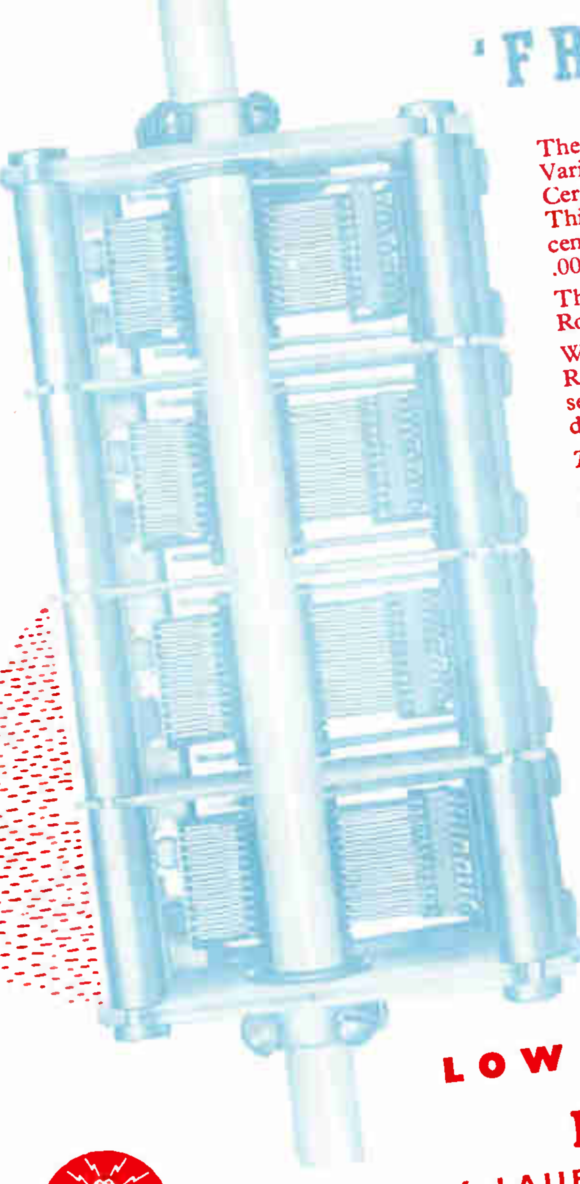
WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

JULY 1952

VOL. 29 No. 346 THREE SHILLINGS AND SIXPENCE



FOR HIGH-FREQUENCY INSULATION—*specify*

'FREQUELEX'

The illustration shows a Four Gang Radio Variable Condenser using our **"FREQUELEX"** Ceramic Rod for the Centre Rotating Spindle. This Rod is 7½″ long × .437″ diameter, centreless ground to within plus or minus .0005″. Maximum camber allowance of .002″.

This is only one of many applications where Rods made to close limits are required.

We specialise in the manufacture of Ceramic Rods and Tubes of various sections in several classes of materials over wide dimensional ranges.

The Principal Materials Are :—

1. **Porcelain for general insulation.**
2. **Frequelex for High Frequency insulation.**
3. **Permalex and Templex for Capacitors.**

The degree of accuracy depends on the size of the Rod or Tube, but the standard degree of accuracy is outlined in the Inter Service Component Manufacturer's Council—Panel R Specification embodied in our Catalogue of Radio Frequency Ceramics, copy of which will be sent on request.

Large Rods up to 44″ long and 1¼″ square are used as supports for Tuning Coils, etc.

We shall be pleased to have your enquiries for all sizes of Tubes and Rods. Prompt deliveries can be given for most sizes.

Condenser manufactured by Messrs. WINGROVE & ROGERS LTD.

Bullers

LOW LOSS CERAMICS

Bullers Limited

6 LAURENCE POUNTNEY HILL, E.C.4

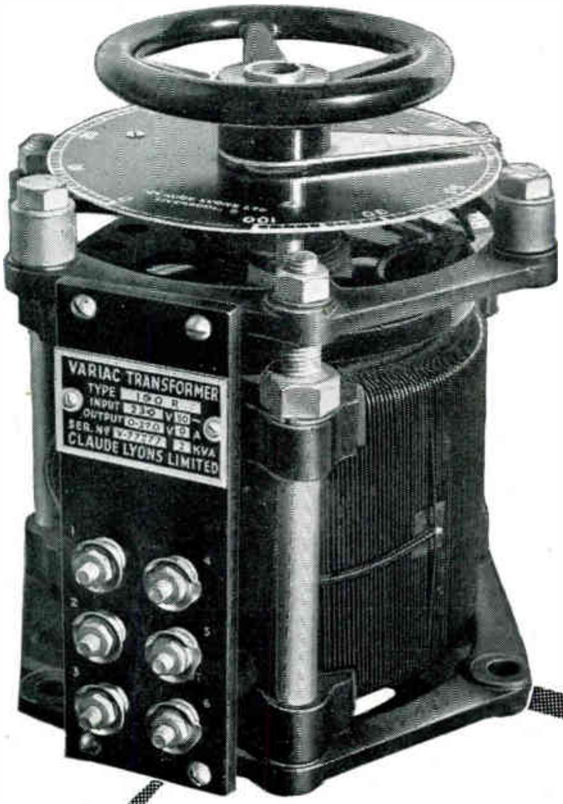
Phone: MANsion House 9971 (3 lines). Grams: 'Bullers, Cannon, London'

TRADE MARK

World Radio History

'VARIAC' voltage regulating transformers

Reg'd Trade Mark



'VARIAC' infinitely variable voltage-regulating transformers are designed and constructed for many years of trouble-free operation. Not only do they supply perfectly smooth control of voltage from zero, but many types (including 100-R) also furnish output voltages considerable above line voltage while the 100-RM/2B is a dual output type. Illustration left shows Type 100-R, Rating 2,000 va., Input Voltage 230/115, Output Voltage 0-270.

Left—
Type 200 C.U.H.

Right—
Type 50-B.

SERIES 100 'VARIAC' TRANSFORMERS.

TYPE	LOAD RATING	SPECIFICATIONS				NO-LOAD LOSS	NET PRICE ‡		
		INPUT VOLTAGE	CURRENT		OUTPUT VOLTAGE				
			RATED	MAXIMUM			£	s.	d.
100-K	2000 va.	115	15 a.	17.5 a.	0-115	20 watts	17	17	0
100-KM	2000 va.	115	15 a.	17.5 a.	0-115	20 watts	18	12	0
100-L	2000 va.	230/115	8 a.	9 a.	0-230	25 watts	17	17	0
100-LM	2000 va.	230/115	8 a.	9 a.	0-230	25 watts	18	12	0
100-Q	2000 va.	115	15 a.	17.5 a.	0-135	20 watts	18	9	0
100-QM	2000 va.	115	15 a.	17.5 a.	0-135	20 watts	19	4	0
100-R	2000 va.	230/115	8 a.	9 a.	0-270	30 watts	18	9	0
100-RM	2000 va.	230/115	8 a.	9 a.	0-270	30 watts	19	4	0
100-LH	1200 va.	480/240	2 a.	2.5 a.	0-480	25 watts	21	15	0
500-L *	1450 va.	180	8 a.	9 a.	0-180	25 watts	17	17	0
2000-K †	1000 va.	125	8 a.	9 a.	0-125	25 watts	17	17	0

* For 500 cycles † For 2,000 cycle service ‡ All 'VARIAC' prices plus 20% as from 23rd Feb. 1952

Write for catalogue V549 which gives full details of 'VARIAC' transformers and suggestions for use.

CLAUDE LYONS LIMITED

ELECTRICAL AND RADIO LABORATORY APPARATUS, ETC.

180 Tottenham Court Road, London, W.1; and 76 Oldhall Street, Liverpool 3, Lancs.

A*

UNIVERSAL UNITS

RESISTANCE · CAPACITANCE · INDUCTANCE

In education and in industry, these units find a host of applications. There is a physical reality about them which appeals to the elementary student and which is necessarily missing from the more expensive boxes where switches are hidden mysteries and connexions must be taken on trust. This unit form of construction is economical and very convenient, and the moulded containers are sensibly engineered, so that fixing to a panel or to each other is quite simple.

WRITE FOR DESCRIPTIVE LITERATURE

MUIRHEAD & Co., LTD.
PRECISION ELECTRICAL INSTRUMENT MAKERS
BECKENHAM · KENT · ENGLAND
Phone: BECkenham 0041 Telegrams & Cables: MUIRHEADS ELMERS-END

PRECISION
MUIRHEAD
ELECTRICAL INSTRUMENTS

543

STYRAFOIL REGD.

AN EXCELLENT H.F. DIELECTRIC

specially suited for condensers

Styrafoil is an orientated film of polystyrene, possessing outstanding electrical characteristics (Power factor ·0003—·0005; permittivity 2·6—2·7; dielectric strength 4000 volts/mil at ·002″ thickness). It is supplied in various thicknesses from ·0004″ (10 micron), and in slit widths.

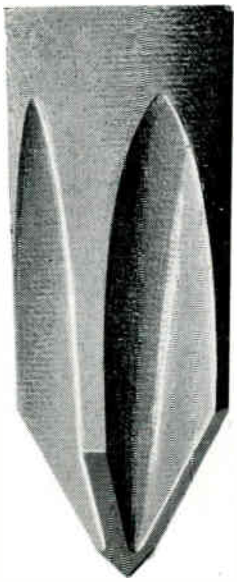
Prompt delivery. Samples available on request.

BX PLASTICS LTD., CHINGFORD, LONDON, E.4.
LARkswood 5511.

T.A. 4447

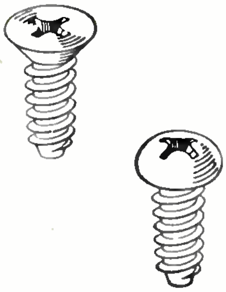
World Radio History

N-P-K

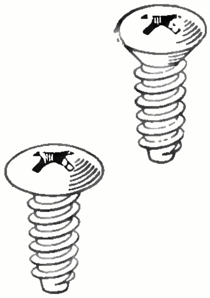


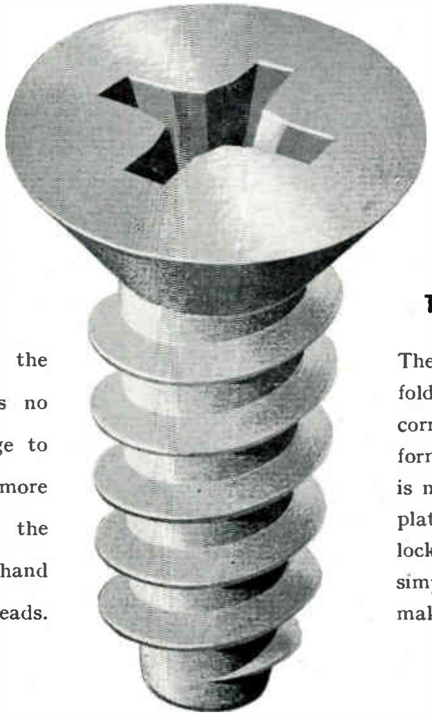
SELF-TAPPING SCREWS

WITH PHILLIPS RECESS HEADS



Available in
a complete range
of head styles





THE PHILLIPS HEAD

The special driver mates perfectly with the recess head and cannot slip. There is no risk of injury to the operator or damage to the article. This makes for faster, more efficient work with less strain on the user. Power driver bits as well as hand drivers are available for Phillips Heads.

THE N.P.K. THREAD

The hardened threads of Nettlefolds Parker-Kalon screws cut corresponding threads in drilled, formed or moulded holes. There is no need for tapping, tapping plates, inserts, clinch nuts or lock washers. N.P.K. screws simplify assembly methods and make stronger fastenings.

Full details on application from :

GUEST KEEN & NETTLEFOLDS (MIDLANDS) LTD.
SCREW DIVISION : Box 24, Heath Street, Birmingham, 18.

G K N

S/P/NPK/2902

Delay cables

CHARACTERISTICS AND NOMINAL DIMENSIONS

Telcon offers the engineer a series of high impedance delay cables, in which the inner conductor is composed of fine gauge enamelled wire helically wound on an insulating cord. This conductor is provided with a covering of Telcothene* and can be supplied wire-braided and sheathed with Telcovin or finished with a lead sheath, as required.

* *Telcothene (Regd.) is polythene processed by Telcon to provide specific characteristics.*

CODE NUMBER	Z.5	Z.3	Z.1	Z.14	Z.6
Approx. overall size, ins.	5/16	5/8	1	1/2	1
Characteristic impedance, ohms.	130	330	550	1000	1900
Capacitance, mmf/ft.	55	50	50	80	45
Attenuation, db/100 ft. 1 Mc/s.	2.3	1.7	1.4	8	10
10 Mc/s.	8	6	5	30	45
100 Mc/s.	25	22	23	—	—
Velocity ratio v/c	0.14	0.06	0.036	0.014	0.012
Delay microsecs/100 ft.	0.7	1.7	2.8	7.3	8.5

TELCON RF cables

TELCON

THE TELEGRAPH CONSTRUCTION & MAINTENANCE CO. LTD
Head Office: 22 Old Broad Street, London, E.C.2. *Tel: LONdon Wall 7104*
Enquiries to: Telcon Works, Greenwich, S.E.10. *Tel: GREenwich 3291*

Ready Shortly

Musical Engineering

by HARRY F. OLSON, E.E., Ph.D.
Director, Acoustical Laboratory, RCA Laboratories, Princeton, New Jersey

From an engineering viewpoint, here is the first unified treatment of all the elements that enter into the production and reproduction of music. The book covers the nature of sound, music, musical instruments, acoustics, and hearing, in both their physical and some of their psychological aspects. It provides facts of an applied science that will aid in study, measurement and analysis of audio problems of many types.

369 pages 9 × 6 55/6

McGRAW-HILL PUBLISHING COMPANY, LTD.
McGraw-Hill House, 95 Farringdon Street, London, E.C.4

World Radio History

ADVANCE COMPONENTS LTD., BACK ROAD, SHERNHALL STREET, LONDON, E.17 Telephone : LARkswood 4366/7/8

Modern in conception, design and performance, the E.2., with its exceptionally wide range, not only fulfils to-day's needs of radio and television, but anticipates the requirements of tomorrow. More than ordinary care has been used in screening and filtering. As a result, stray field is less than 3µV. at 100 Mc/s.

- *Frequency accuracy of ± 1% extends over the whole range.*
- *Output voltage 1µV. to 100mv. and approx. 1v. at full R.F. Socket.*
- *Internal modulation; external modulation to 80%*
- *A.F. Output variable 0-50v. at 400c/s.*
- *Size 13" × 10¼" × 8".*
- *Weight 17½ lbs.*

Advance

signal generator

ADVANCE TYPE E2

100 Kc/s – 100 Mc/s ON FUNDAMENTALS

Full Technical Details available in Folder S/14/V

ADVANCE COMPONENTS LTD., BACK ROAD, SHERNHALL STREET, LONDON, E.17 Telephone : LARkswood 4366/7/8

The Story so far . . .

Fourth of a Series telling the Story of Goodmans Loudspeakers.

In the first three of this series we have shown the very extensive process control and inspection measures carried out at *every* stage in the production of *every* cone, and we have stressed the vital importance of such control and inspection.

All the components comprising a completed loudspeaker are necessarily the outcome of careful research and development; but none needs more of the designer's attention than the cone. To develop a cone that will transduce to its air load the complex alternating currents passed through its associated speech coil with a minimum of "colouration" or harmonic distortion, "sub-harmonic" distortion, and all the troubles caused by non-linear elements, needs a great deal of often tedious work to determine its precise mechanical requirements. To do this, the designer must consider each part of the cone separately, then as a whole, and the whole must be as near to perfection as he can make it.

The cone surround must have exactly the right degree of compliance to control the bass resonance to within the required close limits. Its thickness, the shape and size of its corrugations, the nature of pulp to be used, and the treatment required are all involved; and while they are being determined it is necessary to ensure that the surround can handle the maximum amplitudes of the vibratory cone without ever imposing any non-linear restraint on it, and without any danger of its tearing, even though its thickness may be only a few thousandths of an inch.

The body of the cone constitutes the major task. The shape, or "profile" has to be determined, and it is largely upon this, together with the thickness, mass, and fibre structure of its material that the success of the cone in reproducing without discrimination the range of frequencies required of it depends. At the same time, the cone profile has a direct effect upon the polar diagram or "off axis" response of the completed loudspeaker, so this too has to be borne in mind in order that the higher frequencies shall not become sharply focused. Since the nature of the cone vibrations in the middle and upper frequency ranges may become highly complex, the designer's problems are formidable. When he has finalised the design of his cone, every part of it is given a detailed manufacturing specification, and it can go into production. The profile can be reproduced to the exact requirements easily enough after the necessary tools have been made, but all the work put into the cone design is wasted if any one of the other features is allowed to "drift" when quantity production starts.

So the routine of control and inspection at *all* stages, for *every* cone, is vital.

In conclusion, we may summarise this routine, which has been dealt with in previous announcements.

The Importance of Pulp is so great that all the attention given to the control of its fibre length and structure is well worth while and as **The Cone Takes Shape** the fibre density of the pulp in suspension must be closely checked to ensure that every finished cone shall have correct thickness, weight, and texture. Finally, after precision moulding, pressure treatment, and in some cases resin treatment, the completed cone is trimmed, checked for correct resonance, and carefully inspected before being built into a loudspeaker.

An Infinite Capacity for taking pains over all stages of production is the secret that lies behind the production of cones or diaphragms that will all always perform as well as the prototype.

AUDIOM 60

12″ 15w. P.M. Loudspeaker

This famous all-purpose loudspeaker, of exceptional smoothness in response and performance, is specially recommended for high-power radio-gramophones, P.A. systems, and small cinemas. It is now available again on the home market.

Details will gladly be sent on request.

GOODMANS

GOODMANS INDUSTRIES LIMITED, AXIOM WORKS, WEMBLEY, MIDDX. *Telephone: WEMbley 1200*

AUDIO OSCILLATORS

Laboratory Standard B.F.O. Type L.O. 800 and Portable Model L.O. 50.

B.S.R. Beat Frequency Oscillators have established themselves throughout the world as leaders in their field.

Models are available up to 100 kc at power outputs of up to 5 watts.

These instruments are distinguished for their superb engineering and individual accuracy.

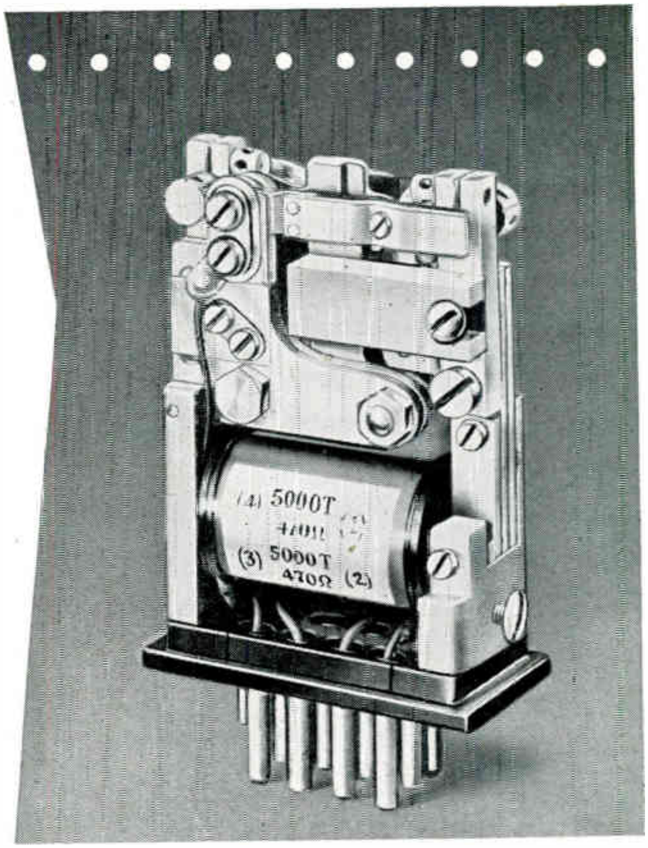
Full technical details and prices gladly sent on request.

BSR British Throughout

BIRMINGHAM SOUND REPRODUCERS LIMITED, OLD HILL, STAFFS.

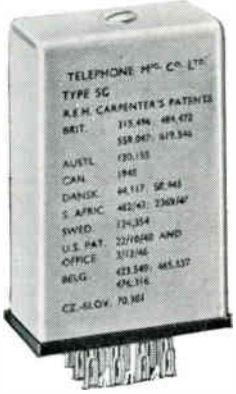
sturdy and strong-

The compact, rugged design of the Type 5 Carpenter Polarized Relay is just one of the many reasons why this small-size relay is so frequently specified in many fields of scientific research and electrical engineering.



Other outstanding features include :—

- HIGH OPERATIONAL SPEED
- FREEDOM FROM CONTACT REBOUND
- IMMUNITY FROM POSITIONAL ERROR
- GOOD CONTACT PRESSURES
- HIGH SENSITIVITY
- ACCURACY OF SIGNAL REPETITION
- EXCEPTIONAL THERMAL STABILITY



Type 5 Relay with cover.

Plug or solder tag base optional.

Complete specification and further details of the complete range of Carpenter Relays may be had on request.

TMC

CARPENTER POLARIZED RELAY TYPE 5

Manufactured by the Sole Licensees:—

TELEPHONE MANUFACTURING CO. LTD

Contractors to Governments of the British Commonwealth and other Nations.

HOLLINGSWORTH WORKS · DULWICH · LONDON S.E.21 · *Telephone: Gipsy Hill 2211 (10 lines)*

Capacitors by Wego

for
C W
V H F
RADAR
X-RAY
SMOOTHING
ENERGY STORAGE
IMPULSE GENERATORS
AND OTHER ELECTRONIC APPLICATIONS

Full information will be supplied on request.

WEGO CONDENSER CO. LTD.

BIDEFORD AVENUE, PERIVALE, GREENFORD, MIDDLESEX. Telephone : Perivale 4277.

UNIVERSAL IMPEDANCE BRIDGE

BPL

MODEL UB 202

RESISTANCE RANGE: 0·1 ohm to 1,000,000 ohms. Basic range: 0·1 to 11 ohms continuously variable, plus nine steps of 10 ohms.

CAPACITY RANGE: 10 pf to 1,000 mFds. Basic range: 10 to 1,100 pf continuously variable, plus nine steps of 1,000 pf.

INDUCTANCE RANGE: 10 microhenries to 1,000 henries. Basic range: 10 to 1,100 microhenries continuously variable, plus nine steps of 1,000 microhenries. 6-way multiplier.

DIMENSIONS AND FINISH: 19" × 10½" × 10" deep. Front panel silver anodised aluminium, steel cabinet zinc-plated and black-crinkle finished.

A general-purpose instrument covering a very wide range of measurements for values of resistance, inductance and capacity. When used for resistance measurement it is connected as a Wheatstone bridge, the required D.C. source of supply and the balance-indicating micro-ammeter both being incorporated in the instrument. When used as a capacity bridge, the condenser under test is connected in a modified De Saute's Bridge. The same dial as used for resistance measurement is used to balance the capacity of the unknown condenser, whilst a second dial in combination with a decade resistance balances the power loss For the measurement of inductance the instrument is converted into a Hay's bridge.

SENSITIVE PANEL MOUNTING METERS

SIZE	2½"	3½"	5"
RANGE	25μA to 50A	10μA to 50A	10μA to 50A

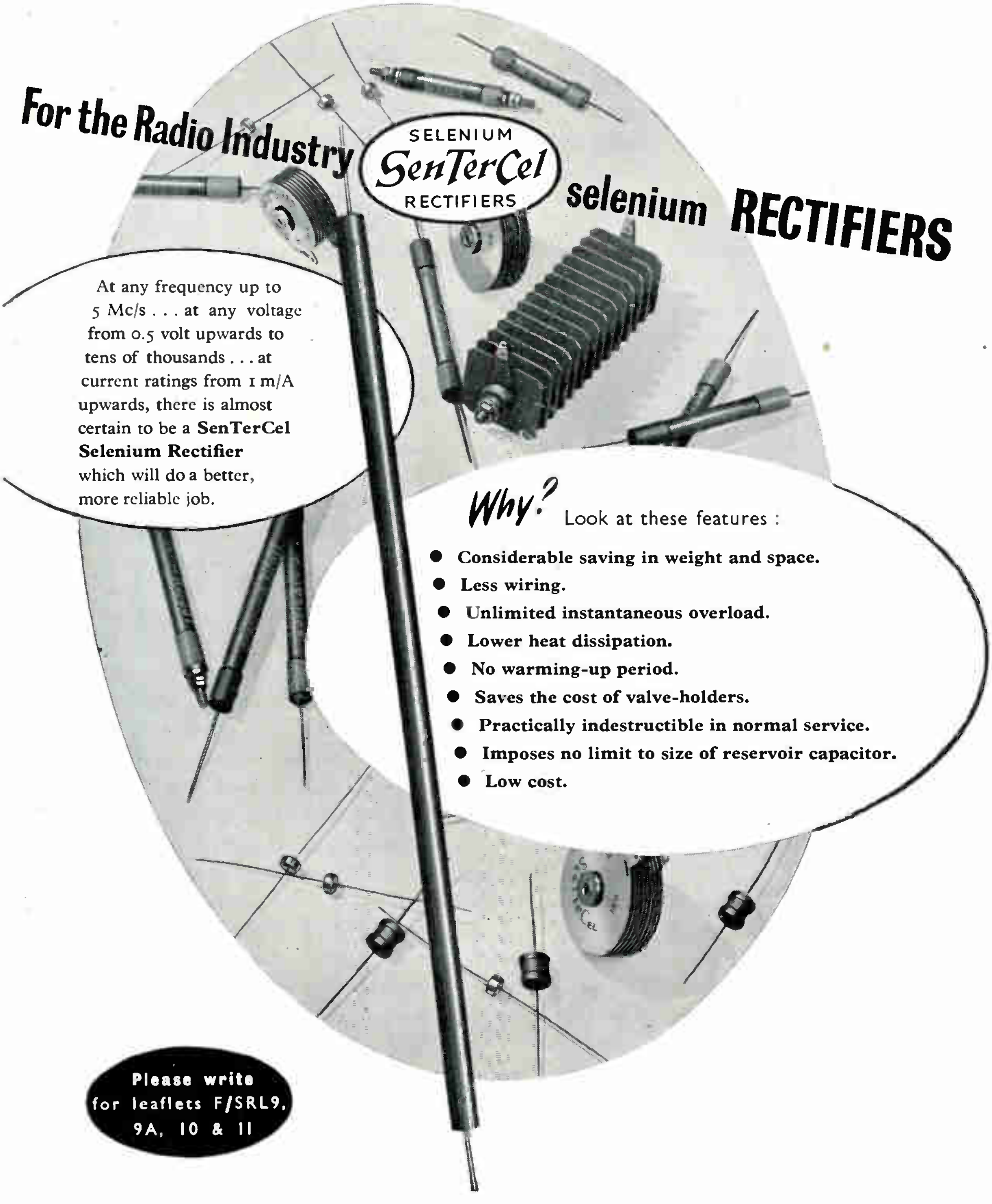
Prices on application

Available for immediate delivery from our Stockists, *M.R.* Supplies, Ltd., 68 *New* Oxford Street, *W.C.1, or write to:*

BRITISH PHYSICAL LABORATORIES

HOUSEBOAT WORKS · RADLETT · HERTS · Telephone: RADlett 5674-5-6

World Radio History



ALL-POWER

REGULATED POWER SUPPLIES

Semi-standard designs are available covering output voltages from 0·1 to 2,000 volts and output currents from 1 mA to 10 amps.

Special units can be made to any specification, and although the demand for our products is continually increasing we can still offer reasonably prompt delivery.

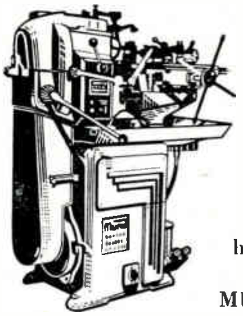
ALL-POWER TRANSFORMERS LTD.
CHERTSEY ROAD, BYFLEET, SURREY.
Tel: Byfleet 3224/5.

HIVAC
THE SCIENTIFIC VALVE
BRITISH MADE

Pioneers and specialists in Small Valves

- SUBMINIATURES
- MINIATURES
- MIDGETS
- GAS TRIODES
- ELECTROMETERS
- COLD CATHODE TUBES

Hivac Ltd
GREENHILL CRESCENT, HARROW-ON-THE-HILL, MIDDX.
Telephone: HARrow 2655



this stands constant repetition...

Outstanding accuracy and very high speed operation make the MURAD 1″ High Speed capstan lathe an ideal tool for rapid and economic production of repetition screw parts.

Murad
CAPSTAN LATHE

Amongst the leading manufacturers who use MURAD capstan lathes in large quantities are such well-known firms as E.M.I., Belling & Co., Ferguson Radio, Pilot Radio, Ultra Electric, E. K. Cole, & Reyrolles.

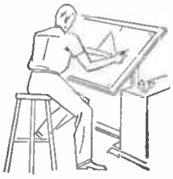
MURAD DEVELOPMENTS LTD., STOCKLAKE, AYLESBURY, BUCKS.
PHONE: AYLESBURY 790 (4 LINES) CABLES: MURADITE, AYLESBURY

MARCONI communication systems

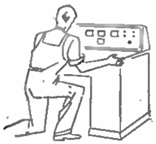
serve mankind

The need to keep in touch is as essential for the scattered look-outs of a forest empire as it is for the offices and homes of a crowded metropolis. What is the best way to go about it? How much will it cost to install? . . . to maintain? It is to such questions that Marconi's will be glad to give the relevant answers, drawn from unrivalled experience in communications all over the world.

SURVEYED



PLANNED



INSTALLED

MARCONI'S WIRELESS TELEGRAPH COMPANY LTD · CHELMSFORD · ESSEX

SIGNAL GENERATORS - BRIDGES - VALVE VOLTMETERS - FREQUENCY STANDARDS

Things that count...

Important Characteristics of the
Marconi F.M. RECEIVER TESTER :—

- ★ *Crystal standardised c.w., f.m. and a.m. signal generator with audio frequency power meter.*
- ★ *Carrier range 21-168 Mc/s in three bands.*
- ★ *Output 1 μV to 31.6 mV, continuously variable; high level 0.1 V max.*
- ★ *Frequency modulation up to 75 kc/s on the low frequency band, 150 kc/s on the medium band or 300 kc/s on the high frequency band.*
- ★ *Amplitude modulation to a nominal depth of 30% over the complete range.*
- ★ *Internal modulation at 1000 c/s. External modulation over wide range.*

F.M. RECEIVER TESTER

Type TF 913

There are other impressive features also in an instrument which is up to date in technique, soundly-designed and carefully engineered. Full specification on request.

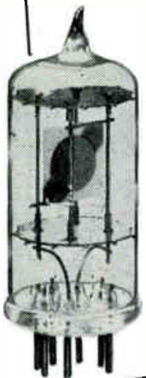
MARCONI instruments

MARCONI INSTRUMENTS LTD · ST. ALBANS · HERTS · PHONE: ST. ALBANS 6161/7

Midland Office: 19 The Parade, Leamington Spa. **Northern Office:** 30 Albion Street, Hull. **Export Office:** Marconi House, Strand, London, W.C.2

OUTPUT METERS - WAVE METERS - WAVE ANALYSERS - BEAT FREQUENCY OSCILLATORS

Crystal Specialists



ANOTHER CRYSTAL OF WORLD RENOWN

TYPE "G" Frequency ranges : 100 kc/s to 500 kc/s, 3 mc/s to 20 mc/s. Evacuated glass envelope having B7G valve base, with crystal connected across pins Nos. 3 and 7.

BROOKES

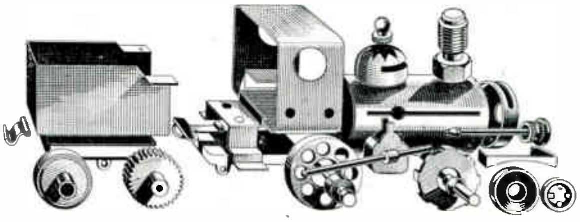
CRYSTALS LIMITED

10 Stockwell St., Greenwich, London, S.E.10

Phone:
GREenwich 1828

'Grams: Xtals, Green, London.
Cables: Xtals, London.

HIGH SPEED AUTOMATICS



Modern machinery and mass production methods give you top quality capstan and automatic work and sheet pressings at a price you are sure to like—and on time.

GRIFFITHS, GILBART, LLOYD
AND COMPANY LIMITED
Empire Works, Park Rd., Birmingham 18
Telephone: NORthern 2132/4

G·G·L

5 ADVANTAGES OF THE NEW METALLISED CERAMICS

Steatite & Porcelain Products' outstanding advance in the technique of metallising ceramics offers these five vital advantages:–

1 Robust and highly resistant to solution in any soft solder alloys.

2 Any method of soldering may be used, without precautions of controlled temperature and soldering time. No special skill needed.

3 May be repeatedly mounted and de-mounted; removed from faulty or broken-down components and used again.

4 High melting-point soft-solders (such as silver-lead) may be used in assembly, eliminating all risk of failure of the hermetic sealing during component assembly into equipment.

5 No gas or oil leakage can occur—the bond between the new metallising and the ceramic is stronger than the ceramic itself.

SEND FOR FULL DETAILS

The new metallising is applied to all the hermetic seals of the standard range (shown in catalogue No. 25, available on request). Special types, including multi-seals, can readily be produced to customer's requirements.

Please write to us for further details. We shall be glad to answer any queries on the new metallised ceramics.

STEATITE & PORCELAIN PRODUCTS LTD

STOURPORT-ON-SEVERN WORCESTERSHIRE TEL: STOURPORT 111. GRAMS: STEATAIN STOURPORT

S.P.86

SULLIVAN PORTABLE GALVANOMETERS

EMPLOYING A NEW

SUSPENDED COIL
PORTABLE GALVANOMETER UNIT

which may be supplied alone or boxed complete with scale, illumination (with Mains Transformer) and novel Scale Magnification

These Galvanometers are also available as

DIRECT-READING
MICROAMMETERS
MILLIVOLTMETERS
and OHMMETERS

A compact, sensitive, yet robustly suspended galvanometer has been developed in our laboratories and, having undergone extensive trials, has proved to be extremely reliable for all purposes. All galvanometers are fitted with shock-absorbing non-sticking stops, thus overloads of up to 100 times full scale-current may be applied without risk of damage to the movement.

It is available as a compact unit for bench use, mounted in a bakelite case measuring only 12 × 8 × 4 cms. and is eminently suitable for mounting in the client's own equipment—a simple bracket mounting is incorporated to facilitate this.

It is available also in portable form in a polished teak case (complete with scale and illumination) with different internal optical arrangements of some novelty which give, in effect, various scale distances without having to resort to large awkwardly shaped boxes. In some cases effective scale-reading magnification of approximately 8 to 1 is obtained within a small box measuring only 27 × 16 × 16 cms. They may be used for all "null" balance measurements, such as for Wheatstone and Kelvin bridge work, in which case they are provided with centre zero scales. They may, however, if desired, be fitted with side zero scales for accurate deflection measurements—a high degree of law linearity rendering this possible.

Galvanometers covering the ranges	*Micro-ammeter 4 ranges*	*Milli-voltmeter 5 ranges*	*Ohmmeters covering the ranges*
COIL RESISTANCES 10 to 500 ohms	(full scale) 0 to 1 μA	(full scale) 0 to 1 mV	0 to 5,000 ohms
PERIODS 1·5 to 2 seconds mm/μA 30 to 2,400	0 to 10 μA 0 to 100 μA 0 to 1,000 μA Period 2 seconds	0 to 10 mV 0 to 100 mV 0 to 1 V 0 to 10 V Period 1 second	0 to 50,000 ohms 0 to 0·5 megohms 0 to 50 megohms

H. W. SULLIVAN
—LIMITED—

LONDON, S.E.15

Telephone : New Cross 3225 (P.B.X.)

Electrical Standards for Research and Industry

Testing and Measuring Apparatus
FOR COMMUNICATION
ENGINEERING

WIRELESS ENGINEER

The Journal of Radio Research and Progress

Managing Editor : HUGH S. POCOCK, M.I.E.E.
Editor: W. T. COCKING, M.I.E.E. Technical Editor: Professor G. W. O. HOWE, D.Sc., LL.D., M.I.E.E.

Volume 29 · Number 346

CONTENTS

JULY 1952

Editorials: The Microwave Gyrator **171**
Effect of Torsion on a Longitudinally-Magnetized Iron Wire **173**
Cylindrical Aerials
by B. Storm **174**
Slow-Speed Circular Time-Base
by A. M. Hardie, M.A., B.Sc., and P. A. V. Thomas, B.Sc.(Eng.) **177**
The Synchrodyne and Coherent Detectors
by D. G. Tucker, D.Sc., Ph.D. **184**
Multiple Reflections in Long Feeders
by L. Lewin **189**
Correspondence **193**
New Books **197**
Standard-Frequency Transmissions **198**
Abstracts and References. Nos. 1797-2098 .. **A.133-A.154**

Published on the sixth of each month

Annual Subscription: Home and overseas, 1 year £2 4s. 6d.; 6 months £1 2s. 3d.; Canada and U.S.A. $7.00

Editorial, Advertising and Publishing Offices: Dorset House, Stamford Street, London, S.E.1
Telephone: Waterloo 3333 (60 *lines*) · *Telegrams: Wirenger, Sedist, London*

BRANCH OFFICES AT BIRMINGHAM · MANCHESTER AND GLASGOW

Radar Display Tubes with High Resolution

The most important requirements of a radar display tube are that it shall be capable of a resolution at least equal to that of the radar system employed; that it shall present a picture of high brilliance and contrast; and that it shall operate reliably under the continuous and arduous conditions of service encountered in navigational radar applications.

The Mullard range of radar display tubes, developed with the advantage of the vast experience gained in the production of television picture tubes, has been specially designed to meet these requirements.

Characterised by very high definition, high brilliance and contrast, low deflection defocusing, low astigmatism, and long after-glow, these tubes are now being extensively used in a wide variety of navigational radar equipments. Brief descriptive details of these tubes are given below; more comprehensive information will gladly be supplied on request.

	MF41-15	**MF31-55**	**MF13-1**	
DESCRIPTION	A 16″ flat-faced, wide angle, radar display tube with a metallized fluoride screen. Ideal for use in harbour radar systems.	A 12″ flat-faced radar display tube with a metallized fluoride screen. This tube is on the Government list of Preferred Types (CV429).	A 5″ compact, flat-faced, radar display tube with a metallized fluoride screen. Designed for small marine and airborne radar displays where high performance coupled with saving in space is required. This tube is the equivalent of the 5FP7A.	
HEATER				
V_h	6.3	6.3	6.3	V
I_h	0.3	0.3	0.3	A
LIMITING VALUES				
(absolute ratings) V_{a2} max.	16	15	11	KV
V_{a2} min.	6	7	5.5	KV
V_{a1} max.	450	†600	450	V
V_{a1} min.	200	250	200	V
$-V_g$ max.	200	200	200	V
DIMENSIONS				
Max. bulb diameter	406	307	127.5	mm
Max. overall length	515	520	289	mm
Useful screen diameter	360	260	108	mm
BASE	B12A	B12A	Octal.	

† Beam current not to exceed 50 μA

Mullard

MULLARD LTD., COMMUNICATIONS AND INDUSTRIAL VALVE DEPT., CENTURY HOUSE, SHAFTESBURY AVE., LONDON, W.C.2

MVT 114

WIRELESS
ENGINEER

Vol. 29 JULY 1952 No. 346

The Microwave Gyrator

IN the May Editorial we discussed the somewhat fictitious device known as a gyrator. It is a four-pole element which violates the reciprocity relation by having its transfer impedance in one direction of opposite sign to that in the reverse direction. In an article by C. L. Hogan in the *Bell System Technical Journal* for January 1952, experiments are described in which the gyrator effect is actually realized for microwaves by making use of the Faraday rotation of the plane of polarization in pieces of ferrite placed in a waveguide.

One may regard the magnetization of a ferromagnetic material as the alignment of the axes of the spinning electrons. Each spinning electron will have a certain magnetic moment and, because of its angular momentum, will act like a spinning top, the axis of which under the force of gravity rotates slowly about the vertical with what is known as precessional motion. When the material is saturated the axes of all the spinning electrons are in the direction of the applied field. Due to its mass each electron will have an angular momentum of

$$J = \tfrac{1}{2}\,(h/2\pi)\ \text{gm cm}^2/\text{sec}$$

and due to its spinning charge a magnetic moment

of $$\mu_B = \frac{eh}{4\pi mc}$$

where h = Planck's constant ($6{\cdot}62 \times 10^{-27}$ erg sec)

e = charge in electrostatic units ($4{\cdot}8 \times 10^{-10}$)

m = mass ($9{\cdot}1 \times 10^{-28}$ gm)

c = velocity of light (3×10^{10} cm/sec)

The ratio μ_B/J is called the gyromagnetic ratio of the spinning electron.

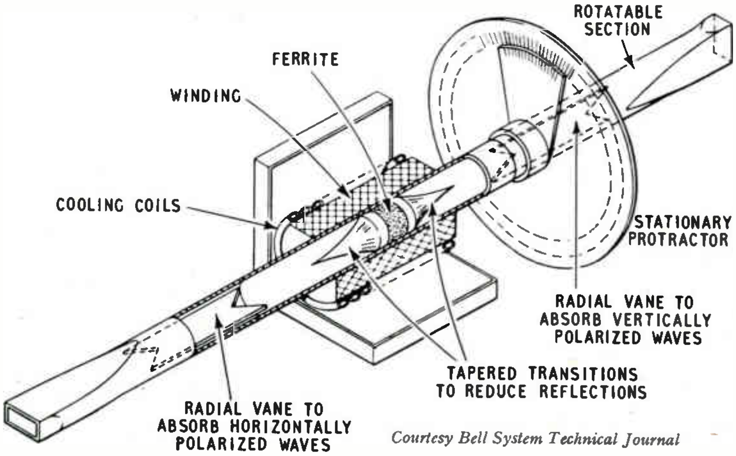
If now a magnetic field is applied at right angles to the main field, the electron experiences a torque tending to shift its axis so that it lies along the resultant field, but because of the gyroscopic action it will precess around this direction, thus producing an alternating magnetic field, not only in the direction of the applied field but also in a direction at right angles to both the main field and the applied field. If two coils are arranged with their axes at right angles to each other and to the axis of the ferromagnetic core, then, if the core is not axially magnetized, an alternating current in one coil will have no effect on the other, but when the core is magnetized this is found to be no longer true. The mutual effect is small unless the strength of the axial magnetic field and the frequency of the cross field are adjusted to give gyromagnetic resonance. Under these circumstances the time of one cycle of the applied field agrees with the time of one precessional revolution of the electron. At lower frequencies the main movement of the electron will be a swing to and fro in the plane of the applied field, but converted into an elliptical movement by the gyromagnetic precession. As the condition of resonance is approached the ellipse approximates to a circle of a radius depending on the damping. The direction of the precessional rotation depends only on the direction of the main axial field and is independent of the direction of the cross field.

The Faraday Effect

If an isotropic transparent material is magnetized by being placed in a solenoid, and a plane-polarized beam of light is transmitted along the axis, its plane of polarization is rotated.

The direction of rotation is the same for both directions of the beam; it depends only on the direction of the magnetic field and therefore on the direction of the current around the solenoid. If a beam, after passing through the material, is reflected and made to retrace its path, the rotation of the plane of polarization is not cancelled but doubled. In this the Faraday effect differs from other optical rotations. Faraday did much research on this subject and in Preston's "Theory of Light" (1890) we read "This rotation must be an affection of, or at least depend on, the matter occupying the field, and does not necessarily lead to the conclusion that the free ether in a magnetic field is in rotatory motion, for the Faraday effect is in one direction in some substances and in the opposite direction in others. It is consequently induced by the action of the magnetic field on the matter molecules occupying it, the effect of the magnetic action being to originate something analogous to a rotation in the matter molecules, and the direction of rotation being determined by the nature of the matter . . . By reflecting the pencil of light backwards and forwards several times through the field, a feeble rotation may be much amplified and rendered sensible, for if the ray traverses the field *n* times the rotation will be *n* times that produced by a single passage . . . A positive rotation occurs when light is transmitted through thin films of magnetic substances such as iron, nickel and cobalt."

Now that we know, it seems a short step from the above to the spinning electron and its gyromagnetic action.



Courtesy Bell System Technical Journal

Microwaves in Ferrites

In the experiments made in the Bell Telephone Laboratories the Faraday rotation was measured in a large number of ferrites, and detailed results are given for manganese zinc ferrite, nickel zinc ferrite, and two others known as ferramic A and G. The frequency employed was about 9,000 Mc/s. The Figure shows the ferrite sample in the test chamber. A cylinder of the ferrite is placed at the centre of a cylindrical waveguide about a foot long, fitted between two rectangular waveguides, the junctions being designed to avoid reflection. The vertically-polarized wave enters by the left-hand guide, a vane being arranged to absorb any horizontal polarization. The right-hand guide, by which the wave leaves, can be rotated and the rotation read on the protractor scale. It only passes waves which are correctly polarized with regard to its cross-section; it carries a vane which absorbs waves which are polarized in a plane at right angles. In the position shown, in the absence of the ferrite, no waves would pass. The circular waveguide which contains the ferrite is surrounded by a magnetizing coil fitted with cooling coils. Tapered transitions are fitted at each end of the ferrite sample to reduce the reflection which would otherwise occur at the sudden change of medium. After passing through various devices the output passes to a cathode-ray oscilloscope.

We do not propose to go into the mathematical treatment, especially as the author of the article in the *Bell Journal* says, "It is almost impossible to get a feeling for what these equations mean with respect to a wave travelling through the medium, especially since μ and K are given by equations which are almost as difficult to perceive."

One can regard the plane-polarized wave as being split into positive and negative circularly-polarized waves which, owing to the gyromagnetic effect, travel with different velocities and on emergence combine to form a plane-polarized wave which may have any plane of polarization. This assumes that conditions are far removed from gyromagnetic resonance; if the steady magnetic field and the frequency are such that resonance occurs, then the positive wave may be absorbed, and only the negative circularly-polarized wave emerge; half the power will have been lost. In the neighbourhood of resonance the two components will differ in magnitude and the emerging wave will be elliptically polarized.

As an indication of the results achieved, tests made on a sample of manganese zinc ferrite to ascertain its dielectric constant and dielectric losses and also its magnetization at saturation, gave results from which the expected rotation of the plane of polarization was calculated to be 121·2° per cm. On test the actual rotation was found to be approximately 123° per cm.

The non-reciprocity of the device is clearly seen by considering the effect of twisting the rectangular guide by which the wave enters through 45°. This will rotate the plane of polarization through 45°, but to a wave going in one direction this rotation will be in the same direction as that caused by the ferrite, whereas to a wave going in the opposite direction the two rotations will be in opposite directions. If the magnetization is adjusted so that the ferrite gives exactly 45° rotation, then to a wave in one direction the two rotations will exactly cancel and the wave will emerge with the same polarization as it had on entry, whereas to a wave in the opposite direction the two rotations are added and the emerging wave will be polarized at 90° to the wave on entry. The device is thus non-reciprocal due to the gyromagnetic effect of the ferrite. G. W. O. H.

Effect of Torsion on a Longitudinally-Magnetized Iron Wire

SINCE the publication of the Editorial with the above title in our May number, our attention has been drawn to the very large amount of work on this subject which has been described in various journals during the last hundred years. We referred to the fact that Matteucci examined the phenomenon as long ago as 1847. In the *Annalen de Chemie et de Physique* of 1858, there is a long translation of a paper by Matteucci in *Nuovo Cimento* describing experiments in which the magnetized iron rod, which can be twisted, forms a part of the circuit of a galvanometer. He concludes as follows:

> 1. Que dans la torsion et la détorsion d'un cylindre de fer aimanté, on obtient des courants induits dans le circuit de ce cylindre;
>
> 2. Qu'il y a aussi développment de courants instantanés dans le circuit de fer au moment où ce cylindre est de nouveau aimanté après avoir été précédemment tordu et détordu sous la première aimantation.

About the same time Wiedemann was carrying out a lot of experiments. He found that an iron wire carrying a current, and therefore circularly magnetized, became a magnet when twisted; he also found that if an iron rod is both circularly and longitudinally magnetized, it becomes twisted, owing to the extension in the direction of magnetization. It is this latter effect that is often referred to in the literature as the Wiedemann effect. In his "Handbook of Inorganic Chemistry" (1934), Gmelin calls the former effect the inverse Wiedemann effect No. 2, the inverse effect No. 1 being that discussed in the May Editorial; viz., the production of circular magnetization by twisting a longitudinally-magnetized iron wire.

As we mentioned in the Editorial, the subject is discussed in Ewing's "Magnetic Induction in Iron and other Metals," and in the *Proc. Royal Soc.* of 1881 (Vol. 33, p. 21) there is a paper by Ewing on "Transient Currents produced by Magnetizing Twisted Rods or by Twisting Magnetized Rods.' It is interesting to note that it was in this connection that he invented the word 'hysteresis'; the lag was not originally of B with regard to H, but of the magnetization with regard to the angle of twist.

In the proceedings of the *Royal Dutch Academy of Science* of 1916, there is a lengthy paper by Elias entitled "On a general electromagnetic thesis and its application to the magnetic state of a twisted iron bar", and in the Italian *Atti Istit. Veneto* of 1932, there are a number of papers on the subject, all describing work carried out at the University of Padua by Gnesotto, Drigo and Alocco. Drigo's paper (p. 681) is entitled "Variations of longitudinal and circular magnetism in cylinders of iron and nickel deformed torsionally, due to a longitudinal alternating field superposed on the constant field"; then at p. 933 there is a further paper of 40 pages under the same title giving curves and tables of results, which are fully discussed, followed by a bibliography of 20 references. The frequencies employed were 42 and 25 c/s, and an electrodynamometer was used as the measuring instrument. The important point for our present purpose is his statement that the results show "the strict relation that exists between the longitudinal alternating e.m.f. and the amplitude of the torsional deformation to which the cylinder is submitted."

The experiments made by Mr. Dromgoole, to which we referred in the Editorial, only differ from these in that he used a much higher frequency (15 kc/s) and a cathode-ray oscilloscope.

Experiments on the subject are being carried out by the Radio and Electrical Engineering Division of the Canadian National Research Council and we are indebted to them for drawing our attention to many of the above items.

G. W. O. H.

CYLINDRICAL AERIALS

New Solution of Hallén's Integral Equation For Current

By B. Storm

*(Imperial College of Science and Technology, London)**

1. Introduction

HALLÉN showed in 1938 generally that it is possible to formulate an integral equation for the current in an aerial. If one is able to solve this integral equation and find the current in terms of the dimensions of the aerial and the driving electromotive force, the aerial impedance or radiation resistance and reactance are also known.

The integral equation cannot be solved exactly. Hallén solved the equation approximately by an iteration method (successive approximation). Later, especially Bouwkamp, M. Gray and R. King, have developed, improved and applied the iteration method and have published curves and tables for the impedance of cylindrical and symmetrical aerials.

Hallén's theory has the great advantage of giving the aerial current and impedance directly and not through complicated computations of the field in the vicinity of the aerial, which involve boundary conditions which cannot be formulated exactly in a simple way.

The aerial theory of Schelkunoff is based on this latter method.

Hallén's aerial theory and the improved theory of R. King also give as yet the best conformity with measurements. Furthermore, the Hallén–King theory can also be applied to aerials with a gap, unsymmetrical aerials and aerials driven from a transmission line. The main difficulty of the Hallén–King theory is, however, the solution of the integral equation. The iteration method which has been used so far gives a slowly converging series for the current or impedance. Only two terms of the series are known, and the accuracy has not been determined. The method fails if one tries to compute more terms of the series due to the mathematical difficulties rapidly becoming prohibitive. A simpler method of solving the integral equation is therefore very desirable.

In the following it is proposed to show a new, simpler and more direct method of solving the integral equation. The solution is *not* based on the iteration method, and the mathematical difficulties do not increase with the order of accuracy. If the order of accuracy is increased by one stage, only the amount of numerical labour becomes greater, but the integrals and functions involved are of the same type. It is hoped, therefore, that the method will prove to be of some value. It should also be more easily applicable to aerials with a gap, unsymmetrical aerials and thick aerials with end surfaces, than the Hallén–King theory. Before giving a survey of the new method, the formulation of Hallén's integral equation and the previous solutions by the iteration method will be briefly indicated.

2. Hallén's Integral Equation for a Symmetrical Cylindrical Aerial

For a cylindrical, symmetrical, perfectly-conducting aerial, excited in the centre, it is relatively simple to show from the condition of vanishing electric field component along the surface of the aerial, that the vector potential along the surface must be sinusoidally axially distributed and given by the expression:

$$A \sin k\,|z| + B \cos k\,z \qquad \ldots \quad \ldots \quad (1)$$

Here A is a constant proportional to the driving voltage in series with the aerial, and B is a constant to be determined during the solution of the integral equation, so as to make the current at the ends of the aerial equal to zero.

On the other hand, the vector potential along the aerial can be written

$$\frac{1}{c}\int_{-l}^{l} I\,(\zeta)\,\frac{e^{-jkr}}{r}\,d\zeta \qquad \ldots \quad \ldots \quad \ldots \quad (2)$$

Now equating (1) and (2) gives Hallén's integral equation for a cylindrical, symmetrical aerial:

$$A \sin k\,|z| + B \cos k\,z = \frac{1}{c}\int_{-l}^{l} I(\zeta)\,\frac{e^{-jkr}}{r}\,d\zeta \quad \ldots \quad (3)$$

Here:

$k = 2\pi/\lambda$ where λ is the wavelength in free space,
$\zeta =$ a point on the axis of the aerial,
$z =$ a point on the surface of the aerial,
$r = \sqrt{(z-\zeta)^2 + a^2}$ where $a =$ the radius of the aerial,
$I\,(\zeta) =$ the current at the point ζ,
$1/c = 30$ when I is measured in amperes and the driving voltage in volts,
$l =$ the half length of the aerial.

MS accepted by the Editor, March 1952

---

* Now at the Norwegian Defence Research Establishment, Kjeller, Lillestrõm, Norway.

The formulation of the integral equation is given in greater detail by Bouwkamp.

3. Previous Solutions by the Iteration Method of Hallén-King

Space does not permit a detailed explanation of the iteration method of Hallén–King in solving the integral equation (3). In short, the basis of the iteration method is as follows:

After a transformation of equation (3) one assumes as a first approximation a current distribution function $I(\zeta)$, which is substituted under the integral sign. By integration one finds a new and better approximation for $I(\zeta)$, which is now substituted under the integral sign a second time. The integrals now become more complicated, but if one can solve them (for instance numerically) one gets a third and still better approximation for $I(\zeta)$, and so on.

The iteration process gives a slowly converging series for $I(\zeta)$ and correspondingly for the impedance in the centre. This impedance is determined by the driving voltage or the discontinuity of the potential in the centre of the aerial divided by the current $I(0)$.

As a first approximation for $I(\zeta)$ Hallén uses $I(z)$ and neglects the retardation; i.e., he considers at first the vector potential at the point z as determined solely by the current at z, as the contributions from the nearest current elements are predominant.

R. King uses a more refined method. He uses as a first approximation a sinusoidal current distribution and obtains in this way a somewhat better convergence of the series for the current and correspondingly a more accurate value of the aerial impedance.

But the common drawback of both methods is that they are very complicated, and that the mathematical difficulties become insurmountable after computation of the second-order approximation.

4. New Method of Solving Hallén's Integral Equation

The new method consists quite simply in expressing the current $I(\zeta)$ under the integral sign in equation (3) as a sum of a sinusoidal dominant current and a trigonometric series. The dominant current and the terms of the trigonometric series are then multiplied by

e^{-jkr}/r and integrated term by term.

By the integration we obtain a series of sums of Si and Ci functions with undetermined complex coefficients. By comparing this resulting series with the left side of equation (3) at, for instance, 5 points along the aerial, one can determine the constant B and 4 coefficients of the series. As B and the coefficients of the series are complex, this means solving a system of 10 equations with 10 unknowns for the case of 5 points.

In this way the aerial current has been determined as the sum of a sinusoidal dominant current and a series of 'higher harmonics', corresponding to the trigonometric correction series. From this the aerial impedance follows immediately.

When working out the method we obtain two types of integrals which must be solved, one type for the dominant current and the other for the terms of the trigonometric series. For the dominant current we obtain:

$$\int_{-l}^{l} \frac{e^{-jkr}}{r} \sin k(l - |\zeta|)d\zeta\ , \ k = \frac{2\pi}{\lambda}$$

This integral can be solved exactly and gives a sum of Si and Ci functions.

For the terms of the trigonometric series we obtain:

$$\int_{-l}^{l} \frac{e^{-jkr}}{r} \cos k_1\zeta d\zeta$$

$$k = \frac{2\pi}{\lambda}\ , \ k_1 = \frac{\pi}{2l}\ , \ 3\ .\ \frac{\pi}{2l}\ , \ 5\ .\ \frac{\pi}{2l} \text{ etc.}$$

It has not been found possible as yet to solve these integrals by reducing them to known Si, Ci or similar functions. This seems only possible when $k = k_1$. We therefore solve the integrals approximately in the following way.

We first observe that $e^{-jkr} = \cos kr - j \sin kr$. The integral can therefore be split into a real and an imaginary part. If we write for the real part

$$\text{Re}\int_{-l}^{l} \frac{e^{-jkr}}{r} \cos k_1\zeta d\zeta \approx \text{Re}\int_{-l}^{l} \frac{e^{-jk|z-\zeta|}}{|z-\zeta|} \cos k_1\zeta d\zeta$$

we observe that the integral to the right diverges when $z = \zeta$; i.e., this approximation can only be used when $z \neq \zeta$. For values of z equal to or very near ζ we can neglect the retardation and substitute for the integral the expression:

$$\cos k_1 z \int_{z-\epsilon}^{z+\epsilon} \frac{d\zeta}{r}$$

Numerical calculations and comparisons with cases which can be solved exactly ($k = k_1$) show that a suitable value of ϵ is $5a$, where $a =$ the radius of the aerial. Accordingly we put:

$$\text{Re}\int_{-l}^{l} \frac{e^{-jkr}}{r} \cos k_1\zeta d\zeta \approx \text{Re}\int_{-l}^{z-5a} \frac{e^{-jk|z-\zeta|}}{|z-\zeta|} \cos k_1\zeta d\zeta$$

$$+ \cos k_1 z \int_{z-5a}^{z+5a} \frac{d\zeta}{r} + \text{Re}\int_{z+5a}^{l} \frac{e^{-jk|z-\zeta|}}{|z-\zeta|} \cos k_1\zeta d\zeta$$

These integrals can be solved without great difficulty.

For the imaginary part of the integral we write:

$$\mathrm{Im} \int_{-l} \frac{e^{-jkr}}{r} \cos k_1 \zeta d\zeta \approx \mathrm{Im} \int_{-l} \frac{e^{-jk|z-\zeta|}}{|z-\zeta|} \cos k_1 \zeta d\zeta$$

It turns out that the integral to the right does *not* diverge when $z = \zeta$. This is obviously due to the fact that the current elements infinitely near the point z do *not* contribute to the *imaginary* part of the integral, because the retardation is zero. These current elements in the immediate vicinity of the point z will on the other hand give large contributions to the *real* part of the integral, as already explained. In this way the difficulties with the integration can be overcome, and the method carried through in practical applications. Theoretically it is possible to calculate the aerial current and impedance with great accuracy. The amount of numerical labour naturally becomes correspondingly great, but no new mathematical difficulties are encountered. One always obtains sums of Si and Ci functions and the number of equations is twice the number of points. It seems that 5 points give quite sufficient accuracy for most practical cases. By increasing the number of points to 7 or 9, it should be possible by the use of a punch-card machine or an electronic computing machine, to obtain an accuracy better than 1 per cent. As yet the method has been tried on a halfwave dipole and on a symmetrical dipole one wavelength long, both with

$$\Omega = 2 \log_e \left(\frac{2l}{a}\right) = 15 \text{ or } \frac{2l}{a} = 1808$$

The results are:

$\lambda/2$-dipole

Calculated with 2 points, $Z_a = 73{\cdot}3 + j42{\cdot}9$ ohms
Calculated with 3 points, $Z_a = 81{\cdot}1 + j43{\cdot}7$ ohms
Calculated with 4 points, $Z_a = 80{\cdot}7 + j44{\cdot}9$ ohms
Calculated with 5 points, $Z_a = 82{\cdot}7 + j45{\cdot}4$ ohms

For comparison we give the following values calculated by R. King:—

King 1st order, $Z_a = 75 + j36$ ohms
King 2nd order, $Z_a = 81 + j46$ ohms

λ-dipole

Calculated with 3 points, $Z_a = 1313 - j1391$ ohms
King 1st order $Z_a = 1560 - j1130$ ohms
King 2nd order $Z_a = 1000 - j1350$ ohms

The calculation of the aerial impedance with a greater number of points and for other aerial lengths and thickness is being continued and will be published in a more complete and detailed paper.

Acknowledgments

The writer would like to thank the Royal Norwegian Council for Scientific and Industrial Research, and the Norwegian Defence Research Establishment, who made possible the study of fundamental aerial theory, which is the basis of the present work.

I would also like to thank Professor Willis Jackson, Head of the Department of Electrical Engineering at the Imperial College of Science and Technology, for accepting me as a post-graduate student and allowing me to concentrate on aerial theory and for his great help and interest in my work.

In conclusion, I would like to thank Mr. J. Garwick, Head of the Computing Department at the Norwegian Defence Research Establishment for many valuable and stimulating discussions, and also K. Nygård and Keilhau, students at the same establishment, who have helped me with the numerical calculations.

REFERENCES

[1] E. Hallén, "Theoretical Investigation into the Transmitting and Receiving Qualities of Antennae," *Novo Acta Upsaliensis*, November 1938, Ser. 4, Vol. 11, pp. 3–44.

[2] C. J. Bouwkamp, "Hallén's Theory for a Straight Perfectly Conducting Wire, used as a Transmitting or Receiving Aerial," *Physica*, July 1942, Vol. 9, pp. 609–631.

[3] M. C. Gray, "A Modification of Hallén's Solution of the Antenna Problem," *J. appl. Phys.*, January 1944, Vol. 15, pp. 54–60.

[4] R. King and D. Middleton, "The Cylindrical Antenna, Current and Impedance," *Quart. appl. Math.*, January 1946, Vol. 3, pp. 302–335.

[5] R. King, "Graphical Representation of the Characteristics of Cylindrical Antennae," *Cruft Lab. Techn. Rep.* 1st October 1947, No. 20.

TECHNICAL PUBLICATIONS

British Standard for Colour Code for Fixed Resistors for Telecommunication Purposes.

B.S. 1852 : 1952. British Standards Institution, 24 Victoria St., London, S.W.1. Price 1s.

British Standards Yearbook 1952

Pp. 460. Contains list in numerical order of British Standards, with a brief description of their contents. British Standard Codes of Practice are also included and general information about standards and the composition of Standards Committees. British Standards Institution, 24 Victoria St., London, S.W.1. Price 7s. 6d.

The Siting of Direction Finding Stations

By W. Ross, M.A., A.M.I.E.E., and F. Horner, M.Sc., A.M.I.E.E. Radio Research Special Report No. 22. Pp. 38 + iv. H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 1s. 6d.

An Investigation to Develop Methods of Test for Impregnating Varnish

By H. R. Heap, B.Sc. Technical Report A/T124, 1951. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 21s.

A Pulse Generator Producing 0·01 Microsec Pulses

By S. F. Pearce and D. C. G. Smith. Technical Report M/T113, 1951. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 7s. 6d.

SLOW-SPEED CIRCULAR TIME-BASE

Development of Improved Sine-Cosine Potentiometer

By A. M. Hardie, M.A., B.Sc., A.M.I.E.E.,* and P. A. V. Thomas, B.Sc. (Eng.), Grad.I.E.E.†

(Research Department, Metropolitan-Vickers Electrical Co., Ltd.)

1. Introduction

THE requirement occasionally arises of displaying signals on the cathode-ray tube in polar form, so that the phenomenon to be examined appears in correct phase relation with reference to a rotating member, such as an engine shaft.

Two methods of accomplishing this are discussed:

(i) An audio-frequency carrier system in conjunction with a cathode-ray tube of the von Ardenne type having a central deflecting electrode sealed through the tube face.

(ii) A sine-cosine potentiometer of special design in conjunction with a normal electrostatic cathode-ray tube.

It is shown that spurious phase shifts in the carrier system result in severe distortion of the circular time base accompanied by poor angular following of the rotating member, and one method of compensating such phase shifts is described.

The advantages of the sine-cosine potentiometer and the difficulty of making an instrument for handling electrical impulses caused by transient phenomena are discussed, and the development of a suitable potentiometer is described briefly.

2. Audio-Frequency Carrier System

In Fig. 1 the rotor shaft of the two-phase magslip transmitter is mechanically coupled either to the reference rotating shaft or to a three-phase magslip receiver which is remotely controlled by the reference shaft.

The oscillator is tuned to a carrier frequency f such that $\omega = 2\pi f \gg p = 2\pi n$, where n is the greatest rotational frequency of the reference member. The e.m.fs developed in the magslip stator windings are then

$$e_1 = a \sin pt \sin \omega t \qquad \tag{1}$$

$$e_2 = a \cos pt \sin \omega t \qquad \tag{2}$$

and if the stator windings and couplings are balanced, $|e_1| = |e_2|$.

If the carrier e.m.f., $b \sin \omega t$, is now added to e_1 and e_2, we obtain

$$\begin{aligned} e_1' &= a \sin pt \sin \omega t + b \sin \omega t \\ &= b \sin \omega t(1 + m \sin pt). \end{aligned} \qquad \tag{3}$$

$$\begin{aligned} e_2' &= a \cos pt \sin \omega t + b \sin \omega t \\ &= b \sin \omega t(1 + m \cos pt) \end{aligned} \qquad \tag{4}$$

where $m = a/b$. Equations (3) and (4) are modulated sine waves, the modulation factor being m, and the modulation envelopes having a phase difference of $\pi/2$.

e_1' and e_2' are applied to the control grids of pairs of balanced push-pull triodes, the negative bias being such that rectification of the modulated wave occurs and currents

$$i_1 = k(1 + m \sin pt) \qquad \tag{5}$$

and

$$i_2 = k(1 + m \cos pt) \qquad \tag{6}$$

flow through the deflecting coils placed in the anode circuits, the high-frequency carrier component (ω) being filtered out.

The alternating components $km \sin pt$ and $km \cos pt$ produce corresponding cross fluxes in the deflecting-coil yoke and thus a rotating magnetic field of constant strength at the modulation frequency.

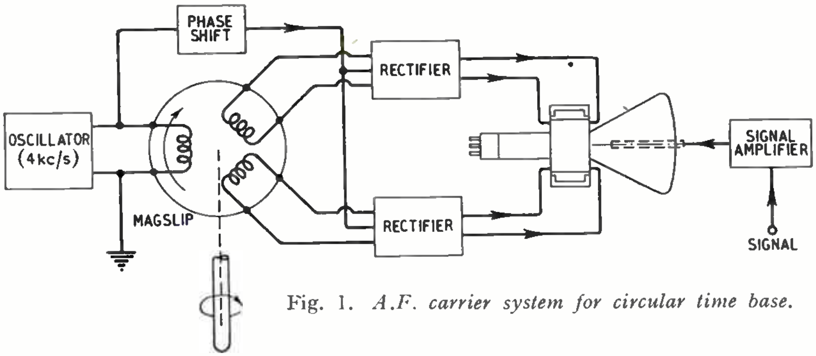


Fig. 1. *A.F. carrier system for circular time base.*

Effect of Carrier Phase Shift Relative to Sideband Products

Let it be assumed that a constant phase difference ± α exists between the added carrier wave

---

MS accepted by the Editor, September 1951

* Now at Robert Gordon's Technical College, Aberdeen

† Now at Royal Technical College, Glasgow

and the output of the magslip stators; i.e., the sideband product.

We then have on addition,

$$e_1' = a \sin pt \sin \omega t + b \sin(\omega t \pm \alpha) \qquad (7)$$

and $$e_2' = a \cos pt \sin \omega t + b \sin(\omega t \pm \alpha) \qquad (8)$$

On expansion and rearrangement these become

$$e_1' = b(1 + m^2 \sin^2 pt + 2m \cos\alpha \sin pt)^{\frac{1}{2}}$$
$$\sin\left[\omega t \pm \tan^{-1}\frac{\sin\alpha}{\cos\alpha + m \sin pt}\right] \quad .. \quad (9)$$

$$e_2' = b(1 + m^2 \cos^2 pt + 2m \cos\alpha \cos pt)^{\frac{1}{2}}$$
$$\sin\left[\omega t \pm \tan^{-1}\frac{\sin\alpha}{\cos\alpha + m \cos pt}\right] \quad (10)$$

Equations (9) and (10) represent amplitude-modulated waves having some degree of phase modulation. Since the phase modulation is small the resultant circle distortion may be determined by consideration of the carrier envelope, which is given by the factors under the radical. These are plotted in Fig. 2 for one complete cycle and various values of α.

The deflecting coils are so wound and connected (Fig. 4) that the direct component of flux is cancelled. We may, therefore, write for the X and Y components of the resultant deflecting field:

$$X = (1 + \sin^2 pt + 2 \cos\alpha \sin pt)^{\frac{1}{2}} - 1$$
$$Y = (1 + \cos^2 pt + 2 \cos\alpha \cos pt)^{\frac{1}{2}} - 1$$

in which the proportionality factor is dropped without loss of generality, and m is unity.

Thus $R = \sqrt{(X^2 + Y^2)}$

$$= [\{(1 + \cos^2 pt + 2 \cos\alpha \cos pt)^{\frac{1}{2}} - 1\}^2$$
$$+ \{(1 + \sin^2 pt + 2 \cos\alpha \sin pt)^{\frac{1}{2}} - 1\}^2]^{\frac{1}{2}} \quad (11)$$

and $\theta = \tan^{-1} Y/X$, where θ is the observed orientation of the fluorescent spot with reference to the vertical. The distortion of the circular trace may, therefore, be found by plotting R and θ throughout one modulation cycle ($2\pi/p$) at equal increments of pt. The result is shown in Fig. 3 for various values of α, and the errors in angular following in Table 1.

The distortion due to phase error may be corrected by interposing a phase-shifting network in the carrier line (Fig. 1). This network may take several forms, and the arrangement used is shown in the circuit diagram of Fig. 5, which is a detailed diagram of the complete time-base generator.

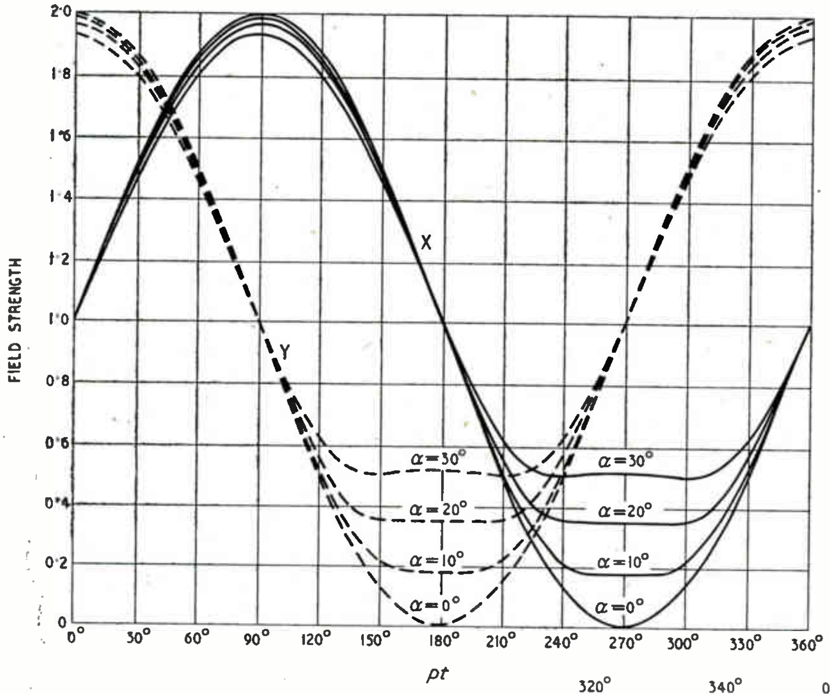
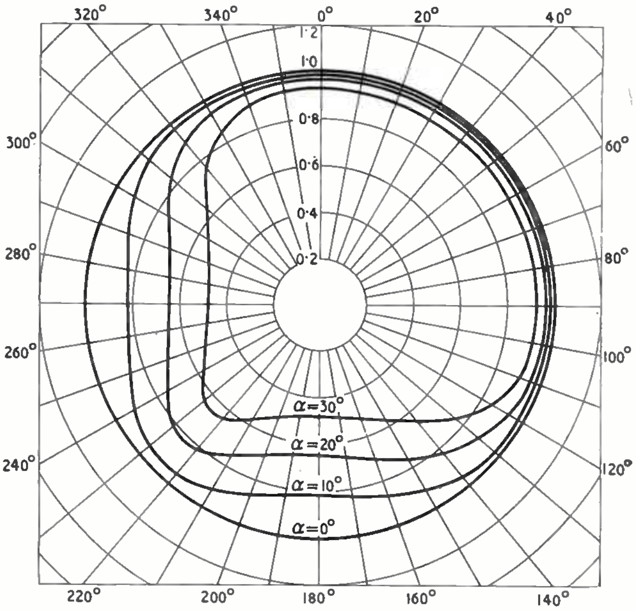


Fig. 2 (left). *The X and Y components of the deflecting field are shown for various values of α.*

Fig. 3 (below). *Effect of phase-shift α on 'circular' trace.*



The stage V_{5A} gives an output voltage with reference to earth which lags the control-grid voltage, while the output of V_{5B} leads its grid voltage. Therefore, if R_{22}, C_4 and R_{23}, C_5 are equal in each stage there is no net phase shift. Phase lag or lead may then be obtained either by varying the appropriate R in one direction, or by leaving one R fixed, say at the centre of its range, and varying the other about this mean position.

By using matched pairs of valves (AC/P4) in the time-base generator, and standard deflecting coils wound on a square laminated yoke, the following error was reduced to a maximum of ± 0·5°. This residual error presumably results mainly from the magslip and slight non-uniformity in the crossed fields of the deflecting coils.

Calibration

In order to check the following accuracy it is essential to have angular reference marks on the trace which may be aligned with an angular scale on the face of the cathode-ray tube. The reference marks are derived from the calibrator which is shown in Fig. 6. The brass disc is perforated by small holes (No. 55 drill) round the circumference of a circle at 15° intervals, the drilling being carried out on a dividing head. The disc is mechanically coupled to the magslip rotor and the impulse obtained from the photo-electric cell is amplified in V_1 and used as a trigger pulse for the flip-flop, $V_{2A}V_{2B}$. The output pulse from V_{2B} is then differentiated and applied to the grid of the cathode-ray tube as a modulating pulse. The circular trace is therefore brightened instantaneously at true 15° intervals. The flip-flop stage renders the shape and amplitude of the modulating pulse independent of speed.

TABLE 1

Angular Error of Circular Time-base

pt degrees	$\alpha = 10°$	$\alpha = 20°$	$\alpha = 30°$
0	0	0	0
30	− 0° 3′	− 0° 12′	− 0° 28′
60	+ 0° 3′	+ 0° 12′	+ 0° 28′
90	0	0	0
120	− 0° 33′	− 2° 8′	− 4° 39′
150	− 2° 5′	− 6° 16′	− 12° 17′
180	0	0	0
210	+ 1° 34′	+ 4° 16′	+ 7° 16′
240	− 1° 34′	− 4° 16′	− 7° 16′
270	0	0	0
300	+ 2° 5′	+ 6° 26′	+ 12° 17′
330	+ 0° 33′	+ 2° 8′	+ 4° 39′
360	0	0	0

A reference circle is drawn on the face of the cathode-ray tube to aid alignment of the trace.

3. The Sine-Cosine Potentiometer

It is clear that there are several possible sources of error in the carrier system:

(i) the magslip; (ii) phase-shift between carrier and modulation products; (iii) non-linearity and unbalance in the valves of the time-base generator; (iv) distortion of the crossed fields in the deflecting coils, including non-squareness of the yoke.

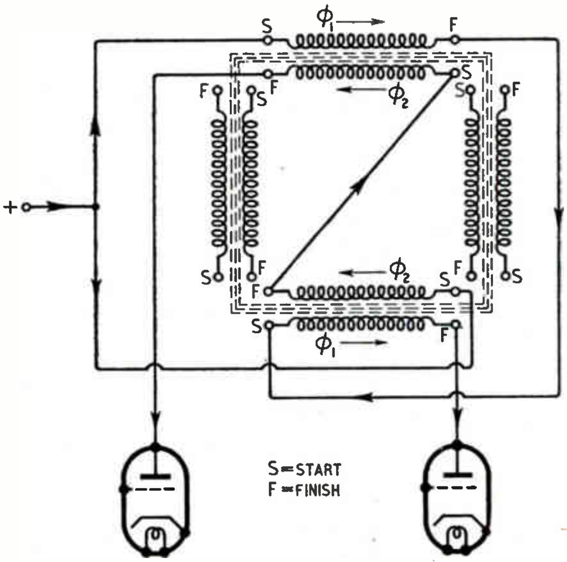


Fig. 4. *Deflecting-coil connections. (The connections to the other pair of valves are identical.)*

The von Ardenne-type cathode-ray tube is comparatively insensitive to deflecting voltages on the central electrode, while serious loss of focus occurs with large amplitude signals displayed on a small base circle. The focus also tends to be non-uniform throughout the periphery of the circle.

These considerations led to further study of the sine-cosine potentiometer in conjunction with a normal electrostatic cathode-ray tube.

The principle of the sine-cosine potentiometer is illustrated in Fig. 7. A p.d. of 2 V is maintained across a uniform block of homogeneous resistive material so that the flow lines and equipotentials form an orthogonal set of parallel straight lines.

If the lower end of the block is earthed, the p.d. between contact A and earth is

$$V_0 = V(1 + k \sin \theta), \text{ where } k = R/l,$$

i.e., V_0 is a sine-wave modulation of V, the modulation factor being k.

If the centre of the block is earthed,

$$V_0 = kV \sin \theta,$$

i.e., V_0 is an alternating p.d. of amplitude k.

By using four contacts at right angles we obtain $V_0 = V(1 \pm k \sin \theta)$ at A and A', and $V_0 = V(1 \pm k \cos \theta)$ at B and B′.

If the potentiometer is required to pass complex electrical transients without distortion, the resistance must be substantially non-inductive and the capacitance kept as low as possible.

In initial experiments various forms of wire-wound cards were made with so-called non-inductive windings. The resistance required was between 1,000 and 5,000 ohms, since the potentiometer was to be used as the load of a cathode-follower stage. The residual inductance was too high with such windings and much trouble was experienced with 'brush-bounce'.

A nichrome film evaporated on an optically-flat glass block (2 in. × 2 in. × ¼ in. thick) was tried as a resistance element, with the contacts rubbing directly on the surface. This gave satisfactory results at first, but every contact material tried ultimately tore the film. A fundamental disadvantage of this technique is that too thick a film must be used in order to obtain a hard surface, resulting in excessively low resistance.

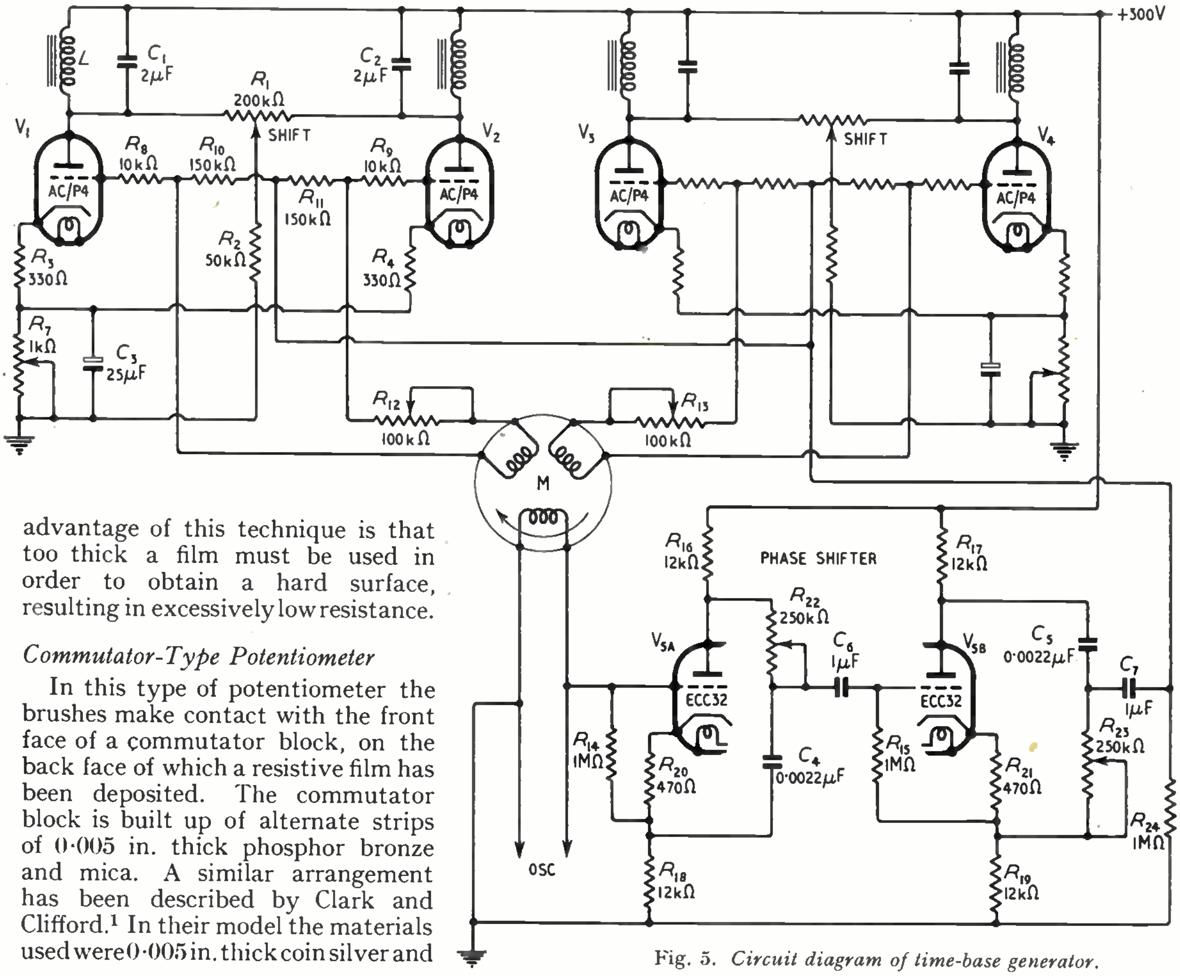


Fig. 5. *Circuit diagram of time-base generator.*

Commutator-Type Potentiometer

In this type of potentiometer the brushes make contact with the front face of a commutator block, on the back face of which a resistive film has been deposited. The commutator block is built up of alternate strips of 0·005 in. thick phosphor bronze and mica. A similar arrangement has been described by Clark and Clifford.[1] In their model the materials used were 0·005 in. thick coin silver and acetate tape, the block rotating against stationary brushes of silver graphalloy. They did not deposit the resistive material directly on the rear face of the block but pressed a card coated with a resistive film against it with a resilient backing.

Construction of Commutator Block

A photograph of a finished block is shown in Fig. 8. The active surface is 2 in. sq., being composed of 200 each of phosphor bronze and mica strips 0·5 in. deep. The mica strips were hand-separated with a sharp pen-knife from thicker leaves cut slightly over-size, the thickness of each strip being measured by micrometer. They were then classified in thickness up to 0·005 in., so that the correct size could be obtained when necessary by using smaller sizes together. Oversize cutting of the micas was adopted in order to avoid the possibility of the short-circuiting of adjacent conducting elements during the subsequent surface finishing process. This can occur owing to ragged edges or slight misalignment of the micas.

The micas and phosphor-bronze strips, having been punched in a jig and the metal burrs removed, were assembled on the tie-rods and tightly clamped. The tie-rods were coated with vitreous enamel which was ground to within 0·002 in. of the diameter of the punched holes. This insulating coating was used on account of the heat treatment during resistance coating of the block surface.

The block may be machine-ground and lapped, but in our experience it was found easier to obtain satisfactory surfaces by hand filing and finishing on a sheet of Grade 00 emery paper placed on a surface plate. A final polish was imparted by rubbing with a few drops of metal-polish on the cloth backing of the emery paper.

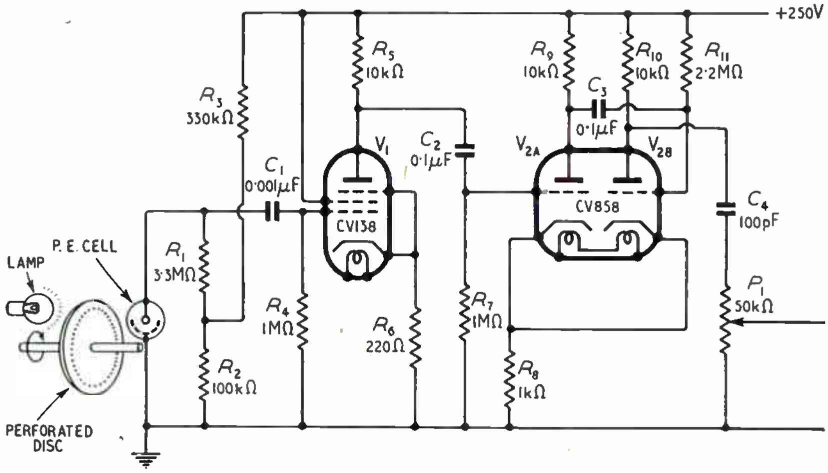


Fig. 6 (left). *Circuit diagram of calibrator. The photo-cell used was a Mullard type 90 CG.*

The Resistive Film

The main difficulty lay in obtaining a satisfactory resistive film. Various methods were attempted including the following:

(i) A Naphtha-Dag film was deposited on the surface by painting, spraying and dipping. All gave indifferent results due to non-uniform thickness and failure to meet the resistance requirements.

(ii) A resistive-coated card was obtained from Morganite Resistors, Ltd., Jarrow, and pressed into intimate contact with the surface. Sufficiently good overall contact could not be obtained.

(iii) A nichrome film was evaporated on to the block but adhesion was poor, due probably to the differential temperature effect of phosphor bronze and mica. The film spontaneously peeled off in strips at the metal-mica interfaces.

(iv) A nichrome film was evaporated on an optically-flat glass block which was then clamped to the commutator.

Initial results were good, but after about four hours' running the film was observed to be scratched in several places. This may have been caused by localized high spots under vibration.

(v) A piece of conducting rubber of the required resistance figure was clamped to the block. The results were poor owing to high and variable contact resistance.

(vi) Sample blocks were submitted to Morganite Resistors, Ltd., Jarrow, who agreed to deposit a resistive film to meet our requirements. The results obtained with all films deposited by their process have been excellent and no further development from this aspect has been carried out.

Errors in Commutator-Type Potentiometer

Since there is a finite number of conducting elements the potential of each contact varies in discrete steps. In a circular time-base the fluorescent spot may be considered as the tip of a rotating vector whose angular position is governed by the relative magnitude of its *X* and *Y* components. The orientation of the spot thus changes in small angular increments. It is clear that the resolution will differ at different contact settings and will be finer the greater the number of elements.

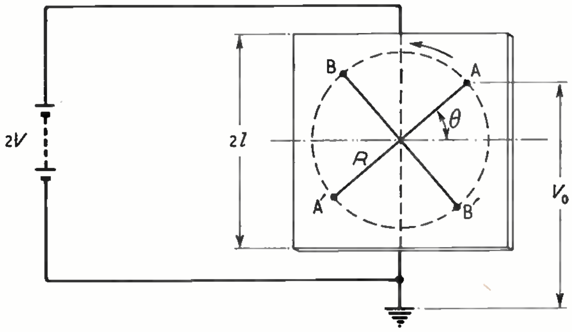


Fig. 7. *Principle of sine-cosine potentiometer.*

The diameter of the contact area must be at least slightly greater than the element thickness to avoid discontinuity in operation. Too large a contact area, on the other hand, results in local distortion of the equipotential lines owing to the short circuit of several conducting strips.

As a representative case consider the diagram of Fig. 9 in which the contact area is circular having a diameter equal to two elements; i.e., 0·01 in. The central conducting element is earthed and the track of the contacts spans the length of the block, so that $R = 1$ in. The p.d. across the block is 100 V. The elements are numbered in pairs below top and centre.

Let the contacts move until B is just clear of the central conductor, as shown at B_1 and A_1. Then

$$\sin \phi_1 = 1{\cdot}5t/R = 0{\cdot}0075$$

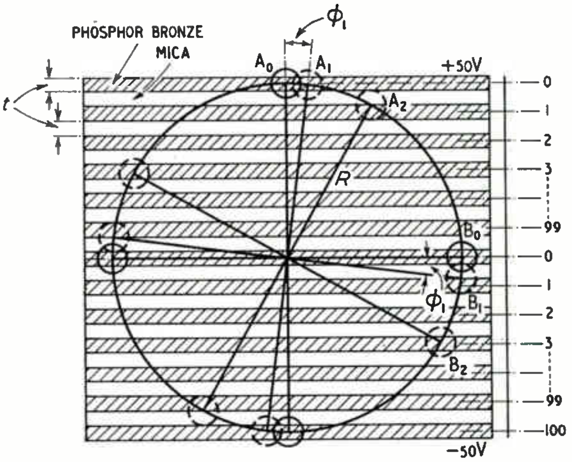
and $\phi_1 = 0° \, 27'$

The potential of B is now $-$ 0·5 V while that of A remans unchanged at + 50 V.

If θ_1 is the orientation of the fluorescent spot, then assuming no subsequent distortion,

$$\tan \theta_1 = 0{\cdot}5/50 = 0{\cdot}01$$

and $\theta_1 = 0° \, 35'$



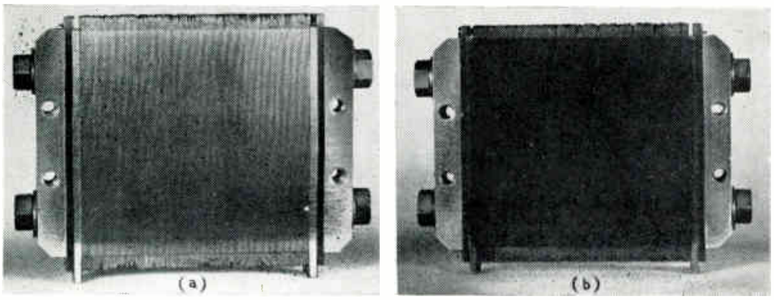


Fig. 8 (left). *Running surface of commutator (a) and rear surface of commutator coated with resistive film (b).*

Fig. 9 (above). *Diagram of potentiometer with circular contact area.*

Fig. 10 (below). *Running surface of commutator* (× 32) *showing part of track.*

In this position, therefore, the resolution is 0° 27′ and the angular error $(\theta_1 - \phi_1)$ is 0° 8′.

The potential of A does not change until A_2, when

$$R - 1{\cdot}5t/R = \cos \phi,$$

i.e., $\cos \phi_2 = 0{\cdot}9925$

and $\phi_2 = 7°, \sin \phi_2 = 0{\cdot}1219$

Contact B is now 0·1219/0·01 = 12·19 pairs of elements below centre, and its potential is — 6 V. Then

$$\tan \theta_2 = 6/49{\cdot}5 = 0{\cdot}1212$$

and $\theta_2 = 6° \, 54'$.

If, however, A is just not clear of the top contact then $\tan \theta_2 = 6/50 = 0{\cdot}1200$

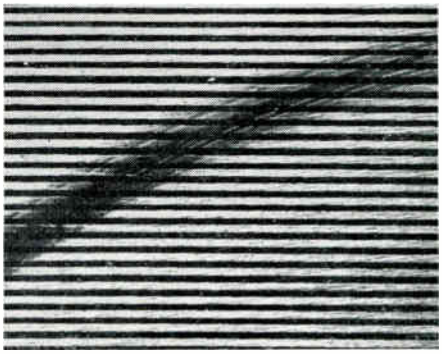
and $\theta_2 = 6° \, 50'$.

In the 45° position contact B has passed over 70·71 pairs of elements and contact A 29·29 pairs. B thus bridges conductors 70 and 71 at a potential of — 35 V while A bridges conductors 29 and 30 at a potential of (50 — 14·5) = 35·5 V. Then $\tan \theta_3 = 35/35{\cdot}5 = 0{\cdot}9859$

and $\theta_3 = 44° \, 35'$

When conductors 29 and 70 are freed, then

$$\tan \theta_3 = 35{\cdot}5/35 = 1{\cdot}0143$$



and $\theta_3 = 45° \, 25'$

The resolution in this position is therefore 0° 50′.

In the above calculation the effect of two or more bridged conducting elements has been neglected. If the potentiometer is connected to a constant-voltage source and two opposite contacts each bridge two conductors, the p.d. across each mica strip is instantaneously altered from 0·5 V to 0·5 × 200/198 = 0·505 V. This leads to a slight modification of the calculated errors and in practice results in noise if the subsequent amplification is high. There is also a small amplitude error accompanying the angular error which in bad cases is visible as a ripple on the periphery of the trace.

Wear

Fig. 10 is a magnified (× 32) photograph of part of the commutator surface after approximately half-a-million revolutions with hemispherical silver contacts under light pressure. It will be observed that the average track thickness is equivalent to about four conducting strips. This is partly owing to slight misalignment of the four contact arms, each wiping over a track of different radius, and partly owing to contact wear.

The average wear on the block surface in this condition is one sixteen-thousandth of an inch as measured on a surface roughness gauge. (The "Talysurf" by Taylor, Taylor & Hobson, Ltd.)

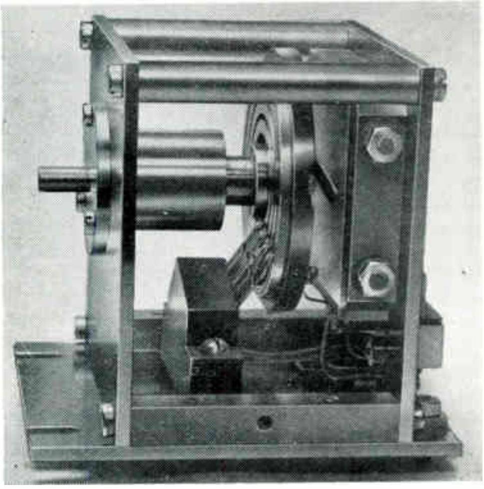


Fig. 11. *General view of sine-cosine potentiometer.*

Contacts

Contact materials tried so far are stainless steel, tungsten, carbon, copper-graphite, beryllium-copper and silver. Silver has given the best results, but trouble is occasionally experienced with deposition of contact material on the track and lubricant aggravates this condition by clogging. Self-cleaning usually follows after a few minutes' running.

The contact assembly is made clear in Figs. 11 and 12. The hemispherical silver contacts are fixed to 0·01 in. thick phosphor-bronze arms which are connected to four brass slip rings. Silver contacts are again used with these. The assembly is mounted on ball bearings.

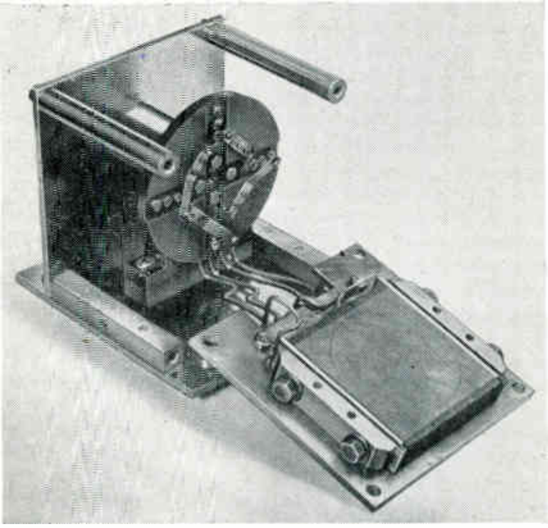


Fig. 12. *Sine-cosine potentiometer with back plate removed to show contact assembly.*

Methods of using the sine-cosine potentiometer to obtain a circular time-base are well-known and need not be described here.

Acknowledgments

The authors wish to thank Mr. N. Holt, superintendent of the electrical workshop; Mr. P. Charity, whose painstaking work made possible the construction of the commutator; Morganite Resistors, Ltd., Jarrow, for their valuable co-operation in depositing the resistive films; Sir Arthur P. M. Fleming, C.B.E., D.Eng., Director of Research and Education, and Mr. B. G. Churcher, M.Sc., M.I.E.E., Manager of the Research Department, Metropolitan-Vickers Electrical Co., Ltd.

The work described in this paper was carried out under Admiralty Contract, and the authors are indebted to those officers of the Royal Naval Scientific Service with whom they were associated during development, and to the Admiralty for permission to make use of the material for publication.

REFERENCE

[1] Clark, T. H., Clifford, V. F. *Electrical Communication*, Sept. 1947, Vol. 24, p. 382.

THE SYNCHRODYNE AND COHERENT DETECTORS

Effect on Signal/Noise Ratios and Comparison with the Linear Detector

By D. G. Tucker, D.Sc., Ph.D., A.M.I.E.E.

(H.M. Underwater Detection Establishment)

SUMMARY.—The synchrodyne and the coherent detector both effect demodulation by the use of a strong local oscillation maintained at the same frequency and phase as the required input signal, the difference between them being that the synchrodyne has its local oscillator automatically synchronized to the input signal, whereas the coherent detector relies on access to the transmitted signal source or on manual adjustment. Their performance with respect to signal/noise ratio when the input signal is accompanied by noise in its own allotted frequency band is compared in this paper with that of the ordinary so-called 'linear' detector in which the received signal is subjected to plain rectification. It is found that there is a very considerable difference in the output noise spectra when the signal is absent or very small and that in the 'linear' detector the noise produces a d.c. output which is absent in the coherent detector. Thus, although there is little difference in performance on continuous or envelope-modulated signals, the coherent detector shows a very considerable improvement over the 'linear' detector on pulse and intermittent signals. The synchrodyne has basically the same performance in these respects as the coherent detector, but it may be slightly inferior due to noise appearing in the output of its local oscillator.

More Important Symbols

E_1 = peak amplitude of applied signal (or carrier, in the case of envelope-modulation)
V_{n1} = input r.m.s. noise voltage
p = angular frequency of applied signal (rads/sec)
q = difference-frequency (rads/sec)
q_m = modulation-frequency (rads/sec)
k = depth of modulation
R_1 = input signal/noise ratio
R_0 = output signal/noise ratio
} for continuous signal, or while signal and noise are present together
$\phi(t)$ = modulating function of modulator; i.e., the variation with time of the circuit transfer voltage ratio (output/input)
h_1 = coefficient of fundamental-frequency component of $\phi(t)$
θ = phase angle between local oscillation and input signal
R_A and R_B are criteria of signal/noise performance in pulse systems and are explained in Section 2.3.

1. Introduction

THE 'synchrodyne' and the 'coherent-detector' types of demodulator operate similarly in that both effect demodulation by the use of a strong local oscillation maintained at the same frequency and phase as the required input signal and applied as the switching signal to a linear modulator. The synchrodyne maintains the correct frequency and phase by actually synchronizing to the input signal and generally, therefore, requires a signal/noise ratio greater than unity. The coherent detector relies on manual adjustment of frequency and phase, or on having access to the source of the signal; in the latter case, the signal must suffer no frequency-shift or fluctuation of phase-shift in the transmission system. In the coherent detector, intermittent signals well below noise level can be detected provided they have sufficient duration to permit a fairly-long integrating time in the detection circuit.

A good deal has been written about the synchrodyne demodulator,[1,2] and in its earlier form—the homodyne—its history goes back nearly 30 years.[3] The coherent detector[4] has no major features that were not well known nearly 30 years ago. It is thus rather surprising that any serious application of these circuits is very recent. So far the literature of the subject, except for reports of limited circulation, has not dealt with the use of these circuits for pulse-transmission systems.* Yet, in respect of signal/noise ratio, they have some considerable advantages over the ordinary rectifier detector—the so-called 'linear' detector, discussed in a previous paper.[5] This matter is analysed in the present paper, but the problem of the detailed adaptation of the circuits to be readily usable in pulse-transmission systems is left to subsequent work.

2. The Coherent Detector

Fig. 1 shows the arrangement of a coherent detector. We deal with this before the synchrodyne because it is simpler; the local oscillator can be assumed to give a pure output free from noise, which is not the case—in general—in the synchrodyne.

The modulator is of the switching type; i.e., the modulating action is controlled entirely by the local oscillator and the signal is assumed to have

MS accepted by the Editor, September 1951

---

* Since this was written, two papers which discuss the detection of pulse signals by coherent detectors have appeared in the *Proceedings of the Institution of Electrical Engineers* (R. A. Smith, Vol. 98, Part IV, p. 43, 1951, and I. L. Davies, Vol. 99, Part III, p. 45, 1952.).

no effect on the action. This is achieved, in practice, by making the local-oscillation voltage large compared with the signal voltage.

Let the input signal be $E_1 \cos (pt + \theta)$ and let the local-oscillator output be $E_e \cos pt$.

The modulator has a modulating (or switching) function which is practically a square-wave and can be written

$$\phi(t) = h_0 + h_1 \left[\cos pt - \tfrac{1}{3} \cos 3pt + \tfrac{1}{5} \cos 5pt - \right] \quad \ldots \quad (1)$$

where h_0 and h_1 are determined by the rectifier (or valve) characteristics and the circuit constants, but *not* by E_e.

The output is then

$$E_1 \cos (pt + \theta) . \phi(t) \quad \ldots \quad (2)$$

and the demodulated (i.e., d.c.) output is

$$E_0 = \tfrac{1}{2} E_1 h_1 \cos \theta \quad \ldots \quad (3)$$

If the input signal is modulated or accompanied by side-frequencies (which may be noise of any sort), then the modulation- or difference-frequency components appear in the output, with amplitudes proportional to cos θ for components of envelope-modulation, but independent of θ for the unrelated side-frequencies. For example, if the input is

$$E_1 \cos (pt + \theta) . \left[1 + k \cos q_m t\right] + E_2 \cos \left[(p - q)t + \theta'\right] \quad \ldots \quad (4)$$

then the output modulation- or difference-frequency components (which we can call the q-band, noting that always we assume $q \ll p$) are

$$\tfrac{1}{2} E_1 h_1 k \cos \theta . \cos q_m t + \tfrac{1}{2} E_2 h_1 \cos (qt - \theta') \quad \ldots \quad (5)$$

We see at once that the performance is quite different from that of the plain linear-rectifier detector, as no distortion is introduced.* Moreover, only the carrier contributes to the d.c. output. It can be appreciated that this circuit is a true linear detector, and shows how unsuitable the term is for the plain rectifier-detector.

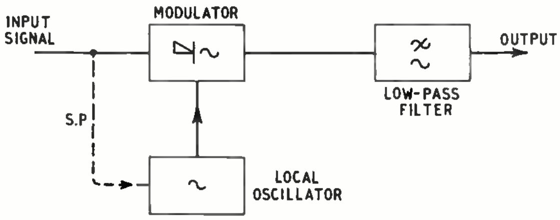


Fig. 1. *Block schematic of synchrodyne and coherent detector. (The local oscillator has the same frequency and approximately the same phase as the input signal; S.P. = synchronizing path; this is absent in the coherent detector.)*

If the signal is accompanied by noise, then the latter can be allowed for as in the previous paper by replacing the side-frequency in (4) by a summation of a large number of small side-tones, each of amplitude $x_r E_1$ and frequency $p - q_r$, so that, if V_{n1} is the input r.m.s. noise voltage, then

$$V_{n1}^2 = \frac{E_1^2}{2} \sum_{r=1}^{n} x_r^2 \quad \ldots \quad (6)$$

and we may let $n \rightarrow \infty$. All these noise 'components' are undistorted by demodulation, and the output noise spectrum has the same shape relative to zero frequency as the input spectrum relative to p, and this applies whatever the signal/noise ratio may be. The process is illustrated in Fig. 2 for a noise input spectrum which is uniform over a band of width $2q_0$ centred on p.

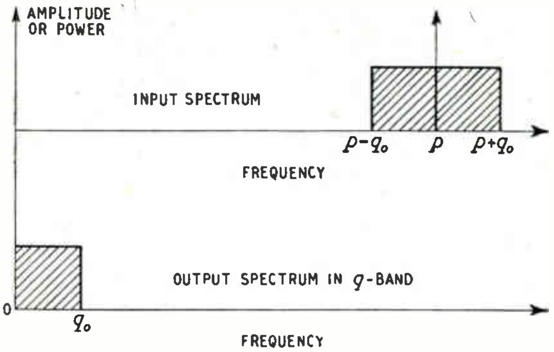


Fig. 2. *Illustrating undistorted demodulation of noise by coherent detector.*

Although the noise is undistorted by demodulation, the signal/noise ratios are not necessarily the same in the output as in the input. Let the input signal/noise ratio be

$$R_1 = \frac{E_1}{\sqrt{2} V_{n1}} \quad \ldots \quad (7)$$

i.e., the ratio of r.m.s. values of signal and noise.

Then if the modulation represents the wanted signal, the output signal/noise ratio is

$$R_0 = k R_1 \cos \theta \quad \ldots \quad (8)$$

If there is no modulation, so that the d.c. represents the wanted output signal, the output signal/noise ratio is

$$R_0 = \sqrt{2} R_1 \cos \theta \quad \ldots \quad (9)$$

where the $\sqrt{2}$ arises because the r.m.s. value of d.c. is the same as the peak value.

It can be seen that the output signal/noise ratios depend on θ, and normally we should try to make $\theta = 0$; i.e., $\cos \theta = 1$.

2.1 *Comparison of Noise Output with that of the 'Linear' Detector*

If we consider first the detector used to demodulate an envelope-modulated signal, we find from the previous paper (Section 3.53) that

---

* See the author's previous paper, ref. (5), for the properties of the linear-rectifier.

for $R_1 > 1$ a 'linear' detector gives an output signal/noise ratio for the modulation component as follows:—

$$R_0 \approx kR_1 \frac{1 - 1/4R_1^2}{1 - (1/8R_1^2)(1 + k^2/2)} \quad \cdots \quad (10)$$

Comparing this with (8) when the coherent detector is correctly phased, we see that the 'linear' detector does not give a serious deterioration of S/N ratio; when the input ratio is unity, the deterioration is only of the order of 1 db. It is worth noting that a square-law detector gives a worse deterioration (see Section 6 of previous paper).

Considering now the case of an unmodulated carrier, where the d.c. is the wanted signal, we find from Sections 3.51 and 3.52 of the previous paper that if $R_1 > 1$,

$$R_0 \approx \sqrt{2}R_1 \left(1 + \frac{3}{8R_1^2}\right) \quad \cdots \quad \cdots \quad (11)$$

so that the 'linear' detector shows an improvement over the coherent detector, amounting to something of the order of 1 db when $R_1 = 2$. (But note that the d.c. does not all disappear when the signal is removed and the noise is left.)

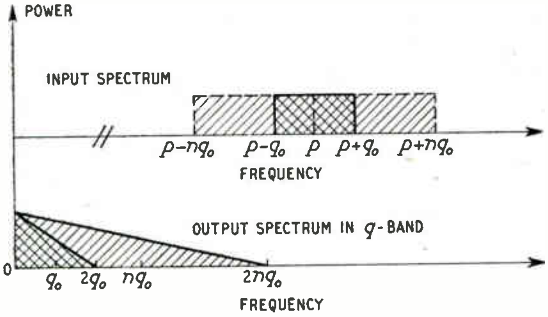


Fig. 3. *Showing distorted output noise spectrum in the 'linear' detector.*

The most interesting comparison is when noise alone is applied, for then the output a.c. spectra in the two types of detector are most distinct from one another. It was shown in the previous paper (Section 3.51 and Fig. 5) that for noise alone with a uniform spectrum applied to a 'linear' detector, the output power spectrum is approximately triangular and of bandwidth $2q_0$ when the input spectrum extends from $p - q_0$ to $p + q_0$. This is shown in Fig. 3. When the input spectrum is widened n times (keeping the same spectral density), the output spectrum is widened n times also, and the spectral density at zero frequency is unchanged; thus the output noise power (given by the area of the spectrum diagram) is linearly related to the input noise power.*

Now in the coherent detector, when the output is restricted by a filter of cut-off q_0, there is no effect on the noise output unless the input spectrum is wider than $2q_0$, and when the input spectrum has a width n times this, the output noise power is reduced in the ratio $1/n$. In the 'linear' detector, however, restricting the output band to q_0 reduces the output noise power to three-quarters when the input band has a width $2q_0$, and to a fraction $\frac{4n-1}{4n^2}$ when the input spectrum is n times this width. Since $\frac{4n-1}{4n^2} < \frac{1}{n}$, it is evident that, although pre-detector and post-detector filtration are equally effective in reducing noise in the coherent detector, yet in the 'linear' detector post-detector filtration is more effective than pre-detector filtration, even though the difference is usually small.* It should be noted that when we come to consider pulse signal/noise *ratio* in Section 2.3, different conclusions are reached owing to the non-linear response to the signal.

A greater distinction between the two types of detector appears in regard to their d.c. outputs when noise alone is applied. The coherent detector (assuming its local oscillator is still running at frequency p) gives no d.c. output from noise. The 'linear' detector gives a d.c. output

$$\frac{1}{2}\sqrt{\frac{\pi}{2}}\, h_1 V_{n1} \quad \cdots \quad \cdots \quad \cdots \quad \cdots \quad (12)$$

so that the d.c. output is proportional to the noise input voltage and follows changes in it whether caused by changes in spectral density or in bandwidth.

2.2 *Signal/Noise Ratios for Pulse Systems*

So far we have discussed signal/noise ratios on the basis of signal and noise simultaneously present. But in pulse systems a more important criterion of performance is often the ratio (R_A) of the total output voltage when the signal is present to the total output when it is absent. Actually, the method of use of the system determines what sort of criterion is needed, and a rather different one suggested by Burgess[6] is the ratio (say R_B) of the increase of the d.c. output on applying a certain signal to the r.m.s. fluctuation of the l.f. output about the d.c. or average level. It would seem that R_A is applicable to systems where the pulse length (in seconds) is of the order of, or not many times greater than, the reciprocal of the bandwidth (in c/s) because then the noise appears

---

* That this must be so is easily seen when it is remembered that the linear rectifier merely removes all negative voltage components and does not distort the envelope.

* It is interesting to observe that the square-law detector is quite different from the 'linear' detector in this respect; it gives the result that pre-detector filtration is much more effective than post-detector filtration.

in pulses rather like the signal pulse; R_B would be a suitable criterion when the pulse length is very great compared with the reciprocal of the bandwidth. In some cases, as in echo-ranging, where the pulses are presented visually or aurally, we have also to consider subjective factors. These have been studied to some extent,[7] but will not be discussed here, although they are often implicit in the choice and interpretation of the criterion.

Taking R_A first, we have:—

$$R_A = \frac{\text{Total output voltage when signal present}}{\text{Total output voltage when signal absent}} \quad .. \quad .. \quad .. \quad (13)$$

An interpretation of this, probably suitable for an intensity-modulated visual display, is:—

$$R_A = \frac{(\text{d.c. output due to signal + noise}) + (\text{r.m.s. value of l.f. noise when signal present})}{\text{d.c. + r.m.s. value of l.f. output when signal absent}} \quad .. \quad (14)$$

On this basis, for the 'linear' detector, using the formulae given in the previous paper (Sections 3.51 and 3.52),

$$R_A = \frac{\frac{1}{2}E_1h_1\,(1 + V_{n1}^2/2E_1^2) + \frac{1}{2}V_{n1}h_1\,(1 - V_{n1}^2/4E_1^2)}{\frac{1}{2}V_{n1}h_1\left(\sqrt{\frac{\pi}{2}} + 0{\cdot}63\right)}$$

where it is assumed that $R_1\ (= E_1/\sqrt{2}\,V_{n1}) > 1$, i.e.,

$$R_A \approx \tfrac{1}{2}\left(\sqrt{2}R_1 + 1 + \frac{1}{2\sqrt{2}R_1}\right) \quad .. \quad (15)$$

For the coherent detector, there is no d.c. in the absence of the signal, and l.f. noise is the same whether the signal is present or not. Therefore,

$$R_A = \sqrt{2}R_1 + 1 \quad .. \quad .. \quad .. \quad (16)$$

assuming that the local oscillator is correctly phased; i.e., that $\theta = 0$.

It can be seen at once that the coherent detector gives a value of R_A approaching 6 db better than that given by the 'linear' detector. Or if we say that a limiting value of R_A should be approximately 2, then R_1 can be 9 db worse for the coherent detector than for the 'linear' detector—corresponding to a very considerable extension of the working range of signal level. These results are shown graphically in Fig. 4.*

Coming now to the other criterion, R_B, we have

$$R_B = \frac{\text{Increase in d.c. on applying signal}}{\text{l.f. output}} \quad .. \quad (17)$$

The main use of this definition is likely to be when the input signal/noise ratio is small, so that in the 'linear' detector it is not necessary to specify whether the l.f. output is in the presence or absence of signal.

For the 'linear' detector, we use the formulae for $R_1 < 1$ quoted in the previous paper, and obtain

$$R_B = \frac{\frac{1}{2}\sqrt{\pi/2}\;V_{n1}h_1R_1^2}{\frac{1}{2} \times 0{\cdot}63\;V_{n1}h_1} \approx R_1^2 \quad .. \quad (18)$$

For the coherent detector, assuming $\theta = 0$,

$$R_B = \sqrt{2}\,R_1 \quad .. \quad .. \quad .. \quad .. \quad (19)$$

Thus, if the input signal/noise ratio is less than unity, the coherent detector is far superior to the 'linear' detector. It is easily shown that when $R_1 \gg 1$, the 'linear' detector gives $R_B \rightarrow \sqrt{2}\,R_1$, so that then the two types perform equally well according to this criterion.

2.3 *Effect of Integrating Time*

The criterion R_B implies that the pulse is long enough for the increase in d.c. to be different in nature from the l.f. noise fluctuation. This means that the input bandwidth is much larger than the reciprocal of the pulse length. With this assumption, it is interesting to see the effect of using a circuit with a large time-constant (t_0) in the output, t_0 being, of course, less than the pulse length. Obviously such a circuit will smooth out

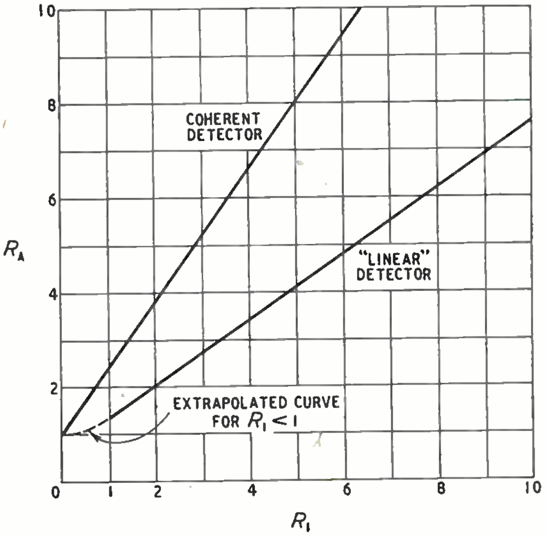


Fig. 4. *Graphs of pulse signal/noise criterion (R_A) against input signal/noise ratio (R_1).*

---

* Another interpretation of (13) is to consider the ratio

$$R_A = \frac{\text{r.m.s. of d.c. + l. f components when signal present}}{\text{ditto} \qquad \text{when signal absent}}$$

which leads to the same conclusion that the coherent detector is better than the 'linear' detector, although the difference is somewhat less.

much of the l.f. output noise. If we also assume that the input bandwidth is large compared with $1/t_0$, so that we are working only at the left-hand end of the triangular spectrum of Fig. 3, then the l.f. output (voltage) is proportional to $1/\sqrt{t_0}$ for both coherent and 'linear' detectors, and therefore

$$R_B \propto \sqrt{t_0} \quad \ldots \quad (20)$$

It is thus clear that the ability of the circuit to detect the pulse depends on the integration time, and ultimately, therefore, on the pulse-length itself.

Reducing the input bandwidth (B) also improves detection in the 'linear' detector, and, assuming a long-time-constant output circuit, we see that the l.f. output is not affected by the input bandwidth, so that now

$$R_B \propto 1/\sqrt{B} \quad \ldots \quad (21)$$

although in the same circumstances the coherent detector gives R_B independent of input bandwidth. Taking this result in conjunction with equs. (18) and (19), we see that decreasing the input bandwidth makes the performance of the 'linear' detector approach more nearly that of the coherent detector.

3. The Synchrodyne

The synchrodyne is different from the coherent detector only in that the local oscillator is synchronized to the incoming signal by some automatic means. In the simplest arrangement, the synchronization is effected by injecting some of the input voltage into the oscillator circuit.[8] Owing to the non-linear properties of the oscillator circuit, the injected mixture of signal and noise is subjected to an amplitude discrimination in addition to any frequency discrimination due to the regenerative tuned circuit, and so, provided that the signal has a level sufficiently high in relation to the noise level, the output of the oscillator is a reasonably pure tone. This was discussed in a previous paper[9] in relation to single interfering frequencies. The analysis can be extended to a continuous noise interference, but is very laborious, and the performance is so closely the same as for a single tone that it is not worth while discussing it further here.

The effect of noise in the oscillator output on the signal/noise ratio of the output of the synchrodyne demodulator can be calculated by using the same method as was used in the previous paper for the 'linear' rectifier. The only difference is that whereas in the 'linear' rectifier the switching signal was identical with the input signal, in the synchrodyne the switching function is derived from a considerably purer signal. Thus, provided the input signal/noise ratio is high enough for the oscillator output to have a signal/noise ratio considerably greater than unity, the effect of the noise in the oscillator output is often quite negligible. For instance, the following formulae can be derived, in which

R_1 = input signal/noise ratio as before,
R_G = signal/noise ratio in oscillator output,
R_0 = signal/noise ratio in synchrodyne output,
and E_0 = d.c. output, assuming unmodulated signal:—

$$E_0 \approx \tfrac{1}{2}E_1 h_1 \cos\theta \left(1 + \frac{1}{2R_1R_G}\right) \quad \ldots \quad (22)$$

$$\text{and } R_0 \approx \sqrt{2}R_1 \left(1 + \frac{1}{2R_1R_G} + \frac{1}{4R_G^2}\right) \quad (23)$$

assuming $\theta = 0$.

These formulae assume $R_G \gg 1$, but R_1 may have any value. As would be expected, (23) is intermediate between the coherent detector (9) and the 'linear' detector (11).

It must be observed that the synchrodyne is not suited for working with signals of level so far below the noise level that a value of $R_G > 1$ cannot be obtained.

As regards working with pulse signals, the main difficulty is that in the simple system discussed above it is not possible to control the oscillator frequency very closely in the intervals between pulses. This can be overcome to a large extent by using an automatic phase and frequency control, as described in a previous paper,[2] in which the control circuit has a very large decay time-constant, so that the oscillator frequency is held fairly constant in between pulses. But a good deal of work is still necessary to investigate these possibilities fully.

Acknowledgment

This paper is published by permission of the Admiralty.

REFERENCES

[1] Tucker, D. G., "The Synchrodyne," *Electronic Engineering*, Vol. 19, pp. 75, 241, 276, 366, 1947; Vol. 20, p. 49, 1948.

[2] Tucker, D. G., and Seymour, R. A., "The Synchrodyne as a Precision Demodulator," *Wireless Engineer*, Vol. 27, p. 227, 1950. (References to preceding literature are given.)

[3] Colebrook, F. M., "Homodyne," *Wireless World and Radio Review*, Vol. 13, p. 645, 1924.

[4] Middleton, D., and Hatch, R. M., "The Coherent Detector," Cruft Lab. Tech. Report No. 80, Harvard University, 1949.

[5] Tucker, D. G., "Linear-Rectifiers and Limiters," *Wireless Engineer*, Vol. 29, p. 128, 1952.

[6] Burgess, R. E., "The Rectification and Observation of Signals in the Presence of Noise," *Phil. Mag.*, Vol. 42, p. 475, 1951.

[7] Lawson, J. L., and Uhlenbeck, G. E., "Threshold Signals," Radiation Lab. Series No. 24, McGraw-Hill, New York, 1950.

[8] Tucker, D. G., "Forced Oscillations in Oscillator Circuits and the Synchronization of Oscillators," *J. Instn elect. Engrs*, Vol. 92, Part III, p. 226, 1945.

[9] Tucker, D. G., "Non-linear Regenerative Circuits," *Wireless Engineer*, Vol. 24, p. 178, 1947.

MULTIPLE REFLECTIONS IN LONG FEEDERS

By L. Lewin

(Standard Telecommunication Laboratories, London)

SUMMARY.—The signal distortion produced by reflections at many points along a mis-matched feeder is analysed in terms of harmonic distortion, for a single-tone signal, and in terms of inter-channel interference in the case of a multi-channel source. The intra-feeder effects are shown to be negligible for short feeders, but dominant for very long ones. Measurements on a long feeder confirm the incoherent nature of the reflected waves. It is recommended that attention be given to the question of reducing the discontinuities occurring on long waveguide runs, and that the possibility of using longer sections be investigated.

1. Introduction

IN a paper[1] "Phase Distortion in Feeders" the effects of two reflecting discontinuities (one at each end of a long feeder) on the properties of a frequency-modulated wave were examined in terms of the harmonic distortion of the video output from an ideal demodulator. In a further paper[2] the general relation between harmonic distortion and inter-channel interference was examined, and applied to the long feeder case just described. In both cases the distortion arises from reflections at the ends of the feeder. In practice, in which a long waveguide run is composed of a number of short lengths, there will be, in addition, a series of small reflections arising from the various joins, or from various distortions and irregularities along the run. The object of the present paper is to extend the above analyses to include this case, it being assumed that the individual reflections along the run are each small compared with those existing at the ends.

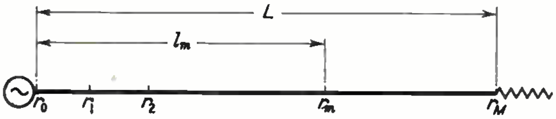


Fig. 1. *Schematic form of long feeder with discontinuities.*

2. The Transmitted Signal

Fig. 1 shows in schematic form a long feeder with reflections r_1, r_2, – – – r_M arising from discontinuities spaced l_1, l_2 – – – l_M from the input. l_M is the total length, L, of the feeder, and r_M is the reflection from the load (aerial). The reflection from the source is denoted by r_0. If the transmitted signal, in the absence of discontinuities is $S(t)$, then the effect of the reflections, to a first order, is to replace $S(t)$ by

$$S = S(t) + \sum_{n=0}^{M-1} \sum_{m=n+1}^{M} S(t - 2\tau_{nm}) r_n r_m \qquad (1)$$

MS accepted by the Editor, July 1951

where $\tau_{nm} = (l_m - l_n)/V_g$ and V_g is the group velocity along the feeder.

The correction terms arise from waves (of small amplitude) reflected from the mth discontinuity back to the nth discontinuity and then forwards again along the feeder to the aerial. Relative to $S(t)$ they are delayed in time by $2\tau_{nm}$ in the process. The summation in equation (1) is over all values of m and n that are less than or equal to M, subject to $n < m$. Equation (1) is a generalization of equation (1) of reference (1) in which only the term $r_0 r_M$ appears, and in which here the phase changes occurring at reflection have, for convenience, been absorbed in τ_{nm}. The effect of this is to make the electrical lengths slightly different from the physical lengths, l_m, and since the reflections from arbitrary discontinuities will have random phases the resulting waves will be incoherent, despite the fact that the joins may be accurately equispaced. A confirmation of this is given in Section 7.

3. Harmonic Distortion

An audio signal of angular frequency ω_a and peak deviation $\Delta\omega$ is used to modulate the carrier. The harmonic content of the output is given by equation (6) of reference (1), modified to the multiple reflection case.

$$P_q = 2(q\omega_a/\Delta\omega)^2 \sum_{n=0}^{M-1} \sum_{m=n+1}^{M} r_n{}^2 r_m{}^2 J_q{}^2(2\Delta\omega\tau_{nm}) \qquad \ldots \quad \ldots \quad (2)$$

Here J_q is a Bessel function, and P_q is the power in the qth harmonic relative to that in the fundamental (the recovered signal). The power-wise addition follows from the incoherence of the components, each of which involves a factor of the form $\cos(\omega_c\tau_{nm})$ where ω_c is the r.f. carrier angular frequency. As discussed above, these terms are randomly phased and the mean-square value of the components is accordingly taken.

By splitting the summations in (2) into four parts, the following equivalent form is obtained

$$P_q = 2(q\omega_a/\Delta\omega)^2 \left\{ r_0^2 r_M^2 J_q^2(2\Delta\omega\tau_{M0}) + \sum_{n=1}^{M-2} \sum_{m=n+1}^{M-1} r_n^2 r_m^2 J_q^2(2\Delta\omega\tau_{mn}) + r_0^2 \sum_{1}^{M-1} r_m^2 J_q^2(2\Delta\omega\tau_{m0}) + r_M^2 \sum_{1}^{M-1} r_n^2 J_q^2(2\Delta\omega\tau_{Mn}) \right\} \quad \ldots \quad \ldots \quad (3)$$

The first term is recognized as that arising from reflections between the two ends of the feeder and the second term from multiple reflections within the feeder. The third and fourth terms arise from reflections between one end or the other of the feeder and from the discontinuities within. The justification for separating the terms in this way is based on the initial assumption that the individual reflections r_m within the feeder are each considerably less than r_0 and r_M. When the r_m are zero only the first term remains, and the result is equivalent to equation (6) of reference (1).

For the remainder of this paper it will be assumed that the magnitudes of the internal reflections r_m are all equal, and that the physical spacings of the discontinuities are also the same. Thus we take $r_m = r$ and $l_m = mL/M$. The summations in (3) are replaced approximately by integrations (see Appendix 1), and the following form is obtained

$$P_q = 2(q\omega_a/\Delta\omega)^2 \{ r_0^2 r_m^2 F_1(\theta) + Mr^2(r_0^2 + r_M^2) \times F_2(\theta) + M^2 r^4 F_3(\theta) \} \quad \ldots \quad (4)$$

where $\theta = 2\Delta\omega L/V_g$

$$F_1(\theta) = J_q^2(\theta)$$

$$F_2(\theta) = \int_0^1 J_q^2(\theta x)dx$$

$$F_3(\theta) = \int_0^1 (1 - x)J_q^2(\theta x)dx$$

As explained in reference (2), harmonic analysis of a single-tone test signal is only significant for obtaining an indication of the interference in a multi-channel signal when the feeder is short, corresponding to a value of θ less than about 1·5. In this case only the low-order harmonics need be investigated. For $q = 2$ a series expansion gives the following approximations

$$F_1(\theta) \approx \frac{\theta^4}{64}(1 - \theta^2/6)$$

$$F_2(\theta) \approx \frac{\theta^4}{320}(1 - 5\theta^2/42) \quad \ldots \quad \ldots \quad (5)$$

$$F_3(\theta) \approx \frac{\theta^4}{1920}(1 - 5\theta^2/56)$$

Since M will ordinarily be small for a feeder satisfying the above condition, it is apparent that in this case the term $r_0^2 r_M^2 F_1(\theta)$ gives the dominant contribution to the distortion, and the effects of the remaining discontinuities may be ignored. *Since, however, they may make an appreciable contribution to the input standing-wave ratio of the feeder, r_M should be determined by measurements at the aerial directly and not via the feeder.*

4. Inter-channel Interference

In reference (2) the formulae for harmonic distortion of a test signal were used to deduce the inter-channel interference for a multi-channel signal.

The following symbols are used.

$\tau = L/V_g$ = delay along the feeder.
x = r.m.s. angular deviation of the multi-channel signal (the equivalent of $\Delta\omega/\sqrt{2}$ for the test signal).
N = number of channels.
ω_N = angular frequency (video) at the top of the multi-channel band.
y = parameter determining the channel position ($y = 1$ at the top and 0 at the bottom of the band).
α = channel occupancy factor (approximately a quarter).
$G^2(x)$ = Power interference level in a working channel, referred to the working channel level.

When there are no discontinuities within the feeder, equation (18) of reference (2) gives the form

$$G^2(x) = \alpha r_0^2 r_M^2 (\tfrac{1}{2} y\omega_N/x)^2 \phi^2(\tau x)$$

where

$$\phi(\tau x) = \left[\frac{4}{\pi} \int_0^\infty \cos y\theta \left\{ \exp(4\tau^2 x^2 \sin\theta/\theta) - 1 - 4\tau^2 x^2 \sin\theta/\theta \right\} d\theta \right]^{\frac{1}{2}} e^{-2\tau^2 x^2} \quad \ldots \quad (6)$$

Here $\phi(\tau x)$ takes the place of the Bessel function of the harmonic formula. The generalization to include multiple reflections within the feeder can be seen immediately from the form of equation (3), or, for the particular case of equal equi-spaced reflections, from equation (4). Restricting attention to the top of the band ($y = 1$) we get

$$G_1^2 = (\alpha\omega_N^2/4x^2)[r_0^2 r_M^2 F_1(\beta) + Mr^2(r_0^2 + r_M^2) \times F_2(\beta) + M^2 r^4 F_3(\beta)] \quad \ldots \quad \ldots \quad (7)$$

where

$$F_1(\beta) = \frac{4}{\pi} \int_0^\infty e^{-\beta} [e^{\beta \sin\theta/\theta} - 1 - \beta \sin\theta/\theta] \cos\theta d\theta$$

$$F_2(\beta) = \frac{4}{\pi} \int_0^1 \int_0^\infty e^{-\beta z^2} [e^{\beta z^2 \sin\theta/\theta} - 1 - \beta z^2 \sin\theta/\theta] \cos\theta \, d\theta \, dz$$

$$F_3(\beta) = \frac{4}{\pi}\int_0^1\int_0^\infty e^{-\beta z^2}\left[e^{\beta z^2 \sin\theta/\theta} - 1 - \beta z^2 \sin\theta/\theta\right] \cos\theta(1 - z)\,d\theta\,dz$$

and $\beta = 4\tau^2x^2$

The mode of formation of F_2 and F_3 from F_1 is the same as that used in equation (4) for the harmonic content. $F_1(\beta)$, $F_2(\beta)$ and $F_3(\beta)$ are obtained by numerical integration, and are shown in Fig. 2.

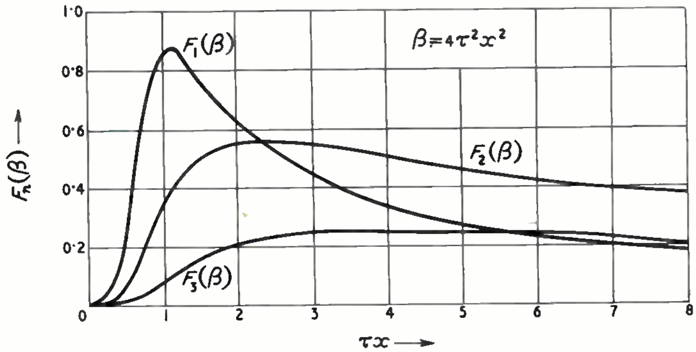


Fig. 2. *Values of the functions $F_1(\beta)$, $F_2(\beta)$ and $F_3(\beta)$ obtained by numerical integration.*

5. Feeder Attenuation

So far feeder attenuation has been neglected, but for the longer feeders this effect becomes more and more important. If the voltage wave is attenuated by $e^{-\alpha l}$ in a distance l, then the product r_nr_m should be replaced by $r_nr_me^{-2\alpha(l_m - l_n)}$, corresponding to the extra distance $2(l_m - l_n)$ travelled by the wave. Strictly speaking, the altered form should be included under the integral signs in the formulae for $F_n(\beta)$ in equation (7), but the effects may be considered independently by an approximate method (see Appendix 2), with the result that $F_1(\beta)$, $F_2(\beta)$ and $F_3(\beta)$ are multiplied respectively by

$$\begin{array}{l} e^{-4\alpha L} \\ (1 - e^{-4\alpha L})/4\alpha L \\ 2(e^{-4\alpha L} - 1 + 4\alpha L)/(4\alpha L)^2 \end{array} \qquad \ldots \quad \ldots \qquad (8)$$

These three functions are shown in Fig. 3.

6. Numerial Example

We consider a 200-ft waveguide run of attenuation 3 db/100 ft, made up of 10-ft lengths with reflections of 1% at the joins. The group velocity will be taken as 0·7 light velocity and the r.m.s. deviation of the video signal 1 Mc/s. The reflection at the aerial is taken as 3%, and that at the feed 5%.

Then $M = 20$, $\beta = 13$, $\tau x = 1{\cdot}8$ and $\alpha L = 0{\cdot}69$. The three terms in equation (7), as modified by the attenuation (second factor) are respectively.

$$(1{\cdot}53 \times 10^{-6}) \times 0{\cdot}063 = 9{\cdot}6 \times 10^{-8}$$
$$(3{\cdot}69 \times 10^{-6}) \times 0{\cdot}34 = 1{\cdot}25 \times 10^{-6}$$
$$(7{\cdot}68 \times 10^{-7}) \times 0{\cdot}48 = 3{\cdot}68 \times 10^{-7}$$

The overall level (with $\alpha = \frac{1}{4}$ and $\omega_x = 2\pi \times 800$ kc/s) is $G_1{}^2 = 6{\cdot}8 \times 10^{-8} = 72$ db down on the working-channel level.

It is seen that the most serious cause of distortion arises from the second term; i.e., from reflections within the feeder in conjunction with a further reflection from either end. The next most important source arises from double reflections within the feeder. The least serious, owing largely to the attenuation, is the effect due to reflections between the two ends.

In the absence of attenuation, the distortion would have been 66 db down on the working channel level; a figure which, in the further absence of reflections within the feeder, would (by coincidence) have been back at the 72-db level.

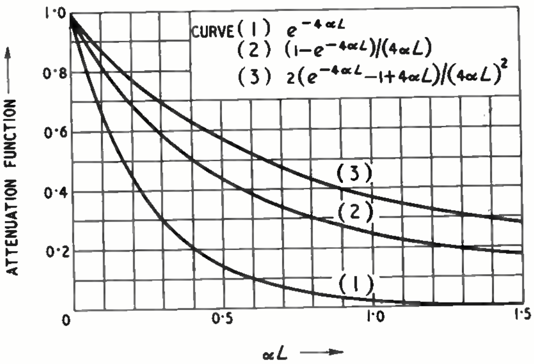


Fig. 3. *Correction functions for attenuation in the feeder.*

7. Measurements on a Long Feeder

The purpose of these measurements was to confirm the random nature of the reflections from the joins. If the input standing-wave ratio, with varying frequency, shows a periodic variation corresponding to the section lengths, then these reflections must be presumed to be coherent. If, on the other hand, the measurements show a random scatter with a 'grain' corresponding to the total length, when the feeder is matched, then the reflections can be taken as incoherent, confirming the validity of the 'power-wise' addition so far assumed.

A run of 120 ft of waveguide, composed of 10-ft sections, was constructed. The guide was of poor quality, and considerably weathered, and no special care was taken to ensure reflection-less joins. The resulting input reflection, plotted against frequency, is shown in Fig. 4. No trace of periodicity is observable. The mean total reflection is 2·76%, and the r.m.s. reflection 3·03%. The measured attenuation is 6 db, and from this, and the assumption of incoherent addition of equal reflections, r, the value of reflection at a join may be deduced.

The mean-square reflection is $\sum_{1}^{M} r_m^2 e^{-4\alpha mL/M}$, which can be summed to $Mr^2(1 - e^{-4\alpha L})/4\alpha L$ on the assumption of equal reflections. Equating this to $(3{\cdot}03\%)^2$ with $e^{-\alpha L} = 0{\cdot}5$ gives the value

$$r = 1{\cdot}5\%$$

which was confirmed by one or two individual measurements on short lengths. This figure is rather high, but carefully-constructed joins can reduce it by a factor of about three. Even so, the formulae of Section 6 show that internal feeder reflections at this level, in conjunction with the termination reflections, are responsible for most of the distortion arising from the sources considered here.

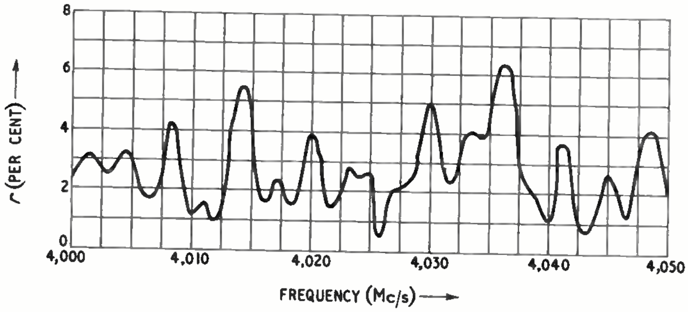


Fig. 4. *Measured reflections in a 120-ft matched feeder comprising twelve 10-ft sections.*

8. Conclusions

The relative importance of the end terminations and the internal discontinuities depends mainly on the number of sections of which the run is composed. For short runs the end reflections are most important. For long runs the two sources are of about equal effect. And for very long runs the internal reflections are the most serious source of interference. It is felt that an appreciable improvement would result from more attention to the reflections at the joins; and the possibility of longer sections for use in constructing very long runs might be considered. There seems no justification for making the sections of unequal length, since the random nature of the discontinuities ensures incoherence of the reflected waves.

Acknowledgment

The above work was carried out at the Standard Telecommunication Laboratories, Enfield, and permission to publish is gratefully acknowledged.

REFERENCES

[1] "Phase Distortion in Feeders–Effect of Mis-matching on Long Lines," L. Lewin, J. J. Muller and R. Basard. *Wireless Engineer*, May 1950. Also *Electrical Communication*, December 1950.

[2] "Interference in Multi-Channel Circuits—Dependence on Harmonic Generation," L. Lewin. *Wireless Engineer*, December 1950. Also *Electrical Communication*, June 1951.

APPENDIX I

The sum $\sum_{1}^{M-1} r_m^2 J_q^2(2\Delta\omega\tau_{m0})$, with $r_m = r$ and $\tau_{m0} = mL/MV_g$ can be replaced by an integration using the approximate formula $f(n) \approx \int_{n-\frac{1}{2}}^{n+\frac{1}{2}} f(x)dx$. This gives, putting $2\Delta\omega L/V_g = \theta$

$$\sum^{M-1} r^2 J_q^2(2\omega mL/MV_g) \approx r^2 \int_{\frac{1}{2}}^{M-\frac{1}{2}} J_q^2(\theta x/M)dx$$

Taking x/M as a new variable of integration, we get $Mr^2 \int_0^1 J_q^2(\theta x)dx$ as an approximation to the last integral, for large M.

The double series $\sum_{n=1}^{M-2} \sum_{m=n+1}^{M-1} r_n^2 r_m^2 J_q^2(2\Delta\omega\tau_{mn})$ is similarly replaced by $r^4 \sum_{n=1}^{M-2} \sum_{m=n+1}^{M-1} J_q^2[\theta(m-n)/M]$

$$\approx r^4 \int_{\frac{1}{2}}^{M-\frac{3}{2}} \int_{x+\frac{1}{2}}^{M-\frac{1}{2}} J_q^2[\theta(y-x)/M]dx\,dy$$

$$\approx M^2 r^4 \int_0^1 \int_x^1 J_q^2[\theta(y-x)]dx\,dy \text{ for large } M.$$

The double integral can be replaced by a single integral in the following way. If $F(x) = \int_0^x f(x)dx$ then, integrating by parts, we get

$$\int_0^1 \int_x^1 f(y-x)dx\,dy = \int_0^1 F(y-x)\Big|_x^1 dx = \int_0^1 F(1-x)dx$$

$$= \int_0^1 F(x)dx = xF(x)\Big|_0^1 - \int_0^1 xf(x)dx =$$

$$\int_0^1 f(x)dx - \int_0^1 xf(x)dx = \int_0^1 f(x)(1-x)dx$$

Using this formula, we obtain the form

$$M^2r^4\int_0^1 J_q^2(\theta x)\ (1-x)dx$$

quoted in the text.

APPENDIX 2

The possibility of the separation described in the text depends on the approximation

$$\int_a^b f(x)g(x)dx \approx \frac{1}{a-b}\int_a^b f(x)dx\int_a^b g(x)dx.$$

(The mean of the product approximately equals the product of the means.) This result may be used provided neither $f(x)$ nor $g(x)$ changes sign or varies rapidly in the range of integration.

The appropriate attenuation factors are, on the above assumptions

$$\int_0^1 e^{-4\alpha Ly}\,dy = (1-e^{-4\alpha L})/4\alpha L$$

and $$2\int_0^1\int_x^1 e^{-4\alpha L(y-x)}\,dx\,dy = 2\int_0^1 e^{-4\alpha Lx}(1-x)dx =$$
$$= 2(e^{-4\alpha L}-1+4\alpha L)/(4\alpha L)^2$$

CORRESPONDENCE

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

Mechanical Force on the Short Side of a Long Rectangular Circuit

SIR,—Apropos of your interesting editorial in the April issue, I think that readers of *Wireless Engineer* may be interested in a direct method of evaluating the mechanical force on the short side of the circuit by calculating the force acting on any typical element of the short side, due to its being situated in a magnetic field.

This can be done very easily provided the whole rectangle is thought of as being made of stranded cable, instead of solid rod. Thus, imagine a long rectangular coil consisting of very many turns of fine wire and wound in such a manner that the many strands which compose each of the long sides of the rectangular coil are arranged so as to form a stranded cable of circular cross-section. Possibly there comes to mind the picture of a former-wound dynamo-coil, although of rather an unusual shape. Let there be n turns in the rectangular coil and let a current i be passed through it: then the total current passing along any side is $ni = I$.

Fig. 1 is intended to represent the cross-section of the two cables taken at the end of a long side. In it, C and D represent the cross-sections of two typical and similarly situated strands and CD is the 'end connection' joining them.

Within the body of each cable there is a magnetic field $H = I\dfrac{r}{a^2}$ *, due to the current ni which flows along it.

Each element of the portion CF of the 'end connection' CD is situated in this field H, but is not perpendicular to it. Consideration will show that the force, perpendicular to the paper, on CF is the same as the force would be on CE if this piece of radius carried a current i. Accordingly

$$\text{Force on CF} = \int_{r_1}^{a} H.i.dr = \frac{I^2}{na^2}\int_{r_1}^{a} r.dr$$
$$= \frac{I^2}{2n}\left(1-\frac{r_1^2}{a^2}\right)$$

Now liken CD to a connecting rod joining the two cranks AC and BD, and suppose that AC is turning slowly and counter-clockwise about A. Imagine C when it has reached the position C′ in Fig. 1; then the portion of the end connection which we are considering is C′F. But the net force on C′F is the force on CF because the net force, perpendicular to the paper, on CC′ is zero. Consideration will show that the net force, perpendicular to the paper, on the end connection is equal to $\dfrac{I^2}{2n}\left(1-\dfrac{r_1^2}{a^2}\right)$ for all values of θ. The number of strands in the ring of radius r_1 and thickness δr is $\dfrac{2r_1\ \delta r}{a^2}\ n$ and accordingly the total force on the CF portion of end connections to the ring of strands at radius r_1 is

$$I^2\frac{r_1dr}{a^2}\left(1-\frac{r_1^2}{a^2}\right).$$

Accordingly, the total force on all the CF portions

is equal to $$\frac{I^2}{a^2}\int_0^a\left(r-\frac{r^3}{a^2}\right)dr = \tfrac{1}{4}\,I^2.$$

Now we must calculate the force on the portion FD of the typical end connection CD in the figure.

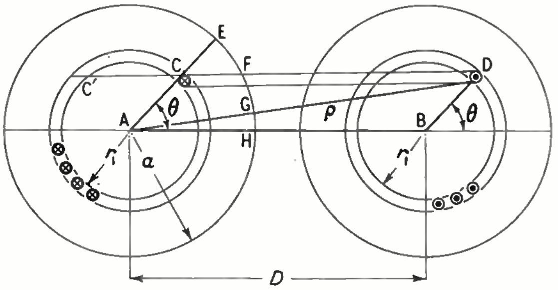


Fig. 1.

The left-hand conductor produces a field outside it which is disposed in circles centred on A and of strength varying inversely as the distance from A. The portion FD of the end connection CD lies in this field, but is not perpendicular to it. Consideration will show that the force on FD, perpendicular to the paper, is the same as that on a current i flowing along the radial length GD. Accordingly

$$\text{Force on FD} = I\int_{\text{AG}}^{\text{AD}}\frac{i}{r}\,dr = \frac{I^2}{n}\log\frac{\rho}{a}$$

Since the distance ρ does not remain constant as the point D moves round the circle of radius r_1, it is necessary to perform an integration. It is not difficult to perform this integration de novo but brief consideration will show that the result is in fact well known to all.

---

* This component of field is half what it would be if the cable extended to infinity, both out of the paper as well as into it; hence the absence of the familiar 2 in the equation for H.

To remind the reader of this well-known result it is perhaps simpler to draw a fresh figure, though it is not essential to do so. Let the circle in Fig. 2 represent the cross-section of a metal cylinder carrying an electric charge q per unit length. Then it is well known that the electric force at the point P is radial and equal to $2q/D$, irrespective of the radius of the cylinder. Let V be the potential at P then $-\frac{dV}{dD} = \frac{2q}{D}$, whence $V = K - 2q \log D$. But it would also have been natural to calculate V by adding up the potentials contributed by filaments typified by Q distant ρ from P. Then

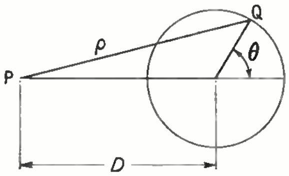


Fig. 2

$$V = 2q \int_0^{2\pi} \log \rho \, \frac{d\theta}{2\pi}.$$

But this is the integral which is required for calculating the total force on all the portions of end connection typified by FD in Fig. 1. By comparison, it now follows that

$$\int_0^{2\pi} \log \rho \, d\theta = \log D.$$

Accordingly it now follows that the total force on all the end connections, typified by FD in Fig. 1, is the same as it would be if all n of them were placed along HB and thus it is equal to $n \times I^2/n \log D/a$; accordingly the total force on all the end connections, taken together, equals

$$I^2\left(\log \frac{D}{a} + \tfrac{1}{4}\right).$$

But here we have calculated the force on the end connections which arises from the current in the left-hand cable. If the radius of the two cables is equal then there is an equal force arising from the current in the right-hand cable: accordingly

$$\frac{F}{I^2} = 2\left(\log \frac{D}{a} + \tfrac{1}{4}\right) \dagger\text{, if the cables are similar,}$$

$$\text{or } = \left(\log \frac{D^2}{a_1 a_2} + \tfrac{1}{2}\right)\text{, in the general case,}$$

Thus, we have calculated directly the force on the short side of the rectangle provided it consists of a flat plate. The indirect method of calculation, by means of dL/dl, suggests that the result could be generalized to apply to a cable bent round a peg of radius $\frac{1}{2}(D - d)$; but we shall not attempt to do this.

The same method can be used to calculate the self-inductance per unit length of the rectangle, defined as the total linkages through the coil of n turns. Thus, the total linkages through the width typified by FD is $2nI \log D/a$, because the lines of force are circles. Similarly the total linkages through the width typified by CF is $\frac{1}{2}nI$: whence

$$\begin{aligned} L &= 4nI\,(\log D/a + \tfrac{1}{4}) \\ &= 4n^2 i\,(\log D/a + \tfrac{1}{4}) \\ \text{or } &= 2n^2 i\left(\log \frac{D^2}{a_1 a_2} + \tfrac{1}{2}\right)\text{, in the general case.} \end{aligned}$$

E. B. MOULLIN.

Engineering Laboratory,
Cambridge.
22nd April, 1952.

New Graphical Methods for Analysis and Design

SIR,—I would refer to the paper by Saraga and Fosgate in the March issue of *Wireless Engineer*. In connection with the "Direct Computation of Insertion Loss" (Section 7) and the "Design of Insertion-Parameter Filters" (Section 8) it may be of historical, as well as of practical, interest that Piloty in 1939* had already shown two ways of determining the insertion loss of 'insertion-loss parameter filters' for stop and transmission ranges: the practical way for setting up E^2 by adding 'elementary factors' (Elementarfaktoren) graphically to the required shape (template method) and the mathematical way for setting up E^2 by means of Tchebychev's approximation. Saraga's adding of straight lines is equivalent to Piloty's adding of 'elementary factors.'

The template method of adding 'elementary factors' $\log_e \left(\frac{x}{a} - \frac{a}{x}\right)$, compare rewritten equation (11a) of Saraga according to Piloty, has been used in practice for insertion-parameter filters since 1939 in Germany. The attenuation requirement was rewritten into a requirement for E^2 using the equation $E^2 = e^{2\alpha} - 1$ where α is the required attenuation in nepers. The requirement for E^2 was then fulfilled by adding elementary factors $\log_e \left(\frac{x}{a} - \frac{a}{x}\right)$.

Thus the procedure was reduced to a method as simple as the adding of the attenuation of single sections in the classical theory. In using this method a smoothly-increasing curve of insertion loss in the transmission range (i.e., a smooth return loss) results as a border-line case where the attenuation peaks of the 'elementary factors' in the transmission range happen to be at zero or infinite frequencies only.

In practice a greater clarity and a better physical explanation of the whole setting up procedure for E^2 can be achieved in general if the 'Feldtkeller Equation' is used. This equation links the insertion-loss attenuation α_i (nepers) with the return-loss attenuation α_r (nepers) for the same frequency of any one reactance network by

$$e^{-2\alpha_i} + e^{-2\alpha_r} = 1$$

Thus the return loss and the insertion loss are equivalent conceptions of any reactance network and either may be used as convenient. The equation makes it clear that zeros of insertion loss are infinity points of the return loss.

In Fig. 10 (Saraga) the lower part of curve 7 (leading to the insertion loss in the transmission range) is then the direct representation of the return loss in the transmission range while the upper portion of curve 7 represents the insertion loss in the stop range.

Using this interpretation for setting up E^2, it is clear that the transmission range and the stop range have to undergo the same equivalent treatment and procedure. The transmission range can be regarded as fixed by the return loss and the stop range controlled by the insertion-loss attenuation. Both ranges are then represented in relatively high attenuation values and they can be built up in the same way, with the same tolerance in attenuation by adding elementary factors to fulfil the requirement for $E^2 = e^{2\alpha} - 1$ where α means the required attenuation for respective insertion and return loss.

There may be peaks or there may be no peaks (smoothly increasing curve) of the return loss (zeros of insertion loss) in the transmission range at finite frequencies and similarly for the insertion loss in the stop range. This depends only on the practical requirements. The fixing of H resp H' is then also just a parallel shift of the abscissa axis.

By this it is made clear that the use of the L/X chart of Saraga for insertion-parameter filters "requires roughly

---

† I regret to say that this force was calculated incorrectly on p. 87 of my book on "The Principles of Electromagnetism"; my thanks are due to Dr. G. F. C. Searle, for pointing out the error to me.

twice as much work" as the use of the α/X chart of Saraga for image-parameter filters.

It is just the consequence of the basic assumption of the classical theory that for the image-parameter method the insertion-loss attenuation of a reactance network (composed of two factors: mismatch and image attenuation) has to be calculated separately for the transmission and for the stop range. This basic assumption is (in order to simplify the analytic and mathematical methods and thus being able to use a tandem arrangement of sections) that the conceptions 'image impedance' and 'image propagation constant' had to be introduced as completely independent of each other.

G. R. SCHNEIDER.

Bromley,
Kent.
8th May, 1952.

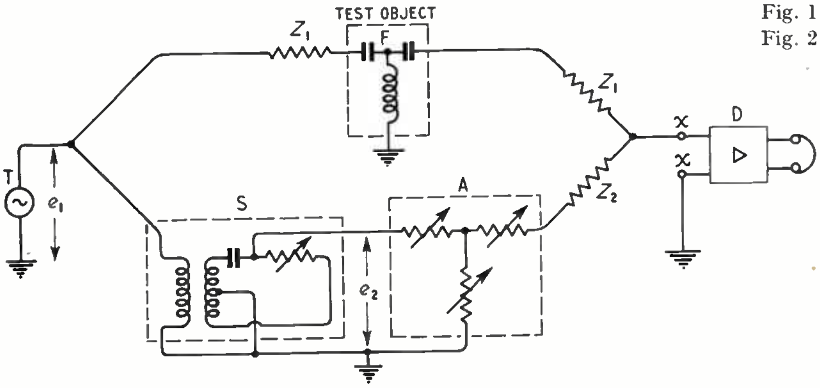
---

*Piloty. "Weichenfilter." *TFT*, 1939, Vol. 28/8, 9.
Piloty. "Wellenfilter." *TFT*, 1939, Vol. 28/10.

Null-Balance Technique for Filter Measurement

SIR,—I feel that the following description of a new measuring technique may be of general interest.

There is no difficulty in measuring the cut-off attenuation of a high-pass filter when there are available a tone-source of low harmonic content, subsidiary filters, and a wave-analyser as a measuring instrument. In the absence of such apparatus, however, the technique described here can be used to achieve closely equivalent accuracy.



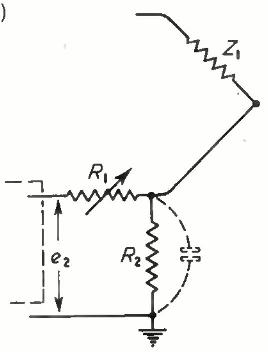


Fig. 1 (left)
Fig. 2 (right)

It is assumed that there are available a tone-source of average purity (harmonic content 2–3%), an amplifier of maximum gain 40–50 db, a valve-voltmeter accurate to ± 0·2 db at an input of −10 dbm or so, and, either a calibrated constant-impedance attenuator, or several calibrated rheostats. Subsidiary phase-shifting circuits are required, but, as these need no calibration, they can be constructed from generally available laboratory equipment.

If the calibrated attenuator is available, the circuit of Fig. 1 is used. The stability and accuracy of this circuit is primarily due to the common earth points on the tone-source (T), phase-shifter (S), attenuator (A), detector (D) and 'test object' (F), which is assumed to be an 'unbalanced' filter of design impedance equal to Z_1. The circuit principle is as follows: S and A are adjusted consecutively until the fundamental-frequency signal at the points XX becomes zero. The currents in the load impedances Z_1 and Z_2 are then equal, while F is correctly terminated by Z_1 and A by Z_2. The loss in the side chain is then equal to the filter loss plus a constant, which equals 6 db if $Z_1 = Z_2$. It is relatively easy to derive this loss, since the filter output level is given by the valve-voltmeter reading e_2 less N db (the loss in A). If e_2 is set to be 16 db below the input level e_1, the filter insertion loss equals $(N + 10)$ db and can be read direct from A. In these circumstances, since the permissible loss is so large, there is a variety of well-known RC phase-shifting circuits which may be used in S; one of these is indicated in the figure.

In Fig. 2 a calibrated rheostat, R_1, replaces the attenuator. A low resistance R_2 is used to reduce hum-level in D; its value has no effect upon the loss measurement. At balance the loss in the filter chain is equal to

$$20 \log_{10} \frac{(e_1 \cdot R_1)}{(e_2 \cdot R_2)} \text{ db.}$$

Figs. 3 and 4 illustrate the precision obtainable (using the circuit of Fig. 1). The filter input level was 0 dbm. Headphones were used throughout the frequency range, the output of D (gain 30 db) being modulated with 1000 c/s to make the signal audible at frequencies below 200 c/s. Since the phase shifter S had been calibrated,* it was possible to draw the phase diagram of Fig. 4. At the peak attenuation readings to better than 0·5 db and 2·0° were possible. The tone-source (T) generated about 3% of 2nd and 3rd harmonics, and it was found that these could overload D and produce spurious fundamental signals causing errors of the order of 1 db; the gain should therefore be kept to a minimum, or a

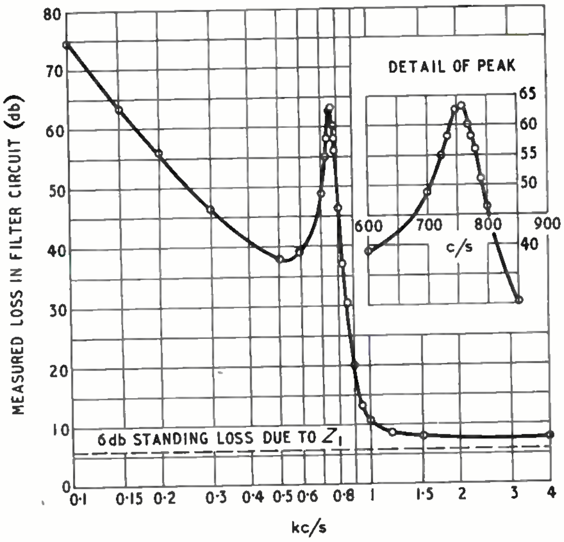


Fig. 3

large capacitor connected across XX to reduce the harmonic level fed to D.

As an indication of the sensitivity of the technique it may be mentioned that, in a test on a low-pass filter, attenuations of 110 db were measurable to ± 1·0 db without difficulty.

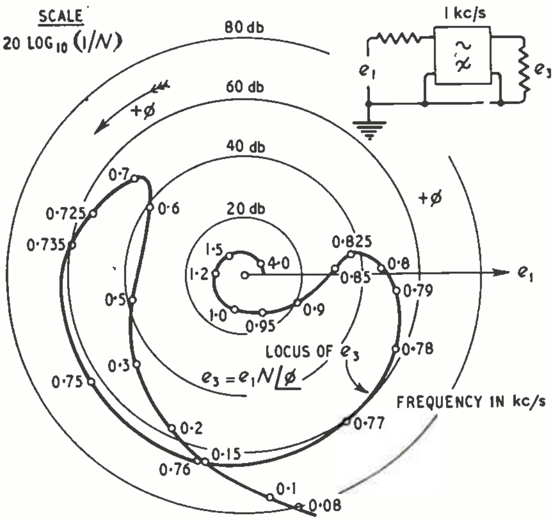


Fig. 4

Unusual features of this circuit appear when the load Z_1 is removed. The test object (which might be a transformer for instance) is then on dead short circuit, while the short-circuit current appears in Z_2, where it is readily measured. This feature of the technique can be exploited in a number of ways which cannot be detailed here.

E. Ramsay Wigan

B.B.C. Laboratories,
Kingswood Warren,
Tadworth, Surrey.
9th May, 1952.

---

[*] Wigan: *Wireless Engineer*, January 1952, p. 27.

Television Definition

Sir,—There is a superficial resemblance between a long-standing convention in television practice and one aspect of theory of the communication of information which is so plausible that I fear it may hinder an appreciation of the limitations of existing practice and the possibilities of improvement. I refer to the television convention that the number of picture points which can be transmitted per second (without coding) is equal to twice the video bandwidth in cycles per second, and the law of communication theory that the *maximum* number of independent 'data' which can be transmitted through a given channel is equal to twice the product of the bandwidth and the time of transmission.

This feature of communication theory has been established both by Gabor[1] in formal mathematical terms and by Shannon[2] in his 'sampling theorem', but its apparent equivalence with the television convention vanishes when one notes that communication theory prescribes two data per unit of time-bandwidth as the *maximum* rate which can only be attained if the transmission is so coded as to make efficient use of the channel. No such coding is used in the conventional black-and-white television systems which employ direct amplitude modulation at the transmitter and merely extract the video signal by means of a 'detector' or 'rectifier' at the receiver, and with such systems (e.g., as currently used in British broadcast reception) *it is not in fact possible to reproduce two independent picture elements per second for each cycle-per-second of bandwidth.* The traditional argument has been that alternate light and dark picture elements may be represented by positive and negative half cycles of the maximum video frequency, thus giving two elements per cycle. But these are not *independent* elements, because we have presupposed that each light element is followed by a dark one, and with this prior assumption the picture could equally well be reconstructed at the receiver from the transmission of one element only (e.g., the light element) per cycle: the real rate of transmission in such a case would be at most only half that conventionally assumed. But in fact if the pattern were uniform over the whole picture, only the single (maximum) video frequency need be transmitted, the rest of the band being empty. Clearly negligible information can be transmitted in this condition, using infinitesimal bandwidth for a single frequency, and patterns involving multiple frequencies must be considered.

The simplest way to take account of the general picture, rather than the maximum-frequency, cyclic pattern, is to examine the step function which involves all video frequencies and from combinations of which any pattern can be constructed. In a transmission system which is equivalent to an 'ideal filter', the receiver response to a step-function signal at the input of the system will complete the greater part of its rise (approximately from 10% to 90% of the step) in half the period of the maximum frequency, but the complete swing from the lowest point of the 'undershoot' preceding the main rise to the peak of the overshoot occupies a whole period T of the highest frequency. If information of some sort is conveyed by the height of the step, one cannot communicate a second piece of information independent of the first until the transmission system has been restored to its original state again; and even on the restricted basis of $T/2$ sufficing for the greater part of the transition, this requires a time T for the rise and fall associated with each unit of information; i.e., only one datum can be transmitted per cycle in a simple amplitude-modulated system. Another way of putting this is that the shortest rectangular-pulse test object which will produce a receiver response of nearly full amplitude is one scanned at the transmitter in time $T/2$, but the time occupied by its reproduction at the receiver is T. (Even so it is reduced in effective amplitude by being converted from a rectangle to a triangle, but the half-sine-wave representation also provides only an instantaneous attainment of full amplitude.)

Another point is that the optical definition of resolving power is the number of *similar* lines (light lines on a dark ground or vice versa) which can be distinguished, and the optical resolution in a picture is only half the number of television lines. The optical convention for the distinguishability of two images is that the maximum in the diffraction pattern of one should fall on the first minimum of the other, and this has been criticised on the ground that more-closely meshed patterns can be distinguished with the aid of a device which is sufficiently sensitive to changes of intensity as one scans across the joint pattern. But this criticism is not valid in the theory of electrical communication, since this deals only in *independent* data, and they are independent only if one can be measured while the other is zero. The effect of sensitivity to amplitude change is taken into account separately, for the Shannon-Hartley law can be put in the form

$$C = 2W \log (1 + P/N)^{\frac{1}{2}}$$

where C is the communication rate, W the bandwidth, and P/N the signal/noise power ratio. Then $2W$ is the number of independent data, and $\log\ (1 + P/N)^{\frac{1}{2}}$ describes the effect of the amplitude-sensitivity of the system. Since the response to an impulse of an ideal filter is of the form $(\sin \omega_c t)/\omega_c t$, with the first minimum later than the maximum by a half period of the cut-off frequency, it is in theory possible to communicate independently two pulses separated only by $T/2$ when their waveforms are spaced in the same way as the diffraction patterns in the optical resolution test. But in the electrical case this requires that they originate from pulse signals (comparable with point objects in optics) and that the received waveforms be examined with the aid of a narrow sampling-pulse or gate, which is not part of a conventional black-and-white television receiver.

It thus appears that optical theory and communication theory are mutually consistent, but that the convention which has been widely used in television lends itself to an over-optimistic view of the performance of conventional television systems. When we are debating how many Mc/s are necessary for a television channel, and what is the best number of lines for a given bandwidth, it should be remembered that the conventional black-and-white system is utilising its (video) band with an efficiency of only about 50%. If this margin for a possible 2:1 improvement is to be retained as a reserve for colour television, this policy should be made explicit.

D. A. Bell.

Birmingham.
31st May, 1952.

REFERENCES

[1] D. Gabor, *J. Instn. Elect. Engrs.*, Pt. III, Vol. 93, p. 429, 1946.
[2] C. E. Shannon, *Proc. Inst. Radio Engrs.*, Vol. 37, p. 10, 1949.

NEW BOOKS

The Magnetron

By R. Latham, M.A., Ph.D., A. H. King, M.A. and L. Rushforth, M.B.E., B.Sc., M.I.E.E. Pp. 142 + ix with 82 illustrations. Chapman & Hall Ltd., 37 Essex St., London, W.C.2. Price 18s.

In their preface the authors say that "The purpose of this book is twofold. It is intended at the same time to explain the construction and properties of the magnetron to those without specialized knowledge of high frequency techniques, and also to provide a basis for those with specialized knowledge who wish for more detailed information."

The book opens with a very short and elementary description of radar, and in the second chapter goes on to describe the various forms of v.h.f. oscillator, while in the third it covers in 4½ pages the early development of mutli-resonator magnetrons. A chapter on the properties of the anode block follows. Thus far, the treatment is almost completely non-mathematical, only a few simple equations being quoted.

Chapter 5 covers output couplings and includes a mathematical treatment of Q values. In the next three chapters the electronic side of the magnetron is dealt with and again the treatment is of a somewhat mathematical kind. There is nothing very difficult, however, and there is a good deal of simple explanation so that one obtains a very good general picture of what goes on in the valve. The concluding chapters cover cathodes, constructional techniques, testing and radar applications, all rather briefly.

The first part of the authors' purpose in writing the book has undoubtedly been fulfilled. It does explain the construction and properties of the magnetron in a manner suited to the needs of those without specialized knowledge of centimetre-wave technique, and it forms a good introduction to the magnetron. It is more doubtful if the authors have succeeded in their second aim of providing "a basis for those with specialized knowledge who wish for more detailed information." The two aims are so very different that it is hardly possible for both to be equally successful and one cannot help feeling that the specialist will want a much more detailed and thorough treatment. The bibliography provided after each chapter does, of course, indicate suitable further reading, but the addition of a bibliography does not turn the book into one for the specialist. For the newcomer to the magnetron the book is undoubtedly a good one.

W. T. C.

Electronic Valves

Book V. Application of the Electronic Valve in Radio Receivers and Amplifiers; Vol. 2, A.F. Amplification, The Output Stage, Power Supply. By Dr. B. G. Dammers, J. Haantjes, J. Otte and H. Van Suchtelen. Pp. 431 with 343 illustrations. Price 45s.

Book VII. Transmitting Valves.
By J. P. Heyboer and P. Zÿlstra. Pp. 284 + xii with 256 illustrations. Price 35s. Cleaver-Hume Press, Ltd., 42a South Audley Street, London, W.1.

These books are part of a series published by N.V. Philips Gloeilampenfabrieken, Eindhoven, Holland, under the general title of "Electronic Valves." Book I was reviewed in *Wireless Engineer* for December 1949, and Books II, III and IV in the issue for June 1950. Book V is a companion to Book IV and is called Vol. 2, although Book IV does not bear the designation of Vol. 1.

In Book IV the applications of the valve to radio receivers and amplifiers were dealt with up to the detector stage of a receiver. In Book V the treatment is continued to cover the audio-frequency side including the power supply. The two books together thus cover the whole of the receiver with the exception of negative feedback, stability problems and interference. These are matters to be dealt with in Book VI, which has not yet been received.

Book V is divided into three sections covering a.f. amplification, the output stage and the power supply. The first of these is sub-divided into four sections dealing with a.f. amplifying circuits, phase-splitters, frequency response, a.f. transformers and non-linear distortion. The output stage covers pentodes and triodes in Class A, Class B and Class AB with a discussion of the different modes of operation, distortion and the complex load, while under 'Power Supply' are treated filament and heater requirements, rectifiers and h.t. stabilizers.

The general treatment is of a somewhat unusual character in that a large part is quite elementary and mainly descriptive; there are some sections which the reader will find much more difficult and for which he will need a moderately-good mathematical background. Another peculiarity is that the whole outlook is coloured strongly by the broadcast receiver. Almost without exception the examples are drawn from broadcast receiver practice. This will undoubtedly be regarded as a major asset by those whose main interests lie in this field, but it does detract somewhat from the value of the book as a general text. It is not intended to criticize the book for not being a different book; the authors have chosen to make it almost a text-book of broadcast receiver practice and have succeeded admirably in doing so.

A point of very great value is that in most important circuits practical values of components are given with quite a lot of measured data on performance. It is impossible in a short review to deal with everything, or even to enumerate all the subjects treated, but as an illustration of the general thoroughness it may be mentioned that rather more than five pages are given to the problem of dial lights in a.c./d.c. sets. This is a matter which most authors seem to regard as too trivial to mention, but one which can cause a designer many headaches and which can have serious commercial repercussions if he fails to find a satisfactory solution to the difficulties.

The book is a translation and is also published in French, Dutch and German. On the whole the translation is a good one, but there are some peculiarities of English; mathematical symbols conform to Continental rather than to British practice and there are some peculiarities of symbol in circuit diagrams. An unusual practice is the use of a percentage response scale, instead of a decibel scale, in the plotting of frequency-response curves.

Book VII deals with transmitting valves. After introducing chapters covering technology and classification there are chapters on the triode, tetrode and pentode as r.f. power amplifiers, then one on the modulation of a power amplifier. After that the transmitting valve is treated first as an oscillator then as a frequency multiplier. There is a chapter on special items and a concluding one on valves for high frequencies. In this, operation at frequencies of the order of 20 Mc/s is dealt with, but there is some information about valves for frequencies up to about 200 Mc/s.

The treatment as a whole follows similar lines to that of the receiving books, but is rather more general in that it is not confined to a particular class of transmitter. It is, too, slightly more mathematical in character; this follows inevitably from the fact that transmitting valves almost invariably operate under class B or class C conditions. The book is a worthy comparison to the 'receiving' ones.

W. T. C.

Modern Electrical Contracting

By H. R. Taunton, A.M.I.E.E. Pp. 176. Published for *Electrical Review* by Iliffe & Sons, Ltd., Dorset House, Stamford St., London, S.E.1. Price 10s. 6d.

Wireless and Electrical Trader Year Book, 1952

23rd Edition. Pp. 264. Trader Publishing Co., Ltd., Dorset House, Stamford St., London, S.E.1. Price 10s. 6d.

Sound Recording and Reproduction

By J. W. Godfrey and S. W. Amos, B.Sc., A.M.I.E.E. B.B.C. Engineering Training Manual. Pp. 272 with 176 illustrations and 10 plates. Published for *Wireless World* by Iliffe & Sons, Ltd., Dorset House, Stamford St., London, S.E.1. Price 30s.

Electrical Who's Who, 1952

Pp. 322. *Electrical Review* Publications, Ltd., distributed by Iliffe & Sons, Dorset House, Stamford St., London, S.E.1. Price 12s. 6d.

Radiological Monitoring Methods and Instruments

National Bureau of Standards Handbook 51. Pp. 33. Government Printing Office, Washington 25, D.C., U.S.A. Price 15 cents.

Stainless Steel Magnetic Recording Wire

By Prof. H. Sucksmith, F.R.S. E.R.A. Technical Report N/T61. Pp. 9. The British Electrical & Allied Industries Research Association, Thorncroft Manor, Dorking Rd., Leatherhead, Surrey. Price 6s.

PHYSICAL SOCIETY'S COMPETITION

The competition for apprentices and learners engaged in work connected with the design or manufacture of scientific instruments, which is held annually by the Physical Society, was originally confined to the employees of firms exhibiting at the Physical Society's Exhibition. It is now open also to employees in workshops or drawing offices, to students attending recognized workshop or machine-drawing courses at technical colleges or schools and to selected bodies invited by the Council of the Physical Society.

Competitors must be under 22 years of age on 31st March 1953, and entries must be made by 21st February. Entry forms and details of the competition are obtainable from The Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Values for May, 1952

Date 1952 May	Frequency deviation from nominal: parts in 10^8		Lead of MSF impulses on GBR 1000 G.M.T. time signal in milliseconds
	MSF 60 kc/s 1029-1130 G.M.T.	Droitwich 200 kc/s 1030 G.M.T.	
1*	+ 0·1	+ 3	− 18·9
2**	—	+ 2	—
3	0·0	+ 3	− 20·5
4	0·0	+ 3	− 20·6
5*	0·0	+ 4	N.M.
6**	—	+ 4	—
7	0·0	+ 4	− 22·5
8	0·0	+ 3	N.M.
9	0·0	+ 4	− 23·3
10	0·0	+ 4	− 24·2
11	0·0	+ 4	N.M.
12	− 0·1	+ 4	− 25·1
13	− 0·1	− 3	− 26·1
14*	− 0·1	− 3	− 26·2
15	− 0·1	− 3	− 27·8
16	− 0·1	− 4	− 28·4
17	− 0·1	− 4	− 27·8
18	− 0·1	− 4	N.M.
19	0·0	− 4	− 30·2
20	+ 0·1	− 4	− 30·3
21	− 0·1	− 4	− 31·0
22	0·0	− 3	− 31·1
23	0·0	− 3	− 31·6
24	− 0·2	− 3	− 31·6
25	N.M.	− 3	N.M.
26	− 0·2	− 4	− 33·9
27*	− 0·3	− 2	− 33·8
28*	− 0·4	− 2	− 34·1
29*	− 0·4	− 2	− 34·2
30*	− 0·4	− 2	N.M.
31	− 0·4	− 2	− 35·3

The values were estimated on 1st June, 1952.

The transmitter employed for the 60-kc/s signal is sometimes required for another service.

N.M. = Not measured

* = No MSF transmission at 1029 G.M.T. Results for 1429-1530 G.M.T.

** = No MSF transmission at 1029 or 1429 G.M.T.

ABSTRACTS and REFERENCES

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research and published by arrangement with that Department.

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. U.D.C. numbers marked with a dagger (†) must be regarded as provisional. 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 it.

	PAGE A
Acoustics and Audio Frequencies	133
Aerials and Transmission Lines	135
Circuits and Circuit Elements	136
General Physics	139
Geophysical and Extraterrestrial Phenomena	140
Location and Aids to Navigation	142
Materials and Subsidiary Techniques	142
Mathematics	144
Measurements and Test Gear	144
Other Applications of Radio and Electronics	147
Propagation of Waves	148
Reception	148
Stations and Communication Systems	149
Subsidiary Apparatus	150
Television and Phototelegraphy	151
Transmission	152
Valves and Thermionics	152
Miscellaneous	154

ACOUSTICS AND AUDIO FREQUENCIES

016 : 534 1797

References to Contemporary Papers on Acoustics.—R. T. Beyer. (*J. acoust. Soc. Amer.*, Jan. 1952, Vol. 24, No. 1, pp. 92–97.) Continuation of 1487 of June.

534.213 : 621.395.623.75 1798

Exact and Approximate Equations for Wave Propagation in Acoustic Horns.—A. F. Stevenson. (*J. appl. Phys.*, Dec. 1951, Vol. 22, No. 12, pp. 1461–1463.) "Exact equations are given for the propagation of acoustic waves in horns of arbitrary shape. These equations are similar to, though simpler than, the equations previously found for electromagnetic horns [1841 below], and can be regarded as giving rise to an infinite number of coupled modes of propagation. If the coupling is neglected, the equation for the fundamental mode is the familiar one, but the theory also furnishes equations for the higher modes. The error involved in neglecting coupling is discussed."

534.232 1799

The Design of Optimum Directional Acoustic Arrays.—N. Davids, E. G. Thurston & R. E. Mueser. (*J. acoust. Soc. Amer.*, Jan. 1952, Vol. 24, No. 1, pp. 50–56.) Dolph's theory (2487 of 1946) for broadside aerial arrays is applied to the design of acoustic arrays with optimum directive properties. Tchebycheff polynomials are used to obtain the best possible relation between side-lobe level and main-beam width. Experimental results are shown in diagrams and confirm the theory.

534.232 1800

Directionality Patterns for Acoustic Radiation from a Source on a Rigid Cylinder.—D. T. Laird & H. Cohen. (*J. acoust. Soc. Amer.*, Jan. 1952, Vol. 24, No. 1, pp. 46–49.) Morse's theory (1575 of 1949) of radiation from an infinitely long strip vibrating on the side of a rigid cylinder is extended to apply to a finite source such as a rectangular strip.

534.232 : 538.652 1801

Ferrite [magnetostrictive] **Oscillators.**—K. Sixtus. (*Frequenz*, Nov./Dec. 1951, Vol. 5, Nos. 11/12, pp. 335–339.) The temperature coefficient for the resonance frequency and the Q value of ferrite-cored magnetostriction oscillators are determined from results of impedance measurements. Equivalent-circuit elements are evaluated. Properties and applications are discussed.

534.232 : 538.652 : 621.3.012.8 1802

The Equivalent Circuit of the Ferro-Magnetostrictive Transducer.—H. Schönfeld. (*Frequenz*, Nov./Dec. 1951, Vol. 5, Nos. 11/12, pp. 331–334.) The equivalent circuit is derived by analysis based on the change in length with magnetization, and the variation of the magnetization curve with tensile stress. At frequencies near natural resonance it comprises the coil inductance in parallel with a series resonant circuit.

534.26 + 535.43 1803

Multiple Scattering of Radiation by an Arbitrary Configuration of Parallel Cylinders.—V. Twersky. (*J. acoust. Soc. Amer.*, Jan. 1952, Vol. 24, No. 1, pp. 42–46.) "A formal solution in terms of cylindrical wave functions is obtained for the scattering of a plane acoustic or electromagnetic wave by an arbitrary configuration of parallel cylinders, which takes into account all possible contributions to the excitation of a particular cylinder by the radiation scattered by the remaining cylinders."

534.321.9 : 532.528 1804

Cavitation produced by Ultrasonics: Theoretical Conditions for the Onset of Cavitation.—E. A. Neppiras & B. E. Noltingk. (*Proc. phys. Soc.*, 1st Dec. 1951, Vol. 64, No. 384B, pp. 1032–1038.) Theoretical investigation indicates that cavitation is restricted to a definite range of variations of alternating-pressure amplitude, pressure-wave frequency, radius of bubble nucleus, and hydrostatic pressure.

534.321.9 : 534.22 : 538.69 1805

Effect of a Magnetic Field on the Propagation of Sound Waves in a Ferromagnetic Material.—J. de Klerk. (*Nature, Lond.*, 1st Dec. 1951, Vol. 168, No. 4283, pp. 963–964.) Transverse or longitudinal magnetic fields applied to a rod of ferromagnetic material cause a decrease in the attenuation of longitudinal ultrasonic waves, a minimum value being attained at magnetic saturation. Graphs of attenuation against magnetic-field strength are given for Ni and Fe-Ni using a frequency of 2·5 Mc/s.

534.321.9 : 534.373-14 **1806**

An Anomalous Effect in the Ultrasonic Absorption of Electrolytic Solution.—R. E. Barrett & R. T. Beyer. (*Phys. Rev.*, 1st Dec. 1951, Vol. 84, No. 5, pp. 1060–1061.) Absorption measurements were made on aqueous solutions of sodium acetate in the frequency range 9–45 Mc/s. The results indicate that the absorption coefficient cannot be assumed to be the sum of the coefficients for solvent and solute considered separately.

534.321.9 : 534.511.1 **1807**

A Precise Recording Ultrasonic Interferometer and its Application to Dispersion Tests in Liquids.—R. Barthel & A. W. Nolle. (*J. acoust. Soc. Amer.*, Jan. 1952, Vol. 24, No. 1, pp. 8–15.)

534.321.9 : 534.511.1 **1808**

On the Theory of the Fixed-Path Acoustic Interferometer.—F. E. Borgnis. (*J. acoust. Soc. Amer.*, Jan. 1952, Vol. 24, No. 1, pp. 19–21.) A general expression is given for the electrical input impedance of the acoustic interferometer. From this expression formulae are derived for determining the velocity of sound by a frequency variation method, or for determining changes in velocity due to variations of pressure, temperature, etc.

534.321.9 : 534.511.1 **1809**

A Recording Ultrasonic Interferometer and its Alignment.—J. L. Stewart & E. S. Stewart. (*J. acoust. Soc. Amer.*, Jan. 1952, Vol. 24, No. 1, pp. 22–26.)

534.321.9 : 535.37 **1810**

The Application of Phosphorescent Materials in the Detection of Ultrasonic Waves.—L. Pétermann. (*Helv. phys. Acta*, 31st Dec. 1951, Vol. 24, No. 6, pp. 596–599. In French.) 1951 Société Suisse de Physique Lucerne Meeting paper.

534.321.9-14 : 534.22 **1811**

Ultrasonic Propagation in Liquids under High Pressures: Velocity Measurements on Water.—G. Holton. (*J. appl. Phys.*, Dec. 1951, Vol. 22, No. 12, pp. 1407–1413.) Values are given for the velocity of 15-Mc/s waves in water at 30° and 50°C as a function of pressure to about 6 000 atm. Information on the temperature coefficient of the velocity and on the ratio of specific heats at increasing pressures is derived.

534.373-14 **1812**

Attenuation of Sound in Water containing Air Bubbles.—D. T. Laird & P. M. Kendig. (*J. acoust. Soc. Amer.*, Jan. 1952, Vol. 24, No. 1, pp. 29–32.) The bubbles were produced by forcing air through the cloth covering of four metal trays lying on the bottom of a lake. The attenuation of sound was found to be very large at frequencies coincident with bubble resonance frequencies, and much less at other frequencies, indicating that bubble resonance is the principal phenomenon concerned.

534.43 : 534.372 **1813**

The Application of Damping to Phonograph Reproducer Arms.—W. S. Bachman. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 133–137.) 1951 I.R.E. National Convention paper.

534.6 : 621.395.623 **1814**

Experimental Comparison between the Average Human Ear and some Artificial Ears.—P. Schiaffino. (*Poste e Telecomunicazioni*, Dec. 1951, Vol. 19, No. 12, pp. 567–570.) The results of tests on British, Swiss, Italian and American artificial ears and on the average human ear, using six different types of telephone receiver, are presented in graphs of acoustic pressure, referred to a level of 1 dyne/cm^2 for 0·1 mA current, against frequency.

534.76 : 534.861 **1815**

Information Theory. Elements of Space Information in Microphone-Transmission Systems.—A. Moles. (*C. R. Acad. Sci., Paris*, 19th Dec. 1951, Vol. 233, No. 25, pp. 1583–1585.) Stereophonic transmission is considered; the element of space information is defined as the smallest displacement of the sound source perceptible by the listener. Experiments using three distinct microphone channels indicate that this element is of the order 1–2 m for an ordinary broadcasting studio. The number of elements of space information to be transmitted is thus small compared with the number of elements of sound information proper; hence instead of using separate channels, the space information can conveniently be transmitted as an infrasonic signal via the main sound channel.

534.833 **1816**

The Problem of Noise Abatement in the Offices of the Administration francaise des P.T.T.—P. Chavasse & R. Lehmann. (*Ann. Télécommun.*, Dec. 1951, Vol. 6, No. 12, pp. 381–396.) Causes of noise, and methods of reducing it, are considered from both the theoretical and the practical points of view, with details of work actually carried out on walls, floors, etc.

534.844.1 **1817**

Equipment for Acoustic Measurements: Part 4 — The Direct Measurement of Reverberation Time.—C. G. Mayo & D. G. Beadle. (*Electronic Engng*, Dec. 1951, Vol. 23 No. 286, pp. 462–465.) A description is given, with detailed circuit diagrams, of (*a*) a logarithmic amplifier, (*b*) a decay calibrator and noise generator. A special scale enables reverberation times to be read directly from the decay curve displayed on a c.r.o. Part 1: 946 of April. Part 2: 1382 of May. Part 3: 1681 of June.

534.845 **1818**

The Theory of Sound Absorptive Materials.—C. M. Harris & C. T. Molloy. (*J. acoust. Soc. Amer.*, Jan. 1952, Vol. 24, No. 1, pp. 1–7.) Review of modern theories and discussion of the relation between the absorption coefficient and acoustic impedance.

621.395.61 : 546.431.824-31 **1819**

The Frequency Response of Barium Titanate Transducers.—T. F. Hueter & E. Dozois. (*J. acoust. Soc. Amer.*, Jan. 1952, Vol. 24, No. 1, pp. 85–86.) The frequency response curves of a large number of $BaTiO_3$ ceramic transducers resonant at frequencies from 0·5 to 3 Mc/s, operated in the thickness mode into a water load, consistently show one subsidiary peak (in some cases two) at a frequency slightly higher than the main resonance, the frequency ratio being near 1·05. All the available evidence indicates that the side peak is excited because of incomplete alignment of the domains in polarized $BaTiO_3$. Domains inclined to the direction of the driving field excite a symmetrical shear mode that has a thickness component.

621.395.623.7 : 621.395.42 **1820**

Acoustic Problems in Intercommunication Systems.—H. Gemperle. (*Radio Tech., Vienna*, Dec. 1951, Vol. 27, No. 12, pp. 522–524.) The response characteristics of a 9-cm loudspeaker (*a*) without baffle, (*b*) fitted in a cabinet with cotton-wool damping, are shown when used for sound output and when used as a microphone. The overall characteristic of an intercommunication system obtained by combination of the two curves shows for (*a*) a resonance peak near 200 c/s, and for (*b*) undesirable accentuation of the middle frequencies.

621.395.623.8 **1821**

Sound Reinforcement and Production for Royal Festival Hall.—J. L. Goodwin. (*Elect. Commun.*, Dec. 1951, Vol. 28, No. 4, pp. 243–250.) An outline description of the system installed for reinforcing the voice of a speaker, for distributing programmes relayed from outside the hall and for similar purposes. The ancillary arrangements for deaf-aids and announcing are also reviewed. Two pairs of loudspeakers mounted on the orchestra canopy and two supplementary ones behind the platform are fed by two separate amplifier chains, thus permitting stereophonic reproduction when required. At the inputs to the amplifiers are two six-channel fader units which in turn are fed from any desired jacks in the 20-position field to which the incoming circuits are brought. Suitable low-level switching arrangements permit considerable flexibility of operation: the control console is situated within the auditorium. The deaf-aid jacks, which are associated with 15% of the seats, are supplied through amplifiers from the output circuit of the system described above and also from a separate microphone suspended over the orchestra. An independent announcing system includes arrangements for playing gramophone records and for radiating a musical interval tone, the latter replacing the usual bells in refreshment rooms and foyers.

621.395.623.8 **1822**

Note on [sound-] Radiator-Array Technique.—S. Sawade. (*Elektrotech Z.*, 15th Dec. 1951, Vol. 72, No. 24, p. 720.) Radiation patterns for 1 kc/s and 6 kc/s are given to illustrate how the characteristics of modern cone loudspeakers have made the use of loudspeaker arrays practicable for public address work.

621.395.625.3 **1823**

A Tape Editing and Duplicating Machine.—R. P. Ledbetter. (*Audio Engng*, Dec. 1951, Vol. 35, No. 12, pp. 18–20 . . 45.) A 4-unit rack-mounted equipment with separate amplification and equalization for the play-back, duplicating and cueing operations.

621.395.625.3 : 621.317.35 **1824**

Boundary-Displacement Magnetic Recording.—Daniels. (See 1963.)

AERIALS AND TRANSMISSION LINES

621.315.052.63 : 621.396.44.018.8 **1825**

The Attenuation of Carrier-Frequency Waves on Lines due to Hoar Frost.—A. de Quervain. (*Bull. schweiz. elektrotech. Ver.*, 1st Dec. 1951, Vol. 42, No. 24, pp. 949–953. In German.) Measurements were made over a period of several years on the 1 400-m high-voltage line between Schwägalp and Säntis, using carrier frequencies of 50 and 130 kc/s. Results are discussed in relation to the nature and thickness of the frost layer, and are compared with calculated and measured values found previously. Attenuation is attributed to dielectric losses in the frost layer; it increases with frequency.

621.315.21 **1826**

Plastic-Insulated Land Communication Cables.—A. L. Meyers. (*J. Brit. Instn Radio Engrs*, Dec. 1951, Vol. 11, No. 12, pp. 556–560. Discussion, p. 560.) A description of multiquad cables insulated and sheathed with Telcothene and of a new air-spaced coaxial cable in which the spacer is a helical membrane of Telcothene and the outer conductor a seamless aluminium tube. An account is given of jointing methods, and features of the cable in operation are considered.

621.315.212 : [621.392.43 + 621.314.25 **1827**

Balancing and Transformation with Coaxial Lines.—A. Ruhrmann. (*Telefunken Ztg*, Dec. 1951, Vol. 24, No. 93, pp. 237–250.) A comprehensive review of methods and equipment suitable for short and very short waves. 29 references.

621.392 : 621.317.34 **1828**

The Measurement of Image Impedance and Image Attenuation Coefficient.—Guenot. (See 1961.)

621.392.2 + 621.385.029.63/.64 **1829**

Slow Electromagnetic Waves.—A. I. Akhiezer & Ya. B. Faynberg. (*Uspekhi fiz. Nauk*, July 1951, Vol. 44, No. 3, pp. 321–368.) A mathematical discussion is presented on various methods for obtaining electromagnetic waves with phase velocity lower than that of light in vacuo. In the methods reviewed use is made of (*a*) waveguides partly filled with dielectric, (*b*) periodic structures such as chains of cavity resonators, and (*c*) helical transmission lines. The interaction between the slow waves and charged particles, which is of importance in the generation and amplification of u.h.f. oscillations, is discussed and general laws governing these processes are derived.

621.392.22 : 517.512.2 **1830**

Fourier Transforms in the Theory of Inhomogeneous Transmission Lines.—F. Bolinder. (*Acta polyt., Stockholm*, 1951, No. 88, 84 pp.) Reprint. See 2909 of 1951.

621.392.26 **1831**

Waves on Inhomogeneous Cylindrical Structures.—R. B. Adler. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 339–348.) Analysis of some of the basic properties of exponential modes on passive cylindrical structures whose physical and electrical properties vary over the cross-section.

621.392.26 **1832**

The Problem of the Elimination of Reflections in Waveguides with Varying Cross-Section.—B. L. Rozhdestvenski & D. N. Chetaev. (*C. R. Acad. Sci. U.R.S.S.*, 21st July 1951, Vol. 79, No. 3, pp. 427–430. In Russian.) It is proved mathematically that reflections in a rectangular waveguide with varying cross-section can be eliminated if the waveguide is filled with a nonuniform medium the characteristics of which are related in a definite manner to the shape. As an example, the case of a waveguide bent at an angle (Fig. 2) is discussed. The conclusions reached remain fundamentally valid for dielectrics with finite conductivity. Complete elimination of reflections is possible only with an ideal medium with continuously graded characteristics, but it can be closely approached by a medium with discrete nonuniformity.

621.392.26 **1833**

The Short-Slot Hybrid Junction.—H. J. Riblet. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 180–184.) Theory and description of an X-band junction with outputs in phase quadrature, suitable for use in the construction of balanced duplexers and mixers. Over the frequency range 8·5–9·6 kMc/s, power equality within ± 0·25 db, isolation in excess of 30 db, and a s.w.r. $< 1{\cdot}07$ are obtainable.

621.392.26 : 621.392.52 **1834**

Tunable Waveguide Filters.—W. Sichak & H. A. Augenblick. (*Elect. Commun.*, March 1952, Vol. 29, No. 1, pp. 65–70.) Reprint. See 353 of February.

621.392.26 : 621.396.677 : 621.317.336.1 **1835**

Mutual Coupling of a Slot with a Dipole Antenna.—W. J. Surtees. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 208–211.) "A parameter is defined from which may be obtained the mutual coupling between a radiating slot, cut in a plane perfectly-conducting sheet, and a dipole fed at its base on the conducting plane. Using a slot cut in a sheet of copper and fed by a waveguide, experimental values of this parameter were obtained for various positions of the dipole relative to the slot. These values are plotted and compared with the theoretical ones, very good agreement being obtained."

621.392.26.012.3 **1836**

Square Wave-Guide Attenuation.—(*Radio & Televis. News, Radio-Electronic Engng Section*, Dec. 1951, Vol. 46, No. 6, p. 32.) An abac enabling the attenuation of the $TM_{1,1}$ mode in a waveguide with square cross-section to be calculated for various materials and waveguide dimensions.

621.392.43 **1837**

A Method of Matching Balanced Transmitters to Unbalanced Transmission Lines by means of Lumped Reactances.—F. Moyano Reina. (*Rev. Telecomunicación, Madrid*, Dec. 1951, Vol. 6, No. 26, pp. 2–4.) Design formulae are derived for the elements of a matching unit from consideration of its equivalent T network.

621.396.67 **1838**

Aerials at the Langenberg/Rhld High-Power Broadcasting Station, 1926–1951.—A. Wurbs. (*Fernmeldetech. Z.*, Dec. 1951, Vol. 4, No. 12, pp. 525–530.) An account of the different wooden and steel mast and tower types erected during the 25-year period of operation of this station, finishing with descriptions of two modern u.s.w. aerials.

621.396.67.011.21 **1839**

The Input Impedances of Slit Antennas.—S. Uda & Y. Mushiake. (*Technol. Rep. Tohoku Univ.*, 1949, Vol. 14, No. 1, pp. 46–59.) The equations giving the input impedance are derived in terms of the electric and magnetic fields existing in complementary plates and slots, without using the concept of radiated power. The method can be applied to slot aerials of any length and of arbitrary shape.

621.396.67.029.63 : 621.397.6 **1840**

Receiving Antennas for U.H.F. Television.—E. O. Johnson & J. D. Callaghan. (*Tele-Tech*, Dec. 1951, Vol. 10, No. 12, pp. 38–41 . . 82.) A review of the results of field tests carried out in the last three years near Washington, D.C., and Bridgeport, Conn. Types considered are (*a*) single and stacked fan dipoles, (*b*) single and stacked rhombic aerials, (*c*) stacked V aerials, (*d*) sheet, parabolic, and corner reflectors, (*e*) Yagi arrays. The performance of each type is analysed as regards gain, directivity and bandwidth, with indication of suitable field of application.

621.396.677 **1841**

General Theory of Electromagnetic Horns.—A. F. Stevenson. (*J. appl. Phys.*, Dec. 1951, Vol. 22, No. 12, pp. 1447–1460.) The propagation of electromagnetic waves in a conducting horn of arbitrary shape is described exactly by an infinite set of linear differential equations, which represent a system of coupled E and H waves. By neglecting the coupling, only one equation is required to describe each E and H wave. The equations may then be solved approximately, and lead to the distinction between transmission regions and attenuation regions found by Barrow & Chu (1446 of 1939). The error caused by neglecting the coupling is examined. A detailed study is made of the propagation characteristics of several special shapes of horn.

621.396.677 **1842**

Radiation Patterns and Conductance of Slotted-Cylinder Antennas.—O. C. Haycock & F. L. Wiley. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 349–352.) "A theoretical solution to the radiation patterns and conductance is obtained by solving Maxwell's equations for the fields in the far zone, and requiring them to satisfy the known boundary conditions at the surface of the cylinder."

621.392.2 **1843**

Einführung in die Theorie der Ausbreitung elektromagnetischer Wellen in Leitungen und Hohlkabeln (Introduction to the Theory of the Propagation of Electromagnetic Waves in Transmission Lines and Waveguides). [Book Review]—H. Bomke & J. Gefahrt. Publishers: Wissenschaftliche Verlagsanstalt, Stuttgart, 1950, 163 pp., 21.50 DM. (*Arch. elekt. Übertragung*, Nov. 1951, Vol. 5, No. 11, p. 530.) A clear mathematical presentation of the subject, developed from Maxwell's field equations.

621.396.67 : [621.397.6 + 621.396.619.13 **1844**

Television and F.M. Antenna Guide. [Book Review]—E. M. Noll & M. Mandl. Publishers: Macmillan, New York and London, 1951, 311 pp., 41s.(*Electronic Engng*, March 1952, Vol. 24, No. 289, p. 139.) "Should be of great value to anyone interested in or working with v.h.f. aerials."

CIRCUITS AND CIRCUIT ELEMENTS

537.312.6 : 621.315.59 **1845**

Conductivity of Electronic Semiconductors and Thermistors.—N'Guyen Thien-Chi & J. Suchet. (*Onde élect.*, Dec. 1951, Vol. 31, No. 297, pp. 473–489.) A description of the electronic structure and conduction mechanism of semiconductors, together with a detailed review of commercial types of thermistor, their properties and applications. See also 44 of 1951, 165 and 199 of January.

621.3.015.7 : 621.387.4 **1846**

A Pulse-Height Distribution Analyzer.—W. E. Glenn. (*Nucleonics*, Dec. 1951, Vol. 9, No. 6, pp. 24–28.) This 20-channel unit has a Du Mont Type K1059 c.r. tube with 10 collecting electrodes for pulse sorting. It has been used with a scintillation counter and an ionization chamber, and may be adapted for coincidence pulse analysis and the measurement of very short half-lives of radioactive materials.

621.314.2 **1847**

R.F. Current Transformers.—T. J. Douma. (*Electronics*, April 1952, Vol. 25, No. 4, pp. 156 . . 174.) An account of experiments indicating that if precautions are taken to suppress transformer-coil resonances, a rectifier type of instrument reading to 100 mA can be constructed for the frequency range 10 kc/s–50 Mc/s.

621.314.25 **1848**

An Analysis of the Split-Load Phase Inverter.—G. E. Jones, Jr. (*Audio Engng*, Dec. 1951, Vol. 35, No. 12, pp. 16 . . 41.) Mathematical theory. When the inverter has substantially equal load impedances and is driven at a relatively low level, the h.f. response is about equal to that of a cathode follower.

621.314.3† **1849**

Some Aspects of Magnetic-Amplifier Technique.—F. E. Butcher & R. Willheim. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 261–270.) Principles are described for the design of precision d.c. to d.c. magnetic amplifiers adaptable to a wide range of input impedance and output requirements. Graphical methods for design of the circuit elements and for predicting the performance of the assembly are set out and applied to push-pull amplifiers. Performance limits imposed by zero stability and response time are reviewed and estimated.

621.316.726.078.3 : 538.569.4.029.64 **1850**

Frequency Stabilization by Microwave Absorption.—H. R. L. Lamont. (*Physica*, March/April 1951, Vol. 17, Nos. 3/4, pp. 446–452.) Description of the method used for stabilization at wavelengths near 1·25 cm by means of NH_3 absorption lines, and discussion of possibilities for mm waves.

621.316.86 : 621.316.723.2 **1851**

Electronically Controllable Resistors.—J. N. Thurston. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, p. 315.) The bias current, and hence the dynamic resistance of a nonlinear resistor such as SiC or Ge, is controlled by a thermionic valve. The volt/ampere characteristic can be controlled by additional series and parallel linear resistors.

621.318.563 **1852**

Ferroresonant Flip-Flops.—C. Isborn. (*Electronics*, April 1952, Vol. 25, No. 4, pp. 121–123.) A low-resistance circuit comprising a capacitor and an iron-cored inductor has, with a suitably chosen operating voltage, two possible stable states, one characterized by low current and high inductive reactance, the other by high current and low capacitive reactance. Such a circuit can be triggered by application of a d.c. pulse. A combination of two of these circuits is described which has two inputs and two outputs, one output always being in antiphase to the other. This is well adapted to parallel-gated binary-counting systems, since each element is capable of considerable power gain. The complete circuit is given of a two-stage arrangement for binary operation and also an outline description of a decade unit using no valves, nonlinear thyrite resistors replacing the usual diodes.

621.319.4 + 621.385.032.213.2] : 621.771.3 **1853**

The Wire Capacitor and other Composite Drawn Products.—J. L. H. Jonker & P. W. Haaijman. (*Philips tech. Rev.*, Dec. 1951, Vol. 13, No. 6, pp. 145–151.) The wire capacitor is produced from a metal tube 20 cm long with outer diameter 20 mm and wall thickness 2 mm. A wire core 8 mm thick is centred in the tube and the annular space tightly packed with insulating powder. The whole is then hammered and drawn out to a wire about 40 m in length and less than 1 mm in diameter, which is cut into lengths each having a capacitance of about 100 pF. Two methods of removing one end of the jacket and insulation prior to soldering on the core lead are described. Suitable choice of insulating material and dimensions keeps the temperature dependence low, while dielectric loss fluctuation is minimized by aging. Application of these capacitors in i.f. transformers has enabled transformer units to be produced with dimensions of 60 mm × 27 mm diameter and 36 mm × 25 mm × 10 mm respectively. The drawing process has further been applied in the manufacture of indirectly heated cathodes.

621.392.016.2 **1854**

A Critical Study of the Circuit Concept.—J. G. Chaney. (*J. appl. Phys.*, Dec. 1951, Vol. 22, No. 12, pp. 1429–1436.) From Maxwell's equations, an expression for the complex power associated with a wire circuit is formulated and resolved into an input power and a power into the external field. The internal and external impedances of the circuit are obtained for unspecified current distributions. This concept is extended to coupled circuits and the application to circuits with lumped elements is shown.

621.392.43 **1855**

Shorted Stubs of High Resonant Impedance.—J. M. Diamond. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 188–189.) Curves are developed from which the parameters of a coaxial or twin-line shorted stub of maximum resonance impedance can be determined, given the operating frequency, overall dimension, and the lumped-capacitance load at the open end.

621.392.43 **1856**

A Method of Matching Balanced Transmitters to Unbalanced Transmission Lines by means of Lumped Reactances.—Moyano Reina. (See 1837.)

621.392.43 : 621.396.645 **1857**

How to Design R.F. Coupling Circuits.—W. B. Bruene. (*Electronics*, May 1952, Vol. 25, No. 5, pp. 134–139.) Charts and practical rules are given which simplify the problem of selecting a suitable circuit for coupling an amplifier to an aerial, transmission line, or other load, resistive or complex, and determining the values of the components of the coupling circuit. Examples illustrate the design of L, T, Π and Π-L coupling units.

621.392.5 **1858**

Maxwell's Reciprocity Law and Thévenin's Theorem applied to the Study of the Passive Quadripole.—H. Thompson. (*Rev. gén. Élect.*, Dec 1951, Vol. 60, No. 12, pp. 516–520.) From Maxwell's reciprocity law, Thévenin's theorem and the principle of superposition, three equations relating the six characteristic parameters of the passive quadripole are formulated. Starting from one of these equations the construction of the circle diagram is explained and the significance of the different vectors in the diagram pointed out. The cases of the transformer and the asynchronous motor are also examined.

621.392.5.011.21 **1859**

The Impedance of a Network.—J. Thouzéry. (*Radio franç.*, Dec. 1951, No. 12, pp. 1–5.) Application of tensor analysis in determination of the impedance of a complex network gives results in a useful form. The method is based on the introduction of a number of new variables equal to the number of closed loops in the network, and transformation of the corresponding matrix into one of lower order. The procedure is applied to Wheatstone's bridge and to a double-T filter. See also 2670 of 1951.

621.392.5.018.782.4† **1860**

The Effect of Delay Distortion on Waveform Fidelity in the Transmission of Signals.—G. Schaffstein. (*Frequenz*, Nov./Dec. 1951, Vol. 5, Nos. 11/12, pp. 328–331.) Extension of the frequency range towards higher frequencies to improve the transmission quality of a wide-band system is only effective if the phase errors caused by delay distortion at these frequencies are $< 180°$. A brief analysis is made of the effects of delay distortion on (*a*) the ripple amplitude of square pulses, (*b*) triangular pulses, and (*c*) step voltages.

621.392.5.092 **1861**

Cascade Connection of 90-Degree Phase-Shift Networks.—O. G. Villard, Jr. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 334–337.) A method applicable to a.f. networks for use in selective-sideband transmission and reception. Three networks are needed to obtain twice the rejection (in db) of a single circuit.

621.392.52 **1862**

Proposed Revision of the Conventional Method of Wave-Filter Design.—P. J. Selgin. (*Bur. Stand. J. Res.*, Dec. 1951, Vol. 47, No. 6, pp. 479–490.) The revision consists of introducing new parameters termed 'frequency numbers' (n), which permit the design to be made from specification of peak and cut-off attenuation rather than the idealized cut-off frequency as in the conventional method. The ratio of the impedances Z_s and Z_p of the component half-sections is expressed in terms of appropriately chosen values of n for high-pass, low-pass and symmetrical band-pass filters. The calculation of the maximum permissible dissipation factor of terminating half-sections and of the filter elements is described and illustrated.

621.392.52 : 621.314.2 **1863**

Tuned Transformers and Filters of Maximum Bandwidth.—G. Rutelli. (*Alta Frequenza*, Feb. 1950, Vol. 19, No. 1, pp. 26–49.) Theory is developed for the filter properties of tuned-circuit transformers having minimum attenuation for a given bandwidth or maximum bandwidth for a given attenuation. Design curves are given, whose use is explained by numerical examples.

621.392.52.029.4 **1864**

The Heterodyne Filter.—G. Fant. (*Kungl. tekn. Högsk. Handl., Stockholm*, 1952, No. 55, 78 pp.) A heterodyne filter for the speech-frequency range is described. It can be used as a band-pass filter with continuously variable low-frequency cut-off and high-frequency cut-off chosen independently in the frequency range 40–4 000 c/s. The attenuation outside the pass band is >60 db and the steepness of the cut-off slopes is 1 db per 1 c/s deviation. Bandwidth and low-frequency cut-off are varied by two separate controls. A band-stop filter can also be obtained, with variable mid-frequency of the suppressed band but with bandwidths restricted to two alternative values, 300 c/s and 800 c/s. The filter is designed for articulation and hearing tests, and also as a wave analyser of bandwidth continuously variable from 45 to 4 000 c/s in the frequency range 40–20 000 c/s.

621.396.6 : 621.317.7 **1865**

Components for Instruments.—R. E. Hall & E. Coop. (*Proc. Instn elect. Engrs*, Part II, Dec. 1951, Vol. 98, No. 66, pp. 738–752. Discussion, pp. 753–759.) Valves, resistors and capacitors (both fixed and variable), transformers and chokes, meters, and quartz-crystal units are considered. A precision variable capacitor which can be made to extremely fine limits on a production basis is described. Details are given of the shortcomings and failures of some present-day components and of the effort to overcome them by using new materials, processes, methods of manufacture and by improved design. 21 references.

621.396.611.4 **1866**

Mode Conversion Losses in a TE$_{01}$-Type Cavity Resonator with Tilted End-Plate.—K. Shimoda. (*J. phys. Soc. Japan*, Sept./Oct. 1951, Vol. 6, No. 5, pp. 378–383.) The reduction in *Q* value due to the tilting of the end-plate is deduced theoretically. In experiments with a copper resonator at 3 kMc/s, the *Q* value was halved by a tilt of about ¼ degree, in good agreement with a calculated value.

621.396.615 **1867**

Theory of RC and RL Oscillators.—A. Blaquière. (*C. R. Acad. Sci., Paris*, 3rd Dec. 1951, Vol. 233, No. 23, pp. 1434–1436.) Expressions for the stabilized amplitude are derived from theory previously given (335 of February), and are in satisfactory agreement with results obtained by other methods.

621.396.615 : 621.316.729 **1868**

On Synchronization of LC Oscillators.—J. van Slooten. (*Electronic Applic. Bull.*, June/July 1951, Vol. 12, Nos. 6/7, pp. 105–110.) Analysis of this problem has previously been based on the solution of a nonlinear differential equation. A simple method of calculation is shown to be possible if the oscillations produced are assumed to be nearly sinusoidal. The treatment gives a clear explanation of the way in which synchronization is effected by a series of pulses or by a signal of arbitrary waveform. The representation is similar to that of the synchronization of a multivibrator or a blocking oscillator.

621.396.615.018.424† **1869**

Seven-League Oscillator.—F. B. Anderson. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, p. 328.) Corrections to paper abstracted in 81 of January.

621.396.615.11 **1870**

RC Oscillators.—D. J. H. Admiraal. (*Electronic Applic. Bull.*, June/July 1951, Vol. 12, Nos. 6/7, pp. 111–131.) General considerations include discussion of (*a*) calculation of the oscillator frequency, (*b*) phase shift in the amplifier, (*c*) the necessity of amplitude limitation, (*d*) loading of the amplifier output circuit by the filter. A detailed treatment of the RC oscillator with bridge input circuit is given. The phase-correcting action of the bridge is explained and two methods of limiting the oscillation amplitude are considered: (*a*) by means of an incandescent lamp, (*b*) by means of NTC (negative-temperature-coefficient) resistors. The relation between phase shift in the amplifier and the current through the NTC resistor is examined and the effect of the ambient temperature considered. A detailed description, with complete circuit diagram, is given of an oscillator using ganged wire-wound resistors for frequency adjustment and a NTC resistor for amplitude limiting. Temperature compensation is effected by including a NTC resistor in the voltage divider used to feed the power amplifier. A push-pull output can be obtained by operation of a switch. The output voltage is constant within 1% from 20 c/s to 20 kc/s.

621.396.615.17/.18 **1871**

Multivibrator Frequency Divider.—R. R. Rathbone & R. L. Best. (*Radio & Televis. News, Radio-Electronic Engng Section*, Dec. 1951, Vol. 46, No. 6, pp. 6–7, 29.) A unit using two multivibrators to cover the range 60 c/s–200 kc/s and having associated delay circuits and pulse generators. Two output pulses are available, one of 0·1-μs duration variable up to 25 V across a 93-Ω load, the other a trigger pulse variable up to −100 V and with a 5–100-μs delay time.

621.396.615.17 **1872**

Generation of Sawtooth Voltages by Transformation of Sinusoidal Voltages.—G. Francini. (*Alta Frequenza*, Feb. 1950, Vol. 19, No. 1, pp. 9–25.) Square pulses are first derived. These are applied to a RC or LC integrating circuit, the design of which is discussed. Voltages with symmetrical or asymmetrical triangular waveform of high precision may be obtained.

621.396.615.17.015.7 **1873**

2-Channel Rectangular-Pulse Generator.—T. D. Graybeal. (*Electronics*, April 1952, Vol. 25, No. 4, pp. 141–143.) Description of a stimulator useful for studies in neuromuscular physiology. Pulse recurrence frequencies are adjustable from 0·5 to 500/sec, pulse voltage from 0 to 80 V and duration from 25 μs to 7·5 ms.

621.396.619.27.018.78 **1874**

Cubic Distortion in the Ring Modulator.—L. Christiansen. (*Frequenz*, Nov./Dec. 1951, Vol. 5, Nos. 11/12, pp. 298–303.) Discussion of distortion occurring in the conducting and the blocking arms of a modulator using Ge rectifiers. Methods discussed for reducing this include the addition of resistance in the conducting arms, insertion of resistance in front of the modulator ring, division of the ring to form a push-pull circuit, and adjustment of the load resistance.

621.396.645 : 536.48 **1875**

The Possibility for using an Amplifier at Low Temperatures.—A. N. Gerritsen & F. van den Burg. (*Physica*, Oct. 1951, Vol. 17, No. 10, pp. 930–932.) The gain of a 3-valve amplifier using Type-DF65 triodes was measured at ambient temperatures of 290°, 77°, 20° and 14°K. At the two lowest temperatures the gain was only about a third of that at room temperature, the reduction being partly accounted for by capacitance variation. A suitable choice of temperature-dependent resistors and capacitors and the operating points of valves should enable a pentode amplifier to be constructed with a much higher gain at low temperatures.

621.396.645 : 621.396.822 **1876**

Noise Suppression in Triode Amplifiers.—A. van der Ziel. (*Canad. J. Technol.*, Dec. 1951, Vol. 29, No. 12, pp. 540–553.) An experimental verification of previous theoretical work (2751 of 1950). Measurements of the correlated and uncorrelated parts of the induced grid noise are presented; for 6J4 and 6AC7 valves only 30 to 40% of the induced grid noise is correlated with the valve noise itself. The noise factor of a grounded-grid circuit and that of a grounded-cathode circuit with tuned anode-grid capacitance and properly detuned input circuit are shown to be identical, as required by the theory.

621.396.645.35 **1877**

Driftless D.C. Amplifier.—F. R. Bradley & R. McCoy. (*Electronics*, April 1952, Vol. 25, No. 4, pp. 144–148.) Description, with detailed circuit diagrams, of the high-gain phase-inverting amplifiers used in the REAC analogue computer. Drift is counteracted by means of a chopper and auxiliary amplifier which provide continuous balancing. A 2-page table shows input and output networks for use with the amplifier to generate different transfer functions for summation in the computer.

621.396.645.35.087.6 **1878**

A Frequency-Compensated Direct-Coupled Amplifier for Use with a Four-Channel Pen Recorder.—J. A. Tanner & B. G. V. Harrington. (*J. sci. Instrum.*, Dec. 1951, Vol. 28, No. 12, p. 384.) Discussion on 1603 of 1951.

621.396.645.371 : 621.3.015.3 **1879**

The Transmission of the Step Function by the Negative-Feedback Amplifier.—J. Müller. (*Fernmeldetech. Z.*, Dec. 1951, Vol. 4, No. 12, pp. 547–551.) Advantages of the transient-response method over the steady-state-response method for investigating wide-band and television circuits are indicated; the transient-response method can provide direct information regarding the quality of the television picture. The effect on transient response of varying the degree of negative feedback is examined theoretically for simple circuits; results are shown graphically. For more complex feedback arrangements the effect is investigated experimentally using an oscillographic method with a square-wave generator (209 of January).

GENERAL PHYSICS

530.145.61 : 535.37 **1880**

Attempts to apply Wave Mechanics in [the theory of] **Phosphorescence.**—D. Curie. (*J. Phys. Radium*, Dec. 1951, Vol. 12, No. 10, pp. 920–929.)

534.014.5 **1881**

Studies in Nonlinear-Vibration Theory.—S. Fifer. (*J. appl. Phys.*, Dec. 1951, Vol. 22, No. 12, pp. 1421–1428.) The stability of periodic solutions of the Duffing and van der Pol equations is determined. Application is made to the forced oscillations of a triode oscillator with a fifth-order valve characteristic.

535.37 : 539.2 **1882**

Transfer and Transport of Energy by Resonance Processes in Luminescent Solids.—T. P. J. Botden. (*Philips Res. Rep.*, Dec. 1951, Vol. 6, No. 6, pp. 425–473.)

535.42 **1883**

Diffraction of Light by a Semi-transparent Sheet.—F. B. Pidduck. (*Quart. J. Math.*, Dec. 1951, Vol. 2, No. 8, pp. 316–320.) The perfected Fresnel-zone theory for the cases of a thin disk and a straight edge is developed, with discussion of the assumptions made and the effect of the approximations involved. The field in which the theory may be applied excludes large angles of diffraction and small apertures, such as those of gratings.

535.43 + 534.26 **1884**

Multiple Scattering of Radiation by an Arbitrary Configuration of Parallel Cylinders.—Twersky. (See 1803.)

537.221 **1885**

The Volta Effect.—R. Bourion. (*J. Phys. Radium*, Dec. 1951, Vol. 12, No. 10, pp. 930–941.) The origin of contact potential differences is discussed, various measurement techniques recently used are described, and results obtained on metals and semiconductors are summarized and discussed in relation to the experimental conditions. The influence of surface structure, connected with the anisotropy of the work function for single crystals, is also considered.

537.315 : 539.23 **1886**

Contact-Potential Variations on Freshly Condensed Metal Films at Low Pressures.—L. L. Antes & N. Hackerman. (*J. appl. Phys.*, Dec. 1951, Vol. 22, No. 12, pp. 1395–1398.) Curves showing the variation with time of the contact potentials of films of Al, Cu, Au, Ni, Fe, Cr are shown for different pressures, Pt serving as reference standard. Resistance measurements are correlated with the potential measurements.

537.52 **1887**

Theoretical and Experimental Research on the Excitation of Gases by Ultra-High Frequencies.—M. Bayet. (*Rev. sci., Paris*, Nov./Dec. 1951, Vol. 89, No. 3314, pp. 351–394.) A comprehensive treatment. Tests with short-duration 600-Mc/s pulses show an increase in the recombination coefficient of positive ions and electrons when the electron velocity decreases on suppression of the excitation. 79 references.

537.523.4 : 535.89 **1888**

A Repetitive Spark Source for Shadow and Schlieren Photography.—G. K. Adams. (*J. sci. Instrum.*, Dec. 1951, Vol. 28, No. 12, pp. 379–384.) Description of two methods of producing sparks of high brightness and short duration at high repetition frequencies. The first method gives a limited number of discharges (4–8) at individually determined time intervals of 10 μs or more with an error $< 1\,\mu$s. The second method, used with a rotating-drum or -mirror camera, gives a greater number of light pulses at preset repetition frequencies up to 10 000/sec. The energy of each spark is of the order of 1 joule, and the effective photographic duration $< 1\,\mu$s.

537.525 **1889**

Self-Magnetic Field in High-Current Discharges.—M. Blackman. (*Proc. phys. Soc.*, 1st Dec. 1951, Vol. 64, No. 384B, pp. 1039–1045.) Theory is developed for the case of a nonconducting envelope. Comparison with the theory of Thonemann & Cowhig (2146 of 1951) shows good agreement.

537.525.6 **1890**

Behavior of Gas-Discharge Plasma in High-Frequency Electromagnetic Fields.—L. Goldstein & N. L. Cohen. (*Elect. Commun.*, Dec. 1951, Vol. 28, No. 4, pp. 305–321.) Studies were made of the complex conductivity of the gas-discharge plasma situated in a h.f. e.m. field. Measurements were also made of the noise produced by the discharge and of the transmission characteristics when the discharge was pulsed. For the experiments in the frequency band 1 500–2 300 Mc/s, the monatomic rare gases were used, the discharge tube being arranged as part of a coaxial-line circuit. In supplementary measurements on phase velocity, made at a frequency of 9 450 Mc/s, the discharge was set up in a waveguide. Experimental results are given in some detail.

537.525.6 : 538.56 **1891**

Current Fluctuations in the Direct-Current Gas Discharge Plasma.—P. Parzen & L. Goldstein. (*Elect. Commun.*, March 1952, Vol. 29, No. 1, pp. 71–74.) Reprint. See 2974 of 1951.

537.582 **1892**

Some Remarks on the Equation of Thermionic Emission.—Y. Watanabe. (*Technol. Rep. Tohoku Univ.*, 1949, Vol. 14, No. 1, pp. 1–9.) Discussion of the Richardson and Nordheim emission equations, which are consistent if a different value of the apparent electron density is used in Richardson's equation.

538.312 : 621.318.423 : 513.647.1 **1893**

A General Theory of the Helical Line.—H. Kaden. (*Arch. elekt. Übertragung*, Dec. 1951, Vol. 5, No. 12, pp. 534–538.) Formulae are derived for the e.m. field and the transmission parameters of a helical line for any values of operating frequency and pitch of the helix. The characteristic impedance is a measure of the energy transmitted in the axial direction; when plotted against pitch, for a given wavelength, it exhibits a minimum and approaches a constant value for very small values of pitch. Both delay time and attenuation increase monotonically with decreasing pitch.

538.56 : 537.2-7 **1894**

Radiation Capacity.—H. Weyl. (*Proc. nat. Acad. Sci., Wash.*, Dec. 1951, Vol. 37, No. 12, pp. 832–836.) The mathematical theory of capacitance in the electrostatic field is outlined and the extent of its applicability to the unquantized radiation field is discussed.

538.566.2 **1895**

Note on Cut-Off Frequency in Dielectric Plates.—H. Ott. (*Z. angew. Phys.*, Dec. 1951, Vol. 3, No. 12, pp. 456–458.) Using Fresnel's optics formulae it is possible to determine whether a lower cut-off frequency exists for the propagation of e.m. waves in a dielectric plate under given boundary conditions; a formula is derived for calculating this cut-off frequency. The question whether waves of unlimited length can be excited in the plate is discussed briefly as a separate issue.

538.569.4.029.65 **1896**

Microwave Spectroscopy in the Region from Two to Three Millimeters: Part 2.—C. M. Johnson, R. Trambarulo & W. Gordy. (*Phys. Rev.*, 15th Dec. 1951, Vol. 84, No. 6, pp. 1178–1180.) Report of results obtained by using the fourth and fifth harmonics of K-band klystrons. A list of all frequencies so far measured in the 2–3-mm range is included. See also 1668 of 1950 (Gilliam et al.) and *Phys. Rev.*, 1951, Vol. 83, p. 1061 (Anderson, Johnson & Gordy).

621.39.001.11 **1897**

Information Aspect of Some Uncertainty Relations.—R. Vallée. (*C. R. Acad. Sci., Paris*, 19th Dec. 1951, Vol. 233, No. 25, pp. 1580–1581.) An extension of the relation discussed by Gabor (1057 of 1947) between the uncertainty regarding the mean time of occurrence of a signal and the uncertainty regarding its mean frequency.

621.39.001.11 : 517.433 **1898**

'Observation Operators' and Information Theory.—R. Vallée. (*C. R. Acad. Sci., Paris*, 3rd Dec. 1951, Vol. 233, No. 23, pp. 1428–1430.) A general expression for the maximum quantity of information furnished by any experiment is derived, using the observation operators defined in 1570 of June. Among the particular cases to which this applies is Shannon's expression for maximum information content of a transmission channel.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.5 **1899**

The Velocity Distribution of Sporadic Meteors: Part 1.—M. Almond, J. G. Davies & A. C. B. Lovell. (*Mon. Not. R. astr. Soc.*, 1951, Vol. 111, No. 6, pp. 585–608.) Report of three sets of measurements of velocity distributions, using radio-echo diffraction technique. No evidence was found for a significant hyperbolic velocity component.

523.72 : 537.562 **1900**

Excitation of Electron Oscillations in a Shock Wave. Application to Radio Astronomy.—J. F. Denisse & Y. Rocard. (*J. Phys. Radium*, Dec. 1951, Vol. 12, No. 10, pp. 893–899.) Analysis of the propagation of a shock wave in a strongly ionized medium. Effects of diffusion and thermal diffusion combine to concentrate electrons ahead of the wave front. This causes a polarization of the medium which finally limits the diffusion effects, and a distribution of electron velocities widely different from a Maxwellian distribution; if the energy of the shock wave is sufficiently great, the electrons may be divided into two groups with different mean velocities. Amplified plasma oscillations result; this mechanism may explain the most intense solar r.f. radiation.

523.72 : 621.396.822 **1901**

The Position and Movement on the Solar Disk of Sources of Radiation at a Frequency of 97 Mc/s: Part 1—Equipment.—A. G. Little & R. Payne-Scott. (*Aust. J. sci. Res., Ser. A*, Dec. 1951, Vol. 4, No. 4, pp. 489–507.) Description of an interferometer using spaced aerials. The interference pattern is produced by changing the phase of one aerial relative to that of the other 25 times per second, thus swinging the lobe pattern across the source. Position and polarization of a source can be determined in 1 sec and the accuracy of location is within ± 2 minutes of arc. The system may be used as a fixed-lobe interferometer to measure the angular size of a source. Part 2: 1902 below.

523.72 : 621.396.822 **1902**

The Position and Movement on the Solar Disk of Sources of Radiation at a Frequency of 97 Mc/s: Part 2—Noise Storms.—R. Payne-Scott & A. G. Little. (*Aust. J. sci. Res., Ser. A*, Dec. 1951, Vol. 4, No. 4, pp. 508–525.) Analysis of experimental results obtained with the equipment described in 1901 above. Storm radiation is associated with the largest sunspot of a group and not with the rest of the group; the spot size gives the best criterion for the occurrence of storms. The direction of rotation of the circular polarization depends on the magnetic polarity of the spot. Deviations between the apparent positions of the radio storm centres and visible spots are explained by assuming the origin of the storm radiation to be high in the corona. Part 1: 1901 above.

523.8 : 621.396.822 **1903**

An Attempt to Measure the Annual Parallax or Proper Motion of Four Radio Stars.—F. G. Smith. (*Nature, Lond.*, 1st Dec. 1951, Vol. 168, No. 4283, pp. 962–963.) The errors in interferometer measurements of the positions of radio stars due to phase-retardation inconstancy of the transmission lines to the aerials of the interferometer may be largely eliminated by measuring the relative positions of radio stars. From the results of two series of measurements during 1951 of the apparent right ascension of four intense radio stars, using wavelengths of 3·7 m and 1·4 m, it is concluded that their angular movements are attributable to ionospheric refraction. The distances of these stars are probably greater than ½ parsec.

523.85 : 621.396.822 **1904**

A Radio Survey of the Cygnus Region: Part 1 — The Localized Source Cygnus (1).—R. H. Brown & C. Hazard. (*Mon. Not. R. astr. Soc.*, 1951, Vol. 111, No. 6, pp. 576–584.) An account of the observations, with comparison of the values of the celestial coordinates and intensity of the source with the results obtained by other observers using interferometer methods.

523.854 : 621.396.822 **1905**

Galactic Radiation at Radio Frequencies: Part 4 — The Distribution of Radio Stars in the Galaxy.—J. G. Bolton & K. C. Westfold. (*Aust. J. sci. Res., Ser. A*, Dec. 1951, Vol. 4, No. 4, pp. 476–488.) The distribution was deduced from a previous survey at 100 Mc/s. The effects of absorption and emission within the interstellar gas are considered and found negligible at this frequency. The existence of an isotropic background radiation is discussed and estimates are made of the local number density, the flux from a typical star, and the distances of certain observed sources. Part 3: 866 of 1951.

523.854 : 621.396.822 **1906**

Observations of Galactic Radiation at Frequencies of 1 210 and 3 000 Mc/s.—J. H. Piddington & H. C. Minnett. (*Aust. J. sci. Res., Ser. A*, Dec. 1951, Vol. 4, No. 4, pp. 459–475.) The intensity was measured near the galactic centre and a new discrete source discovered whose spectrum resembles that of an optically thin thermally radiating gas. Radiation was also observed from the Crab nebula, Centaurus and the moon. No radiation was observed from the nebulae M31 and NGC 7293. Details are given of the aerial systems and the experimental technique. An aerial-temperature change of 0·4°K was detectable.

550.38 **1907**

Indices of Geomagnetic Activity of the Observatories Abinger, Eskdalemuir and Lerwick, August to December 1951.—(*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 3, pp. 196–199.) *K*-indices for 3-hour intervals.

550.384 **1908**

World-wide Simultaneous Magnetic Fluctuations and their Relation to Sudden Commencements.—W. Jackson. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 3, pp. 160–172.) Analysis of magnetograms obtained at a number of widely distributed stations during a period of 2½ years reveals the existence of world-wide perturbations, lasting for several hours and often dissociated from large disturbance, with properties similar to those of sudden commencements.

550.384.4 : 551.510.535 **1909**

Anomalies in the Diurnal Variation of the Geomagnetic Field and their Correlation with the Winds in the Lower Ionosphere.—H. Wiese. (*Z. Met.*, Dec. 1951, Vol. 5, No. 12, pp. 373–377.) The quiet-day variations of the geomagnetic field components are examined. Anomalies observed in the month-to-month variation of the amplitude and phase of the daily fluctuations are related to seasonal inversions of steady circulating currents in the lower ionosphere.

550.385 "1951.09.21" **1910**

New Observations of Very Rapid Pulsations during a Magnetic Storm.—G. Gibault. (*C. R. Acad. Sci., Paris*, 19th Dec. 1951, Vol. 233, No. 25, pp. 1655–1656.) See also 725 of 1947.

551.510.52/.53 : 546.214 **1911**

Ozone Variations in the Troposphere and Stratosphere.—E. Regener. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 3, pp. 173–182. In German.) In the air close to the ground, the ozone content may sink to zero owing to the proximity of oxidizable substances. In the troposphere, advection is the main cause of fluctuations. Large variations of the vertical distribution of ozone have been found recently by spectrographic observations in balloon ascents. To explain this, large-scale horizontal and vertical movements of air at great heights must be assumed.

551.510.535 **1912**

The Nature of the Sporadic-E Layer and Turbulence in the Upper Atmosphere.—R. Gallet. (*C. R. Acad. Sci., Paris*, 19th Dec. 1951, Vol. 233, No. 25, pp. 1649–1650.) A theory is advanced according to which the properties of the E_s layer are produced not by additional ionization but as a result of turbulence in the ionosphere, where fluctuations of atmospheric density are accompanied by fluctuations of electron concentration. The corresponding fluctuations of dielectric constant are relatively very much larger than the fluctuations of density at frequencies near the critical frequency. A more complete theory, in course of development, will explain the different effects at equator and polar regions by taking account of the magnetic field. The theory is relevant to the 'bright ring' of the solar corona.

551.510.535 **1913**

The Theory of Magneto-ionic Triple Splitting.—O. E. H. Rydbeck. (*Acta polyt., Stockholm*, 1951, No. 83, 40 pp.) Reprint. See 2714 of 1951.

551.510.535 **1914**

Continental Sporadic-E Activity.—N. C. Gerson. (*Trans. Amer. geophys. Union*, Feb. 1951, Vol. 32, No. 1, pp. 26–30.) Analysis of observations by American amateurs of contacts effected on 17th–18th June 1949 on 50–54 Mc/s by means of sporadic-E reflection. The results indicate drift of the reflecting regions at a speed of about 175 km/hr.

551.510.535 **1915**

Light — Inadequacy of the Ultraviolet Theory of Ionization in the E-Layer.—E. F. George. (*J. Franklin Inst.*, Dec. 1951, Vol. 252, No. 6, pp. 493–500.) Values of E- and F_1- layer parameters for the period 1944–1949 are analysed. The distribution of ionization is symmetrical about the magnetic rather than the geographical equator, and is periodic with respect to latitude; possible correlation of this periodicity with large-scale air movements is discussed.

551.510.535 : 551.55 **1916**

Measurement of Winds in the Ionosphere.—G. J. Phillips. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 3, pp. 141–154.) Report of investigations extending over a period of more than two years, based on observation of the fading pattern of ionospheric echoes of 2·4-Mc/s signals, receiving aerials being located at the corners of a right-angled triangle (shorter sides 130 m), with a fourth aerial available for checking purposes. The aerials were switched in turn to a single receiver, with gating arrangements enabling four records of echo amplitude to be obtained on a single strip of moving film. The results probably refer to motion of the air at heights of 100–120 km. Regular daily and seasonal changes in the direction of the horizontal movement were found, partly attributable to a solar tide of amplitude 16 m/sec. The order of the velocities, 70 m/sec, agrees with information obtained by other methods.

551.510.535 : 621.3.087.4 **1917**

A Simple Ionosphere Sounder.—R. Aschen & P. Gaillard. (*Philips tech. Rev.*, Dec. 1951, Vol. 13, No. 6, pp. 152–163.) A simple account of the Breit & Tuve method, together with details of equipment suitable for amateur use, for another account of which see 2069 of 1949 (Maguer).

551.510.535 : 621.3.087.4 **1918**

Automatic Ionosphere Recorder.—J. M. Carroll. (*Electronics*, May 1952, Vol. 25, No. 5, pp. 128–131.) Description, with block diagram, of the pulse generator, transmitter, receiver and recorder elements of the Model-C3 equipment used by the Central Radio Propagation Laboratory, National Bureau of Standards. Echoes of pulse transmissions, of frequency swept over the range 1–25 Mc/s, are recorded continuously from the c.r.o. display. Some circuit details are shown of the temperature-controlled v.f.o., the wide-band amplifiers, and the pulse inverter and cathode-follower keyers.

551.594.5 **1919**

The Aurorae. [Book Review]—L. Harang. Publishers: Chapman & Hall, London, 1951, 21s. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 3, pp. 199–200.) Vol. 1 of the International Astrophysics Series.

LOCATION AND AIDS TO NAVIGATION

621.396.9 **1920**

Organ-Pipe Radar Scanner.—K. S. Kelleher & H. H. Hibbs. (*Electronics*, May 1952, Vol. 25, No. 5, pp. 126–127.) Description of an experimental model using a rotating horn to feed in succession a set of 36 waveguide elements arranged with their output ends in a continuous line. When used in conjunction with a 6-ft parabolic cylindrical reflector of focal length 57·6 in., the secondary patterns had good beam-width and side-lobe characteristics.

621.396.9 **1921**

Radar Signal Sampler compresses Bandwidth.—W. Otto. (*Electronics*, April 1952, Vol. 25, No. 4, pp. 132–135.) Description and circuit details of equipment which enables p.p.i. radar presentations to be relayed from aircraft to points far beyond line of sight. The video signal is sampled and synthesized into a similar waveform with a sufficiently low recurrence frequency for handling by a l.f. radio link.

621.396.9 **1922**

Radar Buoys [beacons] **and their Special Circuits.**—J. Moline. (*Radio franç.*, Dec. 1951, No. 12, pp. 12–16.) Discussion of transponder systems. Discriminating circuits for eliminating interrogation pulses either too short, too long, or outside a given range, are shown. The operation of p.w.m. and p.c.m. responder circuits is described and the application of a multi-electrode c.r. tube for p.c.m. is outlined. See also 3418 of 1948.

621.396.932/.933 **1923**

The German Decca Network.—(*Telefunken Ztg*, Dec. 1951, Vol. 24, No. 93, pp. 251–252.) Brief details of the equipment of the master and the three associated slave transmitting stations, designed to extend the Decca system coverage over the whole of the North Sea and the West German Federal Republic.

621.396.932 (083.75) **1924**

British Commercial Radar.—M. Hobbs. (*Electronics*, April 1952, Vol. 25, No. 4, pp. 174 . . 186.) The Ministry of Transport specifications for marine radar are outlined and the principal characteristics of radar sets for the 9·32–9·5 kMc/s band, manufactured by five British firms, are tabulated. A description is given of the operation of magnetic modulators capable of handling high powers. These comprise cascade arrangements of 'pulsactors', saturable reactive switching elements. The characteristics of a typical magnetic modulator are: peak power, 150 kW; pulse voltage, 13 kV; pulse current, 12·5 A and duration and rate $0{\cdot}25\,\mu$s and 1 500/sec. Such modulators have long and trouble-free life, simple auxiliary circuits, freedom from radiated interference, and negligible maintenance costs.

621.396.933 **1925**

Long-Range-Navigation Instrumentation.—B. Alexander. (*Elect. Commun.*, March 1952, Vol. 29, No. 1, pp. 9–11.) Discussion of experience gained with the Navaglobe system [1092 of 1947 (Busignies et al.)]. The aperture of the transmitting aerial is the most characteristic feature of ground-based long-range navigational systems; a dimension of $\lambda/2$ is the best compromise for this aperture.

621.396.933 **1926**

Some Future Developments in Aeradio.—Scott-Farnie & Forsyth-Grant. (See 2037.)

MATERIALS AND SUBSIDIARY TECHNIQUES

531.788.7 **1927**

Notes on the Ionization Gauge.—L. Riddiford. (*J. sci. Instrum.*, Dec. 1951, Vol. 28, No. 12, pp. 375–379.) "The sensitivity of the hot-filament ionization gauge is in good agreement with theoretical values calculated on the basis of a physical picture of a stream of electrons passing to and fro through the ionizing space. The calibration curve is not exactly linear, the sensitivity decreasing as the pressure increases from 10^{-4} to 10^{-3} mm of mercury. The tungsten filament in such a gauge 'pumps' oxygen at a rate which is in agreement with earlier work of Langmuir. The remanent molecules which determine the ultimate pressures of diffusion pumps are strongly adsorbed by the gauge, which behaves as a pump of constant speed S. An account of the nature of this phenomenon is given."

533.5 **1928**

Vacuum Technique — its Application to Radio and Electronics.—D. Latham & B. D. Power. (*J. Brit. Instn Radio Engrs*, Dec. 1951, Vol. 11, No. 12, pp. 561–568.) "A survey of methods of producing and measuring high vacua, special emphasis being given to modern tendencies in the manufacture of electronic tubes. Methods of making vacuum joints and of leak detection are described. Various vacuum processes of interest to the electronics industry such as evaporation, impregnation and resistor manufacture are also discussed."

534.232 : 538.652 **1929**

Magnetostrictive Vibration of Prolate Spheroids. Analysis and Experimental Results.—F. J. Beck, J. S. Kouvelites & L. W. McKeehan. (*Phys. Rev.*, 1st Dec. 1951, Vol. 84, No. 5, pp. 957–963.) Investigation of systems in which specimens of Ni and Ni-Fe alloys are allowed to vibrate in the fundamental mode while subjected simultaneously to a steady and a h.f. magnetic field. From the effects induced in the h.f. magnetizing coil, values are computed for the incremental permeability, magnetostriction constant, modulus of elasticity and dissipation constant of the specimens. Results are consistent with domain theory. See also 1873 of 1951 (Kouvelites & McKeehan).

535.215 : 546.817.221 **1930**

The Photovoltaic Effect in Natural Lead Sulphide.—R. Lawrance. (*Aust. J. sci. Res., Ser. A*, Dec. 1951, Vol. 4, No. 4, pp. 569–578.) Report of investigation of the use of Australian samples of natural PbS as radiation detectors in the near infrared. A close correlation is established between the electrical properties of bulk samples and those given by other workers for thin PbS films.

535.371 **1931**

R.T.M.A. Screen Phosphors.—(*Oscillographer*, Oct./Dec. 1951, Vol. 12, No. 4, pp. 3–6.) A review and tabulation of the characteristics of standard R.T.M.A. screen materials and their applications in oscillography.

537.226 : 537.29 **1932**

Field Dependence of the Dielectric Constant.—J. J. O'Dwyer. (*Proc. phys. Soc.*, 1st Dec. 1951, Vol. 64, No. 384A, pp. 1125–1132.) Fröhlich's calculations (1674 of 1950) for the dielectric constant of a material are extended so as to include the first term of the field dependence. The theory is applied to Kirkwood's model of a dipolar liquid.

537.228.1 : 621.396.611.21 **1933**

New Synthetic Piezoelectric Crystals in Electroacoustics and High-Frequency Technique.—F. Spitzer. (*Arch. elekt. Übertragung*, Dec. 1951, Vol. 5, No. 12, pp. 544–554.) Theory of piezoelectric crystals is discussed with particular reference to the different requirements for a.f. and h.f. purposes. Properties are tabulated of a large number of materials investigated as possible substitutes for Rochelle salt and quartz respectively, for the two fields of application. Consideration of the values of and relations between the piezoelectric, elastic and dielectric properties enables the best materials to be chosen.

537.311.33 : 621.396.822 **1934**

Noise in Photosensitive Semiconductors.—P. Görlich. (*Optik*, Nov. 1951, Vol. 8, No. 11, pp. 512–516.) Results of qualitative investigations of semiconductor noise suggest two sources of noise additional to thermal, shot, flicker and lattice effects [3035 of 1950 (van der Ziel)]. These are (*a*) boundary layers formed by the application of a direct voltage; their effect may be calculated by the formula of Mataré (2976 of 1950) or estimated by Macfarlane's theory (910 of 1951); (*b*) grain boundaries in crystal structures which may affect the electron flow.

538.221 **1935**

Ferromagnetic Properties of Semioxidized Iron and Iron-Cobalt Powders.—F. Lihl. (*Acta phys. austriaca*, May 1951, Vol. 4, No. 4, pp. 360–379.) An experimental investigation was made of the influence of the degree of reduction of the initial iron salts on the coercive force, remanence, and BH product of permanent magnets moulded from powders. Highest values of coercive force and BH product respectively are obtained at different incomplete stages of reduction. When the initial material consists of Fe-Co mixed crystals, coercive force and BH product increase with Co content. The experimental results support Néel's theory.

546.289 : 548.55 : 621.396.822 **1936**

Shot Noise in Germanium Single Crystals.—G. B. Herzog & A. van der Ziel. (*Phys. Rev.*, 15th Dec. 1951, Vol. 84, No. 6, pp. 1249–1250.) The noise ratio n of a particular Ge filament carrying current I at frequencies f in the range 1–1 600 kc/s is represented by $n = 1 + AI^2/f + BI^2/[1 + (f/f_0)^2]$, where A and B are constants and f_0 ($1{\cdot}5 \times 10^5$ c/s) is practically independent of I. The third term is interpreted as representing the shot noise of the holes, in accordance with the theory of semiconductors [3035 of 1950 (van der Ziel)]. For another filament, deviations from the inverse-frequency law could not be detected.

546.289 : 621.314.7 **1937**

Electric Forming of *n*-Germanium Transistors using Donor-Alloy Contacts.—R. L. Longini. (*Phys. Rev.*, 15th Dec. 1951, Vol. 84, No. 6, p. 1254.) The suggestion is made that lattice vacancies diffuse from the collector probe into the Ge, this process preceding the diffusion of donor impurities, so that a *p-n* hook is set up near the probe. Values of current gain higher than can be expected from mobility considerations alone are thus made possible.

546.817.221 + 546.817.241 **1938**

The Optical Constants of Lead Sulphide and Lead Telluride in the Region 0·5–3 Microns.—D. G. Avery. (*Proc. phys. Soc.*, 1st Dec. 1951, Vol. 64, No. 384B, pp. 1087–1088.) Refractive indices and absorption constants are shown graphically for polished PbS and PbTe crystals; the method of measurement is outlined.

621.314.6 : 537.311.33 **1939**

On Rectifiers.—W. C. van Geel. (*Physica*, Aug. 1951, Vol. 17, No. 8, pp. 761–776.) Combinations of (*a*) excess-semiconductor/deficit-semiconductor, (*b*) Al/Al_2O_3/semiconductor, (*c*) metal/resin-layer/semiconductor were all found to have rectification properties. It is suggested that in all three cases the contact between two layers with charge carriers of opposite sign is the source of the rectification effects.

621.315.61 : 621.317.7 **1940**

The Properties of Insulating Materials used in Instruments.—C. G. Garton. (*Proc. Instn elect. Engrs*, Part II, Dec. 1951, Vol. 98, No. 66, pp. 728–737. Discussion, pp. 753–759.) Mechanical and electrical properties, and chemical structure of newer synthetic materials, are discussed and tabulated. The use of composite materials is also discussed. 19 references.

621.315.612.4 : 546.831.824-31 **1941**

Effects of Firing Temperature on the Dielectric Properties of Barium-Titanate Ceramics.—A. Kobayashi & H. Hino. (*J. phys. Soc. Japan*, Sept./Oct. 1951, Vol. 6, No. 5, pp. 371–373.)

621.318.13 : 621.317.7 **1942**

Some Special Characteristics of Soft Magnetic Materials used in Instrument Manufacture.—G. A. V. Sowter. (*Proc. Instn elect. Engrs*, Part II, Dec. 1951, Vol. 98, No. 66, pp. 714–727. Discussion, pp. 753–759.) Merits of high-μ materials for various applications are considered. Losses and harmonic generation are calculated, especially as affected by nonuniform flux distribution. Magnetostriction and variation of magnetic properties with temperature are treated, and costs of various materials are compared. Many design curves are given.

621.396.611.21.002.2 **1943**

The Deposition of H.F. Crystal Electrodes by Vacuum Coating.—L. Holland. (*Electronic Engng*, Jan. 1952, Vol. 24, No. 287, pp. 10–13.) Comparison of sputtering and evaporation methods for depositing thin gold films as electrodes or for frequency adjustments. Direct adjustment of crystal frequency during coating is possible with the evaporation technique. An evaporation unit is described which has been used successfully for coating and calibrating 4-Mc/s crystals.

MATHEMATICS

517.56 **1944**

Epicycloidal Functions and some New Relations between Bessel Functions.—C. Agostinelli. (*R. C. Accad. naz. Lincei*, Dec. 1951, Vol. 11, No. 6, pp. 339–344.)

517.93 **1945**

Nonlinear Systems. A Method of Solution by Graphical Analysis.—(*Elect. Times*, 20th Dec. 1951, Vol. 120, No. 3137, pp. 1128–1129. Discussion, p. 1129.) Short account of a paper on 'A Graphical Analysis for Nonlinear Systems' by Miss Pei-Su Hsia, describing a method of solving second-order nonlinear differential equations.

521.401.3 : 621.385.83 **1946**

Perturbation Characteristic Functions and their Application to Electron Optics.—P. A. Sturrock. (*Proc. roy. Soc. A*, 20th Dec. 1951, Vol. 210, No. 1101, pp. 269–289.)

681.142 **1947**

Some Limitations on the Accuracy of Electronic Differential Analyzers.—A. B. Macnee. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 303–308.) Discussion of probable errors in the solution of differential equations with constant coefficients by means of analogue computers.

681.142 **1948**

Automatic Calculating Machines.—M. V. Wilkes. (*J. R. Soc. Arts*, 14th Dec. 1951, Vol. 100, No. 4862, pp. 56–90.) An account of the development of digital computers, with descriptions of their operation and use.

681.142 **1949**

Multi-stable Magnetic Memory Techniques.—J. D. Goodell & T. Lode. (*Radio & Televis. News, Radio-Electronic Engng Section*, Dec. 1951, Vol. 46, No. 6, pp. 3–5.) Using suitable materials, more than two stable states in a magnetic core may be obtained by arrangements ensuring that the flux change, which is proportional to the voltage/second integral of the applied force, takes place in discrete steps. Core magnetization is then related to the number of applied pulses with an accuracy limited mainly by the slip-back to remanence from saturation. Information may be stored or read in many different ways, either by pulse train, or by single pulses, whose duration or amplitude is varied. The block diagram of an analogue-to-digital translation system is shown; other applications of magnetic structures of this type are as light-weight high-speed storage devices and in arithmetical computing units.

MEASUREMENTS AND TEST GEAR

531.761 : 621.318.5 **1950**

Time-Interval Measurements on Installations during Normal Operation.—J. Schalkwijk. (*Commun. News*, Dec. 1951, Vol. 12, No. 2, pp. 49–56.) A three-range, direct-reading, mains-operated instrument for measuring closing and release times of telephone-exchange relays, or for any time intervals (up to 1 sec) defined by a voltage variation at beginning and end of interval.

621.3.018.4(083.74) **1951**

Frequency Standards in the Microwave Region.—R. Ferrero. (*Ricerca sci.*, Dec. 1951, Vol. 21, No. 12, pp. 2142–2144.) The 1-Mc/s signal from a quartz oscillator is multiplied to 200 Mc/s, and is then passed to three Ge crystals acting as harmonic generators, which, with their associated cavity filters, provide signals of 2, 3 and 10 kMc/s respectively. The power available is of the order of several milliwatts.

621.317 : 537.71(083.74) **1952**

The Accuracy of Measurement of Electrical Standards.—A. Felton. (*Proc. Instn elect. Engrs*, Part II, Dec. 1951, Vol. 98, No. 66, pp. 694–700. Discussion, pp. 710–713.) "The difference between 'international' and 'absolute' electrical units is explained, and the reason for the change made in 1948 from one system to the other is given. The uncertainty of the electrical units defined in terms of length, mass and time is estimated to be about 20 parts in a million, although the accuracy of comparison of electrical quantities may be as high as one part in ten million. The loss of accuracy in the measurement of voltage, current and power when transferring from direct to alternating current is explained: it is estimated that these quantities cannot be measured at power frequencies to better than one part in 10 000." 20 references.

621.317.3 : 551.594.6 **1953**

A Statistical Approach to the Measurement of Atmospheric Noise.—R. S. Hoff & R. C. Johnson. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 185–187.) Description of a measurement method based on determination of the fraction of time that the noise envelope exceeds certain reference levels during an interval of several seconds. Results obtained are compared on a statistical basis with those obtained by other methods.

621.317.3.029.5/.6 **1954**

High-Frequency Measurement Technique.—W. Druey. (*Bull. schweiz. elektrotech. Ver.*, 15th Dec. 1951, Vol. 42, No. 25, pp. 989–1000. In German. Discussion, pp. 1000–1003, in French and German.) A survey paper dealing with measurements of current, voltage, impedance, dielectric properties, frequency and time. A description is given of a telemetry system using a h.f. channel, and the advantages of distributed amplifiers for wide-band operation in c.r. oscillography are discussed.

621.317.326 **1955**

A Method for the Measurement of the Peak Voltage of Periodic Low- or High-Frequency Pulses.—W. Hasselbeck. (*Funk u. Ton*, Dec. 1951, Vol. 5, No. 12, pp. 617–626.) Positive pulses are applied so as to charge a capacitor in series with a diode and resistance; pulses produced across the resistance are amplified, with reversal of sign, and then applied so as to give a supplementary charge to the capacitor via a second diode; the charging continues until the peak voltage is attained, when the first diode cuts off. Practical circuits based on this principle are described, with particular attention to the amplifier design. The measurement error is discussed; its magnitude is about 1% for rectangular l.f. pulses with a mark/space ratio of 1 : 10 000.

621.317.335.3.029.62/.63 **1956**

Use of Coaxial Line terminated by Different Types of Impedance for Permittivity Measurements at Metre and Decimetre Wavelengths.—A. Lebrun & R. Arnoult. (*C. R. Acad. Sci., Paris*, 19th Dec. 1951, Vol. 233, No. 25, pp. 1591–1593.) Description of a method and apparatus permitting measurement accurate to within 1%. Three different types of dielectric cell are shown. The apparatus is suitable for measurements at controlled temperature, and can be used as a wavemeter.

621.317.335.3.029.64 : 546.217 **1957**

The Permittivity of Air at a Wavelength of 10 Centimeters.—W. E. Phillips. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, p. 164.) Discussion on paper abstracted in 2827 of 1950.

621.317.336.029.64 **1958**

Inductive Probe for Microwave Measurement Lines and Near-Field Meters.—F. Tischer. (*Acta polyt., Stockholm*, 1951, No. 81, 18 pp. In German.) Reprint. See 3048 of 1951.

621.317.336.029.64 : 621.396.611.4 **1959**

Resonance-Resistance Measurements at Centimetre Wavelengths.—H. Döring & W. Klein. (*Arch. tech. Messen*, Dec. 1951, No. 191, pp. T135–T136.) In the measurement of the resonance resistance of ordinary cavity resonators, the determination of attenuation and resonance reactance ['Schwingwiderstand' $= \omega_0 L = 1/\omega_0 C$] is involved, but for cavity resonators with extremely small losses a method involving insertion of high-value resistors in parallel with the resonator [see 2755 of 1943 (Borgnis)] is preferable. With a method based on wavelength measurements, errors are $< 5\%$ but with a method involving detector meter readings the error may be as high as 10%. The results of measurements on three cylindrical cavity resonators and one coaxial-line cavity are in fairly good agreement with values calculated from loss data for the dielectric rods used as auxiliary resistors.

621.317.337 : 621.396.611.4 **1960**

The Q of a Microwave Cavity by Comparison with a Calibrated High-Frequency Circuit.—H. LeCaine. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 155–157.) Two superheterodyne channels are fed from a frequency-swept oscillator; the cavity is introduced into the r.f. stage of one channel and a calibrated variable-Q circuit is inserted in the i.f. stage of the other. The resonance curves are displayed together on a c.r.o. and when they coincide the Q of the cavity is n times that of the comparison circuit, where n is the ratio of r.f. to i.f. Q factors between 5 000 and 15 000 can be measured at about 2·8 kMc/s, estimated errors being $< \pm 3\%$. The equivalent shunt resistance of the cavity can also be measured.

621.317.34 : 621.392 **1961**

The Measurement of Image Impedance and Image Attenuation Coefficient.—L. Guenot. (*Ann. Télécommun.*, Dec. 1951, Vol. 6, No. 12, pp. 353–362.) Two methods are considered. In the first, the open-circuit and short-circuit impedances are measured, and the image impedance, image-attenuation and image-phase-change coefficients are evaluated from the results, using either abacs, geometrical constructions or Kennelly's charts. In the second method, the total attenuation is measured for various lengths of non-loaded cable, the slope of the asymptote to the attenuation/length curve giving the attenuation coefficient directly.

621.317.35 **1962**

Ultrasonic Wave Analyzer.—T. A. Benham. (*Radio & Televis. News, Radio-Electronic Engng Section*, Sept. 1951, Vol. 46, No. 3, pp. 12–14.) Description of a heterodyne circuit handling inputs in the frequency range 10–300 kc/s; the design of the crystal filter circuit giving a pass band of 200 c/s is discussed in some detail.

621.317.35 : 621.395.625.3 **1963**

Boundary-Displacement Magnetic Recording.—H. L. Daniels. (*Electronics*, April 1952, Vol. 25, No. 4, pp. 116–120.) Ordinary magnetic tape is used and is magnetized to saturation at all times. In the absence of modulation, one half of the tape has opposite polarity to that of the other half, with an unmagnetized boundary strip down the middle separating the two. With a modulated signal the unmagnetized boundary follows the waveform of the signal. A specially designed recording head is used, but a conventional pickup head serves for reproduction. With the tape mounted on a rotating drum, the system has been applied to the analysis of transient waveforms, frequencies ranging from 1 c/s to 100 kc/s. Application to a.f. recording is under investigation.

621.317.361 **1964**

A Self-Interpolating Crystal Calibrator for Setting Up and Measuring Radio Frequencies.—D. Cooke. (*Electronic Engng*, Jan. 1952, Vol. 24, No. 287, pp. 23–25.) The fundamental (f_c) and harmonics of a crystal oscillator are used to modulate a carrier which is continuously variable between nf_c and $(n + 1)f_c$; by using the sidebands corresponding to the harmonics, calibration frequencies of any value within a wide band can be obtained without loss of the accuracy associated with the crystal.

1965

621.317.365 + 621.317.341] : 621.392.26 : 621.315.61

Measurements of Wavelengths and Attenuation in Dielectric Waveguides for Lower Modes.—C. W. Horton & C. M. McKinney. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 177–180.) Measurements of the wavelength of a wave guided by a cylindrical dielectric rod give results for various modes and dielectric materials in good agreement with solutions of the characteristic equation. Measurements of attenuation due to losses and to bending of the dielectric guide are also reported.

621.317.7 **1966**

New Principles in Electrical Instruments.—D. C. Gall. (*Proc. Instn elect. Engrs*, Part II, Dec. 1951, Vol. 98, No. 66, pp. 665–670. Discussion, pp. 686–693.) For small d.c. measurements, magnetic amplifiers and valves for amplifying the modulated d.c. signal are mentioned; also the Butterworth bridge comprising high-μ wires whose resistance changes in a magnetic field. New stable rectifiers make the phase-sensitive bridge practical. D.c. and a.c. stabilization and generation of standard voltages are discussed briefly. A shockproof galvanometer whose coil is of the same density as the medium supporting it, power measurement by calorimetry, testing of materials by ultrasonics, and the NH_3-absorption-line time standard are mentioned. The cost of increasing instrumental accuracy is analysed. 18 references.

621.317.7 : 621.385 : 621.396.822 **1967**

Direct-Reading Instrument measures Tube Noise.—A. van der Ziel. (*Electronics*, April 1952, Vol. 25, No. 4, pp. 136–137.) Details of a 4-valve circuit enabling rapid and accurate determination of valve noise resistance by unskilled personnel. Results of tests on a few types of valve (6J4, 6AG5, 6AC7, 6J6 and 6AK5) are noted.

621.317.7.001.2 **1968**

Some Aspects of Electrical Instrument Design.—L. Hartshorn. (*Proc. Instn elect. Engrs*, Part II, Dec. 1951, Vol. 98, No. 66, pp. 657–664.) A discussion of requirements for accurate measurement. Short descriptions are given of the N.P.L. precision balance (error < 1 in 10) and quartz-fibre micro-balance (sensitivity 10^{-8}g). Application of these to modern galvanometers and wattmeters is discussed. The Farmer valve-electrometer and recent measurements by Ramsey on residual leakage in high-quality dielectrics are described.

621.317.7.029.6 **1969**

Instruments for use in the Microwave Band.—A. F. Harvey. (*Proc. Instn elect. Engrs*, Part II, Dec. 1951, Vol. 98, No. 66, pp. 781–789. Discussion, pp. 789–792. Summary, *ibid*, Part III, Jan. 1952, Vol. 99, No. 57, p. 32.) Description of instruments used in the microwave band for the measurement of power, frequency and impedance; the majority of them use waveguide methods of transmission, but coaxial systems at the longer wavelengths and free-space semi-optical systems at the shorter wavelengths are also described. Emphasis is laid upon more recent instruments and on those for the millimetrewavelength region. Methods of manufacture and their influence on performance and design are also discussed. 35 references.

621.317.7.085/.087 **1970**

A Survey of Modern Methods of Presentation of Instrument Readings and Recordings.—L. B. S. Golds. (*Proc. Instn elect. Engrs*, Part II, Dec. 1951, Vol. 98, No. 66, pp. 671–685. Discussion, pp. 686–693.) Types of pointers and scales, lettering, etc., on electrical instruments (mostly of power-station type) are described in detail and compared with a view to assessing best readability. Other methods of presentation are also considered. Possible future developments are outlined.

621.317.7.088 **1971**

Performance Limits in Electrical Instruments.—A. H. M. Arnold. (*Proc. Instn elect Engrs*, Part II, Dec. 1951, Vol. 98, No. 66, pp. 701–710. Discussion, pp. 710–713.) Potentiometers, voltmeters, ammeters, instrument transformers and wattmeters operating up to high audio frequencies are considered, defects found in instruments submitted to N.P.L. for test being described in detail. Some theoretical performance limits are analysed.

621.317.715 : 621.396.645 **1972**

An Analysis of the Galvanometer Amplifier and its Response to Alternating Electromotive Forces and Mechanical Vibrations.—R. G. Wylie & A. F. A. Harper. (*Aust. J. sci. Res., Ser. A*, Dec. 1951, Vol. 4, No. 4, pp. 560–568.) A mathematical analysis of a representative system. Circuit constants may be chosen to provide critical damping such that the frequency response curve of the amplifier resembles that of the galvanometer alone. The bandwidth may be increased by the use of feedback, which also increases the effect of mechanical vibration having a rotational component about the axis of the galvanometer coil.

621.317.725 **1973**

Linear Diode Voltmeter.—(*Radio tech. Dig., Édn franç.*, 1951, Vol. 5, No. 6, pp. 327–337.) Adaptation of Burgess's analysis (2736 of 1948 and 736 of March) with supplementary data from other sources.

621.317.727 : 621.316.722.4 **1974**

Calculation of Capacitive Voltage Regulator with Wide Regulation Range.—O. Schmid. (*Funk u. Ton*, Dec. 1951, Vol. 5, No. 12, pp. 627–637.) Design formulae are derived for a capacitive voltage divider for h.f. measurement apparatus, using a variable capacitor with earthed rotor between two stators. Operation is practically independent of load and of generator impedance. A numerical example is calculated.

621.317.733 **1975**

The Wheatstone Bridge with Load-Dependent Resistances: Part 2 — Applications.—G. Nidetzky. (*Arch. tech. Messen*, Nov. 1951, No. 190, pp. T129–T130.) Discussion of operating conditions whereby fluctuations of input voltage may be either suppressed or separated from the fundamental. Part 1: 446 of February.

621.317.733 **1976**

A Note on a Selective RC Bridge.—P. G. Sulzer. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 338–339.) Details of a bridge used as a frequency-determining element in an a.f. oscillator and providing higher selectivity than the Wien bridge.

621.317.755 **1977**

The Production of Three-Dimensional Characteristics with the Cathode-Ray Oscillograph.—R. Grevel, F. W. Gundlach & H. Herklotz. (*Arch. tech. Messen*, Nov. 1951, No. 190, pp. T128.) An outline of principles and circuits used.

621.317.755.087 : 621.3.015.3 **1978**

Cathode-Ray Tube for Recording High-Speed Transients.—S. T. Smith, R. V. Talbot & C. H. Smith, Jr. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 297–302.) Description of a travelling-wave tube having a vertical sensitivity of 33 V/cm and a writing speed of $1{\cdot}5 \times 10^7$ m/sec. Photographs of a 3-kMc/s sine wave and a pulse with a rise time of $0{\cdot}5 \times 10^{-9}$ sec are shown.

621.317.76 **1979**

Equipment for Accurate Comparison of Nearly Equal Frequencies.—Andrieux & Dayonnet. (*Onde élect.*, Dec. 1951, Vol. 31, No. 297, pp. 469–472.) The particular method described is based on phase discrimination between the two frequencies f_1 and f_2 in a double-diode circuit. The difference-frequency voltage is applied to a double-pentode circuit, thus deriving short pulses separated by the time interval $1/(f_1 - f_2)$. These pulses trigger a control circuit energizing a commercial electronic counter so arranged that push-button operation gives an immediate indication of the time interval. One of the frequencies is a standard frequency of 100 kc/s, and the relative frequency difference is of the order of 10^{-6}. Measurement accuracy is within 1 part in 10^9.

621.317.772.087.4 **1980**

High-Frequency Phase Measurement with Direct Indication: Part 3 — Curve Tracers.—A. Ruhrmann. (*Arch. tech. Messen*, Nov. 1951, No. 190, pp. T121–T122.) Description with block diagrams of different instruments for phase recording in polar and Cartesian co-ordinates. Part 2: 3101 of 1950.

621.317.772.089.6 **1981**

Precision Calibrator for Low-Frequency Phase-Meters.—M. F. Wintle. (*Elect. Commun.*, March 1952, Vol. 29, No. 1, pp. 51–64.) Reprint. See 2770 of 1951.

621.317.784 **1982**

A General-Purpose Electronic Wattmeter.—D. E. Garrett & F. G. Cole. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 165–171.) Detailed description of a meter for frequencies from zero to 71 kc/s and powers up to 50 W, with accuracy to within 3%.

621.317.79 : 621.318.4 **1983**

An Instrument for the Measurement of the Number of Turns of Cylindrical Coils.—B. Ehlermann. (*Frequenz*, Nov./Dec. 1951, Vol. 5, Nos. 11/12, pp. 303–307.) Description of an accurate comparator-type test set.

621.396.62.001.4 : 621.396.619.13 **1984**

Proposed Test Procedure for F.M. Broadcast Receivers.—D. Maurice, G. F. Newell & J. G. Spencer. (*Electronic Engng*, March 1952, Vol. 24, No. 289, pp. 106–111.) An outline of a procedure found convenient for testing f.m. receivers, including tests of sensitivity, selectivity, frequency stability, co-channel suppression ratio, a.m. suppression, impulsive interference performance, and distortion. Results of tests on three different receivers are analysed.

621.396.621 : 621.396.619.13 **1985**

A New Method for Predicting the Adjacent-Channel Performance of Mobile Radio Equipments by Graphical Analysis.—(*FM-TV*, Oct. 1951, Vol. 11, No. 10, p. 6.) In 745 of March please cancel T.S. Eader as author and substitute H. H. Davids.

621.396.822 : 621.327.43 **1986**

A Portable, Direct-Reading Microwave Noise Generator.—E. L. Chinnock. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 160–164.) The discharge in an ordinary fluorescent lamp is used as source. The variation, with operating temperature, of the noise-power output and of the impedance match to the associated waveguide are considered. A resistance thermometer is incorporated and calibrated to give a direct-reading db scale for excess noise-power output. Circuit details are given.

621.396.822 : 621.385.16 **1987**

A Generator of Electrical Noise.—A. P. G. Peterson. (*Gen. Radio Exp.*, Dec. 1951, Vol. 26, No. 7, pp. 1–9.) Description of Type 1390-A random-noise generator, which uses a gas-discharge tube with transverse magnetic field as noise source. Three ranges are available, with upper frequency limits of 20 kc/s, 500 kc/s and 5 Mc/s respectively and maximum open-circuit output voltage of 1 V r.m.s. Various applications are mentioned.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

534.321.9 : 621.9.02 **1988**

New Process for Producing Holes in Hard Materials.—A. Kuris. (*Machinery, Lond.*, 6th Dec. 1951, Vol. 79, No. 2038, pp. 991–992.) Description of the 'cavitron' process. A boron-carbide abrasive mixed with water is directed on to a blunt-ended tool of the required cross-section. This is made to vibrate 27 000 times per second by means of a magnetostriction oscillator. About 30 min is required to make a ¼-in. square hole in carbide ¼-in. thick, using a solid tool. With a hollow tool the time would be shorter.

539.16.08 **1989**

Radiation Measuring Instruments for X Rays to Cosmic Rays.—D. Taylor & W. Abson. (*Proc. Instn elect. Engrs*, Part II, Dec. 1951, Vol. 98, No. 66, pp. 760–770. Summary, *ibid*, Part III, Jan. 1952, Vol. 99, No. 57, pp. 28–30.) A review of techniques. 22 references.

621.317.083.7 **1990**

Guided-Missile Test Center Telemetering System.—J. B. Wynn, Jr, & S. L. Ackerman. (*Electronics*, May 1952, Vol. 25, No. 5, pp. 106–111.) General description of the equipment and methods used at the U.S. Air Force test centre in the Caribbean. The information is transmitted from the missile as f.m. of a carrier wave, the frequency range being 215–235 Mc/s. Sixteen channels are provided, six being used on a time-sharing basis to give a total of 172 information channels. The effective range is 200 miles at 30 000 ft height. Nine receiving sites are spaced at about 175-mile intervals in the 1 500-mile chain. Receiving, recording and data-presentation equipment are described.

621.317.794 : 535.61-15/-31 **1991**

Radiation Measuring Instruments for the Infrared to Ultraviolet Waveband.—A. C. Menzies. (*Proc. Instn elect. Engrs*, Part II, Dec. 1951, Vol. 98, No. 66, pp. 771–780. Discussion, pp. 789–792. Summary, *ibid*, Part III, Jan. 1952, Vol. 99, No. 57, pp. 30–31.) Infrared techniques are considered in some detail and typical electrical methods of emission and absorption spectroscopy in the visible and ultraviolet regions are described. A new type of CdSe photoconductive cell with maximum sensitivity at 7 200 Å and ⅓ that sensitivity at 4 000 Å, decreasing slowly through the ultraviolet, is mentioned. Direct recording of Raman spectra and spectroscopy in the vacuum ultraviolet region are also considered. 33 references.

621.383.001.8 **1992**

Photoelectric Device for scanning Curves.—H. J. Dreyer. (*Z. angew. Phys.*, Dec. 1951, Vol. 3, No. 12, pp. 453–456.)

621.384.611.1† **1993**

The 31-MeV Betatron (Ray Transformer).—R. Wideröe. (*Brown Boveri Rev.*, Sept./Oct. 1951, Vol. 38, Nos. 9/10, pp. 260–272.) Description of dual-beam equipment and of the properties and applications of the X rays produced.

621.384.611.1† **1994**

The 31-MeV Betatron Installation at the University Radiological Institute attached to the Zurich Cantonal Hospital.—A. von Arx. (*Brown Boveri Rev.*, Sept./Oct. 1951, Vol. 38, Nos. 9/10, pp. 273–280.) Description of the apparatus and the control arrangements.

621.384.611.1† **1995**

The Betatron and its Applications.—M. Bohn. (*Rev. gén. Élect.*, Dec. 1951, Vol. 60, No. 12, pp. 489–494.) General principles of operation and applications in radio therapy and industry are described, with some details of the equipment to be installed at the Cancer-Research Institute Gustave-Roussy, Villejuif, France.

621.384.611.1† : 61 **1996**

Adaptation of 31-MeV Betatron to Medical Applications, and Shielding Problems.—G. Joyet & W. Mauderli. (*Brown Boveri Rev.*, Sept./Oct. 1951, Vol. 38, Nos. 9/10, pp. 281–291.) Problems of dosage and protection of patients and operators are considered.

621.385.83 : 521.401.3 **1997**

Perturbation Characteristic Functions and their Application to Electron Optics.—P. A. Sturrock. (*Proc. roy. Soc. A*, 20th Dec. 1951, Vol. 210, No. 1101, pp. 269–289.)

621.385.833 **1998**

The Refractive Index in Electron Optics.—W. Ehrenberg & R. E. Siday: W. Glaser. (*Proc. phys. Soc.* 1st Dec. 1951, Vol. 64, No. 384B, pp. 1088–1089.) Further comment. See 1741 of 1951 (Glaser).

621.385.833 **1999**

New Results on the Electron-Optical Properties of Magnetic Deflection Fields.—R. F. K. Herzog. (*Acta phys. austriaca*, May 1951, Vol. 4, No. 4, pp. 431–444.) Apart from its deflecting action, a homogeneous magnetic deflection field acts as a system of two crossed cylindrical lenses; this system is analysed, and some special cases are examined.

621.385.833 **2000**

A Potential Model for the Study of the Three-Electrode [electron] Lens.—M. Bernard. (*C. R. Acad. Sci., Paris*, 3rd Dec. 1951, Vol. 233, No. 23, pp. 1438–1440.) The equation for the electron trajectories is integrated by successive approximation and simple expressions for the lens parameters are then obtained and evaluated. Comparison with Regenstreif's results (2500 of 1951) shows good agreement.

621.385.833 **2001**

Theory of Third-Order Rays in the Independent Electrostatic [electron] Lens.—E. Regenstreif. (*C. R. Acad. Sci., Paris*, 19th Dec. 1951, Vol. 233, No. 25, pp. 1588–1590.)

621.385.833 : 537.133 **2002**

The First Images obtained with a Proton Microscope.—P. Chanson & C. Magnan. (*C. .R Acad. Sci., Paris*, 3rd Dec. 1951, Vol. 233, No. 23, pp. 1436–1438.) The apparatus has three e.s. lenses permitting magnification up to 25 000, the ellipticity error of the central diaphragms being $< 0{\cdot}1\,\mu$. The proton source used is of the h.f. excitation type, working at 80 Mc/s with a power of 50 W. From photographs obtained at a magnification of 3 000, the resolution limit is under 300 Å.

621.387.424 **2003**

Xenon-Filled Geiger Counters.—G. Barrère. (*C. R. Acad. Sci., Paris*, 3rd Dec. 1951, Vol. 233, No. 23, pp. 1442–1444.) Description of the construction and method of filling. The resulting counters were stable, with a plateau range of 400 V and slope of 3%.

621.387.462 : 549.211 **2004**

An Explanation of Differences in Counting Properties among Diamond Specimens.—G. P. Freeman & H. A. van der Velden. (*Phys. Rev.*, 1st Dec. 1951, Vol. 84, No. 5, pp. 1050–1051.)

621.39.001.11 : 6 **2005**

Cybernetics.—J. Loeb. (*Onde élect.*, Dec. 1951, Vol. 31, No. 297, pp. 457–468.) See 233 of January.

PROPAGATION OF WAVES

538.566.2 **2006**

The Reflection of Plane Electromagnetic Waves in Slightly Inhomogeneous Layers.—G. Eckart. (*Arch. elekt. Übertragung*, Dec. 1951, Vol. 5, No. 12, pp. 555–560.) See 1882 of 1951.

621.396.11 **2007**

Waves in Nonuniform Propagation Conditions.—H. Poeverlein. (*Z. Naturf.*, Sept. 1950, Vol. 5a, No. 9, pp. 492–499.) In crystal optics and in the case of radio wave propagation in an anisotropic medium such as the ionosphere, MacCullagh's index surface is of the fourth order, so that double refraction occurs, with four solutions for the waves in an anisotropic medium, two increasing and two decreasing waves. An index surface of the fourth order can lead to all sorts of remarkable phenomena in inhomogeneous (layered) media, as experience with radio waves shows.

621.396.11 : 523.3 **2008**

An U.H.F. Moon Relay.—P. G. Sulzer, G. F. Montgomery & I. H. Gerks. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, p. 361.) Report of the successful transmission of a short message from Cedar Rapids, Iowa, to Sterling, Va, using the moon as a reflector of the 418-Mc/s c.w. signals. With a transmitter output of 20 kW and high-gain aerials, the estimated received power was about 7×10^{-17} W, a value corresponding, for the receiver used, to a signal/noise ratio of 8·6 db, which is in good agreement with the observed ratio.

621.396.11 : 551.510.535 **2009**

Group Velocities and Group Heights from the Magneto-ionic Theory.—D. H. Shinn & H. A. Whale. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 3, p. 200.) Corrections to paper abstracted in 1405 of May.

621.396.11 : 621.317.353.3 **2010**

Experimental Determination of the Resonance Curve in the Gyro-interaction Phenomenon.—M. Cutolo, R. Ferrero & M. Motzo. (*Alta Frequenza*, Feb. 1950, Vol. 19, No. 1, pp. 3–8.) Experiments were made in June–July 1949 on the lines of those previously reported (2328 of 1950). The resonance curves experimentally obtained are regarded as confirming Bailey's prediction of a double humped curve. The discrepancy between the experimentally obtained value of gyromagnetic frequency and the theoretical value is attributed to the variation of resonance frequency with hour of night.

621.396.11 : 621.317.353.3 **2011**

Ionospheric Interaction in Disturbed Conditions.—D. A. Bell. (*Proc. phys. Soc.*, 1st Dec. 1951, Vol. 64, No. 384B, pp. 1053–1062.) Describes the use of averaging methods to extract information from observations taken under disturbed conditions. The existence of a 'low-frequency anomaly' (Huxley, *Proc. roy. Soc. A*, 1950, Vol. 200, p. 507) is confirmed, and a possible mechanism suggested. No exceptional interaction was found for a variation in frequency of the disturbing wave around the gyromagnetic resonance frequency.

621.396.11.029.62 **2012**

The Anomalous Propagation of Radio Waves in the 10-Metre Band.—F. H. Northover. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 3, p. 200.) Corrections to paper noted in 1409 of May.

621.396.81 **2013**

Field-Strength Measurements in the Neighbourhood of a Discontinuity. Application of Millington's Method.—P. Pernet. (*HF, Brussels*, 1951, No. 12, pp. 317–325.) In these 3·86-Mc/s measurements, made over a land/sea path near Ostende, special difficulties were encountered due to coastal topography, the presence of local sources of field disturbance and the necessity of taking readings on board a tugboat. Hence the results are not considered sufficient either in quantity or accuracy for a good determination of the characteristics of propagation paths in a polder region, but only to indicate the general trend of the field variation over the paths considered. Agreement with Millington's theory (1758 of 1949) is good, the phenomena of abrupt fall and recovery of signal strength on crossing the land/sea boundary being clearly shown.

RECEPTION

621.396.62.001.4 : 621.396.619.13 **2014**

Proposed Test Procedure for F.M. Broadcast Receivers.—Maurice, Newell & Spencer. (See 1984.)

621.396.621 **2015**

Flexible Selectivity for Communications Receivers.—O. G. Villard, Jr, & W. L. Rorden. (*Electronics*, April 1952, Vol. 25, No. 4, pp. 138–140.) Details of a single-valve circuit using Q multiplication to achieve i.f. selectivity equivalent to that obtainable with a quartz-crystal filter.

621.396.621 : 621.396.619.13 **2016**

The Theory of Amplitude-Modulation Rejection in the Ratio Detector.—B. D. Loughlin. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 289–296.) The procedure for a complete mathematical analysis of the a.m.-rejection properties of the ratio detector is presented. From the theory, the effect of variations of the parameters of ratio-detector transformers on the a.m.-rejection properties is predicted. Unbalance effects and their mutual cancellation are briefly considered. The degree of apparent limiting action within the ratio-detector circuit is only incidental and is not related to its a.m.-rejection properties; it thus represents an inadequate design basis for the ratio detector. Summary noted in 1501 of 1950.

621.396.621 : 621.396.65 **2017**

Design Considerations for a Radiotelegraph Receiving System.—J. D. Holland. (*Elect. Commun.*, March 1952, Vol. 29, No. 1, pp. 34–50.) Reprint. See 2822 of 1951.

621.396.621.54 **2018**

Improvement in Gain Stability of the Superheterodyne Mixer through the Application of Negative Feedback.—G. E. Boggs. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 202–207.) Expressions are derived which show the improvement in stability when feedback is applied at i.f. between the mixer anode and input grid. An increased gain-bandwidth product is obtained by the use of a two-stage mixer. A generalized design procedure and performance details of experimental mixers are given.

621.396.621.54 **2019**

The Design of the I.F. Stage, with Particular Reference to the MHG [multipath h.f. feedback] **Circuit.**—G. Lander. (*Funk u. Ton*, Dec. 1951, Vol. 5, No. 12, pp. 638–642.) Description of a variable selectivity arrangement used in Saba receivers, in which the i.f. stage includes six filter circuits, and multipath feedback is applied to widen the flat top of the response curve.

621.396.828 **2020**

Suppression of [negative-] **Impulse Interference by means of Gradient Limiting.**—M. R. Mantz. (*Commun. News*, Dec. 1951, Vol. 12, No. 2, pp. 43–48.) The gradient referred to is the slope of the input-voltage curve. For pulses the slope is generally greater than for wanted signals; circuits are described which discriminate between signals on this basis. These circuits are useful in m-λ and dm-λ communication reception, and also in broadcast reception if loss of the higher audio frequencies is tolerable.

621.396.828 : 621.397.62 **2021**

Suppression of Interference in Radio Receivers caused by Television Receivers.—H. Fighiera. (*Télévis. franç.*, Dec. 1951, No. 77, pp. 12–13.) Discussion of causes of interference, particularly in the timebase circuit. Remedies suggested are the use of screened cable of minimum length for connecting between certain circuits of the television receiver, screening its cabinet, use of a mains filter, and of a high-pass filter in the aerial lead.

STATIONS AND COMMUNICATION SYSTEMS

621.395.43 + 621.396.41 : [621.396.619.13 : 621.396.813 **2022**

Echo Distortion in the F.M. Transmission of Frequency-Division Multiplex.—W. J. Albersheim & J. P. Schafer. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 316–328.) Signal intermodulation by echoes is investigated analytically and experimentally. Two types of echo are considered: (*a*) weak echoes with delays $> 0{\cdot}1\,\mu$s, caused mainly by mismatched long lines; (*b*) strong echoes with delays $< 0{\cdot}01\,\mu$s, caused by multipath transmission and leading to selective fading. Random-noise signals were used to evaluate the echo distortion as a function of various parameters of the echo, the bandwidth and the r.f. modulation.

621.396.226 : 061.75 **2023**

Anniversary of Transatlantic Radio.—R. L. Smith-Rose. (*Nature, Lond.*, 8th Dec. 1951, Vol. 168, No. 4284, p. 980.) A short account of Marconi's early experiments and of the successful transmission of radio signals from Poldhu, Cornwall, to Signal Hill, Newfoundland, on 12th December 1901. See also *Electrician*, 21st Dec. 1951, Vol. 147, No. 3836, pp. 1965–1966, and *Elect. Times*, 13th Dec. 1951, Vol. 120, No. 3136, pp. 1070–1071.)

621.396.44 : 621.315.052.63 **2024**

Type-N Power-Line Carrier Equipment.—J. McCulloch. (*G.E.C. Telecommun.*, 1951, Vol. 6, No. 2, pp. 85–99.) Full details of the Type-NA equipment designed for duplex operation in the range 136–264 kc/s and providing up to eight communication circuits. Other assemblies are available with different frequency bands within the range 80–600 kc/s.

621.396.5 **2025**

Techniques for Close Channel Spacing at V.H.F. and Higher Frequencies.—C. F. Hobbs. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 329–334.) A v.h.f. communication system is proposed in which the transmitter and local-oscillator frequencies of the individual stations are derived by frequency division and s.s.b. technique from a common reference carrier. This carrier would be radiated by a central station. Use of this technique would permit 5 kc/s spacing of R/T channels operating at about 1 kMc/s. Laboratory tests on experimental equipment confirmed this.

621.396.619.11.029.62 : 621.396.97 **2026**

Very High Frequency Sound Broadcasting — The Case for Amplitude Modulation.—J. R. Brinkley. (*J. Brit. Instn Radio Engrs*, Dec. 1951, Vol. 11, No. 12, pp. 585–592. Discussion, p. 593.) The high cost of a v.h.f. broadcasting system in Britain is considered to be unjustified if such a service is used merely to duplicate existing services instead of being used to make available large numbers of new programmes and other services not possible in the present medium-wavelength band. The relative merits of f.m. and a.m. for such a service are considered; a.m. is considered preferable because of the smaller frequency band required and because of lower cost of receivers and frequency converters.

621.396.619.13 : 621.3.018.78 **2027**

Distortion of a Frequency-Modulated Signal by Small Loss and Phase Variations.—F. Assadourian. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 172–176.) 1950 I.R.E. National Convention paper. General formulae are developed for the harmonic and total distortion in the outputs of linear transmission systems with pure f.m. inputs, and with amplitude and phase characteristics involving ripples that can be represented approximately by single sine functions of small amplitude.

621.396.65 **2028**

Radio Links. General Technical Considerations.—P. Marzin. (*Ann. Télécommun.*, Dec. 1951, Vol. 6, No. 12, pp. 363–380.) A survey paper reviewing propagation, types of aerial and transmission line, modulation systems and valves. Four actual installations exemplifying various link types are briefly described, (*a*) a 6- or 12-channel metre-wave p.p.m. portable multiplex equipment; (*b*) a 24-channel 20-cm-wavelength p.p.m. multiplex unit operating between Deauville and Le Havre; (*c*) the 60-channel Dijon-Strasbourg f.m. link with two relay stations, operating on wavelengths of about 1 m; (*d*) the Paris-Lille f.m. link with four relay stations, operating at frequencies centred on 3·78 kMc/s and providing two channels with 240 subdivisions each and one television channel.

621.396.65 **2029**

A Short-Haul Radio Communication Link channelized by Time Division.—E. M. Mortenson & C. B. Young. (*Elect. Engng, N.Y.*, Dec. 1951, Vol. 70, No. 12, pp. 1094–1099.) Description of a p.a.m. system and equipment providing eight 3-kc/s channels. Refinements required for long-distance operation, such as repeater relays, diversity receivers and fault-locating circuits, are eliminated.

621.396.65 **2030**

Radio Relay Design Data, 60 to 600 Mc/s.—R. Guenther. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, p. 337.) Corrections to paper abstracted in 495 of February.

621.396.65 : 621.311 **2031**

Radio Links for Power Stations.—L. Persson. (*Ericsson Rev.*, 1951, No. 2, pp. 42–47.) Description of a particular link developed in Sweden, combining one telephony channel with a number of a.f. tone channels for telemetry and telecontrol. The equipment comprises a 20-W ph.m. transmitter operated in the 160-Mc/s band and providing a total a.f. channel from 300 to 7 500 c/s, and a double-frequency-conversion receiver.

621.396.65.029.62 **2032**

Transportable U.S.W. Directional-Link Equipment.—R. Siegert. (*Telefunken Ztg*, Dec. 1951, Vol. 24, No. 93, pp. 204–212.) This 250-W f.m. equipment is considered to afford the best compromise between output power and equipment weight considerations. Designed for 12-channel operation, it can be modified for 24-channel operation, and is continuously tunable over the 41–75-Mc/s band. Effective range is normally 120–200 km, depending on terrain; for greater distances relay stations must be used, the overall distance being limited to about 300 km if C.C.I.F. requirements are to be met.

621.396.65.029.63/.64 : [621.396.5 + 621.397.5 **2033**

Planning Radio Links (Section Planning).—K. O. Schmidt. (*Fernmeldetech. Z.*, Dec. 1951, Vol. 4, No. 12, pp. 531–536.) A general discussion of communication-channel aspects, route layout, design of aerial towers, etc., with particular reference to plans for relaying television on decimetre wavelengths between Hamburg and Cologne and also between Cologne and Frankfort, in combination with a multichannel telephone system. A zig-zag route is used, and the length of the path between adjacent relay stations does not exceed about 40 km. See also 1431 of May.

621.396.712 : 621.396.66 **2034**

The Design of Automatic Equipment for Programme Routing and Sequential Monitoring.—H. D. M. Ellis & J. C. Taylor. (*B.B.C. Quart.*, Winter 1951/1952, Vol. 6, No. 4, pp. 241–256.) A description of the automatic system used at the B.B.C. s.w. transmitting station at Skelton, Cumberland, for routing six incoming (different) programmes to the 18 separate transmitters and for monitoring the radiated programmes. The programmes are directed to the transmitters via a preset switching mechanism controlled from the station master-clock in accordance with the desired 24-hour schedule; connections to the sequential monitor are similarly controlled. The monitor enables a single operator to listen alternately to a programme line and then to the output of each transmitter connected to that line, each programme line (with associated transmitters) being examined in turn. At worst a fault is discovered in slightly less than 90 seconds. The automatic apparatus is designed to provide reliability of a high order.

621.396.931 : 621.396.619.13 **2035**

Mobile Radio Equipment, Type SRR 178.—D. J. Braak. (*Commun. News*, Dec. 1951, Vol. 12, No. 2, pp. 57–67.) The equipment, designed for duplex operation, has a choice of 10 crystal-controlled frequencies in the 156–174-Mc/s or the 70–87·5-Mc/s band. Phase modulation is used. Special coaxial-line filters enable a single aerial to be used for both transmission and reception.

621.396.931.029.6 **2036**

Switching Methods for V.H.F. [radiocommunication] **Networks.**—E. P. Fairbairn. (*J. Brit. Instn Radio Engrs*, Dec. 1951, Vol. 11, No. 12, pp. 576–584.) A description is given of v.h.f. and u.h.f. types of communication network. The simplex, duplex and two-frequency simplex methods of operation are described and consideration is given to methods for covering large areas of country and to the principles used in selective calling systems.

621.396.933 **2037**

Some Future Developments in Aeradio.—G. R. Scott-Farnie & M. I. Forsyth-Grant. (*J. Brit. Instn Radio Engrs*, Dec. 1951, Vol. 11, No. 12, pp. 595–606.) Developments up to 1939 are briefly reviewed and post-war developments are considered in greater detail. Future developments in air/ground communications are discussed, with particular reference to the effect of extended use of radio teletype equipment. Radio aids to navigation, approach and landing are considered briefly and an outline is given of an 'ideal aeradio' plan which could possibly materialize within the next 10 years.

SUBSIDIARY APPARATUS

621-526 **2038**

Servomechanisms.—H. Chestnut & R. W. Mayer. (*Gen. elect. Rev.*, Dec. 1951, Vol. 54, No. 12, pp. 39–46.) Text of the first chapter of a book (816 of March) dealing with stability and accuracy in automatic control systems.

621-526 **2039**

A Logarithmic Plotting Technique for the Design of Closed-Loop [control] **Systems.**—J. A. Tanner. (*Trans. Soc. Instrum. Technol.*, Dec. 1951, Vol. 3, No. 4, pp. 170–181. Discussion, pp. 181–182.) Description of a design technique based on steady-state response. An explanation is given of the resolution of the gain/frequency characteristic (plotted on logarithmic scales) into asymptotes whose intersection points are determined by the time constants of the control system considered. Reference is made to the gain-phase interrelations developed by Bode. Correlation between the asymptotic gain characteristic and the Nyquist diagram is established and the stability margin is considered. The procedure for determining the characteristics of stabilizing networks is outlined and examples are given of stabilization by means of series elements and by minor-loop elements. Determination of system time constants from experimental frequency response curves is considered briefly.

621-526 **2040**

A Generalized Method for Analyzing Servomechanisms.—A. A. Hauser, Jr. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 197–202.)

621-526 : 621.3.016.352 **2041**

'Hereditary' Phenomena in Servomechanisms; a General Criterion of Stability.—J. Loeb. (*Ann. Télécommun.*, Dec. 1951, Vol. 6, No. 12, pp. 346–352.) If the point (-1, j0) lies outside the area occupied by the family of curves $A\ (x,\ \omega)$ representing a single servo element, the system is stable. If it lies inside this area, the system may oscillate. Nyquist's and Kochenburger's stability criteria are shown to be particular cases of this general criterion. The case of stable oscillations is considered. See also 502 of February.

621.314.63 : 537.311.33 **2042**

The 'Unforming' of Electrolytic Rectifiers and of some Barrier-Layer Rectifiers.—W. C. van Geel & B. C. Bouma. (*Philips Res. Rep.*, Dec. 1951, Vol. 6, No. 6, pp. 401–424. In French.) Unforming, or removal of rectifying properties, is performed by passing current in the opposite direction to the forming current; reforming can be performed by passing current in the same direction as the original forming current, or by passing a.c. These processes are studied experimentally for various electrolytic rectifiers and for Zr-ZrO$_2$-(CuI + I), Se and resin-layer types. It is suggested that in all these cases the rectification is due to a two-layer barrier, one layer being an *n*-type and the other a *p*-type semiconductor; the unforming current removes the conductivity from one of these layers, thus destroying the rectifying properties.

621.314.632.1 **2043**

On the Deviation from Ohm's Law at the Anode Surface of Cuprous-Oxide Rectifiers.—M. Ono. (*J. phys. Soc. Japan*, Sept./Oct. 1951, Vol. 6, No. 5, p. 397.) A discussion of the effects of nonlinear contact resistance between the graphite anode and the cuprous oxide.

621.314.634 **2044**

Creep Phenomena of Selenium Rectifiers.—M. Tomura. (*J. phys. Soc. Japan*, Sept./Oct. 1951, Vol. 6, No. 5, pp. 357–361.) A study of the initial decay of current in the hard-flow direction after application of voltages ranging up to 30 V.

621.316.722.078.3 **2045**

The Design of Series-Parallel Valve Voltage Stabilizers.—F. A. Benson. (*Electronic Engng*, March 1952, Vol. 24, No. 289, pp. 118–119.) Discussion of various factors affecting the achievement of high stability with this type of stabilizer.

621.316.722.078.3 **2046**

An A.C. Stabilizer.—B. Collinge & T. N. Marsham. (*J. sci. Instrum.*, Dec. 1951, Vol. 28, No. 12, p. 374.) "A voltage stabilizer is described which provides a continuously variable alternating voltage which is independent of mains frequency variations and free from waveform distortion. Electronic control of a 2-kVA Variac is used to provide an output voltage constant to within ± ½ V."

621.319.35 **2047**

The Production of High Direct Voltages by Charging Mercury Drops.—A. Dobrowsky. (*Elektrotech. u. Maschinenb.*, 15th Dec. 1951, Vol. 68, No. 24, pp. 577–580.) Discussion of a proposed method in which Hg is sprayed under pressure into an evacuated vessel, the drops being charged during passage through a grid before falling into an iron container, where they coalesce, the voltage consequently rising. Theory is developed, and calculations of performance made.

621.352.39 **2048**

Miniature High-Capacity Battery Cells.—R. R. Clune. (*Electronics*, April 1952, Vol. 25, No. 4, pp. 216 . . 222.) Description of the construction of the RM (Ruben-Mallory) type of cell. The RM-1 is 0·625 in. in diameter, 0·65 in. high, weighs 0·43 oz. and is rated at 1 000 mAh. It will operate efficiently at currents up to 100 mA. A longer cell (1·95 in.) is rated at 3 600 mAh and can furnish currents up to 200 mA. Special construction avoids leakage and renders the cells self-sealing after any escape of gas.

778.37 **2049**

The Photographic Study of Rapid Events. [Book Review]—W. D. Chesterman. Publishers: Oxford University Press, London, 167 pp., 21s. (*Brit. J. appl. Phys.*, Dec. 1951, Vol. 2, No. 12, pp. 368–369.) A valuable reference book for research workers in all spheres of scientific investigation. Methods and equipment for high-speed photography are classified according to the character, speed and duration of the phenomena investigated.

TELEVISION AND PHOTOTELEGRAPHY

621.397.5 : 06.053 **2050**

Television at the Sixth Full Meeting of the C.C.I.R. in Geneva, 1951.—Kirschstein. (*Fernmeldetech. Z.*, Dec. 1951, Vol. 4, No. 12, pp. 542–544.) A brief report of the proceedings. Tables are given showing the stage of development reached and the different operating standards used in the various participating countries.

621.397.5 : 535.62 **2051**

Colour Television and Colorimetry.—W. T. Wintringham. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, p. 357.) Corrections to paper noted in 825 of March.

621.397.5 + 621.396.5]: 621.396.65.029.63/.64 **2052**

Planning Radio Links (Section Planning).—Schmidt. (See 2033.)

621.397.5(204.1) **2053**

Underwater Television.—(*Engineer, Lond.*, 14th Dec. 1951, Vol. 192, No. 5003, p. 764; *Engineering, Lond.*, 14th Dec. 1951, Vol. 172, No. 4481, p. 765.) Describes the rapid adaptation of the Marconi image-orthicon camera to work under water in the search for the submarine 'Affray'. Instrumental modifications included remote operation of camera heating and cooling, remote level indication, and water-leak detection. No electronic modifications were necessary. The camera worked with a 2-in. f-1.29 lens (set at f 4) at a depth of 280 ft. Lighting was provided by a 1·5-kW diver's lamp. Effective range under these conditions was 15 ft and the equipment could be used continuously for two hours or more, whereas a diver could only work for a few minutes.

621.397.61 **2054**

Development Problems of Television Transmitters.—W. Burkhardtsmaier. (*Telefunken Ztg*, Dec. 1951, Vol. 24, No. 93, pp. 193–203.) A survey of the principal problems arising in the design of video transmitters, and discussion of the merits of various solutions proposed. The 1-kW transmitter built for Hamburg N.W.D.R. is described briefly. It operates in the frequency range 174–216 Mc/s, has a bandwidth of 5·75 Mc/s, and the frequency is constant to within ± 1 kc/s.

621.397.611.2 **2055**

Improvements in Image Iconoscopes by Pulsed Biasing the Storage Surface.—R. Theile & F. H. Townsend. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 146–154.) The disadvantages associated with high-velocity electron scanning in storage-type television camera tubes are minimized by periodically irradiating the storage surface with high-velocity electrons, while simultaneously reducing the collector potential. The method is most successful in the transmission of intermittently projected pictures such as 'memory-scanned' cinema films.

621.397.611.2 **2056**

Portable Pickup Equipment for 625-Line Television.—H. Hewel. (*Funk u. Ton*, Dec. 1951, Vol. 5, No. 12, pp. 643–657.) The equipment described consists of four units, (*a*) pulse generator, (*b*) mixer, (*c*) camera and control unit and (*d*) 30-m cable on drum with camera stand; it is operated from a 50-c/s supply at 220 V, 125 V or 110 V, and takes 450 W. The output from the 70-Ω wide-band cable is a 21-Mc/s carrier modulated with the 0–6-Mc/s vision signal.

621.397.62 **2057**

Television Receiver with Interchangeable Units.—(*Télévision*, Dec. 1951, No. 19, pp. 285–289, 295.) Description of a receiver for 819- or 441-line television in which servicing is facilitated by constructing the various functional units on separate chassis.

621.397.62 **2058.**

Choice of Intermediate Frequency in Television Receivers.—J. Harmans. (*Frequenz*, Nov./Dec. 1951, Vol. 5, Nos. 11/12, pp. 307–311.) Harmonic and second-channel interference in the vision signal may be avoided if the i.f. is sufficiently high. The highest i.f. possible in the case of stagger-tuned circuits is determined as a function of bandwidth, number of stages, and valve type. Limiting i.f. values for six different valves are tabulated.

621.397.62 : 621.396.622.72 **2059**

Constant-Input-Impedance TV Second Detector.—W. K. Squires & R. A. Goundry. (*Electronics*, April 1952, Vol. 25, No. 4, pp. 109–111.) A triode with low grid-cathode capacitance is operated with a high-value cathode resistor so that it is self-biased nearly to cut-off. Detection is effected by means of the nonlinearity of the grid-anode characteristic in the cut-off region. Under these conditions the input impedance is practically constant at any given frequency, and for all frequencies is the same as that of a typical i.f. amplifier with the same input capacitance. When this type of detector is used in a receiver with suitably designed video and i.f. circuits, performance is superior to that of an equivalent receiver with a diode detector, particularly as regards transient response.

621.397.621 **2060**

The Theory and Design of Television Frame Output Stages.—E. T. Emms. (*Electronic Engng*, March 1952, Vol. 24, No. 289, pp 96–101.) Two modes of operation are discussed which may be more efficient than the commonly used transformer method with sawtooth-current input. These modes are termed (*a*) the 'minimum mean-anode current' condition and (*b*) the 'zero initial slope' condition. Analysis based on an equivalent circuit is given for the transformer circuit, and the special features of the two modes are described, with particular reference to anode-current waveform. Design examples are outlined for each mode and comparison is made of designs for a peak current of 35·5 mA. This shows that mode (*b*) leads to larger transformer inductances, and greater mean anode current and voltage swing, than mode (*a*). The use of a negative-feedback network to obtain the desired parabolic anode-current waveform is considered and a practical frame timebase circuit is given, with component details.

621.397.621.2 : 621.396.615 **2061**

Blocking-Tube Oscillator Design for Television Receivers.—A. F. Giordano. (*Elect. Engng, N.Y.*, Dec. 1951, Vol. 70, No. 12, pp. 1050–1055.) Essentially full text of 1951 A.I.E.E. Fall General Meeting Paper. When used in a receiver vertical-deflection circuit, the oscillator may be adjusted with its free-running frequency below the synchronizing frequency, so that timing is controlled by the synchronizing pulse. Loss of synchronization may occur due to excessive drift of the free-running frequency; this problem and others relating to interlacing and noise are discussed.

621.397.645 **2062**

The Contribution of the I.F. Amplifier to the Signal Build-Up in Television Receivers.—H. Zimmermann. (*Fernmeldetech. Z.*, Dec. 1951, Vol. 4, No. 12, pp. 537–542.) A theoretical investigation is made of the closeness with which the optimum transmission curve required by the 625-line television standard can be approached using a stagger-tuned three-stage i.f. amplifier. The corresponding build-up transients are shown for ideal conditions and for actual operating conditions. The significance of the phase build-up in the intercarrier process is indicated.

621.397.828 **2063**

Suppression of Harmonics in Radio Transmitters.—G. T. Royden. (*Elect. Commun.*, Dec. 1951, Vol. 28, No. 4, p. 321.) Correction to paper abstracted in 3144 of 1951.

TRANSMISSION

621.396.61 **2064**

A Range of 100 and 150-Watt Transmitters for the M.F., H.F. and V.H.F. Bands.—J. Campbell. (*G.E.C. Telecommun.*, 1951, Vol. 6, No. 2, pp. 72–84.) Technical details of five communication transmitters for which 15 types of standardized unit were developed.

621.396.61 : 621.396.65 **2065**

The LD-T2 Radio Transmitter.—N. F. Schlaack. (*Bell Lab. Rec.*, Dec. 1951, Vol. 29, No. 12, pp. 561–564, 570.) Description of a multichannel s.s.b. transmitter used in the Bell System long-distance radiotelephony network. Operating frequency is in the range 4–23 Mc/s. The transmitter accepts two independent a.f. bands from 100 c/s to 6 kc/s and uses a low-amplitude triple-modulation system followed by a six-stage linear amplifier.

621.396.619.13 **2066**

Realizability of the Point of Inflexion of a Modulation Characteristic for F.M. by means of Reactance Valves.—W. Mansfeld. (*Frequenz*, Nov./Dec. 1951, Vol. 5, Nos. 11/12, pp. 317–323.) Operating conditions for a parallel-connected reactance-valve circuit are discussed. The greatest linearity is obtained in operation about the point of inflexion in the frequency curve. A considerable improvement in linearity can be obtained with a push-pull circuit. The ratio of the voltages across the two parts of the voltage divider for the reactance valve should be smaller in the capacitive than in the inductive type of circuit.

621.396.619.13 **2067**

Frequency Modulation by means of a Capacitor with Controlled Charging Cycle.—R. Otto. (*Frequenz*, Nov./Dec. 1951, Vol. 5, Nos. 11/12, pp. 323–327.) The modulation voltage is applied across two rectifiers connected in series, one of which is directly in series with the fixed capacitor (C) in the h.f. circuit. Control of the charging time can thus be achieved and the effective capacitance of C varied between 10% and 90% of its nominal value, with little distortion. The system works well provided the resistance of the rectifier when conducting is $< \frac{1}{5}$ of the h.f. impedance of the capacitor C. Circuits have been operated satisfactorily at frequencies up to over 100 Mc/s with a frequency swing of 100 kc/s and distortion $<1\%$.

621.397.828 **2068**

Suppression of Harmonics in Radio Transmitters.—G. T. Royden. (*Elect. Commun.*, Dec. 1951, Vol. 28, No. 4, p. 321.) Correction to paper abstracted in 3144 of 1951.

VALVES AND THERMIONICS

621.383 **2069**

The Photoelectric Effect in Cs-Ga, Cs-In and Cs-Tl Photocathodes.—N. Schaetti, W. Baumgartner & C. Flury. (*Helv. phys. Acta*, 31st Dec. 1951, Vol. 24, No. 6, pp. 609–613. In German.) 1951 Société Suisse de Physique Lucerne Meeting paper. Spectral sensitivity and conductivity data are presented and the effects on Cs-Sb cells of additions of In and Tl are reported.

621.383 **2070**

The Properties of Cs-Sb Photocathodes at Different Temperatures.—N. Schaetti & W. Baumgartner. (*Helv. phys. Acta*, 31st Dec. 1951, Vol. 24, No. 6, pp. 614–619.) 1951 Société Suisse de Physique Lucerne Meeting paper. Measurements at temperatures down to −196°C show in all cases a backward shift of the long-wave limit, with conductivity curves of the semiconductor type.

621.384.52 **2071**

The Cold-Cathode Glow Discharge Tube.—D. S. Peck. (*Bell Lab. Rec.*, Dec. 1951, Vol. 29, No. 12, pp. 550–553.) A simple account of the construction and operation of diodes and triodes, with particular reference to Western Electric types, which contain a small quantity of radioactive material as ionization source. Measurements of ionization times under different conditions are reported.

621.385 **2072**

Control of the Current Distribution in Electron Beams.—E. Gundert. (*Telefunken Ztg*, Dec. 1951, Vol. 24, No. 93, pp. 223–236.) Detailed analysis of control by an auxiliary negative grid between two positive electrodes such as the screen grid and anode. The electron trajectories, particularly for the limiting case of oscillation near the grid plane, are calculated to a first approximation. Assuming a uniform electron stream at some distance from the control grid, the control-grid characteristics are determined from the path separation in the limiting case. Three distributions of current about the angle of incidence of electrons on the grid are considered: (*a*) uniform distribution, (*b*) distribution following a trapezoidal law, (*c*) distribution following a bell-shaped curve. Calculations to a second order of approximation give the dependence of the slope of the characteristic on the ratio of the field strengths on the two sides of the grid. Mathematical calculations are mainly confined to appendices.

621.385 : 621.396.822 : 621.317.7 **2073**

Direct-Reading Instrument measures Tube Noise.—van der Ziel. (See 1967.)

621.385-713 **2074**

Evaporation-Cooled Power Tubes.—C. Beurtheret. (*Electronics*, March 1952, Vol. 25, No. 3, pp. 106–107.) Description of the cooling system used in some high-power French broadcasting transmitters. Cooling is so effective that valves can be operated at about three times their normal power rating for conventional water cooling.

621.385.029.6 **2075**

A Travelling-Wave Valve without Retarding Line.—H. Kleinwächter. (*Elektrotech Z.*, 15th Dec. 1951, Vol. 72, No. 24, pp. 714–717.) In usual types of travelling-wave valve the signal wave is greatly retarded to match its velocity to that of the beam electrons. In the valve described here, a density-modulated beam is caused to traverse a path along which the direction of the electric field is alternately positive and negative (e.g. by using a cylindrical waveguide divided into short cylinders, all the odd and all the even members being connected together). An idealized chart showing electron positions at different instants illustrates how signal amplification is achieved. Calculation indicates that there will be three progressive wave components in the beam current, one of which can have an infinitely high phase velocity and can hence supply energy to an unretarded E wave. The valve is superficially similar to that described by Field et al. (2068 of 1951), but operates on a different principle.

621.385.029.63/.64 + 621.392.2 **2076**

Slow Electromagnetic Waves.—Akhiezer & Faynberg. (See 1829.)

621.385.029.64 **2077**

On the Theory of Electron-Wave Tubes.—O. E. H. Rydbeck & S. K. H. Forsgren. (*Acta polyt., Stockholm*, 1951, No. 84, 31 pp.) Reprint. See 2866 of 1951.

621.385.032.216 **2078**

Space-Current Changes in Thermionic Valves following Small Pulses of Current.—J. R. Tillman. (*Proc. phys. Soc.*, 1st Dec. 1951, Vol. 64, No. 384B, pp. 1046–1052.) Amplitude-modulated pulses of voltage were applied to the control grid of a commercial valve working conventionally, and produced space-current changes of up to 0.01 A/cm^2 from the oxide-coated cathode. An unmodulated pulse train sampled the anode current after a delay *t*, and showed a small component at the modulation frequency which decayed with a time constant of about 1 ms as *t* increased. The component was sometimes in phase with the component at $t = 0$ (emission enhancement) and sometimes in antiphase (fatigue). These effects were often related to the history of the valve, but not, apparently, to the impedance between cathode core and coating. Fatigue may be largely a surface effect.

621.385.032.216 **2079**

The Influence of the Core Material on the Thermionic Emission of Oxide Cathodes.—H. A. Poehler. (*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 190–196.)

621.385.032.216 **2080**

The L-Cathode Structure.—G. A. Espersen. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 284–289.) Basic features of this type of cathode are reviewed and methods of measuring the rate of Ba evaporation are described. Data on cathode life of various types of valve are tabulated and briefly discussed. See also 773 of 1951 (Lemmens et al.).

621.385.032.216 **2081**

On Poisoning of Oxide Cathodes by Atmospheric Sulphur.—H. A. Stahl. (*Appl. sci. Res.*, 1950, Vol. B1, No. 6, pp. 397–412.) Detailed account of work noted in 2051 of 1951.

621.385.032.216 : 537.525.92 **2082**

Space-Charge Effect in the Oxide-Cathode Layer.—T. Shindo. (*J. phys. Soc. Japan*, Sept./Oct. 1951, Vol. 6, No. 5, pp. 352–356.) The existence of space charge in the oxide layer, near the surface, is deduced from a theoretical study of a one-dimensional model. The effect of this space charge on the emission properties is indicated.

621.385.032.216 : 537.582 **2083**

On the Equation of Thermionic Emission of the Oxide-Coated Cathode.—Y. Watanabe, E. Takagi & S. Katsura. (*Technol. Rep. Tohoku Univ.*, 1949, Vol. 14, No. 1, pp. 26–45.) A summary of the emission theories, with discussion of the experimental results obtained by Takagi on the initial current characteristic of diodes with cathodes activated to varying degrees.

621.385.2 : [537.315.6 + 621.3.012.6 **2084**

A Method of Calculating the Space Distribution of Potential and the I/V$_a$ Curve for a Diode.—H. Bonifas. (*Bull. Soc. franç. Élect.*, Dec. 1951, Vol. 1, No. 12, pp. 741–757. Correction, *ibid*, March 1952, Vol. 2, No. 15, p. 115.) For calculation of the space distribution of potential see 1162 of April. The I/V$_a$ curve can be conveniently divided into three sections for purposes of calculation. The first comprises the lower bend and the part that is practically a straight line, i.e. covers low values of I. It is determined from the relation $V_a/l = K'\{(I - I_0)/I_{th}\}^{\frac{1}{2}}$, where l = anode-cathode distance, K′ is a coefficient depending on the nature and operating temperature of the cathode, I_0 = anode current for zero voltage, I_{th} = saturation current. The second section comprises the upper bend in the curve, and the third the upper part which is nearly straight and horizontal. Both are calculated from variants of the equation given above, modified to take account of the effect of the cathode field. The method used reproduces the shape of the experimental curve even for high values of l. Appendices establish a theorem applied in the calculation and give a rigorous derivation of Schottky's equation.

621.385.3 **2085**

Effective Grid Potential and Cathode Current Density of a Planar Triode, taking account of 'Island' Formation.—W. Dahlke. (*Telefunken Ztg*, Dec. 1951, Vol. 24, No. 93, pp. 213–222.) The triode is represented by the sum of elementary three-plate capacitors, the grid being replaced by an electrode consisting of a solid plate whose shape and effective potential determine the discharge properties of the valve. This potential is calculated, (*a*) neglecting, (*b*) taking account of space charge. The plate shape is dependent on the degree of 'island' formation, approaching more closely in longitudinal cross-section to a sine wave, of wavelength the same as the pitch of the grid wires, the greater the 'island' formation. The mean penetration factor and its relative variation, as well as the cathode current density and the slope, are shown in a series of diagrams.

621.385.3.029.62/.63 **2086**

Triode Amplifiers in the Frequency Range 100 Mc/s to 420 Mc/s.—D. C. Rogers. (*J. Brit. Instn Radio Engrs*, Dec. 1951, Vol. 11, No. 12, pp. 569–575; *Elect. Commun.*, March 1952, Vol. 29, No. 1, pp. 12–19.) "It has been found possible, by careful attention to the geometry of electrodes and leads, to design triode valves capable of operation at frequencies up to 420 Mc/s in grounded-grid circuits, and yet mounted on conventional pressed-glass bases, and using only the recognized techniques of receiving-valve manufacture. This paper outlines the design features requiring special consideration and gives some of the results achieved with various special valve types."

621.385.832 **2087**

Elementary Theory of the Generation of Electron Beams by means of Triode Systems: Part 1—Properties of the Static Field of commonly used Beam Systems.—M. Ploke. (*Z. angew. Phys.*, Dec. 1951, Vol. 3, No. 12, pp. 441–449.) Electron guns with pillbox and with hairpin cathodes are investigated. The potential field near the cathode exhibits a singularity which is practically independent of the electrode shapes and which gives rise to the observed conical shape of the beam. The axial potential and the dependence of the cathode field on gun dimensions and voltages are determined.

621.385.832 **2088**

Correction of Deflection Defocusing in Cathode-Ray Tubes.—J. E. Rosenthal. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 353–357.) Discussion on paper noted in 1806 of 1951.

621.396.615.141.2 **2089**

The Cut-Off Characteristic and the Potential Distribution of the Magnetron Tube.—Y. Watanabe & S. Katsura. (*Technol. Rep. Tohoku Univ.*, 1949, Vol. 14, No. 1, pp. 10–25.) The curvature of the anode-current/field-coil-current characteristic is discussed in terms of the distribution of initial velocities of the emitted electrons and the change of potential distribution under the magnetic field.

621.396.615.142.2 **2090**

Recent Developments in Klystrons.—R. H. Varian. (*Electronics*, April 1952, Vol. 25, No. 4, pp. 112–115.) A review of progress in the design of reflex, amplifier, and floating-drift klystrons, with mention of an amplifier developed at Stanford University with an output of 10 MW at 3 kMc/s.

621.396.615.142.2 **2091**

The Duplex Traveling-Wave Klystron.—T. G. Mihran. (*Proc. Inst. Radio Engrs*, March 1952, Vol. 40, No. 3, pp. 308–315.) Theory and description of an experimental model designed to combine the properties of the two-cavity klystron and the 'distributed' amplifier.

621.396.615.142.2 **2092**

Power-Amplifier Klystron for Air Navigation.—V. Learned. (*Electronics*, May 1952, Vol. 25, No. 5, pp. 156..166.) Description of the construction of the three-cavity Type-SAL39 klystron, with technical operating data. The frequency range is 0·96–1·215 kMc/s, with corresponding peak output power from 25 to 10 kW.

621.385 **2093**

Elektronenröhren und ihre Schaltungen (Valves and Valve Circuits). [Book Review]—M. Kulp. Publishers: Verlag Vandenhoeck & Ruprecht, Göttingen, 1951, 346 pp., 26.50 DM. (*Fernmeldetech. Z.*, Nov. 1951, Vol. 4, No. 11, p. 523.) "The book will prove extremely useful for scientists of all technical branches."

621.385.032.216 **2094**

The Oxide-Coated Cathode, Vol. 1: Manufacture. [Book Review]—G. Hermann & S. Wagener. Publishers: Chapman & Hall, London, 1951, 148 pp., 21s. (*Z. angew. Math. Phys.*, 15th Nov. 1951, Vol. 2, No. 6, p. 497.) Translation by Wagener of the second volume (see 2603 of 1951) of a standard German work, with additional data on magnetron cathodes.

621.396.615.142 **2095**

Les Tubes Électroniques à Commande par Modulation de Vitesse (Velocity-Modulation Valves). [Book Review]—R. Warnecke & P. Guénard. Publishers: Gauthier-Villars, Paris, 773 pp., 7000 francs. (*Wireless Engr*, April 1952, Vol. 29, No. 343, pp. 112–113.) "In a work with 385 references the authors have set out to present all that is known about velocity-modulation valves, from the point of view both of theory of performance and design and of practical operation and application." . . . They "are to be congratulated on producing this very comprehensive book, not only for the quality of the material presented, but also on account of the enormous effort which must have been necessary to produce such a work."

MISCELLANEOUS

061.3 : 621.39 **2096**

1952 I.R.E. National Convention, New York, 3rd-6th March.—(*Proc. Inst. Radio Engrs*, Feb. 1952, Vol. 40, No. 2, pp. 212–234.) Schedule of the various sessions and summaries of the 211 papers presented.

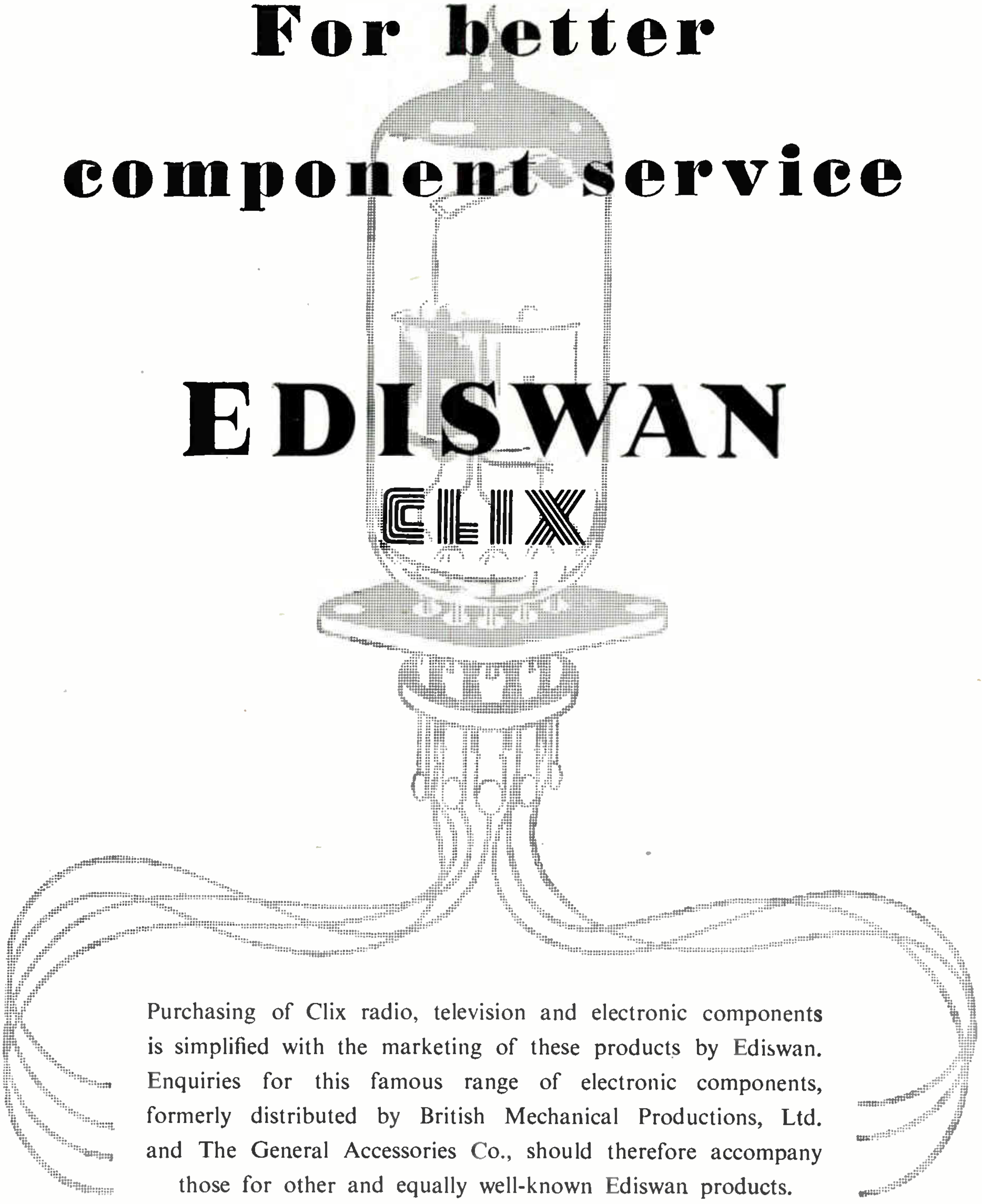
061.4 : 621.396 **2097**

Telecommunications, Radio Navigation and Electronics at the XIXth Salon international de l'Aéronautique (Paris, 15th June-1st July 1951).—M. Adam. (*Génie civil*, 1st Nov. 1951, Vol. 128, No. 21, pp. 401–405.) Report on equipment and components on show.

621.3(083.71/.74) **2098**

Standardisation of Technical Terms and Circuit Presentation.—J. Scott-Taggart. (*Electronic Engng*, Feb. 1952, Vol. 24, No. 288, pp. 63–65.) Condensed version of paper in 'Naval Radio and Electrical Review' discussing the most recent recommendations made by the B.S.I., the British Services and other authorities regarding the choice of technical terms and the use of symbols and abbreviations in publications relating to radio and allied subjects.

For better component service



EDISWAN

CLIX

Purchasing of Clix radio, television and electronic components is simplified with the marketing of these products by Ediswan. Enquiries for this famous range of electronic components, formerly distributed by British Mechanical Productions, Ltd. and The General Accessories Co., should therefore accompany those for other and equally well-known Ediswan products.

THE EDISON SWAN ELECTRIC COMPANY LIMITED
155 Charing Cross Road, London, W.C.2, and branches

Member of the A.E.I. Group of Companies

ER7

ASSOCIATED
ILIFFE
TECHNICAL BOOKS

Reliable and up-to-date works of reference

The books described below are obtainable at all booksellers or direct from: Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. A complete list of Iliffe Technical Books will be sent free on application to the publishers.

SOUND RECORDING AND REPRODUCTION

This book, by J. W. Godfrey and S. W. Amos, B.SC., A.M.I.E.E., has been primarily written as an instruction manual for the BBC engineering staff but will prove invaluable to all interested in the technique of high-quality sound recording. It covers in detail the theory and practice of disc, magnetic and film recording, special reference being made to equipment used by the B.B.C. A number of appendices contains a generous amount of reference information not readily available elsewhere and a wealth of photographs, diagrams, graphs, etc. Published in conjunction with "Wireless World." **30s. net.** *By post 30s. 8d.*

PHENOLIC RESINS

Their Chemistry and Technology. By P. Robitschek, A.P.I., and A. Lewin, B.SC., A.R.I.C., A.P.I. A work of immense value to technologists and chemists in that expanding range of industries which make, compound or use phenolic resins. It describes in detail the history, science and technology, properties, recent industrial developments and applications of the most important group of synthetic resins. Its purpose is to integrate theoretical knowledge and industrial practice, thus providing a close link between the science and technics of phenolic resins. Published in conjunction with "British Plastics." **30s. net.** *By post 30s. 7d.*

ELECTRONS, ATOMS, METALS AND ALLOYS

By Dr. William Hume-Rothery, M.A., D.SC., F.R.S. An elementary introduction to modern atomic theory with special reference to metals and alloys. The subject matter is presented in the form of a dialogue between an Older Metallurgist and a Younger Scientist, thus contrasting the old and new viewpoints and avoiding formal text-book descriptions. Published in conjunction with "Metal Industry." **25s. net.** *By post 25s. 6d.*

METALS AND ALLOYS

Specifications of over 4,500 Non-ferrous Alloys. Fifth edition. The alloys listed in this book are usually regarded as non-ferrous and are limited to those containing not more than 50 per cent. of iron. Many have definite "names," but there are also many which, although not proprietary or no longer so, usually have a recognised composition. A large number of alloys to which specific names are not attached is also included—usually with a description of their purpose. Published in conjunction with "Metal Industry." **15s. net.** *By post 15s. 5d.*

INDUSTRIAL POLISHING OF METALS

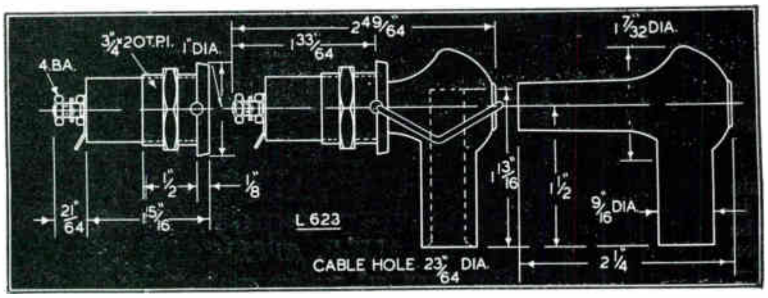
By Gerald F. Weill. Gives in detail the various procedures required for polishing many different kinds of metal articles and describes the tools and materials of the polishing shop. The techniques of automatic, barrel and electrolytic polishing are treated at length, and there are chapters on common defects in polishing, costing, dust extraction and health precautions. Published in conjunction with "Metal Industry." **21s. net.** *By post 21s. 8d.*

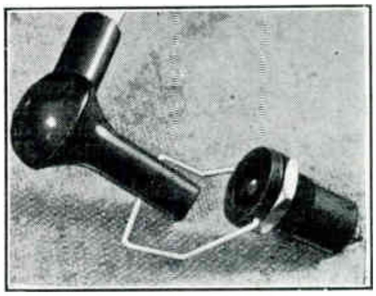
PHOTOGRAPHIC ENLARGING

Second Edition. By David Charles, F.R.P.S. Provides practical guidance on every phase of the subject, from selecting the enlarger itself to mounting the finished print. Material is so arranged that any part of the procedure can be found—and followed—with the minimum amount of trouble. The sections on rigging up a temporary darkroom and selecting papers and chemicals are especially useful. Published in conjunction with "Amateur Photographer." **4s. 6d. net.** *By post 4s. 9d.*

World Radio History

The "Belling-Lee" page for Engineers



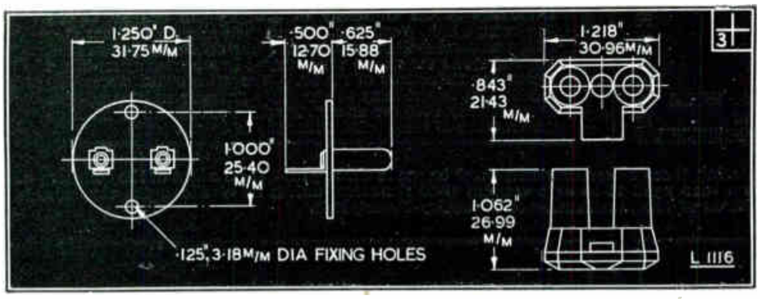


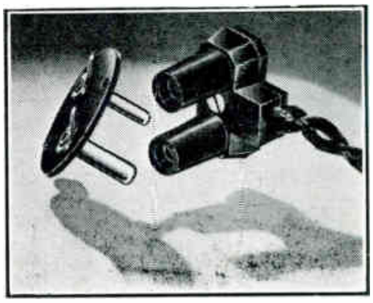
HIGH-TENSION PLUG & SOCKET

L.623/S Flex Socket

L.623/P Panel Plug

Suitable for television and other H.T. apparatus. Adequate insulation is provided together with means for attaching a standard "cabtyre" connecting lead up to 9 mm. "O-Z" construction. It is substantially moulded in phenolic material and the chassis section is of the one-hole fixing type with anti-twist dowel. This is supplied with a retaining clip to prevent the flex part from being inadvertently withdrawn. Either part can be live. Peak working voltage 7,000.





MAINS INPUT CONNECTOR

L.1116/P 2-pole 5 amp Chassis Plug

L.1116/P 2-pole 5 amp Flex Socket

This connector conforms to B.S. 372 specification. It consists of a neatly designed though robust flex socket, the body of which is moulded in black phenolic material.

Socket parts are shrouded for safe handling, and the turned brass inserts are resilient, ensuring positive contact. Efficient cord grip with side entry to discourage withdrawal by pulling cable. Grub screw loading; screw assembly. The plug panel is punched from synthetic resin bonded paper. Tin tipped solder tags.

Please write for booklet P.347/WE.

BELLING & LEE LTD

CAMBRIDGE ARTERIAL RD., ENFIELD, MIDDX., ENGLAND

THE UNIVERSITY OF SOUTHAMPTON
Scholarship in Electronics

Applications are invited for a joint Post-graduate course in Electronics at the University of Southampton and at Vickers Armstrongs, Ltd., Weybridge. The graduate selected will attend the Diploma course in Electronics at the University during the first year, and will spend the second year training in special projects in the Electronics Laboratory of the firm. The value of the scholarship will be that appertaining to the firm's graduate training scheme, approximately £400 per annum. Applications should be made to the Professor of Electronics, University of Southampton.

APPOINTMENTS—The engagement of persons answering these advertisements must be made through the local office of the Ministry of Labour and National Service, etc., if the applicant is a man aged 18-64 or a woman 18-59 inclusive, unless he or she or the employer is excepted from the provisions of The Notification of Vacancies Order, 1952.

CROWN AGENTS FOR THE COLONIES

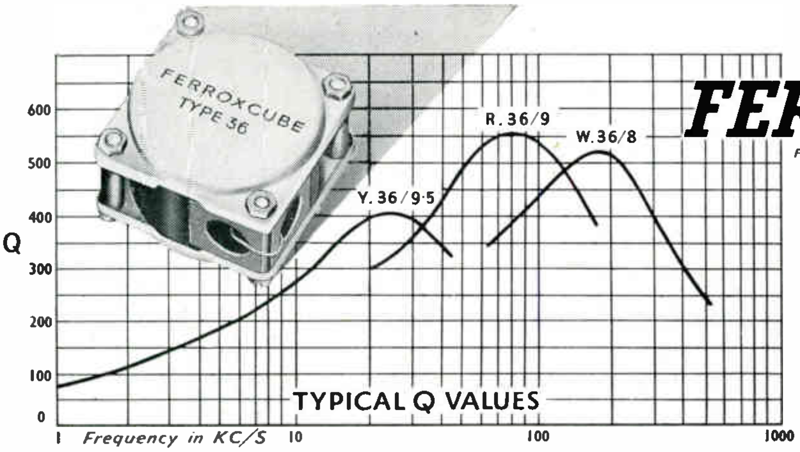
(A) Diesel-Electric Mechanic (M.29389.B.) and

(B) Wireless Operator Mechanic (M.29387.B.) required for the Falkland Islands Dependencies survey for one tour of 18 or 30 months in the first instance. Salary according to qualifications and age in scale £250 rising to £415 a year. Duty allowance of £40 a year. Quarters, subsistence, clothing and liberal routine canteen stores are provided free of charge while serving in Dependencies; it is possible for officers to save almost all emoluments. Liberal leave on full salary. For both posts candidates should preferably be single. For post (A) they must possess a general working knowledge of electricity, and be capable of running and maintaining small diesel generating sets with associated switchboards, accumulators, etc. For post (B) candidates must be able to transmit and receive morse at 25 words a minute (plain language or code) and be capable of elementary maintenance of wireless transmitting and receiving equipment.

Apply at once by letter, stating age, full names in block letters and full particulars of qualifications and experience and mentioning this paper to the Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting on letter the reference number against the appointment for which application is made.

The Crown Agents cannot undertake to acknowledge all applications and will communicate only with applicants selected for further consideration.

Electronic Engineers required by Ministry of Supply in London. **Qualifications:** British, of British parentage; recognised engineering apprenticeship; corporate membership of one of the Institutions of Civil, Mechanical or Electrical Engineers or exempting qualification. Candidates should be familiar with large scale production in industry, and have good knowledge of radar principles and practices *or* lightweight and miniaturised electronic airborne equipment *or* modern ground radio-communications equipment. Practical experience of the types of equipment used by the R.A.F. an advantage. **Duties:** Planning production, progressing and assisting in clearing manufacturing and supply problems connected with a wide range of general radar equipment, or airborne radar equipment, or ground radio communications equipment. Liaison with industry, attendance at technical meetings and examination of expansion schemes. **Salary:** Two grades within the range £655 (at age 26)-£1,280 p.a. according to age, qualifications and experience. Opportunities occur periodically for established pensionable posts. Ref. No. D261/52A. Also Electronic Engineer Technical Grade I. **Qualifications:** Recognised engineering apprenticeship; knowledge of radio systems (including transmitters, receivers, arrays, etc.); experience in radio manufacture; capability to assess the potentialities of manufacturers' plant and to deal with production problems. Higher National Certificate or equivalent qualification desirable. **Duties:** Connected with production of radar and associated equipment, and co-ordination of industrial manufacture and Service requirements. **Salary:** Within the range £733-£891 p.a. Opportunities for established pensionable posts may arise. Ref. No. D262/52A. Application forms from Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1. Quoting appropriate Ref. No.



FERROXCUBE TYPE 36
600
500
400
Q
300
200
100
0
R.36/9
W.36/8
Y.36/9·5
TYPICAL Q VALUES
1
Frequency in KC/S
10
100
1000

Draughtswomen. Owing to the shortage of well-trained draughtsmen a well-known firm of electrical and mechanical engineers in the Greater London area is prepared to offer exceptional chances to draughtswomen of proved ability either as full time or part time.

They must be able to prepare complete layouts from engineer's sketches of either light precision mechanisms or alternatively electronic devices. Those having a bent for mechanical design must be used to specifying fits and tolerances appropriate to precision apparatus.

Salaries will be on a generous scale according to age and experience. Apply to Box 0794, c/o *Wireless Engineer*, quoting ref. E.M.

Electronic engineering company, Teddington area, requires electronic engineer with wide knowledge of industrial electronics including pulse techniques, to take charge of development of new equipments. Well established company. Salary £1,250 plus. Good chance of becoming technical director as present technical director will be going abroad to start foreign branch. Please state education and experience to Box 0868, c/o *Wireless Engineer.*

UNIVERSITY OF BRISTOL

Applications are invited for two Lectureships (Grade II or III) in Electrical Engineering. Salary Scales £400 to £1,100, according to qualifications and experience, with F.S.S.U. benefits and family allowances. Candidates should have an honours degree and some relevant postgraduate experience. For one past, a power engineer with an interest in electrical measurements would bepref erred; for the other, qualifications in high frequency radio are desired. Further details may be obtained on request, and applications should be sent within 3 weeks to The Registrar, The University, Bristol, 8.

Development Engineer required for design of High Frequency heating equipment. Minimum qualifications—Higher National Certificate in Electrical Engineering. Experience in H.F. Heating or Transmitter Development an advantage. Write in first instance stating age, experience and salary required to Philips Balham Works, Ltd., 45 Nightingale Lane, Balham, S.W.12.

VACANCIES IN GOVERNMENT SERVICE

Skilled Craftsmen required for maintenance of Radio, Teleprinter and Electronic apparatus; also Assembler-Testers with experience of Telecommunications equipment by Government Establishments situated in (*a*) Middlesex and Kent (*b*) Gloucestershire. Basic pay (*a*) £6 14s. 6d., (*b*) £6 12s. 0d. plus merit pay up to £2 10s. 0d. according to skill and experience. Paid annual and sick leave according to normal Civil Service Industrial Regulations. Opportunities of securing permanent and pensionable posts.—Apply Box 0883, c/o *Wireless Engineer*,

---

COMMISSIONERS OF NORTHERN LIGHTHOUSES

Applications are invited for the post of RADIO ENGINEER for duties in connection with the maintenance and development of radio aids to marine navigation. Good academic qualifications, a sound knowledge of electronics, and practical experience are essential. Salary scale £880 to £1,170 per annum. Superannuation conditions are similar to those in the Civil Service.

Applicants should apply in writing to the Secretary, Northern Lighthouse Board, 84 George Street, Edinburgh, stating age, qualifications, experience, and enclosing copies of testimonials.

Are you looking for hard work, interesting problems, and a reward proportional to effort? An engineering company on the outskirts of London engaged on an important Guided Weapon project requires several graduate electronic and mechanical development engineers and technical assistants for range work. Engineers should be British born, between the ages of 25 and 30. Salaries range from £500 to £900 and depend on qualifications and experience. The project is new, and there are good prospects for promotion.

Technical Assistants should have practical experience of conducting field trials of electronic and communications equipment. Experience of service radar and telecommunications equipment would be an advantage. Age range 25 to 30, salary range £500 to £700. Apply to Box 0795 c/o *Wireless Engineer*, quoting ref. E.D. for engineers and T.T. for technical assistants.

Designer, with degree or H.N.C. and with experience in light mechanical engineering, is required for work at Stanmore by the G.E.C. Research Laboratories, Wembley, Middlesex. This is a first-class opening for an experienced engineer interested in working with experimental research and development teams. Apply to the Staff Manager (Ref. GBLC/S/186) stating age, qualifications and experience.

The General Electric Co., Ltd., Research Laboratories, Wembley, Middlesex, have vacancies for engineers and physicists for electronic research and development work in the microwave field. Applications will be considered from graduates and also from men with rather lower qualifications. Write to the Staff Manager (Ref. GBLC/S/187) stating age, qualifications and experience.

Senior Appointment—The Research Laboratories of the General Electric Co., Ltd., have a vacancy for a senior engineer or physicist at Stanmore (Middx.) to direct a small research team working in radiocommunications and radar problems. He must be interested in the fundamental aspects of such work and be familiar with centimetric measuring techniques, circuitry, aerials and propagation. He will also be called upon to advise project groups working in these fields. Attractive salary commensurate with experience and qualifications. Apply to the Staff Manager (Ref. GBLC/S/188), G.E.C. Research Laboratories, Wembley, Middlesex.

General Electric Company have two vacancies for graduates for work at Stanmore. (*a*) An experienced man is required to take major responsibility for the design and operation of system test apparatus to be used in connection with airborne radar equipment. (*b*) Physicist or engineer for work on electronic simulators. Apply in writing to the Staff Manager (Ref. GBLC/S/140) Research Laboratories of The General Electric Co., Ltd., Wembley, Middlesex, stating age, experience and qualifications.

Senior and Junior grades of Development Engineers and Draughtsmen required. First-class men able to work with minimum of supervision; good salary, prospects, pension scheme.—Box 153, Gordon House, Farringdon Street, E.C.4.

Technical Publications. Man required to take charge of small Technical Publications section handling Instruction Leaflets, Service Bulletins, etc., on radio and television. Good salary, pension scheme.—Box 154, Gordon House, Farringdon Street, E.C.4

E. K. COLE, LTD. (Malmesbury Division), invite applications from Electronic Engineers for permanent posts in Development Laboratories engaged on long-term projects involving the following techniques:—

1. Pulse Generation and Transmission.
2. Servo Mechanism.
3. Centimetric and V.H.F. Systems.
4. Video and Feedback Amplifiers.
5. V.H.F. Transmission and Reception.
6. Electronics as applied to Atomic Physics.

There are vacancies in the Senior Engineer, Engineers and Junior Grades. Candidates should have had at least 3 years' industrial experience in the above types of work, together with educational qualifications equivalent to A.M.I.E.E. examination standard. Commencing salary and status will be commensurate with qualifications and experience. Excellent opportunities for advancement are offered with entry into a Pension Scheme after a period of service. Forms of application may be obtained from Personnel Manager, EKCO Works, Malmesbury, Wilts.

Electronic Engineer required by Ministry of Supply in London. Qualifications: British, of British parentage; recognized engineering apprenticeship; corporate membership of one of the Institutions of Civil, Mechanical or Electrical Engineers or exempting qualification; production experience related to high vacuum techniques. Knowledge of valve design principles an advantage. Duties: Planning production programmes and progressing contracts for radio valves and cathode ray tubes. Salary: Within the range £655 (at age 26)—£970 p.a. Opportunities occur periodically for established pensionable posts. Application forms from Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London S.W.1. Quoting D.260 52A.

Belling & Lee, Ltd., Cambridge Arterial Road, Enfield, Middlesex, require research assistants in connection with work on electronic components, fuses, interference suppressors and television aerials. Applicants must be graduates of the I.E.E. or possess equivalent qualifications together with similar laboratory experience. Salary will be commensurate with previous experience: five-day week, contributory pension scheme. Applications must be detailed and concise, and will be treated as confidential.

Experienced Engineer required by Company in North-West England for design and development of Television Aerials and Associated Components. Write giving age, experience and salary required to Box 0869 c/o *Wireless Engineer*.

Government department requires Electronic Engineers for laboratory research and development work in Telecommunications, auto-telegraphy, carrier systems, V.H.F. pulse and filter techniques and circuitry.

Candidates should preferably have some experience in one or more of these or related subjects and should be graduates in physics, tele-communications or electrical engineering, or hold Higher National Certificate or City and Guilds final, in radio subjects. Salary in accordance with qualifications and experience within the scales £623/£728 and £445/£623. Location: Cheltenham, except that a period at Sevenoaks will be required for senior appointment. Application forms from Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D 184/52A.

Wanted a Graduate in physics, chemistry or electrical engineering or equivalent to be trained in the capacitor laboratory on the development of new materials, and the exploitation of new manufacturing techniques. No previous experience is necessary, and there are excellent prospects of advancement. Apply to Personnel Department, Standard Telephones & Cables, Ltd., North Woolwich, London, E.16, stating age, qualifications and salary required.

Vacancies exist in a development laboratory engaged in frequency control systems, work which requires initiative and ability to work from basic ideas. Applicants must have at least H.N.C. and some industrial electronics experience. In the near future the laboratory will move to a country location where housing will be available to all suitable applicants. Apply in writing giving full details of academic and other qualifications to the Personnel Manager, Standard Telephones & Cables, Ltd., North Woolwich, London, E.16.

A Senior Radar or Electronic Engineer with an original mind is required near London to anticipate, with suitable new circuits, the radar defensive measures of an ingenious scientific enemy against a new important defence project. Starting salary up to £1,000 according to experience. Write quoting ref. DEF and giving full details to Box 0793, c/o *Wireless Engineer*.

Applications are invited by an expanding Electronic Engineering Company in Buckinghamshire for the following vacancies:—Technical Assistants with experience of electronic equipment; Senior Engineer with B.Sc., Engineering, in electronic subjects, preferably telecommunication, and at least three years' experience of electronic equipment. Accommodation may be available later. Please write, giving full details and salary required, to the Personnel Officer, Airmec Laboratories, Ltd., High Wycombe.

The General Electric Co., Ltd., Brown's Lane, Coventry, have vacancies for Development Engineers, Senior Development Engineers, Mechanical and Electronic, for their Development Laboratories on work of national importance. Fields include microwave and pulse applications. Salary range £400-£1,250 per annum. Vacancies also exist for Specialist Engineers in component design, valve applications, electro-mechanical devices and small mechanisms. The Company's Laboratories provide excellent working conditions with social and welfare facilities. Superannuation Scheme. Assistance with housing in special cases. Apply by letter stating age and experience to The Personnel Manager (Ref. CHC.).

Mathematicians, Physicists or Electronic Engineers with special interest in theoretical problems are wanted urgently for a Guided Weapon project by English Electric Co., Ltd., Luton. Vacancies exist in both junior and senior grades. Salaries from £450-£900 according to qualifications and experience. Please write, giving full details and quoting reference 441G to Central Personnel Services, English Electric Co., Ltd., 24/30 Gillingham Street, London, S.W.1.

Qualified radio, radar, television and servo control engineers and optical system designers, as well as physicists interested in these subjects, wanted for important work of special interest. Posts permanent and progressive. Starting salaries from £450 to £1,000 per annum: a few more senior posts open. Apply, giving full details, to L. H. Bedford, Esq., Chief Engineer, English Electric Co. Ltd., Luton, Beds.

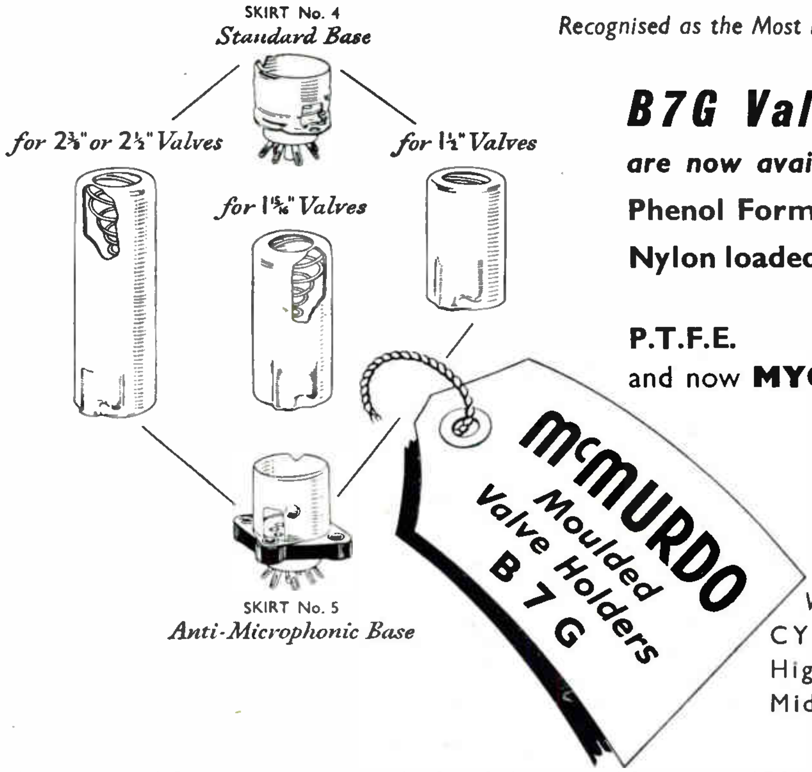
Cable and Wireless, Ltd., invite applications from telecommunications engineers for the development and installation of wireless and telephone projects on the Company's overseas system. Candidates should possess an engineering degree. Commencing basic salary £440 (at 22) to £670 (at 29) and over) per annum according to age, plus a 12½% non-pensionable temporary allowance. Whilst employed overseas they will receive a further allowance of 15% of basic salary, travelling and board lodging expenses being defrayed by the Company. Suitable candidates will be appointed to the Permanent Staff and Superannuation Scheme. Applications in writing, giving full details, should be addressed to the Managing Director, Cable and Wireless, Ltd., Electra House, Victoria Embankment, London, W.C.2.

Applications are invited for the posts of Senior Designers and Senior Draughtsmen with a well-known West Country firm specialising in high-class manufacture of scientific instruments. Experience is essential in one or two at least of the following fields: Development of electro-mechanical devices, servo mechanisms, electronic computing equipment. Applicant sshould be British by birth and at least 27 years of age. Write in the first instance with full details of past experience, whether married or single (assistance will be given in obtaining accommodation), full details of past career and qualifications. Interviews will then be arranged and expenses granted.—Box 0792, *Wireless Engineer*.

Electronic Engineers with several years research or development experience are invited to apply for posts with a well-established company engaged on the development of precision laboratory instruments. Applicants should preferably possess an Honours Degree or equivalent qualifications in physics or light electrical engineering, although this is not essential as considerable practical experience is equally acceptable. The appointments are of a permanent nature for engineers of ability who are capable of developing new projects to the prototype stage, and offer scope for the exercise of individual initiative. The work is of absorbing interest and covers a wide range of electronic instruments. Salaries are commensurate with qualifications and experience. Applications should be made in writing to the Personnel Manager, Furzehill Laboratories, Ltd., Boreham Wood, Herts.

The Plessey Co., Ltd., Vicarage Lane, Ilford, have an immediate vacancy for a graduate engineer between the ages of 25 and 35 with an interest in light electro-mechanical devices and another for an electronic circuit designer. Applicants must be British born, and should preferably have had some experience in design work in these fields. The posts are progressive and pensionable, and are in a newly formed division of the company. Salaries will be in accordance with age and experience. Application should be made, in writing, to the Personnel Manager, quoting ref. G.C.

Draughtsmen and Draughtswomen. A few interesting vacancies exist in the Plessey Co., Ltd., Vicarage Lane, Ilford, for experienced male or female drawing office staff in connection with precision electrical and mechanical equipment. Salaries will be in accordance with age and experience. Apply, in writing, to the Personnel Manager, quoting ref. C.W.



Recognised as the Most Reliable Valveholders

B7G Valveholders

are now available moulded in:—

Phenol Formaldehyde *(Black).*

Nylon loaded Phenol Formaldehyde *(Natural Brown).*

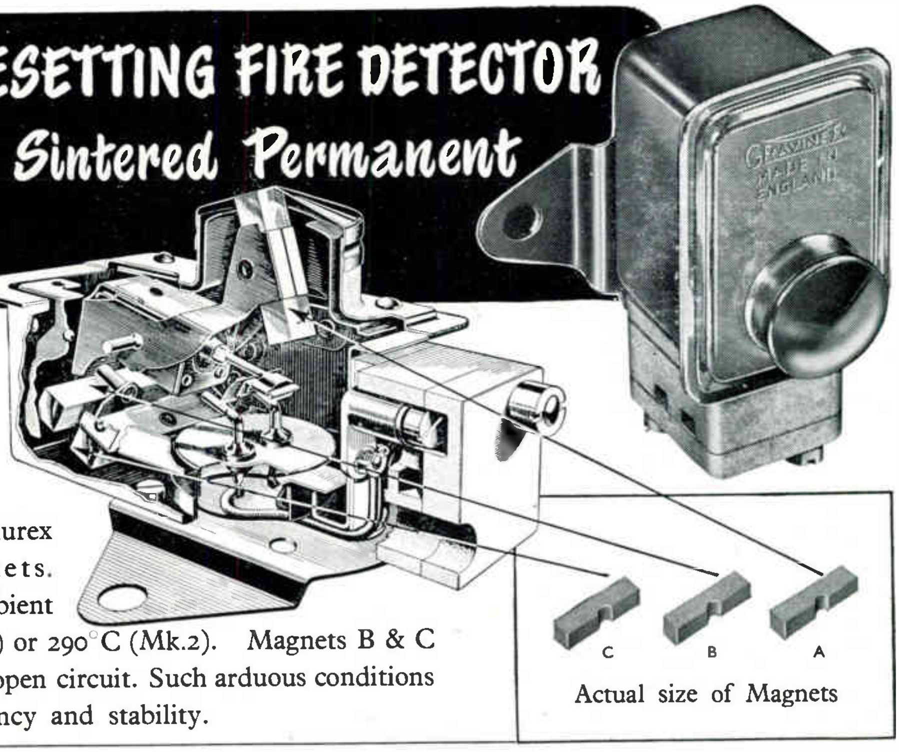
P.T.F.E.

and now **MYCALEX.**

Wholesale Enquiries:—
CYRIL FRENCH LTD.,
High St., Hampton Wick,
Middlesex. KIN. 2240.

Manufacturers' Enquiries: THE McMURDO INSTRUMENT CO. LTD., VICTORIA WORKS, ASHTEAD, SURREY
ASHTEAD 3401

GRAVINER RESETTING FIRE DETECTOR uses MUREX Sintered Permanent MAGNETS

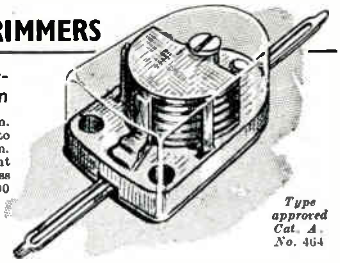


Actual size of Magnets

Another application of Murex permanent sintered magnets. Magnet A is subjected to ambient temperatures of 170°C (Mk.1) or 290°C (Mk.2). Magnets B & C are working in repulsion and open circuit. Such arduous conditions call for high magnetic efficiency and stability.

MUREX LIMITED *(Powder Metallurgy Division)* **Rainham · Essex** *Telephone: Rainham, Essex, 3322*

LONDON SALES OFFICE: CENTRAL HOUSE, UPPER WOBURN PLACE, W.C.1. *Telephone: EUSton 8265*



Index to Advertisers

PAGE
Advance Components, Ltd. 5
All-Power Transformers, Ltd. 10
Appointments 20, 22, 24
Automatic Coil Winder & Electrical Equipment Co., Ltd. 21

Belling & Lee, Ltd. 19
Birmingham Sound Reproducers, Ltd. 6
British Physical Laboratories 8
Brookes Crystals, Ltd. 12
Bullers, Ltd. .... Cover ii
BX Plastics, Ltd. 2

Edison Swan Electric Co., Ltd., The 17
Foyle, W. & G., Ltd. 20

Goodmans Industries, Ltd. 6
Griffiths, Gilbart, Lloyd & Co., Ltd. 12
Guest, Keen & Nettlefolds, Ltd. 3

PAGE
Hivac, Ltd. 10
Hunt, A. H., Ltd. .... Cover iv

Jay Developments 20

Lyons, Claude, Ltd. 1

Marconi Instruments, Ltd. 12
Marconi Wireless Telegraph Co., Ltd. 11
McGraw-Hill Publishing Co., Ltd. 4
McMurdo Instrument Co., Ltd. 25
Muirhead & Co., Ltd. 2
Mullard, Ltd. 16, 21
Murad Developments, Ltd. 10
Murex, Ltd. 25

Oxley Developments Co., Ltd. 26

Pitman, Sir Isaac & Sons, Ltd. 20

PAGE
Reproducers & Amplifiers, Ltd. 26

Salford Electrical Instruments, Ltd. 23
Standard Telephones & Cables, Ltd. 9
Steatite & Porcelain Products, Ltd. 13
Sullivan, H. W., Ltd. 14

Telegraph Condenser Co., Ltd., The .... Cover iii
Telegraph Construction & Maintenance Co., Ltd., The 4
Telephone Mfg. Co., Ltd. 7

University of Southampton 20

Wayne Kerr Laboratories, Ltd., The 23
Webb's Radio 26
Wego Condenser Co., Ltd. 8

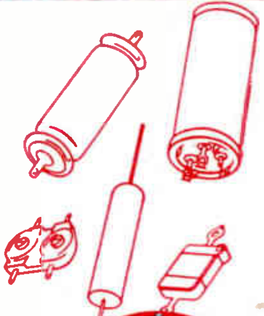
Printed in Great Britain for the Publishers, Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1, at The Baynard Press by Sanders Phillips & Co., Ltd., Chryssell Road, London, S.W.9.

Quest and Test — symbols of Condenser Perfection

There are many men and women at T.C.C. who are employed solely to keep production down! They are, of course, the keen-eyed testers whose job it is to ensure that no condenser which does not meet every required standard ever leaves the works.

To aid them in their unrelaxing vigilance, batteries of truly "mechanical brains" — designed and built in the works — perform miracles of selection and rejection. These machines — exclusive to T.C.C. — progressively subject the condensers to capacity, insulation and over-voltage tests, some of them marking each condenser according to its performance.

This is part of the never-ending pursuit of perfection which is the background of leadership — and has been for 45 years.



TCC

SPECIALISTS IN CONDENSERS SINCE 1906

THE TELEGRAPH CONDENSER CO. LTD · *RADIO DIVISION* · LONDON · W.3 Tel: ACORN 0061 (9 lines)

MICA CAPACITORS FOR TRANSMITTERS & INDUSTRIAL ELECTRONIC EQUIPMENT

Mica capacitors designed and built to handle R.F. power are available in a variety of housings and sizes. The range includes open clamp construction and stacked mica types in porcelain or metal tank containers.

The standard range of metal tank types covers four sizes of cast aluminium containers and is extended with steel and non-ferrous tanks.

A greatly improved Mark 51 version of the HUNT-INGRAM (Mycalex product) type of R.F. Capacitor is now available. Full details on request.

The very special nature of these types, however, means that to provide for efficiency and economy in use, specific designs must often be prepared to meet individual needs. Hunts specialise in such work and enquiries from designers are most welcome.

OPEN CLAMP CONSTRUCTION TYPES L74 AND L75
Alternative to oil filled tanks for handling considerable R.F. Power in limited space.

PORCELAIN CASED TYPE L76
Range includes ratings up to 10 kVA and D.C. Voltages up to 10 kV peak.

METAL TANK TYPE L73—oil filled—for application where the R.F. conditions exceed 10 kVA.

REGISTERED TRADE MARK

HUNTS CAPACITORS

THE TRADE MARK OF RELIABILITY

ESTABLISHED 1901

A. H. HUNT (Capacitors) LTD. WANDSWORTH, LONDON, S.W.18 BATtersea 3131

Meet us at **STAND No. 56,** The National Radio Show, Earls Court, Aug. 26-Sept. 6