WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

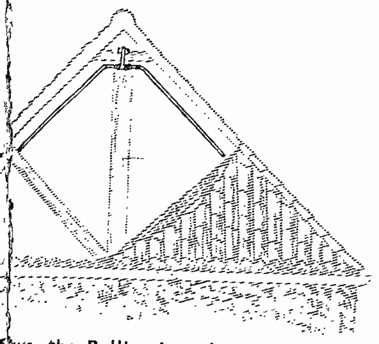
JULY 1947

VOL. XXIV   TWO SHILLINGS AND SIXPENCE · · No. 286

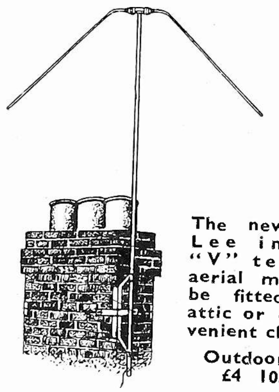

VOLTAGE
CONTROL
WITH
VARIACS

THE BELLING-LEE INVERTED "V" TELEVISION RECEIVING AERIAL

(Patent applied for)



ws the Belling-Lee inverted "V" vision aerial mounted in the attic. Attic Model sells at £2 7s. 6d.



The new Belling-Lee inverted "V" television aerial may either be fitted in the attic or on a convenient chimney.

Outdoor Model, £4 10s. 0d.

his inverted V aerial was designed, in the first place, for use in vicinities where the field strength was sufficiently to dispense with outdoor aerials. Apart from the sym- l manner in which this aerial fits in with the roof shape, ding of each element to an angle of 45° introduces a technical feature, namely the independance of the pon the angle of polarisation of the incident signal wave. hough the signal wave is vertically polarised in the ce, the presence of metallic conductors such as con- ter pipings, etc., can, by re-radiation, cause a major n the polarisation of the signal wave at the receiving These changes are looked after, automatically, by rted V construction of our aerial.

re is naturally some loss of signal, the terminal voltage mid-point being 6 db less than that from a single half wave dipole. Since the aerial is only intended for r conditions of high field strength this loss is quite tant.

ddition to this non-polarising feature the aerial is al, possessing sharp minima at right angles to its This property is of very great use in removing a ' due to the multipath transmission, or for eliminating interference from electronic heating or diathermy apparatus.

As regards the limits of distance (from the transmitter) at which the inverted V aerial can be expected to work satisfactorily, a great deal obviously depends upon the amount of local screening. Experience indicates that, in suburban districts, a distance up to five miles can usually be relied upon. If the aerial is mounted out of doors at a height of about 40ft. the above distance can be doubled.

The aerial is designed to be connected to a twin balanced feeder of 80 ohms nominal characteristic impedance (our L.336) but co-axial feeder (our L.600) may be used with negligible difference in results.

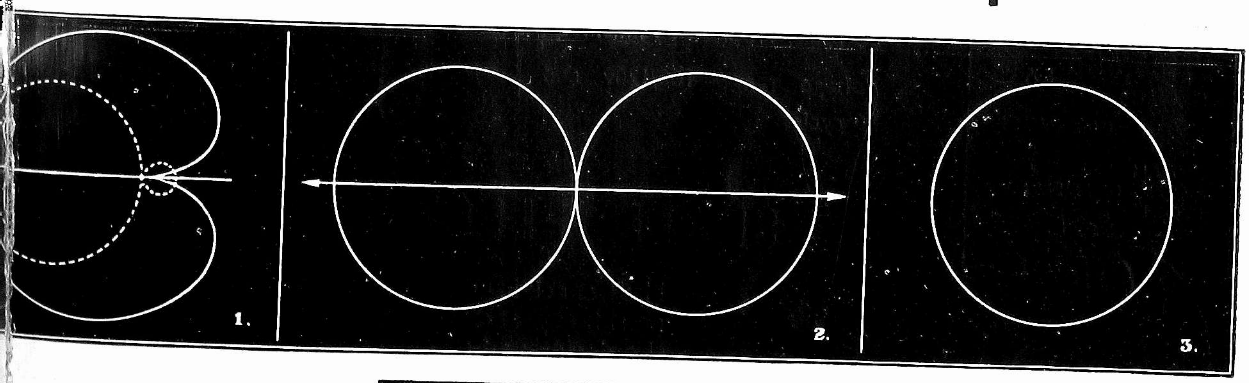
Due to the partial folding of the elements, the band-width of the aerial is somewhat greater than that of the conventional dipole using elements of the same diameters, and is more than adequate for both the sound and vision channels as at present transmitted.

As a matter of interest the relative polar diagrams of our three aerial systems are depicted below: they are not to scale on an amplitude basis but merely serve to show the directional characteristics.

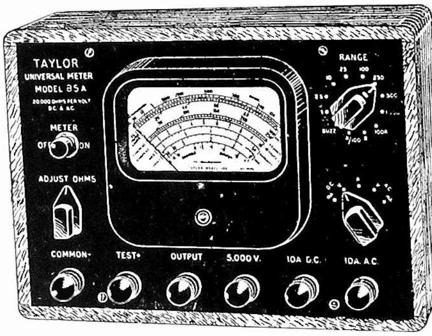
Fig. 1. L.502 vertical dipole and reflector (Gain +6db relative to a simple dipole). The vision polar diagram is shown dotted and the sound heavy.

Fig. 2. L.605 and 606 Inverted V (Gain −6 db relative to a simple dipole). Both sound and vision polar diagrams are identical.

Fig. 3. L.501 Simple vertical dipole. Both sound and vision polar diagrams are identical.



BELLING & LEE LTD
CAMBRIDGE ARTERIAL ROAD, ENFIELD, MIDDX



UNIVERSAL TAYLOR METER MODEL 85A

The sensitivity of this 90-range Universal meter, 20,000 ohms per volt on all D.C. and A.C. ranges, is unequalled, and its accuracy is fully up to its class. The meter has a 4″ scale and knife-edge pointer, and is provided with overload protection on all D.C. and A.C. ranges. Voltage range: 5,000 DC/AC to 1mV D.C. and 0.1 volts A.C. Current range: 10 amps to 1 microamp DC/AC. Resistance range: 0.1 ohms to 20 Megohms, and 2,000 Megohms with external battery. Buzzer for continuity tests. Decibels −34 to +69. Adaptors give Capacity, Inductance and extra Voltage and Current measurements. Leaflet on request.

Price: Portable Model with cover and carrying handle. Now reduced to:— £19.19.0d.

made to MEASURE—

Верстà

Verst to you—
is the Russian mile,
(3,500 English Feet.)

In the land of the droshky and the troika, they measure th... vodka by the tcharkas and their caviare in poods, but wh... it comes to electrical measurements, Russians rely on ... international volt, ampere, and ohm. Even the most intr... sigeant national could not help respecting the accura... associated with every electrical measuring instrument tha...

—TAYLOR made

Full particulars of Taylor Instruments and Meters from your usual Factors or direct ...

TAYLOR ELECTRICAL INSTRUMENTS LTD.

419-424 Montrose Avenue, SLOUGH, BUCKS.

Phones: Slough 21381 (4 lines)

SINGLE AND THREE PHASE MOTORS.
AIRCRAFT GENERATORS.
ELECTRIC GRAMOPHONE MOTORS.
TRANSFORMERS.
ELECTRIC TRACTION MOTORS.
PETROL SET GENERATORS AND SWITCHBOARDS.
ALTERNATORS AND MOTORS OF NORMAL MEDIUM AND HIGH FREQUENCY.
ABRASIVE SAW MACHINES.
MOTOR GENERATOR SETS.
DYNAMOTORS AND ROTARY CONVERTERS, ETC., ETC.

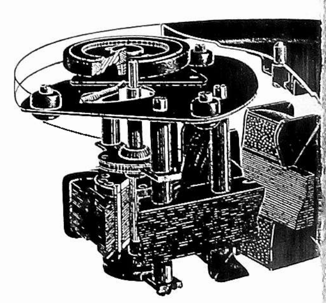
SEM EST 1914

Electric Gramophone Moto...

SEM Engineers have been successful in producing an electric gramophone motor of simple, reliable and efficient design incorporating such features as :—

Quiet running, High starting torque and Overload reserve power, Self-lubricating bearings, Tropicalised finish.

Voltage range—100/120v and 200/240v. 50 cycles.



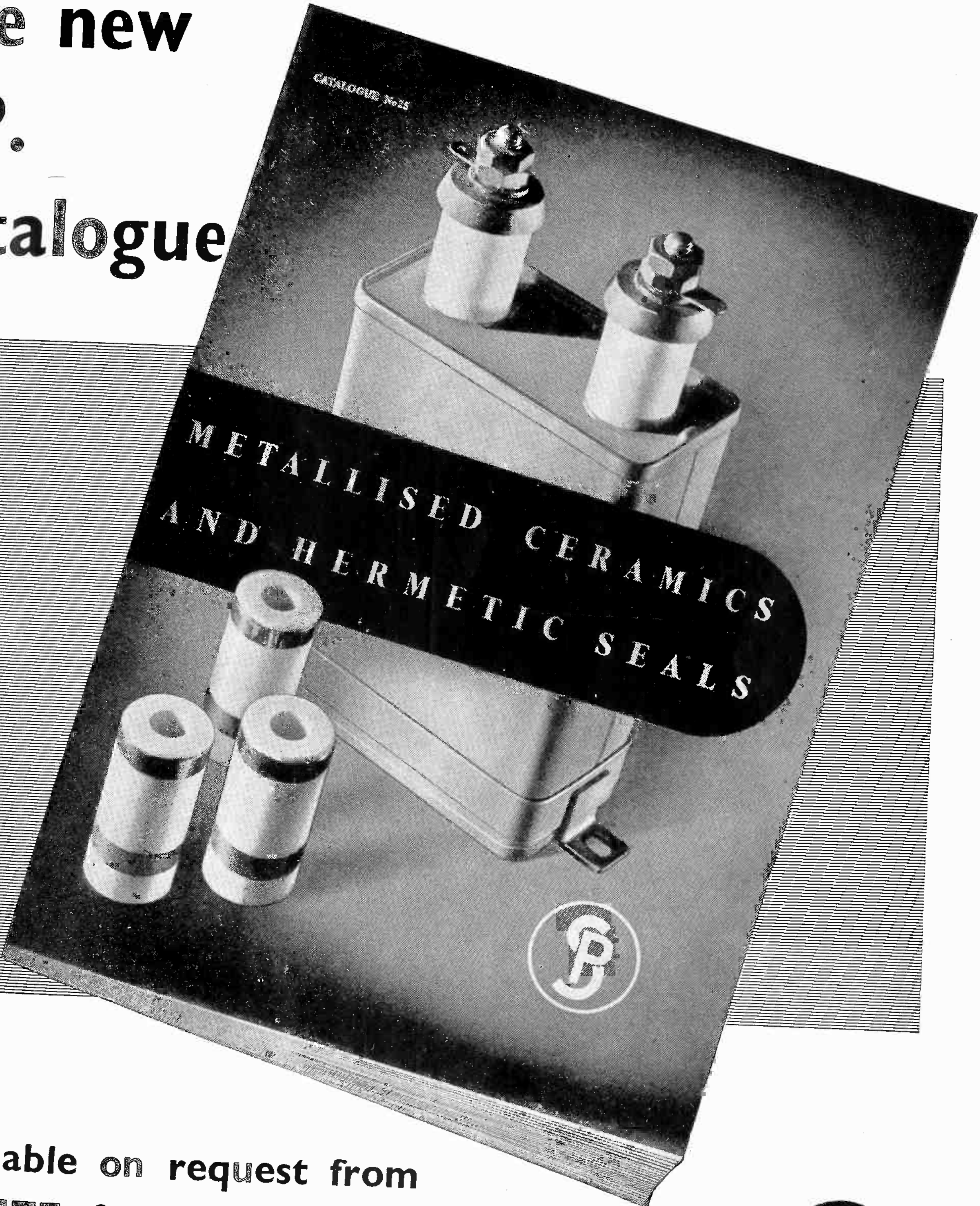
SEM CONSTANT concealed rim drive, Gramophone Unit.

SMALL ELECTRIC MOTORS L...

Have specialized for over 30 years in making electrical machinery and equipment and are experienced in the design and manufacture of the products as listed.

BECKENHAM, KENT. *Telephone : BECkenham 0066 & 1152*

he new
P.
atalogue



ailable on request from

TITE & PORCELAIN PRODUCTS LTD.

on Severn, Worcs. Telephone: Stourport III. Telegrams: Steatain, Stourport.

S.P.48


RM
ELECTRIC LIMITED
TEAM VALLEY, GATESHEAD 11
RM
ELECTRIC
LTD
UNIVERSAL
OUTPUT
TRANSFORMER

THE

COSSOR

HIGH VACUUM

DOUBLE BEAM OSCILLOGRAPH

giving

VISUAL TWO-DIMENSIONAL
delineation of any recurrent law.

●

RELATIVE TIMING OF EVENTS
and other comparative measurements
with extreme accuracy.

●

PHOTOGRAPHIC RECORDING
of transient phenomena

and

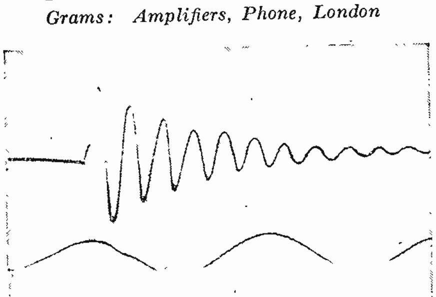
SIMULTANEOUS INDICATION
of two variables on a common time axis.

Completely embracing all the above functions, of which the last is unique, the Cossor Double Beam Oscillograph is inherently applicable to all problems arising in

RECORDING, INDICATING & MONITORING
when the effects examined can be made available as a voltage.

A. C. COSSOR LTD.,
INSTRUMENT DEPT.,
HIGHBURY, LONDON, N.5

Phone: *CANonbury* 1234 (30 *lines*)
Grams: *Amplifiers, Phone, London*



Which Switch is the right switch?

. . . is it Rotary or Pushbutton or Slider ? Is it wanted for circuit selection, band selection, tap switching ? Is it for a new design or in quantities for a well proved circuit ?

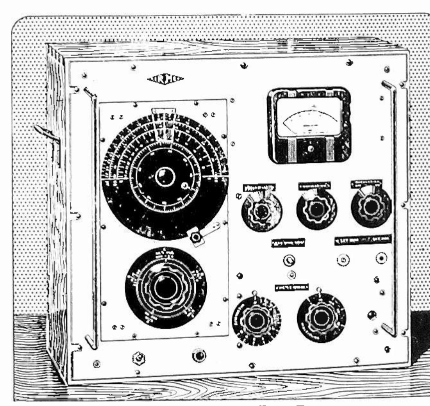
Whatever it is — the answer is always OAK !

The basic design of all Oak switches is one of strength and efficient functioning, including such exclusive features as the double-contact clip and the floating rotor, ensuring self-alignment of each section.

NSF AND AB

OAK SWITCHES

BRITISH N.S.F. CO. LTD., Keighley, Yorkshire
(Sole Licensees of OAK Manufacturing Co., Chicago)
A.B. METAL PRODUCTS LTD., Feltham, Middx.
(Sub-Licensees of N.S.F.)
The only Manufacturers of OAK Switches under Patent Nos. 478391 & 478392



Standard Signal Generator

With its *extreme accuracy* and *stability*, the Airmec Signal Generator is an indispensable instrument wherever radio-frequency measurements are made. Whether in a laboratory, a service station, or on a production line, it will speed the work and guarantee accurate results.

Write for full descriptive literature

AIRMEC LIMITED
Wadsworth Road, Perivale, Greenford, Middlesex
Telephone: *Perivale 3344*

AIRMEC

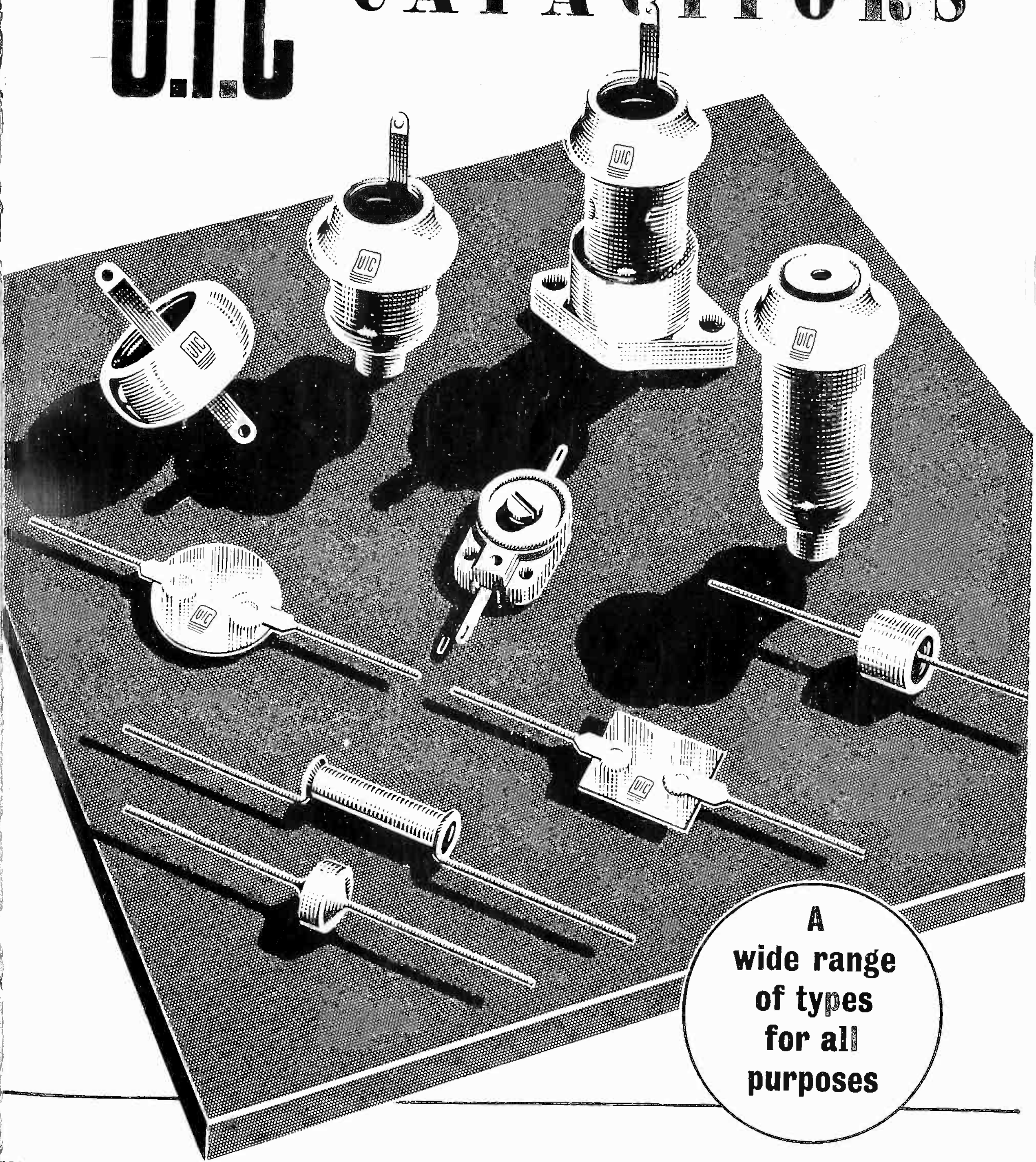
A Group Company of Radio & Television Trust Ltd.

GV8-II

U.I.C

Silvered Mica & Ceramic

CAPACITORS



UNITED INSULATOR CO. LTD., OAKCROFT ROAD, TOLWORTH, SURBITON, SURREY

Telephone : Elmbridge 5241 (6 lines) *Telegrams : Calanel, Surbiton*

Unsurpassed In Ceramics

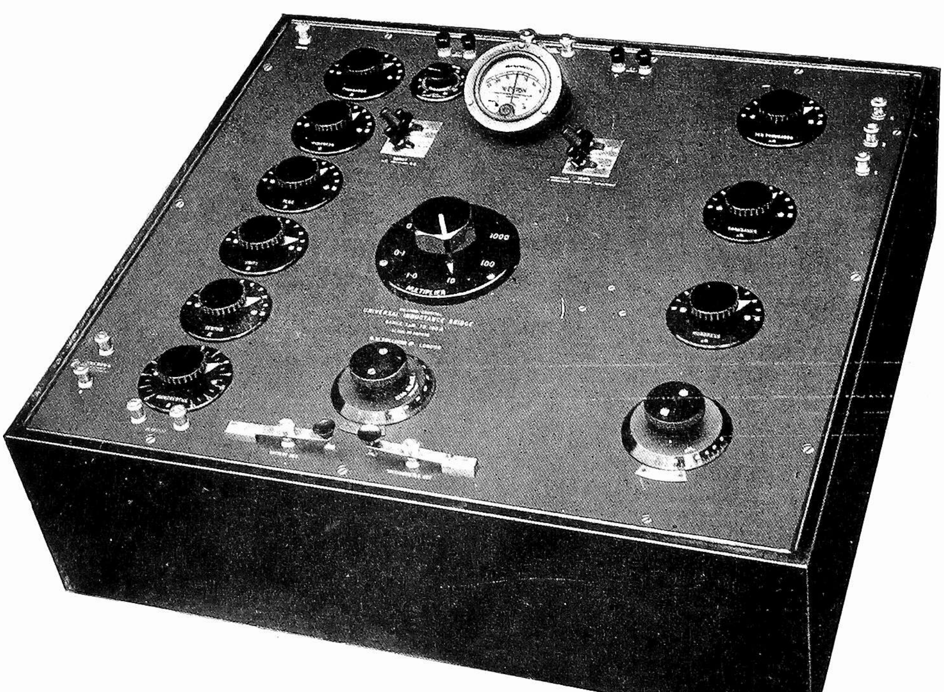
INDUCTANCE MEASUREMENT

One of the most outstanding technical developments of

H. W. Sullivan Limited

is the Sullivan-Griffiths Precision Inductance Bridge.

Its range 1 μH to 100H; its direct reading accuracy 0.1% or 0.1 μH (quite unaffected by temperature and having good frequency characteristics) and facilities provided for the direct reading measurement of resistance 0.01 ohm to 10 Megohms, capacitance 10 $\mu\mu$F to 1 μF and the inductance and losses of iron-cored inductances with superposed direct current up to 2 amperes . . . . . . make this bridge invaluable to any factory or laboratory concerned with inductance measurements.



An advertisement of H. W. Sullivan Limited, London, S.E.15. Telephone : New Cross 3225 (Private Branch Exchange).

WIRELESS ENGINEER

The Journal of Radio Research & Progress

JULY 1947

Vol. XXIV. No. 286

CONTENTS

Published on the sixth of each month

SUBSCRIPTIONS

Home and Abroad: One Year 32/-. Six Months 16/-.

Editorial, Advertising and Publishing Offices:

DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1

Telephone: WATerloo 3333 (50 lines) Telegrams: Wirenger, Sedist, London.

Branch Offices:

COVENTRY
8-10, Corporation Street.
Telephone: Coventry 5210.
Telegrams:
"*Autocar, Coventry.*"

BIRMINGHAM 2
King Edward House,
New Street.
Telephone: Midland 7191 (7 lines).
Telegrams:
"*Autopress, Birmingham 2.*"

MANCHESTER 3
260, Deansgate
Telephone:
Blackfriars 4412 (4 lines).
Telegrams:
"*Iliffe, Manchester 3.*"

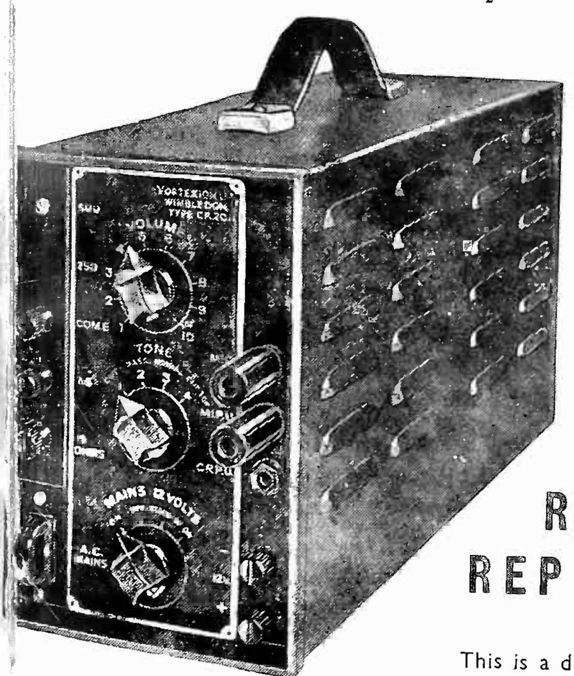
GLASGOW C2
26B, Renfield Street.
Telephone: Central 1857
Telegrams:
"*Iliffe, Glasgow C2.*"

Vortexion

"SUPER FIFTY WATT" AMPLIFIER

his **AMPLIFIER** has a response of 30 cps. to 5,000 cps., within ½ db, under 2 per cent. distortion t 40 watts and 1 per cent. at 15 watts, including noise nd distortion of pre-amplifier and microphone ransformer. Electronic mixing for microphone and ramophone of either high or low impedance with top nd bass controls. Output for 15/250 ohms with enerous voice coil feedback to minimise speaker istortion. New style easy access steel case gives cessed controls, making transport safe and easy. cceedingly well ventilated for long life. Amplifier mplete in steel case, with built-in 15 ohm mu-metal ielded microphone transformer, tropical finish.

As illustrated. Price **36½ Gns.**



C.P.20A. 15 WATT AMPLIFIER

for 12 volt battery and A.C. Mains operation. This improved version has switch change-over from A.C. to D.C. and "stand by" positions and only consumes 5½ amperes from 12 volt battery. Fitted mu-metal shielded microphone transformer for 15 ohm microphone, and provision for crystal or moving iron pick-up with tone control for bass and top and outputs for 7.5 and 15 ohms. Complete in steel case with valves.

As illustrated. Price £28 0 0

RECORD REPRODUCER

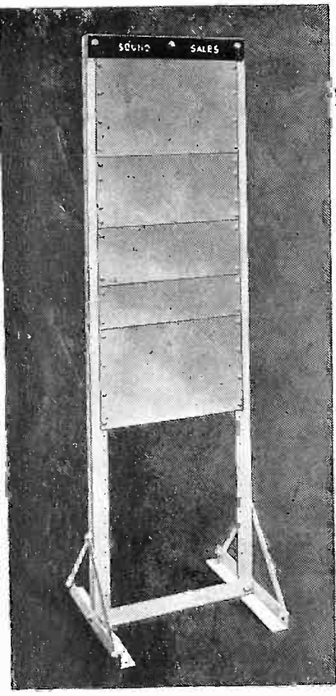
This is a development of the A.C.20 amplifier with special attention to low noise level, good response (30—18,000 cps.) and low harmonic distortion (1 per cent. at 10 watts). Suitable for any type of pick-up with switch for record compensation, double negative feedback circuit to minimise distortion generated by speaker. Has fitted plug to supply 6.3 v. 3 amp. L.T. and 300 v. 30 m/A. H.T. to a mixer or feeder unit. **Complete in metal cabinet** and extra microphone stage. *As illustrated.* Price **25½ Gns.**
CHASSIS, without extra microphone stage. Price **£21 0 0.**

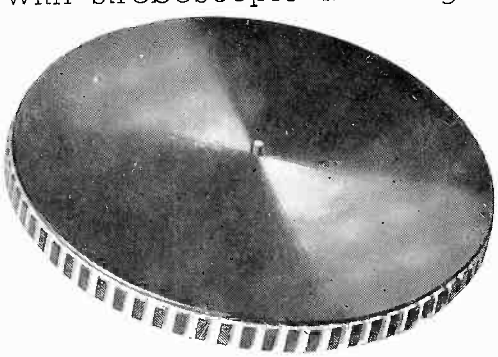
Vortexion LIMITED

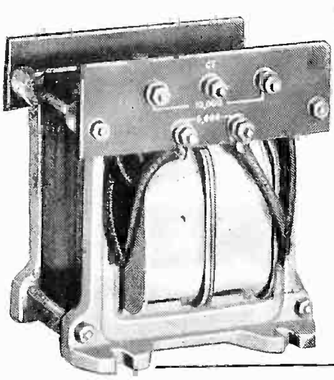
257-261, THE BROADWAY, WIMBLEDON, LONDON, S.W.19

TELEPHONES: LIBerty 2814 and 6242-3.

TELEGRAMS: "VORTEXION, WIMBLE, LONDON."

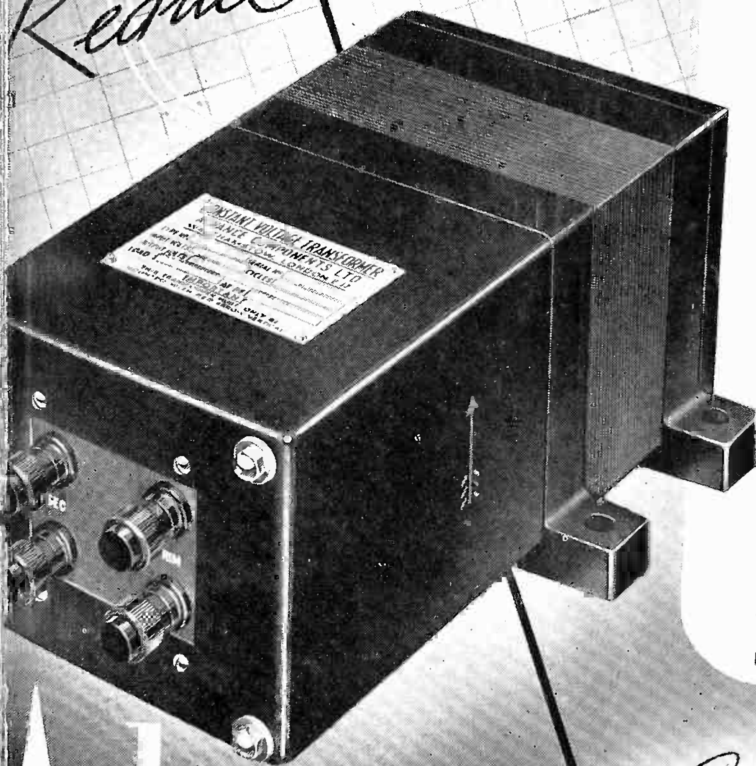






This is where *we* come in

Reduce LINE VOLTAGE VARIATIONS TO ±1%



INPUT POWER FACTOR OVER 90%

MODELS NOW IN PRODUCTION

Type No.	Input. Volts.	Output. Volts-R.M.S.	Watts.	Price. £	s.	d.
MT.189A	190-260	230	10	3	15	0
MT.189E	,,	6	4	3	15	0
MT.189F	,,	12	4	3	15	0
MT.161A	,,	230	60	7	11	3
MT.161C	95-130	110	60	7	11	3
MT.161D	,,	230	60	7	11	3
MT.161E	190-260	6	50	7	11	3
MT.161F	,,	12	50	7	11	3
MT.140A	,,	230	150	10	0	0
MT.140B	,,	110	150	10	0	0
MT.140C	95-130	110	150	10	0	0
MT.140D	,,	230	150	10	0	0
MT.140E	190-260	6	120	10	0	0
MT.140F	,,	12	120	10	0	0
MT.267A	,,	230	250	15	0	0
MT.267B	,,	110	250	15	0	0
MT.262A	,,	230	500	21	0	0
MT.266A	,,	230	1,000	35	0	0
MT.218A	,,	230	1,800	50	0	0

Special Quotations for Quantities.

ADVANCE COMPONENTS, LTD.,
Back Road, Shernhall Street, Walthamstow,
London, E.17. *Telephone: Larkswood 4366-7-8.*

Advance *Constant Voltage* TRANSFORMERS

E.M.I. RESEARCH LABORATORIES LTD., have vacancies for qualified research engineers with experience in the design and development of

a) **High Frequency Transmitters**
b) **Transmitting Aerial Systems**
c) **Radar Equipment**
d) **Electro-acoustic Equipment**

Applications, giving full particulars of qualifications and experience, together with the salary expected, should be addressed to

The Personnel Manager,

The Gramophone Co. Ltd., Hayes, Middlesex

Mechanical designers with experience in the design of small mechanisms are invited to apply for progressive posts with a leading firm manufacturing Radio Communication, Civil Aviation (Airborne and ground) and Radar equipment. Applicants should give full details of experience and quote salary required to Box No. 915.

Well-known firm require draughtsmen with experience in laying out and detailing of designs for Broadcast and Television Receivers and communication equipment; Stable posts for suitable applicants. State experience and salary required to Box No. 916.

Electronic Engineer required by progressive firm on East Coast, for construction, development and maintenance of process test equipment. Must be really practical man. Five day week. Please state full details education, training, experience, age. All applications will be treated with confidence. Box No. 688.

A firm which manufactures a very wide range of tele-communications equipment requires engineers to develop radio communications equipment in its rapidly expanding V.H.F, and centimetre fields. Excellent opportunities exist for suitable applicants, the equivalent of a degree and preferably some experience in design is required. Apply stating age, experience and salary required, to Box 753.

Radar Engineer required for planning and demonstration commercial marine instruments. Will be based on London area. Apply in writing stating age, qualifications and salary required to Box No. 375.

Senior and junior draughtsmen required for work on prototype equipment in connection with television transmitters. Seniors should have some experience in light electrical engineering. Apply by letter only, stating age, experience and qualifications to the Director, Research Laboratories of the General Electric Co., Ltd., Wembley, Middx.

Honours graduate, aged under 28, with some experience in research work and development of wide band amplifiers, is required for research and development work on ultra high frequency and television apparatus. Apply by letter only, stating age, qualifications and experience to the Director, Research Laboratories of the General Electric Co. Ltd., Wembley, Middx.

APPOINTMENT

TEST ENGINEER required, with knowledge of high power high frequency valve generators. *Box No. 6853.*

A. C. Cossor, Ltd., Radio and Television Manufacturers, require Rad Research Engineers with Physics, Engineering or Mathematics degre or equivalent technical experience in Radio, Television, Acoustic electronic instrument design. The vacancies are for experienced e gineers only. Salaries, £600—£900 p.a., according to qualification Also required, University Graduates without commercial experien who will receive an engineering training at commencing salaries £400 p.a. 5-day week. Canteen on premises. Apply by letter Staff Manager, A. C. Cossor, Ltd., Research Laboratories .Highbu Grove, N.5.

Philips Group of Companies have vacancies for Senior Engineers, Electrical and Mechanical, for work on Radio and Television Receiver design at Mitcham. The posts are permanencies and salary ranging from £500 to £800 per annum will be offered to suitable applicants according to qualifications and previous experience. Apply in writing to Secretary, Mitcham Works Limited, Mitcham Junction, Surrey.

Required in Slough district, development and design engineers experienced in the following categories of radio work: (1) H.F. high power transmitters: (2) V.H.F. low power multiple-channel F.M. transmitters: (3) V.H.F. receivers for (2): (4) Portable single channel transmitter/receiver sets. Salary according to experience Write Box 590, Dorlands, 18/20, Regent Street, London, S.W.1.

Leading component manufacturers require the services of a graduate radio engineer to carry out research and development programmes in connection with electronic components, fuses and suppressors. Good background in general physics and some inventive ability essential. Salary will be in accordance with qualifications and experience but will not exceed £500 per annum Give full details of age, education and experience. Box No. 276.

WHAT'S BEHIND IT ALL?

Extensive research laboratories, special design and development departments, wide manufacturing resources—all at your service, but not on your overheads! When you use any Hunt Capacitor, whether a normal type or as advanced as the Hunts exclusive Metallised Paper series, you are benefiting from everything that Hunt's have achieved many years of whole-hearted spec isation in capacitor design and manuf ture. To specify Hunts as standard, choose Hunts for replacements, to dec on Hunts for special purpo —all are the wise actions people who demand nothi but complete reliabili

HUNTS CAPACITORS
TRADE MARK

A. H. HUNT LTD · LONDON · S.W.18

Established 1901

Printed in Great Britain 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

Vol. XXIV. JULY 1947 No. 286

EDITORIAL

Amplitude and Frequency Modulation

IN this number we publish an article sent to us from the U.S.A. by M. G. Nicholson in which the relative merits of the two methods of modulation are compared. This article should serve as a warning to those who are under the impression that frequency modulation is greatly superior to amplitude modulation in most, if not in all, circumstances. One is apt to gain such an impression from the campaign that is being waged on behalf of frequency modulation, especially in America. Mr. Nicholson says that much confusion is caused by comparison between the two under entirely differents sets of conditions. When the conditions are similar he maintains that there is surprisingly little to choose between them. It is obviously useless to compare results obtained with amplitude modulation at medium frequencies with those obtained with frequency modulation at very high frequencies; the comparisons must be made under similar conditions. The article is based on both theoretical and practical results.

In comparing the fidelity of reproduction, better results are naturally obtained with f.m. at a frequency of 50 Mc/s and a channel width of 200 kc/s than with a.m. at 1 Mc/s and a channel width of only 10 kc/s, but this must not be put to the credit of the method of modulation but to that of the high frequency which makes the greater channel width possible.

The author discusses the effects of all the various forms of interference and, as can be seen at once from his conclusions, finds that only where fluctuation noise is the limiting factor is frequency modulation superior to amplitude modulation; in all other cases he maintains that the latter is the better of the two. This is very important in view of the frequent complaints of the interference caused by motor-car ignition systems. The author goes very fully into such impulse interference and comes to the conclusion that amplitude modulation is superior to frequency modulation in discriminating against it.

Considerable attention is devoted to the subjects of pre-emphasis and de-emphasis which are essential in f.m. in order to reduce the excessive noise at high audio frequencies, and which consequently give a greater improvement in f.m. than in a.m.

Even if some of the results are queried, it is obvious that any organisation proposing to install and test frequency modulation must, if the results are to be of any value, also install and test amplitude modulation of the same, or a similar, transmitting station under identical conditions. If Mr. Nicholson's arguments and experimental results are even approximately correct, there should be surprisingly little difference in the final performance.

G.W.O.H.

B

Vicalloy—A Workable Alloy for Permanent Magnets

A MONOGRAPH by E. A. Nesbitt with this title has recently been issued by the Bell Telephone System. Phenomenal advances have been made in the last sixteen years in materials suitable for permanent magnets. In the Editorial of July 1942 we discussed some of these advances and pointed out that the mechanical properties of the new alloys of the Alnico or Ticonal type had revolutionized production methods, since they cannot be turned, milled, drilled or tapped, and the magnets have consequently to be cast and ground. This is due to the excessive brittleness of these alloys. In the new alloy called Vicalloy (v=vanadium, i=iron, c=cobalt) this disadvantage is eliminated to a large extent and the material can be rolled and drawn. It has been used commercially as a tape 0.002 in by 0.05 in for the recording of speech in the Western Electric Mirrorphone. The range of percentage composition is given as—iron 30 to 52, cobalt 36 to 62, vanadium 4 to 16. In many ways the properties of the alloy are quite contrary to what one would expect from experience with the old-fashioned carbon steels. After quenching in oil from 1,200° C the residual B_r was 4,950 and the coercive force H_c, 51; after aging—one can scarcely call it annealing—for 8 hours at 600° C B_r had increased to 9,000 and H_c to 300; in fact this aging process is necessary to give it its permanent magnet properties. Another strange result is that, although Vicalloy with 14 per cent vanadium is almost non-magnetic before it is cold-worked, by rolling and drawing it cold until its cross-section is reduced to 5 per cent of its original value and then aging at 600° C one obtains a material with the very high (BH) maximum value of 2.8×10^6 in the longitudinal direction. In the transverse direction the value of $(BH)_m$ would be only a fraction of this.

Although the magnetic properties of Vicalloy are inferior to those obtainable with Ticonal, its mechanical properties, which allow it to be machined, punched, drilled, and tapped, will in many applications more than compensate for its magnetic inferiority.

G. W. O. H.

TRANSMISSION IN WAVEGUIDES*

Cross-section Partly of Solid Dielectric

By Alice M. Woodward, M.A.

(Telecommunications Research Establishment, Ministry of Supply)

SUMMARY.—The theory of transmission of an H_{01} wave† in a rectangular wave-guide containing longitudinal slabs of solid dielectric is developed. Formulae are given for phase constant and attenuation which take into account imperfect conductivity of the guide walls as well as losses in the dielectric. Numerical values are given for polythene as dielectric. At high frequencies most of the energy travelling down the guide is confined to the dielectric slabs. The phase constant and attenuation are then nearly equal to their values for a completely-filled guide.

Introduction

MANY papers[1, 2, 3, 4, 5] have now been written on the theory of the transmission of electromagnetic waves in waveguides completely-filled with a dielectric material. They show that the phase velocity of the wave depends on its frequency and on the dielectric material used, being greatest for a guide filled with air. It is evident then, that the phase-velocity of a wave of any given frequency can be controlled by varying the dielectric constant of the material in the guide or, as this is not always convenient, by using two dielectrics in varying proportions. Energy considerations prompt the use of air as one of the dielectrics, since the conductivity of a solid dielectric leads to quite considerable losses. Moreover, it has

* MS. accepted by the Editor, July, 1946.

† An H-wave in a guide is defined as one in which there is no electric vector in the direction of the length of the guide.

been pointed out[5] that the losses in the conducting walls of an air-filled guide are less than those in a guide filled with any other dielectric. Polythene is a convenient material for the other dielectric.

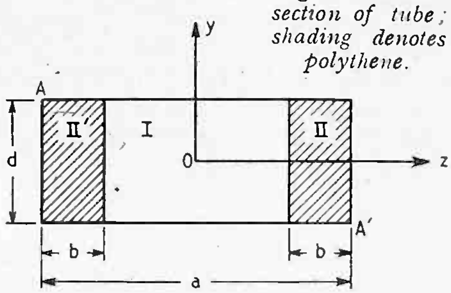


Fig. 1. *Cross-section of tube; shading denotes polythene.*

This paper, which was first prepared as a T.R.E. Report in October 1941, deals with a rectangular waveguide partially filled with polythene, its cross-section being as indicated in Fig. 1. An H_{01}-wave is propagated down the guide, its electric vector parallel to Oy. In Sections 2 and 3, the phase-constant and the attenuation due to losses in the polythene are derived on the assumption that the walls of the guide are perfectly conducting, as their imperfect conductivity makes a negligible correction. The attenuation of the wave due to losses in the imperfectly conducting walls is taken account of separately in Section 4.

2. Phase-Constant in a Perfectly-Conducting Guide

In Fig. 1, AA′ represents the cross-section of a conducting pipe of great length perpendicular to the paper. Regions II and II′ are filled with a solid dielectric of dielectric constant κ_1, permeability μ_1 and conductivity σ_1. Region I is air-filled, with dielectric constant κ_0, and permeability μ_0.

Suppose an H_{01}-wave to be travelling down the guide. The field-intensities of electromagnetic waves in pipes have been derived elsewhere and it is sufficient to state here that, in Region I,

$$\left.\begin{aligned} E_y &= A\cos\{z\sqrt{k_0^2+P^2}\}\,e^{-Px+j\omega t} \\ H_z &= \frac{P_1}{j\omega\mu_0}\times \\ &\quad A\cos\{z\sqrt{k_0^2+P^2}\}\,e^{-Px+j\omega t} \\ H_x &= -\frac{\sqrt{k_0^2+P^2}}{j\omega\mu_0}\times \\ &\quad A\sin\{z\sqrt{k_0^2+P^2}\}\,e^{-Px+j\omega t} \end{aligned}\right\} \quad 2.1$$

where $k_0^2 = \omega^2\mu_0\kappa_0$, and $\omega = 2\pi \times$ frequency: P, the propagation constant $= \alpha + j\beta$.

Assuming, at first, that the tube is a perfect conductor, the fields in II are, likewise,

$$\left.\begin{aligned} E_y &= B\sin\{(\tfrac{1}{2}a - z)\sqrt{k_1^2+P^2}\}\,e^{-Px+j\omega t} \\ H_z &= \frac{P}{j\omega\mu_1}B\sin\{(\tfrac{1}{2}a - z)\sqrt{k_1^2+P^2}\}\,e^{-Px+j\omega t} \\ H_x &= -\frac{\sqrt{k_1^2+P^2}}{j\omega\mu_1}B\cos\{(\tfrac{1}{2}a - z)\sqrt{k_1^2+P^2}\}\,e^{-Px+j\omega t} \end{aligned}\right\} \quad \ldots \quad 2.2$$

where $k_1^2 = \omega^2\mu_1\kappa_1 - j\omega\mu_1\sigma_1$.

The propagation constant, P, is obtained from the boundary conditions at the interface of the air and the dielectric where E_y and H_x must be matched. This gives

$$A\cos\{(\tfrac{1}{2}a - b)\sqrt{k_0^2+P^2}\}$$
$$= B\sin\{b\sqrt{k_1^2+P^2}\}\times$$
$$\frac{\sqrt{k_0^2+P^2}}{j\omega\mu_0}A\sin\{(\tfrac{1}{2}a - b)\sqrt{k_0^2+P^2}\}$$
$$= \frac{\sqrt{k_1^2+P^2}}{j\omega\mu_1}B\cos\{b\sqrt{k_1^2+P^2}\},$$

yielding

$$\frac{\sqrt{k_0^2+P^2}}{\mu_0}\tan\{(\tfrac{1}{2}a - b)\sqrt{k_0^2+P^2}\}$$
$$= \frac{\sqrt{k_1^2+P}}{\mu_1}\operatorname{cotan}\{b\sqrt{k_1^2+P^2}\} \quad \ldots \quad 2.3$$

Neglecting σ_1 initially, so that $\alpha = 0$, Equation 2.3, rewritten with $P = j\beta$ is

$$\left.\begin{aligned} \frac{\sqrt{k_0^2-\beta^2}}{\mu_0}\tan\{(\tfrac{1}{2}a - b)\sqrt{k_0^2-\beta^2}\} &= \frac{\sqrt{k_1^2-\beta^2}}{\mu_1}\operatorname{cotan}\{b\sqrt{k_1^2-\beta^2}\},\ \text{for } \beta^2<k_0^2 \\ -\frac{\sqrt{\beta^2-k_0^2}}{\mu_0}\tanh\{(\tfrac{1}{2}a - b)\sqrt{\beta^2-k_0^2}\} &= \frac{\sqrt{k_1^2-\beta^2}}{\mu_1}\operatorname{cotan}\{b\sqrt{k_1^2-\beta^2}\},\ \text{for } k_0^2<\beta^2<k_1^2 \end{aligned}\right\} \quad 2.4$$

Equations 2.4 may be solved graphically for β, the first branches of the curves giving β for the H_{01} wave. Subsequent branches give higher order waves. The product of tube-width, a, and cut-off frequency is obtained from Equation 2.4 by putting $\beta = 0$, and is plotted against b/a in Fig. 2.

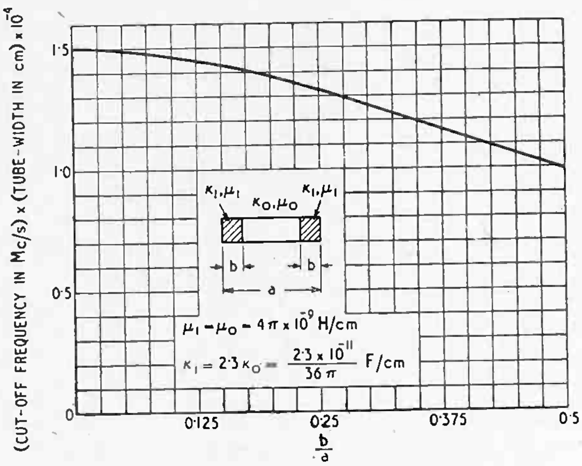


Fig. 2. *Cut-off frequency.*

Fig. 3 gives graphs, calculated from Equation 2.4, of $a\beta$ against the product of a and frequency for

$$\frac{b}{a} = 0, \frac{1}{8}, \frac{1}{4}, \frac{3}{8}, \frac{1}{2}.$$

The solid dielectric used is polythene, for which the following constants are assumed:

$$\mu_1 = \mu_0 = 4\pi \,.\, 10^{-9} \text{ henrys/cm}$$

$$\kappa_1 = 2.3\kappa_0 = 2.3 \,.\, 10^{-11}/36\pi \text{ farads/cm.}$$

It is interesting to notice that the curves tend to follow that for $\frac{b}{a} = 0$ (the curve for the air-filled guide) but then bend away from it towards the curve, $\frac{b}{a} = \frac{1}{2}$ (the guide completely filled with polythene). This is particularly evident on the curve $\frac{b}{a} = \frac{1}{8}$. The bend in the curves occurs where

$$\beta_2{}^2 = k_0{}^2 = k_1{}^2 - \left(\frac{\pi}{2b}\right)^2 \quad \ldots \quad \ldots \quad 2.5$$

which is the equation of a straight line through the origin in Fig. 3, and defines the frequency at which the wave in the air-filled part of the guide is plane and travels with the velocity of light in free space. It has been shown elsewhere[5] that the wave in the guide can be split up into two elementary plane waves travelling in directions making angles $\tan^{-1}\left\{\pm\frac{\sqrt{k^2 - \beta^2}}{\beta}\right\}$ with the direction of the length of the tube. These angles are the critical or Brewster angles for the slabs of polythene when $\beta = k_0$, and above this frequency, which is defined in Equation 2.5, the elementary waves undergo complete internal reflection in the polythene. Below this frequency the transverse components of the electric and magnetic fields are at a maximum in the air-filled part of the guide, above it their maxima occurs in the dielectric.

3. Losses in the Dielectrics

In the preceding section, $j\beta$ was found as a first approximation to P in Equation 2.3. In order to find the attenuation constant α, let $k_1{}^2$ assume its correct value,

$$k_1{}^2 = \omega^2\mu_1\kappa_1 - j\omega\mu_1\sigma_1$$

$$= \omega^2\mu_1\left(\kappa_1 - j\frac{\sigma_1}{\omega_1}\right)$$

Then $P = \alpha + j\beta = j(\beta - j\alpha)$.

If σ_1 is sufficiently small, it may be assumed that β has substantially the same value as for $\sigma_1 = 0$, and that $j\alpha$ is a small purely imaginary correction to it. If Equation 2.3 be written

$$f\left(\beta - j\alpha,\ \kappa_1 - j\frac{\sigma_1}{\omega},\ \omega\right) = 0$$

then, since $j\alpha$ and $j\sigma_1/\omega$ are small, the function f can be approximated to by the

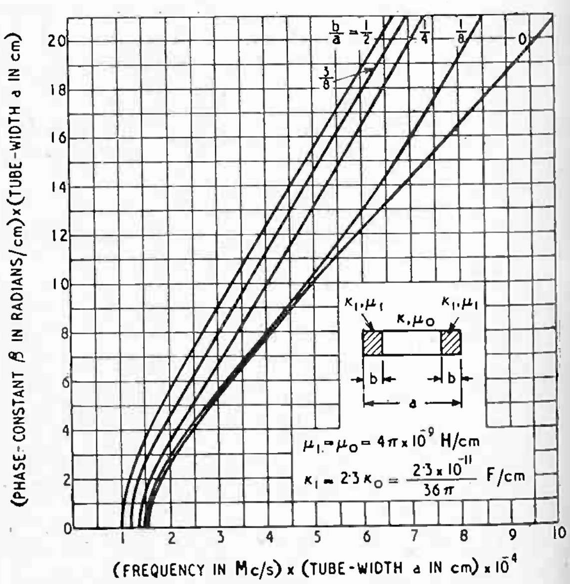


Fig. 3. *Phase-constant for H_{01} wave with E parallel to interfaces between air and polythene.*

first two terms of its expansion in powers of $j\alpha$ and $j\sigma_1/\omega$. Thus

$$\left.\begin{aligned} f(\beta, \kappa_1, \omega) - j\alpha \frac{\partial}{\partial\beta} f(\beta, \kappa_1, \omega) \\ - j\frac{\sigma_1}{\omega}\frac{\partial}{\partial\kappa_1} f(\beta, \kappa_1, \omega) = 0 \end{aligned}\right\} \quad 3.1$$

and $f(\beta, \kappa_1, \omega) = 0$.

This reduces to

$$\frac{\alpha\beta}{\mu_1}\left[-\frac{k_1^2 - k_0^2}{(k_0^2 - \beta^2)\sqrt{k_1^2 - \beta^2}}\operatorname{cotan}\{b\sqrt{k_1^2 - \beta^2}\} + \frac{\mu_1}{\mu_0}(\tfrac{1}{2}a - b) + b \right.$$
$$\left. + \{(\tfrac{1}{2}a - b)\frac{\mu_0}{\mu_1}\frac{k_1^2 - \beta^2}{k_0^2 - \beta^2} + b\}\operatorname{cotan}^2\{b\sqrt{k_1^2 - \beta^2}\}\right]$$
$$= \tfrac{1}{2}\sigma\omega\left[b + b\operatorname{cotan}^2\{b\sqrt{k_1^2 - \beta^2}\} - \frac{\operatorname{cotan}\{b\sqrt{k_1^2 - \beta^2}\}}{\sqrt{k_1^2 - \beta^2}}\right] \quad \ldots \quad 3.2$$

where β is given by Equations 2.4.

Equation 3.2 gives the attenuation constant, α, of an H_{01}-wave in the tube, the attenuation being due to the losses in the dielectric. Graphs of this attenuation, when the dielectric is polythene of conductivity 1.9×10^{-6} mhos/cm, are given in Fig. 4 for several values of $\frac{b}{a}$. In every case, as the frequency increases indefinitely, the attenuation tends to the same value. The reason for this may be made clear from the discussion at the end of Section 2. As the frequency increases above the value, given by Equation 2.5, at which the wave travels down the guide with a phase-velocity equal to the velocity of light, more and more of the energy in the wave is confined to the solid dielectric in the guide. This means that a greater proportion of the energy in the wave is lost in heating up the dielectric. Thus for high frequencies the attenuation suffered by the wave in a partially-filled guide increases with increasing frequency, and in the limit has the same value as it would have if the solid dielectric completely filled the guide.

4. Losses in the Conducting Walls of the Tube

Up to this stage the walls of the tube have been assumed perfectly conducting. In fact, they have a finite, though very large, conductivity. The form of the wave is not appreciably distorted from its form in a perfectly conducting tube, but instead of perfect reflection occurring at the walls of the tube, a rapidly attenuated wave travels into them. The ratio of electric to magnetic field-intensity in this wave is given by[6]

$$\frac{E}{H} = \left(\frac{j\omega\mu_2}{\sigma_2}\right)^{1/2}$$

where μ_2 is the specific inductance, and σ_2 the conductivity of the metal. The power going into this wave represents a loss of energy to the wave travelling down the tube.

The average power per cycle flowing through unit area in any direction is

$S =$ Real part of $\tfrac{1}{2}E \wedge H^*$,

where E and H are the electric and magnetic vectors perpendicular to the given direction,

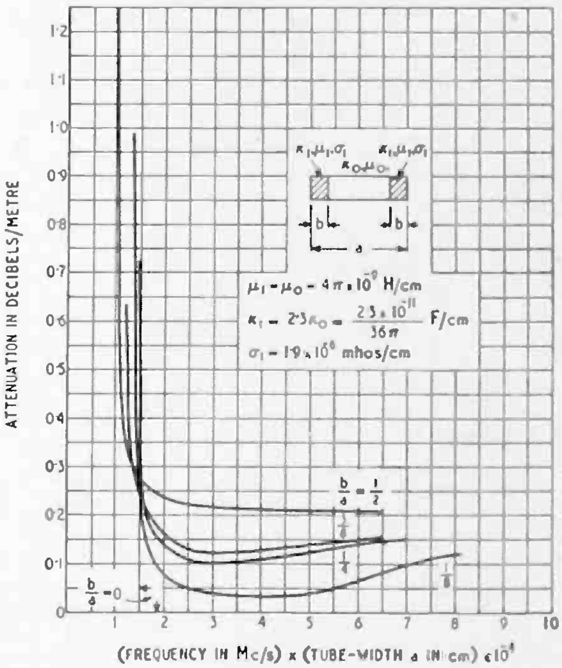


Fig. 4. *Dielectric losses for H_{01} wave with E parallel to interfaces between air and polythene.*

H^* denotes the complex conjugate of H and $\wedge$ signifies vector product. Power flowing per unit area into the metal is, therefore,

$$S = \tfrac{1}{2}|H|^2\left(\frac{\omega\mu_2}{2\sigma_2}\right)^{1/2}$$

where H is the tangential component of the magnetic-field intensity at the surface of the tube and, provided the conductivity is large, is very nearly equal to H of Equations 2.1 and 2.2 for walls of infinite conductivity. The small difference between them may be neglected.

Thus the average power absorbed per unit length of tube by the walls $z = \pm\frac{a}{2}$ is

$$S_1 = \frac{A^2 d}{\omega^2\mu_1^2}\left(\frac{\omega\mu_2}{2\sigma_2}\right)^{1/2}(k_1^2 - \beta^2) \times \frac{\cos^2\{(\frac{1}{2}a - b)\sqrt{k_0^2 - \beta^2}\}}{\sin^2\{b\sqrt{k_1^2 - \beta^2}\}}$$

Average power absorbed per unit length by the walls $y = \pm\frac{d}{2}$ in Region I is

$$S_2 = A^2(\tfrac{1}{2}a - b)\left(\frac{\omega\mu_2}{2\sigma_2}\right)^{1/2}\frac{k_0^2}{\omega^2\mu_0^2}.$$

Average power absorbed per unit length by walls $y = \pm\frac{d}{2}$ in Region II is

$$S_3 = \frac{A^2 b}{\omega^2\mu_1^2}\sqrt{\frac{\omega\mu_2}{2\sigma_2}}\,k_1^2 \times \frac{\cos^2\{(\frac{1}{2}a - b)\sqrt{k_0^2 - \beta^2}\}}{\sin^2\{b\sqrt{k_1^2 - \beta^2}\}}$$

Average power flow in direction of tube through I is

$$W_1 = A^2 d\frac{\beta}{\omega\mu_0}\left[\tfrac{1}{4}a - \tfrac{1}{2}b + \frac{\sin\{(a - 2b)\sqrt{k_0^2 - \beta^2}\}}{4\sqrt{k_0^2 - \beta^2}}\right]$$

Average power flow in direction of tube through II is

$$W_2 = A^2 d\frac{\beta}{\omega\mu_1}\frac{\cos^2\{(\frac{1}{2}a - b)\sqrt{k_0^2 - \beta^2}\}}{\sin^2\{b\sqrt{k_1^2 - \beta^2}\}} \times \left[\tfrac{1}{2}b - \frac{\sin\{2b\sqrt{k_1^2 - \beta^2}\}}{4\sqrt{k_1^2 - \beta^2}}\right]$$

The attenuation constant due to losses in the conducting walls of the tube is[6]

$$\alpha' = \frac{1}{2}\cdot\frac{\text{Power loss per unit length of tube}}{\text{Power transmitted down the tube}} = \frac{S_1 + S_2 + S_3}{2(W_1 + W_2)}$$

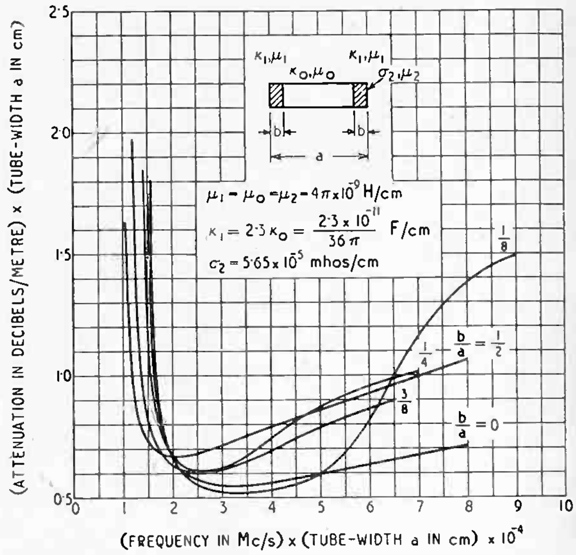


Fig. 5. *Copper losses for H_{01} wave with E parallel to interfaces between air and polythene.*

Fig. 5 illustrates the attenuation for a copper pipe, of conductivity 5.65×10^5 mhos/cm. Again all the curves except that for $b = 0$ have the same asymptote as frequency increases indefinitely.

REFERENCES

[1] Lord Rayleigh, "On the Passage of Electromagnetic Waves through Tubes, or the Vibration of Dielectric Cylinders," *Phil. Mag.*, February 1897

[2] J. R. Carson, S. P. Mead, and S. A. Schelkunoff, "Hyper-frequency Wave Guides—Mathematical Theory," *Bell Syst. tech J.*, April 1936.

[3] W. L. Barrow, "Transmission of Electromagnetic Waves in Hollow Tubes of Metal," *Proc. Inst. Radio Engrs.*, October 1936.

[4] S. A. Schelkunoff, "Transmission Theory of Plane Electromagnetic Waves," *Proc. Inst. Radio Engrs.*, November 1937.

[5] L. J. Chu and W. L. Barrow, "Electromagnetic Waves in Hollow Metal Tubes of Rectangular Cross-section," *Proc. Inst. Radio Engrs.*, December 1938.

[6] Stratton, "Electromagnetic Theory," p. 543 *et seq.*

COMPARISON OF AMPLITUDE AND FREQUENCY MODULATION

By M. G. Nicholson

(Research Department, Colonial Radio Corporation, Buffalo, N.Y.)

WHILE much has been published about the comparison of amplitude and frequency modulation, there is still much confusion on this controversial subject. Unfortunately, most of this confusion has been brought about by comparing the two under entirely different sets of conditions. The usual comparison has been between f.m. at 40–50 Mc/s with a channel width of about 200 kc/s, and a.m. restricted to a channel width of about 10 kc/s at a signal frequency of 1 Mc/s or less. Under such widely different conditions, static, natural and man-made, is radically different. Likewise, so called "high-fidelity" cannot be obtained on a restricted channel width of 10 kc/s, whether the type of modulation is f.m. or a.m. It is of interest to compare a.m. and f.m. under identical conditions of operation at the frequencies normally used for f.m. When the conditions of operation are substantially alike, and when good engineering is used in the design and construction of both systems, it has been found that there is surprisingly little difference in the final results.

This discussion is primarily centred around those conditions (frequency stability, channel-width, receiver bandwidth, etc.) normally realized in the v.h.f. band (30 to 300 Mc/s), as they affect interference and noise with f.m. and a.m. signals under similar conditions. Comparison of a.m. and f.m. will be made with respect to co-channel and adjacent channel interference, random noise, effects of frequency instability, and so-called "satellite" station performance.

Interference

In the reception of two f.m. signals operating on substantially the same frequency, the weaker signal is suppressed to a great extent. In the case of two a.m. signals operating on substantially the same frequency, no such suppression exists. The resulting interference in a.m. is directly proportional to the ratio of the r.m.s. voltage of the weaker signal to the r.m.s. voltage of the stronger signal. Interference is defined here as the ratio of the r.m.s voltage in the a.f. output circuit which results from the presence of the weaker signal, to the r.m.s. voltage which results from full modulation of the stronger signal alone, [1,2]. Since the r.m.s. voltage of the weaker a.m. signal with 100 per cent modulation is only 3 db above that for no modulation, it follows that the interference is primarily that of the heterodyne beat note.

Theoretical and field test comparisons of a.m. and f.m. with the interfering signal on substantially the same frequency have been published,[3, 4, 5, 6,] showing that under these restricted conditions f.m. will experience less interference than a.m. Unfortunately, virtually no information has been published concerning the comparison of a.m. and f.m. at frequency differences between the desired and undesired signals corresponding to adjacent-channel separation. Hans Roder points out that f.m. may be as much as 40 db inferior to a.m. under certain conditions of operation.[7] The degree of selectivity assumed by Roder in arriving at this value was definitely greater than is likely to be used. Calculations based upon Roder's method, but with a degree of selectivity more nearly that of an average f.m. receiver indicate marked superiority of a.m. over f.m. in the suppression of an undesired signal on an adjacent channel or on a second-channel separation.

In order to obtain more specific information on the relative abilities of f.m. and a.m. to combat interference, an f.m. receiver was used in making the comparison. For a.m. reception, the limiter grid circuit served as the a.m. detector, while the output of the limiter fed a balanced discriminator which served as the f.m. detector. The degree of selectivity in the receiver used in this test was quite similar to published data [8, 9] on receivers designed for f.m. using a 75-kc/s deviation. Curve A of Fig. 1 is the selectivity of this receiver. The bandwidth at an attenuation of 6 db is 175 kc/s. De-emphasis of the higher audio frequencies was applied to the outputs of the a.m. detector and of the f.m. discriminator, the frequency response of the network being that of a 75-μsec time-constant circuit, which is the present recommendation for f.m. broadcast reception.

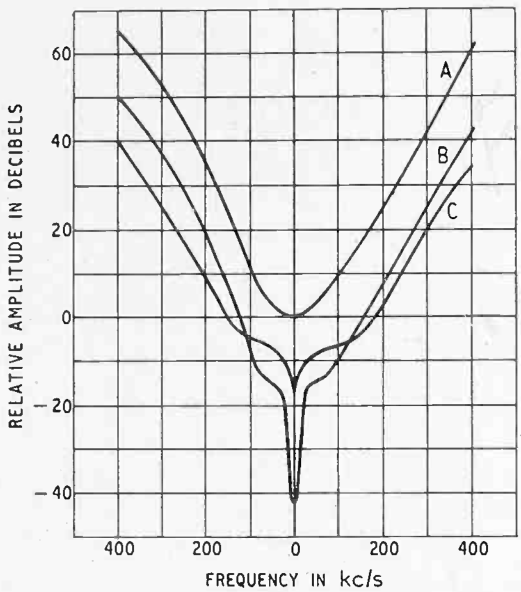


Fig. 1. *The selectivity curve of the receiver is shown at A, while B and C represent the signal levels causing 40 db interference for a.m. and f.m. respectively.*

The signal sources consisted of two standard-signal generators, one of which could be modulated with either f.m. or a.m. The a.m. was substantially void of f.m. since the modulation was accomplished in a stage well isolated from the oscillator. The f.m. was substantially void of a.m. as the result of careful design and adjustment of the modulator, as well as the action of the limiters following the modulator. This generator supplied the interfering signal for both f.m. and a.m. tests.

In this way, it was possible to use the same signal generators, and the same receiver for both f.m. and a.m., merely by selecting the type of modulation and the type of detection by simple audio-frequency switching. Besides being much more convenient, the accuracy of comparison is greater than if two different pairs of signal generators, and two different receivers had been used for completely separate f.m. and a.m. tests.

The degree of interference used in making these comparisons was such that the interference resulting in the a.f. output circuit was 40 db below the full modulation level of the desired signal. The modulation level of the undesired signal was adjusted to that level which produced maximum interference for each measured point, with the upper limit of modulation at 100 per cent for a.m. and 75 kc/s deviation for f.m. Full modulation produced maximum interference under all conditions of a.m., and also for all conditions of f.m. except where the desired signal and the undesired signal were sufficiently close together in frequency to cause an audible beat note. Under this latter condition, maximum interference occurred with little or no modulation on the undesired signal.

In the case of amplitude modulation the resulting interference is primarily that of the beat frequency between the carrier of the desired signal and the carrier of the undesired signal when the beat frequency is an audible frequency. If, however, the frequency of the beat is above audibility, the remaining interference is only that resulting from the modulation of the undesired carrier. F. E. Terman [10] points out that very great suppression of the weaker signal is brought about whenever the ratio of the signals at the detector is 2 : 1 or greater, provided a linear detector is used. This effect of a linear detector in suppressing the weaker signal has been discussed at some length in technical journals [7, 11, 12, 13, 14], but does not appear to be generally appreciated.

Curve B of Fig. 1 is the relative signal strength of an a.m. signal which interferes with a.m. reception to the extent of 40 db below the 100% modulation level on the desired a.m. signal. It is interesting to note that the vertical distance (db) between this curve and the selectivity curve (curve A) is substantially constant except in the small region where the frequency difference between the desired and undesired signals is within the audio-frequency range. In this region, the interference consists of an audible note in addition to the modulation of the undesired signal. Outside this region, the interference consists only of the modulation of the undesired signal. The degree of suppression of the modulation of the weaker signal by the stronger signal in this specific case amounted to about 23 db, since, in order to obtain a 40 db freedom from the modulation of the interfering signal, only about 17 db difference in signal voltages arriving at the linear detector was found necessary. This measured degree of suppression is in excellent agreement with that calculated for this case by the method used by Roder[7] in his comparison of a.m. and f.m. for interference from a transmission on an adjacent channel.

Curve C of Fig. 1 is the relative signal strength of an f.m. signal which interferes with f.m. reception to the extent of 40 db below the full modulation level (75 kc/s deviation) on the desired f.m. signal. While the general shape of this curve resembles that of the selectivity curve (curve A), there is an increase in vertical distance (db) between these two curves as the frequency difference between the desired signal and the undesired signal is increased. This means that the degree of suppression of the undesired f.m. signal by the desired f.m. signal becomes less effective as the frequency difference is increased into the region where the selectivity of the tuned circuits is an appreciable factor in determining the ratio of the two signal voltages arriving at the input of the limiter.

By comparing Curves B and C of Fig. 1, it is seen that the degree of freedom from interference for f.m. is superior to a.m. only when the separation between the signals is substantially less than the 200 kc/s separation normally used in f.m. broadcast practice. Thus, interference from the two adjacent channels and the two alternate channels will be less with an a.m. system than with an f.m. system under the typical conditions used in these tests. This advantage of a.m. over f.m. is largely counter-balanced by the advantage of f.m. over a.m. where the frequency separation is less than 100 kc/s. However, if the separations between stations are made in multiples of 100 kc/s, instead of 200 kc/s, identical frequency assignments can be substantially eliminated without reducing the number of stations within an area. This results in less total interference with a.m. than with f.m.

"Satellite" Station Operation

Experience in the v.h.f. band has shown that there are many localities which cannot be adequately covered by a single transmitter. The use of two or more a.m. stations on the same frequency carrying the same programme has been tried with rather poor results.

The use of two, or more, f.m. stations on the same frequency carrying the same programme has been somewhat more successful. This is primarily because of the so-called "capture" effect; that is, the stronger signal suppresses the weaker signal operating on the same frequency. Unfortunately, in those areas where the strengths of the two signals are almost equal, the limiter-discriminator combination is unable to receive either signal without considerable noise and distortion resulting from the mutual interference of one signal upon the other. This is often referred to as the "no-capture" area.

"Diversity" Transmission

Recently there has been published[15] the results of a method of operating two or more transmitters on the same channel without the inherent defects of the f.m. or a.m. systems operating on a single frequency. This system employs two or three a.m. transmitters operating within a single v.h.f. channel but with the frequencies of the carriers separated by 20 or 30 kc/s. In this way there is no audible beat note. The phase of the audio modulation at each transmitter must be alike, in order that the audio components arising in the linear detector will likewise be in phase. Unlike f.m., there is a smooth, distortion-free, transition when going from the area where the signal from one transmitter predominates into the area where the signal from a second transmitter predominates. There is not even the slightest suggestion of a "no-capture" area. Of the more obvious applications for such a system is v.h.f. mobile communication, such as between Police Departments and moving cars, and for a public telephone service to privately owned automobiles where a greater service area than that obtainable from a single transmitter is required, for instance, over the complete length of a highway.

In addition to giving better general coverage, this system reduces materially the "flutter" to be found in v.h.f. systems when the receiver is being moved in a field consisting of reflections of the same magnitude as that of the direct wave. The reason why "flutter" is reduced so greatly is that the location of the points of low field intensity from one transmitter bear no relationship to the location of those from the other transmitter, thus the number of points where both field intensities are simultaneously at minima is drastically reduced. Thus, as long as one signal or the other is sufficiently strong, good reception will result, since there is no distortion brought about in the transition from one signal to the other. Where "flutter" is the frequency response of the network being that of a 75-μsec time-constant circuit, which is the present recommendation for f.m. broadcast reception.

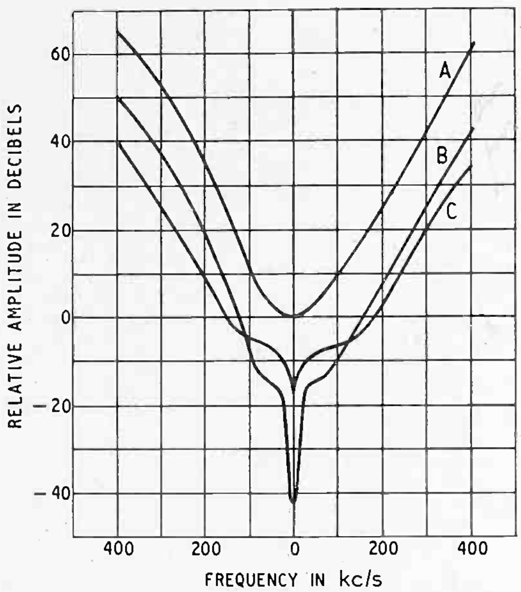


Fig. 1. *The selectivity curve of the receiver is shown at A, while B and C represent the signal levels causing 40 db interference for a.m. and f.m. respectively.*

The signal sources consisted of two standard-signal generators, one of which could be modulated with either f.m. or a.m. The a.m. was substantially void of f.m. since the modulation was accomplished in a stage well isolated from the oscillator. The f.m. was substantially void of a.m. as the result of careful design and adjustment of the modulator, as well as the action of the limiters following the modulator. This generator supplied the interfering signal for both f.m. and a.m. tests.

In this way, it was possible to use the same signal generators, and the same receiver for both f.m. and a.m., merely by selecting the type of modulation and the type of detection by simple audio-frequency switching. Besides being much more convenient, the accuracy of comparison is greater than if two different pairs of signal generators, and two different receivers had been used for completely separate f.m. and a.m. tests.

The degree of interference used in making these comparisons was such that the interference resulting in the a.f. output circuit was 40 db below the full modulation level of the desired signal. The modulation level of the undesired signal was adjusted to that level which produced maximum interference for each measured point, with the upper limit of modulation at 100 per cent for a.m. and 75 kc/s deviation for f.m. Full modulation produced maximum interference under all conditions of a.m., and also for all conditions of f.m. except where the desired signal and the undesired signal were sufficiently close together in frequency to cause an audible beat note. Under this latter condition, maximum interference occurred with little or no modulation on the undesired signal.

In the case of amplitude modulation the resulting interference is primarily that of the beat frequency between the carrier of the desired signal and the carrier of the undesired signal when the beat frequency is an audible frequency. If, however, the frequency of the beat is above audibility, the remaining interference is only that resulting from the modulation of the undesired carrier. F. E. Terman [10] points out that very great suppression of the weaker signal is brought about whenever the ratio of the signals at the detector is 2 : 1 or greater, provided a linear detector is used. This effect of a linear detector in suppressing the weaker signal has been discussed at some length in technical journals [7, 11, 12, 13, 14,] but does not appear to be generally appreciated.

Curve B of Fig. 1 is the relative signal strength of an a.m. signal which interferes with a.m. reception to the extent of 40 db below the 100% modulation level on the desired a.m. signal. It is interesting to note that the vertical distance (db) between this curve and the selectivity curve (curve A) is substantially constant except in the small region where the frequency difference between the desired and undesired signals is within the audio-frequency range. In this region, the interference consists of an audible note in addition to the modulation of the undesired signal. Outside this region, the interference consists only of the modulation of the undesired signal. The degree of suppression of the modulation of the weaker signal by the stronger signal in this specific case amounted to about 23 db, since, in order to obtain a 40 db freedom from the modulation of the interfering signal, only about 17 db difference in signal voltages arriving at the linear detector was found necessary. This measured degree of suppression is in excellent agreement with that calculated for this case by the method used by Roder[7] in his comparison of a.m. and f.m. for interference from a transmission on an adjacent channel.

Curve C of Fig. 1 is the relative signal strength of an f.m. signal which interferes with f.m. reception to the extent of 40 db below the full modulation level (75 kc/s deviation) on the desired f.m. signal. While the general shape of this curve resembles that of the selectivity curve (curve A), there is an increase in vertical distance (db) between these two curves as the frequency difference between the desired signal and the undesired signal is increased. This means that the degree of suppression of the undesired f.m. signal by the desired f.m. signal becomes less effective as the frequency difference is increased into the region where the selectivity of the tuned circuits is an appreciable factor in determining the ratio of the two signal voltages arriving at the input of the limiter.

By comparing Curves B and C of Fig. 1, it is seen that the degree of freedom from interference for f.m. is superior to a.m. only when the separation between the signals is substantially less than the 200 kc/s separation normally used in f.m. broadcast practice. Thus, interference from the two adjacent channels and the two alternate channels will be less with an a.m. system than with an f.m. system under the typical conditions used in these tests. This advantage of a.m. over f.m. is largely counter-balanced by the advantage of f.m. over a.m. where the frequency separation is less than 100 kc/s. However, if the separations between stations are made in multiples of 100 kc/s, instead of 200 kc/s, identical frequency assignments can be substantially eliminated without reducing the number of stations within an area. This results in less total interference with a.m. than with f.m.

"Satellite" Station Operation

Experience in the v.h.f. band has shown that there are many localities which cannot be adequately covered by a single transmitter. The use of two or more a.m. stations on the same frequency carrying the same programme has been tried with rather poor results.

The use of two, or more, f.m. stations on the same frequency carrying the same programme has been somewhat more successful. This is primarily because of the so-called "capture" effect; that is, the stronger signal suppresses the weaker signal operating on the same frequency. Unfortunately, in those areas where the strengths of the two signals are almost equal, the limiter-discriminator combination is unable to receive either signal without considerable noise and distortion resulting from the mutual interference of one signal upon the other. This is often referred to as the "no-capture" area.

"Diversity" Transmission

Recently there has been published[15] the results of a method of operating two or more transmitters on the same channel without the inherent defects of the f.m. or a.m. systems operating on a single frequency. This system employs two or three a.m. transmitters operating within a single v.h.f. channel but with the frequencies of the carriers separated by 20 or 30 kc/s. In this way there is no audible beat note. The phase of the audio modulation at each transmitter must be alike, in order that the audio components arising in the linear detector will likewise be in phase. Unlike f.m., there is a smooth, distortion-free, transition when going from the area where the signal from one transmitter predominates into the area where the signal from a second transmitter predominates. There is not even the slightest suggestion of a "no-capture" area. Of the more obvious applications for such a system is v.h.f. mobile communication, such as between Police Departments and moving cars, and for a public telephone service to privately owned automobiles where a greater service area than that obtainable from a single transmitter is required, for instance, over the complete length of a highway.

In addition to giving better general coverage, this system reduces materially the "flutter" to be found in v.h.f. systems when the receiver is being moved in a field consisting of reflections of the same magnitude as that of the direct wave. The reason why "flutter" is reduced so greatly is that the location of the points of low field intensity from one transmitter bear no relationship to the location of those from the other transmitter, thus the number of points where both field intensities are simultaneously at minima is drastically reduced. Thus, as long as one signal or the other is sufficiently strong, good reception will result, since there is no distortion brought about in the transition from one signal to the other. Where "flutter" is the primary problem, the use of two a.m. transmitters with their aerials located as little as 100 feet apart will bring about a marked reduction in "flutter." This type of service has been called "diversity transmission" due to its similarity to diversity reception. There is one outstanding difference, which is that the additional equipment for diversity transmission is at the transmitter, while the receiver is unchanged. This is an important factor in mobile equipment where diversity reception is hardly practicable.

The question arises as to how practicable such a system would be for broadcasting. The most serious factor is the space-phase relationship; that is, the difference in arrival time at the receiver due to the difference in time paths from the common programme source. This would limit the spacing between stations to something of the order of ten miles. While such a system could be extended to cover any desired area with a single channel, by using many low-power transmitters linked together, it probably would be prohibitive in initial and maintenance expenses.

Noise

Radio-frequency disturbances, generally referred to as "noise", consist of two distinctly different types. One type of noise produces "hiss" in the audio output, and is known variously as hiss, fluctuation, random, thermal agitation and "shot effect" noise. This fluctuation noise is characterized by a uniform distribution of energy with respect to frequency, with a ratio of peak voltage to r.m.s. voltage of about four for any given bandwidth of fluctuation noise.[16] The primary sources of fluctuation noise in a radio receiver are: (1) electron stream in the first stage of the r.f. amplifier, or in the frequency-changer if no r.f. amplifier is used; (2) electron thermal agitation in the aerial tuned circuits, and (3) fluctuation noise received by the aerial.

The second type of noise, impulse noise, consists of very short bursts of electrical energy, separated one from the other by periods of time substantially longer than the duration of an individual impulse. While impulse noise in the v.h.f. band may be caused by electrical storms (static), it is much more likely to be the result of man-made interference from electrical equipment such as electrical refrigerators, fans, elevators, switches, thermostatically controlled irons, oil-burning furnaces, automobile ignition systems, electric razors, or street cars.

Fluctuation Noise

Frequency modulation has a distinct advantage over amplitude modulation in discriminating against fluctuation noise under most conditions of operation. The magnitude of this advantage varies with the conditions of operation. Also, care must be taken in interpreting the measured or calculated differences into their probable effect upon the listener, since the frequency distribution of the audible noise from an f.m. receiver is substantially different from that from an a.m. receiver.

It is quite generally agreed that the improvement against fluctuation noise by the use of f.m. as opposed to a.m. is an r.m.s. ratio of $\sqrt{3}$, or about 4.8 db, when the deviation is equal to the highest modulation frequency. Also, this improvement increases in direct proportion to the ratio of the deviation to the highest modulation frequency. For signal levels where the amplitude of the f.m. signal is less than twice the peak amplitude of the fluctuation noise, the above relationships are no longer true, but the r.m.s. difference between f.m. and a.m. is greatly reduced. This has been called the "sputter point." It is to be noted that this critical value of signal-to-fluctuation noise ratio, below which an f.m. receiver quickly deteriorates in performance, is dependent only upon the ratio of the signal-to-fluctuation noise, and not upon the ratio of the deviation-to-highest modulation frequency. This means that any increase in the bandwidth of the receiver, over and above that necessary just to accommodate the full deviation, will raise the critical value, thereby requiring a larger signal to produce the same performance as obtained with a minimum bandwidth receiver. This may be of significance when the bandwidth of the receiver is made considerably greater than the minimum in order to allow for frequency drift of the receiver oscillator as well as for inaccuracies in tuning.

For communication[17], where the transmission of intelligence is the primary objective, consideration of the low signal level condition is particularly important, since communication can be maintained at signal levels less than twice that of the peaks of the fluctuation noise. If it is possible to maintain proper tuning when using a bandwidth only sufficiently wide to accommodate a deviation equal to the highest audio modulation frequency, f.m. should have a greater range than a.m. If, however, the bandwidth must be substantially wider, it becomes doubtful if f.m. will have any advantage over a.m. in discriminating against fluctuation noise in a communication system.

There now is a definite trend in the other direction; that is, towards the design of f.m. communication receivers with the bandwidth substantially less than that of the maximum deviation of the transmitter. In order to receive full deviation, sufficient extra amplification and limiting is included so that the attenuation of the carrier at maximum excursion due to the selectivity is compensated for in the limiter. This will work satisfactorily at any level of signal substantially above the fluctuation noise level. However, at low signal levels, a parodoxical situation exists; that is, the signal-to-noise ratio, as conventionally measured may be quite good, yet the intelligibility of the received signal may be very poor. Under these conditions of test, f.m. would appear decidedly superior to a.m., yet field tests show little difference in performance where intelligibility is the criterion.

This apparent discrepancy is readily understood if the action of such an f.m. receiver at signal levels comparable with that of the fluctuation noise is carefully analysed. As an example, let the signal be twice as strong as that signal which is just at the sputter point. Now, by slowly detuning the receiver from the carrier, the fluctuation noise will rise slowly until the sputter point is reached, beyond which, the noise quickly rises to the level which the receiver has in the absence of a carrier. Since the level of the carrier is only double that for the sputter point at exact tuning, the degree of detuning to reach the sputter point corresponds to two-to-one down on the selectivity curve of the receiver. Instead of detuning the receiver, frequency modulating the transmitter will, of course, do the same thing, except that it will be done at the modulating frequency. Thus, when the deviation extends beyond the sputter points, on each side of the centre, the modulation will be greatly distorted, and during those parts of the modulation cycle beyond the sputter point, noise will be, in effect, substituted for the modulation. From this it is seen that the use of high selectivity can result in an excessive rise in noise with modulation and high distortion at low signal levels, while at medium signal levels the performance is entirely normal.

Probably the reason for designing f.m. receivers with excessive selectivity lies in the method used for measuring the signal-to-noise ratio of a receiver. This method yields better apparent signal-to-noise ratios as the selectivity is increased. The method consists in comparing the noise output of a receiver, when there is no modulation, with the total output of the receiver at full modulation. If this is carried to the extreme, the output during modulation consists primarily of noise, modulated at the modulation frequency; thus, the so-called signal-to-noise ratio can be the noise-to-noise ratio, where the noise during modulation is compared to the noise when there is no modulation.

Pre-Emphasis and De-Emphasis

A closer examination of the nature of the audible noise arising from fluctuation noise in f.m. and a.m. receivers reveals marked differences[5, 18]. The audible noise from an a.m. receiver has the same general characteristic as fluctuation noise; that is, equal noise energy per unit of frequency increment. On the other hand, the audible noise in an f.m. receiver (without special provisions) does not have this flat frequency characteristic, but the noise energy per unit of frequency increment increases as the square of the audio frequency corresponding to each increment. Since the higher audio frequencies have the ability of arresting one's attention so much more than the lower audio frequencies, it becomes almost imperative to do something to reduce them. This is normally done by "tone controlling" the receiver, now known as de-emphasis, while at the transmitter an inverse network (so-called pre-emphasis) is used to accentuate the higher audio frequencies. In this way, the overall response of the system is made uniform. This addition to the f.m. system improves its signal-to-noise ratio. The addition of pre-emphasis and de-emphasis to an a.m. system will likewise improve its signal-to-noise ratio. However, the r.m.s. value of improvement is greater for f.m. than for a.m., since most of the noise in the f.m. receiver is in the high end of the audio spectrum, as compared to a uniform distribution in the a.m. receiver. The use of de-emphasis in an f.m. receiver will alter the noise energy distribution so that it is flat above that frequency at which the de-emphasis network becomes effective. While for an a.m. receiver, the noise energy distribution remains flat up to the point where the de-emphasis network becomes effective, above which, the noise energy per unit of frequency increment decreases at the rate corresponding to the inverse of the square of the frequency.

From this, one must conclude that while f.m. is, in general, superior to a.m. in discriminating against fluctuation noise, it is necessary to take into account the effect of different noise distribution spectra upon the listener as a correction factor upon any calculated or measured r.m.s. value of comparative merit. This means that the effectiveness of f.m. over a.m. against fluctuation noise is less than that indicated by the r.m.s. values. However, in addition to the noise distribution correction, there is another factor which is brought about by a necessary reduction of programme level entering the pre-emphasis network at the transmitter. This must be done in order to avoid over-modulation, since there is an appreciable amount of energy in the higher frequency part of the audio spectrum. Published calculations on the improvement brought about by the use of pre-emphasis and de-emphasis have usually ignored this correction, by assuming that the pre-emphasis can be applied without a reduction in the level of the lower audio frequencies.

Standard Pre-Emphasis

The degree of pre-emphasis for f.m. broadcasting has now been standardized as the voltage—frequency characteristic of an inductor and resistor in series, with a time constant of 75 μsec, and being fed from a constant-current source. Published data on the previous standard of 100 μsec time constant of pre-emphasis gave a theoretical improvement of 7.4 db to f.m. over a.m., when the programme modulation level correction was not taken into account.[5] The necessary reduction in programme level entering the 100–μsec pre-emphasis network has been reported as being from 2.5 db to 4.5 db for various types of programme material.[18]

The British Broadcasting Corporation reports[19] that a reduction of 6.5 db in programme level is generally necessary for 100–μsec pre-emphasis. While for a 50–μsec pre-emphasis the necessary level reduction is reported as 3 db. Whatever may be the magnitude of level reduction necessary for 75–μsec pre-emphasis, it should be taken into account when calculating the advantage of pre-emphasis.

Impulse Noise

Impulse noise seldom causes perceptible interference, unless the peak amplitudes of the impulses are equal or greater (usually considerably greater) than those of the signal being received, whether it is an f.m. or an a.m. signal. During these very brief periods the noise obscures the signal, while in the relatively long period between the impulses, the signal is free from noise. While the individual impulses differ greatly in duration, depending upon the electrical characteristics of the source, they are almost always substantially less than one microsecond in length, prior to passing through tuned circuits.

Practically all of the published articles dealing with the theoretical considerations of the effect of impulse noise upon an f.m. receiver in comparison with that upon an a.m. receiver have assumed the peak voltage of the noise impulses to be, at a maximum, equal to that of the signal voltage. Under these restricted conditions, f.m. is theoretically superior to a.m. in rejecting noise impulses, but in practice, such low-level noise impulses are insignificant. Probably the reason for the confinement of the theoretical considerations to this region is that the mathematical processes used have been applicable only to this restricted region of operation, and become discontinuous functions as soon as the peak voltage of the noise exceeds that of the signal. This is most unfortunate for it is the effect of high level impulse noise that is the primary factor in comparing a.m. with f.m. against impulse noise as normally encountered in practice.

The duration of noise impulses is much too short to pass through the tuned circuits of the receiver without being lengthened considerably. The final lengths of such short impulses after passing through the tuned circuits are almost entirely independent of their original lengths, and are dependent rather upon the bandwidth and phase characteristics of the receiver.[16, 20]

The final length of an impulse is inversely proportional to the bandwidth of the receiver, while the peak amplitude is directly proportional to bandwidth. Thus, the greater the bandwidth of the receiver, f.m. or a.m., the shorter will be the time during which a noise impulse will obliterate the signal. Also, the greater will be the time during which the signal can be received in those periods of time between noise impulses. Since the amplitude of the impulses increases with an increase in bandwidth, it becomes necessary to use some sort of amplitude limiter, in both f.m. and a.m. receivers, in order to realize the advantage brought about by the use of increased bandwidth.

The action of a strong impulse upon such a receiver is to put a " hole " in the signal, lasting perhaps ten microseconds for a receiver with bandwidth characteristics such as the one used in the example given in the interference measurements, and shown in Fig. 1, Curve A. If such impulses occur at a rate of 1,000 per second, they should interfere with the signal only 1 per cent of the total time, while the signal should be received 99 per cent of the total time with no interference.

Radar Conditions

A very good example of a highly sensitive receiver operating in the presence of strong impulse interference is a radar receiver. The interfering impulses are the transmitting impulses received either directly from the common feed line to the common aerial for transmitting and receiving or from a receiving aerial located only a few feet from the transmitting aerial, while the desired signals are the reflected waves arising from the transmitted waves being reflected back to the receiver. Here the interfering signal is likely to be several hundred volts at the input terminals of the receiver, while desired signals (echoes) of only a few microvolts may be received with substantially no interference during the time between transmitting impulses (interference).

It is interesting to note that the interference voltage is often more than a million times greater than the desired signal voltage, yet substantially no interference exists except during the short periods of time when the transmission of the impulses is taking place.

Three important factors affecting the performance of a receiver (f.m., a.m. or radar) in the presence of impulse interference are the following:

(1) The time necessary for the receiver to return completely to its condition prior to the reception of a noise impulse.

(2) The increase in length of an impulse in passing through the receiver.

(3) The amplitude of the impulse after passing through the receiver in comparison with that of the desired signal.

While the recovery time (1) is dependent upon the effective bandwidth, it may be adversely affected by the use of a circuit whose operating conditions are changed by the reception of an impulse and do not quickly return to their original state. An example of this is a grid circuit consisting of a coupling capacitor and a grid resistor, whose time constant is appreciably greater than the duration of the impulse. An impulse with a positive amplitude greater than the negative grid bias voltage will cause grid current to flow, thus changing the charge in the capacitor, resulting in an increased bias by the end of the impulse. This increase in negative bias may be sufficient to render the tube inoperative for an appreciable length of time after the impulse. Under extreme conditions the impulses may occur sufficiently often to keep the tube beyond cut-off between impulses, thus eliminating the desired signal entirely. One remedy for this could be the decrease of the time constant of the circuit to the point where the circuit could follow the wave shape of the impulse. Another remedy could be the increase of the value of capacitance to a sufficiently high value such that a single impulse would not cause an appreciable change in the voltage across the capacitor, and the reduction of the value of resistance in the grid circuit to the point where the summation of impulses would not raise the average level of grid bias appreciably.

The increase in impulse length (2) brought about by the receiver is primarily dependent upon the effective bandwidth of the receiver. In order to obtain minimum impulse noise interference for either f.m. or a.m., the bandwidth prior to the limiter should be made as wide as possible, consistent with other receiver requirements. Also, the effective bandwidth after the limiter should be as narrow as possible, consistent with other receiver requirements [21, 22].

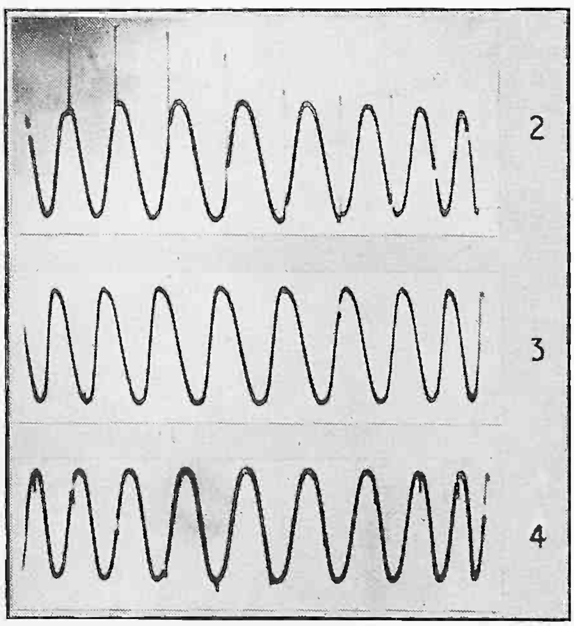
The amplitude of the impulse (3) after passing through the receiver is dependent upon the effectiveness of the limiter and the effect of the limited amplitude upon the circuits following the limiter.

Up to the point of limiting, there is little difference in the basic design of a receiver for minimum impulse interference susceptibility, whether it is for f.m. or a.m. The limiter and detector for f.m. are quite different in design and action from those for a.m. Due to these large differences, each system will be described separately, with the comparisons confined to the final results of each system.

Impulse Noise in F.M. Reception

The combination of an amplitude limiter and a balanced discriminator, operating in this order, is used for f.m. throughout these comparisons[23]. The action of the limiter is such that the equivalent frequency of its output is substantially that of the stronger signal, whether it is the desired signal or a noise impulse reaching the input of the limiter ; the amplitude of the output is a constant.

First, let us consider the reception of an unmodulated carrier. The steady output voltage of a balanced discriminator will be dependent upon the relationship between the carrier frequency and the discriminator balance frequency. The application of a carrier with a frequency slightly higher than the balance frequency will cause the discriminator to have a finite output voltage, but, if the applied carrier has a frequency slightly lower than the balance frequency, the output voltage will be of opposite polarity. Over normal operating range of modulation (up to maximum frequency deviation) this relationship should be linear in order to be able to convert the frequency modulated wave into the corresponding audio-frequency wave without introducing distortion.

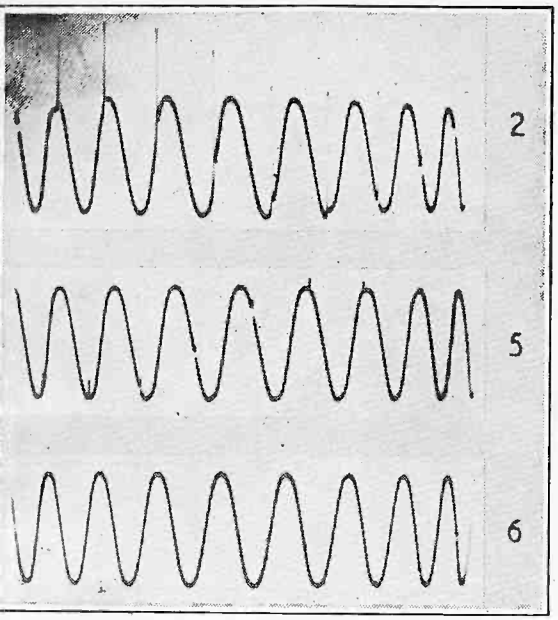


Figs. 2, 3 and 4. *Impulse noise in a.m. reception without a limiter ; with an accurately tuned f.m. receiver ; and with an f.m. receiver detuned by* 50 *kc/s.*

Next, let us consider the reception of strong noise impulses having the usual short duration, but unaccompanied by a signal carrier. Since the duration of the impulses is too short to be passed without being considerably lengthened by the effect of the tuned circuits, it follows that the average or equivalent frequency of the impulse arriving at the limiter is the centre frequency of the selectivity response curve, provided it is symmetrical. Likewise, the equivalent frequency of the output of the limiter during the impulse is this centre frequency, but with a limited amplitude. For the noise impulse to produce minimum disturbance, the balanced discriminator must be aligned to balance at this frequency. If, however, the centre frequency of the selectivity curve does not coincide with the frequency at which the discriminator balances, noise impulses will reach the audio amplifier. The amplitude of the impulse from the discriminator for misalignment corresponds to the peak output voltage at this same point as produced by an f.m. signal having a deviation equal to the magnitude of this misalignment.

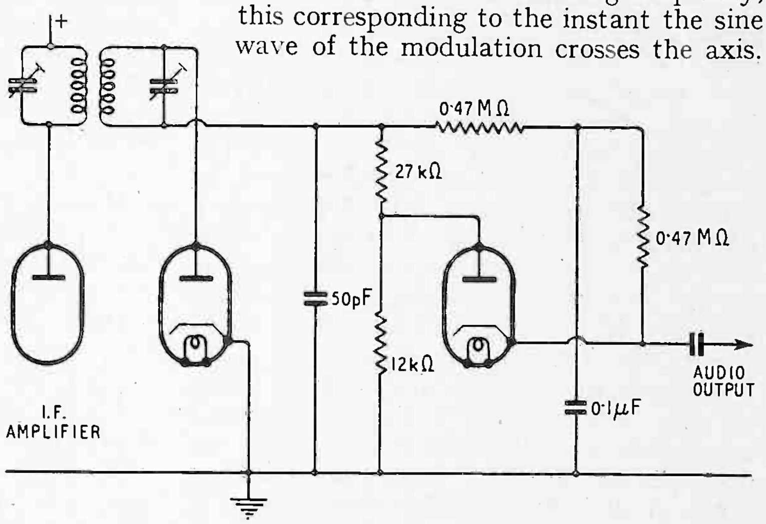
Now, let us consider the reception of an unmodulated carrier accompanied by noise impulses. Since the equivalent output frequency of the limiter is determined by whichever is the stronger at any instant, it follows that output of the discriminator alternates between the values determined by the carrier alone and by the noise impulse when it is in control of the limiter. If the output voltage and polarity are the same for the two conditions, there will be practically no noise. If, however, the output voltages are not the same, noise impulses will be reproduced with an amplitude corresponding to this difference in voltage. Thus, if the receiver is detuned 25 kc/s from the point of minimum impulse interference, the amplitude of the impulses at the output of the discriminator will be the same as the peak value obtained from an f.m. signal having a deviation ot 25 kc/s. Also, if the carrier is frequency modulated, the peak value of a noise impulse will be dependent upon the instantaneous frequency of the signal at the time of arrival of the noise impulse. It should also be noted that the tuning point for minimum impulse interference is not the discriminator balance point unless the selectivity ahead of the limiter is symmetrical.

The peak amplitude of the noise impulse can be reduced by passing the output of the discriminator through a low-pass filter designed to eliminate the super-audible frequencies, yet still pass the audible fre-



Figs. 2, 5 and 6 (above). *Impulse noise in a.m. reception without a limiter; with a Kaar-Fyler limiter, and with the limiter of Fig. 8.*

Fig. 7 (right). *The Kaar-Fyler noise limiter.*



uencies. The degree of reuction in peak amplitude of ıch impulses will be the ratio f the effective bandwidth f the receiver to the limiter ıput divided by the bandidth of the low-pass filter. he use of 75-μsec demphasis will produce this fect to the extent of about ght-to-one for a typical f.m. eceiver. This same ratio of eight-to-one rought about by de-emphasis will also be ue for an a.m. receiver having similar wideand responses through the detector but ith the restricted frequency response in the f. amplifier.

Oscillograms of noise impulses mixed with the signal under various conditions of operation show the action of noise limiting. Fig. 2 is an oscillogram showing the relationship of the noise impulses to the modulation used in the oscillograms to follow. The modulation is a sine wave of one frequency, while the repetition rate of the noise impulses corresponds to a pulse per cycle of a frequency differing slightly from the modulation frequency. This enables one to obtain a single oscillogram of several cycles showing the results of noise impulses occurring at various parts of the audio cycle. This oscillogram was taken with a.m. instead of f.m., but at an identical signal level with the f.m. oscillograms to be described. The same receiver was used for both f.m. and a.m. The limiter input grid was used as the diode for a.m. reception, thus making it possible to have identical circuit conditions for both f.m. and a.m. ahead of the f.m. limiter and the a.m. detector. The same degree of de-emphasis was used for both. The levels of modulation were 30% for a.m. and 30% of the maximum allowable 75-kc/s deviation for f.m.

Fig. 3 is the oscillogram for f.m. accurately tuned to give minimum noise at zero deviation. The magnitude of the resulting impulse is practically zero if the impulse occurs at zero deviation of the modulating frequency, this corresponding to the instant the sine wave of the modulation crosses the axis.

The result of detuning the receiver by 50 kc/s is shown in Fig. 4. The polarity of the resulting impulses is dependent on which way the receiver is detuned from the discriminator balance frequency. A comparison of Figs. 3 and 4 indicates the importance of exact tuning for maximum rejection of impulse noise.

Impulse Noise in A.M. Reception

Fig. 2 is the oscillogram of the a.m. detector output after passing through a de-emphasis network equivalent to the one used between the f.m. discriminator and the audio output. If no de-emphasis were used, the amplitude of the impulses would be several times larger, being limited to the point of overload of the i.f. amplifier of the receiver. Thus, the peaks of all the impulses would have the same overload level. However, the de-emphasis network reduces the inadvertently limited impulses by a relatively constant ratio, resulting in the impulses appearing to vary in amplitude with the instantaneous value of the modulation at the time of occurrence of each of the impulses. Attempts to photograph the trace obtained with no de-emphasis were unsuccessful, due to the low intensity of the trace resulting from the high velocity of the spot on the oscilloscope screen during the impulse.

Fig. 5 is the oscillogram of the output of an a.m. detector after passing first through an amplitude limiter and then through the de-emphasis network. Any one of several types of limiters could have been used to give comparable results [21, 24, 25]. The particular limiter used in this receiver consisted of a diode in series with the output of the detector, so connected and biased as to operate as a closed circuit for any amplitude of signal up to that equivalent to 100 % modulation, but to become an open circuit to greater amplitudes. This particular arrangement is often referred to as "series diode" or Kaar-Fyler[26] noise limiter. The circuit and values used in these tests are shown in Fig. 7.

Fig. 6 shows the results obtained with a.m. in conjunction with a noise limiter developed by the writer. The operation of this system of noise limiting is to leave the instantaneous audio voltage at whatever voltage it was at the beginning of a noise impulse until the noise impulse is over. If the duration of the noise impulses is short compared to the length of a cycle of modulation, the impulses will cause only very slight disturbances on the modulation, since at the end of the noise impulse the instantaneous audio voltage needs to shift only a very small amount to be back to the audio output voltage of the detector.

The action of these a.m. receiver noise limiters theoretically is not adversely affected by detuning so long as the signal is kept within the pass-band of the receiver. In the receiver used detuning the signal by 50 kc/s had no discernible effect upon the resulting signal-to-noise ratio or upon the oscillograms of the signal and noise impulses.

Fig. 8 is a circuit diagram of this special noise limiter used in obtaining Fig. 6. Diode 1 serves as the detector. The audio output is taken from a tap on the diode load through Diode 2. Diode 2 is made conductive by passing through it a polarizing current derived from Diode 1. The path of this current is through resistors A, B and C and Diode 3. The 0.1-μF capacitor at the junction of A and B serves to attenuate the

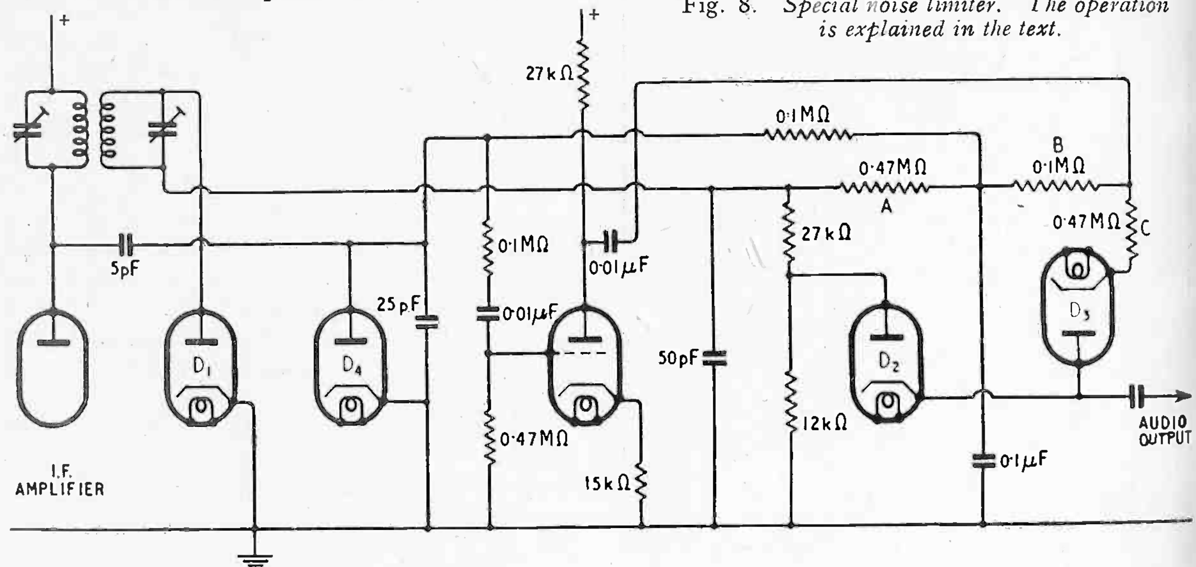


Fig. 8. *Special noise limiter. The operation is explained in the text.*

audio-frequency component to a negligible value. Diode 4 is biased by the voltage at this junction so as to make it inoperative on signals with peaks equal to or less than twice the value of the carrier. For high amplitude noise impulses it becomes operative, with the detected impulses being amplified by the triode and impressed upon Diode 3 with such a polarity as completely to counteract the normal polarizing current. Thus, Diode 2 and Diode 3 are effectively open circuits for the duration of an impulse. At the completion of an impulse, normal operation is quickly resumed with the instantaneous voltage of the audio output having been only slightly displaced by the action of the impulse. Such a system as this should give better rejection of impulse noise in a.m. than that to be expected in f.m. even with most favourable adjustments for f.m.; that is: (1) symmetrical noise impulses over the bandwidth of the receiver, (2) symmetrical band-pass characteristics of the receiver, (3) perfect limiting, and (4) perfect tuning. Practical results, when extreme care is taken to fulfil these exacting requirements for f.m., substantiate the conclusion that a.m. is superior to f.m. in rejecting impulse noise, as can be noted by comparing Figs. 6 and 3.

Impulse Noise Generation

The noise impulses used in these comparisons were generated by spark discharges. The discharge was accomplished by charging a capacitor to a sufficiently high voltage to cause a spark gap connected in the circuit to break down. A 10-ohm resistor was connected in series with the spark gap. The impulse noise voltage was taken from across the resistor, passed through an attenuator and then through a shielded cable to the receiver under test. The complete generator was sufficiently well shielded to reduce any stray radiation to a negligible value. The duration of the impulse was substantially less than one microsecond.

Noise impulses from two other types of generators were compared with those from the spark gap generator, with varying results, but in general even less favourable results were obtained for f.m. in comparison with a.m. than with the spark gap impulse generator.

One of the other types of noise generator consisted of a pulse-modulated radio-frequency amplifier and a standard-signal generator. The signal leakage through the modulated amplifier during the time between impulses actually caused more interference than the impulses themselves, even though this leakage was only about one per cent. This equipment did not give any true indication as to the impulse noise susceptibility of either f.m. receivers or a.m. receivers.

The remaining type of noise generator tested in these comparisons consisted of an oscillator and an impulse generator so arranged that the oscillator operated only during an impulse; thus, the signal could be received with no interference during the time between noise impulses. Oscillograms of f.m. and a.m. reception through the impulse noise interference generated in this manner were substantially identical with those obtained with the spark-gap generator, provided the duration of the impulse was not over 5 μsec. For longer impulses, extreme care had to be taken in aligning the interfering signal centre frequency to that of the signal carrier, otherwise the f.m. performance was poorer than with the spark-gap interference. This is to be expected when one considers the characteristic energy distribution of an impulse in respect to its duration[27]. As an example, for a duration of a radio-frequency impulse of 2 μsec, with constant amplitude during the impulse, the relative amplitudes of the various components within 200 kc/s of the central frequency are shown by Curve A of Fig. 9. This curve represents the locus of the amplitudes of these various components, while the spacing between the

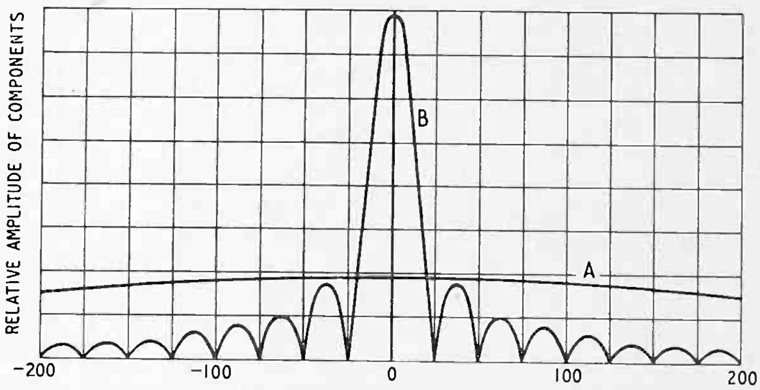


Fig. 9. *Curves A and B show respectively the amplitudes of components of 2-μsec and 40-μsec impulses.*

individual components is dependent only upon the repetition rate of the impulses. If, for example, the repetition rate were 1,000 per second, there would be a spacing of only 1 kc/s between the adjacent components.

Since there is so little difference in the amplitudes of the various components of a 2-μsec impulse around the centre frequency, it follows that small discrepancies in the alignment of this centre frequency to that of the desired signal will have practically no effect upon measurements of signal-to-noise ratios.

If, on the other hand, one attempts to measure impulse susceptibility of an f.m. receiver by applying relatively long duration impulses, such as 40μsec, very accurate alignment is required, otherwise erratic readings will be obtained. It becomes apparent why this is the case when one analyses the spectrum resulting from 40-μsec impulses. Curve B of Fig. 9 represents the locus of the amplitudes of the various components of 40-μsec impulses. Since this curve is much " sharper " than the selectivity of the receiver being tested, the equivalent frequency of the output of the limiter will be substantially equal to the centre frequency of the impulses. If this frequency differs from the frequency of the f.m. signal, the output of the discriminator will contain impulses corresponding in peak amplitude to that resulting from an f.m. signal with a deviation equal to this difference in frequency. Perfect limiting and re-tuning of the receiver will not improve the results, since the equivalent output frequency of the limiter is shifting to and fro between that of the carrier and that of the noise impulses. However, if 2-μsec impulses were used instead of the 40-μsec impulses, the equivalent frequency of the impulse output of the limiter would be essentially that of the centre of the selectivity curve since those components passing through the receiver have substantially equal amplitudes upon entering the receiver ; thus, proper tuning of the receiver will give minimum impulse noise response, as in actual practice.

Conclusions

F.M. is superior to a.m. only where fluctuation noise is the limiting factor.

A.M. is superior to f.m. in the matter of interference, even though the selectivity of the a.m. receiver is identical with that of the f.m. receiver. The optimum station spacing for a.m. is somewhat different from the 200-kc/s spacing used in f.m.

A.M. is superior to f.m. in discriminating against impulse noise.

A.M. is much less adversely affected by imperfect tuning than is f.m.

A.M. is superior to f.m. in " satellite " station operation.

In a given area (city, state, or country) it would appear that for a given band in the v.h.f. spectrum, more signals would be available to any individual receiver (with the same bandwidth for f.m. and a.m.) by the use of a.m. provided sufficient additional transmitting power were available to overcome the fluctuation noise problem in fringe areas, or sufficient additional stations were used to reduce substantially the size of the fringe area.

REFERENCES

[1] Charles B. Aiken, " The Detection of Two Modulated Waves which Differ Slightly in Carrier Frequency," *Proc. Inst. Radio Engrs*, Jan. 1941, Vol. 19, No. 1, pages 120–137.

[2] P. P. Eckersley, " On the Simultaneous Operation of Different Broadcast Stations on the Same Channel," *Proc. Inst. Radio Engrs*, Feb. 1931, Vol. 19, No. 3, pages 175–194.

[3] Harold A. Wheeler, " Common Channel Interference Between Two FM Signals," *Proc. Inst. Radio Engrs*, Jan. 1942, Vol. 30, No. 1.

[4] Irwin R. Weir, " Comparative Field Tests of FM and AM Transmitters," *Proceedings of Radio Club of America*, July 1939, Vol. 16, No. 2.

[5] R. F. Guy and R. M. Morris, " N.B.C. Frequency Modulation Field Test," *R.C.A. Review*, Oct. 1940, Vol. 5, pages 190–235.

[6] Stanford Goldman, " FM Noise and Interference," *Electronics*, August 1941, Vol. 14, No. 8, pages 37–44.

[7] Hans Roder, " Effect of Tuned Circuits Upon a Frequency Modulated Signal," *Proc. Inst. Radio Engrs*, Dec. 1937, Vol. 25, No. 12, page 1646.

[8] M. L. Levy, " FM—AM Engineering Data," *FM*, March 1941, Vol. 1, No. 5, page 11.

[9] August Hund, " Frequency Modulation," Chapter IV, Section 51, page 257, Fig. 81 (b).

[10] F. E. Terman, " Radio Engineering," Chapter X, Section 69, pages 319–320.

[11] R. T. Beatty, " Apparent Demodulation of a Weak Station by a Stronger One," *Experimental Wireless and Wireless Engineer*, June 1928, Vol. 5.

[12] S. Butterworth, " Note on the Apparent Demodulation of Weak Station by a Stronger One," *Experimental Wireless and Wireless Engineer*, November 1929, Vol. 6.

[13] F. M. Colebrook, " A Further Note on Apparent Demodulation," *Experimental Wireless and Wireless Engineer*, August 1931 Vol. 8.

[14] G. W. O. Howe, " Mutual Demodulation and Allied Problems," *Experimental Wireless and Wireless Engineer*, August 1931, Vol. 8.

[15] J. R. Brinkley, " A Method of Increasing the Range of V.H.F. Communication Systems by Multi-Carrier AM," *J. Instn Elec. Engrs*, May 1946, Vol. 93, Part III, No. 23.

[16] V. D. Landon, " A Study of the Characteristics of Noise," *Proc. Inst. Radio Engrs*, Nov. 1936, Vol. 24, No. 11, pages 1514–1521.

[17] M. G. Crosby, " Bandwidth and Readability in Frequency Modulation," *R.C.A. Review*, Jan. 1941, Vol. V, No. 3, pages 363–370.

[18] M. G. Crosby, " The Service Range of Frequency Modulation," *R.C.A. Review*, Jan. 1940, Vol. IV, No. 3, pages 349–371.

[19] " FM Tests," *Wireless World*, October 1946, Vol. LII, No. 10.

[20] V. D. Landon, " The Distribution of Amplitude with Time in Fluctuation Noise," *Proc. Inst. Radio Engrs*, Feb. 1941, Vol. 29, No. 2, pages 50–55.

[21] M. G. Nicholson, " A Noise Reducing Circuit," *Electronics*, October 1936, Vol. 9, No. 10.

[22] V. D. Landon, U.S. Patent 2,087,288.

[23] V. D. Landon, " Impulse Noise in FM Reception," *Electronics*, February 1941, Vol. 14, No. 2.

[24] James J. Lamb, U.S. Patent 2,101,549.

[25] James J. Lamb, " A Noise-silencing I.F. Circuit for Superheterodyne Receivers," *QST*, February 1936, Vol. 20.

[26] I. J. Kaar, U.S. Patent 2,207,587, and co-pending application by George W. Fyler of July 13, 1936, Serial 85,077.

[27] F. R. Stansel, " Some Analyses of Wave Shapes Used in Harmonic Producers," *Bell Syst. tech. J.*, July 1941, Vol. XX, No. 3.

VERY-WIDE BAND RADIO-FREQUENCY TRANSFORMERS

By D. Maurice, Ing. E.S.E. (Paris), A.M.I.E.E. and R. H. Minns, A.M.I.E.E.

(British Broadcasting Corporation)

(Concluded from page 177 June issue)

5. Low-pass Filter Technique

We have shown methods for the determination of L and C. They are both of them a nuisance as they restrict the value of f_2. We can, however, make the best of a bad job by arranging that together they form a single π-section low-pass filter. This need only be done when the frequency range required is rather great for the desired impedance level. In most cases it is only necessary to make L as small as possible and leave C to look after itself. The transformer may then be looked upon at the high-frequency end of the pass range as an ideal transformer.

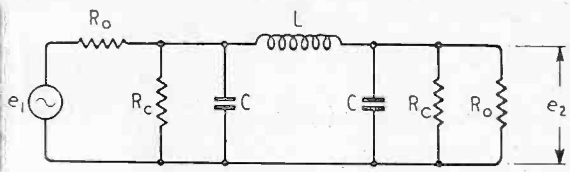


Fig. 17. *Low-pass filter equivalent of a transformer.*

Consider now a low-pass filter formed by L and C, Fig. 17. R_c represents the shunt losses at f_2, usually due to dielectric losses in the interwinding insulation. R_c can usually be left out of account if good insulation is used, but becomes of importance at impedance levels higher than about 500 ohms at frequencies greater than about 25 Mc/s. If we let $R_c \to \infty$ and

$$(2\pi f_2)^2 LC = 1 \qquad \ldots \quad \ldots \quad \ldots \quad (32)$$

and $2\pi f_2 L = R_0 \qquad \ldots \quad \ldots \quad \ldots \quad (33)$

then the amplitude and phase responses of $\frac{e_2}{e_1}$ are shown in Fig. 18 (*a*). If we let R_c have such a value that the insertion loss is 2 db at f_2 we obtain Fig. 18 (*b*). The value of R_c which brings this about is

$$R_c = 6.33 R_0 \qquad \ldots \quad \ldots \quad \ldots \quad (34)$$

A technique much employed is to make

$$L = \frac{R_0}{2\pi f_2} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (33)$$

and arrange that

$$C < \frac{1}{2\pi f_2 R_0} \qquad \ldots \quad \ldots \quad \ldots \quad (35)$$

and then add the necessary fixed capacitances on to the C's in order to raise the total terminating capacitance to the correct value. Quite often it is necessary only to ensure that both C and L obey the inequalities (35) and (36).

$$L < \frac{R_0}{2\pi f_2} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (36)$$

This means that the actual cut-off frequency will be greater than f_2. This cannot be allowed, however, if the transformer is required to discriminate against frequencies outside the stated range.

The information so far given is sufficient to design a normal two-winding transformer; but before giving any example of actual design we shall discuss some further ques-

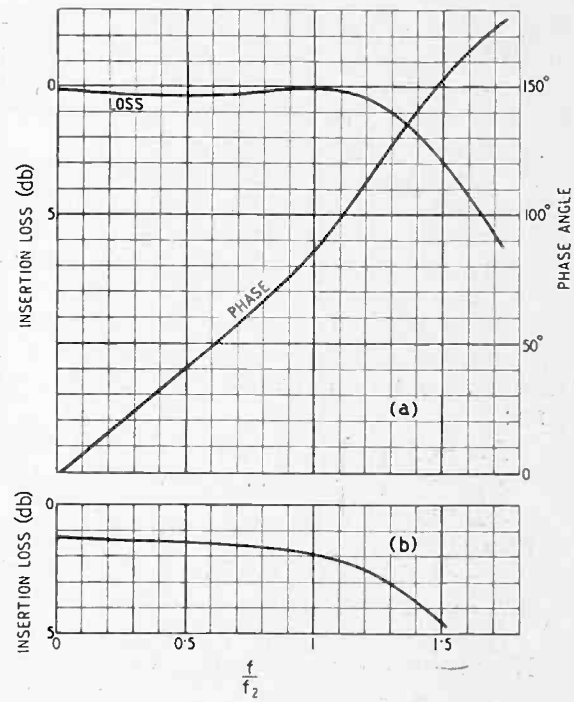


Fig. 18. *Amplitude and phase responses of low-pass filter (a) when $R_c \to \infty$ and (b) when R_c is of such value that the insertion loss is 2 db at f_2; i.e., $R_c = 6.33\, R_0$.*

tions, some of which are directly applicable only to multi-winding transformers. The insight gained by the following discussion will be of value, however, in the design of any transformer.

6. Partial Leakage Inductance

Consider a three-winding transformer with one end of all windings at a common potential and of impedance ratios one to one to one, Fig. 19 (*a*). Neglect for simplicity all shunt losses, including the shunt capacitances. Neglecting the shunt capacitances will in no way affect the following discussion because they can always be put across the transformer windings afterwards. If we re-draw windings of wide, infinitely thin copper strip. Putting (39) into (38)

$$l_1 = \frac{2\pi n^2}{1000h}\left(A_{12} + A_{13} - A_{23}\right) = \frac{4\pi n^2}{1000h} A_{12} > 0 \quad .. \quad (40.1)$$

$$l_2 = \frac{2\pi n^2}{1000h}\left(A_{12} - A_{13} + A_{23}\right) = 0 \quad .. \quad (40.2)$$

$$l_3 = \frac{2\pi n^2}{1000h}\cdot\left(- A_{12} + A_{13} + A_{23}\right) = \frac{4\pi n^2}{1000h} A_{23} > 0 \quad .. \quad (40.3)$$

Thus Fig. 19 (*c*) becomes (*d*).

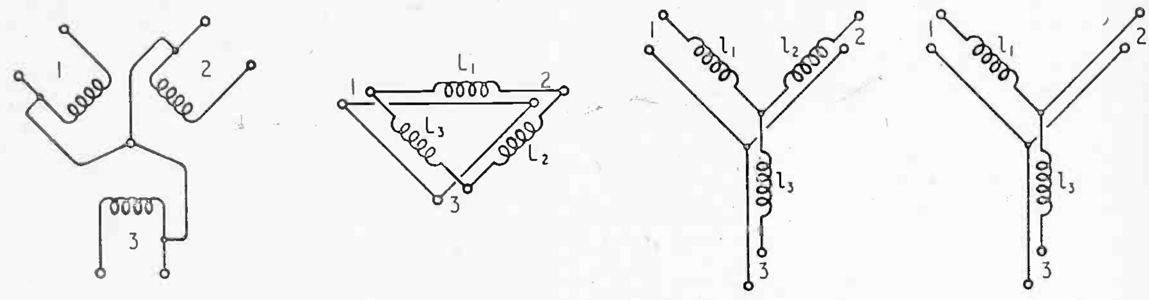


Fig. 19. *A three-winding transformer (a) has the delta and star equivalents (b) and (c). The last can be reduced to (d).*

Fig. 19 (*a*) leaving only the leakage inductances L_1, L_2 and L_3 we arrive at (*b*) which is obtained by regarding L_1 as the leakage between windings 1 and 2, L_2 as that between windings 2 and 3 and likewise for L_3.

A more useful combination than the delta is the star of Fig. 19 (*c*). Let L_{12} be the inductance between terminals 1 when terminals 2 are short-circuited, L_{13} the inductance between terminals 1 when terminals 3 are short-circuited, and L_{23} the inductance between terminals 2 when terminals 3 are shorted. As the transformer ratios are 1 : 1 : 1

$$\left.\begin{aligned} L_{12} &= L_{21} \\ L_{13} &= L_{31} \\ L_{23} &= L_{32} \end{aligned}\right\} \quad .. \quad .. \quad .. \quad (37)$$

From Fig. 19 (*c*)

$$l_1 = \tfrac{1}{2}(L_{12} + L_{13} - L_{23}) \quad .. \quad (38.1)$$

$$l_2 = \tfrac{1}{2}(L_{12} - L_{13} + L_{23}) \quad .. \quad (38.2)$$

$$l_3 = \tfrac{1}{2}(- L_{12} + L_{13} + L_{23}) \quad .. \quad (38.3)$$

Now rewrite expression (8) as

$$L = \frac{4\pi n^2}{1{,}000} \cdot \frac{A}{h} \quad .. \quad .. \quad .. \quad (39)$$

where A is the cross-sectional area of the annular space between any two spiral

Suppose that the middle winding is spaced equally from the inner and outer windings, $A_{12} = A_{23} = A$. Now parallel terminals 1 and 3. The result is a two-winding transformer of leakage inductance only half what it would have been had we wound a simple two-winding transformer with the same spacing between windings as was used with the three-winding transformer. We would gain no such advantage by paralleling terminals 2 and 3. If we now assume that our transformer consists of three *interwound* spiral windings of infinitely thin wide copper strip, we get from equations (9) and (38)

$$l_1 = \frac{4\pi}{1000h}\left[nA + 4\pi(n+2)(n-1)\epsilon^2\right] > 0 \quad .. \quad .. \quad (41.1)$$

$$l_2 = -\frac{8\pi^2}{1000h}(n+2)(n-1)\epsilon^2 < 0 \quad (41.2)$$

$$l_3 = \frac{4\pi}{1000h}\left[nA + 4\pi(n+2)(n-1)\epsilon^2\right] = l_1 > 0 \quad .. \quad (41.3)$$

where ϵ is the distance between turns in centimetres and A is as before in square centimetres. If, as before, we connect terminals 1 in parallel with terminals 3 and use the device as a simple two-winding transformer, the leakage inductance becomes $\frac{1}{2n}$ of the value it would have had in an ordinary two-winding transformer with the same physical constants but wherein the windings are not interwound. An interwound two-winding transformer would have $2\left[1 + \frac{2\pi\epsilon^2}{nA}(n+2)(n-1)\right]$ times the leakage inductance of the interwound three-winding transformer connected as stated above.

Thus we see that by judicious employment of three windings we can make better transformers than with only two windings. There are, of course, many applications of three-winding transformers where all three windings are separately used, each feeding separate circuits. These applications go far beyond the scope of this work, and it is necessary to mention only two.

Certain types of radio-frequency measurement bridges employ transformers, Fig. 20. The input transformer requires no special attention apart from screening between primary and secondary but the output transformer must be carefully studied. Two cases should be considered. When the turns ratio between AB and CB is not unity it would be desirable to have the zero partial leakage inductance in the lower impedance arm when this impedance is so low that inevitable wiring stray inductances might enter the problem. If the impedance level is not as low as this then it might be better to have the zero partial in the output arm, maintaining the turns ratio between the two bridge winding partials.

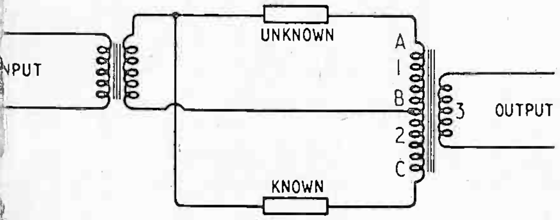


Fig. 20. *Illustrating the use of a transformer in a bridge.*

A case of a transformer required to connect three different circuits together which occurred in practice is shown in Fig. 21. A receiver had to be fed simultaneously from an 80-ohm dipole and a 150-ohm standard signal generator. The electromagnetic field to be measured was received on the dipole and produced a meter reading in the receiver. The dipole was then replaced by an 80-ohm resistor and the same receiver meter reading obtained with the aid of the standard signal generator. The mis-match into the receiver was intentionally arranged so that variations in receiver input impedance did not affect transformer loading on the feed circuits.

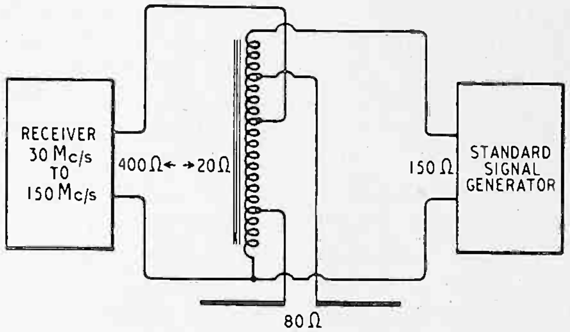


Fig. 21. *Transformer for connecting an aerial and a signal-generator to a receiver.*

The foregoing ideas on three-winding transformers may be extended to multi-winding transformers. However many windings are used, only one partial leakage inductance can be made zero. The rather tedious calculations may be summarized for the case of an m-winding (spiral) transformer of unity impedance ratios in which the windings are not interwound.

$$l_1 = \frac{4\pi n^2}{1000h} A_{12} \quad \ldots \quad (42.1)$$

$$l_2 = 0 \quad \ldots \quad (42.2)$$

$$l_3 = \frac{4\pi n^2}{1000h} A_{23} \quad \ldots \quad (42.3)$$

$$l_4 = \frac{4\pi n^2}{1000h} (A_{23} + A_{34}) \quad \ldots \quad (42.4)$$

$$l_m = \frac{4\pi^2 n}{1000h}(A_{23} + A_{34} + A_{45} + \ldots\ldots + A\,(m-1)m) \quad \ldots \quad (42.5)$$

7. Auto-transformers

This type of transformer is of very great utility, in fact most of the transformers designed by the authors come into this category. The reason for this is that, all other things being equal, an auto-transformer has lower leakage than its separate winding counterpart.

Consider Fig. 22 (*a*) and (*b*) which shows an auto-transformer and its equivalent separate winding transformer. Neglect all shunt losses and re-draw in the form (*c*) and (*d*). The " not-ideal " transformer can be re-drawn as in (*e*). This assumes that the leakage referred to the n-turn side is the same in both the n to $n + m$ and n to m transformers. As this means they both have the same coupling factors it is a reasonable assumption. By moving the leakage l from primary to secondary we get (*f*).

The two ideal primaries in parallel may be drawn as one so Fig. 22 (*f*) becomes (*g*). Changing the leakage from secondary to primary we get (*h*). Thus the ratio of the leakage inductance of a separate-winding transformer to that of an auto-transformer is, comparing Fig. 22 (*h*) with (*d*).

$$\frac{\text{2-winding transformer leakage}}{\text{auto-transformer leakage}} = \left(1 + \frac{n}{m}\right)^2 \quad \ldots \quad (43)$$

This advantage is nearly always worth having.

This equation does *not* hold when $\dfrac{n}{m} = 0$

It may be seen from Fig. 23 (*a*) that this type of auto-transformer is a special case of a three-winding transformer. A quick method of determining the effective leakage inductance between the balanced windings and the unbalanced windings for purposes of deciding on the best positions for them is as follows: [see Fig. 23 (*a*) for winding numbers].

$$L = \frac{1 + n/m}{2}\left(\frac{L_{13} - L_{12}}{n/m} + L_{23}\right) \quad \ldots \quad (45)$$

where L is as shown in Fig. 23 (*b*) and L_{13}, L_{12} and L_{23} have the same significance as in Section 6 and equations (37).

8. Transformer Balance

When the transformer specification calls for one of the windings to be balanced and

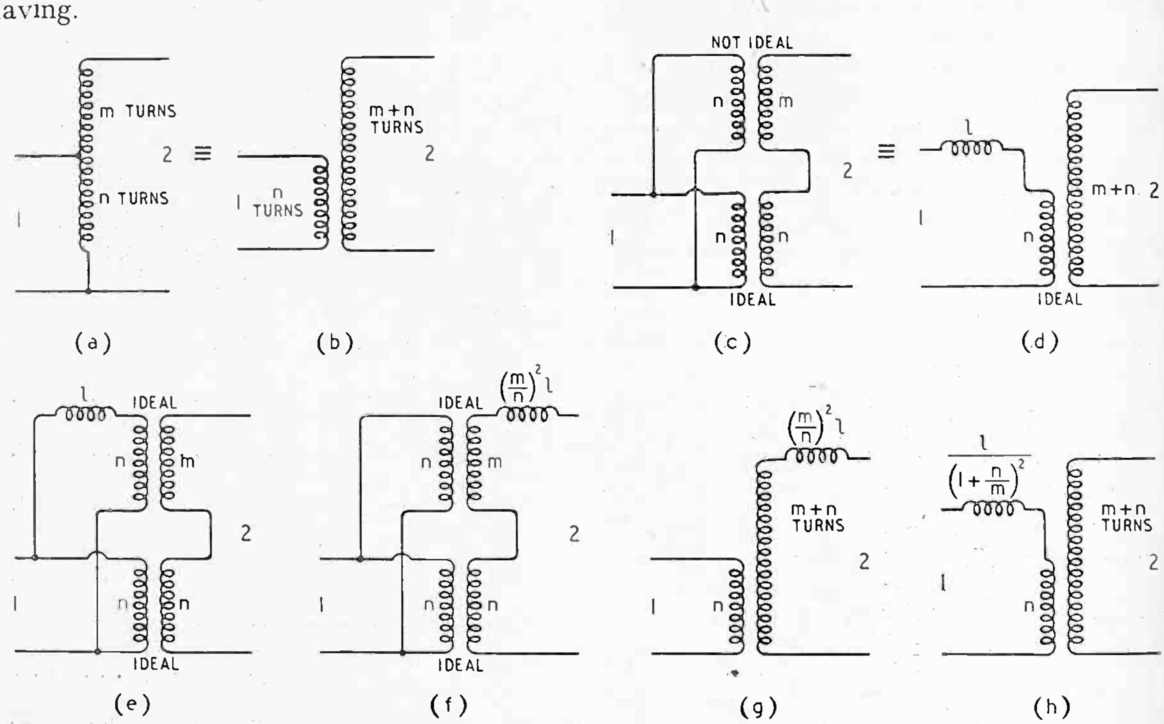


Fig. 22. *An auto-transformer* (*a*) *has the equivalent transformer* (*b*). *Neglecting shunt losses these can be drawn in the form* (*c*) *and* (*d*). *In the steps shown the final equivalent of* (*h*) *is reached.*

The above deals with an unbalanced-to-unbalanced case but a very frequent application is that of unbalanced-to-balanced transformers as in Fig. 23. In this case we have

$$\frac{\text{2-winding transformer leakage}}{\text{auto-transformer leakage}} = \frac{4\left(1 + \dfrac{n}{m}\right)^2}{3\left(\dfrac{n}{m}\right)^2 + 2} \quad \ldots \quad (44)$$

the other one not, it is desirable that the degree of balance should be at least 20 db and usually it is not necessary for it to exceed 40 db. There are two common types of balance required. In one case the transformer might be required to feed a balanced circuit and usually it is sufficient if [Fig. 24 (*a*)]

$$20 \log_{10} \frac{V_A - V_B}{V_A + V_B} \leqslant -20 \text{ db} \quad \ldots \quad (46)$$

The second case is that in which a balanced circuit feeds an unbalanced circuit. In this case it is often necessary to have a somewhat better balance. Consider Fig. 24 (*b*) wherein

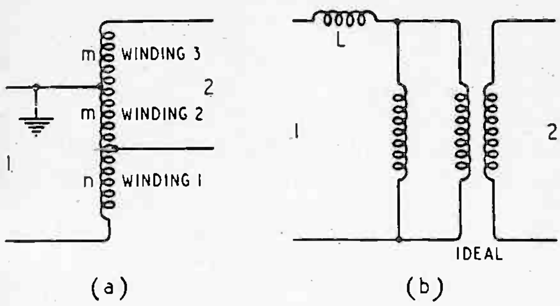


Fig. 23. *Unbalanced-to-balanced auto-transformer (a) with its equivalent (b).*

a balanced aerial feeds a coaxial cable. Normally there will be unbalanced or push-push voltages represented by *e*. If the transformer balance were perfect there would be no voltage across the coaxial cable due to *e*. The degree of balance may well be measured in the manner shown in Fig. 24 (*c*). A voltage V from a standard signal generator represents the aerial push-push voltage. V_1 is the undesired unbalanced voltage due to V. Normally the transformer may be considered satisfactory if

$$10 \log_{10} \frac{\dfrac{V_1^2}{R_1}}{\dfrac{V^2}{R}} = 20 \log_{10} \frac{V_1}{V} + 10 \log_{10} \frac{R}{R_1} \leqslant -25 \text{ db} \quad \ldots \quad (47)$$

Unbalance is due to asymmetry of winding and of shunt capacitances between the two halves of the balanced winding, and to electrostatic coupling between the balanced and unbalanced windings. Asymmetry is obvious and must be avoided as far as possible. The electrostatic coupling capacitances are shown in Fig. 24 (*d*).

C_1 and C_2 can be rendered harmless by the interposition of a copper screen between the unbalanced and balanced windings. Care must then be taken that they are either small or equal, otherwise they will cause flux due to currents caused by *e*. The screen may be dispensed with if the leakage inductance between the two halves of the balanced winding be made small enough. The voltages at *a* and *b* due to push-push currents are the same as at 0, namely zero. If L_2 and L_3 are small enough the voltages at A and B will likewise be zero. An entirely adequate balance for most normal purposes can be obtained without the use of screens by using concentric spiral windings of wide strip. Usually the leakage between the two halves is so small that the presence of C_1 and C_2 is not troublesome. If the above leakage is not so small, C_1 and C_2 can be made practically zero by careful positioning of the windings.

9. Examples.

As an example of the application of some of the foregoing information we shall design a transformer to fulfil the following specification :

Impedance Ratio : 100 ohms unbalanced to 100 ohms balanced and centre-tapped.

Frequency Range : 50 kc/s to 75 Mc/s.

Insertion Loss : to be not greater than 2 db.

Power Handling Capacity : to be not greater than one watt.

Primary-Secondary Insulation : not insulated.

Phase Response : unimportant.

Use : balanced cable to unbalanced cable, balance cable to receiver input, etc.

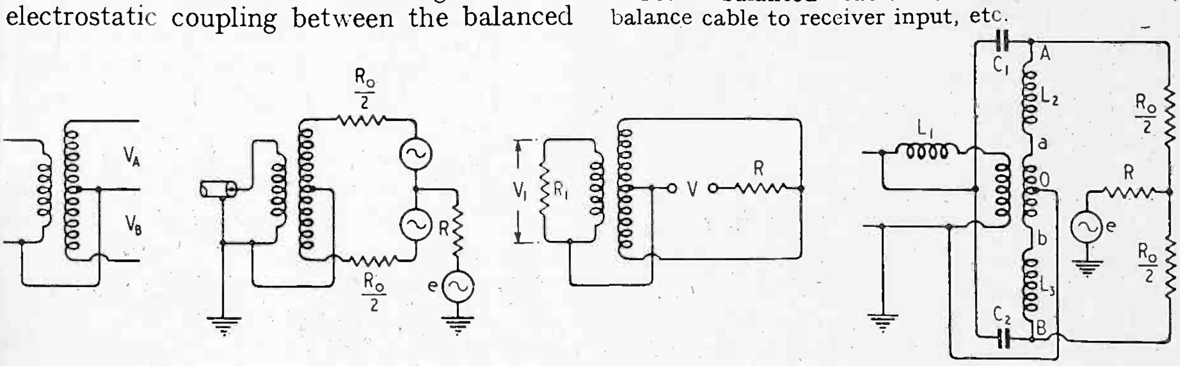


Fig. 24. *A balanced transformer has the form (a). If used to feed an unbalanced cable (b), push-push voltages e will produce a current in the cable unless the balance is perfect. This is shown at (c) and he effect of capacitance at (d).*

9.1. *Design.*

The primary-secondary insulation requirement allows the use of an auto-transformer of the type shown in Fig. 23(*a*). We shall adopt a toroidal core, and inspection of Fig. 5 shows that Mumetal permits of the lowest number of turns for a 2-db insertion loss at 50 kc/s. From Fig. 5 we see that fourteen turns for each 100-ohm winding will suffice. As we shall make it an auto-transformer the total number of turns need be twenty-one only, as one seven-turn winding will be in both the primary and secondary circuits. The advantage we gain by the use of an auto-transformer is, from

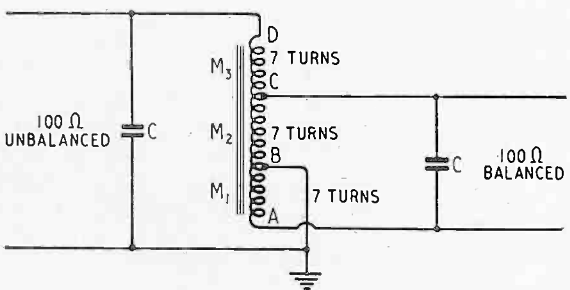


Fig. 25. *The auto-transformer of which the design is given as an example.*

equation (44), 3.2 times less leakage. We shall want the lowest possible leakage between the two halves of the balanced secondary so let us use concentric spiral windings of flat strip with the two half-secondary windings inside, and the half-primary winding outside. As we want minimum balanced-winding leakage and the electrostatic coupling capacitances will be practically zero because of the concentric spiral type of winding we shall use the widest possible strip and check that the shunt capacitances will not be too great. If this check proves satisfactory we shall then calculate the leakages and again if satisfactory proceed with the design specification.

9.2. *Shunt Capacitances.*

Let the winding strip consist of $\frac{1}{2}$ in $\times$ 0.001 in copper. Let the interturn insulation be $\frac{3}{4}$ in $\times$ 0.001 in rice tissue.

Let the core insulation be four layers of $\frac{1}{4}$ in $\times$ 0.001 in rice tissue half-lapped on the outer periphery of the toroid and doped with polystyrene. The thickness of core insulation therefore becomes 0.001 in $\times$ 4 $\times$ 2 = 0.008 in on the outside of the toroid and 0.016 in on the inside; say an average thickness of 0.012 in. The core cross section is $\frac{1}{4}$ in $\times$ $\frac{1}{4}$ in so that the periphery of the cross section of the insulated core becomes 4 (0.25 + 2 $\times$ 0.012) = 1.096 in. If we assume this core cross section to be a circle of equal periphery, the radius will be $r_1 =$ 0.175 in. This is the radius of the start of the balanced winding, Fig. 25. The radius of the finish of this winding, that is the radius of the point C will be 0.175 + 14 $\times$ 2 $\times$ 0.001 = 0.203 in. The average radius will be $\frac{0.175 + 0.203}{2} = 0.189$ in. The interturn capacitance, called C_2 in Section 4.2 is evidently

$$C_2 = \frac{K \times \text{Area}}{4\pi \times \text{Distance}}$$

$$= \frac{2.3 \times 2\pi \times 0.189 \times 5}{4\pi \times 0.001} \times 2.54 \times 1.1 \text{ pF}$$

$$C_2 = 304 \text{ pF}$$

From equation (29)

$$C = \frac{14 - 1}{14^2} \times 304 \text{ pF}$$

$$C = 20 \text{ pF}$$

The capacitance between B and D, Fig. 25, will be slightly higher than this because the average winding radius will be greater, but such a small difference as this is not worth taking into account in view of the poor precision of shunt capacitance calculations.

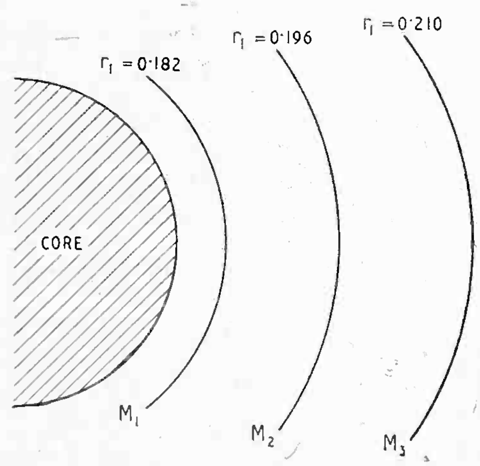


Fig. 26. *The core and windings M_1, M_2, M_3 of the transformer.*

Now if we apply equations (32) and (33) with $f_2 = 75$ Mc/s and $R_0 = 100\ \Omega$ we find that $C = 21$ pF so that we shall just succeed in our design if we adopt the low-pass filter technique in Section 5. The maximum permissible leakage inductance is from equation (33) $L = 0.21\ \mu$H. This must be calculated from equation (45) when we are in a position to know the short circuit inductances L_{12}, L_{23} and L_{13}.

9.3. *Leakage Inductance.*

We shall consider each of the three windings M_1, M_2 and M_3 as if they had no radial thickness and assume them to be concentrated at a distance from the centre of the core cross section equal to the mean radius of each winding, Fig. 26.

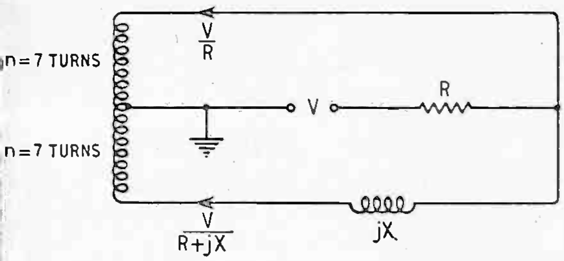


Fig. 27. *The leakage inductance of the balanced winding appears on one side only.*

Now apply equations (39) and (37): $h = \frac{1}{2}$ in; $A_{12} = 2\pi \times 0.189 \times 0.014 = 0.0166$ in^2; $A_{23} = 2\pi \times 0.203 \times 0.014 = 0.0178$ in^2; $A_{13} = A_{12} + A_{23} = 0.0344$ in^2;

$$L_{12} = \frac{4\pi \times 7^2 \times 0.0166}{1000 \times \frac{1}{2}} \times 2.54$$
$$= 0.052\ \mu\text{H};$$
$$L_{13} = \frac{4\pi \times 7^2 \times 0.0344}{1000 \times \frac{1}{2}} \times 2.54$$
$$= 0.107\ \mu\text{H};$$
$$L_{23} = \frac{4\pi \times 7^2 \times 0.0178}{1000 \times \frac{1}{2}} \times 2.54$$
$$= 0.0557\ \mu\text{H}.$$

Now apply equation (45) wherein $n = m$

$$L = 2L_{23} = 0.11\ \mu\text{H}$$

which is well below the maximum permissible, 0.21 μH. It might be advisable in view of the closeness of the capacitance to the limiting value of 21 pF and the considerable tolerance on the leakage, to investigate a re-design using thinner strip, say $\frac{1}{4}$ in wide instead of $\frac{1}{2}$ in. This is not worth trying, however, until a model has been made up based on the present design, because one must not rely on the capacitance and leakage inductance formulae to give an actual working design but only as an indication that a design is feasible.

9.4. *Balance.*

As previously stated the electrostatic coupling between windings is negligible. Lack of balance will be due to actual asymmetry in the balanced winding. Consider the three partial inductances obtained by regarding the transformer as a three-winding device. Equations (40) give

$$l_1 = L_{12} = 0.052\ \mu\text{H}$$
$$l_2 = 0 \text{ very nearly}$$
$$l_3 = L_{23} = 0.056\ \mu\text{H}.$$

From this it may be seen that the leakage between the two halves of the balanced winding is entirely on one side of the centre-tap and equal in value to 0.052 μH. Thus the circulating current in the balanced winding due to a push-push voltage V, Fig. 27, is

$$\frac{V}{R}\,\frac{1}{\sqrt{\left(\frac{R}{X}\right)^2 + 1}}$$

This current will appear on the unbalanced winding and will cause a voltage to appear

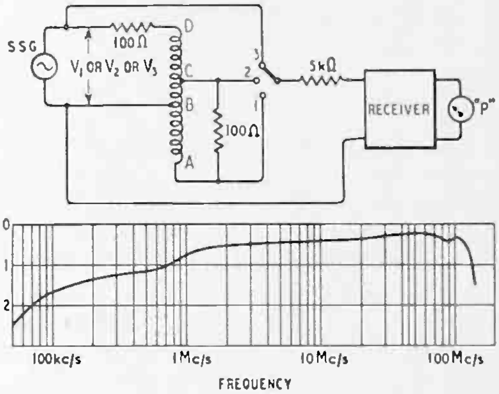


Fig. 28. *Frequency response of the auto-transformer described. The receiver output P was kept constant and the signal generator output varied; V_1, V_2, and V_3 were found by connecting the receiver input to 1, 2, and 3 respectively.*

across the terminating resistor R_1 (100 Ω in our case) equal to $V\,\frac{R_1}{R}\,\frac{1}{\sqrt{\left(\frac{R}{X}\right)^2 + 1}}$.

The unbalance ratio as described by equation (47) becomes

$$20 \log_{10} \frac{R_1}{R\sqrt{\left(\frac{R}{X}\right)^2 + 1}} + 10 \log_{10} \frac{R}{R_1}$$

If we let $R_1 = R = 100\ \Omega$ and X be the reactance of $0.052\ \mu H$ at 75 Mc/s the above ratio becomes $- 12\frac{1}{2}$ db. This is rather poor discrimination against push-push voltage but not so bad as to cancel the making of a first model. A test model transformer was made

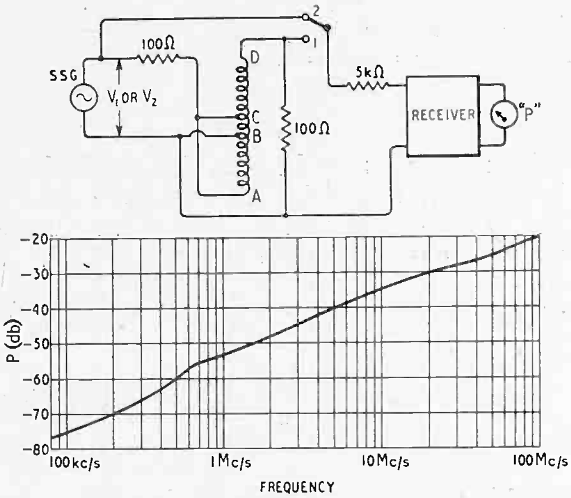


Fig. 29. *Unbalanced voltage ratio of the transformer* $= P_{db} = 20 \log_{10} (V_2/V_1)$. *The receiver output P was kept constant and the signal generator output varied; V_1 and V_2 were found by connecting the receiver input to 1 and 2 respectively.*

on the above lines. The shunt capacitance turned out to be 10 pF instead of the calculated 20 pF. The leakage between balanced and unbalanced windings was actually $0.12\ \mu H$ instead of the calculated $0.11\ \mu H$. The unbalance ratio was $- 22$ db at 75 Mc/s instead of the calculated $- 12\frac{1}{2}$ db. The combination of the actual measured shunt capacitance and leakage inductance is such that the transformer cut-off becomes 150 Mc/s instead of 75 Mc/s.

Fig. 28 shows the insertion loss of the transformer while Fig. 29 shows the unbalance ratio.

10. Acknowledgments

The basic principles underlying the foregoing work are well known but their application to transformer design was first shown to the authors by C. G. Mayo to whom much is owed, not only as regards technique but also courage to apply the basic principles of audio-frequency transformer design to very-high frequencies.

The authors wish to thank Miss M. Richards for making the many tedious measurements necessary for the compilation of Figs. 5, 6, 7, and 8. Much assistance was given by D. P. Thurnell, particularly as regards the making and testing of the example transformer. The authors are very grateful to H. L. Kirke for the continual interest and encouragement which they have received. Their thanks are also due to The British Broadcasting Corporation for kind permission to publish this paper.

REFERENCES

[1] "Magnetic Circuits and Transformers," by Members of the Staff of the Dept. of Electrical Engineering of Massachusetts Institute of Technology.

[2] "Equivalent Capacitances of Transformer Windings," by W. T. Duerdoth, *Wireless Engineer*, June 1946.

[3] "Mathematics Applied to Electrical Engineering," by A. G. Warren, for formulae relating to interwinding capacitances, paragraph 8.7.

HONOURS AND AWARDS

In the Birthday Honours, the following have been appointed Commanders of the British Empire :—

O. F. Brown. Headquarters Intelligence Division of the Department of Scientific and Industrial Research.

H. L. Kirke. Head of the Research Department of the British Broadcasting Corporation.

The award of the Medal for Merit was recently made by the Government of the United States to a number of British Scientists for "exceptionally meritorious conduct in the performance of outstanding services to the United Nations." Listed below are some of those awarded the medal, with extracts from the citations :—

Sir Edward Appleton. "Organized and supported scientific workers, prosecuting many of the important scientific projects which resulted in Allied supremacy. He was outstanding in the effectiveness of his work for co-operation between British and American scientists, and was responsible for important phases of the early research leading to the development in England and the United States of modern radar."

Dr. Robert Cockburn. "Was instrumental in devising new electronic techniques to counter the enemy's use of fire control methods, navigational aids and bombing devices."

Albert Percival Rowe. "Exercised a dominant role in the development of radar and countermeasures in the United Kingdom. In the development and employment of electronics in warfare he made important contributions."

Sir Robert Watson Watt. "His years of work . . . largely formed the basis of the extraordinary early success of British radar. . . . The success attained in the military employment of these new scientific devices and methods inspired and stimulated the great radar programme in the United States. . . . In the development and effective combat employment of superior types of radar, radar countermeasures and communications equipment his services were of enormous value."

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.

Valve Equivalent Circuit

To The Editor, "Wireless Engineer,"

SIR,—I should like to comment on the question of the relative validity of the constant-voltage and constant-current generator "equivalent" circuits of the thermionic valve, raised by Dr. Salzberg in the April issue of *Wireless Engineer*.

I believe the origin of the alternative representations to be two-fold. First, analysis of the constant-voltage generator circuit (Dr. Salzberg's Fig. 1) yields

$$|i_p| = \frac{\mu}{r_p + R}|e_g| \quad \ldots \quad (1)$$

from which

$$|e_o| = R|i_p|$$
$$= R \cdot \frac{g_m r_p}{r_p + R}|e_g|, \text{ using } \mu = g_m r_p$$
$$= \frac{g_m}{y_p + Y}|e_g| \quad \ldots \quad (2)$$

The correspondence between expression (1) above and Fig. 1, suggests the possibility of setting up a configuration equivalent to expression (2); this is the origin of Fig. 2. This development has been given in one form or another in several standard texts; e.g., F. E. Terman, *Radio Engineering*, p. 173. While (2) has been derived from (1) the derivation could with equal validity be reversed. It should be noted that the two expressions differ by a constant factor R and cannot therefore have exact equivalence. A further point is that r_p, y_p are regarded as passive elements in these equivalent circuits; the significance of this point will appear later.

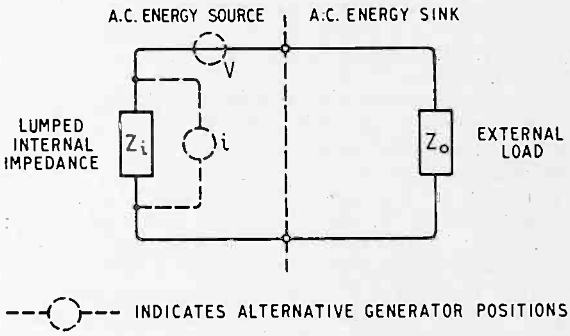
It is of interest to observe that the two expressions and their respective equivalent configurations are related by the principle of duality. This fact arises naturally since (1) is concerned with current distribution while (2) expresses the distribution of voltage; moreover it explains the agreement between expressions (2) and (4) of Dr. Salzberg's letter in the special case $r_p = R$. Duality does not, of course, necessarily imply even partial equivalence.

The second origin of the two "equivalent" circuits is provided by the Helmholtz-Thévenin Theorem on which basis a source of e.m.f. may be dissociated from its impedances and the latter lumped into a single equivalent two-terminal impedance. Two possibilities arise here since the generator may be connected either in series or in parallel with its own equivalent impedance according as it (the pure generator) is imagined to have zero or infinite impedance respectively.

Turning now to the discrepancy noted by Dr. Salzberg, it cannot be expected that the total power absorbed in the two circuits will be identical if only the one variable, the input voltage, is made the same for each circuit. Equal power distribution requires equal input powers; i.e., $(\mu e_g)^2/(r_p + R)$ for Fig. 1 must be numerically equal to $(g_m e_g)^2/(y_p + Y)$ for Fig. 2. Using $g_m/y_p = \mu$, this equality can only be satisfied when $I_p = R$, or $y_p = Y$.

With regard to the physical processes occurring in an actual valve circuit, so lucidly treated in your editorial of the same issue, the following appear to be the significant facts from the point of view of setting up an equivalent linear configuration. First, assuming linear negative-grid operation, the signal source contributes no power to the a.c. output circuit. Secondly the mean power supplied to the output circuit by the d.c. source is independent of signal amplitude. Finally, the energy released by the application of the signal arises, and is dissipated, within the same (the output circuit) loop. These features allow the d.c source to be omitted from the equivalent circuit.

Coming now to the correct method of arriving at the equivalent circuit it will be convenient to obtain first the correct impedance conditions, on the basis of the Helmholtz-Thévenin Theorem. The result is shown in the figure. The separation of the



active generating element from its inherent impedance(s), for the purpose of facilitating analysis, allows the alternative methods of connection indicated, provided the series generator has zero impedance and the shunt generator has infinite impedance. Theoretically it would appear equally valid to inject either e.m.f. or current by either method, provided the transfer constant relating the magnitude and phase of the injected quantity to the grid voltage be appropriately chosen. Of the two methods of injection the series method presents no difficulties; the shunt method, however, is open to ambiguous interpretation since the generated current may be imagined to flow through the hypothetically separate infinite impedance generator or through the parallel finite impedance path representing the inherent impedance of the source being represented. I believe that the first possibility is conventionally accepted, presumably following Wigge's Dual Theorem, with the result noted by Dr Salzberg, and would suggest that the second interpretation is correct since the finite parallel impedance must logically dissipate the power lost within the actual generator and must therefore pass the entire output current. In other words, from the energy view point r_p is an active element in the equivalent circuits.

It is not suggested that Wigge's theorem is incorrect but that it is not applicable to the accompanying figure since z_i represents an *active* impedance.

In conclusion, I feel that teachers of radio theory, to whom problems of the kind under discussion are of the utmost importance, would be extremely grateful if you would leave your columns open on this question until definite clarification has been obtained. A. W. KEEN

Harrow, Middx.

To the Editor " Wireless Engineer."

Sir,—In my previous letter[1] I pointed out that the two well-known first-order a.c. equivalent circuit representations for the vacuum tube yield identical results for the voltage across, current through, and power developed in the external impedance, and dissimilar results for the voltage across, current through, and power developed in the internal resistance. I stated that the result for the power developed in the internal resistance, as computed on the basis of the constant-voltage generator equivalent circuit was the correct one, and furthermore that this circuit is more fundamental than the alternative constant-current generator circuit. The objects of my present letter are to discuss the matter further, and to present a revised conclusion. Re-consideration of the subject was prompted by an exchange of views with Dr. H. Krutter of the N.R.L. Field Station, Boston.

Although the two equivalent circuit representations do indeed provide dissimilar results for the power developed in the internal resistance, one result is no more correct than the other, nor is one circuit more fundamental than the other. One reason for this revised conclusion is the following: Eq. (10) of the previous letter expresses i_p in two different ways. The first is an expression for current through Z in a constant-current generator circuit which contains the shunt elements r_p and Z. The second is an expression for current in a constant-voltage generator circuit which contains the series elements r_p and Z. The two circuit representations are arrived at simultaneously, and one circuit need not be regarded as having been derived from the other on the basis of equivalence with respect to voltage across and current through the external impedance. Consequently, it cannot be concluded that one circuit is more fundamental than the other, nor that the result yielded by one for the power developed in the internal resistance is more correct than the dissimilar result yielded by the other.

At first thought, it may appear that this curious lack of uniqueness between the two equivalent-circuit representations may be resolved by a consideration of the tube plate dissipation, a matter which was not discussed in the previous note. In general the tube plate dissipation is equal to the difference between the power supplied by the plate battery and that developed in the external impedance. Since the two circuit representations provide identical expressions for the power developed in the external impedance, as stated previously[1], both lead to the same value of plate dissipation.

It has been pointed out[2] that the power developed in the external impedance is equal to the difference between the total power supplied by the voltage generator of the constant-voltage generator circuit and that developed in the internal resistance; and furthermore, that these two terms may be interpreted as contributing to plate cooling and to plate heating, respectively. Equally well, it may be pointed out that the power developed in the external impedance is equal to the difference between the total power supplied by the current generator of the constant-current generator circuit and the corresponding power developed in the internal resistance, with a similar interpretation. Both the total generated power and the power developed in the internal resistance, as computed on the basis of the two circuit representations, are dissimilar. Nevertheless, the results yielded by one circuit are no more correct than those yielded by the other. As far as all external measurements are concerned, including plate dissipation, both circuit representations provide identical results.

The situation for the vacuum tube is quite unlike that which exists in the following analogous case: Suppose it were required to determine whether a given two-terminal source is a constant-voltage or constant-current generator. Consideration will reveal that no measurement of voltage across, current through, or power developed in an external impedance connected to the two terminals could be used to decide the matter. However if a measurement could be made by a calorimeter experiment, say, of the power developed within the internal resistance of the device, with the external terminals either open-circuited or short-circuited, the answer would be determined immediately.

Washington, D.C., U.S.A. BERNARD SALZBERG. Naval Research Laboratory.

[1] Bernard Salzberg, " On Use of Equivalent Circuits to Represent the Vacuum Tube," *Wireless Engineer*, Vol. xxiv, No. 283, p. 124, April 1947.
(See also April Editorial).

[2] Harry Stockman, " The Validity of the Equivalent Plate-Circuit Theorem for Power Calculations," *Proc. Inst. Radio Engrs*, June 1944, Vol. 32, No. 6, p. 373.

Permeability of Dust Cores

To the Editor, " Wireless Engineer."

SIR,—At the risk of boring your readers by perhaps over-working the analysis of permeability of magnetic dust cores, I am rising to the bait cast by yourself and several letter-to-the-editor writers.[1] It appears that the chief subject of debate is the failure of nature to conform to simple mathematical analysis. This is always disappointing to physicists, or to engineers, who, for example, prefer Boyle's Law to more accurate, if more obscure, statements of the behaviour of gases.

It is noteworthy that several correspondents are disturbed or see anomaly in the failure of a ferromagnetic body to conform to cubical or spherical patterns which can be treated by straightforward mathematical means. Ferromagnetism is a veritable morass for such efforts, and as often as not it finally compels its votaries to resort to the empirical approach, if anything tangible is to be achieved in their lifetimes.

The permeability of a dust core depends indeed upon the permeability of the material of each magnetic particle, and upon the effective airgap in the magnetic circuit. But neither of these dimensions is directly accessible to our knowledge in a practical core.

The initial permeability of mechanically hard-worked molybdenum-permalloy is about 50, while that of well-annealed, stress-free material is several thousand. The annealing treatment of molybdenum-permalloy dust cores is not sufficient to develop the highest intrinsic permeability, nor to remove all the mechanical stresses which depress permeability. We thus infer that the intrinsic permeability of dust-core particles lies well above 50, but we cannot infer from our knowledge of the mechanical and heat treatments how much higher it is.

The particle size and shape vary widely, depending upon the grain structure in the permalloy as originally cast, and upon the method and intensity of the pulverization process. Thus magnetic particles of various shapes and sizes are present, together with insulating material, which, it is hoped, is uniformly spread on the surfaces of the magnetic particles. The force used in compressing the core is sufficient to cause metallic flow in all obstinate particles which attempt to bridge gaps, or which resist nesting together with other particles. The force may be enough in spots to drive metal protuberances right through the insulating layers, and into direct contact with each other (to make magnetic bridges). And after that the annealing treatment serves to sinter neighbouring metallic particles together wherever possible. This introduces other stresses and discontinuities in the sensitive magnetic alloy, and it yields sinuous flux paths, with miscellaneous air-gaps and flux concentrations.

It is evident from the above that any analysis of magnetic behaviour will entail such great complication as to be unprofitable. The empirical equation $\mu = \mu_i{}^p$ of the Legg-Given paper was propounded as useful and simple. It gave the permeability of molybdenum-permalloy dust cores with tolerable accuracy for a wide range of conditions of core pressure and dilution, ranging from $\mu = 3$ up to $\mu = 125$. It requires only two parameters, the "intrinsic permeability" μ_i, and the metallic packing factor p. Such a simple and reliable equation is worthy of respect and use despite any difficulty in tracing its theoretical antecedents.

The extrapolation to $\mu_i = 220$ yields a value of intrinsic permeability which is at least reasonable, in view of the minimum and maximum limits on permeability already discussed. The estimate $\mu_i =$ 1,000 made by Bardell on the basis of a core pressed with no insulation is not reliable, since the amount of sintering, and resultant easy magnetic paths on the one hand, and residual internal stresses on the the other hand, complicate the resultant permeability. This compels resort again to the relationship which has been found to apply for cores as insulated and as annealed, without any invalidating assumptions.

Derivation of a formula for core permeability from assumptions closely related to the complex physical facts remains as a problem for those who are dissatisfied without such derivations. This may be expedited by the time-honoured procedure of "working backward" from a known correct answer, as provided by our equation.

V. E. Legg.

New York. Bell Telephone Laboratories.

[1] *Wireless Engineer*, February 1947, pp. 33 and 63; November 1946, Vol. XXIV, pp. 291 and 313

Degrees for Ex-Servicemen

To the Editor, "Wireless Engineer."

Sir,—With reference to my letter in the April issue on Science and Engineering Degrees for Ex-Servicemen and others, I have received a total to date of ninety-three completed questionnaires. Of these, fifty-one are from the London area, including Dartford and South-West Essex, and ten from Stoke-on-Trent. The numbers in each of the other localities are unfortunately too small to make it possible to ask the Ministry of Education to take action, but it is hoped that in London and Stoke it may be possible to bring about the desired results.

I am communicating with the Ministry of Education, to whom the questionnaires and an analysis of the results are being sent.

I should like very much to thank those who have completed questionnaires and to request those who have received them but who have not yet returned them to do so immediately, especially if they wish to take courses in the London area or in Stoke.

Langley Park, Nr. Slough, Bucks. O. S. Puckle, R.F. Equipment, Ltd.

1947 RADIO CONVENTION

The British Institution of Radio Engineers held a convention at Bournemouth from 19th to 23rd May. The following papers were read :—

Transmitting Valves for Communication on Short Wavelengths, by W. H. Aldous.

Television Receiving Aerials, by D. A. Bell.

The Exploitation of Micro-Waves for Trunk Wave-guide Multi-Channel Communications, by Prof. H. M. Barlow.

A One Kilowatt V.H.F. Frequency Modulated Transmitter, by J. B. Lovell Foot.

International Telegraph Networks, by Dr. E. V. D. Glazier.

Ultra High Frequency Modulation on Wave Guide, by Drs. H. Gutton and J. A. Ortusi.

Automatic Audio Frequency Response Curve Tracer, by G. L. Hamburger.

Functional Requirements for Radio Aids to Civil Aviation, by Capt. V. A. M. Hunt.

The Klystron as Amplifier at Centimetric Wave-lengths, by R. Kompfner.

The Problems of Radio Communication with Moving Trains, by G. H. Leversedge.

The Allouis (France) Short-Wave Broadcasting Centre, by Dr. M. Matricon.

A Direct Reading Frequency Measuring Set, by F. C. F. Phillips.

Radio Navigational Aids, by W. J. O'Brien.

International Automatic Telegraph Networks, by Commander J. D. M. Robinson, R.N.

The Broadcast Antenna, by Dr. H. Paul Williams.

PROFESSOR G. W. O. HOWE

On 25th June, Prof. G. W. O. Howe received the honorary degree of Doctor of Laws from the University of Glasgow. Some months ago he retired from the Chair of Electrical Engineering of the University.

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.

DIRECTIONAL AND NAVIGATIONAL SYSTEMS

581 057.—Filtering arrangement for increasing the signal-to-noise ratio, when receiving the reflected echo-signals in radiolocation, or in pulsed communication systems.
Standard Telephones and Cables Ltd. (assignees of E. Labin and R. B. Hoffman). Convention date (U.S.A.) 9th September, 1943.

581 120.—System for locating the instantaneous position of a moving target, and predicting its course, by the use of a continuous exploring wave.
Standard Telephones and Cables Ltd., B. B. Jacobsen and B. Secker. Application dates 12th December 1939, and 7th March, 1940.

581 126.—Dynamometer indicator for blind-approach systems of the overlapping-beam type.
Standard Telephones and Cables Ltd. and C. W. Earp. Application date 26th December, 1941.

581 165.—Radiolocation system in which (*a*) exploring pulses are generated by a super-regenerative oscillator, and (*b*) the reflected pulses are received during the quiescent intervals and also determine the quenching frequency.
Marconi's W.T. Co. Ltd., J. M. Furnival and N. M. Rust. Application dates 1st April and 1st September, 1941.

581 160.—Range-finding system in which the target is explored (*a*) by a frequency-modulated and (*b*) by an unmodulated wave, the reflected echoes being fed to separate receivers.
Nash and Thompson Ltd., A. G. Frazer-Nash and A. Whitaker. Application date 8th November, 1939.

581 161.—Balanced impedance bridge for measuring small capacitances, particularly in an arrangement for indicating the altitude of an aeroplane in terms of its capacitance to ground.
A. D. Blumlein. Application dates 10th January, 11th March and 17th June, 1940.

581 166.—Determining the speed of a radio-pulsed target by passing part of the echo-signal through a delay circuit, and then mixing that signal with an undelayed signal.
J. Forman and Pye Ltd. Application date 17th April, 1941.

581 167.—Quarter-wave transmission-line bridge for balancing stray capacitances, for instance in radiolocation equipment.
E. C. Cork and A. D. Blumlein. Application date 5th May, 1941.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

581 018.—Television system in which a two-stage limiter "clips" the video-signal components in order to provide a clear-cut synchronizing-signal.
Haseltine Corporation (assignees of J. A. Rado). Convention date (U.S.A.) 14th May, 1943.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

580 378.—Waveguide made of synthetic resin, the inner surface being first coated with metal-foil and then electroplated.
C. E. Fenwick and C. S. Wright. Application date 28th March, 1944.

580 528.—Heterodyne arrangement for ensuring stability in intercommunication systems operating over a wide range of predetermined wavelengths.
Soc. Française Radio-Electrique. Convention dates (France) 26th January and 3rd August, 1940.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

581 005.—Band-pass filter-circuit for converting time-modulated signal pulses into a phase- or frequency-modulated wave.
Standard Telephones and Cables Ltd. and C. T. Scully. Application date 19th May, 1943.

581 218.—Diversity-reception, or other multiple-path system, in which the harmonics produced by a limiter valve in one path control the gain-characteristic of another path.
Western Electric Co. Inc. Convention date (U.S.A.) 1st July, 1943.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

581 481.—Velocity-modulation device comprising an electron-discharge tube coupled transversely to the longitudinal axis of a wave-guide.
Standard Telephones and Cables Ltd. and S. G. Tomlin. Application date 29th August 1941.

SUBSIDIARY APPARATUS AND MATERIALS

580 844.—Generating square-wave triggering-voltages by a circuit comprising a master-oscillator and two slave-oscillators.
M. E. Haine and Metropolitan-Vickers Electrical Co. Ltd. Application date 8th January, 1943.

580 891.—Time-base circuit for a cathode-ray indicator, with means for "expanding" a selected portion of the sweep, so as to enlarge the image or trace under observation.
J. M. Debski. Application date 28th June 1944.

581 613.—Multivibrator of the pentode type with means for "gating" a selected signal-pulse, and for preventing fortuitous triggering.
Standard Telephones and Cables Ltd. and C. W. Earp. Application date 15th September, 1944.

ABSTRACTS AND REFERENCES

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

The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. The abbreviations of the titles of journals are taken from the World List of Scientific Periodicals. Titles that do not appear in this List are abbreviated in a style conforming to the World List practice.

ACOUSTICS AND AUDIO FREQUENCIES

4.213 : 539.31 : 678.7 **1974**

Acoustic Determination of the Physical Constants Rubber-Like Materials.—A. W. Nolle. (*J. oust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 194–1.)

4.22.093.3-8 **1975**

Temperature Coefficient of Ultrasonic Velocity in lutions.—G. W. Willard. (*J. acoust. Soc. Amer.*, n. 1947, Vol. 19, No. 1, pp. 235–241.) Measurents at 10 Mc/s of the velocity in liquids and uid mixtures. All liquids tested except water ve large negative temperature coefficients in the nge 0–80°C. Water has a large positive coefficient normal temperature, which decreases to zero at °C and then becomes negative. Increase of ncentration raises the peak velocity slightly.

.232 **1976**

Asymmetrical Vibrations of Cones.—P. G. Bordoni. *acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, 146–155.) The natural frequencies of a cone are same as those of a disk of the same radius and ckness if the diameter is greater than eight times wavelength of the vibration. If this ratio n is than eight the frequencies are p times those of corresponding disk, where

$$p = 1 + \sin\phi\,\{1 - \cos(\pi/2n)\}$$

ϕ is the total apex angle.

534.232 **1977**

Acoustic Wave Fronts from a "Piston" Source.—A. O. Williams, Jr. (*J. Acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 156–161.) Calculation of the shape of wave fronts generated by a concave piston source. A few rough comparisons with experimental results are given.

534.26 **1978**

Diffraction of Sound around a Circular Disk.—H. Primakoff, M. J. Klein, J. B. Keller & E. L. Carstensen. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 132–142.) Computations based on the Kirchhoff surface integral and the Maggi transformation. Comparison is made with calculations using Green's function.

534.78 **1979**

Factors governing the Intelligibility of Speech Sounds.—N. R. French & J. C. Steinberg. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 90–119.) Characteristics of speech, hearing, and noise are discussed in relation to intelligibility. It is shown that intelligibility can be related to a quantity called 'the articulation index' which can be computed from the intensity/frequency relationships for speech and for unwanted sounds received by the ear.

534.78 **1980**

Premodulation Clipping in A. M. Voice Communication.—K. D. Kryter, J. C. R. Licklider & S. S. Stevens. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 125–131.) Saving of 14 db in carrier power can be achieved, without loss in intelligibility, by 24 db of premodulation peak clipping followed by 24 db of linear gain to obtain 100% modulation.

534.78 **1981**

More on Speech Clipping.—W. W. Smith. (*QST*, March 1947, Vol. 31, No. 3, pp. 18–22.) Stresses the importance of design and operating details and gives some new circuits, including a full-wave series clipper maintaining constant load on an RC driving circuit and a high-level half-wave clipper-filter system for use with 8 000-Ω to 10 000-Ω loads and anode voltages up to 2 000. For an earlier article see 1724 of 1946; see also 933 of March.

534.78 : 621.317.35 **1982**

Waveform Analysis of Speech.—J. Dreyfus-Graf. (*Helv. Phys. Acta*, 18th Dec. 1946, Vol. 19, Nos. 6/7, pp. 404–408.) The nature of speech and hearing are expressed as far as possible in terms of analogous electrical circuits of which a block diagram is given.

534.78 (23.03) 1983
Effects of Distortion on the Intelligibility of Speech at High Altitudes.—G. A. Miller & S. Mitchell. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 120–125.) Using mask-microphone equipment at altitudes of 40 000 ft intelligibility can be improved by amplitude limitation; it may also be desirable to filter out frequencies below 500 c/s. A summary was abstracted in 3522 of 1946.

534.833.4-8 1984
Absorption of Supersonic Waves in Water near One Megacycle.—L. W. Labaw & A. O. Williams, Jr. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 30–34.) Absorption measurements between 1.09 and 1.30 Mc/s do not confirm earlier measurements indicative of a strong absorption peak near 1 Mc/s, but a fairly reliable upper limit of the absorption coefficient has been obtained.

534.851 1985
Improved Theory of the Light Pattern Method for the Modulation Measurement in Groove Recording.—J. Hornbostel. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 165–169.)

534.851 1986
Sound Embossing at the High Frequencies.—M. Morse. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 169–172.) Optimum loading, stylus dimensions, etc., for embossing at 5 000 c/s.

534.851 : 621.395.813 1987
Wire Recorder Wow.—A. W. Sear. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 172–178.)

551.596.1 1988
Calculation of Sound Rays in the Atmosphere.—P. Rothwell. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 205–221.)

551.596.1 : 534.22-8 1989
Ultrasonic Propagation in Open Air.—H. K. Schilling, M. P. Givens, W. L. Nyborg, W. A. Pielemeier & H. A. Thorpe. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 222–234.) Absorption and scattering properties at frequencies up to 30 kc/s.

621.395.623 1990
A General Theory of Passive Linear Electro-acoustic Transducers and the Electroacoustic Reciprocity Theorem: Part 2. H. Primakoff & L. L. Foldy. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 50–58.) Continuation of 264 of 1946. If a transducer is considered to consist of media characterized by appropriate linear relations between stress, strain, electric and magnetic polarization, charge and current density, and electric and magnetic field intensity, the validity of the linear relations and the 'reciprocity relations' assumed in part 1 can be established, provided certain sufficient conditions are satisfied. These conditions are: (*a*) that the coefficients in the constitutive relations satisfy certain 'symmetry conditions', (*b*) that no magnetostrictive media and no static magnetic field, or no piezoelectric media and no static charge density, are present in the transducer, and (*c*) that the transducer does not radiate electromagnetic waves from its surface.

621.395.623.64.08 1991
Headphone Measurements and Their Interpretation.—D. W. Martin & L. J. Anderson. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 63–70.) Fundamental headphone data are presented in a form suitable for users; the importance of analysis of the performance on different wearers is emphasized. Requirements for an improved artificial ear are outlined.

621.395.623.8 1992
Radio Translation.—(*Wireless World*, March 1947, Vol. 53, No. 3, p. 96.) At Lake Success six low-power transmitters on frequencies of about 120 Mc/s radiate the original speech and translations in five languages. United Nations General Assembly delegates carry small receivers, with simple dial switches. These have a working range up to 200 yd.

621.395.625 1993
Lateral Recording: Part 1.—W. H. Robinson. (*Communications*, Feb. 1947, Vol. 27, No. 2, pp. 26..28.) The first of a series of papers giving a general discussion of average electromagnetic and crystal cutters, groove depths, disks, volume indicators, measuring equipment, frequency runs, styli, cutting angles, scratch filters and pickups.

621.395.625.3 1994
Recent Developments in the Field of Magnetic Recording.—S. J. Begun. (*J. Soc. Mot. Pict. Engrs*, Jan. 1947, Vol. 48, No. 1, pp. 1–13.) A new type of magnetic tape recorder is described using 8-mm coated paper tape. Frequencies up to 5 000 c/s can be recorded with a tape speed of 7.5 inches/sec.

621.395.625.3 1995
A Magnetic Sound Recorder of Advanced Design.—R. J. Tinkham & J. S. Boyers. (*J. Soc. Mot. Pict. Engrs*, Jan. 1947, Vol. 48, No. 1, pp. 29–35.) "Characterized by good frequency response, low distortion, freedom from 'wow' and flutter, and lock-in synchronous drive."

621.395.625.3 1996
Magnetic Sound Recording on Coated Paper Tape.—H. A. Howell. (*J. Soc. Mot. Pict. Engrs*, Jan. 1947, Vol. 48, No. 1, pp. 36–46. Discussion, pp. 46–49.) The factors affecting the choice of magnetic material and backing medium are considered; this leads to a discussion of the performance of paper tape recording systems. The properties of a recently developed tape are shown graphically.

621.395.625.3 : 778.5 1997
Magnetic Sound for Motion Pictures.—M. Camras. (*J. Soc. Mot. Pict. Engrs*, Jan. 1947, Vol. 48, No. 1, pp. 14–24. Discussion, pp. 25–28.) Advantages and disadvantages of magnetic sound recording on motion picture film. High-quality recording apparatus is described and curves showing frequency response and distortion are given.

621.395.625.6 : 621.383.49 1998
The Use of Sulphur-Thallium Photocells in Sound Pictures.—Kolomiec. (*See* 2199.)

AERIALS AND TRANSMISSION LINES

621.392 + 537.291 1999
Study of the Simultaneous Propagation of a Guided Wave and of an Electron Beam of approximately Equal Velocity.—P. Lapostolle. (*C. R. Acad.*

Sci., Paris, 27th Jan. 1947, Vol. 224, No. 4, pp. 268–270.) For the system of a cylindrical guide formed of a dielectric of high permittivity, metallized on the outside and with an axial hole through which passes the electron beam, three waves are found to be propagated in the direction of the beam, one slightly faster than the beam and without change of amplitude, the others slightly slower, one increasing in amplitude and the other decreasing. See also 1317 and 1330 of May, and 2003 below.

621.392.029.64 2000
On Propagation in Curved Guides of Circular Cross-Section.—M. Jouguet. (*C. R. Acad. Sci., Paris*, 24th Feb. 1947, Vol. 224, No. 8, pp. 549–551.) A summary of the results and conclusions of previous papers noted in 1320 of May and back references, 1005 of April and 1667 and 1668 of June.

[621.392.029.64 + 621.396.611] : 621.384.6 2001
Cavities and Waveguides associated with Charged Particle Accelerators.—Kahan. (*See* 2200.)

621.392.029.64 : 535.231.2 2002
The " Black Body " for Radio Waves.—Malov. (*See* 2059.)

621.392.029.64: 621.385.029.64 2003
Study of the Various Progressive Guided Waves Capable of Propagation in Interaction with an Electronic Beam.—P. Lapostolle. (*C. R. Acad. Sci., Paris*, 24th Feb. 1947, Vol. 224, No. 8, pp. 558–560.) An extension of the work described in 1999 above to the case where the electron velocity may have any value whatever. Only E_0 waves are considered. Certain waves are propagated with neither attenuation nor gain, others with either attenuation or gain. Conditions are given for the various possible types.

621.392.1 2004
Equations for Generalized Transmission Lines.—Frankel. (*Elect. Commun.*, Sept. 1946, Vol. 23, No. 3, pp. 329–331.) The differential equations for voltage and current at points not near discontinuities of a two-wire lossless line are extended to lossless lines consisting of a multiplicity of conductors of arbitrary cross-section.

621.392.2.025.3 2005
Propagation along an Electrically Long Symmetrical Three-Phase Line when a Transmitter is Applied between One Phase and Earth.—A. Chevallier. (*C. R. Acad. Sci., Paris*, 17th July 1944, Vol. 219, No. 3, pp. 89–90.)

621.392.2.025.3 2006
Attenuation of High-Frequency Waves along an Electrically Long Symmetrical Three-Phase Line.—Chevallier. (*C. R. Acad. Sci., Paris*, 31st July, 1944, Vol. 219, No. 5, pp. 157–158.)

621.392.3 2007
Directional Couplers.—W. W. Mumford. (*Proc. Inst. Radio Engrs, W. & E.*, Feb. 1947, Vol. 35, No. 2, pp. 160–165.) Describes the principles governing the independent measurement of the direct and reflected waves in an unmatched transmission line. The use of multi-element ' tapered-element ' couplers is considered as a means of increasing the bandwidth. Application of the method to give a known attenuation and to enable power to be measured is also discussed.

621.392.4.08 : 621.397.5 : 621.396.67 2008
Application of Transmission Line Measurements to Television Antenna Design : Parts 1 & 2.—Hamilton & Olsen. (*See* 2262.)

621.392.5 2009
Spiral Delay Lines.—K. H. Zimmermann. (*Elect. Commun.*, Sept. 1946, Vol. 23, No. 3, pp. 327–328.) A brief discussion of design and applications with particular reference to the K-71 line which has a characteristic impedance of 950 Ω and a delay time of 0.042 μs/ft.

621.396.621.2 2010
Receiver Aerial Couplings for Medium Wavelengths.—S. W. Amos. (*J. Brit. Instn Radio Engrs*, July/Aug. 1946, Vol. 6, No. 4, pp. 144–161. Discussion, pp. 161–164.) A discussion of the electrical nature of an outdoor aerial and the problems arising when it is coupled to the aerial input circuit of a receiver. Equations and curves are given to show the variation of gain and selectivity with various types of aerial coupling. The two desirable features, high voltage transfer and high selectivity, are mutually conflicting, but it is possible to obtain 80% efficiency in gain and in selectivity at half optimum coupling.

Appendices give a detailed mathematical analysis of mutual inductance coupling, and a tabulation of exact and approximate formulae derived in the paper.

621.396.67 2011
The Antenna Laboratory.—(*Engng Exp. Sta. News*, Dec. 1946, Vol. 18, No. 5, pp. 3–24 & 33–40.) A series of papers describing successful war-time methods and equipment for testing the performance of airborne and other aerials by the use of scale models. The papers are entitled : The Antenna Laboratory, by E. E. Dreese. Miniature Antennas —A New Tool for the Antenna Designer, by G. Sinclair. Equipment for determining Aircraft Antenna Characteristics, by D. C. Cleckner. Simulation of the Characteristics of Direction Finder Antennas, by W. E. Rife. Accuracy of Antenna-Pattern Measurements, by R. A. Fouty. Construction of Models, by P. H. Nelson. Antennas Mounted on Vehicles [radiation pattern determined by model technique], by E. A. Jones.

621.396.67 2012
Recent Theories of the Aerial : Parts 1 & 2.—E. Roubine. (*Onde élect.*, Jan. & Feb. 1947, Vol. 27, Nos. 238 & 239, pp. 32–37 & 57–64.) An elementary treatment intended for non-specialists. To be continued.

621.396.67.011.2 2013
Note on the Expression for Mutual Impedance of Parallel Half-Wave Dipoles.—K. J. Affanasiev. (*Proc. Inst. Radio Engrs, W. & E.*, Jan. 1947, Vol. 35, No. 1, p. 48.) Additional note to 23 of January.

621.396.674.011.2 2014
Special Aspects of Balanced Shielded Loops.—L. L. Libby. (*Elect. Commun.*, Sept. 1946, Vol. 23, No. 3, pp. 332–338.) Reprint of 25 of January.

621.396.677 2015
Metal Lenses for Radio.—" Cathode Ray ". (*Wireless World*, March 1947, Vol. 53, No. 3, pp.

84–88.) A concise account of the properties and construction of the directive lenses designed at the Bell Telephone Laboratories. For a more detailed description see 1013 of April.

621.396.677 2016

Radiation Patterns of Ground-Based Antennas.—R. B. Jacques. (*Engng Exp. Sta. News*, Dec. 1946, Vol. 18, No. 5, pp. 24–33.) The output of the aerial to be tested was compared with that of an aerial of known pattern, using a moving airborne transmitter.

621.396.677 2017

Fundamental Beam Patterns.—D. C. Cleckner. (*QST*, March 1947, Vol. 31, No. 3, pp. 23–26.) A simplified method of plotting aerial characteristics.

621.392 2018

An Introduction to Transmission Lines. [Book Review]—C. J. Mitchell. Harrap & Co., London, 64 pp., 3s. 6d. (*Wireless World*, March 1947, Vol. 53, No. 3, p. 83.) A simple approach to the subject that "can be thoroughly recommended".

CIRCUITS AND CIRCUIT ELEMENTS

537.525.72 : 621.396.6 2019

Electrodeless Discharges and Some Allied Problems.—G. I. Babat. (*J. Instn elect. Engrs*, Part III, Jan. 1947, Vol. 94, No. 27, pp. 27–37.) "Electrodeless discharges in high-frequency electromagnetic fields were investigated in conditions where the ratio of linear dimension l of the discharge space to the electromagnetic wavelength λ in air was $10^{-3} < l/\lambda < 10^{-1}$, at frequencies between 10^6 and 10^8 c/s. The power introduced into the discharge space varied from fractions of a watt to 100 kW, and the electric field strength was varied between tens and hundreds of volts per cm. There are two different types of discharge: 'E-discharges' in which the elementary conductance currents are continued by dielectric currents, and 'H-discharges', with elementary conductance currents in the form of closed curves."

537.533.7 2020

Interruption of Electron Beams.—P. Selme. (*C. R. Acad. Sci., Paris*, 26th June 1944, Vol. 218, No. 26, pp. 992–993.) A combination of two pentodes and two thyratrons giving establishment and suppression times which are negligible in comparison with the short exposure time.

538.244+621.3.013.1 2021

Theory of Ferromagnetic Inductances: Production and Use of Harmonics.—P. Bricout. (*Rev. gén. Élect.*, Feb. 1946, Vol. 55, No. 2, pp. 61–74.) A theory based on the method of representation of hysteresis cycles previously given (1746 of June). Tables and graphs permit rapid harmonic analysis of the current intensity. Practical methods are described of isolating odd harmonics and using them for local deformation of sinusoidal currents. This technique has proved useful in improving the operation of triphase dry or contact rectifiers.

621.3.078.3 2022

A Generalization of the Nyquist and Leonhard Stability Criteria.—W. Frey. (*Brown Boveri Rev.*, March 1946, Vol. 33, No. 3, pp. 59–65.) For Nyquist's rule for stability, see 1932 Abstracts, p. 279; for Leonhard's, see 567 of 1946. In the present paper, the underlying principles are considered mathematically; the conditions under which the zeros of a function $f(z)$ of a complex variable z all have negative real parts are derived, where $f(z)$ has a finite number of poles of any order. A more general form of the Nyquist and Leonhard criteria is then deduced, whose application is not restricted to electric circuits.

621.314.3 2023

Some Considerations concerning the Internal Impedance of the Cathode Follower.—H. Goldberg. (*Proc. Inst. Radio Engrs, W. & E.*, Feb. 1947, Vol. 35, No. 2, pp. 168–169.) Discussion of 42 of 1946.

621.316.722 2024

Regulator of Effective Alternating Voltage.—L. Le Blan. (*C. R. Acad. Sci., Paris*, 3rd March 1947, Vol. 224, No. 9, pp. 643–645.) A Wheatstone bridge has two opposite constant-resistance arms while the other two arms are fine nickel wires in vacuo. It is connected across the resistive load and balanced for a particular voltage. The out-of-balance voltage due to a change of the supply voltage is amplified and applied to the grids of a balanced triode system. The anodes of this system are fed from the two halves of a transformer secondary whose primary is included in one supply lead. The variation of the primary impedance acts as an automatic rheostat. Supply voltage variations are divided by a factor of the order of 1 000. A circuit diagram is given.

621.316.722.2 : 621.314.632 2025

Some Notes on the Copper-Oxide Rectifier and the Thermionic Tube in the Voltage-Doubling Circuit.—R. R. Gilmour. (*Proc. Inst. Radio Engrs, W. & E.*, Feb. 1947, Vol. 35, No. 2, pp. 213–216.) Discusses the relative merits of the two rectifiers for a particular application requiring portability, 40 mA output into 500–5 000 Ω, ability to withstand short-circuits, and low ripple.

621.317.757 : 518.4 2026

Second Harmonic Calculator.—W. L. Detwiler. (*Communications*, Jan. 1947, Vol. 27, No. 1, pp. 16, 17..28.) Permits rapid graphical determination of harmonic distortion.

621.318.4 : 621.316.974 : 538.532 2027

The Field of a Coil between Two Parallel Metal Sheets.—Moullin. (*See* 2077.)

621.318.7 2028

Conditions for Common Frequencies in Ladder Networks, of Any Length, terminated by Identical Circuits differing from the Intermediate Circuits.—M. Parodi. (*C. R. Acad. Sci., Paris*, 19th June 1944, Vol. 218, No. 25, pp. 965–967.)

621.319.4 : 621.315.614.63 2029

Metallized Paper Capacitors.—J. I. Cornell. (*Communications*, Jan. 1947, Vol. 27, No. 1, p. 22.) A short account of self-healing capacitors produced by high vacuum vaporization of aluminium, the coatings being 25–100 mμ in thickness. Breakdown at a weak spot in the dielectric vaporizes the film there and re-deposits it as oxide, which is a good insulator. A non-inductive winding method is used for the larger capacitors, which are considerably smaller than those of similar value built from metal foil and paper. A 0.1-μF capacitor for a d.c. working voltage of 200 is only $\frac{5}{8}$ inch long and $\frac{3}{8}$ inch in diameter, while the corresponding metal-foil capacitor is approximately $1\frac{5}{8}$ inch long and $\frac{1}{2}$ inch in diameter. Summary of a Rochester Fall Meeting paper.

621.392 : 003.62 **2030**

Shorthand Circuit Symbols.—A. W. Keen. (*Wireless World*, March 1947, Vol. 53, No. 3, pp. 99–101.) Details of a simplified system, supplementary to existing practice, to save time in drawing circuit diagrams. It could be used with advantage to distinguish equivalent circuits from actual circuit diagrams.

621.392.4 **2031**

A Note on Phase Correction in Electrical Delay Networks.—A. J. Ferguson. (*Canad. J. Res.*, Jan. 1947, Vol. 25, Sec. A, No. 1, pp. 68–71.) By means of mutual inductance between the coils and capacitance across them, the third and fifth order terms in the expression for the variation of phase shift with frequency can be eliminated. A simple relation between the circuit constants is found for this case.

621.392.5 **2032**

Geometrical Considerations in connection with the Theory of Electric Four Terminal Networks. [Thesis]—J. van Slooten. N. V. Philips' Gloeilampenfabrieken Research Laboratory, Eindhoven. Reprints are available. (*Philips tech. Rev.*, Sept. 1946, Vol. 8, No. 9, p. 287.) The first part discusses the properties of quadripoles as impedance transformers. The second gives methods of determining the characteristics of the resultant quadripole obtained by connecting in series or parallel two lossless quadripoles whose transformer properties are known. A Cayley diagram is given for the series connexion. Brief summary only.

621.392.52.011.2 **2033**

The Direct Setting-Up of $Z_{\alpha\beta}$ for Closed-Mesh Networks from the Network Diagram: Part 1.—S. A. Stigant. (*Beama J.*, Jan. 1947, Vol. 54, No. 115, pp. 28–36.) The impedance tensor, $Z_{\alpha\beta}$, of a mesh network can be written down directly in full detail from the network diagram. The $\alpha\beta$ axes may be either loop or branch currents. In the present article loop currents are considered. To be continued.

621.392.52.015.33 **2034**

Transition Time and Pass Band.—C. C. Eaglesfield. (*Proc. Inst. Radio Engrs, W. & E.*, Feb. 1947, Vol. 35, No. 2, pp. 166–167.) Fourier transforms are used to define two functions which may be regarded as definitions of pass band and transition time for a network subjected to a step function voltage. The numerical relation between these functions is that usually quoted, but this approach avoids the 'ideal filter'.

621.392.52.015.33 **2035**

Transient Response of Filters.—V. Belevitch: V. E. Thomson. (*Wireless Engr*, March 1947, Vol. 24, No. 282, pp. 93–94.) Criticisms of a statement in a letter by E. T. Emms (662 of March) that when a voltage $\cos\omega_0 t.\mathbf{1}$ is applied to a band-pass filter the envelope of the output transient is the same as the output voltage produced by a unit step in the equivalent low-pass filter. This statement is shown to be untrue in general, being valid only for a narrow-band filter.

621.394/.397].645 **2036**

Capacitance-Coupled Intermediate-Frequency Amplifiers.—M. J. Larsen & L. L. Merrill. (*Proc. Inst. Radio Engrs, W. & E.*, Jan. 1947, Vol. 35, No. 1, pp. 71–74.) Discusses the design and performance of attenuating traps for television i.f. amplifiers above 20 Mc/s, using double-ended damping to minimize changes in response due to component variations.

621.394/.397].645.3 **2037**

Cathode-Excited Linear Amplifiers.—J. J. Muller. (*Elect. Commun.*, Sept. 1946, Vol. 23, No. 3, pp. 297–305.) The advantages of cathode-excited power amplifiers are outlined. "The use of neutralizing capacitances having values which differ from the internal capacitances of the vacuum tubes, in combination with appropriate reactances between the grids of symmetrical stages, permits control of power amplification, stability and feedback." The distortion characteristics of a cathode-excited stage are illustrated by reference to intermodulation measurements made on a 60-kW two-channel transmitter.

621.395/.396].645.36 **2038**

The Twin Triode Phase-Splitting Amplifier.—J. D. Clare. (*Electronic Engng*, Feb. 1947, Vol. 19, No. 228, pp. 62–63.) A practical circuit modification used to operate the twin triodes under optimum conditions and to give a flat 'gain/frequency' response over a very wide audio band.

621.396.611.1 : 621.316.5 **2039**

The Energy Output of an Oscillatory Circuit excited by a Periodically Interrupted Continuous Current.—J. Cayrel. (*C. R. Acad. Sci., Paris*, 17th Jan. 1944, Vol. 218, No. 3, pp. 109–111.) Experiments show that when a mercury interrupter is used, the output efficiency approximates to 100%, proving that the current break occurs in a time very short with respect to the natural frequency of the oscillatory circuit. Interrupters with solid contacts gave anomalous results.

621.396.611.4 : 534.2 **2040**

New Method for Calculating the Properties of Electromagnetic Resonators.—P. Grivet. (*C. R. Acad. Sci., Paris*, 10th Jan. 1944, Vol. 218, No. 2, pp. 71–73.) An adaptation to the case of electric vibrations of Rayleigh's method for mechanical vibrations. For applications of this method see 2041 below.

621.396.611.4 : 534.2 **2041**

The Natural Wavelength of Certain Electromagnetic Resonators.—P. Grivet. (*C. R. Acad. Sci., Paris*, 31st Jan. 1944, Vol. 218, No. 5, pp. 183–185.) The method described in 2040 above is applied to calculate the natural wavelengths of a cylinder, a ring of rectangular section, a rhumbatron and a sphere.

621.396.615 **2042**

The Calculation of Triode Oscillators.—J Queffelec. (*C. R. Acad. Sci., Paris*, 6th Nov. 1944 Vol. 219, No. 18, pp. 449–451.) Calculation base,. on the assumptions that the triode operates we d below saturation, that the characteristic is linear and that grid current is negligible.

621.396.615.14 : 621.385.029.63/.64 **2043**

The Traveling-Wave Tube as Amplifier at Microwaves.—Kompfner. (*See* 2286.)

621.396.615.142 **2044**

A Wide-Tuning-Range Microwave Oscillator Tube. —Clark & Samuel. (*See* 2291.)

621.396.615.142 **2045**

Transit-Time Effects in Ultra-High-Frequency Class-C Operation.—Dow. (*See* 2290.)

621.396.645 **2046**

Cathode-Coupled Triode Amplifiers.—N. I. Korman. (*Proc. Inst. Radio Engrs, W. & E.*, Jan. 1947, Vol. 35, No. 1, p. 48.) Comment on 3811 of 1945 (Sziklai & Schroeder).

621.396.645 : 621.318.572 **2047**

Photo-Counters and Poisson's Law.—A. Blanc-Lapierre. (*C. R. Acad. Sci., Paris*, 31st Jan. 1944, Vol. 218, No. 5, pp. 188–190.) A study of the output fluctuations of an amplifier excited by equal, short, and random impulses of low density. The series of discharges of a photo-counter can be satisfactorily used, and Poisson's law is in general obeyed. For high densities, see 2048 below.

621.396.645 : 621.38 **2048**

Shot Effect and Fluctuations at the Output of a Linear Amplifier.—A. Blanc-Lapierre. (*C. R. Acad. Sci., Paris*, 14th Feb. 1944, Vol. 218, No. 7, pp. 272–274.) Extension of 2047 above to high impulse densities, using a photoelectric multiplier tube instead of a photo-counter. Two formulae are given from which the output law for any input density may be deduced; the limiting form of this law as the density increases indefinitely is Gaussian.

621.396.645.36 **2049**

Push-Pull Amplifier with Direct Coupling.—S. Petralia & R. Ricamo. (*Nuovo Cim.*, 1st June 1946, Vol. 3, No. 3, pp. 185–197. In Italian with English summary.) A battery-fed push-pull amplifier with linear frequency response to 6 000 c/s and gain of the order of 1.5×10^6. The output is connected to a c.r.o. Drift is low after 5 minutes' operation.

621.396.645.371 **2050**

The Anode Follower.—B. H. Briggs. (*R.S.G.B. Bull.*, March 1947, Vol. 22, No. 9, pp. 138–143.) A full account of the properties of a circuit in which negative feedback is applied to a single valve amplifier. Practical details of design are given, with several applications.

621.396.645.371.029.4 **2051**

The Parallel-T Bridge Amplifier.—A. B. Hillan. (*J. Instn elect. Engrs*, Part III, Jan. 1947, Vol. 94, No. 27, pp. 42–51.) A discussion on the design and performance of low-frequency amplifiers using negative feedback through a parallel-T bridge network to obtain selectivity. "Two basic forms of the circuit giving symmetrical selectivity are analysed, and a method of varying the selectivity while maintaining the magnitude and frequency of the peak amplification constant is indicated."

621.396.662.2 **2052**

Guillotine Tuner for F.M.—(*Electronics*, Feb. 1947, Vol. 20, No. 2, p. 136.) A variable inductance tuning system in which a blade is inserted between the turns of a two-turn coil to change their self-inductance and mutual inductance.

621.396.662.34.029.3 **2053**

An RC Audio-Frequency Filter.—P. N. Nield. (*R.S.G.B. Bull.*, March 1947, Vol. 22, No. 9, pp. 144–145.) A ladder-type filter with a pass band centred usually at about 1 000 c/s.

621.39.09 **2054**

Electrical Transmission in Steady State. [Book Review]—P. J. Selgin. McGraw-Hill Book Co., New York, 427 pp., $5.00. (*Communications*, Jan. 1947, Vol. 27, No. 1, p. 33.) Fundamental circuit, field and network principles, with detailed analysis of circuit characteristics. Field theory and Maxwell's equations are considered for u.h.f., where lumped circuit concepts cease to apply, and coupled circuits and three-conductor systems are studied.

621.396.69 **2055**

Radio Components for Export. [Book Review]—Radio Component Manufacturers' Federation, London. (*Elect. Times*, 13th Feb. 1947, Vol. 111, No. 2886, p. 211.) A new catalogue giving a comprehensive survey of the products of leading British firms. Printed in English, French, and Spanish.

GENERAL PHYSICS

534.213 **2056**

Propagation of Plane Elastic Waves in a Heterogeneous Medium.—M. Parodi. (*C. R. Acad. Sci., Paris*, 10th Jan. 1944, Vol. 218, No. 2, pp. 69–71.) The propagation of such waves in an infinite heterogeneous medium satisfies the quadripole equation. The case of propagation along an arbitrary line was discussed in 2149 of 1944.

534.213 : 548.0 : 537 **2057**

Propagation of Elastic Waves in a Piezoelectric Medium.—M. Cotte. (*C. R. Acad. Sci., Paris*, 13th March 1944, Vol. 218, No. 11, pp. 445–447.)

535.13 **2058**

On the Ellipsoidal Theory of Wave Propagation [liaisons ondulatoires].—J. Dreyfus-Graf. (*Helv. phys. Acta*, 18th Dec. 1946, Vol. 19, Nos. 6/7, pp. 399–404. In French.) A new theory based on the principles of Fermat, of Huyghens and of superposition, leads to the replacement of the Poynting energy vector by an ellipsoid with foci at the transmitter and receiver (ellipsoïde de liaison). This enables the problem of diffraction of a spherical wave front to be solved by elementary mathematics. For the case of diffraction by an absorbing screen, the new theory gives much simpler formulae than the Fresnel integrals. If this theory is correct, all the classical theories based on that of Maxwell involve a fundamental phase error of 45°. Correction of this error is necessary for the solution of problems such as that of the diffraction of a spherical wave front at the edge of a screen. The hope is expressed that competent critics will comment on the new theory.

535.231.2 : 621.392.029.64 2059
The "Black Body" for Radio Waves.—N. Malov. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 4, pp. 383–385.) Southworth has indicated that in order to obtain a pure travelling wave in a waveguide closed by a metallic piston, a slightly absorbing plate should be placed in front of the piston. This plate together with the space between it and the piston acts as a 'black body'. This gives a new method (for which formulae are derived) for investigating the electrical properties of materials at v.h.f. See also *Zh. eksp. teor. Fiz.*, 1946, Vol. 16, No. 6, pp. 495–498 (in Russian).

535.329-15 : 535.81 2060
Dispersion of Several Optical Glasses in the Near Infra-Red.—J. Ramadier. (*C. R. Acad. Sci., Paris*, 24th Feb. 1947, Vol. 224, No. 8, pp. 555–557.)

535.33.072-15 : 539.2 2061
Infra-Red Spectrographic Study of Molecular Groups.—J. Lecomte, G. Champetier & P. Clément. (*C. R. Acad. Sci., Paris*, 24th Feb. 1947, Vol. 224, No. 8, pp. 553–555.)

535.376 2062
Cathodo-Luminescence.—A. V. Moskvin. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1945, Vol. 9, Nos. 4/5, pp. 429–462. In Russian.) The most important properties of substances which become luminescent when excited by an electron beam are discussed and a number of experimental curves are given. A theoretical interpretation of the phenomenon is offered.

535.376 2063
On Cathodo-Luminescence of Solid Phosphors.—E. A. Ab. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1945, Vol. 9, Nos. 4/5, pp. 467–468. In Russian.) Experiments were conducted with $CaWO_4$, Zn_2SiO_4Mn and ZnB_4O_7Mn. Curves are plotted showing the spectral distribution of radiation and the effect of temperature on the performance of these substances.

537.291 2064
The Motion of Positive Ions in the Electric Field in a Gas.—L. Sena. (*Zh. eksp. teor. Fiz.*, 1946, Vol. 16, No. 8, pp. 734–738. In Russian.) An English version was noted in 1405 of May.

537.523.4 2065
The Strong Current Stage of an Electric Spark in a Gas at Atmospheric Pressure. Parts 1 & 2.—S. Marshak. (*Zh. eksp. teor. Fiz.*, 1946, Vol. 16, No. 8, pp. 703–717 & 718–727. In Russian, with English summary.) Current/time and voltage/time curves calculated from energy considerations are obtained. The nature of the limitation of current density increase at a later stage of the discharge is explained.

537.525 2066
On the Oscillation of the Electron Plasma.—L. Landon. (*Zh. eksp. teor. Fiz.*, 1946, Vol. 16, No. 7, pp. 574–586. In Russian.) Equations are derived determining the oscillations arising in a plasma owing to the initial unbalanced distribution of electrons. It is shown that these oscillations decrease with time. The penetration of an external oscillating field into the plasma is also considered.

537.525.5 2067
Spontaneous Electrical Oscillations in Low-Pressure Arc Discharge.—B. Granovsky & L. Bykhovskaya. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 4, pp. 351–359.) Four different modes of oscillation depend upon discharge conditions and especially upon whether the cathode spot is free or anchored. Graphs show the dependence of the frequency and peak amplitude of these oscillations upon pressure, current and arc length.

537.525.5 2068
Rate of Growth of Current in Arc Discharges.—K. D. Froome. (*Nature, Lond.*, 25th Jan. 1947, Vol. 159, No. 4030, p. 129.) Discusses the characteristics of the high-intensity short-duration type of discharge through small gas tubes. A fuller account will be published later.

537.531 : 535.341 2069
Measurement of X-Ray Absorption Coefficients.—J. Devaux & A. Guinier. (*C. R. Acad. Sci., Paris*, 21st Feb. 1944, Vol. 218, No. 8, pp. 318–320.) A monochromatic beam passes successfully through two ionization chambers to which voltages of opposite sign are applied. These chambers are separated by the absorbing material; the first has low sensitivity which is controlled by the displacement of a screen, with micrometer adjustment, in front of the collecting electrode. In equilibrium the ionization currents in the two chambers are equal and opposite. The apparatus is calibrated by noting the micrometer reading corresponding to absorbing material of known composition and thickness. A thickness variation of 1 μ in sheet aluminium 0.25 mm thick causes a galvanometer spot deflexion of 4 cm.

537.533.9 : 778.3 2070
A New Method for Studying the Mechanism of the Photographic Action of Electrons.—P. Selme. (*C. R. Acad. Sci., Paris*, 10th July 1944, Vol. 219, No. 2, pp. 60–62.)

537.562 : 551.510.535 2071
On the Mean Energy of Electrons released in the Ionization of Gas.—G. Drukarev. (*Zh. eksp. teor. Fiz.*, 1946, Vol. 16, No. 6, pp. 483–488. In Russian, with English summary.) As an electron released by ionization gives up its energy during a large number of collisions, the mean energy of the electrons is larger, under certain conditions, than the thermal energy of the remainder of the gas. The conditions under which the electrons may be regarded as a gas having a temperature are considered; a formula for this temperature is derived, and applied to the ionosphere. An English version appears in *J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 1, pp. 81–84.

538.114 : 539.23/24 2072
Theory of the Structure of Ferromagnetic Domains in Films and Small Particles.—C. Kittel. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 965–971.) Discussion of "the theory of the domain structure of ferromagnetic bodies whose smallest dimension is comparable with the thickness of the Weiss domains as found in crystals of ordinary size".

538.22 2073
Thermo-Remanence and the Theory of Metamagnetism.—É. Thellier. (*C. R. Acad. Sci., Paris*, 12th Aug. 1946, Vol. 223, No. 7, pp. 319–321.) Recent researches on the thermo-remanence of $Fe_2O_3\alpha$ and certain baked earths show that these substances are metamagnetic; i.e., paramagnetic and ferromagnetic simultaneously. The essential characteristics of this condition are described by J. Becquerel (Congrès de Strasbourg, 1939, Le Magnétisme, Vol. 1, pp. 97–139; see 3597 of 1946). Three important differences are noted between isothermal remanence and thermo-remanence; theory must allow for these.

538.221 2074
On the Exchange Interaction of the Valence and Inner Electrons in Ferromagnetic (Transition) Metals.—S. Vonsovsky. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 5, pp. 468–475.)

538.245 2075
On the Connection between the Magnetization and Hysteresis Curves of Polycrystalline Ferromagnetic Bodies.—N. Poptzov & L. Tchernikova. (*Zh. eksp. teor. Fiz.*, 1946, Vol. 16, No. 6, pp. 513–522. In Russian, with English summary.) The connexion is considered between the magnetization and hysteresis curves of soft polycrystalline ferromagnetic substances having a small degree of magnetic anisotropy, such as permalloy and alsifer. Specimens of polycrystalline cobalt were also examined.

The experimental hysteresis curves agree with theoretical curves computed from E. Kondorsky's formula (591 of 1944) over the whole range of magnetic field values from zero to the coercive force of the specimen concerned. An English version appears in *J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 1, pp. 85–91.

538.245 : 539.185.9 2076
Neutron Polarization and Ferromagnetic Saturation.—F. Bloch, R. I. Condit & H. H. Staub. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 972–973.)

538.532 : 621.316.974 : 621.318.4 2077
The Field of a Coil between Two Parallel Metal Sheets.—E. B. Moullin. (*J. Instn elect. Engrs*, Part III, Jan. 1947, Vol. 94, No. 27, pp. 78–84.) An investigation of the problem of a circular coil of any radius with its plane parallel to two infinite and perfectly conducting planes separated by any distance. The exact expression for the field when the sheets are close together is derived, giving the absolute calibration for an 'attenuator' of this type. The results obtained are applicable to the case of a coil enclosed in a cylindrical screening can with closed ends. See also 821 of 1941.

538.56 : 535.42 2078
On a Problem of Diffraction of Electromagnetic Waves at the Surface of Separation of Two Media.—L. Robin. (*C. R. Acad. Sci., Paris*, 24th Jan. 1944, Vol. 218, No. 4, pp. 135–136.) A treatment of the case of an infinite diffracting plane. The solution is not limited to sinusoidal functions of the time; the two media are conductors and the scalar equation of propagation of spherical waves is valid. See also 2079 below.

538.56 : 535.42 2079
A Problem of Propagation and of the Diffraction of Electromagnetic Waves at the Surface of Separation of Two Media.—L. Robin. (*C. R. Acad. Sci., Paris*, 26th June 1944, Vol. 218, No. 26, pp. 989–990.) An application of Maxwell's equations to the case treated in 2078 above.

538.56 : 535.421 2080
On a Theorem in the Theory of Diffraction and Its Application to Diffraction by a Narrow Slit of Arbitrary Length.—M. Leontovich. (*Zh. eksp. teor. Fiz.*, 1946, Vol. 16, No. 6, pp. 474–479.) In Russian, with English summary.) The problem of a plane e.m. wave incident on a thin plane perfectly conducting screen with an aperture of arbitrary shape can be reduced to that of a similar wave incident on a perfectly reflecting lamina of the same shape as the aperture. In the special case of a narrow slot, it can be solved completely.

538.566 2081
The Field of a Plane Wave near the Surface of a Conducting Body.—V. Fock. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 5, pp. 399–409.) Expressions are derived for the field at any point on or near the surface of a convex body of finite conductivity. From a knowledge of the distribution of the currents induced by an incident plane wave, an approximate solution can be obtained for the case of diffraction by a conducting convex body of arbitrary shape.

538.691 : 531.553 2082
The Hodoscope.—J. Loeb. (*Onde élect.*, Jan. 1947, Vol. 27, No. 238, pp. 27–31.) A discussion of the principles and possible applications of an instrument by means of which the trajectory of an electrified particle in a stationary magnetic field can be traced without calculation.

541.183.26 : 621.352.36.011.2 2083
The Effect of Physical Adsorption on the Electrical Resistance of Activated Carbon.—R. McIntosh, R. S. Haines & G. C. Benson. (*J. chem. Phys.*, Jan. 1947, Vol. 15, No. 1, pp. 17–27.) Measurements of resistance changes due to adsorption of various vapours.

537.228.1 2084
Piezoelectricity. [Book Review]—W. G. Cady. McGraw-Hill Book Co., New York & London, 806 pp., $9.00 or 45s. (*Elect. Rev., Lond.*, 20th Dec. 1946, Vol. 139, No. 3604, p. 1028; *J. appl. Phys.*, Dec. 1946, Vol. 17, No. 12, pp. 1130–1131.) A detailed survey of the whole domain of crystal physics that centres round piezoelectricity. "To the mature physicist and serious research student the work will be invaluable. . . . The technical applications are only treated insofar as they illustrate the scientific side of the subject."

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.5 : 621.396.82 2085
The Giacobinid Meteor Shower, 1946.—J. S. Hey. (*Nature, Lond.*, 25th Jan. 1947, Vol. 159, No. 4030, pp. 119–121.) A more detailed account of the observations discussed in 1753 of June.

523.53 **2086**

Derivation of Meteor Stream Radiants by Radio Reflexion Methods.—J. S. Hey & G. S. Stewart. (*Nature, Lond.*, 5th Oct. 1946, Vol. 158, No. 4014, pp. 481–482.) With 150-kW peak power on vertical pulse transmissions (λ 4–5 m), definite correlation is found between echo reception peaks and the Quadrantid and Lyrid meteor showers in January and April 1946. The echoing source is sensitive to aspect and a technique is described whereby the activity and radiant directions of the main meteor streams can be observed both by day and by night in all weathers.

523.7 : 621.396.822.029.62 **2087**

On the Radio-Frequency Emission from the Sun : Part 1.—J. V. Garwick. (*C. R. Acad. Sci., Paris*, 10th Feb. 1947, Vol. 224, No. 6, pp. 377–379.) Deductions from the hypothesis attributing the emissions to the rotation of electrons round the lines of force of a magnetic field H are discussed and compared with Appleton's results (323 of 1946). Agreement between the theoretical and experimental curves indicates that for wavelengths above m the radiation intensity is proportional to $H^{\frac{2}{3}}$. Possible explanations are suggested for the discrepancies between theory and experiment for wavelengths from 2 m to 5 m. For part 2 see 758 of June.

23.72 : 621.396.822 **2088**

Origin of Radio Emissions from the Disturbed un.—D. F. Martyn. (*Nature, Lond.*, 4th Jan. 1947, ol. 159, No. 4027, pp. 26–27.) A theory accounting r solar radio emissions associated with sunspots. adiation may occur by virtue of an 'extra-rdinary' mode of oscillation of the ionized gases oove the chromosphere.

3.745 : 550.384 **2089**

Relations between Solar Activity and Fluctuations the Magnetic Declination at Lyons.—J. Dufay & P. ajolet. (*C. R. Acad. Sci., Paris*, 4th Jan. 1944, ol. 218, No. 1, pp. 46–48.) A graph of the mean nplitude A of declination fluctuations and the olf-Wolfer relative number S for sunspot activity r the years from 1884 to 1933 gives a correlation efficient between A and S of $+0.45$ for the creasing phase and of $+0.76$ for the increasing ase. At Paris, Brazier has found, for the years 84 to 1917, a mean value of $+0.33$. See also 90 below.

3.745 : 550.384 **2090**

The Annual Variation of the Magnetic Declination uctuations at Lyons and Its Relations with Solar tivity.—J. Dufay & P. Flajolet. (*C. R. Acad. ., Paris*, 24th Jan. 1944, Vol. 218, No. 4, pp. 162–.) Detailed analysis of the data for the period 4–1933 confirms the results of Kostitzin regard- the retardation of the autumn maximum and large amplitude during the increasing phase of ır activity. During the decreasing phase, on the trary, there is a tendency for the maxima to be placed in the opposite sense and the spring maxim becomes the more important. This can be ributed to two causes : (*a*) solar activity gener- increases more rapidly than it decreases ; (*b*) progressive diminution of the latitude of the spots during the cycle makes them more and e effective. See also 2089 above.

523.746 **2091**

Structure of Sunspots.—G. J. Odgers. (*Mon. Not. R. astr. Soc.*, Vol. 106, No. 2, pp. 101–107.) "The possibility that a sunspot is merely a region in which the product of the absorption coefficient and the density is higher than that of the disk is examined." Solution of the equations of radiative equilibrium shows that the observed contrast between spot and disk can be explained by increased density inside the spot. Other features of spots are explained similarly.

2092

523.78 "1945.07.09" : 621.396.812 : 551.510.535

Radio Observations during the Solar Eclipse of 9th July 1945.—N. D. Papalexi. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1946, Vol. 10, No. 3, pp. 237–242. In Russian.) The following preliminary conclusions were obtained from a general survey of the observations : (*a*) The predominant role of the ultra-violet radiation from the sun in the ionization of all layers of the ionosphere is confirmed. (*b*) The density of the ionization of the F_2 layer diminished by 20 – 30% of the average value some 40 – 50 minutes after totality. (*c*) During the photon eclipse the direction of the signals reflected from the F_2 layer was altered, which indicates curvature of this layer. (*d*) During the period corresponding to the corpuscular eclipse for particles with velocities of the order of 500 km/sec peculiar perturbation effects were observed in the state of ionization of the whole depth of the ionosphere from the F_2 layer to the E layer.

2093

523.78 "1945.07.09" : 621.396.812 : 551.510.535

On Radio Observations during the Solar Eclipse of 9th July 1945.—Ya. L. Al'pert & B. N. Gorozhankin. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1946, Vol. 10, No. 3, pp. 245–251. In Russian.) Observations were carried out near Moscow to determine the effects of the ultra-violet and corpuscular radiations from the sun on the ionization of the upper layers of the atmosphere and to investigate the possible curving of the reflecting regions of the ionosphere during the photon eclipse.

The main results were : (*a*) It was confirmed that the ultra-violet radiation from the sun determines the ionization of the E layer. The measured azimuth values of reflections from the F_2 layer are consistent with the assumption that a certain curvature of the layer takes place during the ultra-violet eclipse of the sun. (*b*) The ionosphere appears to be affected by the corpuscular radiation from the sun and in particular by particles with velocities of 400–600 km/sec.

2094

523.78 "1945.07.09" : 621.396.812 : 551.510.535

On the Results Obtained in the Investigation of the Ionosphere during the Solar Eclipse of 9th July 1945.—A. N. Kazantseff. (*Bull. Acad. Sci. U.R.S.S., sér., phys.*, 1946, Vol 10, No. 3, pp. 261–267. In Russian.) Observations were made at a temporary ionosphere station near Leningrad. The field intensities of the Leningrad and Kuibisheff radio-telephone stations (at frequencies of the order of 7 Mc/s) were also compared at this point.

The observations have confirmed the predominant role of the ultra-violet radiation from the sun in the ionization of the ionosphere. Thus, an abrupt diminution of the absorption and therefore of the ionization of the lower layers was observed during the optical eclipse, together with a decrease in the ionization of the F region. The effects of the corpuscular eclipse were much less obvious, but the gradual increase in the field intensity two hours before the eclipse was probably due to the corpuscular eclipse for fast particles, in accordance with Milne's calculations.

523.78 " 1945.07.09 " : 621.396.812.029.62/.63 **2095**

Observations of the Ultra-Short Wave Propagation during the Solar Eclipse of 9th July 1945.—N. I. Kabanoff. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1946, Vol. 10, No. 3, pp. 275–278. In Russian.) Army radar stations were used for observing signals reflected from obstacles such as hills, tall buildings or masts. Observations were carried out at hundreds of places in the zone of the eclipse over distances up to several tens of kilometres. The main preliminary conclusions reached from a statistical analysis of the data are as follows: during the total eclipse an increase of 15 – 20% in signal amplitude was observed for distances of 20 – 60 km at decametre and metre wavelengths, but for distances of 15–20 km the corresponding increase was much smaller; no increase was observed for distances of 2–10 km at metre and decimetre wavelengths.

523.78 " 1945.07.09 " : 621.396.812.029.62 **2096**

Observations of the Variations of the Ultra Short Wave Intensity during the Solar Eclipse of 9th July 1945.—N. V. Osipoff. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1946, Vol. 10, No. 3, pp. 281–284. In Russian.) Observations were carried out at wavelengths of 1.44 m and 4.00 m over a distance of 55 km due south of Moscow. Preliminary studies were made during the six months preceding the eclipse. During the eclipse the expected increase in the field intensity was observed, accompanied by rather strong fading. The maximum field intensity did not quite coincide with totality; this was probably due to the presence of the fading. It was thus established that during the eclipse the conditions of radio transmission approached for a short period those prevailing at night.

535.338.4 : 551.593.9 **2097**

A New Method of Molecular Spectrum Analysis with Application to the Spectrum of the Night Sky.—D. Barbier. (*C. R. Acad. Sci., Paris*, 10th Feb. 1947, Vol. 224, No. 6, pp. 385–397.)

537.591 **2098**

Showers of Mesotrons and of Slow Particles.—J. Daudin. (*C. R. Acad. Sci., Paris*, 31st Jan. 1944, Vol. 218, No. 5, pp. 192–193.) Apparatus for observation comprises three counters in a mass of lead and a Wilson chamber with lead partition. Results are discussed. For further results see 2099 below.

537.591 **2099**

Showers of Mesotrons and of Slow Particles.—J. Daudin. (*C. R. Acad. Sci., Paris*, 14th Feb. 1944, Vol. 218, No. 7, pp. 275–276.) A discussion of further results obtained with the apparatus described in 2098 above.

537.591 **2100**

Probable Existence of a Particle of Mass 990 m_0 in Cosmic Radiation.—L. Leprince-Ringuet & M. Lhéritier. (*C. R. Acad. Sci., Paris*, 13th Dec. 1944, Vol. 219, No. 23, pp. 618–620.)

537.591 **2101**

Some Mesotron Observations by Simultaneous Registration at Two Stations.—F. A. Benedetto. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 817–820.) Mean life range near sea level was estimated at 9.7 ± 3 km. By correlating ground values of mesotron intensity with variations in the heights at which pressures from 1 000 to 100 mb occur, it is inferred that two production levels for mesotrons exist at approximately 5.5 and 16 km.

537.591 **2102**

Multiple Scattering and the Mass of the Meson.—H. A. Bethe. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 821–831.) Multiple scattering by the atoms of the gas in a cloud chamber can cause large apparent curvature of tracks. An analysis shows that all published meson tracks are compatible with a unique mass of about 200 electron masses. See also 1428 and 1429 of May.

537.591 **2103**

On the Fine Structure of Zenithal Curves of the Cosmic Radiation.—G. Cocconi & V. Tongiorgi. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 850–852.)

537.591 **2104**

The Mean Lifetime of the Meson.—G. Cocconi & V. Tongiorgi. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 855–859.)

537.591 **2105**

On the Mean Life of Slow Mesons.—M. Conversi & O. Piccioni. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 859–873.)

537.591 **2106**

On the Disintegration of Slow Mesons.—M. Conversi & O. Piccioni. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 874–881.)

537.591 **2107**

A Note on the Proton Hypothesis of the Primary Component of Cosmic Rays.—N. Arley. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 975–976.)

537.591.15 **2108**

The Density Spectrum of the Extensive Cosmic-Ray Showers of the Air.—G. Cocconi, A. Loverdo & V. Tongiorgi. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 841–846.)

537.591.15 **2109**

Experimental and Theoretical Evaluation of the Density Spectrum of Extensive Cosmic-Ray Showers. G. Cocconi, A. Loverdo & V. Tongiorgi. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 846–849.)

537.591.15 **2110**

Penetrating Particles in Air Showers.—G. Cocconi, A. Loverdo & V. Tongiorgi. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 852–854.)

537.591.15 **2111**

The Density Spectrum and the Origin of Extensive Atmospheric Cosmic-Ray Showers.—G. Cocconi. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, p. 975.)

537.591.15 2112
The Main Results Obtained by the Pamir Expedition for the Investigation of Cosmic Rays.—D. V. Skobel'tsyn. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1945, Vol. 9, No. 3, pp. 250–258. In Russian.) A brief report on the work of the expedition whose main task was the investigation of showers and nuclear fission at a height of about 3 800 m. See also 1441 of May.

537.591.15 2113
The Problem of Fluctuations in Cosmic Radiation Showers.—M. Della Corte. (*Nuovo Cim.*, 1st June 1946, Vol. 3, No. 3, pp. 142–151. In Italian, with English summary.)

538.566.3 2114
Measurements of Changes of the Phase-Paths of Radio Waves in the Ionosphere.—J. W. Findlay. (*Nature, Lond.*, 11th Jan. 1947, Vol. 159, No. 4028, pp. 58–59.) A modification of the pulse method is described whereby both the magnitude and the sense of a change of phase-path can be determined. The method was used to study the changes of phase-path of pulses reflected from the E and F layers, using wavelengths of 150 and 75 m. On 20 occasions during observations of the E layer Dellinger fade-outs occurred, their start being marked by a rapid reduction of phase-path, of the order of 1 km, in about a minute. The recovery of the echo corresponded to a slower increase of phase-path. The results are discussed and possible explanations given.

538.7 + [523.7 : 538 2115
A Theoretical Interpretation of Terrestrial and Solar Magnetism.—J. Mariani. (*C. R. Acad. Sci., Paris*, 3rd April 1944, Vol. 218, No. 14, pp. 585–586.) A new geometrical interpretation based on a Riemann torsion space.

551.508.19 2116
Pressure and Temperature Measurements in the Upper Atmosphere.—N. R. Best, E. Durand, D. I. Gale & R. J. Havens. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, p. 985.) A description of experiments using a V2 rocket in New Mexico. Measurements were made up to 90 km above sea level.

551.510.535 + 523.746 + 621.396.812 2117
Ionosphere Review.—T. W. Bennington. (*Wireless World*, March 1947, Vol. 53, No. 3, pp. 108–111.) A discussion of the correlation between solar activity and ionosphere effects, with predicted sunspot numbers to 1951 and details of working frequencies for radio transmission during 1947.

551.510.535 : 537.562 2118
On the Mean Energy of Electrons released in the Ionization of Gas.—Drukarev. (*See* 2071.)

551.593.9 2119
Altitude of Emission of the Light of the Night Sky.—P. Abadie, É. Vassy & Mme. É. Vassy. (*C. R. Acad. Sci., Paris*, 24th Jan. 1944, Vol. 218, No. 4, pp. 164–166.) The results obtained at the Pic du Midi can be explained by the assumption of two thin emitting layers, one at a height of 900 to 1 000 km and another at 65 to 70 km, the zenith emission of the lower layer being slightly the weaker. A single thin or thick layer will not explain the results.

551.594.12 2120
Ionic Equilibrium in the Lower Atmosphere.—J. Gilbert. (*C. R. Acad. Sci., Paris*, 24th Feb. 1947, Vol. 224, No. 8, pp. 584–587.) Discussion of the results of various investigators shows that (*a*) the equilibrium relations of Gish and Sherman are applicable if account is taken, apart from Aitken nuclei, of centres not acting as condensation nuclei; (*b*) the number of supplementary centres at Chambon is sensibly constant (about 30 000); and (*c*) the number of centres at Paris is much higher in winter than in summer.

551.594.21 : 539.16.08 2121
On the Application of Wilson's Mechanism to Thunder-Clouds.—J. Bricard. (*C. R. Acad. Sci., Paris*, 17th Feb. 1947, Vol. 224, No. 7, pp. 487–489.) The presence in the cloud of large particles and the operation of Wilson's mechanism can account for the local field increments responsible for luminous discharges.

551.594.6 : 523.746.5 2122
Ionospheric Fluctuations of Sudden Origin and the Eleven-Year Solar Cycle.—R. Bureau. (*C. R. Acad. Sci., Paris*, 6th Nov. 1944, Vol. 219, No. 18, pp. 461–463.) Observations from 1930 to 1944 of sudden increases of the mean level of atmospherics on a wavelength of 11 000 m, show a close connexion between the frequency of their occurrence and the changes of solar activity. Both curves show the eleven-year cycle, with no phase difference.

551.594.6 : 621.39.029 2123
Effect of Wavelength on the General Level of Atmospherics.—R. Bureau. (*C. R. Acad. Sci., Paris*, 9th Oct. 1944, Vol. 219, No. 14, pp. 349–351.) Automatic recording of atmospherics on wavelengths from 25 000 m to 115 m and observations on shorter waves (85 m to 20 m) show that the range of sources of atmospherics decreases from over 3 000 km for 25 000-m waves to about 46 km for 26-m waves. Special features of the effects observed on the shorter waves are discussed and also a crevasse sometimes found in the atmospherics curve for 11 000 m wavelength.

537.591 2124
Les Rayons Cosmiques : Les Mésotons. [Book Review]—L. Leprince-Ringuet. Editions Albin Michel, Paris, 373 pp., 330 fr. (*Rev. sci., Paris*, 15th Oct. 1946, Vol. 84, No. 3259, pp. 432–433.)

LOCATION AND AIDS TO NAVIGATION

621.396.824 2125
Lateral Deviation of Radio Waves at Sunrise.—W. Ross & E. N. Bramley. (*Nature, Lond.*, 25th Jan. 1947, Vol. 159, No. 4030, p. 132.) An account of observations made at Slough on the 6.05-Mc/s B.B.C. transmitter in Cumberland during April and May 1946, the sunrise line being then approximately along the transmission path. "The bearings immediately following the maximum usable frequency condition were usually some ten or twenty degress to the east of the true direction, which was afterwards gradually approached." Calculations of bearing deviation based on changes with time of the equivalent height of reflection agreed with the directional observations.

621.396.93 2126
Radio Direction Finding.—(*Electrician*, 1st Nov.

1946, Vol. 137, No. 3570, pp. 1213–1215.) Summaries of the following papers read before the I.E.E. Radio Section: The Use of Earth Mats to reduce the Polarization Error of U-Type Adcock Direction-Finders, by R. L. Smith-Rose & W. Ross. The Development and Study of a Practical Spaced-Loop Radio Direction-Finder for H.F., by W. Ross. Site and Path Errors, by W. Ross. Experiments on Conducting Screens for a U-Type Spaced-Aerial Radio Direction-Finder in the Frequency Range 600–1 200 Mc/s, by R. R. Pearce. The Location of Thunderstorms by Radio Direction-Finding, by F. Adcock & C. Clarke.

621.396.93 : 621.396.663 **2127**

The Design of Electromagnetic Radiogoniometers for Use in Medium-Frequency Direction-Finding.—J. H. Moon. (*J. Instn elect. Engrs*, Part III, Jan. 1947, Vol. 94, No. 27, pp. 69–77.) An investigation into the causes of errors and an account of modifications designed to reduce them. The more important results obtained with a new and improved design are tabulated; this design is shown to be 6 db better in signal/noise ratio than any existing design and has a maximum instrumental error of less than $\pm\frac{1}{2}°$.

621.396.933 + 621.396.96 **2128**

Radar Navigation.—(*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 2, pp. 511–512.) A discussion led by H. B. Law on 1789/1791 and 1793 of June (Dippy; Jones; Wood; Carter).

621.396.933 **2129**

A Review of Radio Aids in Aviation.—C. B. Bovill. (*J. Brit. Instn Radio Engrs*, Dec. 1946, Vol. 6, No. 6, pp. 250–272.) An introduction to the applications of the radio art to aeronautics, with a discussion of some of the technical and practical problems involved.

621.396.96 **2130**

The Maximum Range of a Radar Set.—K. A. Norton & A. C. Omberg. (*Proc. Inst. Radio Engrs, W. & E.*, Jan. 1947, Vol. 35, No. 1, pp. 4–24.) Formulae are developed for calculating the maximum range. The parameters considered are atmospheric attenuation, transmitted power, aerial gains, transmission-line losses, noise factor of the receiver, visibility of the pulse depending on the pulse width, receiver bandwidth, pulse recurrence frequency and type of display, externally generated noise including fluctuation noise from space or the sun, and position of the aerials with respect to the ground as it affects the polar diagrams and the effective echoing area of the target. The effective area of spherical reflectors is considered in detail in terms of Fresnel zones and the derived formulae are applied to calculate the intensity of radio reflections from the moon. A table gives values of the various parameters for twenty different radar equipments together with the derived range indices. An appendix gives formulae for the characteristics of elliptical ground-reflection Fresnel zones on a plane earth.

621.396.96 : 535.39 **2131**

Frequency Dependence of the Properties of Sea Echo.—Goldstein. (*See* 2218.)

621.396.96 : 621.396.664] : 621.392.029.64 **2132**

High-Speed Waveguide Switch.—Bishop. (*See* 2253.)

621.396.96(71) **2133**

Radar Development in Canada.—F. H. Sanders. (*Proc. Inst. Radio Engrs, W. & E.*, Feb. 1947, Vol. 35, No. 2, pp. 195–200.) A brief survey of the visit of the Canadian group to England in 1939, of the visit of the Tizard Mission to N. America in 1940, and the subsequent development and production of radar in Canada.

621.396.96 **2134**

Radar—What It Is. [Book Review]—J. F. Rider & G. C. B. Rowe. J. F. Rider, New York, 1946, 80 pp., $1.00. (*Proc. Inst. Radio Engrs, W. & E.*, Feb. 1947, Vol. 35, No. 2, p. 190.) For the average non-technical reader.

MATERIALS AND SUBSIDIARY TECHNIQUES

535.37 **2135**

Decay of Zinc Sulphide Type Phosphors.—H. A. Klasens & M. E. Wise. (*Nature, Lond.*, 5th Oct. 1946, Vol. 158, No. 4014, pp. 483–484.) A calculation of luminescence intensities over the whole decay period. See also 1808 of 1946.

535.37 **2136**

On the Mechanism of the Luminescence of Phosphors.—V. V. Antonov-Romanovski. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1945, Vol. 9, Nos. 4/5, pp. 369–390. In Russian.) A critical survey of the present state of knowledge, including some of the author's results.

538.114 : 669.15.24 **2137**

Magnetoresistance and Domain Theory of Iron-Nickel Alloys.—R. M. Bozorth. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 923–932.) Domain theory is applied to iron-nickel alloys to predict the ratio of tension to magnetic field at which the resistivity is equal to that of a normal unmagnetized alloy. The theory is accurately confirmed by measurements. The difference between the resistances measured in (*a*) a transverse, and (*b*) a longitudinal magnetic field is independent of the domain distribution in the normal state.

538.221 **2138**

Ferromagnetic Properties of the Compounds $MnNi_3$ and Fe_3C.—C. Guillaud. (*C. R. Acad. Sci., Paris*, 13th Dec. 1944, Vol. 219, No. 23, pp. 614–616.)

538.3 : 539.215.2 **2139**

The Electrical Constants of a Material Loaded with Spherical Particles.—L. Lewin. (*J. Instn elect. Engrs*, Part III, Jan. 1947, Vol. 94, No. 27, pp. 65–68.) A theoretical investigation of the permittivity and permeability of a mixture consisting of a homogeneous material in which particles are embedded. Air bubbles as 'particles' in dielectrics and iron-dust cores are considered.

The permeability may depart from unity or be complex even when none of the substances is ferromagnetic.

546.287 + 679.5 **2140**

Plastics and Silicones.—(*Gen. elect. Rev.*, Jan. 1947, Vol. 50, No. 1, pp. 47–48.) A list of new developments.

549.514.1 : 537.228.1 **2141**

A Theory of the Control of Twinning in Quartz.—W. A. Wooster. (*Nature, Lond.*, 18th Jan. 1947, Vol. 159, No. 4029, pp. 94–95.) The theory accounts for the production of substantially single-crystalline specimens by the application of a torque at temperatures somewhat lower than the α-β transition point. See also 1874 of 1946.

620.2 : 621.396.69(213) **2142**

Choice of Materials for Tropical Radio Equipment.—D. F. Livingstone & J. W. Whitehead. (*J. Brit. Instn Radio Engrs*, Sept./Nov. 1946, Vol. 6, No. 5, pp. 172–176.) A brief guide intended to assist in the examination of materials and radio equipment to decide whether or not they are suitable for tropical use. No details of tropicalization methods or specific tropical components are included.

621.314.63 : 621.315.59 **2143**

The Thermal Energy of Rectification.—H. I. Amirhanov. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1941, Vol. 5, Nos. 4/5, pp. 447–456. In Russian with English summary.) A semiconductor placed between two electrodes becomes a rectifier if the electrodes are kept at different temperatures. Experiments with Cu_2O and PbS are described and the results tabulated and curves plotted. The direction of rectification depends on whether the conductivity of the sample is of the electron or hole type. The distribution of resistivity in the barrier layer was also investigated. A theoretical interpretation of the results is given.

621.315.6 : 621.396 **2144**

New Dielectric and Insulating Materials in Radio Engineering.—(*J. Instn elect. Engrs*, Part III, Jan. 1947, Vol. 94, No. 27, pp. 58–59.) Summary of I.E.E. Radio Section discussion led by J. C. Swallow and G. P. Britton.

621.315.616.018.14 **2145**

A Note on the Effect of Combined Carbon Monoxide on the Power Factor of Polythene.—W. Jackson & S. A. Forsyth. (*J. Instn elect. Engrs*, Part III, Jan. 1947, Vol. 94, No. 27, pp. 55–57.) Slight concentrations of carbon monoxide in the original ethylene gas are sufficient to cause an appreciable increase in the power factor of the polymer. Power factors of pure and impure polythene are shown graphically. For previous work see 2768 of 1945.

621.315.616.9.015.5 **2146**

Intrinsic Electric Strength of Polythene.—W. G. Oakes. (*Nature, Lond.*, 4th Jan. 1947, Vol. 159, No. 4027, pp. 29–30.) Measurements of the d.c. electric strength support the predictions of Fröhlich's theory.

621.318.23 **2147**

The Design and Application of Modern Permanent Magnets.—A. J. Tyrrell. (*J. Brit. Instn Radio Engrs*, Sept./Nov. 1946, Vol. 6, No. 5, pp. 178–213.) A short account is given of the development of permanent magnetic alloys, with a table of the properties of many commercial magnet materials. Methods of measurement of the magnetic properties and performance are discussed. Manufacturing problems, heat treatment, stabilization and methods of magnetization are fully treated. The general principles of design are considered and detailed design procedure is given for the types of permanent magnets required in loudspeakers, meters, motors, generators, etc. The design of magnetron magnets requires special treatment and is only mentioned briefly. Applications are considered with particular reference to the use of Ticonal-G alloy, for which magnetic characteristic graphs are given.

621.318.23 **2148**

Discussion on the Design and Application of Modern Permanent Magnets.—G. L. Hamburger. (*J. Brit. Instn Radio Engrs*, Dec. 1946, Vol. 6, No. 6, pp. 247–248.) A discussion with special reference to Tyrrell's paper (2147 above).

621.318.323.2.042.14 : 621.317.331 **2149**

Measurement and Control of Interlaminar Resistance of Laminated Magnetic Cores.—Franklin. (*See* 2170.)

621.357.6 **2150**

Electroforming for Precision.—H. R. Clauser. (*Sci. Amer.*, Jan. 1947, Vol. 176, No. 1, pp. 15–17.) The outstanding characteristics of electroforming are the extremely high surface smoothness attainable, the very close dimensional tolerances possible and the ability to produce intricate shapes accurately.

621.357.9 **2151**

Electrolytic Polishing and Superfinishing.—R. Mondon. (*Tech. mod.*, 1st/15th Dec. 1946, Vol. 38, Nos. 23/24, pp. 281–286.) Dissolving the successive surface layers makes it possible to examine their properties. Electrolytic polishing may be of considerable value in studying fatigue in metals.

621.791.353 : 669.018.21 **2152**

Metallic Joining of Light Alloys : Parts 1 & 2.—(*Light Metals*, Jan. & Feb. 1947, Vol. 10, Nos. 108 & 109, pp. 20–32 & 103–108.) General discussion of methods of joining thin light-weight alloys and of the metallurgical aspects of soft soldering. Details are given of the many different soft solders which have been suggested for aluminium. The lack of coordinated investigation and of field test results is stressed. To be continued.

621.798 : 621.396.694 **2153**

General Principles of Valve-Crate Design.—R. A. L. Cole. (*Elect. Commun.*, Sept. 1946, Vol. 23, No. 3, pp. 320–326.)

669.018.58 : 621.318.22 **2154**

Formable Magnets.—(*Sci. Amer.*, Jan. 1947, Vol. 176, No. 1, p. 36.) Two new magnetic alloys, Cunico and Cunife, are soft enough to be machined and can be punched or even drawn into wire, thus allowing magnets to be made of any size or shape.

669.3.019.2 **2155**

Micrographic Study of Copper. Detection of Inclusions, Hardening, Recrystallization and Microcracks.—P. A. Jacquet. (*Tech. mod.*, 1st/15th Nov. 1946, Vol. 38, Nos. 21/22, p. 280.) Summary of a paper published in *Bull. Soc. franç. Métall.*, 1945 (first half of year). See also 648 of 1946 (Jacquet).

669.721.891 + 669.721.5.891 **2156**

Rates of High-Temperature Oxidation of Magnesium and Magnesium Alloys.—T. E. Leontis & F. N. Rhines. (*Metals Technol.*, June 1946, Vol. 13, No. 4, Tech. Publ. No. 2003, 28 pp. Discussion, Jan. 1947, Vol. 14, No. 1, Tech. Publ. No. 2039, pp. 7–9.) The linear oxidation was measured in the temperature range 412 – 575° C. The rate was found to vary exponentially with the absolute temperature. Alloying increases the rate if the melting point is appreciably lowered. A protective oxide film is formed at low temperatures, a non-protective loose scale at higher temperatures. These results are explained theoretically.

669.738 : 620.193.23 2157
Comparison of Electro-Plated Finishes under Humidity Tests.—E. E. Halls : F. Taylor. (*Metallurgia, Manchr*, Jan. 1947, Vol. 35, No. 207, pp. 137–139.) Comment on 1485 of May and Taylor's reply. A table is given of the comparative behaviour of relatively thin electroplate coatings, with and without passivation, on soft iron, when subjected to cycles of the W. T. Board K 110 test. *Note.* U.D.C. of 1485 should read 620.193.23.

678.1.001.5 (773) 2158
Rubber Laboratory.—(*Sci. Amer.*, Jan. 1947, Vol. 176, No. 1, p. 33.) A short account of research activities at the University of Illinois.

678.7 : 539.31 : 534.213 2159
Acoustic Determination of the Physical Constants of Rubber-Like Materials.—A. W. Nolle. (*J. acoust. Soc. Amer.*, Jan. 1947, Vol. 19, No. 1, pp. 194–201.)

679.5 2160
Taking the Stress out of Styrene.—C. A. Breskin. (*Sci. Amer.*, Jan. 1947, Vol. 176, No. 1, pp. 11–14.) Details of annealing processes for removing thermally or mechanically induced strains from moulded parts.

679.5 : 621.3 2161
The Growing Importance of Plastics in the Electrical Industry.—G. Haefely. (*Beama J.*, Jan. 1947, Vol. 54, No. 115, pp. 14–19 ; *Electrician*, 20th Dec. 1946, Vol. 137, No. 3577, pp. 1760–1762.) Summaries of a paper presented before the I.E.E Installations Section. For another account see 1122 of April.

679.5 : 621.365.92 2162
Pre-Heating by High-Frequency Currents.—Maddock. (*See* 2196.)

678.1 : 62 2163
Rubber in Engineering. [Book Notice]—H.M. Stationery Office, London, 10*s.* (*Govt. Publ., Lond.*, Nov. 1946, p. 14.) Joint publication of the Ministry of Supply, the Admiralty and the Ministry of Aircraft Production.

MATHEMATICS

518.5 2164
Machines Speed Science.—(*Sci. News Lett., Wash.*, 25th Jan. 1947, Vol. 51, No. 4, pp. 51–52.) Discusses the operational principles of the Harvard Mark II automatic sequence control calculator, built for use at the Naval Proving Grounds, Dahlgren, Va, to solve problems of guided missile flight and of bomb and shell trajectories.

518.5 : 621.317.733 2165
Bridge Type Electrical Computers.—W. K. Ergen. (*Phys. Rev.*, 15th Jan. 1947, Vol. 71, No. 2, p. 138.) Based on the Wheatstone bridge, with the resistances of three arms proportional to different quantities. Developments include a bridge used for the solution of the quartic equation of a line in bipolar coordinates. Summary of Amer. Phys. Soc. paper.

517.564.4(083.5) 2166
British Association for the Advancement of Science. Mathematical Tables. Part-Volume A : Legendre Polynomials. [Book Review]—Committee for the Calculation of Mathematical Tables. Cambridge University Press, 1946, A42 pp., 8*s.* 6*d.* (*Nature, Lond.*, 11th Jan. 1947, Vol. 159, No. 4028, p. 46.) $P_n(x)$ is tabulated for integers n from 2 to 12, and for the range $x = 0$ to 6 at intervals of 0.01.

518.61 2167
The Escalator Method in Engineering Vibration Problems. [Book Review]—J. Morris. Chapman & Hall, London, 270 pp., 21*s.* (*J. sci. Instrum.*, May 1947, Vol. 24, No. 5, p. 140.) The solution by this method of simultaneous linear equations and Lagrangian frequency equations is fully investigated, with special reference to stiffness and vibration problems. This is the comprehensive account referred to in 463 of February.

MEASUREMENTS AND TEST GEAR

621.3.087 . 621.38 2168
Electronic Recording Instruments.—(*See* 2248.)

621.317.323.027.7 : 537.533.73 2169
Diffraction of Non-Monokinetic Electrons ; Application to the Measurement of High Alternating Voltages.—J. J. Trillat. (*C. R. Acad. Sci., Paris*, 12th Aug. 1946, Vol. 223, No. 7, pp. 322–324.) With a non-monokinetic beam of electrons and a sinusoidal accelerating voltage, the usual spots given by a thin sheet of mica are replaced by 'comets' with bright heads near the centre of the diffraction pattern and tails thinning out radially, finally vanishing completely. Knowing, from X-ray measurements, the constants of the mica sheet, the radial length of the tail of a comet of known order terminating nearest the centre of the diffraction pattern can be used to determine the peak value of the accelerating voltage, from about 10 to 100 kV.

621.317.331 : 621.318.323.2.042.14 2170
Measurement and Control of Interlaminar Resistance of Laminated Magnetic Cores.—R. F. Franklin. (*ASTM Bull.*, Jan. 1947, No. 144, pp. 57–61.) An instrument is described for testing, under simulated operating conditions, films applied to sheet steel. A number of individual multiple contacts to which voltage is applied are pressed against the insulating surface under predetermined conditions of voltage, pressure and temperature and the total current through the contacts is measured. The results obtained have been found more useful than those given by the present A.S.T.M. test ; the new test has proved of great value in the study of insulating films and their application to steel sheets and punchings.

621.317.336.029.63 2171
Impedance Measurements with a Non-Tuned Lecher System.—J. M. van Hofweegen. (*Philips tech. Rev.*, Sept. 1946, Vol. 8, No. 9, pp. 278–286.) From voltage measurements along the Lecher wires when loaded by the impedance to be measured, the reflection factor is determined. The impedance can then be calculated : a graphical method is described. Details are given of apparatus suitable for use with decimetre waves.

[6]21.317.382.08 : 621.392.3 2172
A Coaxial-Type Water Load and Associated [P]ower-Measuring Apparatus.—R. C. Shaw & J. R. [K]ircher. (*Proc. Inst. Radio Engrs, W. & E.*, Jan. [1]947, Vol. 35, No. 1, pp. 84–87.) Describes its [d]esign, construction and use with a thermistor [b]ridge for measuring peak pulse powers of a mega[w]att at λ 10–40 cm with an accuracy of 5–10%.

[62]1.317.4 2173
A.C. Measurements of Magnetic Properties.—[.] W. Lamson. (*Communications*, Jan. 1947, [V]ol. 27, No. 1, p. 19.) An iron-cored inductor should [be] represented by a reactance ωL carrying the [m]agnetizing current and in parallel with a core-loss [re]sistance R carrying the loss current, the combina[ti]on being in series with a copper-loss resistance R_c [ca]rrying the full exciting current. A method is [de]scribed for the study of magnetic cores, whereby [the] necessary data can be obtained, including [th]e hysteresis angle, which is the phase lag of the [m]agnetizing current with reference to the exciting [cu]rrent. Summary of a Rochester Fall Meeting [pa]per.

[621].317.651.029.3 2174
[T]achometric Audio-Frequency Meter.—E. Kasner. [(*El*]*ectronics*, Feb. 1947, Vol. 20, No. 2, pp. 121–123.) [E]ccles-Jordan scale-of-two trigger circuits divide [the] audio input frequency and produce two-phase [in]put for driving a synchronous motor and [ma]gnetic drag tachometer. Frequencies from 30 to [...] cycles are indicated directly by a pointer, with [...]% accuracy."

[621].317.715.5 2175
[E]quipment and Appliances: High-Sensitivity [Mir]ror Galvanometer.—(*Electrician*, 1st Nov. 1946, [Vol.] 137, No. 3570, p. 1202.) A low-resistance [inst]rument with a period of 15–20 sec and negligible [zero] creep, particularly suitable for permeability [and] magnetic measurements. With an 850-Ω coil, [the s]ensitivity at 1 m scale distance is 16 000 mm/μA [... 1]00 mm/μV.

[621.]317.726 2176
[A]n Automatic-Slideback Peak Voltmeter for [Mea]suring Pulses.—C. J. Cleveling & L. Mautner. [(*Pro*]*c. Inst. Radio Engrs, W. & E.*, Feb. 1947, [Vol.] 35, No. 2, pp. 208–211.) Automatic slideback [is p]rovided by the amplified and rectified output [of] a diode in series with the pulse source. The [error] is less than ± 6% for repetition frequencies [...]0–5 000 c/s and pulse durations of ½–15 μs. [An i]mproved version has an error of less than ± 2% [over] the range 25–10 000 c/s.

[621.3]17.738 2177
[Fi]nding the Inductance of R.F. Coils.—R. M. [Sa]nger. (*QST*, March 1947, Vol. 31, No. 3, [pp. 5]4–56.) The circuit and details of a mains[-opera]ted electron-coupled oscillator having a [frequ]ency range of 2–16 Mc/s. A grid current [mete]r is used as an indicator.

[621.3]17.76 2178
[An] Instrument for Short-Period Frequency Com[pariso]ns of Great Accuracy.—H. B. Law. (*J. Instn [elect.] Engrs*, Part III, Jan. 1947, Vol. 94, No. 27, [pp. 3]8–41.) Phases of the two 100-kc/s inputs are compared in a phase discriminator, the output of which controls a trigger circuit. Trigger pulses operate an accurate chronometer which thus measures the time period between consecutive beats. Comparison of frequencies differing by 1 part in 10^6 can be made to an accuracy of 1 part in 10^{11} over the period of a single beat.

621.317.761 2179
A Frequency Meter for the 100-kc/s to 50-Mc/s Range.—A. J. Zink, Jr. (*Communications*, Jan. 1947, Vol. 27, No. 1, pp. 10, 11..37.) Containing an internal calibrating oscillator using a 100-kc/s crystal, a calibrated oscillator with tuning range from 1–2 Mc/s in five 200-kc/s stages, and flexible coupling for external signals.

621.317.761 : 621.396.621 2180
A 100-kc/s Frequency Standard for Receivers.—J. N. Whitaker. (*Communications*, Feb. 1947, Vol. 27, No. 2, pp. 24..39.) A small unit, with 100-kc/s crystal oscillator in aperiodic circuit, adjustable to zero beat of harmonics with Bureau of Standards transmissions. Marker signals are obtained at 100-kc/s intervals throughout the receiver tuning range.

621.317.79 : 621.396.611 2181
The Design of a Universal Automatic Circuit Tester, and Its Application to Mass-Production Testing.—R. C. G. Williams, J. E. Marshall, H. G. T. Bissmire & J. W. Crawley. (*J. Instn elect. Engrs*, Part III, Jan. 1947, Vol. 94, No. 27, pp. 20–26.) A differential valve amplifier circuit compares impedances in the unit under test with standard impedances, a.c. and d.c. being used successively. Connexion into the unit is made through the valve-holders. Operation is automatic and small transmitter-receivers have been tested at a rate of 20 per hour.

621.392.4.08 : 621.397.5 : 621.396.67 2182
Application of Transmission Line Measurements to Television Antenna Design: Parts 1 & 2.—Hamilton & Olsen. (*See* 2262.)

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

518.5 : 621.317.733 2183
Bridge Type Electrical Computers.—Ergen. (*See* 2165.)

534.321.9 : 620.179.1 2184
Supersonic Applications.—M. E. Hutter. (*Elect. Times*, 6th Feb. 1947, Vol. 111, No. 2885, pp. 162–165.) Use of supersonic waves for flaw detection and marine depth sounding.

536.48 2185
On the Possible Use of Brownian Motion for Low Temperature Thermometry.—J. B. Brown & D. K. C. MacDonald: A. W. Lawson & E. A. Long. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 976–978.) Criticism of 483 of February, and the authors' reply.

537.533.7 2186
Interruption of Electron Beams.—Selme. (*See* 2020.)

537.533.8 **2187**
Simple Means of observing Electron Images.—S. Goldsztaub. (*C. R. Acad. Sci., Paris*, 6th Nov. 1944, Vol. 219, No. 18, pp. 445–446.) The X rays emitted when electrons strike a very thin anti-cathode are observed either by coating it with fluorescent material or by applying photographic paper. A resolving power of the order of 0.1 mm is obtainable. Considerably larger images can be obtained by using Lenard window technique.

621.3 : 629.1.001.4 **2188**
Little Shakers test Big Structures.—J. Markus. (*Sci. Amer.*, Jan. 1947, Vol. 176, No. 1, pp. 6–10.) For another account see 1147 of April.

621.3.013.2 : 544 **2189**
Amplified Radio Frequencies identify Chemical Elements.—(*Sci. News Lett., Wash.*, 1st Feb. 1947, Vol. 51, No. 5, p. 71.) A new method developed by F. Bloch, W. W. Hansen and M. Packard at Stanford University. Substances are rotated in a powerful magnetic field and the atomic resonance frequencies are used for identification.

621.318.572 : 531.76 **2190**
An Electronic Decimal Counter Chronometer.—S. S. West. (*Electronic Engng*, Jan. & Feb. 1947, Vol. 19, Nos. 227 & 228, pp. 3–6 & 58–61.) The counter uses a set of scale-of-ten units which enable time intervals to be read directly to five significant figures on a row of meters scaled from 0 to 9. Each unit comprises a scale-of-two and a scale-of-five circuit, whose operation is described in some detail, with a circuit diagram but no component values. The pulse-shaping circuit used to convert an arbitrary input signal to the waveform required by the counter consists essentially of a two-valve trigger circuit giving an output of discontinuous steps even when the input waveform is continuous. Two such trigger pairs are used in the switching circuit which introduces and cuts out a crystal-controlled 100-kc/s oscillator at the start and finish of the time interval to be measured. The number of cycles counted in the interval is shown by the positions taken up by the meter pointers, which remain stationary until the reset push button is pressed. The valves used are EF50 h.f. pentodes. Considerable numbers of these chronometers have been manufactured and they have found many applications in the accurate measurement of short time intervals. A modified version provides a time-interval generator of high accuracy.

621.318.572 : 539.17 **2191**
Electronic " Stopwatch " times Atomic Particles.—(*Sci. News Lett., Wash.*, 25th Jan. 1947, Vol. 51, No. 4, p. 61.) Operation depends upon the synchronization of electrical counters which serve as pulse detectors. Timing to 10^{-9} sec is accomplished by measuring the delay inserted in order to synchronize the counters.

621.318.572 : 621.396.645 **2192**
Photo-Counters and Poisson's Law.—Blanc-Lapierre. (*See* 2047.)

621.365 : 621.396.615.141.2 **2193**
High-Frequency Heating.—(*Gen. elect. Rev.*, Jan. 1947, Vol. 50, No. 1, pp. 25–26.) Development of magnetron equipment for industrial applications.

621.365.92 **2194**
The High-Frequency Heating of Nonconducting Materials.—F. J. Jolly. (*Trans. Amer. Soc. mech. Engrs*, Feb. 1947, Vol. 69, No. 2, pp. 155–162.) An explanation of the theoretical basis and practical limitations of high-frequency dielectric heating and brief descriptions of its applications in various industries.

621.365.92 : 62 **2195**
High-Frequency Induction Heating.—E. May. (*Engineer, Lond.*, 14th Feb. 1947, Vol. 183, No. 4753, pp. 178–180.) Survey of industrial applications: melting, surface hardening, brazing, soldering, etc. About 500 kWh is needed per ton of metal melted; equipment cost is about £100 per kW output; running cost about £1 per 100 kWh.

621.365.92 : 679.5 **2196**
Pre-Heating by High-Frequency Currents.—A. J. Maddock. (*Elect. Commun.*, Sept. 1946, Vol. 23, No. 3, pp. 291–296.) The advantages to be gained by the pre-heating of plastic preforms are discussed in relation to h.f. heating. The effect of the physical properties of the material on equipment design is considered. The variation of heating time with specimen thickness is shown graphically for various types of phenolic thermosetting materials.

621.38.001.8 : 62 **2197**
Electronics in the Caterpillar Tractor Plant.—A. A. McK. (*Electronics*, Feb. 1947, Vol. 20, No. 2, pp. 104–109.) A general description of nearly 50 different applications of electronics, used with the object of improving safety of personnel, or quality or speed of production.

621.38.001.8 : 621.313.2 **2198**
Electronic D.C. Motor.—(*Gen. elect. Rev.*, Jan. 1947, Vol. 50, No. 1, p. 28.) A power supply using sealed ignitrons gives zero to full-speed regulation by armature-voltage control, or zero to base-speed regulation by armature-voltage control, with field control above base speed, for drives from 75 to 600 h.p.

621.383.49 : 621.395.625.6 **2199**
The Use of Sulphur-Thallium Photocells in Sound Pictures.—B. T. Kolomiec. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1941, Vol. 5, Nos. 4/5, pp. 506–509. In Russian with English summary.) Sulphur-thallium photocells can be used for the reproduction of sound. When they were tested in three Leningrad cinemas, it was found that: (*a*) amplifier photocascades were unnecessary, (*b*) the sound-reproduction apparatus was simplified and the rectifier requirements became less stringent, (*c*) the photocells produced no noise, (*d*) the low input resistance removed the influence of electrostatic induction on the amplifier output stage. Sound reproduction was thus improved.

621.384.6 : [621.392.029.64 + 621.396.611 **2200**
Cavities and Waveguides associated with Charged Particle Accelerators.—T. Kahan. (*C. R. Acad. Sci., Paris*, 24th Feb. 1947, Vol. 224, No. 8, pp. 548–549.)

621.385.833 **2201**
" Shadow-Cast " Replicas for Use in the Electron Microscope.—H. Thielsch. (*Metals Technol.*, Feb. 1946, Vol. 13, No. 2, Tech. Publ. No. 1977, 10 pp.

Discussion, Jan. 1947, Vol. 14, No. 1, Tech. Publ. No. 2030, pp. 1-2.) Transparent replicas of collodion or formvar are coated with a thin metallic film by vacuum evaporation. Manganese has been found to give excellent results. For most evaporations the angle between the replica surface and the line from filament to replica should be about 40–50°. Numerous photographs show the results obtained.

621.385.833 **2202**

On the Disturbing Potential due to Ellipticity of Electrostatic Lenses.—F. Bertein. (*C. R. Acad. Sci., Paris*, 24th Feb. 1947, Vol. 224, No. 8, pp. 560-562.) A method is given for calculating the corrective potential appropriate to the ellipticity defect of the system. See 1521 of May.

621.386.1 **2203**

X-Ray Tube with Great Intensity and Point Focus. S. Goldsztaub. (*C. R. Acad. Sci., Paris*, 17th Feb. 1947, Vol. 224, No. 7, pp. 458–459.) The electron beam is focused by means of electronic lenses and a spot of diameter only 0.2 mm is obtained. With a beam current of 1 mA at 30 kV, the brightness is of the order of 475 W/mm².

621.386.1 : 539.4 **2204**

X-Ray Method of Measuring Poisson's Ratio.—J. F. Hanstock & E. H. Lloyd. (*Engineering, Lond.*, 17th Jan. 1947, Vol. 163, No. 4227, pp. 68–70.) An electron diffraction method. Some results obtained for hiduminium RR56 alloy are given.

621.386.1.032.2 **2205**

X-Ray Tube with Movable Anticathode.—A. J. Rose. (*C. R. Acad. Sci., Paris*, 17th Feb. 1947, Vol. 224, No. 7, p. 460.) Uses a flexible metallic tube to permit displacement of the anticathode. Short exposures with high-energy beams are thus obtained.

621.386.84 : 620.179.1 **2206**

20 Million-Volt X-Ray Machine penetrates Heavy Steel Sections.—(*Materials & Methods*, Jan. 1947, Vol. 25, No. 1, p. 138.) A betatron specially designed for industrial radiography and capable of detecting flaws from $\frac{1}{32}$ inch to $\frac{1}{10}$ inch in diameter in forgings, welds, etc., up to 2 ft thick.

621.386 : 535.61-15 **2207**

Infra-Red Equipment for "Night" Vision.—(*Engineer, Lond.*, 14th Feb. 1947, Vol. 183, No. 4753, p. 170.) Brief reference to wartime applications by British Services: midget submarine attacks on the 'Tirpitz', the sinking of the Bergen floating dock, identification of friendly aircraft, etc. The complete signalling equipment weighs $1\frac{1}{4}$ lb; the equivalent German 'Seehund' weighs 16 lb.

621.39.001.8 : 61 **2208**

Electromedical Equipment. Berman Locator.—(*Gen. elect. Rev.*, Jan. 1947, Vol. 50, No. 1, p. 37.) Audible signals rise in pitch as the probe approaches a metallic foreign body.

PROPAGATION OF WAVES

551.510.535 : 523.746 : 621.396.812 **2209**

Ionosphere Review.—Bennington. (*See* 2117.)

551.594.6 : 523.746.5 **2210**

Ionospheric Fluctuations of Sudden Origin and the Eleven-Year Solar Cycle.—Bureau. (*See* 2122.)

621.396.11.029.64 : 517.942 **2211**

Asymptotic Solutions for the Normal Modes in the Theory of Microwave Propagation.—C. L. Pekeris. (*J. appl. Phys.*, Dec. 1946, Vol. 17, No. 12, pp. 1108–1124.) Several extensions of the 'W.K.B.' method for the asymptotic solution of differential equations are considered, with particular reference to the normal-mode theory of microwave propagation. An outline is given of this theory for propagation in an atmosphere with a horizontally stratified refractive index, the case of a surface duct being emphasized. In a study of 'leaky modes' the "aim has been to obtain explicitly the terms after the leading one in the asymptotic expansion of the solution, in order to have an estimate of the order of magnitude of the error introduced by the use of the leading term only".

Equations are given for the first correction terms to the phase-integral solution for the characteristic values of the normal modes. An alternative asymptotic solution for the case of leaky modes, which includes first correction terms, is also given. See also 507 of February.

621.396.619.029.6 **2212**

Propagation of Amplitude- and Frequency-Modulated Short-Wave Oscillations.—Hölzler, Gecks & Kamphausen. (*See* 2236.)

621.396.81.029.6 **2213**

Very-High-Frequency and Ultra-High-Frequency Signal Ranges as Limited by Noise and Co-Channel Interference.—E. W. Allen, Jr. (*Proc. Inst. Radio Engrs, W. & E.*, Feb. 1947, Vol. 35, No. 2, pp. 128–136, Discussion, pp. 136–152.) "Theoretical ground-wave ranges for smooth-earth and standard-atmosphere conditions are shown for frequency-modulation and television broadcast services and for mobile services for frequencies between 30 and 3 000 megacycles, and practical limits of antenna size and antenna gain are discussed. The effects of external noise, terrain, and penetration of buildings are considered and their probable trends with frequency are indicated, together with the need for comprehensive data for their evaluation.

"A comparison is made between theoretical ground-wave and tropospheric ranges computed for 50 megacycles and the results of continuous field-intensity measurements made at various distances, from which it is concluded that theoretical ground-wave curves can be used as reliable measures of service ranges. Theoretical ground-wave curves are found not to be direct measures of probable ranges of tropospheric interference and it is suggested that a factor of 2 be applied to the station-separation distances obtained from such curves at 50 megacycles, with the probability of larger factors for higher frequencies.

"Two families of curves, one for sporadic-E-layer and one for F-layer transmission, showing skip distances as a function of frequency for the frequency band under consideration, are derived from the National Bureau of Standards measurements of layer characteristics at Washington, D.C., for the purpose of estimating the occurrence of interference from one other co-channel station. The effect of increasing the number of stations is investigated, and estimates of five times the single-station interference for sporadic-E-layer and three times for F-layer interference are made.

"Combining the above factors, an estimate is made of comparative service areas at 46 and 105 megacycles for frequency-modulation broadcast stations of 1 kilowatt and 340 kilowatts effective power, and the reduction in area due to the effects of external noise, hills, and station interference by bursts and sporadic-E- and F-layer propagation."

In the discussion C. M. Jansky points out the importance of the paper in that it records the evidence on which the Federal Communications Commission decided to assign to f.m. broadcasting frequencies of about 100 Mc/s instead of 50 Mc/s. He quotes Dellinger who considers that ionospheric interference on both frequency bands is very small.

Armstrong considers that calculations of fields based on propagation in a standard atmosphere are inadequate as fading is not considered. He points out that interference due to sporadic-E is greater than that predicted by the author.

Carnahan and Brown also stress the serious effects of fading at points beyond the horizon.

de Mars gives graphs of theoretical signal variation with distance for different transmitting aerial heights assuming a standard atmosphere, and also of observed signal variations, and shows that the author's estimates are "not in accord with observations and measurements in any portion of the frequency band under consideration".

The author's reply is given.

621.396.81.029.62 2214

Field Intensities beyond Line of Sight at 45.5 and 91 Megacycles.—C. W. Carnahan, N. W. Aram & E. F. Classen, Jr. (*Proc. Inst. Radio Engrs, W. & E.*, Feb. 1947, Vol. 35, No. 2, pp. 152–159.) The effects of tropospheric propagation conditions on the median value of the field strength and on fading are compared for the two frequencies over a path of 76 miles.

2215

621.396.812 : 523.78 "1945.07.09" : 551.510.535

Various Papers on the Solar Eclipse of 9th July 1945 and Its Effects on Propagation and the Ionosphere.—(*See* 2092 to 2096.)

621.396.824 2216

Lateral Deviation of Radio Waves at Sunrise.—Ross & Bramley. (*See* 2125.)

621.396.945 2217

Radio-Geological Conditions for Radio Communication in Mines.—V. Fritsch. (*Radio Welt*, Nov. & Dec. 1946, Vol. 1, Nos. 3 & 4, pp. 39–43 & 59–64.) A discussion of the effects of different types of strata, the occurrence of faults, etc., on underground radio field strengths.

621.396.96.029.64 : 535.39 2218

Frequency Dependence of the Properties of Sea Echo.—H. Goldstein. (*Phys. Rev.*, 1st/15th Dec. 1946, Vol. 70, Nos. 11/12, pp. 938–946.) Measurements were made at 9.2, 3.2, and 1.25 cm at grazing incidence over a wide range of sea states. The wavelength dependence of a quantity termed the 'sea echo cross section per unit area of the sea surface' was found to lie between λ^0 and λ^{-4}, and a modified drop theory is proposed which assumes the presence of drops whose diameter is of the order of λ.

RECEPTION

551.594.6 : 621.39.029 2219

Effect of Wavelength on the General Level of Atmospherics.—Bureau. (*See* 2123.)

621.396.619.13/.14 2220

N.F.M. Reception.—G. G. (*QST*, March 1947, Vol. 31, No. 3, pp. 30–32.) A discussion on narrow-band f.m. reception in the amateur bands, pointing out some of the advantages of phase modulation.

621.396.619.13 2221

Some Investigations on Oscillations with Frequency Modulation. [Thesis]—F. L. H. M. Stumpers. N. V. Philips' Gloeilampenfabrieken Research Laboratory, Eindhoven. Reprints are available. (*Philips tech. Rev.*, Sept. 1946, Vol. 8, No. 9, pp. 287–288.) The frequency spectrum occurring with different kinds of modulation is calculated. Interference, noise and disturbances are investigated. Distortion is calculated by Fourier analysis and the series of Carson and Fry, and by the author's alternative method. Results are compared with experiment. "A new method for determining the distortion of the measuring emitter directly from the spectrum deserves attention." Brief summary only.

621.396.62.029.6 2222

Design of Communication Receivers for the Naval Service with Particular Consideration to the Very-High-Frequency and Ultra-High-Frequency Ranges.—T. McL. Davis & E. Toth. (*Proc. Inst. Radio Engrs, W. & E.*, Feb. 1947, Vol. 35, No. 2, pp. 201-207.) Owing to the close proximity of many transmitting and receiving aerials on a ship, mutual interference is probable. Methods of avoiding this by suitable design of the h.f. and i.f. stages are discussed.

621.396.621.029.62 2223

An Improved Receiver for Two Meters.—C. F. Hadlock. (*QST*, March 1947, Vol. 31, No. 3, pp. 35–40.) Details and circuit diagram of a superheterodyne receiver having an i.f. of 10.7 Mc/s and a superregenerative second detector.

621.396/.397].621.004.67 2224

The Servicing of Radio and Television Receivers.—R. C. G. Williams. (*J. Instn elect. Engrs*, Part III, Jan. 1947, Vol. 94, No. 27, pp. 11–19.) A comprehensive survey of the responsibilities, personnel and equipment problems of the service organization and the inter-relationship between service and design. All relevant statistics are shown graphically. See also 222 of January.

621.396.621(492)" 1943/1945" 2225

Secret Production of Radio Receivers in Occupied Territory.—"One out of many". (*Philips tech. Rev.*, Nov. 1946, Vol. 8, No. 11, pp. 337–340.) An account, with photographs, of many ingenious methods of construction used in Holland.

621.396.645 : 621.38 2226

Shot Effect and Fluctuations at the Output of a Linear Amplifier.—Blanc-Lapierre. (*See* 2048.)

621.396.822 : 621.317.7.089.6 2227

Factors affecting the Accuracy of Radio Noise Meters.—H. E. Dinger & H. G. Paine. (*Proc.*

Inst. Radio Engrs, W. & E., Jan. 1947, Vol. 35, No. 1, pp. 75–81.) Experimental work is needed to make an increase in the absolute accuracy of noise measurements possible, though some of the more serious errors can be avoided by proper design, construction, calibration and operation.

621.396.822 : 621.396.621 **2228**

Input Circuit Noise Calculations for F.M. and Television Receivers.—W. J. Stolze. (*Communications*, Feb. 1947, Vol. 27, No. 2, pp. 12, 13..51.) Discusses the three factors—total noise, sensitivity and signal/noise ratio—that must be taken into consideration in efficient design of the input stages of such receivers and presents formulae for calculating thermal agitation noise, shot noise and induced grid noise. Total noise calculations are made for the grid of a f.m. receiver r.f. amplifier stage.

621.396.822 : 621.396.621.029.64 **2229**

A Note on Noise and Conversion-Gain Measurements.—W. M. Breazeale. (*Proc. Inst. Radio Engrs, W. & E.*, Jan. 1947, Vol. 35, No. 1, pp. 31–34.) "The development of microwave receivers with a low-gain converter as the first stage has made it desirable that the noise level and the conversion gain be determined independently of the following intermediate-frequency amplifier. Often this converter is a crystal with a conversion gain less than one. This paper discusses some of the general procedures that have been used to measure microwave-converter noise levels and conversion gains."

621.396.823 **2230**

Interference Problems arising from Industrial Electronic and Electromedical Apparatus.—(*J. Instn elect. Engrs*, Part III, Jan. 1947, Vol. 94, No. 27, pp. 57–58.) Summary of I.E.E. Radio Section discussion, led by M. R. Gavin.

621.396.823 : 621.327.43 **2231**

Radio Interference by Fluorescent Lamps.—(*Light & Lighting*, Feb. 1947, Vol. 40, No. 2, p. 40.) A summary of a paper by L. F. Shorey & S. M. Gray at the recent Convention of the American Illuminating Engineering Society. The authors conclude that interference can be reduced to a negligible amount by a combination of screening and filtering.

621.396.96.029.62 : 523.3 **2232**

Radio Reflection from the Moon [at 120 Mc/s].—Bay. (*Electronics*, Feb. 1947, Vol. 20, No. 2, pp. 196, 198.) An electrochemical method of integration was used to distinguish the signal from noise. The equipment is also being used to measure solar radiation at 2.6 m.

STATIONS AND COMMUNICATION SYSTEMS

621.3 (494) "1945" **2233**

High-Frequency, Communications, and Remote Control Engineering.—(*Brown Boveri Rev.*, Jan./Feb. 1946, Vol. 33, Nos. 1/2, pp. 43–47.) Progress in 1945 in the design of beam and multichannel telephony and telegraphy equipment, u.h.f. f.m. radio systems for the police and fire services, short-wave telephony and telegraphy transmitters ...–10 kW, broadcasting transmitters, h.f. heating, carrier telephony, and remote control equipments.

621.391.63 **2234**

Transmission with Light.—R. H. Milburn. (*Radio Craft*, Jan. 1947, Vol. 18, No. 4, pp. 62–63, 139.) For short-range communication an NE-30 neon tube is used as the light source, with a suitable lens system for focusing the light on the receiving photoelectric cell. Modulation of the light is effected by a 3-stage amplifier of conventional design fed from a microphone or gramophone pickup. With a simple RC amplifier following the photocell, good reproduction is obtained at short distances.

621.394.44 : 621.396.619.16 **2235**

The Basic Principles of Multi-Channel Transmission with Modulated Impulses.—H. J. v. Baeyer. (*Brown Boveri Rev.*, March 1946, Vol. 33, No. 3, pp. 65–69.) By modulating periodic pulses several channels can be 'multiplexed' on the same carrier and resolved at the receiver by phase-discriminating equipment; the pulse recurrence frequency must be at least twice the highest frequency in the intelligence to be communicated.

621.396.619.029.6 **2236**

Propagation of Amplitude- and Frequency-Modulated Short-Wave Oscillations.—E. Hölzler, F. H. Gecks & G. Kamphausen. (*Elektrotech. Z.*, 20th April 1944, Vol. 65, Nos. 15/16, pp. 133–138.) Single-sideband transmission with carrier suppression, as used between Berlin and New York, reduces very considerably the distortion and signal variations often found in short-wave communication. The use of f.m. for further noise reduction introduces new disturbances whose origin is explained by multipath transmission. The technical aspects of such effects are discussed. Results with model equipment indicate the possibility of evaluating directly the disturbing effect of neighbouring transmitters.

621.396.619.13 **2237**

Frequency Modulation.—K. R. Sturley. (*J. Instn elect. Engrs*, Part III, Jan. 1947, Vol. 94, No. 27, pp. 84–88.) Discussion of 4047 of 1945.

621.396.619.13 **2238**

Frequency-Modulation in Broadcasting.—(*Nature, Lond.*, 4th Jan. 1947, Vol. 159, No. 4027, pp. 15–16.) Summary of 3751 of 1946 (Kirke).

621.396.619.13 **2239**

A New System of Frequency Modulation.—R. Adler. (*Proc. Inst. Radio Engrs, W. & E.*, Jan. 1947, Vol. 35, No. 1, pp. 25–31.) Describes the development of the phasitron modulator in which a radial electron stream in a concentric structure is shaped into a wavelike pattern which progresses continuously round the cathode. The axial modulating magnetic field curves the paths of the electrons in the plane of rotation so that the streams of electrons reaching the segmented anode are advanced or retarded according to the magnetic field. The faults of early models and the steps taken to correct them are analysed.

621.396.619.13 **2240**

Some Investigations on Oscillations with Frequency Modulation. [Thesis] — Stumpers. (*See* 2221.)

pp. 20–21.) Discussion of problems and future possibilities.

621.397.6 2267
Some Special Tubes used in Television.—(*Télévis. franç.*, Feb. 1946, No. 10, pp. 12–13.) Diagrams and brief descriptions of principal characteristics.

621.397.62 2268
Television Receiving Equipment. [Book Review]—Iliffe & Sons, London, 2nd edn, 354 pp., 12s. 6d. (*Wireless World*, March 1947, Vol. 53, No. 3, p. 89.) Brought up to date, with many chapters re-written and some additional material.

TRANSMISSION

534.78 2269
More on Speech Clipping.—Smith. (*See* 1981.)

621.317.761 : 621.396.61 2270
The BC-221 Frequency Meter as a V.F.O.—H. W. Johnson. (*QST*, March 1947, Vol. 31, No. 3, pp. 43–47.) Details of its adaptation without impairing its use as a frequency meter. See also 3099 of 1946.

621.396.61.029.62 2271
Low-Cost Six-Meter 'Phone.—C. V. Chambers. (*QST*, March 1947, Vol. 31, No. 3, pp. 13–17.) A description and circuit diagram of a 15-W 50-Mc/s transmitter. The second harmonic of a 25-Mc/s crystal is obtained from a triode-tetrode oscillator with sufficient output to drive directly a low-power amplifier.

621.396.615.142 2272
Current and Power in Velocity-Modulation Tubes.—L. J. Black & P. L. Morton. (*Proc. Inst. Radio Engrs, W. & E.*, Jan. 1947, Vol. 35, No. 1, p.43.) Discussion by P. J. Wallis and S. G. Tomlin of 3843 of 1944.

621.396.619.13/.14 2273
Development of the Cascade Phase Shift Modulator [for f.m. transmitters].—(*Radio, N.Y.*, Jan. 1947, Vol. 31, No. 1, pp. 11–15.) Distortion in phase shift modulators may occur as nonlinearity of phase modulation or as the result of amplitude modulation of the signal. The paper describes in detail a circuit employing a 100-kc/s crystal oscillator and six pentode-triode resistance-controlled modulators followed by frequency-multiplying stages having a factor of 97.2. The output signal has less than 1% distortion for 100 kc/s deviation at audio frequencies above 50 c/s.

621.396.619.14 2274
Wide-Angle Phase Modulator.—H. K. Bradford. (*Electronics*, Feb. 1947, Vol. 20, No. 2, pp. 100–103.) "Technique for phase modulating a crystal-controlled carrier, whereby two components of fixed phase difference are amplitude modulated and added to give the output, is described. Circuit can be used to give frequency modulation, or modified to give amplitude modulation."

621.396.619.231.029.62 2275
Investigations on Suppressor Grid Modulation at Ultra-High Frequency.—S. K. Chatterjee. (*Electrotechnics*, Dec. 1946, No. 19, pp. 41–51.) An experimental investigation at 40 Mc/s. Main results are high overall efficiency (20%) and good linearity of the modulation characteristic.

VALVES AND THERMIONICS

621.314.632 : 546.289 2276
Properties of Welded Contact Germanium Rectifiers.—H. Q. North. (*J. appl. Phys.*, Nov. 1946, Vol. 17, No. 11, pp. 912–923.) Construction and tests of these rectifiers are described. Welded contact has advantages of mechanical stability, very low forward and high backward resistance, low contact capacity at zero bias, logarithmic d.c. characteristic over a wide current range and high harmonic power output as a microwave generator. Loss and noise ratio measurements are also described.

621.316.722.1 : 621.384.5 2277
A Voltage Stabilizing Tube for Very Constant Voltage.—T. Jurriaanse. (*Philips tech. Rev.*, Sept. 1946, Vol. 8, No. 9, pp. 272–277.) By using a carefully prepared molybdenum cathode and depositing a thick layer of molybdenum on the tube walls by cathode sputtering, the stabilized voltage varies by not more than a few volts for different samples of the same type, and the variation with time is not more than ½ V per 1 000 working hours. Ambient temperature, also, has little effect on the working voltage.

621.383 2278
Elimination of the Residual Current in Photo electric Cells.—A. Lallemand. (*C. R. Acad. Sci., Paris*, 18th Nov. 1946, Vol. 223, No. 21, pp. 856–857.) Difficulties due to residual current can be very considerably reduced by using only a small portion of the cathode, with electrostatic or magnetic lenses between it and the corresponding portion of the anode, which can be pierced and provided with a small collecting disk behind the hole. A 5-stage multiplier on this principle has been constructed, with magnetic lenses forming an electronic image of the photocathode successively on each multiplier, the residual current from the small collecting electrode being 80 times less than from the guard electrode. With this device it has been possible to show that the light reflected or diffused by a photoelectric layer is by no means negligible, and also to measure the gain realized by giving the photosensitive layer in an ordinary cell the form of a black body.

621.383 : 537.533.8 2279
Application of Secondary Emission of Electrons to Multiplier Tubes.—A. Lallemand. (*Rev. sci. Paris*, Aug. 1946, Vol. 84, No. 3255, pp. 131–136.) A review of the phenomena of secondary emission from pure metals, alloys and complex layers, and their practical use in electron multipliers.

621.383.42 2280
Parallel Operation of Several Barrier-Layer Selenium Photocells.—M. Delattre. (*C. R. Acad. Sci., Paris*, 17th Jan. 1944, Vol. 218, No. 3, pp. 112–113.)

621.383.42 : 535.215.4 2281
Investigation of Uniformity of Sensitivity Distribution over the Surface of Selenium Photocells.—I. A. Vladimirov. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1941, Vol. 5, Nos. 4/5, pp. 499–502. In Russian with English summary.) Apparatus is described for recording this sensitivity distribution.

621.383.42 : 535.215.6 2282

On the Gaseous Nature of the Non-Conducting Layer in Selenium Photocells.—D. I. Arkadiev. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1941, Vol. 5, Nos. 4/5, pp. 503–505. In Russian with English summary.) If a selenium rectifier photocell is placed in a high vacuum, the only way in which its electrical and photoelectric properties can be changed is by the formation of selenium amalgam when the mercury vapour is not completely frozen out. Previous suggestions that the rectifier layer consists of adsorbed gaseous molecules or other volatile compounds are not supported by these experiments.

621.383.5 : 620.196 2283

The Influence of Impurities on the Rectifier Photo-effect of Cuprous Oxide.—V. E. Laškarev & K. M. Kosonogova. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1941, Vol. 5, Nos. 4/5, pp. 478–493. In Russian with English summary.) If cuprous oxide cells are prepared by reduction during tempering in salt solutions (of Li, Na, K, Be, Zn, Pb, U) an extra maximum occurs in the red and infra-red region of the spectrum (0.75–1 μ). The position of the maximum is determined by the content of the metallic impurities introduced and is the same for all the above metals. For large impurity contents the principal maximum at $\lambda = 0.54\,\mu$ disappears. The introduction of impurities causes an abrupt increase in the absorption by cuprous oxide in the red region of the spectrum ; it has a marked effect on the dissociation work of the barrier layer. A thermoprobe method reveals, in Cu_2O photocells, the existence, between the upper electrode and the barrier layer, of a layer of oxide which has electronic conductivity. Analysis of the results suggests a new structural scheme for Cu_2O cells. The stability of these cells when temperature varies is increased if impurities are introduced. For relatively large amounts of impurity this stability is of the order of fifty times that for photocells prepared by cathode sputtering. All the observed phenomena can be explained on the assumption that the electropositive impurities result in localized levels whose height is greater than that of the oxygen levels in Cu_2O.

621.385.029.63/.64 2284

Theory of the Beam-Type Traveling-Wave Tube.—J. R. Pierce. (*Proc. Inst. Radio Engrs, W. & E.*, Feb. 1947, Vol. 35, No. 2, pp. 111–123.) The theory is developed assuming small signals. The equations predict three forward waves, one increasing and two attenuated, and one backward wave which is little affected by the electron beam. The dependence of the wave propagation coefficients on voltage, current, circuit loss, and other properties of the transmission mode, together with expressions for gain, noise and power are given and illustrated graphically. Appendices deal with (a) the field in a uniform transmission system due to impressed current (such as an electron stream) in terms of the parameters of the transmission modes, and (b) wave propagation along a helix.

621.385.029.63/.64 2285

Traveling-Wave Tubes.—J. R. Pierce & L. M. Field. (*Proc. Inst. Radio Engrs, W. & E.*, Feb. 1947, Vol. 35, No. 2, pp. 108–111.) Describes a valve with a gain of 23 db at 3 600 Mc/s and power output of 0.2 W. The bandwidth between the 3-db points is 800 Mc/s. A qualitative account of its operation is included ; for theory see 2284 above.

621.385.029.63/.64 : 621.396.615.14 2286

The Traveling-Wave Tube as Amplifier at Microwaves.—R. Kompfner. (*Proc. Inst. Radio Engrs, W. & E.*, Feb. 1947, Vol. 35, No. 2, pp. 124–127.) The inner conductor of a concentric line consists of a wire helix such that the velocity of propagation is about one-tenth of the velocity of light. If an electron beam of voltage of the order of 2 500 and about the same velocity as that of the travelling field is shot along the axis of the helix, the line acts as an amplifier of r.f. power passing along it. A description of the early development of these valves in England and expressions for power gain and noise factor are given.

621.385.1 2287

Time Constant of the Ignition of the Discharge in Rarefied Gases.—J. Moussiegt. (*C. R. Acad. Sci., Paris*, 28th Oct. 1946, Vol. 223, No. 18, pp. 659–661.) A simple theory is given, with formulae, in general agreement with the results previously reported (940 and 941 of March) for the effect of various factors on the value of the current maximum for intermittent gas discharges.

621.385.1.029.62/.63 + 621.396.6 2288

Radar Vacuum-Tube Developments.—J. J. Glauber. (*Elect. Commun.*, Sept. 1946, Vol. 23, No. 3, pp. 306–319.) The development, and factors influencing the design, of high power transmitting triodes for pulsed and c.w. operation in the 200–600 Mc/s band are discussed.

Brief details of air-cooled valves suitable for pulsed operation are given below :—

L200 : operating frequency 200 Mc/s ; power output per pair 150 kW (duty cycle 0.01) ; directly-heated thoriated tungsten cathode ; squirrel-cage type grid connecting to a ring seal ; re-entrant anode.

L400 : operating frequency 400 Mc/s ; generally similar to L200 but shorter anode.

L600E : operating frequency 600 Mc/s ; power output 25 kW.

8C22 : operating frequency 400 Mc/s ; directly-heated cathode specially arranged to reduce electro-mechanical force between adjacent elements thereof ; filament power 1.35 kW ; power output 500 kW.

6C23 : operating frequency 600 Mc/s ; power output 600 kW ; indirectly-heated cathode requiring lower filament power input than 8C22.

Brief details of valves suitable for c.w. operation are given below :—

6C22 : directly-heated water-cooled valve, having smaller grid-to-filament spacing than L600E and larger filament area ; output power 250 W as an oscillator at 600 Mc/s and 500 W as an amplifier with a driving power of 100 W.

L600NR : air-cooled version of 6C22.

8C23 : An improved valve developed from 8C22, having modified grid structure and reduced anode diameter. Incomplete tests using forced air-cooling indicate a power output of 500 W at 400 Mc/s with an anode dissipation of 1 kW : with water cooling, power outputs of 2.7 kW and 1 kW (anode dissipation 5 kW) are anticipated at 400 and 600 Mc/s respectively.

6C23: Early tests on this valve under c.w. operating conditions are described.

621.385.1.032.216 **2289**

Periodic Variations of Anode Current in Valves with Oxide Cathodes.—R. Champeix. (*C. R. Acad. Sci., Paris*, 13th Nov. 1946, Vol. 223, No. 20, pp. 786–788.) The anode current in some of these valves varies periodically, the periods observed ranging from 15 minutes to 4 hours. In some cases the current curves are approximately sinusoidal, but more frequently the maxima, which may be three times the minima, are sharply peaked. The effect is observed much more often with low than with high cathode temperatures and appears to be related to modifications of the cathode saturation current. See also 3810 of 1946.

621.396.615.142 **2290**

Transit-Time Effects in Ultra-High-Frequency Class-C Operation.—W. G. Dow. (*Proc. Inst. Radio Engrs, W. & E.*, Jan. 1947, Vol. 35, No. 1, pp. 35–42.) "Effects discussed are electron-transit reactance; electron-transit phase-delay angle; cathode back-heating; use of a screen grid to improve efficiency; changes in optimum shunt impedance; secondary emission; and anode back-heating by secondary electrons. It is pointed out that by increasing voltage and current density simultaneously the frequency and power can be raised without sacrificing efficiency or bandwidth. An equivalent circuit is described which takes account of certain important transit-time effects."

621.396.615.142 **2291**

A Wide-Tuning-Range Microwave Oscillator Tube.—J. W. Clark & A. L. Samuel. (*Proc. Inst. Radio Engrs, W. & E.*, Jan. 1947, Vol. 35, No. 1, pp. 81–83.) Describes the design of the 2K48 reflex velocity-modulation valve and its associated cavity resonators tuning from 3 000 to 6 000 Mc/s and 5 000 to 10 000 Mc/s respectively.

621.396.615.142 **2292**

Current and Power in Velocity-Modulation Tubes.—Black & Morton. (*See* 2272.)

621.397.6 **2293**

Some Special Tubes used in Television.—(*Télévis. franç.*, Feb. 1946, No. 10, pp. 12–13.) Diagrams and brief descriptions of principal characteristics.

MISCELLANEOUS

001.4 : 621.38 **2294**

Is "Electronics" Overworked?—"Cathode Ray". (*Wireless World*, Feb. 1947, Vol. 53, No. 2, pp. 43–45.)

061.31 **2295**

British Commonwealth Scientific Official Conference, London, 1946. Report of Proceedings. [Book Review]—H.M. Stationery Office, London, 73 pp., 1s. 3d. Terms of reference: "To consider the best means of ensuring the fullest possible collaboration between Civil Government Scientific Organizations of the Commonwealth and to make formal recommendations for the approval of the Governments represented".

061.6 **2296**

20th Annual Report of the Council of the [British] **Institution** [of Radio Engineers].—(*J. Brit. Instn Radio Engrs*, July/Aug. 1946, Vol. 6, No. 4, pp. 130–142.)

061.6 : [526+55] "1946.07.29/.08.02" **2297**

Summary Report on the Extraordinary General Assembly of the International Union of Geodesy and Geophysics (IUGG), Cambridge, England, July 29 to August 2, 1946.—J. M. Stagg. (*Terr. Magn. atmos. Elect.*, Dec. 1946, Vol. 51, No. 4. pp. 509–515.)

371.3 : 621.3 **2298**

I.E.E. and Further Education Grants.—(*Electrician*, 8th Nov. 1946, Vol. 137, No. 3571, p. 1292.) The Ministry of Labour scheme enables university or I.E.E. graduates, whose war service has prevented completion of practical training, to take a specially designed course.

371.3 : 621.3 **2299**

E. R. A. Apprenticeships.—(*Elect. Rev., Lond.*, 7th March 1947, Vol. 140, Nos. 3613/3615, p. 342.) This scheme, involving attendance at college for one or two days each week, whilst not a substitute for full-time university training, makes a useful contribution to the training of electrical engineers.

384 : 654.196(73) **2300**

U.S. Radio Statistics, 1947.—(*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, p. 59.) A table of output of broadcast receiving sets from 1922 to 1946, and of economic statistics for 1946.

519.283 : 62 **2301**

Engineering and Quality Control.—P. L. Alger. (*Elect. Engng, N.Y.*, Jan. 1947, Vol. 66, No. 1, pp. 16–19.) Describes a systematic procedure for taking samples, measuring them, and plotting the results on charts so that variations of importance can be noted before they become serious. The fundamental laws of chance on which this procedure is based are briefly discussed. See also 2421 of 1946.

621.38(083.72) **2302**

"Tron".—(*Toute la Radio*, Jan. 1947, Vol. 14, No. 112, p. 43.) Short definitions of 30 of the 'tron' family, many of which are simply trade names.

621.396.621.004.67 **2303**

Manual of Radio Practice for Servicemen. [Book Review]—E. G. Beard. Philips Electrical Industries of Australia, Sydney, 496 pp. (*Proc. Instn Radio Engrs, Aust.*, Nov. 1946, Vol. 7, No. 11, p. 33.) A comprehensive treatment which should prove useful both to the serviceman and to the radio engineer.

621.396.97 : 06.013 **2304**

Broadcasting. Copy of the Licence and Agreement between His Majesty's Postmaster General and the British Broadcasting Corporation, Nov. 29 1946. [Book Notice]—H.M. Stationery Office, London, 3d. (*Govt Publ., Lond.*, Dec. 1946, p. 6.)

621.396.97 : 06.013 **2305**

Broadcasting. Draft of Royal Charter for the Continuance of the British Broadcasting Corporation for which the Postmaster General proposes to apply. [Book Notice]—H.M. Stationery Office, London, 2d. (*Govt Publ., Lond.*, Dec. 1946, p. 6.)