Collens. Many of the observations made at Kew have been confirmed by observations made by means of a point-discharge recorder, certain differences relating to storm activity being simultaneously revealed with a contrast between temperate and tropical zone storm conditions. It was apparent from these records that a more complicated form of a Simpson-Robinson storm model could advantageously be applied to the task of explaining point-discharge records of lightning phenomena."

1301. THE ELECTRIC SPARK: DISCUSSION ON THEORIES OF DISCHARGE—LIGHTNING AS GUIDE.—J. M. Meek. (*Electrician*, 6th March 1942, Vol. 128, pp. 203–204.) Summary of I.E.E. paper and Discussion.

1302. SURGE PROPAGATION [Methods involving Simple Mathematical Treatment & Graphical Representation].—Wall. (*See* 1293.)

1303. THE FIELD OF ELECTRETS IN THE PRESENCE OF GASEOUS IONS.—A. Gemant. (*Phys. Review*, 1st/15th Jan. 1942, Vol. 61, No. 1/2, pp. 79–83.)

The absence of a definitely established explanation of the polarisation-reversal of electrets has not proved a serious handicap in attempts to make use of these bodies (1961 of 1940 and back reference). Incidentally, the writer's own (piezoelectric) explanation is mentioned here, and he goes on to disclose another apparent anomaly, which leads to a further suggestion concerning a new application. His short analysis of the field of an electret in a space of finite ion concentration (based on double-layer considerations) shows that the field ought to be completely shielded by the ions present in the atmosphere. That this is found experimentally *not* to be the case makes it desirable to ascertain whether the field will diminish with increasing concentration of the ions, and to establish the field/ion-concentration relation. When this has been done, the electret in combination with a suitable measuring device might be used as a quantitative indicator, for the ion concentration of the upper atmosphere, for instance. Another possibility is the use of electrets for bias purposes in gas-filled or vacuum valves, phototubes, cathode-ray tubes, etc. (*cf.* Sheppard & Stranathan, 3251 of 1941). Electrets of higher softening point than the present ones would seem desirable, and the writer suggests research on the making of electrets from modern synthetic plastics and the glasses used for fibre glass.

PROPERTIES OF CIRCUITS

1304. THE LAWS OF SIMILITUDE OF THE ELECTROMAGNETIC FIELD, AND THEIR APPLICATION TO CAVITY RESONATORS.—H. König. (*Hochf: tech. u. Elek:akus.*, Dec. 1941, Vol. 58, No. 6, pp. 174–180.)

In electrostatics, the similarity relations (*e.g.* for two similar condensers of different dimensions) hold good even when the conductivities in the two condensers are different. In quasi-stationary and dynamic processes the position is different: here not only conductivity but also time play decisive parts. Now Barrow & Mieher have found from measurements on cylindrical cavity resonators that the natural frequency of a given oscillatory mode is doubled when the linear dimensions are halved (2951 of 1940): and from this they have deduced that this law of similitude applies generally for all oscillatory modes and for any shape of resonator. Since the oscillatory processes in geometrically similar cavity resonators take place with different frequencies, a purely geometrical similarity of field can no longer occur. It must be replaced by a geometrical-temporal similitude between the processes. That the law of similitude given by Barrow & Mieher is only valid under certain limiting conditions is easily seen from a simple example: the natural frequency of an L, R, C oscillatory circuit made up of linear conductors is shown to obey the law, when the dimensions are reduced by the factor $1/m$, only if the conductivity of the reduced circuit is increased by the factor m, in which case the conductor damping (Joulean heat) remains unchanged at $\pi R\sqrt{C/L}$. "It is therefore to be concluded that the law of similitude given by Barrow & Mieher for the natural frequencies of cavity resonators has a strict validity only if the similarity relation $\mathfrak{k}' = m\mathfrak{k}$ for the conductivity is added. For the perfect conductor $\mathfrak{k}' = \mathfrak{k} = \infty$ it it always fulfilled, independently of m. For finite and equally large $\mathfrak{k}$-values for the two resonators the relation $\mathfrak{k}' = m\mathfrak{k}$ is the better observed, the less the geometrical similitude factor departs from unity. Thus for a general validity of the law of similitude for the natural frequencies of cavity resonators the law has the character, for $\mathfrak{k}' = \mathfrak{k}$, of a limiting law: that is, it is the more accurate the more the conductors in question approach the perfect conductor in their properties."

The laws of similitude are derivable directly from the Maxwellian equations, and the writer carries out these derivations for two systems S and S' composed of an arbitrary number of components: S' is obtained from S by reducing all linear dimensions by the factor $1/m$. In his treatment he makes use of the Π theorem of the theory of dimensions (the Bridgman-Holl book is referred to for this) which states that all the relations derivable from the Maxwellian field equations have the form $\phi(ut/\epsilon x,\ \mu ux/t,\ u/\mathfrak{k}x) = 0$, where the function ϕ contains no physical quantity other than the given arguments. The results are tabulated and applied in Part III to cavity resonators, on the assumption that ϵ and μ remain unaffected by a change in $\mathfrak{k}$: "in well-conducting metals the displacement current can be neglected in comparison with the conduction current, unless excessive frequencies are considered," so that the assumption is justified. If the conductivity of S' is increased with respect to S by the factor m, the relation between the natural frequencies is given by $\omega' = m\omega$, and the field lines form systems of geometrically similar curves at times t and t/m. The dampings of S and S' are equal. On the other hand if, as is usual in practice, the conductivities of S and S' are kept equally high, the similitude between the field lines in the metal will be upset, while in the cavity itself it will remain almost unchanged. The result will be an increase in the damping of S', as compared with that of S, by the factor $\sqrt{m}$. Eqn. 40 gives the relation between the admittances, for a detuning v from resonance, of S' and S: from this, if the resonance curve of S is known, that of S' can be constructed directly. This has been carried out in Fig. 5a, for a cavity resonator when $m = 2$: a comparison with Fig. 5b, where the same has been done for a linear oscillatory circuit with the help of the corresponding relation (eqn. 40a), shows clearly the superiority of the cavity resonator.

1305. GEOMETRICAL CONFIGURATIONS AND DUALITY OF ELECTRICAL NETWORKS.—B. D. H. Tellegen. (*Alta Frequenza*, June 1941, Vol. 10, No. 6, pp. 366–369: summary, from *Rev. tech. Philips*, Nov. 1940, Vol. 5, p. 328 onwards.)

An electrical network is formed out of branches (a branch being a circuit element—resistor, inductance, voltage-generator, etc.), of vertices (a vertex being a junction-point between two or more branches), and of meshes (a mesh being any closed circuit formed of branches of the network). Given a network, it is in general possible to construct its dual by replacing resistance by conductance, inductance by capacitance, series connection by parallel connection, vertex by mesh, vertex potential by mesh current, voltage by current, and *vice versa*. If a correspondence is established between the vertices and meshes of the primary network on the one hand and the meshes and vertices of the dual on the other, the relations applying to one of the two networks can be immediately applied to the other provided that the above-indicated substitutions are carried out. In order to construct the dual of a given network, the problem must be studied from the topological viewpoint: that is, the network must be examined only as regards its geometrical configuration, without taking the electrical significance into account: the only important points are the numbers of vertices and branches and the way the vertices are arranged. Each pair of terminals must be considered as a branch (Fig. 1), so that every branch is traversed by current. Configurations may be of two types, planar and non-planar; the former can be drawn on a plane surface without the branches crossing. But they can also be represented in space as polyhedral structures, and since, topologically, a sphere and a polyhedral are equivalent, the characteristic condition for a configuration to be "plane" is that it should be traceable without crossings on a spherical surface. The number of meshes m, of branches t, and of vertices k are then connected by Euler's relation $k - t + m = 2$. On the other hand the non-planar configurations can all be reduced to one of the two prototypes A and B of Fig. 4, which can be traced without crossings only on surfaces of other kinds, such as a toroid. These non-planar structures have no duals.

If the network is a plane one, its dual can be constructed by tracing the configuration on a spherical (or plane) surface so that there are no crossings: meshes, bounding "fields," are obtained, which must correspond to the vertices of the dual structure. Inside each mesh (in the plane and outside the outer mesh) a new vertex is selected and each pair of these, in two adjacent meshes, is connected by a new branch which cuts the branch common to the two meshes: the construction is illustrated in Fig. 5.

1306. CONCERNING THE TRANSMISSION OF ENERGY THROUGH QUADRIPOLES.— R. Possenti: A. Ferrari-Toniolo. (*Alta Frequenza*, May 1941, Vol. 10, No. 5, pp. 286–296.)

In his paper dealt with in 1359 of 1940, Ferrari-Toniolo dealt with the efficiency of energy-transmission through a four-terminal network and showed that it is not correct to affirm that the image transfer "degree" (for the difference between this quantity and the usual image transfer factor *see* p. 292) expresses the efficiency: this is exact "only in the special hypothesis that the image impedances are ohmic resistances." Although agreeing with the general conclusion, the present writer considers the quoted sentence to be too restrictive. He discusses this and other points in Ferrari-Toniolo's paper, and goes on to derive the conditions for max. efficiency. In his reply, Ferrari-Toniolo gives a useful table of 35 principal quantities involved in such transmission, giving the mathematical expressions and the Italian names, together with (where possible) the English, French, and German equivalents.

1307. GRAPHICAL PROCESS FOR THE DETERMINATION OF THE PROPERTIES OF ELECTRIC WAVE FILTERS ON THE BASIS OF THE WAVE PARAMETERS.—K. H. Haase. (*T.F.T.*, June, July, & Aug. 1941, Vol. 30, Nos. 6, 7, & 8, pp. 168–175, 197–205, & 231–235.)

Work under the auspices of H. Piloty. Author's summary:—"After the important results and laws of the theory for the calculation of wave filters have been given in Part I, Part II describes a graphical method of determining the quadripole transmission equivalent and characteristic impedance of low-pass, high-pass, band-pass, and band-suppression filters of any class. Part III gives a further development of the graphical method, for determining the operating transmission equivalent for symmetrical and antimetrical filters [for "antimetrical" filters *see* p. 170, r-h column, and 959 of 1940] of these types, and finally Part IV deals with the graphical determination of the operating transmission equivalent for high/low separating filters. The method is illustrated by some examples."

1308. THE DETERMINATION OF THE DIPOLE FUNCTIONS $Z_{1,2}(\lambda)$ and $Y_{1,2}(\lambda)$ FOR THE CALCULATION OF BRIDGE-TYPE FILTERS: PART II [with Complete Tables].—K. Steffenhagen: W. Cauer. (*Funktech. Monatshefte*, Dec. 1940, No. 12, pp. 182–192.) Continued from 858 of 1938.

1309. BAND-REJECTION FILTERS COMPOSED OF X-CIRCUITS AND OF ZOBEL NETWORKS [Extension of Feldtkeller's Band-Pass Calculations to Band-Rejection].—H. Wucherer. (*T.F.T.*, March 1941, Vol. 30, No. 3, pp. 65–72.)

1310. ADJUSTABLE FILTERS FOR THE 2B PILOT CHANNEL [including Stability of Band Location with Temperature].—F. S. Farkas. (*Bell Lab. Record;* June 1941, Vol. 19, No. 10, pp. 323–326.) *See* also 580 of February.

1311. OPERATIONAL ANALYSIS OF NON-LINEAR DYNAMICAL SYSTEMS [Operational Adaptation of Lindsted-Liapounoff Method: Laplacian Transformation: Free Vibrations of Non-Linear Oscillator: Vibrations of Pendulum: Non-Linear Electrical Circuit: Oscillator Non-Linearly Damped: Forced Non-Linear Vibrations].—L. A. Pipes. (*Journ. Applied Phys.*, Feb. 1942, Vol. 13, No. 2, pp. 117–128.) *Cf.* 1202/3 of April, and for other recent work by Pipes *see* 618/9 of March.

1312. THE TRANSIENT BEHAVIOUR OF FOUR-TERMINAL NETWORKS [Treatment by Application of Laplacian Transformation & Matrix Algebra: Complicated Structures & Smooth Transmission Line: including Table of List of Transforms (previously Widely Scattered over the Literature): etc.].—L. A. Pipes. (*Phil. Mag.*, March 1942, Vol. 33, No. 218, pp. 174–214.) For previous work *see* 57, 58, & 3554 of 1941 and 618, 619 of March.

1313. A NEW EQUIVALENT CIRCUIT FOR THE CALCULATION OF TRANSIENT PROCESSES [using the "Line Harp" Concept].—Gensel. (*See* 1442.)

1314. DATA SHEETS IV AND V: ON THE HIGH FREQUENCY CHARACTERISTIC IMPEDANCE OF TRANSMISSION LINES, *and* VI, VII, AND VIII: ON THE RESONANT LENGTH OF THE CAPACITY-LOADED QUARTER-WAVE TRANSMISSION LINE.—(*Electronic Eng:g,* July & Aug. 1941, Vol. 14, Nos. 161 & 162, 4-page Insets.)

For examples of the use of Sheets VI, VII, & VIII, and some corrections, *see* Sept. issue, No. 163, which also contains Sheets IX & X on the resonant length of capacitance-loaded lines.

1315. THE SKIN EFFECT IN A CYLINDRICAL TUBE WITH CIRCULAR CROSS SECTION.—J. Fischer. (*Hochf:tech. u. Elek:akus.*, Dec. 1941, Vol. 58, No. 6, pp. 171–174.)

The writer cites some of the many papers already published on this subject, including Försterling's 1924 work on approximate formulae for very high frequencies and the writer's own paper (*see* Fischer, Strutt, 1933 Abstracts, p. 576 and back reference). For practical calculation, however, "one wants to use books of tables which are convenient and accessible, such as the function tables of Jahnke-Emde. The different authors employ cylindrical functions of different types. The differences in the definitions and applications of the various useful cylindrical functions are, it is true, simple in conception, and it is also true that the papers referred to often deal with the mathematical side of the problem. Nevertheless it is burdensome to have to remember these differences each time the book of tables is used, or to have to refer to the original paper and its mathematical developments." The writer therefore returns to the problem of the tube and at the same time draws some comparisons with other skin-effect and eddy-current phenomena: thus of his eqn. 8, for a tube of wall-thickness $b-a$, he points out that completely similar expressions apply to the plane unidimensional skin effect in a rectangular bar embedded in the slot of an iron armature, calculated by Emde: another useful comparison is with Sommerfeld's calculations for the cylindrical coil with "idealised" winding of thickness $b-a$. Other comparisons are with the current distribution (Fig. 2a) in a tube serving as a sheath to a cylinder carrying alternating current, the tube itself being supplied with no current (Krarup cable: 1934 Abstracts, p. 444: this paper also considers the "quite unusual skin effect which occurs if the iron sheath is not insulated from the copper core"): and with the case of two parallel rectangular bars, close together and carrying equal and opposed alternating currents (*i.e.* joined at one end: Fig. 2b).

The writer concludes: "Thus if the penetration depth is definitely smaller than the thickness of the tube wall: or than the thickness of the parallel bar: or than the thickness of the winding of the cylindrical coil: or than the half radius of the solid cylinder: then the Rayleigh formulae are valid for the ratio of the internal a.c. resistance to the d.c. resistance."

1316. CAPACITANCE EFFECTS IN HIGH OHMIC RESISTANCES [and the Advantages of the "Radial Spiral"].—A. Klemt. (*Hochf:tech. u. Elek:akus.*, Dec. 1941, Vol. 58, No. 6, pp. 159–163.)

The writer deals first with space capacitances, which can be calculated by line equations: since a special type of line is involved (short line, negligible self-inductance and leakage, etc.) approximate formulae can be used. The d.c. resistance R_{gl} is equal to the sum of the partial resistances R_1, R_2 . . . into which the line is split up, and the total parallel space capacitance C_E to the sum of the partial capacitances C_1, C_2 . . . On the assumption that $R_{gl} < 1/\omega C_E$, the non-earthed resistance (Fig. 1) has a dissipative resistance between a and a' of $R_w = 3/(R_{gl} . \omega^2 C_E{}^2)$, and the equivalent capacitance C parallel to this is equal to the static capacitance C_E. A resistance earthed on one side (Fig. 2) has a dissipative resistance $R_w = R_{gl}$, and the equivalent parallel capacitance C is equal to one-third of the static capacitance C_E.

Applied to the three types of leaky-grid detector circuit, where the grid leak is connected (a) in the grid lead, (b) between grid and cathode, and (c) in the cathode lead, these results yield the following conclusions. On the assumption that the oscillatory circuit LC has a resonance resistance of 300 kilohms, corresponding (at 1 Mc/s and $C = 50$ pF) to a quality factor G of about 100, the effective parallel resistance R_w due to the 2-megohm leak R (with $C_E = 0.3$ pF) is about 420 kilohms in case (a) and about 1.9 megohms in case (b); the resulting decreases in G are 40% and 13% respectively. In case (c) the space capacitances are without effect: the cathode lead is obviously the right place for the grid leak.

The final section of this part dealing with space capacitances considers the case when R_{gl} is no longer assumed to be less than $1/\omega C_E$, and particularly the case when $1/\omega C_E$ is equal to or less than $1/5\ R_{gl}$, when open-circuit and short-circuit resistances are both equal to the characteristic impedance. Fig. 4 gives the dissipative resistances and parallel capacitances of a 100 kilohm and a 1 megohm resistance: for frequencies when $R_{gl} > 1/\omega C_E$ the measured resistances are up to 50% greater than the calculated, this discrepancy being attributed to the deformation of the field along the resistance, produced by the terminal caps, making the space capacitances not fully effective. Section 3 then deals briefly with the parallel capacitances due to terminals and leads: if they can be considered as loss-free, they simply produce an increase of the phase angle, but if their loss resistance approaches the magnitude of the d.c. or equivalent dissipative resistance, they will also produce a decrease in the latter. A potentiometer, for instance, may have a terminal-capacitance of 1 pF with a loss factor of 10% at 100 Mc/s (Pertinax insulation): the parallel loss-resistance is 16 kilohms, and "the effective resistance of such a component at frequencies equal to or below 100 Mc/s can be considered as constant only for resistances R_{gl} less than or equal to 1 kilohm. The necessity for the use of a low-loss material is obvious."

Section 4 then deals with the transverse capacitances between points at different potentials, such as between the adjacent turns of a resistance-layer in a spiral form (Fig. 5); the effects of the space capacitances are first neglected and then taken into account. Finally the conclusions obtained from the whole work are given, as follows: the various capacitances of high ohmic resistances have two results, the increasing of the parallel capacitance and the diminution of the dissipative resistance. The desire, particularly in measuring and short-wave technique, for small space and parallel capacitances leads to the greatest possible reduction of dimensions, the limit being set by the permissible energy consumption: commercial resistances of ½ w and ¼ w types have space capacitances of the order of 0.3 pF and 0.2 pF respectively: for recent 0.1 and 0.025 w types the values were only 0.1 and 0.05 pF. A high limiting frequency (a limiting frequency being that below which the effective dissipative resistance is constant and can be taken as equal to the d.c. resistance) can be attained by low space and transverse capacitances and small loss factor in the material composing the coil former. The last requirement can be fulfilled easily, the first two are to some extent contradictory, for to reduce the transverse capacitances the spacing and number of turns in the spiral should be large, and this leads to large dimensions when the usual design (spiral parallel to the axis) is kept to.

Better results are obtained if the width of the spiral strip is made to lie radially (Fig. 7, lower sketch), when the transverse capacitance is reduced by some 15 to 50%, according to the spacing of the spiral, compared with the spiral parallel to the axis and having the same spacing a and strip width b. Or the *same* transverse capacitance can be obtained with reduced spacing, and thus with reduced length and space capacitance for the whole resistance. Fig. 8 compares the measured dissipative resistances of two ½ watt 100 kilohm resistances, one with the usual axis-parallel spiral and the other with a radial spiral: for the former the critical frequency is about 7 Mc/s, and at 100 Mc/s the resistance decrease amounts to 60%, while for the latter the critical frequency is 15 Mc/s and the small resistance decrease above this (reaching about 16% at 100 Mc/s) is to be attributed simply to space capacitance. Curve c in the same diagram, for an axis-parallel 0.1 w 100 kilohm spiral, shows that in spite of the much smaller space capacitance the dissipative resistance still decreases very much like that of the larger spiral, because of the relatively large transverse capacitance due to the small number of turns. The practical construction of the radial-spiral resistances is facilitated by the fact that the angle α (Fig. 7), which the spiral strip makes with the longitudinal axis of the resistance, need not be 90°; it may be decreased to 45° without an appreciable increase in transverse capacitance.

1317. HIGH-FREQUENCY TUNING INDUCTANCE [with Adjustable Non-Magnetic Core: Effect of Core Movement on Distributed Winding Capacitance almost Eliminated by Electrostatic Shield with Longitudinal Gap].—General Electric (America). (*Electronic Eng:g*, Aug. 1941, Vol. 14, No. 162, p. 369.)

1318. AN ANALYSIS OF THE OPERATION OF TWO COUPLED RELAXATION OSCILLATORS.—Bremzen & Faynberg. (*See* 1453.)

1319. ON THE FREQUENCY DOUBLING OF AMPLITUDE-MODULATED SIGNALS.—Cocci: Santoro. (*See* 1335.)

1320. DIODE AMPLITUDE-LIMITING CIRCUITS.—Santoro. (*See* 1334.)

1321. THE VOLTAGE DROP IN DIODE DETECTORS [Examination of Wheeler's Expression for the Equivalent Resistance producing the Drop].—G. Cocci: H. A. Wheeler. (*Alta Frequenza*, May 1941, Vol. 10, No. 5, pp. 282–286.)

Wheeler's treatment (3544 of 1938) of the diode detector circuit of Fig. 1 led to his concluding that the drop in the mean d.c. voltage was equal to that which would be produced by a resistance $R_1 = \pi/\omega \cdot (1/C_1 + 1/C_2)$. The present writer, failing to find either in Wheeler's paper or elsewhere any explanation of this expression (at any rate as regards the term $1/C_1$), now examines the problem, shows how the equation is arrived at, and concludes that in practice the voltage drop can be calculated in a first approximation by that equation, as regards the effects of the condensers C_1 and C_2, and by methods outlined as regards the effect of the internal resistance of the diode. The drop actually measured will be a little smaller than the value thus calculated: a more exact determination would only be possible by taking other effects into account and would involve considerable analytical difficulty.

1322. VOLTAGE-MULTIPLYING RECTIFIERS: OBTAINING HIGH VOLTAGE WITHOUT A TRANSFORMER [Discussion of Doubler, Tripler, & Quadrupler Circuits, with Valves or Metal Rectifiers].—W. T. Cocking. (*Wireless World*, March 1942, Vol. 48, No. 3, pp. 60–61.) With extracts from Waidelich's paper, 34 of January.

1323. AUTOMATIC PHASE-REVERSAL AMPLIFIER.—Crosby. (*See* 1332.)

1324. A DIRECT-CURRENT AMPLIFIER AND ITS APPLICATION TO INDUSTRIAL MEASUREMENTS AND CONTROL.—Gall. (*See* 1586.)

1325. DATA SHEETS I, II, and III: ON THE HIGH-FREQUENCY PERFORMANCE OF INDUCTANCE-COMPENSATED RESISTANCE-CAPACITANCE-COUPLED AMPLIFIERS.—(*Electronic Eng:g*, June 1941, Vol. 14, No. 160, 4-page Inset.) *See* also 1443, below. For correction to II *see* July issue, No. 161, opposite p. 311.

1326. A NEW NEGATIVE FEEDBACK AMPLIFIER [Reduction of Circuit Elements by dispensing with Separate Path].—R.C.A. Laboratories. (*Electronic Eng:g*, July 1941, Vol. 14, No. 161, p. 305.)

TRANSMISSION

1327. THE LAWS OF SIMILITUDE OF THE ELECTROMAGNETIC FIELD, AND THEIR APPLICATION TO CAVITY RESONATORS.—König. (*See* 1304.)

1328. A MAGNETRON WITH A CONCENTRIC LINE.—M. T. Grekhova, V. I. Gaponov, & R. P. Vasil'ev. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 11, 1941, pp. 1146–1148.)

A preliminary description is given of a magnetron developed by the authors. The oscillating circuit of this magnetron takes the form of a concentric line, *i.e.* of two coaxial cylinders connected respectively to the segments of the anode (Fig. 1). The method of connecting the two cylinders to a four-segment anode is also shown (Fig. 2). The whole assembly is mounted in a glass envelope, and oscillations are taken off by two leads passing through the glass and connected to a loop between the two cylinders. The magnetron in this shape has a fixed frequency. To enable it to be operated over a frequency range it is necessary to vary the length of the concentric line. This can be achieved by dividing the line into two sections, one mounted inside the glass envelope and the other outside it. The necessary adjustments can then be made on the latter section. Suitable methods for connecting the two sections are suggested (Figs. 4–6). A complete investigation of the magnetron will be published in a separate paper.

1329. FREQUENCY-DEVIATION MEASUREMENT OF FREQUENCY-MODULATED TRANSMITTERS [by noting the *Constant-Amplitude* Modulating Frequencies for which the Carrier disappears].—L. N. Holland & L. J. Giacoletto. (*Electronics*, Oct. 1941, Vol. 14, No. 10, pp. 51–52.)

Having advantages (except when there is an appreciable variation of deviation with audio-frequency) over the Crosby method with which the article begins (*see* 3369 of 1940.).

1330. THE FORMATION OF AN ELECTRIC DISCHARGE [as sometimes observed in Short-Wave Transmitters] WHEN THE PRESSURE IS VARIED.—Ya. Matveev. (*Journ. of Tech. Phys.* [in Russian], No. 11, Vol. 11, 1941, pp. 1054–1057.)

The effect of gas pressure on the sustained discharges sometimes observed in short-wave radio transmitters was investigated. The discharge was obtained from a point attached to the anode coil of an oscillator (Fig. 1) operating on wavelengths from 15 to 23 m. The point itself was enclosed in a glass container filled with air, O_2, H_2, N_2, or CO_2. The pressure of the gas was varied from two atmospheres to 3 mm Hg, and voltages up to 5000 v, both direct and alternating, were applied to the oscillator. A number of photographs and sketches showing the structure of the discharge under various conditions are included.

1331. COMPACT PORTABLE TRANSMITTER [in Suit-Case: Output 10 W on 75 m: Loctal-Type Valves (Four 35Z3's in Voltage-Quadrupling Circuit): Devices for Simplification: Telephony & Telegraphy].—E. F. Kiernan. (*Electronics*, Oct. 1941, Vol. 14, No. 10, pp. 54–62.)

1332. AUTOMATIC PHASE REVERSAL AMPLIFIER [to give Station its Greatest Possible Range (about 6 db Increase) by making Higher Peaks in Asymmetrical Speech & Music Modulation modulate Carrier in Upward Direction].—R. P. Crosby. (*Electronics*, Oct. 1941, Vol. 14, No. 10, pp. 64 and 66.)

RECEPTION

1333. CIRCUIT FOR THE RECTIFICATION, ESPECIALLY THE DEMODULATION IN THE MIXING STAGE, OF DECIMETRIC WAVES, USING THREE-ELECTRODE VALVES.—H. Pigge. (*Hochf:tech. u. Elek:akus.*, Dec. 1941, Vol. 58, No. 6, p. 182.)

D.R.P. 705 935, assigned to Dietz & Ritter GmbH. "The neutralisation of the amplifier valve 4 (Fig. 8), whose grid circuit 1 is supplied with the input voltage, and to whose anode circuit 6 (in the case of mixing-stage rectification) the heterodyning voltage is taken, is carried out by the grid/anode gap of the triode 11, functioning as an anode-bend rectifier. The l.f. or i.f. is taken off between the points 17, 18 of an output impedance connected to the input circuit."

1334. DIODE AMPLITUDE-LIMITING CIRCUITS [for Frequency-Modulation Receivers, etc.].—M. Santoro. (*Alta Frequenza*, Oct. 1941, Vol. 10, No. 10, pp. 589–614.)

The usual limiter circuit is that shown in Fig. 1, using a duo-diode such as the 6H6 (Browning, 4253 of 1940) and having the characteristic seen in Fig. 2 with a rounded summit which represents a zone in which the output signal, having reached a maximum, remains practically independent of the input signal. This zone, however, is rather restricted, and this tends to make the limiter circuit inefficient.

But better diode circuits can be devised. Such circuits may be divided into two categories, according to whether their behaviour in the two half-periods of an alternating voltage is the same or different. The first type is represented in Fig. 3, having an auto-transformer to serve as the input to the two diode systems and to provide a way of varying their steady bias from the battery V_b.

The analysis of the action of such a circuit shows that the auto-transformer has several disadvantages, and leads to the consideration of the bridge circuit (with 4 diode gaps) of Fig. 8, whose behaviour under various conditions is analysed: it is seen that exactly the same results can be obtained with the circuit of Fig. 16, a bridge circuit without diagonal, in which two of the diode gaps in Fig. 8, together with the bias battery in the diagonal, have been replaced by batteries of equal voltage in the two adjacent arms. Fig. 17 is the same as Fig. 8 except that the bias battery in the diagonal has been replaced by a resistance-shunted capacitance, to provide self-bias: unlike the circuit of Fig. 8, that of Fig. 17 gives a bias dependent on the amplitude of the input voltage, and if the time constant of the CR_1 circuit (in the diagonal) is smaller than the period of variation of the applied voltage V_1, the circuit will not act as a limiter: if the time constant is much greater than that period, the circuit works identically with those of Figs. 3, 8, and 16.

Coming to the second type of circuit, it is pointed out that although the connection of Fig. 16 behaves exactly as that of Fig. 8 when its two batteries are of the same voltage, if their voltages are different the circuit behaviour will also be different, and the form of the voltage curve beyond the limiter will differ in its two phases (Fig. 18): if one battery is short-circuited (Fig. 22) the shape becomes that of Fig. 19, without any curve below the zero line.

If the input voltage applied to the limiting circuits of Figs. 3, 8, and 16 has a max. value less than or equal to the value of the d.c. bias, the voltage beyond the limiter will be of identically the same shape and value as that of the input. An appendix derives expressions 29 and 30 for the effective and average voltages beyond the limiter, and from these the curves of Fig. 25 are obtained showing the variations of these voltages with the ratio of the d.c. bias to the applied alternating voltage: the abscissae represent ϵ, where ϵ = arc cos(bias-voltage/applied-voltage): *see* also Figs. 4 and 6.

1335. ON THE FREQUENCY DOUBLING OF AMPLITUDE-MODULATED SIGNALS.—G. Cocci: M. Santoro. (*Alta Frequenza*, Oct. 1941, Vol. 10, No. 10, pp. 615–618.)

Cocci writes that in preparing two papers on modulation, in collaboration with Sartori (ref. "1," and 2102 of 1941), he made a special analysis of the functioning of frequency multipliers when dealing with simultaneous amplitude and phase (or frequency) modulation [*cf.* also 517 of 1940], and that in these two papers he discussed also the possible effects obtainable with selective networks combined with frequency multipliers and dividers. He has, therefore, examined with great interest a paper by Santoro in the July 1941 *Alta Frequenza*: particularly what was said in an appendix about the possibility of reducing adjacent-channel interference, and the mention of experimental results which sounded extremely interesting. In the absence of a full description of the apparatus used, however, he suggests that perhaps the frequency doubler may not have been the only difference between the two receivers under comparison and that the phenomena observed might possibly be explained more simply than on the frequency-doubling idea. Certainly nothing in his own or Santoro's theoretical considerations, or in the experimental results, justifies the simple explanation of the disappearance of the 4 kc/s interfering whistle as a result of frequency-doubling. Taking the case of a wanted signal of 467 kc/s and an interfering signal of 471 kc/s, the output would not simply contain two signals of 934 and 942 kc/s, but rather a much more complex mixture: this can be derived from the formulae of Santoro's paper, and the predominant modulation in the output signal is seen to be of a frequency equal to the difference between the original frequencies, that is, 4 kc/s and not 8 kc/s as Santoro's simple reasoning would suggest. The point is further elaborated and it is concluded that the apparent higher selectivity of the frequency-doubling receiver cannot be due to the mere fact of the frequency-doubling, and might well form the subject of further interesting investigations. Finally, Santoro's diagram of a diode frequency-doubler circuit is criticised as showing in the output circuit a resistance-capacitance combination which, if it came into action, would make the circuit act as a peak-value rectifier rather than the average-value rectifier specified in the text and formulae. Santoro replies.

1336. METHODS FOR THE STATISTICAL RECORDING OF ELECTROMAGNETIC INTERFERENCE.— F. Carbenay. (*Comptes Rendus* [Paris], 16th June 1941, Vol. 212, No. 24, pp. 1029–1032.)

The usual methods are based on the accumulation of the pulses during a period characterised by a time constant τ, and involve either a condenser-charging circuit or the measurement of the rapidity with which pulses passing a definite threshold succeed one another ("the radio-cinemograph is an example of this process": *see* 1283, above). A third method would consist in applying the p.d. to the terminals of a self-inductance of sufficient volume: retroaction by a valve would allow a suitable τ to be obtained. From a comparison of the equations representing these three methods it is seen that the function $\Phi(t) = e^{-\alpha t}\int e^{\alpha t} f(t)dt$ (where $\alpha = 1/\tau$) plays a fundamental rôle in the study of interference. The structure of the interference is studied with a time constant as small as possible compared with the duration of the shortest disturbance. The expansion obtained by supposing $f(t)$ to admit of n successive derivatives shows that "if τ tends towards zero, $\Phi(t)$ also tends towards zero, but $\alpha\Phi(t)$ (condenser method) tends towards $f(t)$. The limit is moreover valid whatever $f(t)$ may be." The statistical recording is carried out with a time constant sufficiently large not only in comparison with the length of the longest disturbances but also in comparison with the mean interval separating these. Without making any hypothesis regarding $f(t)$, the equation at the bottom of p. 1030 shows that if the time constant is increased indefinitely, $\Phi(t)$ tends towards $\int f(t)dt$.

The above considerations lead the writer to propose a statistical recording method with multiple time constant, with the use of electro-magnetic or electrometric instruments of such a type that the differential equation of the motion of the moving element admits the special integral $\Phi(t) = e^{-t/\tau}\int e^{t/\tau}f(t)dt$ (where $f(t)$ is the function representing the phenomenon to be recorded) and integrals of the free motion containing, besides the terms Pe^{rt}, one or more terms Me^{st} characterising the form of the disturbances: $-r$ is the inverse of a large time constant τ (principal time constant) and $-s$ is the inverse of a small time constant τ_s (secondary time constant). If $F(t)$ is the couple (or force) acting on the moving element, the necessary and sufficient condition for obtaining the above special integral is found to be that $F(t)$ should be a certain sum of terms in $\Phi(t)$, $f(t)$, and the successive derivatives up to the order $(n - 1)$. If, in addition, the parameters of the moving element are connected with the principal time constant $\tau = 1/\alpha$ by a relation such that $(-\alpha)$ is a root of the characteristic equation, the coefficient of $\Phi(t)$ is zero and $F(t)$ reduces to a sum of terms proportional to $f(t)$ and to its successive derivatives up to the order $(n - 1)$. The elimination of $\Phi(t)$ in the expression for $F(t)$ allows this function to be constituted physically by successive derivations with the help of mutual inductances, resistances, and condensers associated with valves.

1337. New Methods for the Reduction of Interference in Receivers.—G. St. Dallos. (*Funktech. Monatshefte*, May 1941, No. 5, pp. 69–75.)

Continuation of the work dealt with in 2322 of 1939. Comparison of the problem of amplitude-limitation with that of "noiseless" film recording: duo-diode methods based on the steep front of interference: methods depending on the approximately uniform frequency continuum produced by an aperiodic pulse (Landon's R.C.A. patent, with low frequencies reduced and high emphasised, before limiting, and corrected afterwards: Telefunken "two-channel" patent: defects of these methods: the writer's two- or more channel method, and the superiority of duo-diodes as the limiting agents): Gabrilovitch's patent for taking the blocking potential from the higher-frequency part of the a.f. modulation spectrum: discussion of reasons for lack of interference-reducing devices in commercial receivers.

1338. An Improved Interference Suppressor [for Sound or Television: Suppressing Action Unaffected by Variation in Strength of Desired Signals].—R.C.A. Laboratories. (*Electronic Eng:g*, Aug. 1941, Vol. 14, No. 162, p. 362.)

1339. Porcelain Insulator Design [Recent American Developments: Interference-Free Designs: "Prestite," a "Plastic" Porcelain].—R. L. Whitney. (*Electrician*, 13th March 1942, Vol. 128, pp. 222–223.) *See* also 2534 of 1941.

1340. Heater/Cathode Leakage as a Source of Hum [including Operating Conditions to Minimise the Effect].—(*Electronics*, Feb. 1940, Vol. 13, No. 2, pp. 48–49 and 50.)

1341. The Calculation of the Noise Voltage of Wide-Band Amplifiers [with Formulae & Curves].—J. G. Lang. (*Funktech. Monatshefte*, May 1941, No. 5, pp. 65–68.) *Cf.* Borgnis, 694 of March.

1342. Tone Control using a Bridge Circuit.—General Electric (America). (*Electronic Eng:g*, Aug. 1941, Vol. 14, No. 162, p. 369.)

1343. Papers on High Fidelity from the Musician's Viewpoint.—S. W. T. Bartholomew: E. La Prade. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 331: summaries only.) *See* also 698 of March.

1344. Valve Circuits utilising Inductive-Output Currents [for Simple Band-Width Control, Automatic Selectivity Control, etc.].—R.C.A. Laboratories. (*Electronic Eng:g*, July 1941, Vol. 14, No. 161, p. 316.)

1345. Cathode-Ray Tuning Indicators: Increasing the Sensitivity and Extending the Usefulness of the "Magic Eye."—Hay. (*See* 1464.)

1346. Papers on the Testing of Receivers.—Davie: Clack. (*See* 1470/1.)

1347. Proposals for a Uniform Representation of the Test Figures for Broadcast Receivers [to facilitate Comparison of Data from Various Sources: the Measurement of Sensitivity, Selectivity, Automatic Volume Control, Image-Frequency & I.F. Sensitivities, Over-All Frequency Characteristic, Radiation of the Heterodyning Frequency].—R. Moebes. (*T.F.T.*, July 1941, Vol. 30, No. 7, pp. 194–197.)

1348. Tropical Receiver Design [Recommendations based on Experience in India].—J. H. Lemmon. (*Nature*, 14th Feb. 1942, Vol. 149, pp. 191–192: summary only.) *Cf.* Stewart, 91 of January.

1349. The "Eddystone 358": a New Communications Receiver.—(*Electronic Eng:g*, July 1941, Vol. 14, No. 161, pp. 294–297.)

1350. The Status of Service-Men.—H. C. Rylatt. (*Wireless World*, March 1942, Vol. 48, No. 3, pp. 69–70.) From the Hon. Secretary, National Radio Trade Service Association. *See* also p. 65.

AERIALS AND AERIAL SYSTEMS

1351. A Distribution System [with Communal Aerials, for Blocks of Flats, etc.] suitable for All-Wave H.F. Signals, including Television Frequencies.—R.C.A. Laboratories. (*Electronic Eng:g*, June 1941, Vol. 14, No. 160, pp. 268 and 270.)

1352. A Split Horizontal Frame Aerial as Horizontally Polarised All-Round Radiator.—L. E. C. Hughes. (*Electrician*, 27th Feb. 1942, Vol. 128, p. 176.)

VALVES AND THERMIONICS

1353. A MAGNETRON WITH A CONCENTRIC LINE.—Grekhova & others. (*See* 1328.)

1354. THEORY OF THE MAGNETRON [Extension of Work on Whole-Anode Type (107 of January) to Magnetron with Even Number of Anodes].—L. Brillouin. (*Phys. Review*, 1st/15th Jan. 1942, Vol. 61, No. 1/2, p. 103: summary only.)

1355. TRANSIT-TIME PHENOMENA IN ELECTRONIC TUBES: A GRAPHICAL METHOD FOR INVESTIGATION [illustrated by Application to Unbiased Diode (including Result in Conflict with Llewellyn's Statement) & to Diode as Voltmeter].—R. Kompfner. (*Wireless Engineer*, Jan. 1942, Vol. 19, No. 220, pp. 2–7.)

1356. THE GENERATION AND AMPLIFICATION OF MICRO-WAVES: PARTS 1 TO 3—NEGATIVE-GRID VALVES: PART 4—INDUCTIVE-OUTPUT AMPLIFIERS.—C. E. Lockhart. (*Electronic Eng:g*, Aug., Sept., Oct., & Dec. 1941, Vol. 14, Nos. 162/164 & 166.)

1357. THE PENTODE-HEPTODE: A NEW METHOD OF OVERCOMING INPUT LOSS IN H.F. VALVES.—R. L. Freeman: Hazeltine Corporation. (*Electronic Eng:g*, July 1941, Vol. 14, No. 161, pp. 304–305.) Discussion of the Freeman-Hazeltine British Pat. 535 969.

1358. MINIATURE PENTODES [primarily for Western Electric Orthotronic Audiphone: 361A (for RC Amplifier: Gain 37 db): 362A (Normal Output 9 mW)].—(*Bell Lab. Record*, Jan. 1942, Vol. 20, No. 5, p. 126.)

1359. THE AUGETRON AS A FREQUENCY-CHANGER AND I.F. AMPLIFIER.—Vacuum Science Products. (*E. & Television & S-W.W.*, May 1941, Vol. 14, No. 159, p. 235.) For the "Augetron" *see* various 1940 Abstracts.

1360. THE STABILITY OF SECONDARY EMISSION FROM ALKALI-HALIDE CATHODES.—M. M. Vudynski. (*Journ. of Tech. Phys.* [in Russian], No. 11, Vol. 11, 1941, pp. 1066–1071.)

One of the drawbacks of alkali-halide cathodes is the diminution of the secondary emission σ as the electron bombardment proceeds. In the present paper a report is given on experiments with KCl and NaCl emitters in which the effect of temperature, thickness of emitting layer, and primary-current density on the speed with which σ decreases was investigated. Experimental curves are shown and discussed. It has been found that the stability of σ can be increased considerably if the layer is treated with vapours of alkali metals. It has also been found that the σ of both treated and untreated layers increases with the primary-current density.

1361. A NEW METHOD FOR STUDYING THE SECONDARY-ELECTRON EMISSION FROM DIELECTRICS.—Yu. A. Nemilov. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 11, 1941, pp. 854–859.)

One of the difficulties experienced in investigating the secondary emission from thick dielectric layers is that owing to the high transverse resistance the surface does not receive electrons from the part beneath. In the method proposed an incandescent filament is introduced between the electron gun and the layer under investigation (Fig. 1) and an alternating voltage is applied to the layer, with the result that the latter is periodically charged by electrons from the filament. The method was used in an investigation of the secondary emission from mica and KCl, and the results obtained are given.

1362. A NEW DESIGN OF ELECTROLYTIC TROUGH FOR THE PLOTTING OF FIELDS, *and* THE CHOICE OF MATERIALS FOR THE ELECTRODES FOR THE PLOTTING OF FIELDS IN THE ELECTROLYTIC TROUGH.—J. Himpan: R. Theile & J. Himpan. (*Alta Frequenza*, June 1941, Vol. 10, No. 6, pp. 370–371: summaries from *Telefunken-Röhre*, Aug. 1939, No. 16, p. 198 onwards, & June 1940, No. 18, p. 50 onwards.)

The first of these papers was dealt with in 3032 of 1940. The second considers the errors due to chemical reactions between electrodes and electrolyte: these are shown to be quite serious in some cases. A small trough was used, containing two plane parallel electrodes of the material under examination: along the axis of the system the potential should have a linear course, but actually two causes of error were found, potential jumps at the electrode surfaces (probably due to the formation of an oxide insulating layer) and a non-linear course due to an inhomogeneous distribution of the conductivity of the electrolyte. After many experiments, the best results were obtained with iron electrodes in non-distilled water to which small quantities of salts were added to prevent the formation of an oxide skin. With such precautions entirely satisfactory results were obtained in plotting even fields of quite complicated form.

1363. VALVE MODELS IN AIR, CONSISTING OF AN ARRANGEMENT WITH IONS DRIVEN THROUGH FINE-MESHED GRID BY AN ELECTRIFIED POINT AND AN ACCELERATING FIELD.—P. Toulon. (In paper dealt with in 1576, below.)

1364. TECHNIQUE FOR TUBE DATA [Simple Oscilloscope Method of taking Valve Characteristics].—C. C. Street. (*Electronics*, Oct. 1941, Vol. 14, No. 10, pp. 50 and 96..99.)

Differing from usual c.r.o. methods in that it gives the "instantaneous conductance relationship of the same electrode, or between two electrodes so long as the electrodes for which the characteristic is being determined can be connected so as to have a common junction." It is based on the fact that if $y = Af(t)$ and $x = Bf(t)$, then $y = Ax/B$, and the time function disappears. A time-varying signal voltage is applied to one valve-electrode and one set of oscilloscope plates, and the electrode current (converted into a voltage drop) to the remaining pair of plates: the spot will then trace the electrode conductance or transconductance, whatever the form of the applied voltage.

1365. SIMPLE METHODS FOR CHECKING R.F. DISTORTION OR CROSS-MODULATION OF PENTODE AMPLIFIER TUBES [by Accurate Transconductance Bridge with Sharply-Tuned Balance Indicator].—E. W. Herold. (*Electronics*, April 1940, Vol. 13, No. 4, pp. 82..88.)

In the first method the a.c. signal supplied by the bridge to the grid is increased from a small value to one of several volts: in the second, it is kept at its low value but an additional signal, whose fundamental frequency and harmonics do not operate the balance indicator, is superposed. Neither method measures the plate-circuit distortion, but this form of distortion is not usually important in screen-grid pentodes. *Cf.* Koch & Torelli, 1366, below.

1366. The Distortions of Amplifying Valves at Radio-Frequencies, and Methods for Their Determination.—R. Koch & S. Torelli. (*Alta Frequenza*, May & June 1941, Vol. 10, Nos. 5 & 6, pp. 259–281 & 337–357.)

For a summary in English *see* end of either journal. In Part II the methods of measurement briefly described are the method based on direct measurement (rarely used because of its difficulty), the "third-harmonic" method, the amplification-variation method, and the continuous-current method (lengthy, and applicable only when the static and dynamic characteristics are identical). The new method proposed, "presenting notable advantages compared with the previous ones," is based on the bridge-measurement of the transconductance (Figs. 10 & 11): in its exact form it is substantially the same as that developed independently by Herold for measuring the r.f. distortion of amplifier pentodes (1365, above) but certain differences are discussed in a footnote on pp. 351/2. A simplified variation for approximate results is described. One appendix gives a mathematical treatment of the general equation for the anode-current/grid-voltage characteristic, expressed as an exponential series, for the various cases considered in sections 3/6, and obtains for each case the formula to be used in calculating the distortion-coefficient. A second appendix shows how Fig. 6 (interpretation of the anode-current/grid-voltage characteristic of a pentode with variable transconductance as a sum of several straight-line components) can give the values of the constants $A_1, A_2 \ldots$ and $a_1, a_2 \ldots$ of the above exponential series.

1367. The Influence of the Contact Potential on the Initial Current of the High-Vacuum Triode and on the Ignition Characteristic of the Hot-Cathode Ionic Converter.—H. Adam. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 22, 1941, pp. 251–255.)

Gysae & Wagener (154 of 1939) found the initial current of the diode to be independent of the cathode work function, and deduced from this result and its theoretical implications that the same would apply to triodes. The present writer, however, shows that this deduction is incorrect.

Author's summary:—"The initial current to the anode of a high-vacuum triode, when the contact potentials of the individual electrodes are taken into account, is dependent—unlike the initial current of a diode—on the [Richardson] work function ϕ_K of the cathode. This result depends on the fact that even when the contact potentials are neglected the initial potential of the triode lies in the space between the electrodes and is determined by three positive coefficients λ, μ, and ν depending only on the geometry, and individually smaller than unity, being related by the equation $\lambda + \mu + \nu = 1$. In contrast to this, the initial potential in the diode coincides with the anode potential U_a and is independent of the influence ν of the cathode, being determined by one single coefficient, $\mu = 1$, independent of the geometry.

"The application of this result to the ignition characteristic of the gas-filled hot-cathode converter shows that the characteristic is dependent on the work functions of the three electrodes, and thus implicitly on the contact potentials, the relation being of the form $\Delta = \phi_G + D \, . \, \phi_A + (\nu/\lambda) \, \phi_K$. Thus the ignition characteristic is influenced by the work functions of all three electrodes." It is mentioned that λ (influence of grid on the potential minimum) and ν may be of the same order of magnitude: in a commercial triode the values were $\lambda = 0.23$, $\mu = 0.005$, $\nu = 0.76_5$ ("durchgriff" 2.1%). *Cf.* O'Neill, 1070 of April.

1368. Excitation of the Anode Effect [Experimental Investigation, including Empirical Formula for Relation between Total Charge collected by Grid & Total Charge trapped on Grid: Effect of Grid Temperature: etc.].—P. L. Copeland & G. G. Carne. (*Phys. Review*, 1st/15th Jan. 1942, Vol. 61, No. 1/2, p. 103: summary only.) For previous work *see* 3034 of 1940.

1369. Heater/Cathode Leakage as a Source of Hum [including Operating Conditions to Minimise the Effect].—(*Electronics*, Feb. 1940, Vol. 13, No. 2, pp. 48–49 and 50.)

1370. Novel Seamed Indirectly-Heated Cathode Sleeve.—R.C.A. Laboratories. (*Electronic Eng:g*, June 1941, Vol. 14, No. 160, pp. 283 and 288.)

1371. Thermionic Properties of the Iron Group.—Wahlin. (*See* 1534.)

DIRECTIONAL WIRELESS

1372. Blind Landing of Airplanes [Transmitter of 6 W Output at 375 kc/s producing Induction Field in Immediate Neighbourhood of Aerial, Little Radiation: Continuous Indication, on Instrument Board, of Angle between Direction of Transmitter & Horizontal, accurate within 1/6th Degree at Half a Mile].—W. L. Clemmer. (*Science*, 30th Jan. 1942, Vol. 95, Supp. pp. 6–7.) U.S. Patent 2 269 437.

1373. Method for the Transmission and Reception of High-Frequency Pulses [for Pulse Direction-Finding].—P. Kotowski & others. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, p. 150.)

D.R.P. 705 190. Alternate wide and narrow pulses with the same fundamental frequency, or periodic groups of narrow pulses, are sent out, and the band width of the receiver, during the tuning-in to the transmitter or during the synchronising of the indicating c.r. oscillograph, is made so narrow that it only just suffices for the reception of the wide pulse, or group of pulses, so that interference is largely eliminated. After completion of the tuning the band width is increased enough to allow the reception of the narrow pulses also; the interference will then be increased similarly, but the pulses will stand out from them better. *See* also 1402 of 1938.

ACOUSTICS AND AUDIO-FREQUENCIES

1374. AN APPEAL TO SCIENCE FOR SPECIALISED HEARING AIDS OF TRUE SELECTIVE AMPLIFICATION [and particularly the Urgent Need for Means to reach the Residuum of Hearing of the Ever-Increasing Number of Very Young Deaf], *and* HEARING AIDS: UNIFORM AND SELECTIVE: MONAURAL, DIOTIC, AND BINAURAL: AIR AND BONE CONDUCTION.—M. E. Winston: N. A. Watson. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 335: p. 335: summaries only.)

1375. A METHOD FOR MEASURING THE PERCENTAGE OF CAPACITY FOR HEARING SPEECH, *and* RELATION OF AUDIOGRAM MEASUREMENTS TO HEARING-CHARACTERISTICS BASED ON COMMERCIAL EXPERIENCE.—E. P. Fowler: F. W. Kranz & C. E. Rudiger. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 335: p. 335: summaries only.)

1376. A BASIS FOR THE PREDICTION OF PERFORMANCE OF DEAF AIDS, *and* SOME CONSIDERATIONS RELATIVE TO THE CALIBRATION OF BONE-CONDUCTION RECEIVERS FOR AUDIOMETERS.—C. M. R. Balbi: L. A. Watson. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 335–336: p. 336: summaries only.)

1377. METHODS FOR MEASURING THE PERFORMANCE OF HEARING AIDS.—F. F. Romanow. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 294–304.) Dealt with in 743 of March.

1378. CORRECTION TO "PHASE DISTORTION IN ELECTROACOUSTIC SYSTEMS."—F. M. Wiener. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 317.) *See* 726 of March.

1379. POLARISATION OF ROCHELLE-SALT CRYSTALS AT LOW VOLTAGES.—R. D. Shulvas-Sorokina. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 11, 1941, pp. 947–958.)

The investigation is limited in the main to the initial portion I (Fig. 1) of the polarisation curve $P_1 = f(E_1)$ determined by equation 1. Electric fields of intensities up to 12 v/cm and mechanical pressures up to 10 gm/cm^2 were applied to the crystals at frequencies from 3 to 3000 c/s. It appears that in both cases polarisation varies non-linearly with load and the curves are of the saturation type. It is only when the above limits are exceeded that a rapid increase in polarisation is observed. A number of experimental curves are shown and a theoretical interpretation of the results obtained is given.

1380. HIGH - FIDELITY SOUND REPRODUCTION [Loudspeaker as Limiting Mechanism in the System: Comparison of Various Types], *and* LOUDSPEAKERS.—F. V. Hunt & J. A. Pierce: A. DiMarzo. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, p. 361: p. 361: summaries only.)

1381. PAPERS ON HIGH FIDELITY FROM THE MUSICIAN'S VIEWPOINT.—S. W. T. Bartholomew: E. La Prade. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 331: summaries only.) *See* also 698 of March.

1382. SCALE DISTORTION [More Correspondence on Evans's Paper].—A. S. Evans. (*Wireless World*, March 1942, Vol. 48, No. 3, p. 71.) *See* 737 of March.

1383. THE NON-LINEAR-DISTORTION FACTOR OF THE OUTPUT TRANSFORMER [as a Function of the Magnetic Induction: Effect of introducing an Air Gap: etc.].—P. Miram. (*Funktech. Monatshefte*, March 1941, No. 3, pp. 33–38.)

1384. THE DESIGN CALCULATIONS OF A PUSH-PULL POWER AMPLIFIER WITH PHASE-REVERSING STAGE [for Frequency Range 50 c/s to 50 kc/s].—E. Bleicher. (*Funktech. Monatshefte*, March 1941, No. 3, pp. 39–47.)

1385. REMOTE AMPLIFIER [for Broadcasting] WITH SELECTIVE PRE-EMPHASIS.—N. Wilcox. (*Electronics*, Oct. 1941, Vol. 14, No. 10, pp. 68..72.)

1386. ON THE DEVELOPMENT OF UNIT FUNDAMENTAL COMPONENTS FOR CARRIER-FREQUENCY MULTIPLE-UTILISATION OF TELEPHONE LINES [including Wire-Band Cables, the MG System for Overhead Lines, etc.].—D. Thierbach & F. Vogel. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 141–145.)

1387. PRACTICAL STUDIO SPEECH-INPUT SYSTEMS AND SYSTEM OBJECTIVES FOR RADIO BROADCAST SERVICE.—H. F. Scarr. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, p. 359: summary only.)

1388. CONTEMPORARY PROBLEMS IN TELEVISION SOUND [New Problems in Sound Pick-Up and Operation].—C. L. Townsend. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 334: summary only.)

1389. THE MIRROPHONE: COMPACT MAGNETIC RECORDER AND PLAY-BACK UNIT.—Western Electric. (*Wireless World*, Feb. 1942, Vol. 48, No. 2, pp. 42–43.) *See* also 2153 of 1941.

1390. RESEARCH BEATS THE PRIORITIES [Account of Development of Glass-Base Recording Discs to replace Aluminium].—C. J. LeBel. (*Electronics*, Oct. 1941, Vol. 14, No. 10, pp. 27–30 and 78..83.)

Instead of being a mere substitute, the glass-base disc is an improvement in several ways. One curious fact is the report from recording engineers that the new discs "sound better, clearer," although distortion and frequency-response tests up to 7.5 kc/s detect no difference (this recalls the well-known experience that a cutter may have a marvellous characteristic and yet may give such bad records as to be unusable). It is suggested that the present result is due to the better internal damping of vitreous material, which may prevent a blurring by waves propagating in the base during the cutting, and reflected back.

1391. THE RECORDING LABORATORY IN THE LIBRARY OF CONGRESS.—J. B. Wiesner. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 288–293.)

1392. HIGH-FIDELITY LATERAL RECORDING AND REPRODUCTION.—B. F. Fredendall. (*Proc. I.R.E.*, Sept. 1941, Vol. 29, No. 9, p. 526: summary only.)

1393. PROPERTIES OF THE DULLED LACQUER-CUTTING STYLUS [for "Instantaneous" (Nitrocellulose-Lacquer) Recordings: the Addition of a Burnishing Surface to polish Walls after Front-Edge has cut Them: Experimental Investigation of Conditions for Best Results].—C. J. LeBel. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 265–273.)

1394. A PHONOGRAPH PICK-UP OF THE MOVING-COIL TYPE [Reduced Mass, Higher Stylus-Compliance, "Unique Floating-Head Arm Design," etc.]—T. Lindenberg, Jr. (*Journ Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 330: summary only.)

1395. TRACING-DISTORTION IN THE REPRODUCTION OF CONSTANT AMPLITUDE RECORDINGS [and Comparison with Constant-Velocity Recordings: Improvement in Peak Distortion in Mid-Frequency Range: Need for Smaller Reproducing Stylus for High-Quality, High-Fidelity Reproduction: etc.]—L. W. Sepmeyer. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 276–280.)

1396. A LARGE-RADIUS STYLUS FOR THE REPRODUCTION OF LATERAL-CUT PHONOGRAPH RECORDS [Unexpected Benefits from Point touching only Upper Side-Walls of Groove].—J. D. Reid. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 274–275: p. 330.) From the Crosley Corporation: *cf.* 735 of March, and *see* also p. 330, where it is mentioned that this stylus is embodied in the special needle described by Goldsmith, 1397, below.

1397. A NOISE AND WEAR REDUCING PHONOGRAPH REPRODUCER WITH CONTROLLED RESPONSE [Design based on the Five General Criticisms, by Users, of Previous Reproducers: Torque-Type Rochelle-Salt Element combined with Needle consisting of Shaft riveted to Flexible-Spring Stylus-Arm carrying Sapphire Stylus & Protecting Bumper].—F. H. Goldsmith. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 281–283.) *See* also 1396, above.

1398. THE CORRELATION BETWEEN ELASTIC DEFORMATION AND VERTICAL FORCES [in connection with the "Pinch Effect"] IN LATERAL RECORDING.—S. J. Begun & T. E. Lynch. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 284–287.) "No special practical necessity" for the recent idea of providing an element, flexible to vertical motion and generating no voltages due to vertical excitation, between stylus tip and generating unit.

1399. THE GENERAL ENGINEERING ASPECTS IN REGARD TO THE PRODUCTION OF "FANTASIA."—M. C. Batsel & others. (*Proc. I.R.E.*, Aug. 1941, Vol. 29, No. 8, p. 472: summary of series of papers.)

1400. ACOUSTIC EXPERIMENTS WITH AN ELECTRONIC SWITCH [Possibilities in Secret Communication, Stereophonic Effects, etc.]—Wolf. (*See* 1575.)

1401. APPARATUS FOR THE DIRECT MEASUREMENT OF FORCE/DISPLACEMENT CHARACTERISTICS OF MECHANICAL SYSTEMS AT AUDIO-FREQUENCIES [Crystal (for Dynamic Force) & Parallel-Plate Condenser (for Displacement) working with C. R. Oscilloscope: for Study of Microphones, Sliding of Metal Contacts, etc.]—J. R. Haynes. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 332: summary only.)

1402. AUTOMATIC CURVE TRACER [for Observation or Photographic Recording of Frequency-Response Characteristics of Audio-Amplifiers].—R.C.A. (*Electronics*, Feb. 1940, Vol. 13, No. 2, p. 65.)

1403. AN ANALYSER FOR SUB-AUDIBLE FREQUENCIES [General Radio Type 762-A Vibration Analyser].—Scott. (*See* 1587.)

1404. A LOGARITHMIC RECORDING VOLTMETER.—S. Vaccarino. (*Alta Frequenza*, May 1941, Vol. 10, No. 5, pp. 312–320.)

Based on the dry-plate-rectifier voltmeter circuit proposed by Akazawa & Uno and developed further by Manfrino: *see* 2747 of 1941. Using Westinghouse Type M10 copper-oxide rectifiers, in two exactly similar circuits combined with suitable amplifying and mains-supply arrangements, the writer obtains a differential voltmeter with logarithmic recording, which he applies to the registration of loudspeaker, telephone-receiver, and piezo-electric-microphone characteristics (Figs. 9–11).

1405. THE DECIBEL: DOES IT NEED CLARIFICATION?—Bacon. (*See* 1473.)

1406. FROM "BARKHAUSEN-PHON" TO THE DIN SOUND-LEVEL UNIT [Historical Survey].—W. Janovsky. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 118–120.)

1407. THE DIN NOISE-METER [including the Calibration Method using Falling Steel Balls].—Siemens & Halske. (*Helios* [Leipzig], 12th Oct. 1941, Vol. 47, No. 41, pp. 1273–1279: in French & German.)

1408. OPTICAL TESTS FOR DETERMINING THE DIRECTIONAL DISTRIBUTION OF SOUND IN A ROOM.—R. Vermeulen. (*Alta Frequenza*, May 1941, Vol. 10, No. 5, pp. 297–298: summary, from *Rev. tech. Philips*, Nov. 1940, Vol. 5, No. 11, p. 325 onwards.)

Further development of the work dealt with in 3843 of 1936. The previous tests only gave the acoustic intensity at a given point, not the direction of the incident sound: this characteristic is very important in broadcasting, in connection with the siting of the microphone. The present paper describes the use of a small portable "camera obscura" of cubical shape, with two apertures: the photographs obtained (on a double-sided central plate), when stuck on the outside of a cube of equal dimensions, give a picture of the directional distribution at the point in question.

1409. POLYCYLINDRICAL DIFFUSERS IN ROOM ACOUSTIC DESIGN, *and* PERFORMANCE OF BROADCAST STUDIOS DESIGNED WITH CONVEX SURFACES OF PLYWOOD.—J. E. Volkmann: C. P. Boner. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 234–243: pp. 244–247.)

1410. ACOUSTIC IMPEDANCE OF POROUS MATERIALS [including Derivation of Equations giving Specific Normal Impedance ("Surface Impedance") for Normal & Arbitrary Angles of Incidence and for Rigid Wall & Cavity Backing: Experimental Confirmation: Suggestion that Gaseous Expansions are Isothermal, with Consequence that Air Cavity becomes *Less* Stiff to Dynamic Compression when Very Porous Finely Divided Material is Added: Experimental Checking: Points requiring Further Investigation: etc.].—L. L. Beranek. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 248–260.)

1411. AN ACOUSTIC TUBE FOR MEASURING THE SOUND ABSORPTION COEFFICIENTS OF SMALL SAMPLES [by Method requiring Measurement only of Maximum, not Minimum, Pressures].—D. P. Loye & R. L. Morgan. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 261–264.)

1412. EXPERIMENTAL RESEARCHES ON THE THEORY OF THE PROPAGATION OF SOUND IN ABSORBENT TUBES [Results in Agreement with Cremer's Theory].—W. Lippert. (*Alta Frequenza*, Oct. 1941, Vol. 10, No. 10, p. 622: summary, from *Akust. Zeitschr.*, Jan. 1941, Vol. 6, p. 46 onwards.)

1413. ACOUSTIC FILTRATION BY MEMBRANES [Equally Spaced Sequence of Similar Membranes converts Conduit into Acoustic Filter: Theory, with Experimental Agreement good up to 5000 c/s: Central Circular Hole converts from High-Pass to Low-Pass].—L. W. Labaw. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 333: summary only.) For previous work on filtration *see* 3072 of 1941.

1414. AN INVESTIGATION OF THE IMPEDANCE OF FRICTION LAYERS USED IN SOUND-ABSORBING SYSTEMS.—S. N. Rzhevkin & S. T. Terosipyants. (*Journ. of Tech. Phys.* [in Russian], No. 1/2, Vol. 11, 1941, pp. 149–159.)

Formulae are derived for determining the acoustic impedance of closely perforated or meshed screens, and suggestions made for reducing the reactive component of the impedance. Experiments were carried out to check the theoretical conclusions.

1415. OBLIQUE INCIDENCE OF SOUND ON A DOUBLE RESONANCE SYSTEM.—K. A. Vital. (*Journ. of Tech. Phys.* [in Russian], No. 11, Vol. 11, 1941, pp. 1029–1034.)

A resonance sound absorber utilising a single perforated sheet can give high absorption ($\alpha \geqslant 0.9$) within a limited frequency range of one octave only. Nesterov has shown (2629 of 1940 and 3389 of 1941) that if two parallel perforated sheets are used the frequency range can be extended beyond two octaves. His investigation, however, was confined to perpendicular incidence of the sound waves on the absorber. The case of oblique incidence (Fig. 1) was discussed by the author in a previous paper (*ibid.*, Vol. 10, 1940, p. 980 onwards), and in the present paper formulae are derived for calculating the input impedance and α of the absorber.

1416. PRACTICAL STUDIO CONSTRUCTION [Elimination of Undesired Sound: Control of Desired Sound].—H. J. Sabine. (*Proc. I.R.E.*, June 1941, Vol. 29, No. 6, pp. 360–361: summary only.)

1417. WHAT CAN THE HOSPITAL DO ABOUT NOISE? *and* INDUSTRIAL NOISES AND INDUSTRIAL DEAFNESS.—C. F. Neergaard: W. A. Rosenblith. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 217–219: pp. 220–225.)

1418. THE EFFECT OF HIGH-INTENSITY NOISE LEVELS ON SURROUNDING AREAS [Investigation of Atmospheric Radiation Losses over Wide Band of Frequencies, in connection with Nuisance of Noise due to Aircraft-Engine Testing].—J. S. Parkinson. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 332: summary only.)

1419. DISCUSSION ON "THE LIMITATION OF TRANSFORMER NOISE."—B. G. Churcher & A. J. King. (*Journ. I.E.E.*, June 1941, Vol. 88, Part II, No. 3, pp. 241–244.) Continued from 799 of 1941.

1420. ELECTRONIC MUSICAL INSTRUMENTS [including the Emereef Organ].—P. A. Kransz. (*Proc. I.R.E.*, Sept. 1941, Vol. 29, No. 9, p. 526: summary only.)

1421. ARTIFICIAL REVERBERATION FOR ELECTRONIC ORGAN MUSIC [Reverberation Device with Delay caused by Coiled Springs transferring Vibrations to Rochelle-Salt Pick-Ups].—L. Hammond. (*Electronics*, March 1940, Vol. 13, No. 3, pp. 42 and 44.)

1422. Harmonic Relations in the Partials of Organ Pipes and of Vibrating Strings, *and* The Initial Transients of Organ Pipes.—A. W. Nolle & C. P. Boner. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 145–148: pp. 149–155.) *See* also issue for Jan. 1942, Vol. 13, No. 3, p. 33.

1423. The Comma in Music: II [Perronet Thompson & His "Enharmonic Organ"] and III [Mercator's Proposal of Octave divided into 53 Equal Parts].—A. F. Dufton. (*Phil. Mag.*, Feb. 1942, Vol. 33, No. 217, pp. 151–154: pp. 155–156.)

The writer ends by apologising for his failure (in Part I, 3395 of 1941) to collect, in the words of an 1807 quotation, "that previous knowledge of all that has been already done with the same view, which . . . he ought to acquire . . . before he calls on the world at large to participate in his improvements and discoveries"

1424. Electrical Devices in the Teaching of Music [particularly the "Staff Keyboard Correlator" for Sight Singing, etc.]—W. Willmott. (*Electrician*, 26th Dec. 1941, Vol. 127, p. 358: summary only.)

1425. The Perception of Note Pitch.— J. F. Schouten. (*Alta Frequenza*, June 1941, Vol. 10, No. 6, pp. 369–370: summary, from *Rev. tech. Philips*, Oct. 1940, Vol. 5, p. 290 onwards.)

The fact that a sound containing many harmonics is in general perceived as a sound with the pitch of the fundamental, even when that fundamental may be very weak or even entirely absent, has hitherto been explained as a result of the non-linearity of the ear, by which each pair of successive harmonics gives rise to a difference frequency equal to that of the fundamental. The writer's experiments contradict this explanation, and a new theory, based on the notion of a low-pitch "residuum," is formulated. This theory involves a particular interaction between the higher harmonics, due to the limited resolving power of the ear: such an action is illustrated by a model of the basilar membrane.

1426. Sound Reception in Beast and Man [Survey].—H. Autrum. (*Naturwiss.*, 30th Jan. 1942, Vol. 30, No. 5/6, pp. 69–85.)

1427. The Stapedius Muscle in Relation to the Conduction of Sound to the Inner Ear [Fundamental Function is to Protect against Over-Stimulation: Effects on Distortion-Patterns: etc.].—E. G. Wever & C. W. Bray. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 334: summary only.)

1428. The Effect of Middle-Ear Pressure upon Distortion [Overtones, Combination Tones, & Interference].—E. G. Wever & others. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 182–187.)

1429. A Cinematographic Study of the Conduction of Sound in the Human Ear.—H. G. Kobrak. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 179–181.)

1430. The Velocity of Sound in Methyl Methacrylate Polymer [Lucite].—L. R. Weber & F. P. Goeder. (*Phys. Review*, 1st/15th Jan. 1942, Vol. 61, No. 1/2, pp. 94–95.)

1431. Temperature Variation of Sound Velocity in Liquids [Formula derived by Combination of Andrade's Viscosity Relations & Rao's Velocity/Intermolecular-Distance Relation: Confirmation for Water and Other Liquids].—G. Suryan. (*Current Science* [Bangalore], Nov. 1941, Vol. 10, No. 11, p. 489.)

1432. The Velocity of Sound in Air [Rigorous Equation set up & employed to calculate Velocity in Dry Air from Beattie-Bridgeman Equation, Spectroscopic Data, etc: Comparison with Reported Experimental Values: the Writers' Measurements].—H. C. Hardy & others. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 226–233.)

1433. Steady Circulations in the Kundt's Tube [Derivation of Equations for Radial & Axial Components of "Wind" Velocity: Expression for Maximum Velocity confirmed by Smoke Test].—K. Schuster & W. Matz. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 320: summary, from *Akust. Zeitschr.*, Vol. 5, 1940, p. 349 onwards.)

1434. Studies on the Velocity of Propagation of Supersonic Waves [particularly in Electrolyte Solutions & Binary Mixtures].—A. Giacomini. (*Alta Frequenza*, June 1941, Vol. 10, No. 6, p. 381: short summary, from *La Ricerca Scientifica* of March 1941.)

PHOTOTELEGRAPHY AND TELEVISION

1435. Department of Agriculture uses Television to Teach Housewives how to Buy Effectively.—(*Sci. News Letter*, 27th Dec. 1941, Vol. 40, No. 26, p. 402: paragraph only.)

1436. Contemporary Problems in Television Sound [New Problems in Sound Pick-Up and Operation].—C. L. Townsend. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 334: summary only.)

1437. Television Experiments on Coaxial Cable [Comparison of Results with Experimental Circuit of 800 Miles and with Direct Connection].—(*Bell Lab. Record*, June 1941, Vol. 19, No. 10, p. 315: paragraph only.) The 800 miles circuit was obtained by connecting the four units of the Stevens-Point/Minneapolis cable (1438, below) in series.

1438. Stevens Point and Minneapolis linked by Coaxial System [based on Experience gained with New-York/Philadelphia Experimental Cable: Four Coaxial Units in Sheath: Laying Technique: Experience in Lightning Seasons, etc.].—K. C. Black. (*Bell Lab. Record*, Jan. 1942, Vol. 20, No. 5, pp. 127–132.) *See* also 1437, above. The real purpose of this cable is for L-1 carrier working.

1439. Storage in Television Reception [Some Scophony Developments: Supersonic (Liquid Cell) Light Control & Its Advantages over Kerr Cells, etc: Mechanical Scanning (20-Mirror Polygon, 47250 r.p.m. for 525 Lines): Optical ("Split Focus") System: Combination of Supersonic Light Control with Multi-Beam Electronic Scanning: the Skiatron (Crystalline Screen)].—A. H. Rosenthal. (*Electronics*, Oct. 1941, Vol. 14, No. 10, pp. 46–49 and 115, 116.)

1440. Automatic Background Control of Television Pictures [Improved Method].—General Electric (America). (*Electronic Eng:g*, Aug. 1941, Vol. 14, No. 162, p. 364.) For the original method *see* 3946 of 1940.

1441. An Improved Interference Suppressor [for Sound or Television].—R.C.A. Laboratories. (*See* 1338.)

1442. A New Equivalent Circuit for the Calculation of Transient Processes.—J. Gensel. (*T.F.T.*, May 1941, Vol. 30, No. 5, pp. 127–131.)

The treatment of such processes by strict mathematical methods is often very complicated even when the process itself is comparatively simple and no particular accuracy is required. In an attempt to obtain a useful approximate method, Strecker obtained by Fourier analysis the important result that a given circuit can be replaced by an equivalent circuit made up of distortionless lines (2460 of 1941 and back ref.), and Feldtkeller has applied this technique to a resonant circuit connected between two amplifier valves, and to more general cases (3417 of 1941). The present writer, working on the same lines of thought, develops a new equivalent circuit very simple in use and giving very good results.

Author's summary:—"With the help of the known behaviour of distortionless lines a transmission link is defined which is given the name 'line harp' and which displays a trapezoidal building-up process [Fig. 3: amplitude increases linearly from zero during the building-up time T to a stationary value Z and then remains constant: it is the limiting form of the "step" characteristic of Fig. 4, with height and width of steps Z/n and T/n respectively, obtained when n tends to infinity. Such a "stepped" amplitude rise is given (for $\Omega = 0$) by the circuit of Fig. 5 consisting of n distortionless lines of characteristic impedance Z/n and transmission times $\nu \, . \, T/n$ (where $\nu = 1, 2 \ldots n$) which are represented by their lengths, so that when n is very large and the trapezoidal shape of the building-up curve is obtained, the diagram gives some idea of a harp]. With such 'harps' an equivalent diagram of the resonant circuit is described and used for the calculation of the building-up process for the case $\Omega = 1$. The procedure gives the true relations with little expenditure of calculation or drawing. The application of the 'line harp' to other transient problems will be dealt with in a later paper."

1443. The Design of Wide-Band Video-Frequency Amplifiers: Part I—High Frequency Correction by Series Inductance.—C. E. Lockhart. (*Electronic Eng:g*, June 1941, Vol. 14, No. 160, pp. 258–261 and opposite p. 267.) *See* also 1325, above.

1444. Film Scanner for testing Television-Transmission [in Graybar-Varick Laboratories: used in Studies of 3 Mc/s New-York/Philadelphia Channel].—W. A. Knoop. (*Bell Lab. Record*, June 1941, Vol. 19, No. 10, pp. 298–301.) *Cf.* Jensen, 3409 of 1941.

1445. The Formula of the Selenium Barrier-Layer Photocell [View of Action different from That given in Data-Book of Photronic Cell leads to Different Formula, verified by Tests on Various Types: Theoretical Justification].—R. A. Houstoun. (*Phil. Mag.*, March 1942, Vol. 33, No. 218, pp. 226–237.) For previous work *see* 3433 of 1941.

MEASUREMENTS AND STANDARDS

1446. Ammeter for High Frequencies [Double-Refraction Principle].—H. Straubel. (*Hochf:tech. u. Elek:akus.*, Dec. 1941, Vol. 58, No. 6, p. 183.) D.R.P. 705 376: *cf.* 1117 of April.

1447. Frequency-Deviation Measurement of Frequency-Modulated Transmitters [by noting the *Constant-Amplitude* Modulating Frequencies for which the Carrier disappears].—Holland & Giacoletto. (*See* 1329.)

1448. A Convenient Mechanical Adjustment for an Ultra-Short-Wave Resonant-Line Oscillator [keeping Anode & Grid Leads to Minimum Length: Use of Corrugated Metal Bellows as Fine Adjustment: etc.].—R.C.A. Laboratories. (*Electronic Eng:g*, June 1941, Vol. 14, No. 160, p. 248.)

1449. Direct-Reading Wavemeter.—H. Straubel. (*Hochf:tech. u. Elek:akus.*, Dec. 1941, Vol. 58, No. 6, p. 183.)

D.R.P. 705 377. The natural frequency of a resonance circuit is displaced over a definite range by a variable condenser rotated at (say) 6000 r.p.m: from this circuit rectified signal pulses of uniform strength are taken (through a current limiter) to an amplifier valve whose anode circuit contains an indicating instrument. The anode or grid bias of this valve is varied synchronously with the condenser rotation, *e.g.* at 50 c/s, so that when, for example, the condenser is at its maximum (longest wave), the anode circuit voltage is at its highest, and a signal effective for this condenser value will produce the fullest deflection on the wavelength-calibrated scale.

1450. Equipment for Frequency Measurement at the Galileo Ferraris Institute [and the Relative-Error Curves of the Primary Frequency Standard, from 1938 to 1941].—A. Bressi. (*Alta Frequenza*, Oct. 1941, Vol. 10, No. 10, pp. 631–635.) These errors are both positive and negative; the maximum positive errors occur at about the same period of each year.

1451. An Investigation of Piezo-Quartz-Plate Oscillations by the Interference Method.—M. L. Kotlyarevski & E. Ya. Pumper. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 11, 1941, pp. 843–853.)

The reflection of light from the polished surface of a crystal (Fig. 1) was used in this investigation for obtaining light-interference patterns. The apparatus is described and photographs are shown of a number of interference patterns. The amplitudes of the oscillations were measured and the frequency spectra of oscillating crystals studied. The effect of the heterogeneity of crystals on the oscillations was investigated as well as the effects of mechanical pressure of the crystal holders, temperature, and non-uniformity of the field applied to the crystal. One of the conclusions reached is that the oscillations of the opposite faces of a crystal are antisymmetrical, *i.e.* the oscillations of the lower face form an inverse image of those of the upper face.

1452. Polarisation of Rochelle-Salt Crystals at Low Voltages.—Shulvas-Sorokina. (*See* 1379.)

1453. An Analysis of the Operation of Two Coupled Relaxation Oscillators.—A. S. Bremzen & I. S. Faynberg. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 11, 1941, pp. 959–971.)

The operation of a system comprising two resistance-coupled multivibrators (Fig. 1) is considered. Each multivibrator employs two valves, the first of which is used for phase shifting and linear amplification of the voltage fed to the grid of the second valve. Non-linear differential equations of the first order (1) determining the operation of the system are written down, and using these equations phase images of the system on the phase plane are derived for different operating conditions. An analysis of these images is given and the trajectory of the process is determined. Relationships are established for calculating the amplitude of oscillations and the synchronised frequency of the two oscillators. Several particular cases are also discussed. Of these the most interesting is the one in which steady oscillations appear in the system although each oscillator, if taken separately, does not oscillate. The theoretical conclusions reached have been verified experimentally, and a number of oscillograms are shown.

1454. Wide-Utility Crystal Frequency Standard [Hallicrafters Type HT-7, with Special Features].—(*Electronics*, March 1940, Vol. 13, No. 3, p. 78.) *See* also *Electronic Eng:g*, Aug. 1941, Vol. 14, No. 162, p. 366. The frequency range is from 0.54 to 43.5 Mc/s.

1455. Direct-Reading Interpolation Oscillator [Combined Instrument having 100 kc/s Quartz Bar & Multivibrators giving Strong Outputs at every 100, 50, & 10 kc/s Interval, and Interpolation Oscillator giving Precision Readings between the 10 kc/s Points: for Received-Signal Frequency Measurement].—D. R. Tibbetts. (*Electronics*,. Oct. 1941, Vol. 14, No. 10, pp. 35–37.)

1456. A New Frequency Generator: the Muirhead-Wigan Decade Oscillator [with Four Direct-Reading Decade Dials covering Range 1 c/s to 100 kc/s].—(*Electronic Eng:g*, June 1941, Vol. 14, No. 160, pp. 246–248.)

1457. Recent Improvements in Air-Cored Inductances [with Thermal Compensation, for Standards & Substandards, etc: Difference between Stability of Effective Value & of True Value: Humidity Component of Instability & Its Elimination: a New Frequency-Compensated Standard: etc.].—W. H. F. Griffiths. (*Wireless Engineer*, Jan. & Feb. 1942, Vol. 19, Nos. 220 & 221, pp. 8–19 & 56–63.)

1458. Mutual Inductance: a Simple Method of Calculation for Single-Layer Coils on the Same Former [using Nagaoka's Formulae & Figures for Self-Inductances].—T. H. Turney. (*Wireless World*, March 1942, Vol. 48, No. 3, pp. 72–73.)

1459. Apparatus for the Measurement of Impedances at Radio Frequencies [particularly for Wide-Band Cables].—G. Zin. (*Alta Frequenza*, June 1941, Vol. 10, No. 6, pp. 323–336.)

For a summary in English *see* opposite p. 384. The substitution method here developed is based on two principal ideas: of replacing the usual reading of the voltage at the terminals of the measuring circuit by the reading of the ratio between the measuring-circuit voltage and that of the oscillator, since this ratio is independent of generator-fluctuations: and of obtaining this ratio not from separate voltmeters but by way of the determination of the ratio of two resistances carrying d.c., by reading the scale of a d.c. potentiometer. This d.c. is obtained from two 6H6 rectifier valves, one applied to the measuring circuit and the other to the generator. The arrangement may be considered as a kind of bridge circuit in which two sides carry h.f. current and the other two d.c: thus the accuracy of the method is high because the r.f. measurement is converted into a d.c. measurement, with its greater precision. It has given good results on cables, up to 10 Mc/s, though the usual range is from 1 Mc/s to 4–5 Mc/s. In a slightly modified form (Fig. 8) it was used for the measurement of dielectric loss (1454 of 1941).

1460. An Improved Capacitance Bridge for Precision Measurements ["No. 12" Bridge, with New Features in Design leading to New Order of Accuracy combined with Ease & Speed of Operation].—W. D. Voelker. (*Bell Lab. Record*, Jan. 1942, Vol. 20, No. 5, pp. 133–137.) For frequencies up to 200 kc/s, values up to 1.11 μF.

1461. Conductivity Bridge [primarily for Electrolytes, but having All Features of Wheatstone Bridge: 0.2 Ohm to 2 Megohms: Independent of Line-Voltage Fluctuations].—Industrial Instruments. (*Review Scient. Instr.*, Jan. 1942, Vol. 13, No. 1, p. 40.)

1462. RELATION OF ELECTROMOTIVE FORCE TO THE CONCENTRATION OF DEUTERIUM OXIDE IN SATURATED STANDARD CELLS.—L. H. Brickwedde & G. W. Vinal. (*Journ. of Res. of Nat. Bur. of Stds.*, Dec. 1941, Vol. 27, No. 6, pp. 479–489.)

1463. AN ALTERNATING-CURRENT STANDARD ON A PHOTOELECTRIC PRINCIPLE [Lack, hitherto, of Practical Current-Measuring Method, for A.C., corresponding to D.C. Compensation Procedure with Weston Standard Cell & Standard Resistance: the Use of the Moll Thermal Converter & Its Defects: Its Improvement on Photoelectric Lines].—R. Sewig & G. Werkmeister. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 22, 1941, pp. 248–251.)

The symmetry of the Moll circuit is preserved, while the hot wires of the thermal converter are replaced by incandescent lamps, and its thermojunctions by barrier-layer photocells: this means a very thorough decoupling between the two branches (d.c. and a.c.) and thus allows the apparatus to be used for h.f. work, down to short waves.

1464. CATHODE-RAY TUNING INDICATORS: INCREASING THE SENSITIVITY AND EXTENDING THE USEFULNESS OF THE "MAGIC EYE" [Tenfold Sensitivity Increase by Cathode Resistor (Hundredfold by Rather More Complicated Circuit): Successful Application to Slide-Back Diode Voltmeter and to Megohmmeter]—G. A. Hay. (*Wireless World*, March 1942, Vol. 48, No. 3, pp. 63–64.)

1465. AN ELECTRONIC ELECTROSCOPE [for Polarity & Voltage Tests: Use of Electron-Ray Indicator such as 6E5].—E. Moen. (*Electronics*, Oct. 1941, Vol. 14, No. 10, p. 74.) *Cf.* 1464, above.

1466. POWER-FACTOR METER [Direct-Reading, for 150 or 250 Volts, 0.1 to 10 Amperes: Phase-Controlled Thyratron Circuit with D'Arsonval-Type Meter].—A. B. Bereskin. (*Electronics*, Oct. 1941, Vol. 14, No. 10, pp. 38–42.) The valve actually used is an RCA–2051 gas tetrode, but one which could have its filament supplied from a 1.5 volt dry cell in the case would be desirable.

1467. DIRECT-READING PHASE-SHIFT METER.—J. D. Eislen. (*Geophysics*, Oct. 1941, Vol. 6, p. 311 onwards.)

1468. A LOGARITHMIC RECORDING VOLTMETER.—Vaccarino. (*See* 1404.)

1469. CONCERNING THE MEASUREMENT OF SMALL TIME INTERVALS [for Projectile Velocity Measurements, Explosion Times, Aircraft Bomb-Release Times, etc.].—Tommasi: Ferrari-Toniolo. (*See* 1589.)

1470. THE "WOBBULATOR": FREQUENCY MODULATION APPLIED TO CIRCUIT ALIGNMENT.—O. H. Davie. (*Electronic Eng:g*, Aug. 1941, Vol. 14, No. 162, pp. 340–342.) From the Cossor laboratories.

1471. THE TECHNIQUE OF RECEIVER MEASUREMENTS [in Three Parts].—G. T. Clack. (*Electronic Eng:g*, Aug., Sept., & Oct. 1941, Vol. 14, Nos. 162/164.)

1472. PAPERS ON THE MEASUREMENT OF THE R.F. DISTORTION IN AMPLIFIER VALVES.—Herold: Koch & Torelli. (*See* 1365/6.)

1473. THE DECIBEL: DOES IT NEED CLARIFICATION? [and a Suggested Reform].—W. Bacon. (*Electronic Eng:g*, Aug. 1941, Vol. 14, No. 162, pp. 356 and 358.) With comments by Gill and Voigt: further correspondence in Sept. issue, p. 421.

1474. NAMES OF ELECTRICAL UNITS [Suggestion of the "Franklin": but Why retain the E.S.U. System?].—R. O. Kapp: Guggenheim. (*Nature*, 24th Jan. 1942, Vol. 149, pp. 111–112.) Reply to Guggenheim's suggestion, 791 of March.

SUBSIDIARY APPARATUS AND MATERIALS

1475. A SIX-TRACE CATHODE-RAY MICRO-OSCILLOGRAPH.—von Ardenne. (*Hochf:tech. u. Elek:akus.*, Dec. 1941, Vol. 58, No. 6, pp. 156–159.)

In a previous paper (1976 of 1940) the writer described his "micro-oscillograph," a great advantage of which is the reduced expenditure in photographic material (by a factor of more than a hundred): he described also how multiple recording could be obtained with only a single electron-gun. When a high recording speed is required, internal photography becomes necessary, and this means continuous evacuation. The complications of this has hitherto limited the installation of internal-photography equipments to a few large laboratories, but the writer now reports on a six-trace micro-oscillograph with internal photography, working with a Gaede-type vacuum-pump and with cooling by a carbon-dioxide-snow and alcohol mixture. A cold cathode is used, so that the vacuum need not be too high: it is of the hollow type due to W. Krug (no reference is given, but *see* 2772 of 1936). For the same reason the distance between the sixfold electrostatic lens and the photographic film has been increased to 25 mm. This, combined with the comparatively small diameter of the lens apertures (1.2 mm) of the two outer electrodes, gives the best trace-sharpness when the potential between the inner electrode and outer electrodes of the lens is only about a quarter of the whole anode potential: with the result that no discharges could be detected in the lens even at anode potentials of 30 kv and at gas pressures giving strong electron leakage into the space between the anode screen and the lens system. Conditions regarding the vacuum are further improved by covering the porous metal surfaces with a smooth, low-vapour-pressure coating of Glyptal varnish.

A magnetic pre-concentration lens focuses the electron source a little above the aperture of the anode stop and produces, beyond this aperture, just the amount of ray divergence necessary to irradiate all six deflecting systems uniformly. The sixfold electrostatic lens, just below the deflecting systems, reduces the anode-aperture diameter of

0.4 mm in the ratio 1 : 31, giving a spot diameter of just over 0.01 mm; this is suitable for the resolving power, for 20–30 kv electrons, of commercial thin-emulsion film. The adoption of the electrostatic type of lens (Fig. 5) instead of the magnetic "pole-shoe" type (*see* for example 515 of February) was chiefly prompted by the desire for freedom from image-field rotation: this freedom assists in the construction of the complicated deflecting system and its connections (p. 158, r-h column). The careful rounding, chromium plating, and polishing of all the lens electrodes, already described in connection with the writer's short-focus electron-microscope lens (280 of 1940), contributes to the freedom from breakdown mentioned above.

The recording is carried out by a simple spring-driven camera built into the vacuum space: the film carrier is shot by at a uniform speed of several metres per second. Provision is also made for the later use of a roll film. Fig. 8 shows a six-trace oscillogram obtained at 15 kv with the experimental model: the sensitivity is about 4×10^{-3} mm/v, so that changes of 3 v are enough to deflect the spot by an amount equal to its diameter. The highest frequency shown on the oscillogram is 75 kc/s: greater recording speeds would be given at 20 kv and over, but a recording camera of greater "time extension" would be necessary to take advantage of these.

1476. CATHODE-RAY RECORDING OF TRANSIENTS [Satisfactory Negative Density at 1500 Inches/Second with f/4.5, 1000 V, Willemite Screen, Magnification 0.5, Panchromatic Emulsion with Weston Rating of 24.]—DuMont Laboratories. (*Electronics*, Oct. 1941, Vol. 14, No. 10, pp. 72–74.) Empirical data for guidance in other conditions. *Cf.* Fujitaka & others, 1139 of April.

1477. "THE CATHODE-RAY TUBE AND ITS APPLICATIONS: SECOND EDITION" [Book Review].—Parr. (*Electrician*, 6th Feb. 1942, Vol. 128, p. 102.)

1478. THE FIELDS OF ELECTRON-OPTICAL SYSTEMS CONSISTING OF SPHERICAL OR CYLINDRICAL SURFACES WITH APERTURES.—Glushko & Strashkevich. (*Journ. of Tech. Phys.* [in Russian], No. 3, Vol. 11, 1941, pp. 205–228.)

Continuing the work dealt with in 3476 of 1941, a detailed mathematical investigation is presented of electric systems consisting of two or three concentric spheres with small circular apertures, and of two or three coaxial cylinders with narrow slots. Formulae for the potential distribution in the fields of these systems are derived with sufficient accuracy for practical purposes. It is shown that these formulae can be reduced to well known relationships to cover the case of parallel planes with circular apertures and slots. The properties of the systems considered in this paper are discussed and their action as electron lenses is analysed.

1479. COMPUTATION OF OPTICAL ERRORS OF HIGH ORDER IN SYSTEMS OF SPHERICAL SURFACES [General Method avoiding Ray Concept and concentrating on Wave Shape].—Snavely. (*Journ. Opt. Soc. Am.*, Dec. 1941, Vol. 31, No. 12, p. 755: summary only.)

1480. PAPERS ON ELECTROLYTIC TROUGHS FOR THE PLOTTING OF FIELDS.—Himpan & Theile. (*See* 1362.)

1481. THE STABILITY OF SECONDARY EMISSION FROM ALKALI-HALIDE CATHODES, *and* A NEW METHOD FOR STUDYING THE SECONDARY-ELECTRON EMISSION FROM DIELECTRICS.—Vudynski: Nemilov. (*See* 1360 & 1361.)

1482. ON THE EXPLANATION OF THE INCREASE OF DIELECTRIC CONSTANT PRODUCED IN CRYSTAL PHOSPHORS BY ILLUMINATION.—Birus. (*Naturwiss.*, 26th Dec. 1941, Vol. 29, No. 52, pp. 779–780.)

Gudden & Pohl found as long ago as 1920 that the dielectric constant of a ZnS.Cu phosphor could be increased by more than 100% by irradiation with phosphorescence-producing light; but in spite of improved measuring methods no news of the effect being observed in any but a copper phosphor was reported until 1941, when Wesch announced the surprising results (203 & 223 of January) not only that the effect could be considerably increased by a partial replacement of the zinc by cadmium to give (Zn,Cd)S.Cu, but that it occurred to a marked extent in the silver-activated phosphor (Zn,Cd)S.Ag and was unmistakably present in Lenard phosphors and in manganese-activated silicates. This removal of the limitation of the effect to copper phosphors, and the proof of a marked increase with increase of the Cd content and thus of the lattice constant, taken in conjunction with Riehl's recent developments concerning the constitution of the centres (*see* reference "3" at end; *also* 3854 of 1937 and 1580 of 1940 & back references), has led the present writer to a picture, "at first sight surprising," of the whole mechanism of the phosphor and of its activation.

The lattice of the (Zn,Cd)S phosphor is regarded as built up of tetrahedral structures of the individual components (Zn, Cd, and S ions), which mutually penetrate into each other in such a way that a Zn or Cd ion always forms the centre-point of a S tetrahedron, and *vice versa*; only every second tetrahedron is "occupied," the others being empty. It is in these empty tetrahedra that the activating Cu or Ag atoms are "billeted": on excitation by illumination these atoms are ionised and, since they are "superfluous" and not bound into any definite repose position, can follow the forces of an external field the more readily, the less completely they fill their tetrahedral space. Thus the ionised Cu atom can follow these forces much better than the large Ag atom, and both can follow them more easily in the wide-meshed CdS lattice than in the closer ZnS lattice. Among the phenomena explained on these lines are the normally observed inertia of the effect, its decrease with increase in the Cd content, and probably also the complicated frequency-dependence of the dielectric loss angle of crystal phosphors under long-wave irradiation (Gisolf, 285/6 of 1940).

1483. THE DECAY LAW OF THE PHOSPHORESCENCE OF ALKALI-HALIDE AND SILICATE PHOSPHORS.—Birus & Zierold. (*Naturwiss.*, 23rd Jan. 1942, Vol. 30, No. 4, pp. 63–64.)

It has hitherto been assumed that the phosphorescence of alkali-halide phosphors with heavymetal activation decays exponentially. Since, however, this assumption cannot be reconciled with the latest ideas about phosphorescence (recombination between the activator ions and the electrons "billeted" in spaces statistically distributed over the whole crystal), and since, also, Aliavdin & his colleagues have already found signs of a different behaviour in Zn_2SiO_4.Mn (3556 of 1940), the present writers have determined the decay curves of these materials by a photoelectric technique and have found that they cannot be represented by simple *e*-functions, but that over wide ranges they are representable by a hyperbolic law of the form of eqn. 1, obtained by Antonow-Romanowsky for zinc-sulphide phosphors (*see*, for example, 3210 of 1935). These and other results are described and discussed: thus with certain materials a differently decaying, less intensive emission was found (up to times of 30 seconds) superposed on the hyperbolically decaying phosphorescence: this must be the result of an otherwise unknown "intermediate process", since the purely "spontaneous" luminescence (τ about 10^{-2} second) must have disappeared. Finally, the deviations from the hyperbolic law at times longer than 10 minutes are discussed and interpreted in terms of the depths of the electrons below the conductivity band.

1484. Characteristics of Fluorescent Materials [Survey, with Table & Curves].—Stauffer. (*Electronics*, Oct. 1941, Vol. 14, No. 10, pp. 32–34 and 117, 118.)

1485. The Electrical Conductivity of Zinc Oxide.—Miller. (*Phys. Review*, 15th Dec. 1941, Vol. 60, No. 12, pp. 890–895.) For Wolf's work on zinc-oxide phosphors *see* 777 of March.

1486. American Standard Dimensions Z38.1.3–1941 for 70-mm Perforated (and Unperforated) Film [for Oscillographs, etc.].—(*Journ. Opt. Soc. Am.*, Jan. 1942, Vol. 32, No. 1, p. 58.)

1487. Fractional Vacuum Pumps.—Sinel'nikov & others. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 11, 1941, pp. 879–892.)

Glass and metal high-vacuum fractional-oil pumps developed in Russia and handling from 5 to 1000 litres per sec. are described. The advantages of fractional pumps over other types are pointed out.

1488. An Electrostatic Voltage Transformer.—Baskin. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 11, 1941, pp. 838–842.)

A solid dielectric in the shape of a disc, ribbon or the like moves between several pairs of brushes (Fig. 1). The primary voltage is applied to one of the pairs and the charge so received on the dielectric is transferred to the remaining pairs. The latter are connected in series, and the potential at the last brush will therefore be equal to the sum of all potential differences. By applying the primary voltage to the last brush the desired reduced voltage can be taken off from one of the intermediate contacts. The transformer is suitable both for d.c. and low-frequency voltages.

1489. An Electronic Voltage Stabiliser for 1 to 50 Kilovolts and 20 to 500 Milliamperes ["Superdegenerative" Stabiliser using Type 833 Triode with Two Stages of Amplification in Grid Circuit, giving Adjustment to Positive, Negative, or Infinite Stabilisation Ratio: also reduces Residual Ripple].—Parratt & Trischka. (*Review Scient. Instr.*, Jan. 1942, Vol. 13, No. 1, pp. 17–23.)

"An excellent summary and classification of electronic stabilisers has been given by Hunt & Hickman [1691 of 1939], but in this summary the use of grid current is not mentioned. In the literature on this subject the phrase 'high voltage' refers generally to 2 or 3 kilovolts; there have been very few attempts to apply the electronic methods to voltages in excess of a few kilovolts . . ." The writers define a "figure of merit" which they consider of greater significance than the usual stabilisation ratio.

1490. Automatic Voltage Regulator [Revival of Bridge Circuit with Tungsten-Filament Lamps (Resistance proportional to Square Root of Applied Voltage)].—Casselman. (*Electronics*, Oct. 1941, Vol. 14, No. 10, p. 54.)

1491. Voltage-Multiplying Rectifiers: Obtaining High Voltage without a Transformer.—Cocking. (*See* 1322.)

1492. Vibrators [General Discussion, including Superiority of One-Piece Reed over Split Reed: Tests on American Vibrators].—Robinson. (*Electronic Eng:g*, July 1941, Vol. 14, No. 161, pp. 312 and 314.) From Masteradio, Ltd. *Cf.* Nace, 1158 of April.

1493. The Influence of the Contact Potential on the Initial Current of the High-Vacuum Triode and on the Ignition Characteristic of the Hot-Cathode Ionic Converter.—Adam. (*See* 1367.)

1494. Ignitor Characteristics [Current & Voltage Characteristics in Ignitron Rectifiers: Expression for Fraction of Total Current: etc.].—Arnott. (*Journ. Applied Phys.*, Sept. 1941, Vol. 12, No. 9, pp. 660–669.)

1495. Ignition Mechanism of the Ignitron [and Sendytron: Oscillographic Investigation].—Nomoto. (*Electrotech. Journ.* [Tokyo], Nov. 1940, Vol. 4, No. 11, pp. 252–255.)

1496. Excitation Circuits for Ignitron Rectifiers.—Myers & Cox. (*Elec. Engineering*, Oct. 1941, Vol. 60, No. 10, Transactions pp. 943–948.)

1497. Influence of the Ionisation of the Medium on the Time Lag between the Appearance of the Spark in a Spark-Gap and the Application of the Voltage to the Electrodes [Experimental Determination using Different Quantities of Radon].—Moulinier. (*Comptes Rendus* [Paris], 23rd June 1941, Vol. 212, No. 25, p. 1081.)

1498. Photoelectric Effects in the Development of Spark Breakdown: the Photoelectric Effects exhibited by Glow Discharge [Experimental Investigation], *and* On the Formation Stage of Spark Breakdown.—Miyoshi. (*Electrotech. Journ.* [Tokyo], Nov. 1940, Vol. 4, No. 11, pp. 239–242: Jan. 1941, Vol. 5, No. 1, pp. 10–12.)

1499. A Theory of the Anode Fall in Glow Discharges [leading to Determination of Factors governing Dependence of Anode Fall on Current between Electrodes].—von Engel. (*Phil. Mag.*, Nov. 1941, Vol. 32, No. 214, pp. 417–426.)

1500. The Formation of an Electric Discharge when the Pressure is Varied.—Matveev. (*See* 1330.)

1501. The Breakdown of Compressed Gases in a Non-Uniform Field.—Gokhberg [Hochberg] & Oksman. (*Journ. of Tech. Phys.* [in Russian], No. 11, Vol. 11, 1941, pp. 1058–1065.)

The effect of pressure on the breakdown voltages of air, CO_2, N_2, and SF_6 in a non-uniform field was investigated. Experimental curves are shown and discussed.

1502. Effect of Iodine on the Breakdown of Liquid Dielectrics [Impulse Breakdown Voltage of Ethyl Alcohol increased by 20% by Addition of Iodine: Maximum for Proportion 1 Molecule to 2×10^5 Molecules of Alcohol: Increasing Concentration lowers Strength, down to about Half the Original Value].—Suzuki & Fujioka. (*Electrotech. Journ.* [Tokyo], Nov. 1940, Vol. 4, No. 11, p. 260.) *See* also Dec. 1940 issue, p. 274.

1503. Frictional Phenomena: VII—Viscosity of Colloidal Solutions: Application to Synthetic Polymers.—Gemant. (*Journ. Applied Phys.*, Feb. 1942, Vol. 13, No. 2, pp. 90–96.)

1504. Hydrocarbon Polymers [particularly Polythenes ("Alkathene 7, 20, 70, & 200")].—Yarsley. (*Electrician*, 27th Feb. 1942, Vol. 128, pp. 164–166.)

1505. "High Polymeric Reactions: Their Theory and Practice" [Book Review].—Mark & Raff. (*Nature*, 7th March 1942, Vol. 149, p. 260.)

1506. Plastics in the Radio Industry: I—Nature & Types: II—Manufactured Plastic Products: II & IV—Manufacture.—Couzens & Wearmouth. (*Electronic Eng:g*, Nov. & Dec. 1941, Jan. & Feb. 1942, Vol. 14, Nos. 165/168.) For corrections *see* letter on p. 647 of Feb. issue.

1507. Same Plastic may be Hard or Soft, according to whether the Array of Molecules is Orderly or Disorderly: X-Ray Investigations.—Baker & others. (*Sci. News Letter*, 29th Nov. 1941, Vol. 40, No. 22, p. 342.) From the Bell Laboratories.

1508. Dielectric Absorption in Cellulose Nitrate and in Methyl Methacrylate [Lucite: Test of Applicability of Cole & Cole's Conclusions to Plastics].—Burke. (*Phys. Review*, 1st/15th Jan. 1942, Vol. 61, No. 1/2, p. 100: summary only.)

1509. Shear Strength of Moulded Plastic Materials.—Delmonte. (*ASTM Bulletin*, Jan. 1942, No. 114, pp. 25–28.)

1510. Visible D.C. Processes in Synthetic Resins [under about 1 kV: Tests with Polarised Light, etc: Little Colour Change at Cathode, Browning at Anode, extending to Several Millimetres Depth: etc.].—Vieweg & Klingelhöffer. (*E.T.Z.*, 23rd Oct. 1941, Vol. 62, No. 42/43, p. 864: summary only.)

1511. Porcelain Insulator Design [Recent American Developments: Interference-Free Designs: "Prestite," a "Plastic" Porcelain].—Whitney. (*Electrician*, 13th March 1942, Vol. 128, p. 222–223.) *See* also 2534 of 1941.

1512. The Thermal and Electrical Properties of Bitumastic Compounds containing Quartz Sand [to multiply the Thermal Conductivity without Serious Detriment to Electrical Properties].—Jackson. (*Phil. Mag.*, Feb. 1942, Vol. 33, No. 217, pp. 81–89.)

1513. Structure of Vitreous Silica [Evidence against Lu & Chang's Conclusions of Variations of Structure].—Rooksby & Thomas. (*Nature*, 7th March 1942, Vol. 149, pp. 273–274.)

1514. A Study of Dielectric Losses in Boric Glasses at High Frequencies [from 200 kc/s to 50 Mc/s].—Kessenikh. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 11, 1941, pp. 1149–1153.)

The angles of dielectric losses in the B_2O_3-K_2O, B_2O_3-Na_2O and B_2O_3-K_2O-Li_2O glasses were measured at different temperatures (of the order 15°–300°C) and frequencies, and with different proportions of the glass components. Curves are shown and a number of conclusions put forward.

1515. The Dielectric Strength of Glass—an Engineering Viewpoint [with Particular Attention to Edge Effects & Other Factors causing Apparent Inconsistencies in Published Results].—Shand. (*Elec. Engineering*, Aug. 1941, Vol. 60, No. 8, Transactions pp. 814–818.)

1516. The Electrical Conductivity of Titanium Dioxide [shown to be Electronic Semiconductor with Free Electrons as Current Carriers, with Very Small Mean Free Paths: etc.].—Earle. (*Phys. Review*, 1st/15th Jan. 1942, Vol. 61, No. 1/2, pp. 56–62.)

1517. The Sixth Conference on Semiconductors [Summaries of Papers].—Lifshitz. (*Journ. of Tech. Phys.* [in Russian], No. 3, Vol. 11, 1941, pp. 266–274.)

1518. A Resistor Furnace, with Some Preliminary Results up to 2000°C [likely to be Useful in Work on Special Ceramics, etc : Oxidising Atmosphere : heated by Resistors of Nernst-Filament Type].—Geller. (*Journ. of Res. of Nat. Bur. of Stds.*, Dec. 1941, Vol. 27, No. 6, pp. 555–566.)

1519. "Insulation of Electrical Apparatus" [Book Review].—Miner. (*Gen. Elec. Review*, Nov. 1941, Vol. 44, No. 11, p. 642.)

1520. Plug-In Electrolytic Condensers.—Aerovox. (*Review Scient. Instr.*, Jan. 1942, Vol. 13, No. 1, pp. 40–41.)

1521. "Koolohm" Resistors [with Ceramic Product sintered onto Wire, and Ceramic Cores & Shells : can be wound Non-Inductively : "Tele-e-Dot" Spot indicates 25% Overload].—Sprague Specialities. (*Review Scient. Instr.*, Jan. 1942, Vol. 13, No. 1, p. 44.)

1522. Armoured Power Rheostat [25 Watts : for Fighter Aircraft, etc.].—Clarostat. (*Review Scient. Instr.*, Jan. 1942, Vol. 13, No. 1, pp. 39–40.)

1523. Cellulose Acetate Yarn replaces Silk for Wire Insulation.—Brobst. (*Bell Lab. Record*, Jan. 1942, Vol. 20, No. 5, pp. 123–126.)

1524. Automatic Winding : Machinery for producing Insulated Coils [of Self-Supporting Types : "Leesona Machine"].—(*Electrician*, 20th March 1942, Vol. 128, pp. 263–264.)

1525. Recent Improvements in Air-Cored Inductances [with Thermal Compensation].—Griffiths. (*See* 1457.)

1526. Capacitance Effects in High Ohmic Resistances [and the Advantages of the "Radial Spiral"].—Klemt. (*See* 1316.)

1527. The Skin Effect in a Cylindrical Tube with Circular Cross Section.—Fischer. (*See* 1315.)

1528. Environmental Factor in Corrosion [of Lead Alloys in Different Soils].—Albano. (*Bell Lab. Record*, Nov. 1941, Vol. 20, No. 3, pp. 68–70.)

1529. Metal-Shielded Wire [from Single-Conductor to Multi-Cable Types, in Seamless Aluminium or Copper Tubing].—(*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, Advt. p. 10.)

1530. Graphite Coatings for Electrostatic Screening [Recommended Procedure for coating with "Aquadag" Colloidal Graphite].—Acheson, Limited. (*Engineering*, 27th Feb. 1942, Vol. 153, p. 178.) *See* also *Electrician*, 6th March 1942, Vol. 128, pp. 196–197.

1531. Improved Method of Splicing Rubber-Insulated Wire [Brass Sleeves pressed by Toggle-Action Pliers, & a New ("DR") Insulating Tape with Adhesive Rubber Surface backed with Vulcanised Rubber].—Shafer. (*Bell Lab. Record*, Dec. 1941, Vol. 20, No. 4, pp. 92–94.)

1532. Silver as a Substitute for Copper in Electric Wiring.—McConnell. (*Science*, 7th Nov. 1941, Vol. 94, Supp. pp. 10 and 12.)

1533. Fusing Currents : Their Values for Copper and Aluminium Wires [Inaccuracy of Preece's Formula : a New Version].—Dudley. (*Electrician*, 2nd Jan. 1942, Vol. 128, pp. 5–7.)

1534. Thermionic Properties of the Iron Group [Crystal Structure Transition Point in Iron detectable by Change in Emissivity : Work Functions, & Effect of Impurities : etc.].—Wahlin. (*Phys. Review*, 1st/15th Jan. 1942, Vol. 61, No. 1/2, p. 103 : summary only.)

1535. Anisotropy of Ferromagnetic Powder Particles [Measurements of Magnetic Moment of Sediments of Particles deposited in Magnetic Field show that They are Magnetically Anisotropic : Investigation & Suggested Explanation].—Benedikt. (*Journ. Applied Phys.*, Feb. 1942, Vol. 13, No. 2, pp. 105–109.)

1536. Loading Coils with Cores of Molybdenum Permalloy [having 70% Higher Permeability & Much Lower Hysteresis & Eddy-Current Losses than the Usual "81 Permalloy" : Economy in Material].—Greenidge. (*Bell Lab. Record*, Jan. 1942, Vol. 20, No. 5, pp. 119–122.)

1537. A Simple Type of Flat Induction Coil [for Measurement of Magnetic Fields in Narrow Gaps, etc.].—Benedikt. (*Review Scient. Instr.*, Jan. 1942, Vol. 13, No. 1, p. 38.)

1538. "Metallische Überzüge" [Metallic Coatings (Survey of Thermal, Mechanical, & Electrochemical Methods) : Book Review].—Machu. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 22, 1941, pp. 205–206.)

1539. Aluminium Reflectors [Method of Preparation of Satisfactory Concave Type].—Moriya. (*Electrotech. Journ.* [Tokyo], Dec. 1940, Vol. 4, No. 12, pp. 268–269.) Prompted by the American "Alzak" reflector.

1540. Tricks of the Trade—Properties of Some Materials used in Electrical Manufacturing.—St.Clair. (*Proc. I.R.E.*, Sept. 1941, Vol. 29, No. 9, pp. 524–525 : summary only.)

1541. Experimental Results on Small Accessories for Apparatus for Electrical Communication [Capacitance Measurements, from 1 kc/s to 4 Mc/s, on Italian-Made Terminals, Sockets, Jacks, etc. : Curves of Insertion Loss : Special I.E.N. Designs of Plugs for Screened Cables : etc.].—Ferrari-Toniolo. (*Alta Frequenza*, June 1941, Vol. 10, No. 6, pp. 372–380.)

1542. Effect of Mounting-Plate Vibration on Relay Operation.—Engelberg. (*Bell Lab. Record*, Nov. 1941, Vol. 20, No. 3, pp. 71–75.)

1543. The Hysteresis-Type Motor: is It of Practical Use? [Special Advantages: Possibilities offered by Some New Steels].—Jaeschke. (*Helios* [Leipzig], 12th Oct. 1941, Vol. 47, No. 41, pp. 1261–1264: in French & German.)

1544. A Speed Control for Sector Discs [for Measurement of Critical Fusion Frequency of Eye] or Similar Equipment.—Lee & Crisp. (*Review Scient. Instr.*, Dec. 1941, Vol. 12, No. 12, pp. 607–608.) The principle is taken from "Ingenious Mechanisms for Designers & Inventors," a book edited by Franklin D. Jones.

STATIONS, DESIGN AND OPERATION

1545. W47NV Nashville [Features of the First Frequency-Modulation Station to operate on a Commercial Basis].—(*Electronics*, Oct. 1941, Vol. 14, No. 10, p. 43: photographs & captions only.)

1546. Over-Modulation Monitor for Frequency-Modulated Transmitters.—Buder. (*Funktech. Monatshefte*, May 1941, No. 5, pp. 68–69.)

1547. Wire *versus* Wireless [More Correspondence on "The Eckersley Plan"].—Eckersley. (*Wireless World*, March 1942, Vol. 48, No. 3, pp. 70–71.) *See* 881 of March.

1548. The Supervision of Wire Broadcasting [General Requirements of the Service: Distortions & Interference with Double-Sideband Working (Attenuation & Phase Differences between Sidebands, Cross-Talk, Over-Modulation, Stray Voltages from Power Lines & Exchange Batteries): Measuring Equipment (Siemens & Halske with State P.O.): Limits].—Barthel & Eisele. (*T.F.T.*, May 1941, Vol. 30, No. 5, pp. 141–148.) *See* also 1187 of April.

1549. Ten-Frequency Airplane Radio Equipment: the Ten-Frequency Transmitter: the Ten-Frequency Receiver.—Nordahl: Morrison. (*Bell Lab. Record*, June 1941, Vol. 19, No. 10, pp. 302–309.)

1550. Equipment-Failure Alarm for Communication Networks.—Cook & Petersen. (*Electronics*, Oct. 1941, Vol. 14, No. 10, pp. 44–45 and 105, 106.)

1551. The Siemens-Hell Recorder [Latest Developments & Results].—Schulz. (*T.F.T.*, Feb. 1941, Vol. 30, No. 2, pp. 52–57.) *Cf.* Berck, 2767 of 1940.

GENERAL PHYSICAL ARTICLES

1552. Ionisation of Gases by Collisions of Their Own Accelerated Atoms and Molecules [Experiments on Argon & Nitrogen].—Berry & others. (*Phys. Review*, 1st/15th Jan. 1942, Vol. 61, No. 1/2, pp. 63–64.)

1553. On Some Curious Relations between Certain Numerical Values [h_1, e_1, m_1, f_1, M_1 are all Simple Rational Functions of the Coefficient k_1 of the Boltzmann Constant: etc.].—Prunier: Montel. (*Comptes Rendus* [Paris], 30th June 1941, Vol. 212, No. 26, pp. 1134–1136.) Where $h = h_1 \pm 0.008 \times 10^{-27}$ erg/sec., putting $h_1 = 6.5420$; $e = e_1 \pm 0.0038 \times 10^{-10}$ e.s.u., putting $e_1 = 4.7668$; etc.

1554. The Forces on an Electron, according to Dirac's Wave Equation.—Lees. (*Phil. Mag.*, Feb. 1942, Vol. 33, No. 217, pp. 131–137.)

1555. Corrections to "A Theory of Elementary Particles."—Japolsky. (*Phil. Mag.*, March 1942, Vol. 33, No. 218, p. 240.) *See* 4108 of 1935 [and 810 of 1936].

1556. Relativity Theory of Electromagnetism [Kaluza Extension].—Cattermole. (*Phil. Mag.*, March 1942, Vol. 33, No. 218, pp. 215–225.)

"It is the purpose of this paper to show that the problem of working out the trajectory of a charged particle in an electric, or magnetic, or an electromagnetic field, can be solved using the general five-dimensional theory in the same way as the four-dimensional general theory can be used to work out the motion of a particle in a gravitational field."

MISCELLANEOUS

1557. Approximate Formulae for Functions expressed as Definite Integrals.—Majid Mian & Chapman. (*See* 1282.)

1558. Operational Analysis of Non-Linear Dynamical Systems.—Pipes. (*See* 1311.)

1559. "Operational Methods in Applied Mathematics" [Book Review].—Carslaw & Jaeger. (*Engineering*, 16th Jan. 1942, Vol. 153, p. 43.)

1560. On the Function $H(m, a, x) = \exp(-ix)\,F(m+1-ia, 2m+2, 2ix)$ [satisfying the Equation $x.\mathrm{d}^2H/\mathrm{d}x^2 + (2m+2)\mathrm{d}H/\mathrm{d}x + (x-2a)H = 0$].—Lowan & Horenstein. (*Phys. Review*, 1st/15th Jan. 1942, Vol. 61, No. 1/2, p. 94.) Invitation to physicists from the Mathematical Tables Project.

1561. The Fermi-Dirac Functions [Evaluation for Any Function $\phi(x)$].—Auluck. (*Phil. Mag.*, Feb. 1942, Vol. 33, No. 217, pp. 159–160.)

1562. On Yule's Method of investigating Periodicities of Disturbed Series.—Schumann. (*See* 1288.)

1563. Probabilities of Maximum Oscillations [Arithmetical Sum of Greatest Positive & Greatest Negative Deviations].—Bachelier. (*Comptes Rendus* [Paris], 19th May 1941, Vol. 212, No. 20, pp. 836–838.) The method allows, for example, the calculation of the probability that a given max. deviation x will be reached exactly at a time t.

1564. Remarks on Goodness of Fit of Hypotheses and on Pearson's χ^2 Test ["Imperfect & Sometimes Misleading": etc.]—Sawkins. (*Journ. & Proc. Roy. Soc. New South Wales*, Part 2, Vol. 75, 1941, pp. 85–95.)

1565. Probability Applications.—Evans: Rissik. (*Engineer*, 13th Feb. 1942, Vol. 173, p. 143.) Prompted by Rissik's paper, 297 of January.

1566. An All-Electric Integrator for solving Differential Equations [Accuracy within 0.5% or Better: Electric Coupling eliminates Mechanical Difficulties and reduces Cost enormously].—Varney. (*Review Scient. Instr.*, Jan. 1942, Vol. 13, No. 1, pp. 10–16.)

1567. Science and International Politics [Address to Royal Institute of International Affairs].—Gregory. (*Nature*, 7th March 1942, Vol. 149, pp. 261–263.) *See* also pp. 253–255.

1568. Total Security—a Challenge [Reply to C. E. Wilson's Address: the Problem Not Economic but Social-Economic: the True Solution].—Ackerman: Wilson. (*Elec. Engineering*, Sept. 1941, Vol. 60, No. 9, pp. 464–465.) *See* 299 of January.

1569. Electronics in Industry [Conference on Electronics at Royal Institution: Summaries of Papers & Discussion: Resolution in favour of Formation of Electronics Group of Institute of Physics].—Cockcroft & others. (*Nature*, 7th March 1942, Vol. 149, pp. 278–279.)

1570. The Training of Wireless Engineers [Further Treading on Dalton's Coat-Tail].—Dalton. (*Wireless World*, March 1942, Vol. 48, No. 3, p. 69.) *See* 912 of March, and an Editorial on p. 51.

1571. "Foundations of Wireless: Third Revised Edition" [Book Notice].—Scroggie (Revised by). (*Wireless World*, Feb. 1942, Vol. 48, No. 2, p. 41.)

1572. Chart of Elementary Particles, Ether Spectrum, Radio [Allocation] Spectrum, Photographic & Audible Spectra.—(*Electronics*, April 1940, Vol. 13, No. 4, pp. 50–51.)

1573. The Field of Electrets in the Presence of Gaseous Ions [and Suggestions as to the Improvement & Application of Electrets].—Gemant. (*See* 1303.)

1574. Unit Fundamental Components for Carrier-Frequency Multiple-Utilisation of Telephone Lines.—Thierbach & Vogel. (*See* 1386.)

1575. Acoustic Experiments with an Electronic Switch [transferring "Segmented Portions of Continuously Flowing Electric Sound Currents" from Common Circuit to Two or More Circuits: Analogy to Persistence of Vision: Possibilities in Secret Communication, Stereophonic Effects, etc.].—Wolf. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 332–333: summary only.) *Cf.*, perhaps, Marro, 4228 of 1939 and 2468 of 1940.

1576. An Electrical Method allowing the Statistical Evaluation of the Diameters of Mist Droplets [Penetration into Suspension in Oil effected by Ionising Field].—Pauthenier & Brun. (*Comptes Rendus* [Paris], 23rd June 1941, Vol. 212, No. 25, pp. 1081–1084.)

In a comment on p. 1084 Cotton mentions that Toulon, in a Note lost in the events of 1940, described the impelling, by an electrified point in air, of ions through a fine-meshed grid, with the help of an accelerating voltage due to an auxiliary field: "one obtained thus a sort of triode without the necessity for a vacuum, and one could prepare a whole series of valve models which, in particular cases, present certain advantages."

1577. A Photoelectric Star Counter [counting, & segregating according to Brightness, Stellar Images on Photographic Plate].—McCuskey & Scott. (*Review Scient. Instr.*, Dec. 1941, Vol. 12, No. 12, pp. 597–601.)

1578. The Use of Light Beams and Photoelectric Devices for Width Measurements in Production of Textiles, Paper, and Strip Metal, etc.—Alexander. (*Gen. Elec. Review*, Nov. 1941, Vol. 44, No. 11, pp. 615–617.)

1579. The Use of Register Marks and Photoelectric Control Devices for Maintaining Positioning of Fast-Moving Web or Strip.—Wright. (*Gen. Elec. Review*, Nov. 1941, Vol. 44, No. 11, pp. 629–631.) As in multi-colour printing.

1580. Photoelectric Devices in Manufacturing.—Janzen. (*Hochf:tech. u. Elek:akus.*, Nov. 1941, Vol. 58, No. 5, pp. 120–123.)

In cases where a deviation of only 3% from the normal light flux must actuate the control process, the straightforward photocell method is unsuitable, and the "optical push-pull" system is used (Fig. 2, where the light source at the left sends its rays alternately, according to the instantaneous position of the rotating toothed disc *f*, along the testing path *b–d* including the object, and along the comparison path *a–c* including the optical wedge *e*; in either case the ray reaches the same photocell with its a.c. amplifier *g* and control relay *h*). Such an arrangement is capable of checking the smallest deviations either in dimensions or in surface: the sensitivity of the human eye is attained. The small alternating amplitudes require the use of two stages of amplification, which are combined with the electronic relay to form the three-stage amplifier of Fig. 3.

For testing, counting, and sorting processes where light changes of as much as 25% are available, the "optical push-pull" system is not necessary and a photocell with one stage of amplification only is used successfully for many applications, provided that means are available for stabilising the lamp and valve voltages. Examples are the "safety curtain " for machine tools (*e.g.* Fig. 4), the surface-flatness testing device (*e.g.* for relay armatures) of Fig. 7, and the tester for cold-sprayed tubes, Fig. 8. Examples of the more elaborate and accurate "push-pull" system are the tester for bore-holes with very small tolerances (Fig. 6) and the cigarette-packing control of Fig. 9, where 18 cigarettes per second are adjusted so that their printed labels are facing the right way: here the reflected light from the unprinted and printed sides differs by only a few per cent. Such equipments as these have consistently resulted in a saving of 50–80% of the costs of testing.

1581. PHOTOCELL SCANS DRAWING OR PATTERN & MAKES POINTER FOLLOW OUTLINE, DRIVING SECOND POINTER (OR SMALL BLOW TORCH) TO TRACE (OR CUT OUT) ENLARGED OR REDUCED REPLICA.—(*Sci. News Letter*, 27th Dec. 1941, Vol. 40, No. 26, p. 410: paragraph only.)

1582. INTEGRATOR FOR IRREGULAR PLANE SURFACES [" Photoelectric Profile Gauge," to find Lay-Out giving Minimum Waste of Material, *e.g.* Leather Shoe Patterns].—(*Electronics*, Feb. 1940, Vol. 13, No. 2, pp. 36 and 40.)

1583. ACTIVITIES OF THE GALILEO FERRARIS NATIONAL INSTITUTE [I.E.N.G.F.]: REUNIONS OF THE FIRST QUARTER, 1940/41.—(*Alta Frequenza*, June 1941, Vol. 10, No. 6, pp. 381–394.)

Including a generating frequency meter based on Pinciroli's results with differential negative resistances obtained with negative-transconductance valves of retarding-field type (2686 of 1941): the measurement of photoelectric currents of the order of 10^{-14} A or less, using an electrometer as zero indicator: etc. For a similar report on the third quarter *see* October issue, No. 10, pp. 636–638: the report mentions Dilda's saturated-iron stabiliser (combination of a compensating transformer with air-gap in core and an auto-transformer with saturated core: a suitable capacitance in parallel with the auto-transformer improves the performance considerably), and work on linear negative-feedback in an amplifying system supplying a non-linear load (dry-plate rectifier): this is in connection with a project to increase the calibration constancy and improve the frequency characteristic of a microphone of any type which has a diaphragm, and preliminary results have been promising.

1584. DETECTOR OF METAL FRAGMENTS IN WOUNDS [Moorhead Foreign-Body Finder (R.F. Probe): Successful First Use after Pearl Harbour Raid].—Moorhead. (*Science*, 30th Jan. 1942, Vol. 95, Supp. p. 8.) *Cf.* Siemens, 3208 of 1941.

1585. PROTECTION OF PERSONNEL HANDLING RADIUM [including Description of Experimental & Commercial Exposure Meter, embodying Specially Developed Tube Counter, Amplifier, etc.].—Curtiss. (*ASTM Bulletin*, Jan. 1942, No. 114, pp. 21–24.)

1586. A DIRECT-CURRENT AMPLIFIER [or Electronic Relay] AND ITS APPLICATION TO INDUSTRIAL MEASUREMENTS AND CONTROL.—Gall. (*Electrician*, 20th March 1942, Vol. 128, pp. 249–251.) Summary of I.E.E. paper, with Discussion.

1587. AN ANALYSER FOR SUB-AUDIBLE FREQUENCIES [General Radio Type 762-A Vibration Analyser, on Principle of Selectivity by Negative Feedback: Accurate down to $2\frac{1}{2}$ c/s].—Scott. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 334: summary only.) Supplementing the Type 761-A vibration meter (352 of January) but with other applications also.

1588. ANTI-AIRCRAFT CALCULATING INSTRUMENT, THE " STEREOMAT " [including the Use of a Differential Variable Condenser acting as Capacitive Micrometer].—Fischer. (*Zeitschr. V.D.I.*, 24th Jan. 1942, Vol. 86, No. 3/4, pp. 56–57: summary, from 1938/39 Swiss papers.) *See* also issue for 10th Jan. 1942, No. 1/2, p. 14.

1589. CONCERNING THE MEASUREMENT OF SMALL TIME INTERVALS [for Projectile Velocity Measurements over Bases smaller than One Metre (Times 0.1–1.5 Thousandths of a Second), Explosion Times (10^{-4} to 10^{-5} Second), Aircraft Bomb-Release Times, etc.].—Tommasi: Ferrari-Toniolo. (*Alta Frequenza*, June 1941, Vol. 10, No. 6, p. 358.)

A letter prompted by Ferrari-Toniolo's letter, 2188 of 1941, and referring to Tommasi & May's paper in *L'Elettrotecnica*, 10th & 25th Feb. 1941, on their similar (condenser-charging) apparatus. They discarded the electrostatic voltmeter used in the other equipment in favour of a valve-voltmeter: this allows the charging potential to be reduced from 100–500 volts to about 1 volt and makes the equipment small and robust.

1590. NOTE ON THE PAPER " A METHOD OF MEASURING THE INITIAL SPIN OF A PROJECTILE IN MOTION ".—German Research Establishment: Kömmnick & Wehnelt. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 22, 1941, p. 268.)

The Deutsche Waffen- und Munitionsfabriken A.G. mentions that it has for a long time used a method similar to that described in the above paper (598 of February) and that it has given perfect results. The production of a sufficiently large transverse magnetisation in standard projectiles (" SmK " and " 2-cm ") presented no difficulties. The curves obtained agreed in their form with those given by Kömmnick & Wehnelt in Part II of their paper. This is to be found in the same journal, No. 7, Vol. 22, 1941, pp. 153–158 (*see* also *Physik. Berichte*, No. 22, Vol. 22, 1941, p. 2174) and introduces some modifications into the method. The theory is given, and it is mentioned that the method is also used for velocity measurement (*cf.* Bradford, 1268 of April, and 1589, above).

1591. DETECTING PINHOLES IN RUBBERISED CANVAS [in A.R.P. Work: Method using Saturated Rollers & Valve Relay Circuit].—Russell. (*Electronic Eng:g*, July 1941, Vol. 14, No. 161, p. 316.)