WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

APRIL 1953

VOL. 30 No. 4 THREE SHILLINGS AND SIXPENCE

CARPENTER

POLARIZED RELAYS

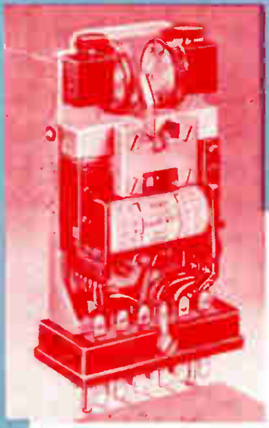
CHIEF CHARACTERISTICS

High operational speeds . Freedom from contact rebound and positional error . Good contact pressure . Accuracy of signal repetition . High sensitivity . Ease of contact adjustment . Contact gap a function of input power.

Due to the unique combination of characteristics inherent in the design of Carpenter Polarized Relays, they are providing practical solutions to many problems in scientific research and electrical engineering.

Their high standard of performance makes them suitable for use where signal impulses of varying time duration must be repeated with the utmost accuracy, for instance in telegraphy, measurement, protection and tele-control schemes.

The relay operates successfully direct from valves, the barrier layer type of photo cell, and also from thermo-couples. In the amplification of very weak D.C. signals, the relay's almost perfect contact performance makes it suitable for the inversion of the D.C. into A.C. to permit electronic amplification. *Three Main Types are available.*



TYPE 3

has maximum speed : maximum contact pressure and sensitivity : minimum transit time. Dimensions : 120 mm. × 61 mm. × 33 mm. Weight 625 gm.

TYPE 4

has longer contact travel than the Type 3, with medium speed and sensitivity. Dimensions : 89 mm. × 56 mm. × 25 mm. Weight 368 gm.

TYPE 5

miniature relay with outstanding performance for size. Rugged design of exceptional thermal stability. Dimensions : 56 mm. × 37 mm. × 19mm. Weight 140 gm.

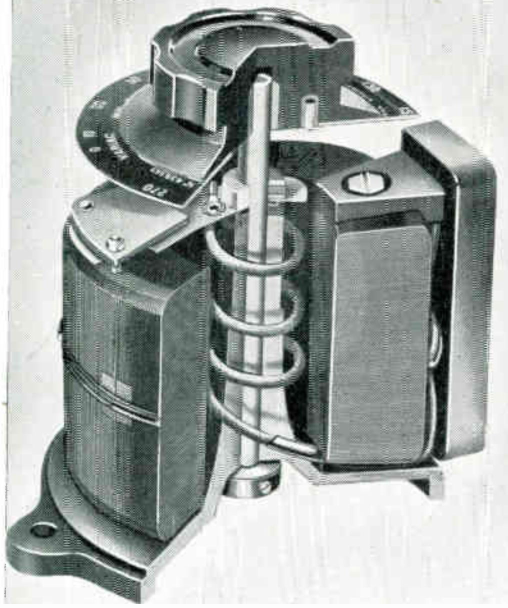
Relays can be supplied with either solder tag or plug base.

Note.—All dimensions quoted exclude connection terminals.

Complete details and performance data will be willingly supplied on request by the Manufacturers:

TELEPHONE MANUFACTURING CO. LTD
HOLLINGSWORTH WORKS · DULWICH · LONDON · S.E.21
Telephone: GIPsy Hill 2211 (10 lines) Cables: BUBASTIS LONDON

TMC



for smooth voltage control

'VARIAC'

Registered Trademark.

—the original continuously-adjustable auto-transformer—is the ideal device for controlling any a-c operated equipment. VARIACS not only supply perfectly smooth control of voltage from zero, but some models also include an "over voltage" feature. VARIACS are designed and built for many years of trouble free operation.

SPECIFICATIONS

SERIES "50" Variacs

Type	Load Rating	Input Voltage	Current		Output Voltage	No-Load Loss	Net Price £ s. d.*
			Rated	Maximum			
50-A	5 kva.	115 v.	40 a.	45 a.	0-135 v.	65 watts	44 18 6
50-B	7 kva.	230/115 v.	20 a.	31 a.	0-270 v.	90 watts	44 18 6

SERIES "100" Variacs

Type	Load Rating	Input Voltage	Current		Output Voltage	No-Load Loss	Net * Price £ s. d.
			Rated	Maximum			
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.

SERIES "200" Variacs

Type	Load Rating	Input Voltage	Current		Output Voltage	No-Load Loss	Net Price £ s. d.*
			Rated	Maximum			
200-CM 200-CU	860 va.	115 v.	5 a.	7.5 a.	0-135 v.	15 watts	7 17 6 6 15 0
200-CMH 200-CUH	580 va.	230 v. 115 v.	2 a. 0.5 a.	2.5 a. 2.5 a.	0-270 v. 0-270 v.	20 watts 20 watts	9 15 0 8 5 9

*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, as well as data on other special patterns.

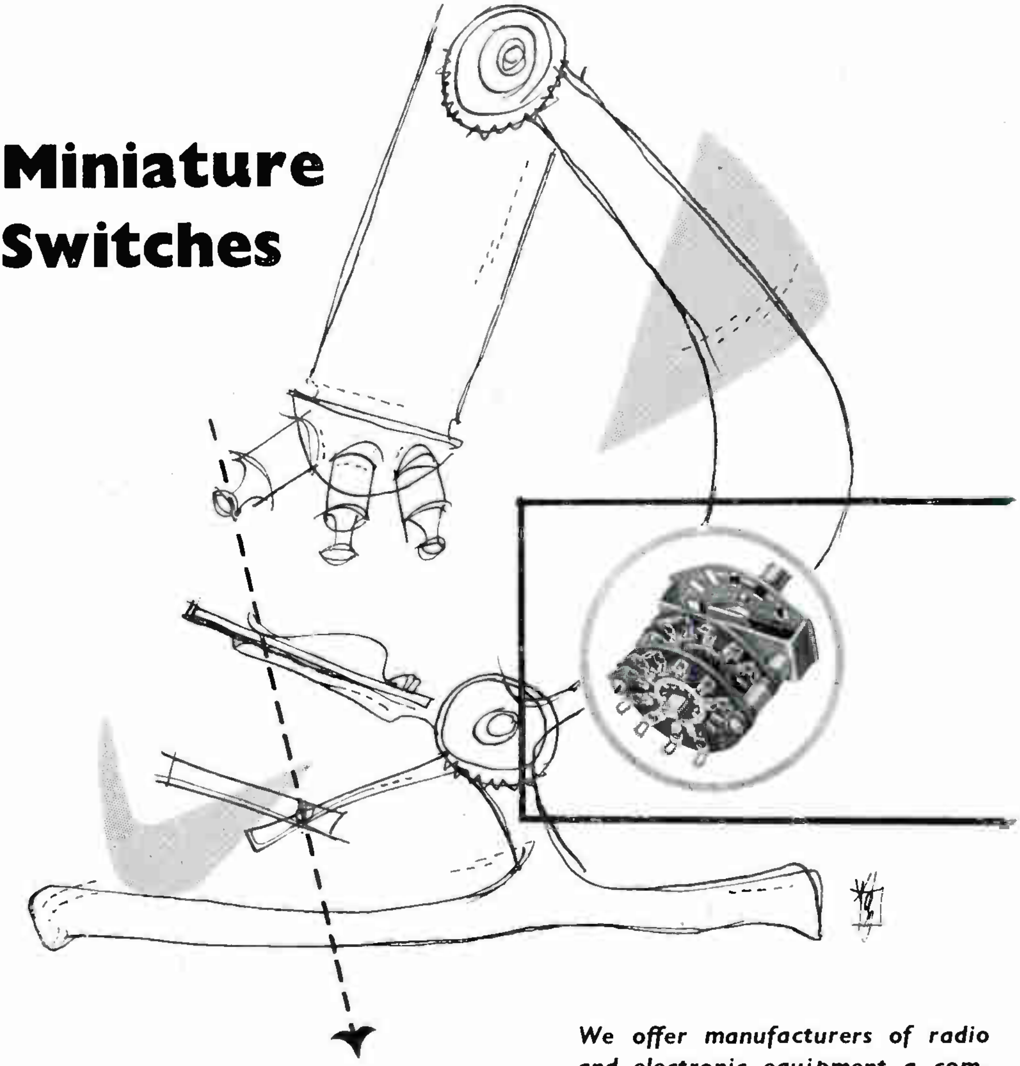
PROMPT DELIVERY

CLAUDE LYONS LIMITED

ELECTRICAL AND RADIO LABORATORY APPARATUS, ETC.

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

Miniature Switches



"A chip off the old block"—this refers, of course, to the miniature version of the well-known A.B. "H" Type switch. It combines all the virtues of the Standard "H" Type—yet takes up so much less space. Of sound and robust design it is capable of operating under widely varying conditions.

We offer manufacturers of radio and electronic equipment a comprehensive range of switches, designed to meet the most exacting requirements.

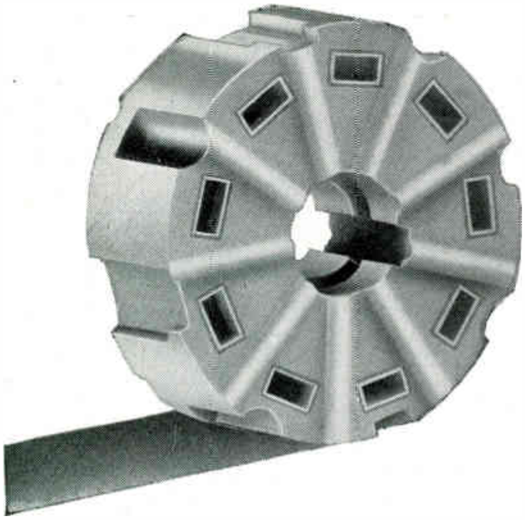
Our illustrated catalogue and Technical Service are freely available, and manufacturers are invited to make fullest use of these facilities.

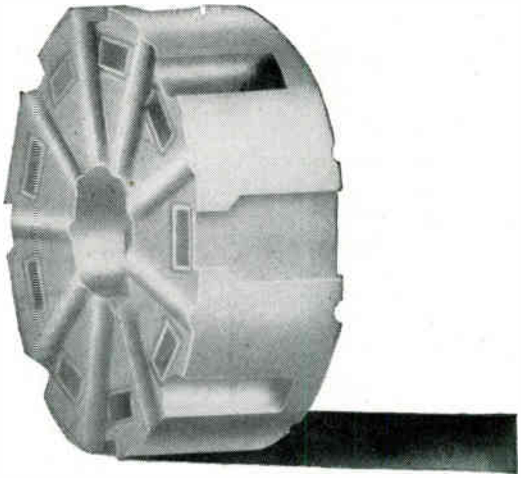
Individual specifications welcomed

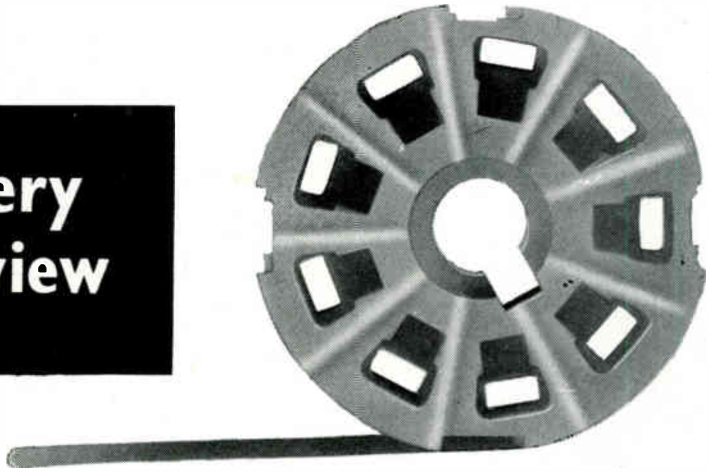
AB Metal Products Ltd

16 BERKELEY STREET, LONDON, W.1

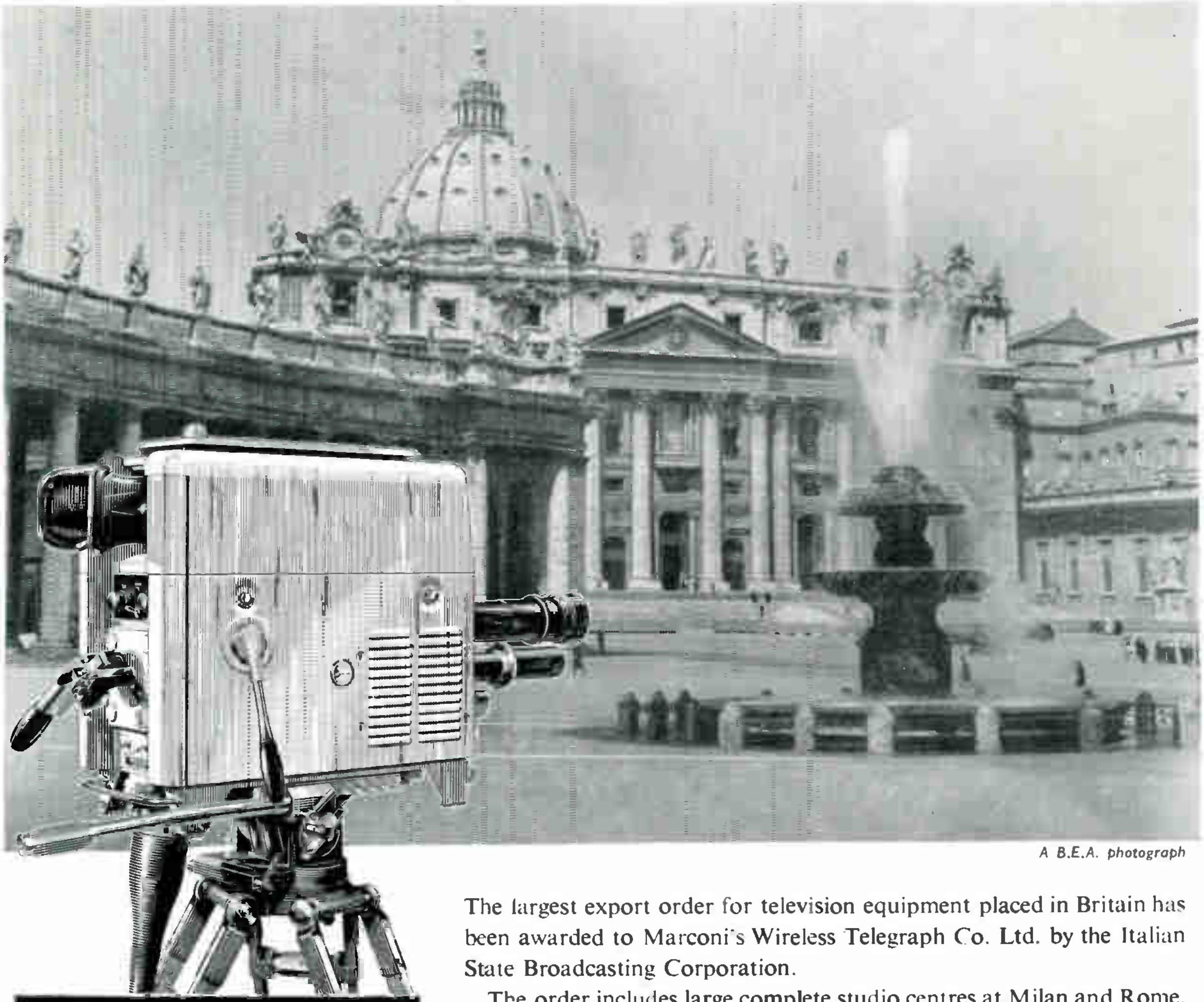
'Phone : GROsvenor 5206/7.







Marconi Television for Italy



A B.E.A. photograph

Equipment purchased by R.A.I. through Italian Marconi Company includes:

- 7½ kW vision transmitters
- 2½ kW sound transmitters
- Marconi Image Orthicon Cameras
- Complete studio installations
- Two mobile O.B. television units, complete with micro-wave links.

The largest export order for television equipment placed in Britain has been awarded to Marconi's Wireless Telegraph Co. Ltd. by the Italian State Broadcasting Corporation.

The order includes large complete studio centres at Milan and Rome, O.B. units for Rome, and medium power transmitting stations at Rome and Pisa.

This order follows those for television installations in the U.S.A., Canada, South America and Thailand.

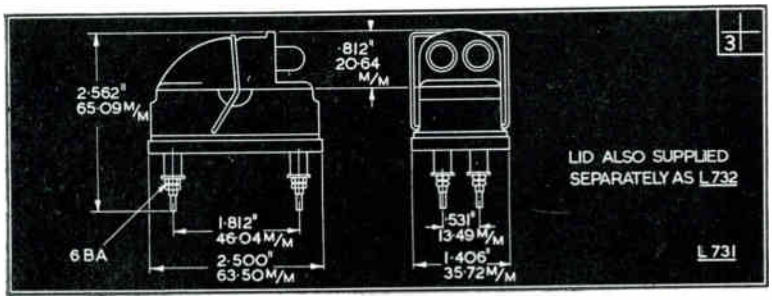
Marconi high power or medium power transmitters and high power aerials have been installed in every one of the B.B.C.'s television transmitter stations.

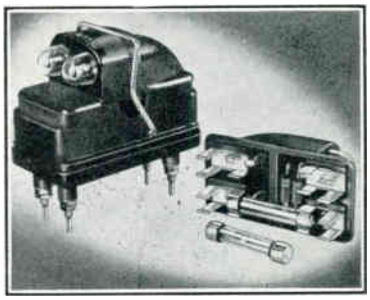
MARCONI

television transmitting equipment

MARCONI'S WIRELESS TELEGRAPH COMPANY LTD · CHELMSFORD · ESSEX

The "Belling-Lee" page for Engineers





L.732
TWIN NEON CARRIER
WITH RETAINING CLIP

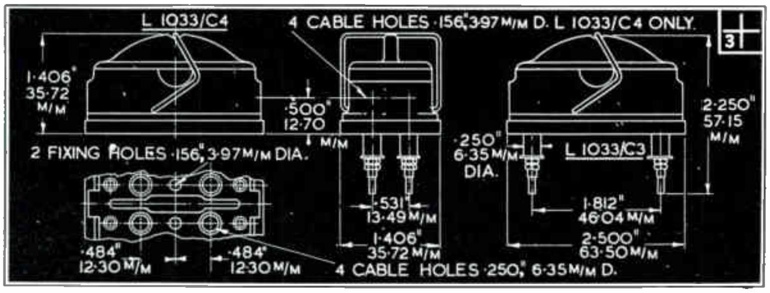
L.730
TWIN FUSEBOX WITH
CARRIER AND RETAINING
CLIP

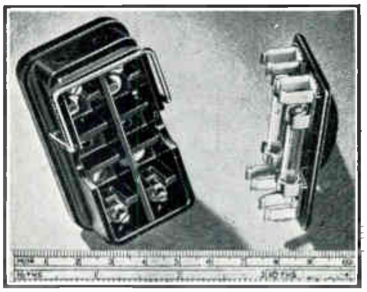
L.731
AS L.730 BUT WITH
BACK CONNECTIONS

TWIN NEON INDICATING FUSEHOLDER

The twin neon indicating fuseholder L732, illustrated above top right, carries two neon lamps, and where required may be used to replace the normal fuse carrier on standard "Belling-Lee" twin fuseboxes L1033, shown below. The overall depth is thereby increased by $\frac{5}{16}$ in, but the panel area remains unchanged.

Two lamp-holders with resistors are built into the moulding, and are arranged in such a manner that the adjacent lamp gives visual indication when either fuse blows. The neons will glow satisfactorily over a voltage range of 180/250V. a.c. (r.m.s.), or 220/250V. d.c.





L.1033/C4
WITH CARRIER RETAINING
CLIP

L.1033/C3
AS ABOVE, WITH
BACK CONNECTIONS
AND BUSHES

A replacement retaining clip is supplied with the carrier. This ensures that when the box is properly wired, the neons can only be inserted in the correct phase of the supply.

Supplied separately or complete with bases.

The above items together with many other new lines will be exhibited on our STAND No. 52, R.E.C.M.F. EXHIBITION, April 14th to 16th.

BELLING & LEE LTD
CAMBRIDGE ARTERIAL RD., ENFIELD, MIDDX., ENGLAND

Standard push button ATTENUATOR

for true V.H.F measurements

This outstanding "*Standard*" V.H.F. Attenuator now in its second year of production remains the first and only accurate instrument of its kind and continues to meet a heavy demand from leading organisations and authorities the world over.

Four models now available

Characteristic Impedance	75 ohms	50 ohms
0-9 db in 1db steps	Type 74600-A	Type 74600-E
0-90 db in 10 db steps	Type 74600-B	Type 74600-F

All types will handle inputs up to 0.25 watts.

Accuracy of D.C. adjustment

0-9 db Models: The insertion loss error will not exceed ±0.05 db for any setting.

0-90 db Models: The insertion loss error for the 90 db setting will not exceed ± 0.3 db. For other settings this limit falls linearly to a value of ±0.06 db at the 10 db setting.

High frequency performance

0-9 db Models : At 50 Mc/s the insertion loss error for the 9 db setting will not exceed ± 0.15 db. For other settings this limit falls linearly to a value of ±0.05 db for the 1 db setting.

0-90 db Models : At 50 Mc/s the insertion loss error will not exceed ±0.1db per step. N.B. All insertion loss errors are relative to zero db setting.

Ready for Building into your own equipment.
Calibration charts for frequencies up to 100 Mc/s for the 0-9 db models or 65 Mc/s for the 0-90 db models can be supplied on request.

Standard Telephones and Cables Limited

Registered Office : Connaught House, Aldwych, London, W.C.2
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Grinding Mullard 'Ticonal' permanent magnets to required size.

MAGNETIC MATERIALS Extensive research and manufacturing facilities have established Mullard as the leading producers of magnetic materials. They were the first, for example, to introduce Ferroxcube, the world's most efficient magnetic ferrite; 'Ticonal' anisotropic permanent magnets, renowned for their high stability and high energy output; and Magnadur, an entirely new type of permanent magnet with the insulating properties of a ceramic.

The wealth of experience gained from these developments is available to all users of magnetic materials through the Mullard advisory service. An enquiry to the address below will put a team of specialised engineers at your disposal.

Mullard

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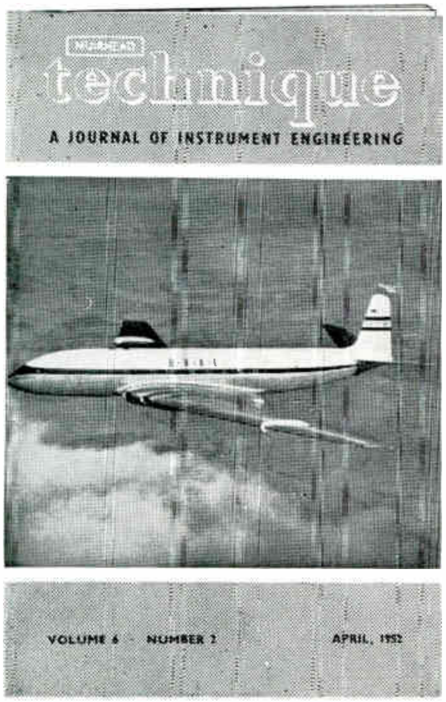
'TICONAL' PERMANENT MAGNETS · MAGNADUR (Formerly Ferroxdure) PERMANENT MAGNETS · FERROXCUBE MAGNETIC CORE MATERIAL

MULLARD LTD., COMPONENT DIVISION, CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2.



MODEL 501
(fitted with end frames)

. . . fix it better,
more quickly and
neatly.
Unbrako Socket Screws
have extra strength
and toughness.
They are made of
high-tensile nickel-chrome
steel alloy.
They stay put
until you want to remove them.
Then—out they come,
smoothly, easily, without damage.
No wonder so many designers and engineers specify Unbrako!

Available for immediate delivery.
Send for free samples.

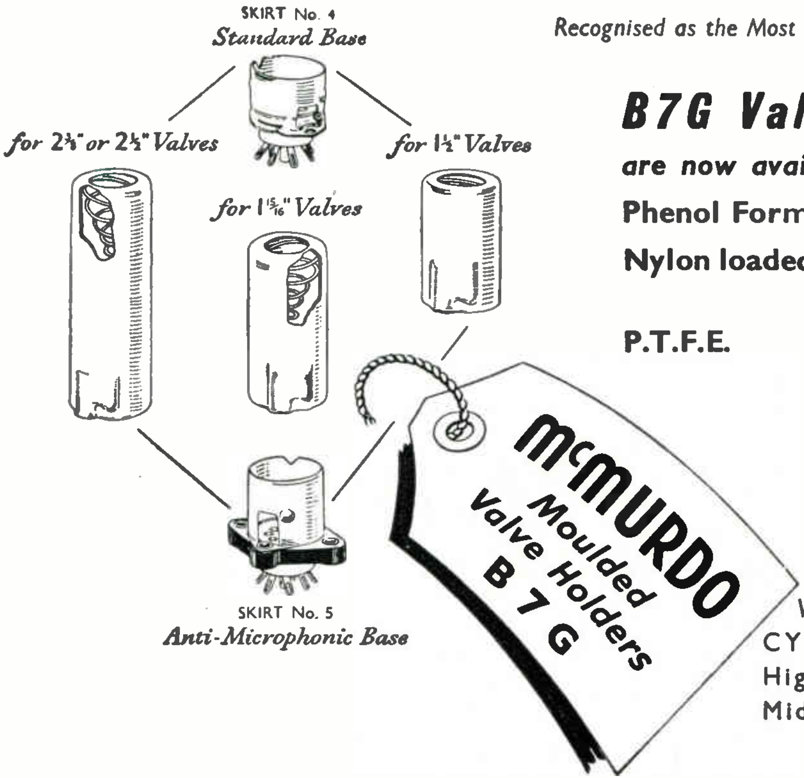
UNBRAKO SOCKET SCREW COMPANY LTD.

Manufacturers of Unbrako standard socket screws and special screws to A.I.D. requirements.

COVENTRY ENGLAND

UNBRAKO

A*


SKIRT No. 4
Standard Base
for 2¼" or 2½" Valves
for 1½" Valves
for 1$\frac{15}{16}$" Valves
McMURDO
Moulded
Valve Holders
B 7 G
SKIRT No. 5
Anti-Microphonic Base

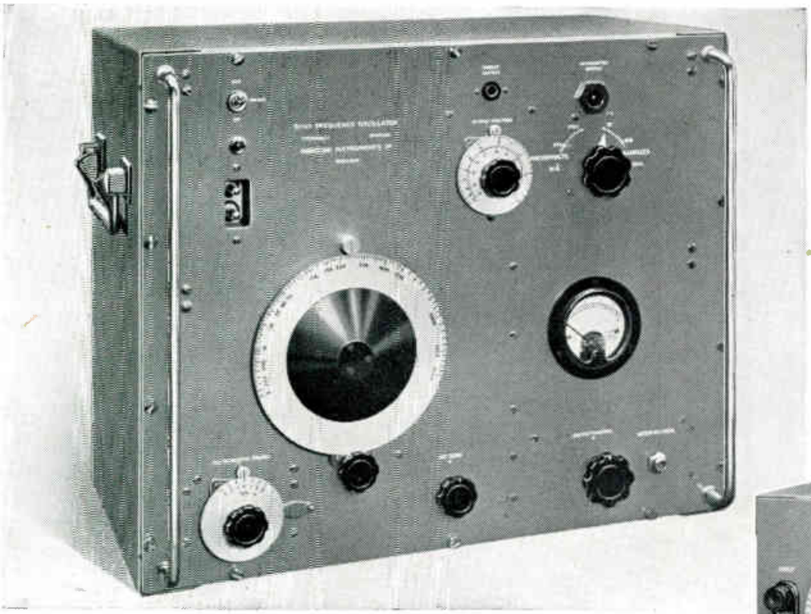
Beat Frequency Oscillators

BEAT FREQUENCY OSCILLATOR TYPE TF195M.

THE MARCONI TF 195M is a low-distortion tone generator of the heterodyne type. This carefully designed instrument covers a frequency range of 10 c/s to 40 kc/s and has a maximum output of 2 watts at source impedances of 600 and 2,500 ohms. Its companion instrument — Wide Range Beat Frequency Oscillator Type TF 195M/5 — has a coverage of 50 c/s to 200 kc/s and incorporates a ladder network output attenuator.

Full details of these, and of other B.F.O.'s in the Marconi range, gladly sent on request.

Ask also for specification of TF 338B 600 ohm VARIABLE ATTENUATOR — of sensibly constant input impedance, suitable for audio frequency measurements; virtually linear decibel scale; with metal panel and case providing screening against external fields.



WIDE RANGE BEAT FREQUENCY OSCILLATOR TYPE TF195M/5.

VARIABLE ATTENUATOR TYPE TF338B.

MARCONI

INSTRUMENTS

SIGNAL GENERATORS · BRIDGES · VALVE VOLTMETERS · FREQUENCY STANDARDS · OUTPUT METERS · WAVE METERS · WAVE ANALYSERS

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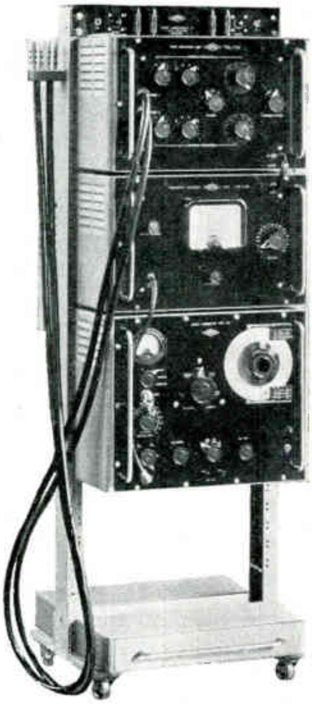

AIRMEC

PHASE MEASURING EQUIPMENT

TYPE RX103

THIS equipment has been developed and manufactured by Airmec Limited from a General Post Office Research Branch design. It was primarily intended for the measurement of the loop phase-shift and gain of feedback repeaters over the frequency range 50 kc/s-20 M/cs, but it is equally suitable for the measurement of these quantities in amplifiers, filters, equalisers and other four terminal networks.

Full details of this or any other Airmec instrument will be forwarded gladly upon request.

AIRMEC LIMITED

HIGH WYCOMBE — BUCKINGHAMSHIRE — ENGLAND

TEL: HIGH WYCOMBE 2060 *CABLES: AIRMEC HIGH WYCOMBE*

Type "S"

Frequency range: 100 Kc/s to 15 Mc/s.
Quartz crystal plate of appropriate cut and dimensions to suit the frequency requirement, mounted in bakelite case 1$\frac{7}{8}$in. high, 1$\frac{9}{16}$in. wide, $\frac{3}{4}$in. thick, with two $\frac{1}{8}$in. diameter pins $\frac{3}{4}$in. apart. Frequency tolerance 0·01% of nominal at 20°C., or better for special applications. Frequency-temperature coefficient better than 2 parts in 10^6 per 1°C., over temperature range of −20°C. to +70°C.

CRYSTAL FREQUENCY CONTROL

Be SURE with

BROOKES

Because we specialise in the exclusive production of Crystals, all our skill and resources are devoted to ensuring precise accuracy and conformity to specification.

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by A. T. Starr
M.A., Ph.D.
M.I.E.E.

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World Radio History

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–it's GOOD whatever you call it!

There has been difficulty in naming ours. Never mind the name—you judge the product!

TRUVOX
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MARK III

These are the main features:—

1. Three motor drive.
2. " Drop-in " Tape loading.
3. Push-button control, electrically and mechanically interlocked.
4. Separate push-button brake.
5. " Fast-forward " and " fast-rewind " without tape wear.
6. Silent drive eliminating " wow " and " flutter."
7. Half-track working, and two Tape speeds of 7½ inches per second, or 3¾ inches per second.
8. Visual playing-time indicator.
9. With a suitable amplifier, the equipment covers a frequency range from 50-10,000 c.p.s. at 7½ inches per second.

22 Gns
MODEL TR2
200/250 volts
A.C. mains only

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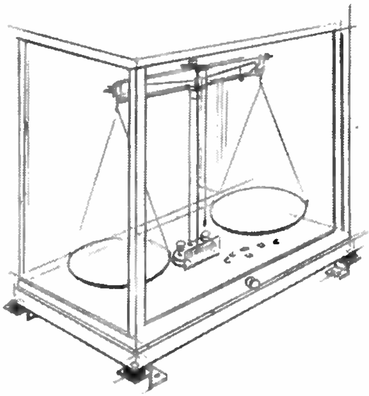
EXHIBITION GROUNDS • WEMBLEY • MIDDX
Telephone: Wembley 1212

Sole distributors to the Wholesale Trade for Rola and Celestion Speakers

APPLICATION 95
SERIES 38



"FLEXILANT" MOUNTINGS
SERIES 38

IN this instance the Series 38 "Flexilant" Mounting protects a delicate instrument from vibration in all its forms. Its other applications are manifold—from aircraft cockpits to power-station instrument panels: from ships' instruments to the protection of pyrometers in a steel works.

We produce a range of components that absorb vibration; eliminate noise; suppress shock. Our new catalogue lists all these for you.

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IN ASSOCIATION WITH EMPIRE RUBBER COMPANY (Proprietors: H.G. MILES LTD.)
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TELEGRAMS SPANDIT. DUNSTABLE

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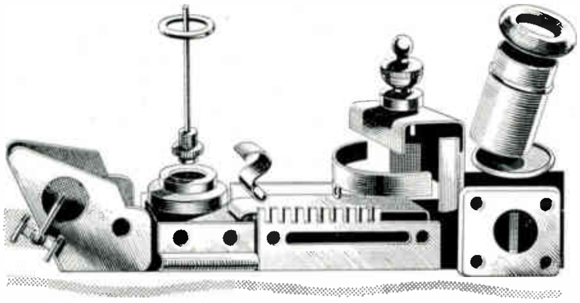
It's all plain sailing at G·G·L



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Empire Works, Park Road, Birmingham 18
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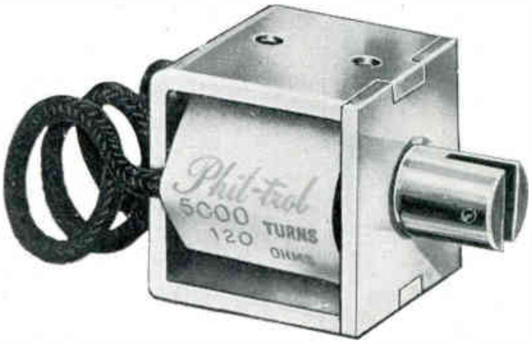
PHIL-TROL SOLENOIDS
NOW AVAILABLE IN STERLING AREAS



Phillips Control Corporation of Joliet, Illinois, announce the opening of their Plant 5. This is situated in Farnborough, Hampshire, England. The first product available from this factory will be the Type 41 and Type 42 Solenoid. Thus this very popular small solenoid is now available against sterling. Watch for announcements regarding other Phil-Trol Products from England.

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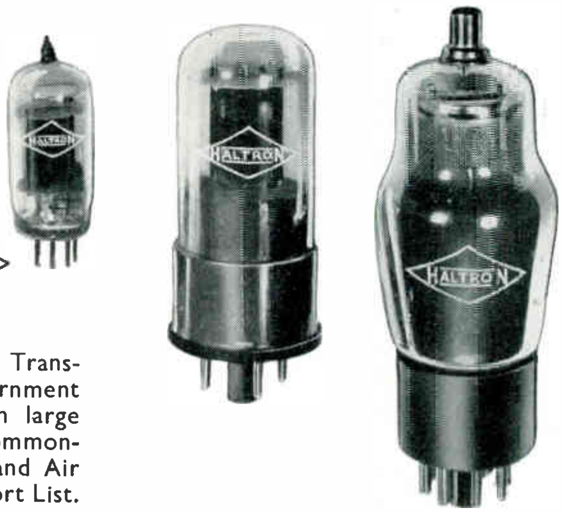
Reliable Agents required in all parts of the world.

World Radio History

STRICTLY EXPORT ONLY

HALTRON



Leading Exporters of all types of Radio Receiving and Transmitting Tubes. Current Production and Ex-Government Surplus Special Purpose Tubes. Over 800 types in large quantities, available Ex-Stock. Contractors to British Commonwealth and Foreign Governments for Army, Navy, and Air Forces, Post Offices, Civil Air Lines, etc. Ask for Export List.

SOME OF THE TYPES CARRIED IN STOCK

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1A7GT
1B24
1C5G
1C5GT
1D5
1D8GT
1E7G
1G4GT
1G5G
1G6GT
1L4
1LA6
1LD5
1LN5
1N5GT
1P5GT
1Q5GT
1R4/1294
1R5
1S4
1S5
1T4
1U5
2A3
2A5
2A6
2A7
2C26
2C34
2E22
2J21A
2J31
2J34
2J36
2J39
2J54
2J54B
2X2/879
2X2A
3A4
3AP1
3B7/1291
3B24
3B26
3BP1/CV814
3CP1
3D6
3DP1
3FP7/CV1761
3Q4
3S4
3V4
4C27/CV92
4D1
4THA
4TPB
5B/502A
5BP1/CV601
5BP4/CV836
5CP1/CV600
5C450(A)
5PF7/CV718
5LP1/CV741
5T4
5U4G
5V4G
5X4G
5Y3G
5Y3GT
5Y4G
5Z3
5Z4G
6A6
6A7
6A8G
6A8GT
6AB7
6AC7
6AG5
6AG6/G
6AJ5
6AK5
6AK6
6AL5
6AM5
6AM6
6AQ5
6AT6
6AU6
6B5
6B7
6B8
6B8G
6BA6
6BE6
6BG6G
6BR7
6BW6
6C4
6C5
6C5G
6C5GT
6C6
6C8G
6D6
6D7
6E6
6F5
6F5G
6F5GT
6F6
6F6G
6F6GT
6F7
6F8G
6G6G
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6R7
6R7G
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6SC7
6SF5
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6SH7
6SH7GT
6SJ7
6SJ7GT
6SJ7Y
6SK7
6SK7GT
6SL7GT
6SN7T
6SQ7
6SQ7GT
6SS7
6ST7
6T7G
6U5G
6U5/6G5
6U7G
6V6
6V6G
6V6GT
6X4
6X5G
6X5GT
6Y6G
6Y7G
6Z5
7A4
7A6
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The Journal of Radio Research and Progress

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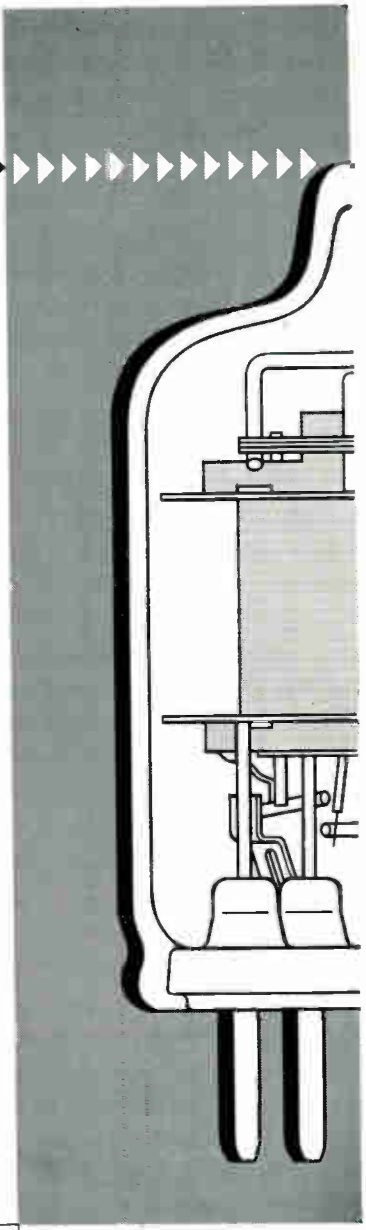
EF95



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TECHNICAL DATA

HEATER		CHARACTERISTICS		LIMITING VALUES	
V_h -	6.3V	V_a -	180 V	V_a max. -	180 V
I_h -	0.175 A	V_{g2} -	120 V	p_a max. -	1.7 W
		V_{g1} -	−2.0 V	V_{g2} max. -	140 V
CAPACITANCES		I_a -	7.7 mA	p_{g2} max. -	0.5 W
C_{in} -	4.0 µµF	I_{g2} -	2.4 mA	I_k max. -	18 mA
C_{out} -	2.8 µµF	g_m -	5.1 mA/V		
$C_{a\text{-}g1}$ -	0.02 µµF	r_a -	690 kΩ	**BASE B7G**	

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Vol. 30 APRIL 1953 No. 4

Microstrip

A CONSIDERABLE amount of research appears to have been carried out recently at the Federal Telecommunication Laboratories, Nutley, N.J. on what is described as a new transmission technique for the kilomegacycle range, and three papers on the subject were read at the National Convention of the I.R.E. in New York in March 1952.*

In the early days microwave transmission was carried out by parallel wires, the so-called Lecher wires; although cheap and simple, they are very exposed to interference and need rigid support to avoid perturbations and resulting radiation and losses. These are avoided in a coaxial line, but this requires very accurate construction and is expensive. In recent years waveguides have been employed; these are also bulky and need very accurate construction and are consequently expensive. In the Editorial of July 1950, we discussed transmission by means of a single wire coated with a dielectric, but this is of limited usefulness due to the spreading of the field and the necessity for wave launching and collecting.

Fig. 1 of our Editorial of September 1949, showed a transmission line consisting of two parallel strips of width b separated by a small distance d; we used it to calculate the intrinsic impedance of space and show that it is 120π ohms. This type of line is the basis of the microstrip. The lower strip can be pictured as wide and earthed without any change except a slight increase in the fringing, or a wide earthed strip can be inserted midway between the two narrow strips, and the lower one can then be removed without affecting the upper half of the picture.

This leads to Fig. 1(b) which is reproduced from the *Proceedings of the Institute of Radio Engineers*; Fig. 1(a) shows an alternative which has also been tried, in which the dielectric is air except for insulating beads which maintain the space between the wire and the ground plane.

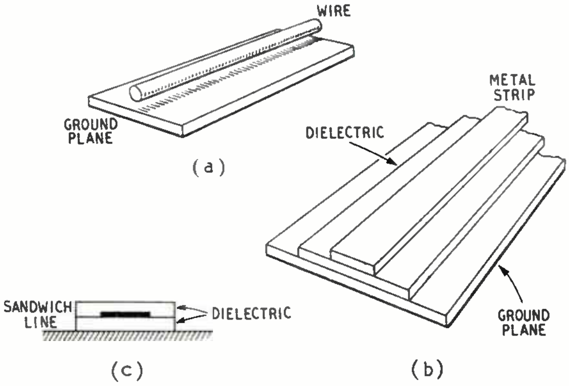

Fig. 1.

In the strip line the insulating material is polystyrene; in an actual case the thickness was 0·064 in., the copper strip being 0·22 in. wide and 2 mils thick; the ground plane was three times as wide as the conductor. In the case of the round copper wire it was 0·125 in. diameter and the polystyrene beads gave it a clearance of 0·024 in. from the ground plane. In both cases the characteristic impedance was 50 ohms. It is

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* *Proc. Inst. Radio Engrs*, Dec. 1952, Vol. 40. D. D. Greig and H. F. Engelmann, p. 1644., F. Assadourian and E. Rimai, p. 1651. J. A. Kostriza, p. 1658.

stated that so-called sandwich material, consisting of the dielectric sandwiched between two high-conductivity metals such as copper and silver, can be purchased on the commercial market. This is obtained of the full width and the outer parts of the upper metal coating are then stripped off leaving the narrow upper strip about a third of the entire width. It is also possible to remove the unwanted metal by a chemical process, using a ferric chloride etching process.*

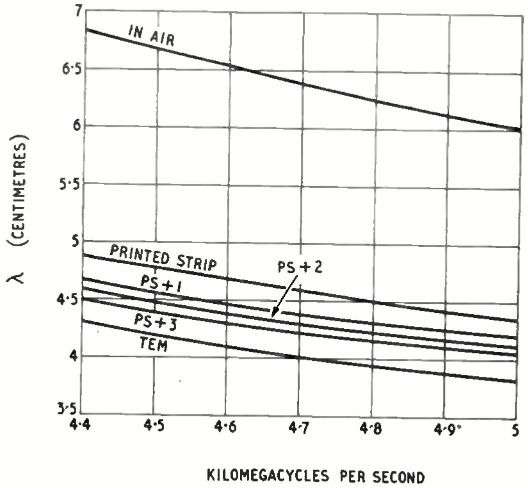

Fig 2.

The use of microstrip conductors necessitates the construction of suitable components. Instead of stripping superfluous metal from sandwich material, one can start with sheets of polystyrene or laminated phenolic plastics and cement the metal to the surface under pressure. Another type of line that has been employed is called a dielectric sandwich line; it is shown in Fig. 1(c). In this the strip line already considered has a strip of dielectric of the full width cemented to it so that the conducting strip is immersed entirely in dielectric and the fringe of the electric field is more confined to the dielectric. In all cases the depth of penetration at these frequencies is so small that printing-circuit techniques can be used to produce on the dielectric surface a conducting ribbon of sufficient thickness; thicknesses of from 1 to 5 mils have been found satisfactory.

That even with the layer of dielectric above the strip, as shown in Fig. 1(c), a considerable amount of the electric field passes outside the dielectric, is shown by Fig. 2 (based on Kostriza's paper) in which the wavelength is plotted against frequency. In air the wavelength λ would fall from 6·8 to 6 cm as shown by the upper curve. The next curve is for the strip with no upper layer of dielectric; curves +1, +2 and +3 show the effect of adding successive layers of dielectric. The lower curve shows the theoretical values based on the dielectric constant of the polystyrene, which is 2·55. These results are not surprising as the thickness of the successive layers was only 0·063 in.; the width of the strip was 0·22 in. If the electric field were confined entirely to the dielectric the wavelength would be reduced in the ratio $\sqrt{2{\cdot}55}$ (i.e., 1·6) as compared with its value in air; thus in Fig. 2 at 5 kMc/s, $\lambda = 6$ cm in air and about 3·75 cm in polystyrene. Tests of the effect of varying the width of the ground plane showed an increase of transmitted power of only 2·5% when the width of the ground plane was increased from twice to five times the diameter of the round wire conductor.

The use of such transmission lines introduces many problems in connection with suitable components such as crystal mounts, variable attenuators and transitions from the microstrip to other types of transmission. A great amount of attention has been paid to these problems and many drawings and photographs of the apparatus are given in the original papers.

G. W. O. H.

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* See *Electrical Communications*, Dec. 1952, p. 251, for a description of this process with many illustrations.

NOTE ON A NETWORK THEOREM

By Leo Storch

IN a recent paper[1] the following network theorem is formulated by E. E. Zepler, but in different words:—

> In a linear network containing a generator E, an impedance Z may be replaced, without changing the effect on the generator, by another impedance Z_x connected in parallel with the generator. The value of Z_x is such that the power in Z_x (i.e., E^2/Z_x) is equal to the power in the circuit obtained from Thévenin's Theorem for the original network; i.e., $E'^2/(Z + Z_i)$. E' and Z_i are the two quantities which specify the Thévenin circuit.

1. Impedance (Admittance) vs. 'Power' Formulation

It is not at all clear why Zepler has seen fit to introduce an esoteric concept for power in order to establish the 'Network Theorem.' The designation of terms of the form E^2/Z_q as 'power', which may be 'partly or wholly imaginary', seems unwarranted on general grounds. Moreover, the formulation of the theorem in terms of entities E^2/Z_q obfuscates rather than simplifies its derivation and understanding, no matter what name is given to the E^2/Z_q terms.

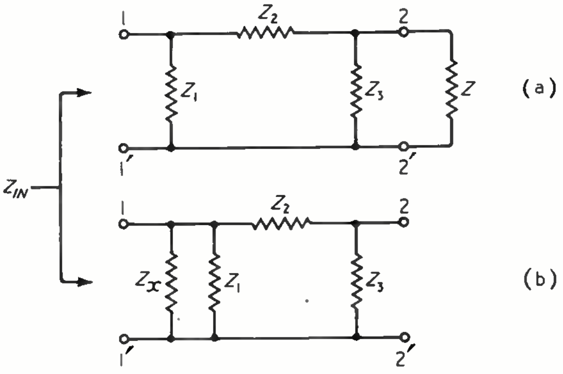

Fig. 1. *Replacement of Z by Z_x.*

In essence, Zepler poses the problem: what must Z_x in Fig. 1(b) be so that the input impedance Z_{in} is identical in Fig. 1(a) and (b). The impedance Z_1 may be omitted since it has the same effect in both cases, and this has been done in Fig. 2. It follows that:

$$\frac{1}{Z_x} + \frac{1}{Z_2 + Z_3} = \frac{1}{Z_2 + \dfrac{ZZ_3}{Z + Z_3}} = \frac{1}{Z_2 + Z_3}$$

$$+ \left(\frac{Z_3}{Z_2 + Z_3}\right)^2 \cdot \frac{1}{Z + \dfrac{Z_2 Z_3}{Z_2 + Z_3}}.$$

$$\therefore Z_x = \left(\frac{Z_2 + Z_3}{Z_3}\right)^2 \cdot \left(Z + \frac{Z_2 Z_3}{Z_2 + Z_3}\right)$$

Obviously, this is exclusively an impedance-combining problem and only simple series-parallel impedance combinations are involved. That this is so may be seen also from Zepler's derivation. When all terms of his equation are divided by E^2, it reduces to the above equation. It appears to this writer that the use of the conventional impedance concept produces a much more lucid derivation than the use of an unconventional 'power' concept which deviates from the firmly established meaning of this term.

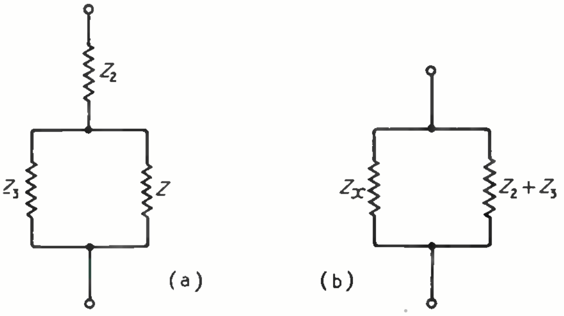

Fig. 2. *Replacement of Z by Z_x (simplified circuit diagram).*

2. Generalized Derivation

It is sufficient to prove the theorem for a π-section ($Z_1 Z_2 Z_3$ in Fig. 1) in order to establish it for any arbitrary linear, passive*, two-terminal-pair network. If the π-section represents the equivalent of a more complex network, $\dfrac{Z_2 + Z_3}{Z_3}$ may be identified with its voltage ratio $\left.\dfrac{E_{1-1'}}{E_{2-2'}}\right|_{Z=\infty}$ and $\dfrac{Z_2 Z_3}{Z_2 + Z_3}$ may be identified with its impedance across terminals 2-2′ when $Z = \infty$ and terminals 1-1′ are shorted.

However, it is not difficult to prove the theorem directly for the general case, although Zepler seems to think so. Let the network be characterized by its general circuit parameters A, B, C D.[2] Then Z_x must satisfy equation (1) if it is to have the desired properties (see Fig. 3):

$$\frac{\dfrac{A}{C} \cdot Z_x}{\dfrac{A}{C} + Z_x} = \frac{AZ + B}{CZ + D} \quad \cdots \quad \cdots \quad \cdots \quad (1)$$

MS accepted by the Editor, May 1952

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* "Passive" implies compliance with the reciprocity theorem (i.e., bilateralness) in this paper.

or $Z_x (AD - BC) = A^2 Z + BA$

$$\therefore Z_x = \frac{A^2}{AD - BC}\left(Z + \frac{B}{A}\right) \quad .. \quad (2)$$

For passive networks, the equality

$$AD - BC = 1 \quad .. \quad .. \quad .. \quad (3)$$

applies and equation (2) reduces to:

$$Z_x = A^2\left(Z + \frac{B}{A}\right) = A^2 (Z + Z_{s2}) .. \quad (4)$$

In this equation A is the vector-ratio of input to output voltage of the network itself [Fig. 3(a)] and $Z_{s2} = B/A$ is the impedance presented to the Z-terminals when the Z_x-terminals are shorted [Fig. 3(d)].

Zepler's statement "in a linear network containing a generator, etc.," leaves in doubt whether he is restricting the Network Theorem to passive networks or not, although the subsequent derivation in terms of a π-network would tend to indicate it. In any case his formulation, which is equivalent to equation (4), is correct only for passive networks which satisfy the reciprocity theorem; i.e., equation (3). Otherwise (e.g., circuits containing linear valve amplifiers or unilateral control devices), the more general equation (2) applies. Equation (2) actually contains only three independent parameters since $\dfrac{A^2}{AD - BC}$ may be written as $\dfrac{\frac{A}{C}}{\frac{D}{C} - \frac{B}{A}}$. The three ratios can be interpreted very conveniently in terms of open- and short-circuit impedances such that:

$$Z_x = \frac{Z_{01}}{Z_{02} - Z_{s2}} (Z + Z_{s2}), \quad .. \quad .. \quad (5)$$

where Z_{01} and Z_{s2} have already been explained, and Z_{02} is the impedance across terminals 2-2′ when terminals 1-1′ are open.

Since (5) applies for any value of $AD - BC$, it is also valid when $AD - BC = 1$. Therefore, it is an alternative for (4). It may be even more attractive than (4), since Z_{02} is usually more convenient to calculate than A.

3. Nature of the Network Theorem and Some Alternatives

The generalized derivation based on the circuit parameters A, B, C, D is more compact and satisfying than the one based on the equivalent π-section. It also illuminates much more clearly the genesis of the Network Theorem, which is readily seen to be the result of the elimination of D, by means of (3), from the standard input-impedance equation:

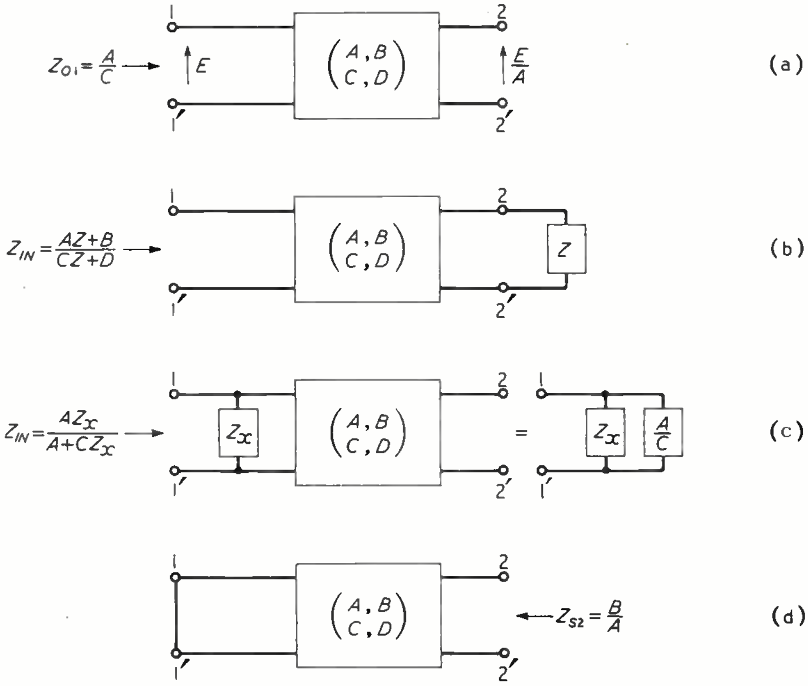

Fig. 3. *Relationships in the general two-terminal-pair network.*

$$Z_{in} = \frac{AZ + B}{CZ + D}. \quad .. \quad .. \quad .. \quad (6)$$

That is:

$$Z_{in} = \frac{AZ + B}{CZ + \frac{1 + BC}{A}} = \frac{1}{\frac{C}{A} + \frac{1}{A(AZ + B)}}$$

$$= \frac{\frac{A}{C} \cdot A^2\left(Z + \frac{B}{A}\right)}{\frac{A}{C} + A^2\left(Z + \frac{B}{A}\right)} \quad .. \quad .. \quad (7)$$

It is, of course, common practice to eliminate one of the four general circuit parameters by means of (3) when dealing with linear, passive networks, unless one prefers to calculate all four and to use the relation $AD - BC = 1$ for checking the computations.

There is no reason why D should be singled out for elimination. The process can be applied just as well to A, or B, or C.

When A is eliminated by means of (3):

$$Z_{in} = \frac{B}{D} + \frac{Z}{DCZ + D^2} = \frac{B}{D} + \frac{1}{D^2 \cdot \dfrac{C}{D} + \dfrac{D^2}{Z}}$$

$$= Z_{s1} + \frac{1}{\dfrac{D^2}{Z_{02}} + \dfrac{D^2}{Z}}, \quad .. \quad .. \quad (8)$$

where Z_{s1} is the impedance across terminals 1-1′ when 2-2′ are shorted, and D is the ratio $\left.\dfrac{I_{1-1'}}{I_{2-2'}}\right|_{Z=0}$. If one wishes, equation (8) may be diagrammed as the connection of Z_{s1} in series with the parallel arrangement of the two impedances Z/D^2 and Z_{02}/D^2.

Similarly, when B is eliminated:

$$Z_{in} = \frac{A}{C} - \frac{1}{C^2\left(Z + \dfrac{D}{C}\right)} = Z_{01} - \frac{1}{C^2Z + C^2Z_{02}} \quad (9)$$

and when C is eliminated:

$$Z_{in} = \frac{B(AZ + B)}{D(AZ + B) - Z} = \frac{1}{\dfrac{D}{B} - \dfrac{1}{AB + \dfrac{B^2}{Z}}}$$

$$= \frac{1}{\dfrac{1}{Z_{s1}} - \dfrac{1}{\dfrac{B^2}{Z_{02}} + \dfrac{B^2}{Z}}} \quad .. \quad .. \quad .. \quad (10)$$

where $B = \left.\dfrac{E_{1-1'}}{I_{2-2'}}\right|_{Z=0}$ and $C = \left.\dfrac{I_{1-1'}}{E_{2-2'}}\right|_{Z=\infty}$

The two expressions (9) and (10) can also readily be diagrammed as the series-parallel connection of three impedances (some of which are non-physical). However, in any of the four cases there seems to be hardly any advantage in utilizing the equivalent circuit rather than the more compact algebraic equation. This would appear to be true even when the criteria include ease of memorizing and visualizing, besides computational efficiency.

An attractive form of writing Z_{in} is obtained from (6) by factoring A in the numerator and C in the denominator:

$$Z_{in} = Z_{01} \cdot \frac{Z + Z_{s2}}{Z + Z_{02}}. \quad .. \quad .. \quad (11)$$

In this form Z_{in} is expressed entirely in terms of driving-point impedances, which are generally more convenient to compute than transfer impedances or voltage and current ratios. Equation (11) also makes it clear that the input-impedance equation of a linear network contains only three independent parameters, since the fourth one in (6) can always be removed by division.

Actually, equation (11) is a specific case of the more general equation:

$$\frac{Z_{in} - Z_{in1}}{Z_{in} - Z_{in2}} \cdot \frac{Z_{in3} - Z_{in2}}{Z_{in3} - Z_{in1}} = \frac{Z - Z_1}{Z - Z_2} \cdot \frac{Z_3 - Z_2}{Z_3 - Z_1}. \quad .. \quad .. \quad .. \quad (12)$$

The input-impedance function of a linear network is completely specified as soon as three pairs of corresponding input and load impedances $Z_{inq} \longleftrightarrow Z_q (q = 1,2,3)$ are known. Equation (12) reduces to (11) when a suitable choice is made for two of the pairs in terms of open- and short-circuit impedances.

The significance of (12) is due to the link it establishes with two-dimensional projective geometry. On account of this nexus, the resources of projective geometry can be tapped immediately for very valuable geometrical interpretations of the impedance-transforming properties of linear, two-terminal-pair networks.[3]

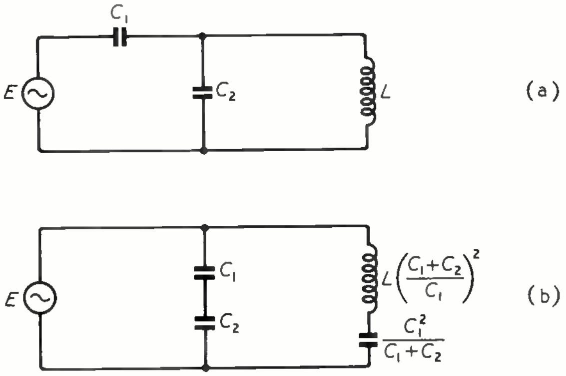

Fig. 4. *Zepler's 1st example.*

4. Usefulness of the Network Theorem

The practical usefulness of the Network Theorem is rather questionable. To obtain the equivalent circuit,* one must solve the given network in the forward direction for the open-circuit voltage transfer-ratio and solve it again in the reverse direction for the short-circuit input impedance. Then one has to calculate Z_x from (4), or (5) respectively. Finally, one has to solve the equivalent circuit, which is approximately of the same degree of complexity as the original network. It appears, therefore, that in many cases one may actually do almost three times as much work when the Network Theorem is applied as compared to a straightforward solution of the given network.

Using Zepler's own examples, the original circuit of Fig. 4(a) is certainly just as easy to solve

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* Equivalent only with respect to the input terminals.

as the equivalent circuit of Fig. 4(b). The additional effort required to obtain the equivalent circuit of Fig. 4(b) may be considered as wasted, since it results in a two-mesh, three-element circuit being converted into a two-mesh, four-element circuit.

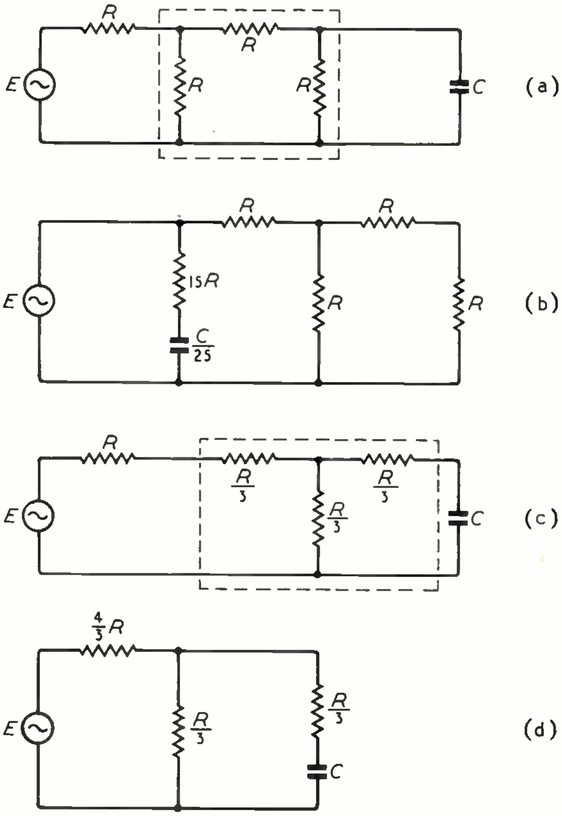

Fig. 5. *A different approach to Zepler's 2nd example.*

His second example [Fig. 5(a)] will be solved by several methods in order to test their relative merits.

The solution in accordance with the Network Theorem proceeds as follows:

$$E_{2-2'}\Big|_{Z=\infty} = \frac{E}{A} = \frac{E}{\frac{2R}{3}+R}\cdot\frac{R}{3R}\cdot R = \frac{1}{5}$$

$$Z_{s2} = \frac{\left(\frac{R}{2}+R\right)R}{2R+\frac{R}{2}} = \frac{3}{5}R$$

$$Z_x = 25\left(\frac{1}{j\omega C}+\frac{3}{5}R\right) = 15R+\frac{25}{j\omega C}$$

This establishes the equivalent circuit of Fig. 5(b). From Fig. 5(b):

$$Z_{in} = \frac{\left(\frac{2}{3}R+R\right)\left(15R+\frac{25}{j\omega C}\right)}{\frac{50}{3}R+\frac{25}{j\omega C}}$$

$$= \frac{\frac{1}{3}R\left(3R+\frac{5}{j\omega C}\right)}{\frac{2}{3}R+\frac{1}{j\omega C}} = \frac{R(5+j3\omega RC)}{3+j2\omega RC}$$

Of interest is also the solution according to (11):

$$Z_{01} = \frac{2R}{3}+R = \frac{5}{3}R$$

$$Z_{s2} = \frac{\left(\frac{R}{2}+R\right)R}{2R+\frac{R}{2}} = \frac{3}{5}R$$

$$Z_{02} = \frac{2}{3}R$$

$$Z_{in} = \frac{5}{3}R\cdot\frac{\frac{1}{j\omega C}+\frac{3}{5}R}{\frac{1}{j\omega C}+\frac{2}{3}R} = \frac{R(5+j3\omega RC)}{3+j2\omega RC}$$

It appears to be superior to Zepler's method.

These methods may be compared with the straightforward solution:

$$Z_{in} = \frac{\left(\frac{R}{1+j\omega RC}+R\right)R}{2R+\frac{R}{1+j\omega RC}}+R$$

$$= \frac{(2+j\omega RC)\,R+R(3+j2\omega RC)}{3+j2\omega RC}$$

$$= \frac{R(5+j3\omega RC)}{3+j2\omega RC}$$

The standard impedance-combining solution is also superior to Zepler's method. As a matter of fact, the disadvantages of Zepler's method would be much more pronounced if the four equal resistances R were replaced by four unlike complex impedances.

If it is preferred to resort to an equivalent circuit rather than to work with the original, it appears logical to perform a π-T transformation on the elements enclosed by dotted lines in Fig. 5(a). This operation produces the equivalent circuit of Fig. 5(c) and (d). While the application of the Network Theorem does not change the number of meshes, and even increases the number of elements, the simpler conversion of the π-section to a T-section reduces the number of meshes from three to two. Even so, the calculation of Z_{in} is not simplified appreciably as compared to the straightforward solution.

For his third and last example, Zepler has chosen the circuit of Fig. 6(a). By applying the Network Theorem he derives the circuit of Fig. 6(b) which is equivalent in input impedance to Fig. 6(a). Considerable judgment—or, more probably, a series of trials—is necessary in order to locate an advantageous pair of load terminals, which reduces the amount of calculations. In making the calculation leading to Z_x, Zepler employs a type of equivalent circuit for the transformer. If, instead, the transformer is replaced by its π-equivalent, the equivalent circuit of Fig. 6(c) and 6(d) results immediately, which compares very favourably with Fig. 6(b). This method does not require any judgment in optimizing the choice of load terminals nor any of the intermediate calculations and circuit considerations. If the π-equivalent of a transformer is not readily available, it can be obtained very simply from the universally known T-equivalent. The fact that the circuit of Fig. 6(c) and (d) is equivalent to Fig. 6(a), not only with respect to the generator terminals, but also with respect to the actual load terminals (i.e., the terminals to which C_2 is connected), may also be considered in favour of Fig. 6(c) as compared to the Network Theorem and Fig. 6(b).

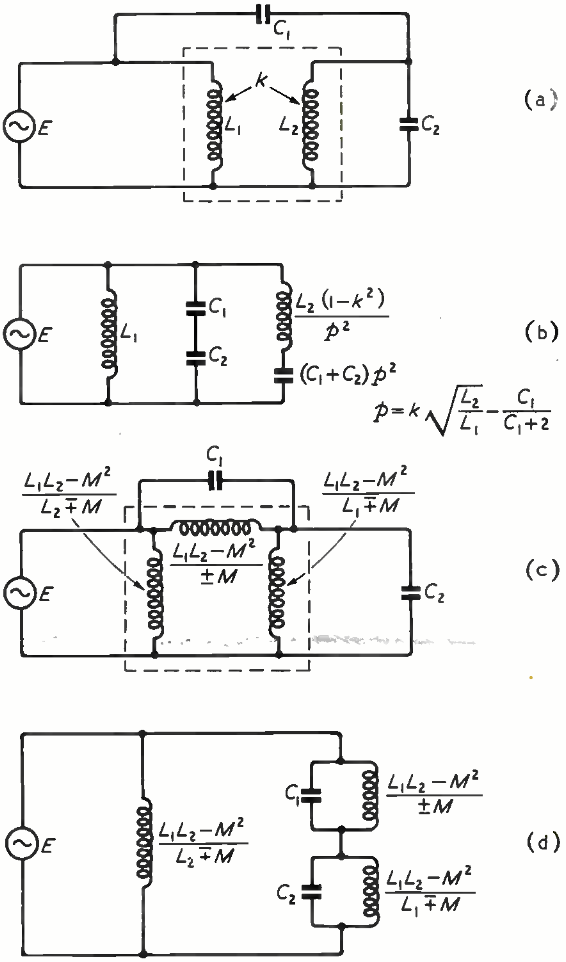

Fig. 6. *A different approach to Zepler's 3rd example.*

5. Conclusions

The Network Theorem[1] amounts, in essence, to a method of calculating the input impedance of a linear, passive network by means of the general circuit parameters[2] or their ratios $\left(\text{i.e.}, A, \frac{A}{C}, \frac{B}{A}\right)$.

It has been shown to be equivalent to the standard input-impedance equation (6), from which D has been eliminated by means of the determinental equation (3). It can be deduced, furthermore, that it is actually a member of a group of several such theorems.

It would appear that the calculation of input impedance by means of general circuit parameters is economical only when a table listing A, B, C, D for the more common networks is available and the network under investigation coincides with one of these networks or can be readily resolved into a cascade connection of several of these networks. The Network Theorem and its variants may, therefore, be of only limited usefulness.

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TELEVISION AERIALS

Performance Measurements

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SUMMARY.—Some of the characteristics which need to be considered in specifying the performance of a television receiving aerial are outlined, and methods of measuring this performance are discussed. The determination of the gain, radiation pattern and impedance of an aerial is described, and the precautions necessary to ensure good accuracy in the measurements are indicated. Results obtained from an investigation of the characteristics of nine outdoor television aerials of British manufacture are included in the paper.

1. Introduction

MANY different aerials for use in the reception of television broadcasting have appeared in recent years. These aerials have various features and characteristics which are claimed to be advantageous over the simple half-wave dipole, and it now seems opportune to consider by what criteria the performance of a television receiving aerial should be judged and also to ascertain to what extent commercially-available aerials satisfy the requirements. The work described in the present paper has been carried out with these two objectives in mind. Although not all aerials on the market were examined, a number of representative types have been investigated, and it is believed that the main advantages and disadvantages of the kinds of aerial most commonly in use have been brought out.

2. General Considerations

The function of an aerial and its associated transmission line is to give the best possible ratio of signal-to-noise at the terminals of a receiver. With an aerial having directional properties this ratio can be improved, first by increasing the reception of the wanted signal, and secondly by reducing the reception of noise and interfering signals generally from directions other than that of the wanted signal. Any statement of performance should therefore show how far the aerial meets these requirements.

Perhaps the most important characteristics which need to be investigated are the gain, the polar diagram, or radiation pattern, and the impedance of the aerial. The front-to-back ratio and the angular width of the major lobe can be obtained from the polar diagram. Since a television signal covers a band of frequencies several Mc/s wide, and as the best reception requires equal response at all frequencies within the band, it is necessary to measure these characteristics at more than one frequency. In all British transmitters, except Alexandra Palace, vestigial-sideband transmission is used, and the vision and sound carrier frequencies lie towards the opposite edges of the appropriate frequency channel. Characteristics measured at these two frequencies will therefore give some indication of the variation in aerial performance with frequency, although ideally many more observations at frequencies in the band would be required.

The characteristics of an aerial will be changed by the presence of reflecting objects and it is, therefore, necessary in comparing the performance of different aerials to standardize the conditions under which the tests are carried out. A testing site that is open, level and free from surrounding objects is most suitable, but it must be realized that performance measurements made on such a site may be modified by the conditions under which the aerial is finally used in practice.

2.1. *Measurement of Forward Gain*

To measure the forward gain of a given television aerial a comparison is required between the response of the aerial in the forward direction and that of some standard aerial. The simplest practical form of standard is the resonant half-wave-length dipole. At the present time all British television transmissions are vertically polarized and it would seem appropriate to carry out the comparison using vertically-polarized waves. With the standard dipole in the vertical position, however, the presence of the feeder cable will affect its response and this, together with the direct pick-up on the cable, may lead to an inaccurate value for the gain of the aerial under test. When the comparison is made using horizontally-polarized waves the cable may easily be disposed so that the dipole will not be affected by its proximity and as the cable is vertical the direct pick-up will be small. As will be shown later, the errors introduced when using vertically-polarized waves for the comparison are considerable and the use of horizontal polarization is to be preferred. It should be emphasized, however, that the value of forward gain obtained in this way may be modified to some extent by the feeder

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when the aerial under test is used vertically and may either be increased or decreased according to the length of the feeder and its position with respect to the aerial elements.

2.2. *Measurement of Polar Radiation Diagrams*

The measurement of the polar radiation diagrams of a directional aerial enables not only the width of the major lobe to be determined but also gives a comparison of the response in the forward direction with that in other directions. Although the front-to-back ratio may give a measure of the rejection of interference from the rear of the aerial the points of minimum response are often 20 to 40 degrees on each side of this position. The maximum degree of suppression of an interfering signal may be obtained by orienting the aerial so that the source of interference lies within a zone of minimum response, provided that by so doing there is not much reduction in the reception of the wanted signal. It is, therefore, also useful to know the maximum to minimum response ratio.

It is desirable to know the polar radiation diagram both in the plane containing the elements of the aerial and in that perpendicular to them since interference can come from below as well as from behind the aerial. The nomenclature to be used for these two planes may cause some difficulty. Although at the present time the designation 'vertical' and 'horizontal' is satisfactory, ambiguity may arise in the future when the same or similar aerials are used to receive horizontally-polarized transmissions from the proposed low power television stations. The terms E-plane and H-plane (indicating the principal planes containing the electric and magnetic vectors respectively) will therefore be used here to denote the plane of the aerial elements and that perpendicular to them.*

2.3. *Measurement of Aerial Impedance*

To obtain the best performance from an aerial its impedance should be matched to the characteristic impedance of the associated feeder as far as possible over the whole band of frequencies it is intended to receive. Of the possible methods for the determination of an impedance at television frequencies the most convenient is to measure the corresponding admittance on a suitable bridge.[1] Usually the unknown admittance is connected directly to the bridge terminals, but for measurements on aerials other methods of connection can be used.

Of the possible arrangements, three would appear suitable:—

Method (a). The aerial may be connected directly to the bridge by leads the length of which is a very small fraction of a wavelength. The admittance in this case may be modified by the presence of the bridge and operator.

Method (b). Connection to the bridge may be made by a transmission line adjusted to be an exact number of half-wavelengths long, thus maintaining a transformation ratio of unity.

Method (c). A balanced or unbalanced cable of fixed length and several wavelengths long may be used between bridge and aerial, derivation of the required result then involving the transformation of admittances by the use of circle diagrams or Smith charts.

The first method has the advantage that measurements can be made quickly at a series of frequencies with the minimum of adjustment. Method (b) gives a measurement of the aerial admittance without further calculation but requires adjustment of the line for each frequency. Method (c) allows the aerial to be raised to a considerable height above ground and possible modifications of the admittance of the aerial due to its proximity to the earth will be minimized. This method, however, necessitates the previous measurement of the constants of the cable used and its electrical length at each frequency.

2.4. *Presentation of Aerial Characteristics*

Various methods are in use by manufacturers for expressing the characteristics of their aerials, and some degree of standardization is required if a comparison is to be made between the various aerials. A specification which would meet most needs would include the forward gain relative to a resonant half-wavelength dipole expressed in decibels, the front-to-back ratio in decibels and the beamwidth, or acceptance angle, between the points 3 db below the maximum response; that is, the 'half-power points'. Of the various possible ways of plotting polar radiation diagrams, two have been used in the present work: in the first the ratio of the response of the aerial concerned in any given direction to the minimum value is expressed in decibels, while in the second the standard of reference is the response of a simple half-wavelength dipole and the corresponding voltage ratio is expressed in linear units. The first method shows clearly the nature of the minor lobes and the minima in the radiation pattern, while the second is perhaps more suitable for the comparison of the characteristics of different aerials.

3. Measurement of Gain and Polar Diagram

3.1. *Equipment and Layout*

To obtain accurate measurements of gain and other characteristics, the aerial under test should be placed in an electromagnetic field which changes as little as possible with distance in all directions.

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* In the case of a slot aerial the terms are reversed, the E-plane being the plane perpendicular to the slot elements.

In practice the best approach to such conditions is to work at a sufficiently great distance from a transmitter over a plane site free from reflecting objects. In the experiments described in the present paper the separation of transmitting and receiving aerials was 50 metres (about 10λ). At this distance the theoretical attenuation of field strength along a radial is such that a difference of $\frac{1}{2}$ to 1 db may exist between the field strengths at the front and back elements of some television aerials which may be spaced up to 2 metres or more. The shortest practical transmission distance was therefore considered to be 50 metres if reasonably accurate measurements of aerial characteristics were to be obtained.

The transmitter used gave an unmodulated carrier wave at any required frequency in the television band and the radiated power was a few milliwatts. The radio-frequency currents in each arm of the transmitting half-wavelength dipole were measured by thermocouples to ensure constancy of radiated power while measurements were being made.

The aerials under test and the comparison dipole could be supported with their elements either vertical or horizontal on the top of a wooden pole capable of being rotated about its axis; the angular position was given by a scale at ground level. The usual height above ground of an aerial mounted on a roof or chimney is between 30 and 40 ft. In the present experiments it was found practicable to raise the aerials to a height of only 30 ft; i.e., approximately 2 wavelengths at the frequencies concerned. The modification of aerial impedance due to the presence of the ground is not very great under these conditions.

The cable connecting the aerial to the receiver was Uniradio 32, a concentric type having a nominal characteristic impedance of 73 ohms and a loss of 3 db per 100 ft and similar to that most commonly used in actual installations. The same piece of cable of length 50 ft (about the average length in practice) was used throughout the measurements to eliminate variations in cable loss. A resistive load of 73 ohms was connected across the receiving end of the cable. The voltage developed across a small part of this load was measured by a superheterodyne receiver having calibrated attenuators in the intermediate-frequency amplifier. By this means a constant matched termination was obtained at the end of the cable despite possible changes in the input impedance of the receiver.

3.2. *Experimental Procedure*

With the equipment set up in the way described, the uniformity of the field at the receiving position was checked with a dipole for a distance of 5 feet in all horizontal directions. For horizontal polarization the variation in field strength was not greater than 0·2 db and for vertical polarization not greater than 0·5 db. The absence of reflections from surrounding objects was confirmed by obtaining polar diagrams for a half-wavelength dipole. With horizontal polarization the maximum disagreement between the experimental points and the theoretical E-plane polar radiation diagram was 0·5 db. The H-plane diagram obtained with vertical polarization, although not a circle, was symmetrical about the line through the transmitting and receiving aerials: the feeder cable in this case was supported at right angles to the dipole for as great a distance as practicable (1·6 m or about $\frac{1}{3}\lambda$) before becoming parallel to it. Even at this distance the presence of the cable distorted the theoretically circular polar diagram and gave variations of about 4 db as the angular position of the cable changed. For this reason the vertical position was rejected as a standard for gain comparison and the horizontal position used instead.

A number of aerials for use at the frequency of the Sutton Coldfield television transmitter were tested (vision and sound frequencies 61·75 Mc/s and 58·25 Mc/s respectively). On each of these frequencies the gain and E-plane polar diagram were obtained with horizontal polarization, and the H-plane polar diagram with vertical polarization. When measuring H-plane diagrams the outer conductor of the concentric cable was connected to the lower half of the dipole element of the aerial, as is usually done in practice, and the cable was fastened to the mast in the position normally occupied between the aerial elements. Some E-plane diagrams showed unusual lobes, the presence of which were checked by turning the aerial over and repeating the measurements in the reverse direction.

Sketches are given in Fig. 1 of a representative selection of aerials together with their polar diagrams in which the response is shown in decibels above the minimum value. For comparison, the vision-frequency polar diagrams of the aerials are replotted in Fig. 2 with the response compared with that of a half-wavelength dipole and expressed as a voltage ratio. The polar diagrams show the relative signal strength that would be obtained as a transmitter is moved around the aerial.

3.3. *Results and Discussion*

Five of the aerials tested were of the two-element type with a dipole and single parasite. The elements had various lengths and spacings and were separated either by a cross arm to form an H-configuration, or by a block of insulating material to form an X. One aerial had three reflectors spaced around an arc of a circle with a dipole at the centre. Two aerials had three elements and one had four elements. From the polar radiation diagrams, the front-to-back ratios and half-power angles were obtained, and these, together with the gain measurements, are listed in Table 1. Front-to-back ratios obtained from corresponding H- and E-plane diagrams

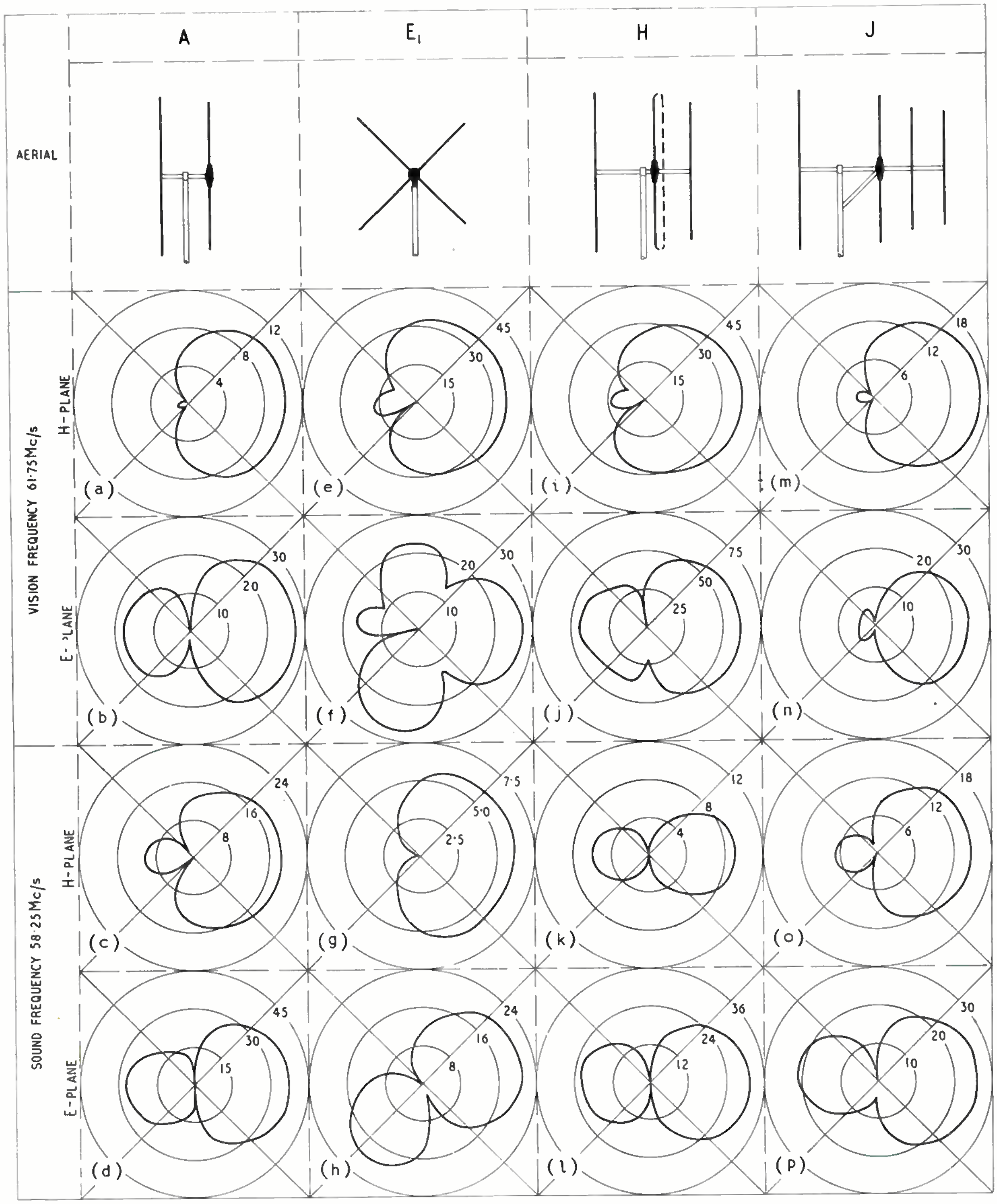

Fig. 1. *Polar diagrams of representative aerials expressed in decibels above minimum response.*

should obviously be the same and any differences shown in Table 1 may possibly be due to the change in the position of the feeder cable. The H-plane value will be more accurate when the aerial is used to receive vertically-polarized waves.

The more interesting features of the various types are:—

2-element, H-types.—These all show similar characteristics, having forward gains at the vision frequency of 2·5 to 3 db and at the sound frequency of 3 db. The front-to-back ratios are of the order of 10 db on vision but fall to 2 db on sound except for the type with 0·15λ spacing. These measurements are in general agreement with previously measured values[2] of the characteristics of a λ/2 dipole aerial with a single parasite.

2-element, X-type.—The gain at the vision frequency was of the same order as for the H-types but at the sound frequency it was lower. The front-to-back ratio was 18 db, well above that for H-types at the vision frequency. One feature of the X-type is the maximum to minimum ratio of 35 db which may be used for the rejection of interference from one particular direction. There is, however, a lobe in the E-plane diagram pointing down to the rear of the aerial which might lead to increased interference from sources below the aerial. When a link joining the lower arm of the dipole element and the centre of the director was removed, the forward gains were increased slightly.

3-reflector type.—The gains and front-to-back ratios at both frequencies are similar to the H-types, but the beam width is some 40° smaller in the H-plane, thus giving a greater angle for the rejection of interference.

3-element types.—At the vision frequency the gain is 5 to 5½ db and the front-to-back ratio 25 db. These fall to 2½ db and 8 db respectively for the sound frequency.

4-element type.—Although the forward gain at the vision frequency is about the same as that for the 3-element types, being 5½ db, it is maintained over the whole band and is still 4 db at the sound frequency.

4. Measurement of Aerial Impedance

4.1. *Equipment and Layout*

The three methods previously outlined (Section 2.3) for the measurement of aerial impedance were investigated.

In the first method (a), the aerial under test was supported about a half wavelength above the ground and the admittance bridge was connected to it by the shortest possible leads, usually 1 or 2 cm long. The bridge was operated from a distance by wooden rods to minimize the effect of the presence of the operator. In the second method (b) the aerial was supported as before and was connected to the bridge by a parallel-wire line made of telescopic tubing which could be adjusted to a half wavelength at the required frequencies, thus acting as a 1 : 1 transformer. In method (c)

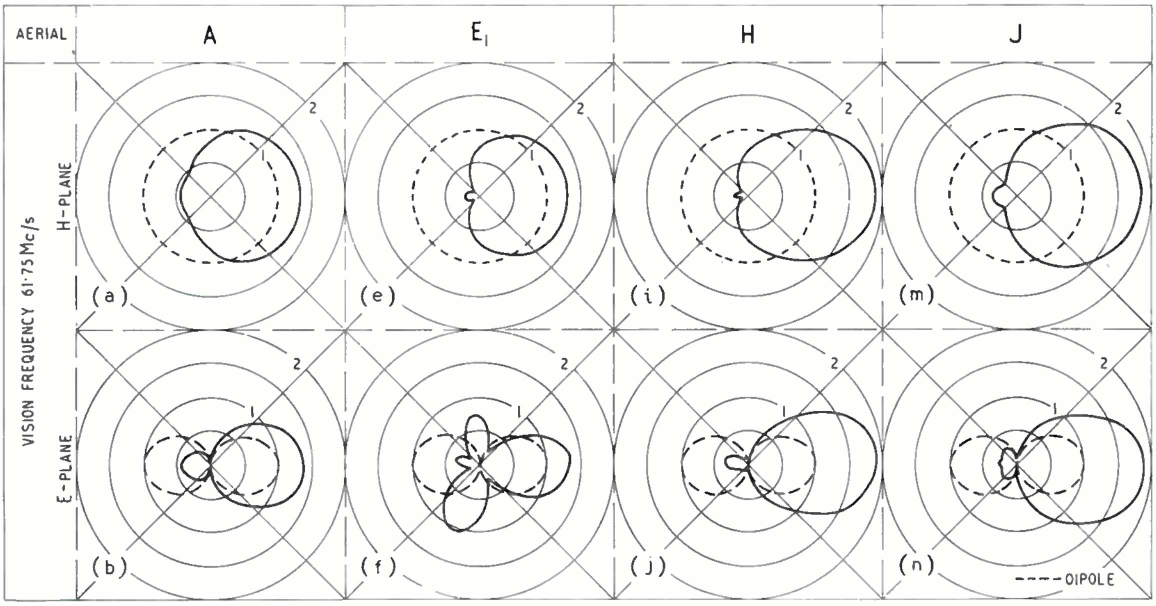

Fig. 2. *Polar diagrams compared with those of λ/2 dipole expressed as a voltage ratio; dashed line indicates the characteristics of a simple dipole.*

TABLE 1

SUMMARY OF GAIN AND POLAR DIAGRAM MEASUREMENTS

		VISION FREQUENCY 61·75 Mc/s						SOUND FREQUENCY 58·25 Mc/s				
		E-PLANE			H-PLANE			E-PLANE			H-PLANE	
No.	DESCRIPTION λ_v = wavelength of vision carrier	Forward Gain Over Dipole (db)	Half-Power Angle (degrees)	Front/ Back Ratio (db)	Front/ Back Ratio (db)	Max./ Min. Ratio (db)	Half-Power Angle (degrees)	Forward Gain Over Dipole (db)	Half-Power Angle (degrees)	Front/ Back Ratio (db)	Front/ Back Ratio (db)	Half-Power Angle (degrees)
A	2-element, H-type, dipole and reflector spaced 0·15λ_v	2·8	± 41	10·9	10·0	10·6	± 74	3·3	± 33	8·3	8·8	± 60
B	2-element, H-type, dipole and reflector spaced 0·17λ_v	3·1	± 34	10·7	7·7	8·0	± 77	2·9	+ 43 − 28	3·0	2·9	± 51
C	2-element, H-type, dipole and reflector spaced 0·18λ_v	2·7	—	10·9	—	—	—	—	—	—	—	—
D	2-element, H-type, dipole and reflector spaced 0·25λ_v	3·0	± 41½	8·8	8·9	13·2	± 75	3·1	± 37	3·5	1·5	± 62
E_1	2-element, X-type, dipole and director. Centre of director linked to lower half dipole	2·4	+ 24 − 31	14·0	17·6	35·0	± 70	1·8	+ 55 − 30	9·5	6·0	± 123
E_2	2-element, X-type, unlinked	3·0	± 30	11·2	22·5	26·0	± 73½	2·0	—	8·8	—	—
F	3-reflectors around arc of circle radius 0·13λ_v, folded dipole at centre.. ..	2·6	± 35	9·0	6·6	12·8	± 55	3·8	± 37	3·5	3·0	± 36
G	3-element, dipole, reflector and director spaced 0·18λ_v and 0·12λ_v respectively	5·2	—	25·2	—	—	—	—	—	—	—	—
H	3-element, folded dipole, reflector and director spaced 0·17λ_v and 0·13λ_v respectively	5·6	± 35	16·6	24·0	38·0	± 50	2·5	± 32	8·0	3·2	± 46
J	4-element, dipole, reflector and 2 directors spaced 0·25λ_v, 0·10λ_v and 0·10λ_v ..	5·3	± 36½	19·5	13·9	16·5	± 58	3·9	± 41	5·7	8·8	± 54

the aerial was supported at the top of a 50-ft wooden mast and was connected by 50 ft of concentric cable (Uniradio 32) to the bridge.

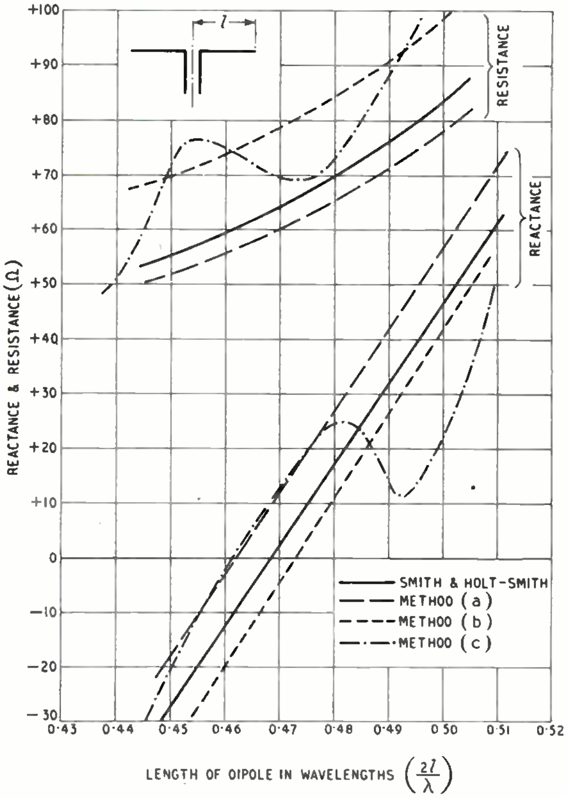

Fig. 3. *Variation of dipole impedance with length.*

4.2. *Experimental Procedure*

In order to compare the accuracies of the three methods, the variation with length of the impedance of a simple dipole was first measured. For methods (a) and (b) the frequency was fixed at 55 Mc/s while the length of the dipole was varied near the half-wavelength position. In method (c) the dipole length was fixed and measurements were made at frequencies from 55 to 65 Mc/s. The characteristic impedance of the cable having been previously determined, and also its electrical length over the frequency range of interest, the impedance of the dipole could be calculated for each frequency, using circle diagrams for the transformation.

The curves of impedance variation with length of dipole in wavelengths for the three methods are shown in Fig. 3, and are compared with previous measurements by other workers[3] which are in good agreement with theory.[4]

The variation of impedance with frequency over the band 55 to 65 Mc/s of a two-element H-type aerial (Aerial B) was similarly obtained by each of the three methods, and the corresponding curves are shown in Fig. 4. The data for Fig. 4, curve (c), were obtained by measuring the variation of impedance at the end of 50 ft of concentric cable connected to this aerial, and this variation is given in Fig. 5.

4.3. *Discussion of Impedance Characteristics*

It is apparent from Fig. 3 that none of the three methods gives good agreement with the theoretical curves for the impedance of a dipole. Method (a), however, gives values in reasonable agreement, despite the proximity of the aerial to the bridge and the ground. As this is also the simplest and quickest method, it seems suitable for approximate measurements at least.

When used to measure the impedance of the H-type aerial the three methods again show considerable disagreement. However, they all give a resistive component rising in value from 20

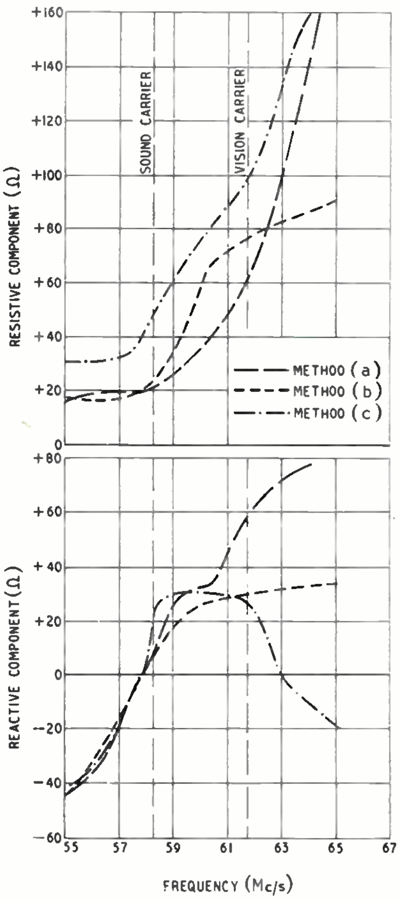

Fig. 4. *Variation of impedance of aerial B with frequency.*

to 90 ohms and a fairly constant reactive component of + 20 to + 30 ohms in the television channel 58 to 62 Mc/s. The sum effect of these impedance variations and the variation in transformation of the impedance by the cable in a particular installation is illustrated in Fig. 5. This shows that variations of 50 to 110 ohms in the resistive component and ± 30 ohms in the reactive component might be presented to the input of a television receiver. If the input impedance of such a receiver is assumed to be purely resistive and equal to the characteristic impedance of the feeder cable over the whole frequency band, the reflection loss due to the mismatch between the aerial and the terminated cable can be obtained directly from the impedance variation at the receiving end (Fig. 5). This reflection loss is also shown in Fig. 5 and varies between 0·17 db and 0·3 db in the television band. These losses correspond to voltage standing-wave ratios of 1·48 and 1·7 respectively which, although not small enough for a transmitting aerial system, are not unsatisfactory for reception. Whether television receiver input impedances can be considered purely resistive and constant with frequency is doubtful, for a few measurements which were made showed considerable departures from this ideal.

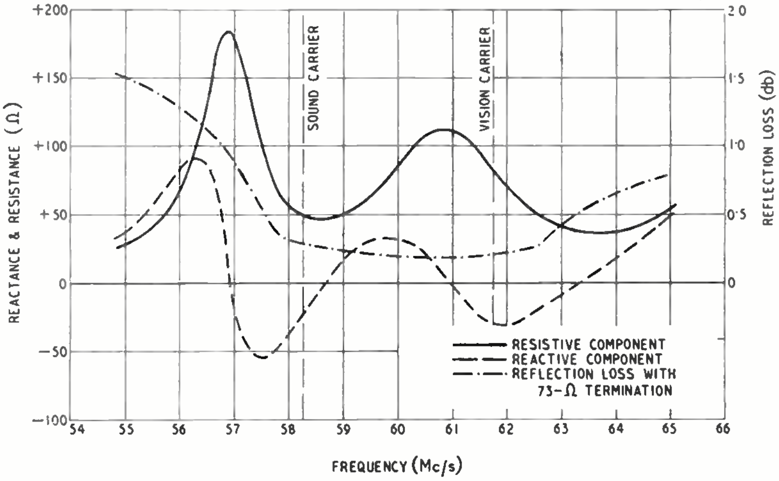

Fig. 5. *Impedance variation with frequency at end of 50 ft of Uniradio 32 connected to aerial B.*

5. Conclusions

Although the measurements were made on a nearly ideal site, which is essential for accurate results but is not likely to be found in many receiving locations, the aerial height and length and type of feeder were similar to those used in actual aerial installations. It is considered that by this means a reasonably realistic comparison has been achieved of the characteristics of various television aerials to be expected in practice.

The method described for the measurement of gain, although only one of several possible ways, will give repeatable results. The values of gain and front-to-back ratio are measured to an accuracy of ± 0·5 db, but differ somewhat from the data published by the manufacturers. However, the performance of an aerial may be modified in actual conditions of use by the presence of the feeder cable and other conducting objects nearby.

Possible improvements in both the gain and impedance measurements might have been obtained by the use of balanced, instead of concentric, cable which may have led to some of the difficulties experienced. The polar radiation diagram of a vertical dipole, for example, might be more nearly a circle if a balanced feeder were used, thus enabling gain comparison to be made using vertical polarization. Another solution to this difficulty would be the use of a 'concentric' type of dipole in which the feeder passes down the inside of the lower element and does not interfere with the radiation pattern. The lower element will also act as a quarter-wave choke preventing voltages induced on the outside of the feeder cable from appearing at the aerial terminals. When the gain comparison is made with horizontal polarization, as in the measurements, a further refinement would be to support the cable in its correct position between the elements on a horizontal wooden boom. Although it is appreciated that errors may have been introduced by not having the cable in this position, it is believed that they are less than those experienced when using vertically-polarized waves and a vertical dipole.

The third method described for the determination of aerial impedance would be improved by the use of balanced cable between the bridge and aerial and should be capable of good accuracy. However, it has been shown that, assuming that the input impedance of the receiver is the same as that of the cable, it is unnecessary to know the impedance of the aerial in order to determine the loss caused by imperfect matching and thus to compare the performance of different aerials.

Acknowledgments

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DESIGN OF SERIES PEAKING TRANSFORMERS

By A. C. Sim

(Standard Telecommunication Laboratories Ltd.)

SUMMARY.—It is shown that voltage peaking transformers can be designed very easily and accurately, with the aid of two surprisingly simple proportionality laws. These are derived without resorting to any analytical representation of the *B-H* characteristic. Predictions of the peak output voltage and of the peak duration can be made to within about 20% of the actual values.

1. Introduction

A SERIES peaking transformer is one which is supplied from a high-impedance source so that the current through it is controlled rather than the voltage across it. Its main characteristic is an output voltage which is zero for most of the cycle, and suddenly rises and falls as the magnetizing current passes through a zero. This voltage peak is a result of the core being saturated by a small proportion of the peak magnetizing current.

Thus the essential differences between a series peaking transformer and most other transformers result from two predominant design features:

(i) the load current is arranged to be negligible compared with the magnetizing current;
(ii) the magnetizing current is allowed to grow to many times the value required to saturate the core.

An allied device which might be called a shunt peaking transformer is supplied from a low impedance source so that a controlled voltage is applied, and if the core is allowed to saturate, a peak of current will be obtained near the voltage zeros.

Because of feature (ii) the core may be regarded as effectively saturated except in the neighbourhood of the primary-current zeros. As this current passes through a zero, the flux density changes rapidly from saturation in one direction to saturation in the other. Thus, appreciable voltage is induced in the secondary winding only for a short time as the current changes direction, and the output waveform is therefore a short voltage pulse repeated every half-cycle with alternating polarity.

To the author's knowledge, only one theoretical procedure has been published for the design of these devices. This method, proposed by Wilkinson,[1] depends upon the *B-H* characteristic resembling the tangent function and is, in consequence, very inaccurate. It is proposed to show that more satisfactory formulae can be derived in terms of an undefined characteristic, the constants involved being found experimentally.

The need for a more rigorous basis of design is exemplified by the numerous applications in the wide field of electronic engineering, and the possibility of further applications once the design procedure is reduced to a simple routine. Wilkinson[1] and Melville[2] discuss the applications in radar modulators, and Melville[3] further points out the possibilities of firing ignitrons directly from peaking transformers. Their uses are already well known in blocking-oscillator circuits and in the generation of short pulses.[4]

Hitherto these transformers have been developed from a succession of prototype models using trial-and-error methods based upon very broad estimations. The procedure to be presented has been in use since 1946, and in most cases no prototype has been found necessary. When the design is critical, however, a prototype is advisable, and the design formulae then give a very clear indication of how this should be modified to correct its performance.

2. Assumptions

The series peaking transformer is usually supplied from some high-impedance sinusoidal source, although the waveform need not be sinusoidal and can equally well consist of rectangular pulses. In order to produce a narrow peak

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the transformer core must saturate with a small fraction of the peak primary current. A typical situation is indicated in Fig. 1, the voltage peak being shown by a dotted line. The transformer must also be effectively unloaded, since a heavy load current reduces the degree of saturation and tends to produce a voltage waveform similar to that of the current. The load which does exist must not be capacitive, as this can cause severe oscillations.

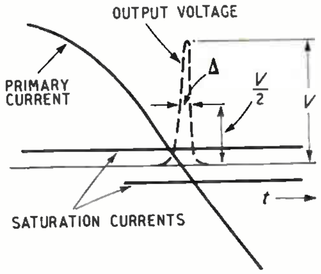

Fig. 1. *Relation between output voltage and primary current.*

The principal assumptions that must be made in order to derive some guiding formulae are as follows:—

(i) the load current is negligible;
(ii) the transformer impedance is negligible;
(iii) all the magnetic flux is in the core;
(iv) the peak current is much greater than the saturation current;
(v) the transformer load is resistive; and
(vi) the voltage peaks occur at the instants of zero flux.

As most of these assumptions must necessarily be justified if the transformer is to give a satisfactory response, they do not impose very severe limitations on the applications of the theory.

3. Theory

In the absence of a d.c. bias, the hysteresis loop corresponding to the conditions in the core will be symmetrical. The moment of peak voltage will ordinarily occur when the flux is zero, and the magnetizing current has some small value i_c which depends upon the coercive force. The instant of zero flux may be conveniently taken as the time origin, and if t_c is the time taken for the current to rise from zero to the value i_c, the instant of zero current will be $t = -t_c$, since the voltage peak will follow *after* the current zero. As may be seen from the figure, if the core saturates with a reasonably small current so that the voltage peak is sharp, the current waveform during the peak will be effectively linear, whatever the general waveform may be. It is therefore accurate to adopt an approximation (with D equal to the slope di/dt at the current zero):

$$i \approx D(t + t_c) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

for the time of interest during the peak.

The explicit mathematical form of the B-H curve being followed during the peak is, of course, unknown. It is sufficient, however, to assume only that B is some function of H, and hence of Ni/l, where N is the number of primary turns and l is the mean magnetic path length in the core; this function can be written as

$$B = f(Ni/l) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

The function applying during the next peak (of opposite polarity) is exactly the same because of symmetry in the hysteresis loop. If a d.c. bias is used, a different function will apply. Thus no severe assumptions are necessary concerning the core characteristics, since hysteresis does not affect any given peak provided f is chosen appropriately. In the method to be described, the significant properties of f are found experimentally, so that very good accuracy may be expected.

If the core has a cross-sectional area A cm², and the voltage across the primary winding is v, then

$$v = \frac{NA}{10^8}\cdot\frac{dB}{dt} = \frac{N^2A}{10^8 l}\cdot\frac{di}{dt}\cdot f'\left(\frac{Ni}{l}\right)$$

$$\approx \frac{N^2AD}{10^8 l}\cdot f'\left(\frac{Ni}{l}\right) \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

The peak primary voltage V is given by (3) when f' has its maximum value; since this is independent of the design and varies only with the core material, the peak voltage may be written:

$$V = K_1 \,.\, N^2AD/l \text{ volts} \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

in which K_1 is some iron constant.

One other item of information should be sufficient to design the transformer, and for this purpose the peak duration at $v = V/2$ has been selected. Let the instant at which $v = V/2$, be $t = T$ so that, using (1), (3) and (4)

$$10^8 \,.\, K_1 = 2f'\left(\frac{ND\,(T + t_c)}{l}\right) \quad \ldots \quad (5)$$

Since the only variable in this equation is the quantity (NDT/l), it follows that this must be made constant. If Δ is the duration of the peak at $v = V/2$, it may therefore be concluded that:

$$\Delta = K_2 \,.\, l/ND \text{ seconds} \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

in which K_2 is another iron constant.

A very important relationship can be derived from equations (4) and (6) by eliminating the turns N:

$$Al = K_3 \,.\, VD\Delta^2 \text{ cm}^3. \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

in which $K_3 = 1/K_1K_2{}^2$.

This equation gives the volume of core material necessary in terms of the peak volts, the peak width, and the rate of change of current.

4. Validity

In the Appendix an approximate investigation is made into the effect of a light resistive load. The results indicate that if the current is sinusoidal, the above formulae will be accurate provided:

$$V \ll 2I_m \,.\, R/\Delta \quad \ldots \quad \ldots \quad (8)$$

and

$$V \ll \Delta Rl/2N \quad \ldots \quad \ldots \quad (9)$$

together with

$$K_4 \left(\frac{N^3\,AD}{Rl^2}\right)^2 \ll 1 \quad \ldots \quad \ldots \quad (10)$$

in which R is the load, I_m the peak current in the primary, and K_4 is another iron constant. The conditions (8) and (10) affect the formula for V, while (8) and (9) are necessary if the equation for Δ is to be valid. [It should be noted that R is referred to the primary.]

5. Design Procedure

The constants K_1 and K_2 (and hence K_3), are soon revealed by simple experiments on a carefully wound sample. They depend upon the core material, the lamination thickness, and the frequency of the supply. The form of construction of the sample also affects the constants and reliable results, as is well known, can only be obtained if the transformers are rigidly constructed preferably using annealed cores. If very accurate results are desired, it is imperative that K_1 and K_2 be measured for the particular material and core construction to be used. For less stringent requirements the values given in Table 1 should be sufficiently accurate for design guidance.

TABLE 1

Constant		Stampings or Strip	Toroid or C-Core
Radiometal or Permalloy B.	K_1	$2{\cdot}5 \times 10^{-4}$	3×10^{-4}
	K_2	0·70	0·60
	K_3	9,000	9,300
	K_4	10^{-6}	2×10^{-6}
Mumetal or Permalloy C.	K_1	10^{-3}	$1{\cdot}2 \times 10^{-3}$
	K_2	0·10	0·08
	K_3	10,000	14,000
	K_4	4×10^{-6}	10^{-5}

The differences in K_1 and K_2 for the two types of material indicate, as they should, that mumetal will produce larger and narrower peaks than radiometal. But, on the other hand, the constants K_3 show that slightly larger cores are necessary when mumetal is used.

In a normal circumstance, V and Δ are fixed by the application of the transformer, and D is very often known or limited, so that the volume of core material required can be estimated. This gives an immediate indication of whether the project is practicable or not. It has been found that when the volume of the core falls below 0·3 cm³, the design and construction becomes difficult.

If stampings, toroids or C-cores are used, l is not flexible, but otherwise it should be reduced as much as possible. Care should be taken that the magnetic path length does not vary greatly throughout the core cross-section.

Once Al is fixed, and A/l has been chosen, then the necessary number of turns is fixed. For ease of reference the necessary formulae are repeated below:—

$$V = K_1 \,.\, N^2AD/l$$

$$\Delta = K_2 \,.\, l/ND$$

$$Al = K_3 \,.\, V\Delta^2\, D$$

6. Example

To illustrate the method of design a practical case will be described.

For the purpose of triggering a thyratron, a voltage peak of about 100 V with a width at 50 V of about 10 microseconds was required. The supply available was from a 100-V r.m.s. alternator at a frequency of 1,500 c/s, with a current of 3 A (peak). The transformer could thus be inserted in series with the alternator, obviating the need for provision of a special source impedance.

To comply with the assumption (ii) a turns ratio N_2/N_1 of 5 : 1 was selected so that the peak primary voltage would be small compared with the alternator open-circuit voltage. Small radiometal stampings were selected, 0·004-in. thick, having a centre-leg 0·19-in. wide, and a mean magnetic path length of 1·25 in.

The equation for the volume of core material gives

$$A = 9{,}000 \times 20 \times (6\pi \times 1{,}500) \times 10^{-10}$$
$$= 0{\cdot}52 \text{ cm}^3.$$

It follows that 33 laminations should be necessary. Since $l = 3{\cdot}2$ cm, the equation for Δ gives the primary turns as

$$N \approx \frac{0{\cdot}7 \times 3{\cdot}2 \times 10^5}{6\pi \times 1{,}500} \approx 7{\cdot}4$$

A prototype design using 33 stampings and 8 primary turns was constructed, and it was found to produce 76 V, the peak width at 38 V being about 12 microseconds. The equation for Δ thus suggests that a correct design should use 8 × 12/10 or 10 turns. The equation for V then indicates that 10 turns would increase the voltage to 110 V.

A revised model using 33 stampings and 10 primary turns, gave an output of 104 V peak with a peak width of 10·8 microseconds, and this was considered to be satisfactory. The use of constants measured for the stampings employed would possibly have removed the need for the prototype design.

7. Conclusion

Three simple formulae have been given for the design of lightly-loaded series peaking transformers. The successful design of such devices, however, demands considerable care in the choice of construction, and experience is necessary if prototypes are to be entirely avoided. The formulae are of great assistance in indicating the best way to improve an unsatisfactory performance.

APPENDIX

To determine the range of validity of the formulae presented, suppose that the load on the secondary can be represented by a resistance R connected across the primary winding. The equation to be solved is then

$$v = \frac{N^2A}{10^8l}\, f'\left[\frac{N(i-i_l)}{l}\right]\frac{d(i-\ i_l)}{dt} \quad \cdots \quad \cdots \quad (11)$$

where i_l is the current in R so that $v = i_lR$.

To solve equation (11) assume a solution to exist as a power series in $1/R$.

$$v = v_o + v_1/R + v_2/R^2 + - - - \quad \cdots \quad \cdots \quad (12)$$

By Taylor's theorem

$$f'\left[\frac{N(i-i_l)}{l}\right] = \left\{f'\left(\frac{Ni}{l}\right) - \frac{Ni_l}{l}.f''\left(\frac{Ni}{l}\right) - - -\right\}$$

$$= \left\{f'\left(\frac{Ni}{l}\right) - \frac{Nv_o}{Rl}\, f''\left(\frac{Ni}{l}\right) - - -\right\}$$

and substitution into equation (11) using (12) gives

$$v = \frac{N^2A}{10^8l}.f'\left(\frac{Ni}{l}\right).\frac{di}{dt} - \frac{1}{R}\left(\frac{N^2A}{10^8l}\right)^2\left\{f'\left(\frac{Ni}{l}\right)^2.\frac{d^2i}{dt^2}\right.$$

$$\left. + 2\frac{N}{l}f'\left(\frac{Ni}{l}\right).f''\left(\frac{Ni}{l}\right)\frac{di^2}{dt}\right\} - - - \quad \cdots \quad (13)$$

If the term containing the derivative d^2i/dt^2 is to be negligible it is necessary that

$$\left|\left(\frac{N^2A}{10^8Rl}\right).f'\left(\frac{Ni}{l}\right).\frac{d^2i}{dt^2}\Big/\frac{di}{dt}\right| \ll 1 \quad \cdots \quad \cdots \quad (14)$$

and for the other second order term to be omitted:—

$$\left|2\left(\frac{N^2A}{10^8Rl^2}\right).f''\frac{Ni}{l}\ .\frac{di}{dt}\right| \ll 1 \quad \cdots \quad \cdots \quad (15)$$

Let τ be the value of t for which v is a maximum when a load R is connected. Then, using Taylor's theorem (13) can be shown to lead to:

$$v \approx \frac{N^2AD}{10^8l}\ .f'\left\{1 + \tfrac{1}{2}\left(\frac{ND\ \tau}{l}\right)^2 f'''/f'\right.$$

$$\left. - 2\left(\frac{N^3AD}{10^8Rl^2}\right)\left(\frac{ND\ \tau}{l}\right).f'''\right\} \quad \cdots \quad \cdots \quad (16)$$

where it is assumed that $I \approx D(t_. + t_c)$. The quantities f' and f''' are defined by

$$f^{(n)}\left(\frac{NDt_c}{l}\right) \equiv f^{(n)}$$

Since maximum voltage occurs when $dv/d\tau = 0$, it follows from (16) that

$$\tau \approx 2\left(\frac{N^2A}{10^8Rl}\right)f'$$

and a corrected formula for V (ignoring d^2i/dt^2) is

$$\mathrm{V} = \frac{N^2AD}{10^8l}.f'\left\{1 - 2\left(\frac{N^3AD}{10^8Rl^2}\right)^2.f'f''\right\} \quad \cdots \quad (17)$$

Since t_c is defined so as to make f' a maximum, it follows that f' and f''' are iron constants. Equation (17) then leads immediately to the condition (10) in Section 4. Provided (14) is satisfied, (17) could be used to extend the simplified theory of the text, since, in terms of the iron constants, (17) can be written as:

$$V = K_1\,.\,N^2AD/l\,.\left\{1 - K_4\left(\frac{N^3AD}{Rl^2}\right)^2\right\} \quad \cdots \quad (18)$$

An extended formula for Δ is now required. Using a similar approach assume T, the instant of half peak voltage, is given by $T = (T_o + T_1)$, where T_o is its value with no load. Then equation (5) is seen to be an approximation of

$$\left\{2f'\left(\frac{NDT_o}{l}\right) + 2\left(\frac{NDT_1}{l}\right).f''\left(\frac{NDT_o}{l}\right)\right\}$$

$$= \left\{f' + 4f'\left(\frac{NDT_o}{l}\right)f''\left(\frac{NDT_o}{l}\right).\left(\frac{N^3AD}{10^8Rl^2}\right)\right\}$$

and by virtue of equation (5) which defines T_o, this reduces to

$$T_1 = \left(\frac{N^2A}{10\text{-}Rl}\right)f', \quad (= \tau/2)$$

To a first order it may be taken that $|\,2(T - \tau)\,| = \Delta$, which is equivalent to assuming the peak to be fairly symmetrical. This gives

$$\Delta \approx \left\{K_2\,.\,l/ND + 2\left(\frac{N^3AD}{10\text{-}Rl^2}\right)f'\right\}$$

But from (3), $f' \approx \left(\dfrac{10^8\,.\,l}{N^2AD}\right).V$ so that

$$\Delta \approx \left\{K_2\,.\,l/ND + 2NV/Rl\right\} \quad \cdots \quad \cdots \quad (19)$$

This leads immediately to the inequality (9). Thus, the interpretation of the inequality (15) has been made, in so far as it affects the formulae for V and Δ. It now remains to examine the relationship (14), which gives the error due to ignoring d^2i/dt^2.

If $i = I_o \sin \omega t$, then

$$\frac{d^2i}{dt^2}\Big/\frac{di}{dt} \approx -\ \omega t$$

when t is small and i is near a zero. If t is approximately $T \approx \Delta/2$, (14) may be approximated to

$$\frac{V\Delta}{2I_oR} \ll 1 \quad \cdots \quad \cdots \quad \cdots \quad (20)$$

by expressing $f'\left(\dfrac{Ni}{l}\right)$ in terms of V, as above, [and writing $D = \omega I_o$]. This is the condition given by the expression (8), and it will hold to the first order provided the waveform is fairly sinusoidal.

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INHERENT FEEDBACK IN TRIODES

By H. Stockman, S.D.

SUMMARY.—The triode is imagined to be replaced by an infinite-impedance pentode (with its simplified anode-current expression $g_m dV_c$) with a fictitious e.m.f. in the grid circuit to represent the 'back action' of the anode on the field at the cathode. It is shown how this transformation makes it possible to obtain practical triode circuit formulae from conventional feedback theory.

IN comparison with a pentode a triode has both strong and weak points. If in mathematical analyses the triode be considered as an infinite-impedance pentode with negative feedback, certain of its advantages appear as direct and expected results of negative-feedback theory, and in some cases a simplified analysis may result. The method is of particular interest for control circuits and output stages utilizing low-μ triodes, since the back action from the anode on the emission-controlling field at the cathode is then appreciable. This electric field action is fundamentally a form of negative feedback.

Fig. 1(a) shows a conventional pentode, representative of any screen-grid multi-electrode valve. Fig. 1(b) shows a conventional triode. The dynamic mutual conductance g_{md} is for the pentode circuit

$$g_{md} = g_m = \frac{dI_b}{dV_c}, \quad \ldots \quad (1)$$

and for the triode circuit

$$g_{md} = \frac{r_a}{r_a + Z_b} g_m = \frac{dI_b}{dV_c}, \quad \ldots \quad (2)$$

or

$$g_m = \frac{dI_b}{dV_{ce}}, \quad \ldots \quad (3)$$

where the equivalent control voltage, dV_{ce}, is

$$dV_{ce} = dV_c + \frac{1}{\mu} dV_b \quad \ldots \quad \ldots \quad (4)$$

It is seen that Equ. (1) becomes identical with Equ. (3) when the term dV_b/μ in Equ. (4) tends to zero. The presence of this term may then be considered as the result of the removal of one or more shielding or screening grids in the circuit Fig. 1(a). Thus it is logical to consider dV_b/μ as a feedback voltage injected in series with dV_c, and thus added to dV_c, because of lack of electric shielding between the anode and the cathode. (If dV_c is positive, dV_b produces a negative term, hence $dV_{ce} < dV_c$).

Equ. (2) represents a form of the Equivalent Anode Circuit theorem. This theorem also applies to the circuit in Fig. 1(c), where a fictitious screen grid has been inserted between the anode and cathode to justify the transfer of the voltage dV_b from the anode circuit to the grid circuit, where it appears as the fictitious voltage $dV_f = dV_b/\mu$, as required by Equ. (4). Equivalence is now established between the circuit in Fig. 1(c) and the basic circuit for voltage-controlled feedback, Fig. 2(b), where A is the amplification of the triode functioning as a pentode; thus $A = -g_m Z_b$, and β is the feedback transmission coefficient $1/\mu$. The fundamental equation for a triode circuit can now be derived from conventional feedback theory. Thus the actual amplification of the triode takes the well-known form

$$A_a = \frac{A}{1 - \beta A} = \frac{-\mu Z_b}{r_a + Z_b}. \quad \ldots \quad \ldots \quad (5)$$

The combination impedance Z_{AB} seen from right to left between the output terminals A,B in Fig. 1(c) can be determined if, for $dV_c = 0$, a voltage source dV_0 is applied to these output

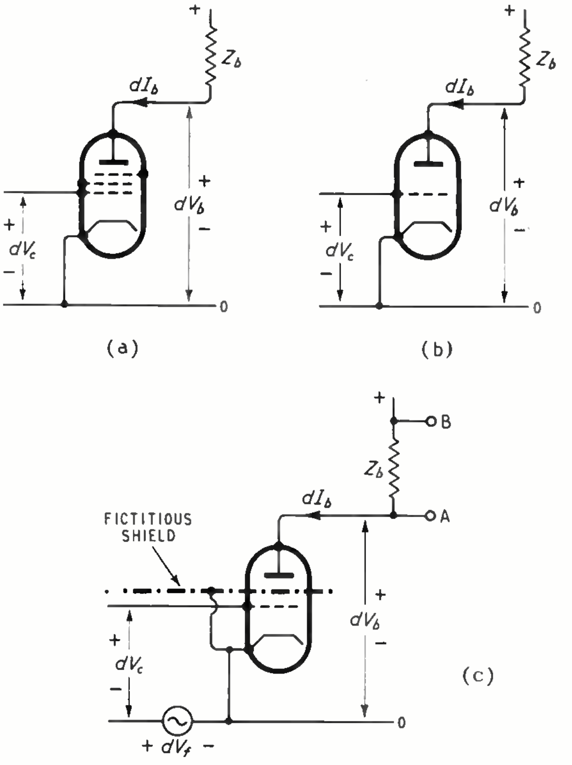

Fig. 1. *Pentode and triode circuits (a) and (b) with an equivalent (c) in which a voltage dV_f in the grid circuit produces the effect of a screen.*

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terminals, sending the current dI_0 into the parallel circuit, and has the obvious form

$$Z_{AB} = \frac{dV_0}{dI_0} = r_a Z_b/(r_a + Z_b) \quad .. \quad .. \quad (6)$$

This equation clearly expresses the reduction in output impedance due to the shunting of Z_b with the low r_a of a low-μ triode. For the above output impedance calculations the fictitious shield is insignificant; there is only one field change at the cathode, no degeneration, and $dV_f = 0$.

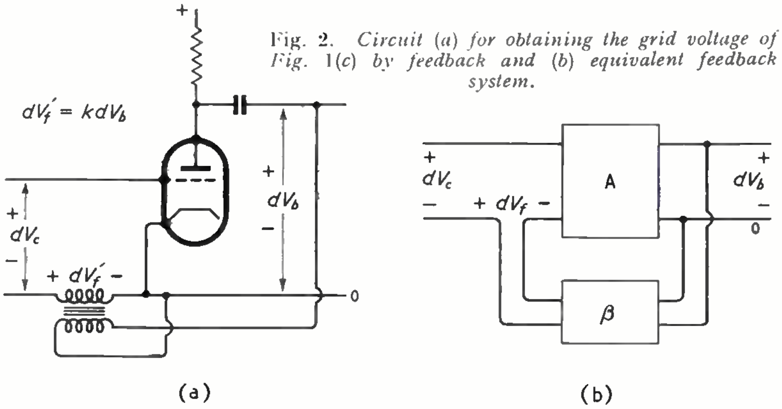

Fig. 2. *Circuit (a) for obtaining the grid voltage of Fig. 1(c) by feedback and (b) equivalent feedback system.*

When external feedback is applied, it may be considered as the logical addition to the already present internal feedback, expressed by the method given above. This implies that the feedback transmission coefficient should be changed to include the externally-established coupling. As an example, a very simple external feedback circuit is shown in Fig. 2 (a), utilizing a transformer to inject the voltage $dV'_f = kdV_b$, where k is a constant, into the grid circuit, so that for increased negative feedback the resulting transmission coefficient becomes

$$\beta = \frac{1}{\mu} + k \quad .. \quad .. \quad .. \quad (7)$$

The actual amplification in this example is therefore

$$A_a = \frac{A}{1 - \beta A} = \frac{-\mu Z_b}{r_a + (\mu k + 1) Z_b} \quad .. \quad (8)$$

Extending the example further, we may consider the transformer in the region of its upper cut-off frequency, with a peak response due to its leakage-reactance resonance. It is well known that this response curve flattens out when external negative feedback is applied. Actually, before any external feedback has been applied, *the response curve is already flattened out by the internal feedback.* If the internal feedback were removed, the response curve would be still more peaked. Thus the quality improvement due to internal feedback is of the same nature as the quality improvement due to external feedback. This line of thought pertaining to negative feedback might be useful in comparing inferior frequency response of a pentode with the frequency response of a triode.

Considering the external application of positive feedback, it follows that we must apply a substantial amount of such feedback to a triode circuit before we have actually applied any feedback at all, in the true sense of the word. This is proved by the feedback Equ. (5), for if $\beta A = 0$, $A_a = A$; indicating no change due to feedback. Reversing the connections on one side of the transformer so as to provide positive feedback, it is seen that the feedback transmission is still represented by Equ. (7), however with reversed sign for k, so that if we apply just enough positive feedback to make $k = 1/\mu$, there is no feedback at all in the circuit; $\beta = 0$. The true status of feedback in a triode valve circuit is of importance when comparing different circuits with *the same amount of feedback applied to each circuit.* Thus, if a quantity such as reduction in noise is to be measured, first without feedback, then with specified amounts of feedback, and if the second term in Equ. (4) is appreciable compared to the first one, it follows that equity obtains only if the 'zero' feedback of the triode is compared with an amount of feedback in the pentode corresponding to the second term in Equ. (4).

If we increase k further, by changing the transformer ratio, the point of oscillation is reached for $\beta A = 1$. Solving Equ. (7) with $k = -k^*$ for this condition, and multiplying by A, we obtain the critical value for oscillation

$$k^* = \frac{1}{g_m Z_b} + \frac{1}{\mu} \quad .. \quad .. \quad (9)$$

This value of k is indicative of a negative resistance in the resulting loop circuit equal to the positive loss resistance. The first term in Equ. (7) represents the positive feedback which would be needed to make the tube oscillate if it were the equivalent of a pentode. The second term represents the additional feedback needed in a triode circuit to overcome the already-present negative feedback, which is due to back action from the anode on the electric field at the cathode.

As a mathematical criterion $\beta A = 1$ is considered a correct indication of oscillation in the above circuit. From a technical point of view the formulae resulting from $\beta A = 1$ are not true, nor do they represent more than an approximation even when βA is unequal to 1, but close to 1. The reason for this is the heavy regeneration that precedes oscillation as β is increased. The circuit is then no longer linear, and since the feedback formula is derived from Kirchhoff's equations, the formula does not fully apply.

While the above theory also applies to high-μ triodes, the second term of Equ. (4) then becomes so small as to be negligible, and there is no further need to shield the anode from the cathode. Since for high-μ valves high-frequency operation is more likely than for low-μ valves, an entirely different shielding or screening, namely of the anode from the signal grid, becomes significant. This shielding, to prevent circuit coupling, so-called Miller effect, is extensively treated in the literature, and will not be discussed here. It should be noted, however, that in the cases where a low-μ triode is used at radio frequencies, the basic theory given above is naturally extended to include the Miller effect, if the transmission coefficient is properly modified to include the effective coupling between the anode and the grid circuits. Thus one generalized feedback theory will cover both the above-discussed gain-controlling phenomena experienced by triodes.

The original invention of the screen-grid valve in 1918 by W. Schottky, Germany, aimed at the removal of the second term in Equ. (4) by removing the anode a.c. field at the cathode, while simultaneously maintaining a d.c. field at the cathode.[1,9] A similar improvement can, theoretically, be obtained by applying positive feedback to cancel the inherent negative feedback. If there existed an ideal solution to this positive-feedback proposition, low-μ triode valves might today be used in many applications now employing pentodes. So far there has been no invention, aiming at the elimination of the second term in Equ. (4), which has been of any significance compared to the simple and ingenious Schottky screen-grid invention (or later beam-tube solutions). Such an invention is, however, not contradictory to the basic laws of physics, and may be made in the future. This is said in view of the fact that future 'grid'-controlled devices, competing with the low-frequency output valve, would make use of basic principles for magnetic amplification, dielectric (ferro-electric) amplification, transistor amplification, and other amplification, where the equivalent to the second term in Equ. (4) is either virtually non-existent, or can be eliminated by methods not applicable to a vacuum tube.

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PREMIUMS FOR TECHNICAL WRITING

The Radio Industry Council has announced that six further premiums for technical writing have been awarded. There are four awards of 25 guineas each to:—

P. H. Parkin, B.Sc., A.M.I.E.E., and P. H. Taylor, A.M.I.E.E., for their article "Speech Reinforcement in St. Paul's Cathedral" which appeared in *Wireless World*, February and March 1952.

T. Somerville, B.Sc., M.I.E.E., F.Inst.P. and C. L. S. Gifford, M.Sc., F.Inst.P., for their article "Composite Cathode Ray Oscillograph Displays," which appeared in the *B.B.C. Quarterly*, Spring 1952.

J. A. Jenkins, M.A., M.Inst.P. and R. P. Chippendale, B.Sc., for their article "Some New Image Converter Tubes," which appeared in *Electronic Engineering*, July 1952.

W. R. Stamp, for his article "Underwater Television," which appeared in *Discovery*, September, 1952.

Ex-gratia awards of £10 each have been made to:—

T. W. Bennington for his article "Propagation of V.H.F. via Sporadic E," which appeared in *Wireless World*, January 1952.

G. N. Patchett, Ph.D., B.Sc., A.M.I.E.E., M.I.R.E., A.M.Brit.I.R.E., for his article "Faulty Interlacing," which appeared in *Wireless World*, July and August 1952.

The presentation of the awards is to take place at a luncheon of the Public Relations Committee of the Radio Industry Council on Thursday, 9th April.

UNIVERSITY OF BIRMINGHAM

A week's course on the "Theory of Electrical Communication" is to be held from 20th-25th July at the Centre for Continued Studies, Primrose Hill, Birmingham. The course is organized by D. A. Bell, M.A., B.Sc., and covers statistical methods, information and entropy, bandwidth v. signal/noise ratio, coding, etc. Those taking the course will be assumed to have a level of general knowledge of the standard of a university degree in electrical engineering or physics.

The fee for the course (excluding meals and accommodation) is £3 3s. 0d. and application should be made to the Director of Extra-Mural Studies, The University, Birmingham 3.

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.

Anode-Follower Derivatives

Sir,—Having (presumably) provoked Mr. M. G. Scroggie's letter objecting to the term 'anode-follower' it appears that I must admit to having used this name to preserve consistency with the prior literature and in the knowledge that it is the one used by engineers concerned with the circuit in question. It is, surely, up to those who object to current usage to suggest more suitable alternatives. Knowing that Mr. Scroggie approves of the See-Saw circuit I am surprised he has not suggested Unit-Gain See-Saw for the anode-follower. In defence of the title of my article, however, I would point out that in the case of the most important derivative (Fig. 5) the output anode does actually follow the input grid.

A. W. Keen.

Technical College,
Coventry.
14th February 1953.

Television Definition

Sir,—In my previous letter[1] I inferred from the general principles of communication theory that it is not possible to transmit two picture-points per cycle of video frequency in a system which does not use some special method of coding; that the half-sine-wave argument, which is commonly based on the example of a chequer-board pattern, is fallacious; and that faithful reproduction would require twice the bandwidth conventionally employed at present.

Two references bearing on this question have since come to my notice. In 1924 Nyquist published a paper entitled "Certain Factors Affecting Telegraph Speed"[2] in which he pointed out the fallacy of equating the telegraph signal to a continuous sine wave on the basis of two telegraph elements per cycle. The telegraph signal, which corresponds to the television chequer-board, is known as "unbroken reversals", and Nyquist pointed out that such a signal conveys no information. More recently Schunack[3] has investigated the bandwidth required for television by a direct analysis of the receiver response when transient signals, such as edges, dots, grids, and abruptly-commencing sinusoidal variations of brightness, are transmitted through a system with limited bandwidth. He makes no appeal to the indirect though fundamental evidence of communication theory. Briefly, Schunack's conclusions are that systems designed on the conventional basis of two picture elements per cycle of video band show the following defects which can in fact be observed in high-definition systems:

(*a*) Alternate light and dark picture elements will be reproduced with greater contrast than a single light element of the same width on a dark ground.

(*b*) At the beginning of a long succession of alternating picture elements, the contrast between the first elements is exaggerated, and maxima and minima of brightness alternate over several periods of the pattern.

Doubling the bandwidth to one cycle per picture element clears both these defects (Schunack states that he set up such a system experimentally in 1938) besides increasing rate-of-rise and reducing overshoot. While agreeing that definition is also limited by size of scanning aperture, and that aperture-effect tends to smooth out overshoot, Schunack points out that aperture-effect and bandwidth-effect are independent and different in kind, so that the existence of one does not justify toleration of the other.

Schunack thus supports my contention that the conventional uncoded systems, which allow only half a cycle per picture element, cannot give correct reproduction. It is also true, however, that a suitable system of coding of the transmission could fully realize the rate which is commonly supposed to be realized without coding. This is in principle achieved by the system of "receiver re-sampling" which is used for some systems of colour television, as has been pointed out by Gouriet.[4]

D. A. Bell.

Department of Electrical Engineering,
University of Birmingham.
12th February 1953.

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[1] D. A. Bell, *Wireless Engr*, Vol. 29, p. 196, 1952.

[2] H. Nyquist, *Bell Syst. Tech. J.*, Vol. 3, p. 324, 1924.

[3] J. Schunack, *Arch. elekt. Ubertragung*, Vol. 3, p. 301 and p. 323, 1949 Vol. 4, p. 75 and p. 113, 1950.

[4] G. G. Gouriet, *Electronic Engng*, Vol. 24, p. 166, 1952.

THE ROYAL SOCIETY

Professor Willis Jackson, who has occupied the chair of Electrical Engineering, Imperial College of Science and Technology, London, since 1946, has been elected a Fellow of the Royal Society. He is distinguished for his work on dielectrics and the performance of transmission lines and waveguides.

In July he will be taking up a full-time appointment as director of research and education with the Metropolitan-Vickers Electrical Co.

I.E.E. MEETINGS

9th April. "Special Effects for Television Studio Productions," by A. M. Spooner, B.Sc.(Eng.) and T. Worswick, M.Sc.

13th April. Discussion on "The Relative Merits of Broad-Band Transmission by Beam, Cable and Waveguide," to be opened by E. C. H. Organ, O.B.E.

14th April. "Digital Computers at Manchester University," by T. Kilburn, M.A., Ph.D., G. C. Tootill, M.A., M.Sc., D. B. G. Edwards, M. Sc., and B. W. Pollard, M.A., and "The Construction and Operation of the Manchester University Computer," by B. W. Pollard, M.A., and K. Lonsdale, B.Sc.Tech.

"Universal High-Speed Digital Computers: A Decimal Storage System," by T. Kilburn, M.A., Ph.D., and G. Ord, M.Sc.

"Recent Advances in Cathode Ray Tube Storage," by Professor F. C. Williams, O.B.E., D.Sc., D.Phil., F.R.S., T. Kilburn, M.A., Ph.D., G. N. W. Litting, B.Sc., D. B. G. Edwards, M.Sc., and G. R. Hoffman, B.Sc.

22nd April. "An Investigation of the Characteristics of Cylindrical Surface Waves," by Professor H. M. Barlow, Ph.D., B.Sc.(Eng.) and A. E. Karbowiak and "Surface Waves," by Professor H. M. Barlow, Ph.D., B.Sc.(Eng.) and A. L. Cullen, Ph.D., B.Sc.(Eng.).

23rd April. Forty-Fourth Kelvin Lecture. "The Dilemma of Lord Kelvin," by Professor P. I. Dee, C.B.E., M.A., F.R.S.

These meetings will be held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2, and will commence at 5.30.

BRIT. I.R.E. MEETING

8th April. "Lens Aerials for Centrimetric Wavelengths," by Lt.-Col. J. P. A. Martindale, B.A. at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, commencing at 6.30.

NEW BOOKS

Analysis of A.C. Circuits

By W. R. LE PAGE, Ph.D. Pp. 444 + xiii, with 340 illustrations. McGraw-Hill Publishing Co., Ltd., 95 Farringdon Street, London, E.C.4. Price 55s. 6d.

The author is Professor of Electrical Engineering at Syracuse University and the stated object of the book is to impart understanding of fundamental principles to the student. Although a first edition, it is based on mimeographed editions which have been used by the teaching staff of the University whom the author thanks for their patience and help. Although nominally concerned with alternating currents, an appendix of 25 pages is devoted to direct-current circuit analysis. Fundamental electrical ideas are assumed to have been already established in previous studies and "it is the application of the mathematics of trigonometric functions to known electrical quantities that is new." The treatment is very thorough, every step being explained with the help of diagrams, analogies and examples. Chapter 2 has for a heading a quotation from Voltaire, "If you wish to converse with me, define your terms;" the title of the Chapter is Introductory Concepts. This is followed by a chapter on Metering and Effective Values. It is stated that in accordance with the American Standards Association, 'potential difference' is used rather than 'voltage', and that it is abbreviated to 'potential' whenever it seems permissible to do so.

It is surprising to find no reference to electromotive force, even in the index; this is explained in a footnote on page 10 where, by way of an apology for speaking of the potential induced in a conductor, they say that this is the indication of an imagined voltmeter connected between the terminals, and they use it rather than "e.m.f. or electromotance." If the flux through a closed circuit is changing, they speak of the induced potential; i.e., the reading which would be obtained on a voltmeter inserted in the circuit. This is in keeping with their argument that they are dealing with the technique of circuit analysis, which is "largely divorced from the general theory of electricity and magnetism."

Chapter 4 deals with the symbolic treatment of sinusoids (i.e., sine waves) and introduces some unusual terms. A line of length equal to the effective value and making an angle with the horizontal equal to the initial angle of the wave (i.e., when $t = 0$) is called a *sinor* and the usual rotating vectors are called *phasors*. Although Chapter 5 has the title "Basic Integrodifferential Equations" it deals with Kirchhoff's laws and the concept of duality; the title arises from such formulae as $i = Gv + C\frac{dv}{dt} + \frac{1}{L}\int v dt$. After a chapter devoted to series and parallel circuits, resonance, etc., Chapter 7 is devoted to power in a.c. circuits, Chapter 8 to complex quantities, Chapter 9 to network terminology and notation, leading up to the analysis of networks, which occupies the two following chapters. Great use is made of the Helmholtz-Thévenin and the Helmholtz-Norton theorems. Chapter 12 deals with magnetic coupling, Chapter 13 with polyphase systems and Chapter 14 with variable-response networks, including impedance and admittance loci of circuit arrangements with different variables, and filters of various types. Then follow chapters on non-sinusoidal periodic waves and Fourier series. An appendix is devoted to the calculation of circuit parameters, such as resistance, inductance, capacitance, etc.

Generally speaking, the book is of a very high standard of production; it is not until one gets near the end that one finds lapses. On page 395 the curve showing the h.f. resistance of a wire is not eventually nearly proportional to the frequency as stated, but to $\sqrt{f}$. It is interesting to note that the symbols k_m and k_e are used for magnetic permeability and dielectric constant.

Every chapter concludes with a large number of problems and questions and references are given to a number of textbooks, classified as introductory or advanced.

G. W. O. H.

Electrical Units (With Special Reference to the M.K.S. System)

By ERIC BRADSHAW, M.B.E., M.Sc.Tech., Ph.D., M.I.E.E. Pp. 64 + 9 illustrations. Chapman and Hall, Ltd., 37 Essex Street, London, W.C.2. Price 9s. 6d.

In the m.k.s. system of electrical units the practical units are inevitable absolute units, rather than concessions of theory to the inconvenient scale of things in everyday life and the formidable speed of light. Rationalization, which effectively shifts the emphasis from point charges and poles to the electromagnetic field in deriving fundamental formulae, helps further in reconciling practical measurements and basic theory. Prof. Bradshaw believes that the m.k.s. rationalized system is educationally the most desirable, and that the only way to understand the units fully is to make a determined effort to use them. His book is admirably directed to this single aim. It is for those readers who seek guidance in applying them, rather than for the unconverted or dimensionally-minded. To the ordinary teacher and the practising engineer, many of the existing discussions on this subject may recall the arguments of the economists about the gold standard twenty years ago; somebody may perhaps be right, but it is all very abstrusely put and remote from everyday experience. It is indeed possible to prejudice the reader's mind against the system by trying to explain matters too fully, and becoming involved in lines of thought which are not directly helpful. The author has wisely avoided such distractions, and concentrated on explaining unit systems in general, with tables for comparing rationalized and unrationalized formulae, and for the conversion of numerical values from one system to another.

Two suggestions may be offered. The first is that while a familiarity with electrical units and theory is properly taken for granted, it is risky to extend this assumption to mechanical units. The joule, the newton, and certainly the watt do not to the average student enjoy a status as 'practical mechanical units,' comparable with that of the volt and the ohm in electricity. Indeed, a good deal of units-trouble can be traced to the state of mind which will cheerfully accept the joule and the watt as *derived from* the volt, coulomb, and ampere. It would have been worth while to emphasise the importance of a thorough understanding of the basic mechanical units. The second is that two particularly valuable points are dealt with in brief appendices, and one might well have been given a fuller treatment. These are the plotting of fields, bringing out the analogy between the conduction field and the induction field suggested by the form of the rationalized equations, and the experiments from Goodier and Ghey by which μ_0 and κ_0 are measured directly, with the assumption of the ampere as the fourth fundamental unit.

The reader will feel that Prof. Bradshaw has made the m.k.s. system easy to understand. To this the author would undoubtedly reply that it is intrinsically easy anyhow, if one is not afraid of it, and the reviewer would agree, while forecasting that the reader will also agree after he has had time to reflect on it and apply it. In short, one can recommend the book thoroughly, and wish it every success.

G. R. N.

Signal, Noise and Resolution in Nuclear Counter Amplifiers

By A. B. Gillespie, B.Sc.(Eng.). Pp 155 + xii. Pergamon Press, Ltd., 2-5 Studio Place, Kinnerton Street, London, S.W.1. Price 21s.

In his introduction, the author is almost apologetic about having included previously-published material and implies that he has done so only in order to give a comprehensive, but simple, treatment of the subject. He claims, however, that in three of the six chapters which comprise the book there is "much theoretical and experimental data which has not been published before."

In his aim of giving a simple and comprehensive treatment the author, has in the main, succeeded most admirably. He has obviously taken great care over the presentation of his material and the early chapters are readily understandable even by one unfamiliar with the subject. The later chapters are not quite so good and would be improved by the addition of a little more explanation here and there, and there are a few involved statements which would be better unravelled.

After the introduction, the nature of the signals from an ionization chamber is explained and this is followed by a chapter on valve and circuit noise. Signal-to-noise ratio is then treated and Chapter 5 deals with sensitivity. In the final chapter, proportional and scintillation counters are explained. There are 18 Appendices in which the mathematical expressions of the text are worked out. The author's treatment is here rather unusual for, except in the simplest cases, he states the problem in mathematical form and goes directly from this to its solution, the intermediate steps being relegated to an appendix.

There are some minor points of criticism. The list of symbols would have been more useful if arranged in alphabetical order than in order of appearance in the text. Then, what is the velocity of a voltage? The author seems to mean the time rate of change of voltage, but velocity is essentially time rate of change of position and is, strictly, a vector. It can be applied to a particle or a wave, but surely not to a voltage. These are but minor points in a generally excellent book, however.

W. T. C.

Elektroakustik: Musik und Sprache

By Dr. F. C. Saic. Pp. 154 with 89 illustrations. Springer-Verlag, Wien 1, Mölkerbastei 5. Price 27s.

The stated object of this book is to give an introduction to the problems of modern musical-physiological acoustics, which, because of the great advances made in acoustical measurement technique, can now be treated objectively rather than subjectively. The author purposely omits any references, in order to preserve the unity of the introductory character of the book. The scope is indicated by the titles of the nine chapters; units; sound radiation; the human ear as a noise and sound analyser; consonance theory; sound sensation and distortion; building up and damping; dynamical distortion; echo, reverberation, etc.; supersonics. Every aspect of noise, speech and music is discussed fully and illustrated by means of diagrams and curves, but no attempt appears to have been made to check the correctness of the mathematical equations and symbols, and many of the mistakes show almost incredible carelessness. On page 5 $(F/p_o)^2$ should obviously be E/E_o, then on page 8, equation (4) correctly gives $n = 10 \log \frac{N_o}{N_n}$ db where N_o is the input power and N_n the output power, but we are then told that if n is greater than 1 there is amplification, but if less than 1 there is attenuation. Not only is this the wrong way round, but if there is neither amplification nor attenuation $N_n = N_o$ and $n = 10 \log 1 = 0$; hence the border line is not $n = 1$ but $n = 0$. On p. 20 the distance 0 should be D, and the abscissae in Fig. 5 are $m/100$ not $m/10$. On p. 66 we are told that it takes about 0·2 second for the ear of a very tired person to respond fully to a suddenly applied sound, whereas the ear of a normal person requires *only 0·5 second.* On p. 95 the statement that 3·5/5000 = 7 milliseconds is said to agree with the results of other observers who obtained values between 5 and 10 milliseconds; there is obviously something radically wrong with the values given on this page. Fig. 70 shows that the 0·15 second given in the text should be 0·20, and in Fig. 72 the 0·5 should be 0·4. On p. 143 the reference to Fig. 88 should be to Fig. 85; on p. 146 the statement about the wavelength in lead appears to be entirely wrong and contrary to the Table on p. 13.

It is hard to believe a very interesting statement made on p. 150 with regard to a vessel containing a liquid subjected to supersonic vibration; it says that although the liquid may have a mean temperature of 20°, a thermometer inserted in it shows −20°, but one dare not touch the vessel for fear of burning one's fingers. No attempt is made to explain these peculiarities.

The book forms a very interesting introduction to the subject of acoustics, but, as we have shown, there is much about it that is unsatisfactory; it is a great pity that more care was not taken in correcting the manuscript and proofs.

G. W. O. H.

Advanced Five-Figure Mathematical Tables

By C. Attwood, B.Sc., B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E. Pp. 69. Macmillan & Co., St. Martin's Street, London, W.C.2. Price 6s. (postage 3d.).

This is a supplement to the author's "Practical Five-Figure Mathematical Tables," reviewed in *Wireless Engineer*, August 1948, Vol. 25, No. 299, p. 267. The main tables consist of (a) multiples and logarithms of powers of π and e, (b) natural, but *not* logarithmic, trigonometrical functions of angles expressed (i) in decimals of a degree, (ii) in radians, (c) hyperbolic sines, cosines and tangents, (d) exp x and exp $(—x)$, (e) the factorial function $x!$ defined as $\int_0^\infty e^{-t}t^x dt$, for $0 < x < 1$, (f) complete elliptic integrals of the first and second kinds, with argument k^2 instead of the more usual but less convenient $\sin^{-1}k$, (g) ordinates of the normal probability curve, (h) areas under the normal probability curve. Subsidiary tables for conversion of radians to decimals of a degree and vice versa, and various standard formulae and series associated with the tabulated functions, their derivatives or their integrals are also included.

As in the earlier tables, the interval of tabulation is skilfully adjusted to suit the rate of change of the tabulated function. Considerable use is also made of "critical tables." In a few cases, second differences are required, and the necessary interpolation technique is fully explained.

The tables are clearly arranged, and the supplement may be regarded as a worthy successor to the original tables. In the original tables, differences which had to be subtracted were printed in red; in the reviewer's opinion it is unfortunate that this could not also be done in the supplement, especially in the table of $x!$ where the differences are sometimes subtracted and sometimes added.

The present tables make it possible to work entirely in radians for trigonometrical computations, and greatly simplify computations involving both circular and hyperbolic functions. They can therefore be thoroughly recommended in themselves, but when they are combined with the earlier set of tables, a whole entity is formed which is much greater than the sum of its parts.

J. W. H.

Remote Control by Radio

By A. H. Bruinsma. Philip's Technical Library. Pp. 95 + viii. Cleaver Hume Press Ltd., 42a South Audley Street, London, W.1. Price 8s. 6d.

This is a paper-backed book containing details of two different forms of remote-control systems of types which are suitable for use with models. One is a two-channel a.m. system, the other is an eight-channel pulse-modulation apparatus. In addition to the explanatory material of the principles underlying their design, the book includes complete circuit diagrams with the values of components.

Construction and Application of Conformal Maps

National Bureau of Standards Applied Mathematics Series 18. Pp. 280. Price $2.25.

Supplementary List of Publications of the National Bureau of Standards 1st July, 1947 to 30th June, 1952.

Supplement to Circular 460. Pp. 223. Price 75 cents.

Tables of Bessel Functions $Y_0(x)$, $Y_1(x)$, $K_0(x)$, $K_1(x)$, $0 < x < 1$.

National Bureau of Standards Applied Mathematics Series 25. Pp. 60. Price 40 cents.

The above three publications can be obtained from the Government Printing Office, Washington 25, D.C., U.S.A.

Selected Problems in the Preparation, Properties and Application of Materials for Radio Purposes.

D.S.I.R., Radio Research Special Report No. 25. Pp. 24 + iv. H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 1s. 6d.

Basic Electronic Test Instruments

By Rufus P. Turner. Pp. 254 + xiv. Rinehart Books Inc., 232 Madison Av., New York 16, U.S.A. Price $4.

Physical Formulae

By T. S. E. Thomas. Pp. 118 + vii. Methuen & Co. Ltd., 36 Essex Street, London, W.C.2. Price 8s. 6d.

Thermionic Vacuum Tubes (6th Edition)

By W. H. Aldous, B.Sc., D.I.C., A.M.I.E.E. and Sir Edward Appleton, F.R.S. Pp. 160 + vii. Methuen & Co. Ltd., 36 Essex Street, London, W.C.2. Price 9s. 6d.

Some Researches on High Frequency Phenomena and Electrical Direct Heating

Edited by Y. Asami. Pp. 105. (In English). The Research Institute of Applied Electricity, Hokkaido University, Sapporo, Japan.

Transmission Téléphonique—Théorie des Lignes

By R. Croze and L. Simon. Pp. 368. Les Editions Eyrolles, 61 boulevard Saint-Germain, Paris Ve, France. Price 2.960 francs.

Les Filtres Électriques (3rd Edition)

By Pierre David. Pp. 192. Gauthier-Villars, 55 Quai des Grands-Augustins, Paris 6e, France. Price 2,500 francs.

Temperature and Humidity Gradients in the First 100m over South-East England.

By A. C. Best, M.Sc., E. Knighting, B.Sc., R. H. Pedlow, B.Sc. and K. Stormonth, B.Sc. Pp. 60. H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 7s. 6d.

BRITISH STANDARDS

Radio Interference Suppression for Motor Vehicles and Internal Combustion Engines.

B.S. 833 : 1953. Price 3s.

Dimensions of Circular Cone Diaphragm Loudspeakers.

B.S. 1927 : 1953. Price 2s.

Lateral-Cut Gramophone Records and Direct Recordings.

B.S. 1928 : 1953. Price 2s. 6d.

The above three publications can be obtained from the British Standards Institution, Sales Branch, 24 Victoria Street, London, S.W.1.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Values for February 1953

Date 1953 February	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	N.M.	+ 6·6
2*	+ 0·1	0	+ 5·3
3*	+ 0·1	0	N.M.
4*	+ 0·2	+ 1	+ 4·9
5*	+ 0·1	+ 2	+ 3·9
6*	N.M.	+ 1	+ 3·8
7	+ 0·2	+ 2	+ 4·0
8	N.M.	N.M.	+ 3·8
9*	+ 0·2	0	+ 3·7
10	0·0	+ 3	+ 4·1
11*	+ 0·3	+ 4	+ 2·8
12	+ 0·1	+ 3	+ 3·0
13*	+ 0·2	+ 3	+ 3·6
14	+ 0·5	+ 1	+ 4·1
15	+ 0·3	N.M.	+ 4·8
16*	+ 0·3	+ 3	+ 5·0
17**	—	+ 1	—
18*	N.M.	+ 2	N.M.
19*	+ 0·3	+ 2	N.M.
20*	+ 0·3	+ 1	+ 6·2
21	+ 0·2	+ 3	+ 7·0
22*	N.M.	N.M.	+ 7·5
23	— 0·3	+ 3	+ 8·0
24**	—	+ 1	—
25**	—	+ 3	—
26**	—	+ 1	—
27**	—	+ 2	—
28	0·0	0	+ 10·1

The values are based on astronomical data available on 1st March 1953.

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 journal titles conform generally with the style of the World List of Scientific Periodicals. An Author and Subject Index to the abstracts is published annually; it includes a list of journals abstracted, the abbreviations of their titles and their publishers' addresses.

ACOUSTICS AND AUDIO FREQUENCIES

016 : 534 **910**

References to Contemporary Papers on Acoustics.—R. T. Beyer. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 790–798.) Continuation of 1 of 1953.

534 + 621.3].001.362 **911**

Acoustics in Relation to Radio Engineering.—E. G. Richardson. (*J. Brit. Instn Radio Engrs*, Nov. 1952, Vol. 12, No. 11, pp. 577–584.) Analogies between acoustic and e.m. phenomena are demonstrated and, in particular, the relations between acoustic and e.m. impedors, resonators, filters, transmission lines, waveguides and radiators are discussed. Phenomena in the application of sound ranging are compared with ionospheric effects in the propagation of e.m. waves.

534.23 : 534.374 **912**

Acoustical Interference Filters.—K. K. Curtis & L. N. Hadley. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 721–725.) The propagation of normally incident waves through a system comprising five parallel layers of distinct media is discussed. Analysis indicates that such a system passes a number of narrow bands whose mid-frequency spacings depend on the thickness of the third layer. The observed response of experimental filters comprising alternate layers of air and 0·02-mm Al foil agrees fairly well with theoretical predictions over the investigated frequency range of 5–20 kc/s.

534.231 **913**

An Exact Solution of the Acoustical Field near a Circular Transducer.—E. W. Guptill. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, p. 784.)

534.24 **914**

The Reflexion of a Spherical Acoustic Pulse by an Absorbent Infinite Plane, and Related Problems.—P. E. Doak. (*Proc. roy. Soc. A.*, 25th Nov. 1952, Vol. 215, No. 1121, pp. 233–254.) A formal integral solution of the problem is given for the case of a plane whose impedance depends in any way on the frequency and angle of incidence of the pulse. In many practical cases the impedance can be assumed to be independent of the angle of incidence; in this case the integral is relatively easy to evaluate, and a simple exact expression, in closed form, is obtained for the reflected pulse when the wall impedance is purely resistive, and consequently independent of frequency. The formal integral solution is evaluated approximately for wall impedances of the types: (*a*) resistance and mass; (*b*) resistance and stiffness; (*c*) resistance, mass and stiffness. The solutions are compared with the corresponding solutions for plane incident waves.

534.321.9 : 621.315.616.9 **915**

The Effectiveness of Plastic Focusing Lenses with High-Intensity Ultrasonic Radiation.—J. A. Bronzo & J. M. Anderson. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 718–720.) Plexiglas and polystyrene lenses were investigated, using a frequency of 1 Mc/s. Plexiglas showed signs of breakdown at intensities above about 2 W/cm², while polystyrene showed no signs of damage at intensities up to 6·6 W/cm².

534.614 **916**

Systematic Errors in Indirect Measurements of the Velocity of Sound.—P. W. Smith, Jr. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 687–695.)

534.64 **917**

Apparatus for Absolute Measurement of Analogous Impedance of Acoustic Elements.—G. B. Thurston. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 649–652.) Description of hydrodynamic test equipment for measuring pressure and flow in liquid-filled tubes, at frequencies up to 700 c/s.

534.78 + 534.756 **918**

A Phase Principle for Complex-Frequency Analysis and its Implications in Auditory Theory.—W. H. Huggins. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 582–589.) A filtering scheme based on the phase-frequency characteristic of a filter is useful for analysing signals, such as speech, which are produced by excitation of a system having one or more resonances. The phase principle is particularly well suited to neural mechanisms of inhibition and facilitation, and may be the principle on which the ear actually operates.

534.78 **919**

Some Experiments on the Perception of Synthetic Speech Sounds.—F. S. Cooper, P. C. Delattre, A. M. Liberman, J. M. Borst & L. J. Gerstman. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 597–606.)

An investigation of the characteristics of some consonant sounds. Methods, results and working hypotheses are discussed.

534.78 : 534.756 — 920

On the Process of Speech Perception.—J. C. R. Licklider. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 590–594.)

534.843.001.57 — 921

Analysis of Transient Acoustic Phenomena by means of Reduced-Scale Models.—T. Korn & F. Kirschner. (*Ann. Télécommun.*, Oct. 1952, Vol. 7, No. 10, pp. 414–420.) In determinations of speech intelligibility in halls, transient phenomena must be taken into account. Methods of investigating such effects, using models, are described in detail. The materials used in the construction of the models must be chosen so that the coefficient of absorption at a frequency $f' = kf$ is equal to that of the corresponding hall materials at the test frequency f, k being the scale reduction factor for the model. Tests made at a frequency of 15·36 kc/s on $\frac{1}{30}$-scale models, using pulses of duration 20 ms, illustrate the importance of hall geometry as regards intelligibility.

534.844/.845 — 922

A Reverberation Chamber with Polycylindrical Walls.—J. H. Botsford, R. N. Lane & R. B. Watson. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 742–744.) A chamber designed for low energy loss is described; it is constructed of reinforced concrete, with diffusing cylinders of random size cast in the ceiling and walls, and the whole of the interior surface is heavily enamelled. The chamber is used for determining the absorption coefficients of materials in the frequency range 250 c/s–12 kc/s.

534.845 — 923

Acoustic Propagation in Granular Media.—R. W. Morse. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 696–700.) Formulae derived for the propagation velocity and attenuation in a medium composed of closely packed solid particles immersed in a fluid give values in good agreement with experimental results obtained by other workers for the case of uniform-size particles.

534.845/.846] : 621.396.712.3 — 924

Membrane Sound Absorbers and their Application to Broadcasting Studios.—C. L. S. Gilford. (*B.B.C. Quart.*, Winter 1952–53, Vol. 7, No. 4, pp. 246–256.) A membrane of ordinary bitumen roofing felt closes the front of a wooden framework with side walls of inexpensive sheet material. The membrane may be backed by a blanket of rock-wool or other absorptive material; this prevents a rapid reduction of absorption as the resonance frequency rises. A protective cover in front of the membrane consists normally of perforated hardboard which acts as an acoustic filter. The air space behind the membrane is divided by partitions. The resonance frequency of such membranes is calculated, the theory of the absorption is discussed, and experimentally determined absorption characteristics of single and double membranes are shown. The use of devices of this type for low-frequency absorption in broadcasting studios is illustrated.

534.845.1 — 925

Tube Method of Measuring Sound Absorption.—H. O. Taylor. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 701–704.) Kennelly & Kurokawa (*Proc. Amer. Acad. Arts Sci.*, 1921, Vol. 56, No. 1) measured acoustic impedance by a method in which a telephone receiver at one end of a tube served both as sound source and detector, the other end of the tube being closed by a sliding piston. A similar technique is now used to determine the absorption of the material forming the face of the piston.

621.395.61 : 546.431.824-31 — 926

Theoretical Sensitivity of a Transversely Loaded Circular Bimorph Transducer.—E. G. Thurston. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 656–659.) A calculation of the sensitivity is made for centrally supported $BaTiO_3$ transducers, on the basis of elasticity theory. A value of 0·5 mV/microbar can easily be attained for low-frequency applications. Experimental results show reasonable agreement.

AERIALS AND TRANSMISSION LINES

621.315.14.027.8 : 621.396.82 — 927

Radio Noise in Relation to the Design of High-Voltage Transmission Lines.—H. L. Rorden & R. S. Gens. (*Elect. Engng, N.Y.*, Oct. 1952, Vol. 71, No. 10, pp. 873–878.) Condensed text of paper presented at the A.I.E.E. Winter General Meeting, January 1952, giving an account of tests carried out by the Bonneville Power Administration on 230-kV power lines. The results obtained indicate that objectionable interference will not be experienced in a radio receiver with aerial 200 ft away from a h.v. transmission line if the fair-weather r.f. field strength at that distance is $\ngtr 15\,\mu$V/m. In rainy weather the radio noise level may be 30 or more times the fair-weather noise level, drops of water on a conductor being far more effective in causing radio noise than conductor irregularities. Radio noise in l.v. lines crossing or parallel to h.v. lines may, owing to coupling between the l.v. and h.v. systems, travel considerable distances along the h.v. lines. For interference levels to be tolerable, conductor diameters should be at least 0·95 in. for 230 kV, 1·25 in. for 300 kV and 1·45 in. for 345 kV.

621.315.212 : 621.397.24 : 621.3.018.78 — 928

Some Factors affecting the Performance of Coaxial Cables for Permanent Television Links.—H. Ashcroft, W. W. H. Clarke & J. D. S. Hinchliffe. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 350–356. Discussion, pp. 472–478.)

621.392.21 : 621.396.67 : 621.397.6 — 929

Suspended Locked-Coil-Rope Television Feeder Systems.—E. C. Cork. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 18, pp. 243–252. Discussion, pp. 264–269.) A detailed description of the feeder system noted in 244 of January.

621.392.21.09 — 930

A U.H.F. Surface-Wave Transmission Line.—C. E. Sharp & G. Goubau. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 107–109.) Description of an aerial-feed unit for operation in the frequency range 1·7–2·4 kMc/s and designed to fulfil the requirements of insertion loss <3 db for 150-ft length and s.w.r. $\ngtr 1·5$. The wire used is 0·102-in. diameter soft-drawn Cu covered with a 0·014-in. layer of extruded polyethylene. The launching device is described and illustrated.

621.392.26 : 538.221 — 931

Ferrites at Microwaves.—N. G. Sakiotis & H. N. Chait. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 87–93.) Propagation in an unbounded ferromagnetic medium and in waveguides containing ferrites is discussed; results are reported of an experimental study on circular and rectangular waveguides enclosing commercially available ferrites, using a frequency of 9·375 Mc/s. Applications to switches, aerials, etc., are described.

621.392.26 : 621.317.352 **932**

Experimental Study and First Results of Measurements of the Attenuation of TE$_{01}$ (H$_{01}$) Waves in Short Sections of Straight Circular Waveguide.—Comte & Ponthus. (See 1068.)

621.396.67 : 621.316.54 **933**

A Radio Transmission-Line Exchange.—(*Engineer, Lond.*, 3rd Oct. 1952, Vol. 194, No. 5045, pp. 451–452.) Another account, with fuller details, of the equipment noted in 33 of January.

621.396.67 : 621.397.6 **934**

Television Transmitting Aerials.—H. Cafferata, C. Gillam & J. F. Ramsay. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 18, pp. 215–230. Discussion, pp. 264–269.) Factors affecting the design of a transmitting aerial are reviewed, with particular reference to common-aerial working for vision and sound. The properties of 2-phase aerial systems are discussed and curves are presented which enable the horizontal radiation patterns of such aerials to be interpreted in terms of impedance measurements on the distribution-feeder system. The development of the Sutton Coldfield aerial is described and modifications adopted for Holme Moss and the later high-power stations are explained.

621.396.677 **935**

Gain of Electromagnetic Horns.—E. H. Braun. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 109–115.) Results obtained by Jakes (1847 of 1951) are verified by further experiments. Theory is developed which gives results in good agreement with experimental data, and explains why the $2D^2/\lambda$ far-field criterion is invalid, D being the larger horn dimension. Curves are presented from which the error in gain measured at any distance may be obtained.

621.396.677 **936**

Plane Reflectors for Ray Deflection with Directive Aerials.—H. G. Unger. (*Frequenz*, Sept. 1952, Vol. 6, No. 9, pp. 272–278.) Systems are considered in which a parabolic or other aerial located on the ground directs radiation on to an elevated reflector which reflects the beam in the required direction of propagation. Using the Kirchhoff-Huyghens diffraction-theory approximation a determination is made of the field strength at the receiver with and without the reflector. The conditions are derived for which the introduction of the reflector causes no reduction of field strength. For large reflector areas there is a gain which has a maximum value for a certain geometrical arrangement; an explanation is given in terms of interference theory.

621.396.677 **937**

A New Electromagnetic Lens.—G. von Trentini. (*Rev. telegr. Electronica, Buenos Aires*, June 1952, Vol. 40, No. 477, pp. 341–345.) The artificial dielectric used consists of two or more linear arrays of vertical wires arranged parallel to the electric vector, each wire being reactively loaded at regular intervals. Tests on various arrays gave results in good agreement with calculation. A 26-cm wide plano-concave lens is described with loading varying from capacitive at the centre to inductive at the outer edges. This results in a refractive index varying discontinuously from 0·2 to 2·1. At λ 3·2 cm, the gain was about 7, half-power beam width 7°, and nearest side lobes 8%, comparing favourably with the performance of a parallel-plate metal lens of width 30 cm.

621.396.677 : 621.396.9 **938**

Wide-Angle-Scan Radar Antenna.—H. N. Chait. (*Electronics*, Jan. 1953, Vol. 26, No. 1, pp. 128–132.) A description is given of the construction and the method of design of an aerial which is the microwave analogue of the Schmidt optical system used in projection-type television receivers. A feed horn pivots about the centre of curvature of a semicylindrical reflector and the plane wave front is restored by means of a specially shaped polystyrene lens. An exact solution for the shape of the correcting lens was obtained by use of the zero-phase method, which is described in detail. Curves are given showing the variation of side-lobe level, beam width and relative gain with change of the scanning angle, and another set of curves shows the improvement resulting from off-axis correction of the lens shape. A scan of 20 beam widths is obtained with side lobes 20 db below the peak intensity.

621.396.677.5 : 621.318.132 **939**

Ferroxcube Aerial Rods.—H. van Suchtelen. (*Electronic Applic. Bull.*, June 1952, Vol. 13, No. 6, pp. 88–100.) The size of loop aerials can be greatly reduced by using a core of some suitable magnetic material. The design is discussed of aerials using small coils wound on rods of ferroxcube. The losses and *Q*-factors of such aerials are investigated and experimental results are quoted. Temperature effects on the permeability of the core material are analysed.

621.396.67.001.11 **940**

Advanced Antenna Theory. [Book Review]—S. A. Schelkunoff. Publishers: J. Wiley & Sons, New York, 1952, 216 pp., $6.50. (*Electronics*, Jan. 1953, Vol. 26, No. 1, pp. 353–354.) "The book will be of interest mainly to those engineers who have an adequate mathematical background."

CIRCUITS AND CIRCUIT ELEMENTS

621.3.015.7 : 621.318.57 **941**

Compensation against Effects of Grid-Cathode Capacitance in Pulse-Height Selectors.—W. M. Grim & A. B. Van Rennes. (*Rev. sci. Instrum.*, Oct. 1952, Vol. 23, No. 10, p. 563.) The precision of the selector may be reduced by an effect due to the grid/cathode capacitance of the input valve. When a 'constant-current' valve is used in the cathode circuit, this effect can be compensated by applying the input signal, appropriately modified, to the grid of the 'constant-current' valve.

621.314.2 **942**

The Design of Thermocouple Transformers for Infrared Chopped Beam Systems.—T. S. Robinson. (*J. sci. Instrum.*, Oct. 1952, Vol. 29, No. 10, pp. 311–313.) Description of transformer for operation at 10 c/s, to be inserted between a thermocouple detector and an amplifier; the design is such as to give at the amplifier output a signal/noise ratio approaching that at the thermocouple terminals.

621.314.3† **943**

Magnetic Amplifiers.—M. Latour. (*Rev. gén. Élect.*, Oct. 1952, Vol. 61, No. 10, pp. 423–424.) Comment on 2132 of 1952 (Pistoulet) pointing out the existence of several French publications and patents on the subject, one paper, by Léonard & Weber, dating back to 1906 and thus being considerably prior to the American paper, by Alexanderson & Nixdorff, quoted by Pistoulet as the first publication on magnetic amplifiers.

621.314.3† **944**

A Mathematical Analysis of Parallel-Connected Magnetic Amplifiers with Resistive Loads.—H. S.

Kirschbaum: L. A. Pipes. (*J. appl. Phys.*, Nov. 1952, Vol. 23, No. 11, pp. 1278–1279.) Comment on 3014 of 1952 and author's reply.

621.314.3† **945**

Magnetic Amplifiers for Industry.—W. F. Horton. (*Radio & Telev. News, Radio-Electronic Engng Section*, Nov. 1952, Vol. 48, No. 5, pp. 10–12.) Description, with outline circuit diagrams, of a series of Westinghouse 'Magamp' instruments with power ratings from 40 mW to 180 W, and examples of their application.

621.316.84/.86 **946**

New Developments in Fixed Resistors for Electronic Applications.—R. A. Osche. (*Elect. Mfg*, April 1951, Vol. 47, No. 4, pp. 118–123 . . 256.) A review of the characteristics of deposited-carbon, metal-film, and borocarbon resistors, and comparison with carbon-composition and wire-wound resistors.

621.316.86 **947**

High-Temperature Carbon-Film Resistors.—(*Electronics*, Jan. 1953, Vol. 26, No. 1, pp. 148 . . 154.) Details are given of the method of pyrolysis used in the production of stable carbon-film resistors with values from 10Ω to 5MΩ and capable of operation at temperatures up to 200°C. The carbon film is deposited on a porcelain base made from alumina mixed with other ingredients such as SiO_2 and CaO in an alcohol binder.

621.316.86 : 537.312.6 **948**

Industrial Applications of Semiconductors: Part 8—Thermistors.—R. E. Burgess. (*Research, Lond.*, Oct. 1952, Vol. 5, No. 10, pp. 469–474.) Description of the characteristics of thermistors, typical forms of construction, and various applications.

621.318.435.3.025.3 : 621.314.3† **949**

Three-Phase Transductor Circuits for Magnetic Amplifiers.—A. G. Milnes. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 336–357. Digest, *ibid.*, Part II, Dec. 1952, Vol. 99, No. 72, pp. 615–619.) Various transductor connections for 3-phase operation are described; a 3-element circuit with separate excitation and a 6-element circuit with auto-excitation are discussed in detail. A theoretical and experimental comparison is made between single-phase and 3-phase circuits. The latter should be used where balanced loading of the supply is sufficiently desirable to compensate for the increased circuit complexity.

621.318.57 : 621.396.615.18 **950**

The Coupling of 'Scale-of-Two' Circuits.—R. Ascoli. (*Nuovo Cim.*, 1st Aug. 1951, Vol. 8, No. 8, pp. 584–585.) A simple and reliable RC divider circuit is described and illustrated.

621.318.57 + 621.392.52] : 621.397.26.029.63 **951**

Ultra-High-Frequency Switches and Filters.—G. F. Small. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 464–472. Discussion, pp. 472–478.) The design of filters and switches for the London-Birmingham television relay link is described. The type of switch adopted uses resonant stub lines in shunt with the main transmission lines; typical performance details are given. The filters are of the band-stop type and consist of stub lines, composed of a series of nominal $\lambda/4$ line sections, shunted across the main transmission line. Design curves are given and typical filter-attenuation curves shown.

621.318.57 : 681.142 **952**

Further Data on the Design of Eccles-Jordan Flip-Flops.—M. Rubinoff. (*Elect. Engng, N.Y.*, Oct. 1952, Vol. 71, No. 10, pp. 905–910.) Full text of paper presented at the A.I.E.E. Summer General Meeting, June 1952. Analysis, under specified conditions, of the grounded-cathode type of flip-flop circuit including no inductors. A graphical design technique is described which should facilitate the design of switching circuits using a large number of identical direct-coupled circuits.

621.319.4 **953**

Fixed Capacitors for Electronic Circuits.—P. S. Schmidt. (*Elect. Mfg*, May 1951, Vol. 47, No. 5, pp. 100–105 . . 248.) A review of the development of new types, involving both new materials and new manufacturing techniques.

621.319.4 : 621.396.615 **954**

Tuning Stability Nomograph.—J. T. Hogan. (*Rev. sci. Instrum.*, Oct. 1952, Vol. 23, No. 10, p. 566.) A chart is given for facilitating calculation of the parallel capacitors required to give an overall temperature coefficient of zero in circuits using inductance tuning.

621.392 : 517.63 **955**

The Calculation of Energy Flow using the Laplace Transformation.—A. C. Sim. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 376–382. Digest, *ibid.*, Part II, Dec. 1952, Vol. 99, No. 72, p. 624.) The Laplace-Parseval integral is applied to determine energy flow directly from the Laplace transforms of the applied force and the resultant response. The method is applicable to both transient and steady states, and leads directly to the most simple form of solution. The method is most advantageous when the applied force possesses several discontinuities. As an example, the classical problem of eddy-current losses in linear sheet conductors is solved in general for arbitrary excitations.

621.392.5 **956**

On Transformations of Linear Active Networks with Applications at Ultra-High Frequencies.—H. Hsu. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 59–67.) A relation similar to the star-delta transformation is developed for linear circuits including valves. Formulae are derived for triode circuits under both negative-grid and positive-grid conditions; the results are extended to tetrodes and pentodes. The method is useful for analysing the operation of u.h.f. triodes and for determining amplifier admittances and gain.

621.392.5 **957**

Response of a Quadripole to Discontinuous Signals. The Phenomenon of Gibbs and Methods of Generalized Summation.—T. Vogel. (*Ann. Télécommun.*, Oct. 1952, Vol. 7, No. 10, pp. 421–428.) Mathematical analysis with application to the design of quadripoles with good transmission characteristics for square-wave signals.

621.392.5 : [621.396.615 + 621.396.645 **958**

Tunable *RC*-Bridge Network with only One Variable Element.—W. Götze. (*Funk u. Ton*, Aug. 1952, Vol. 6, No. 8, pp. 393–399.) A circuit is described with which an output of required phase is obtained by varying either one resistance or one capacitance, the magnitude of the output voltage remaining constant. Details are given of a stable valve generator with frequency ranging from a very low value to 10^7c/s. The circuit can also be used in phase shifters, frequency meters and selective amplifiers.

621.392.5.018.7 **959**

A Theory of Time Series for Waveform-Transmission Systems.—W. E. Thomson. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 397–409.) A theoretical study is made of time series suitable for application to low-pass systems with a fixed upper limit to the pass band. For 'division' and 'inversion' of time series, algebraic division is not, in general, legitimate for time series related to bandwidth limitation, although it is legitimate for certain other forms of time series. More general methods of inversion are treated and an iterative method, which can always be used, is discussed in detail and a practical computing scheme is outlined. See also 55 of January (Lewis), which also deals with the time-series method.

621.392.5.029.63 **960**

A Wide-Band Hybrid Ring for U.H.F.—W. V. Tyminski & A. E. Hylas. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 81–87.) The bandwidth of a $6\lambda/4$ hybrid ring is increased by replacing the $3\lambda/4$ long arm with a $\lambda/4$ line and introducing a frequency-insensitive reversal of phase. Calculations are made of input and transfer admittances, insertion loss and the effect of capacitance across the loads. Some experimental results are given, and applications to power splitters, harmonic generators, mixers etc. are indicated.

621.392.52 **961**

Wave-Filter Characteristics by a Direct Method.—R. C. Taylor & C. U. Watts. (*Elect. Engng, N.Y.*, Oct. 1952, Vol. 71, No. 10, p. 911.) Digest of paper presented at the A.I.E.E. Winter General Meeting, January 1952. A chart is given from which the attenuation (in db) can be directly determined for seven commonly used ladder-filter sections, the abscissae used being the number of bandwidths from the cut-off frequency.

621.392.52 **962**

Formulae for calculating Filter Circuits with Flattened Attenuation Curves.—G. Bosse. (*Funk u. Ton*, Aug. & Sept. 1952, Vol. 6, Nos. 8 & 9, pp. 416–425 & 493.) Simple formulae are given for calculating Tchebycheff-type low-pass filters with attenuation values falling between prescribed limits either inside or outside the pass band. Attenuation curves obtainable with filters thus calculated are shown.

621.392.52 : 621.3.015.3 **963**

The Transient Response of R.F. and I.F. Filters to a Wave Packet.—A. W. Gent. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 326–335.) Full paper. See 350 of February.

621.392.54 : 538.69 **964**

Characteristics of the Magnetic Attenuator at U.H.F.—F. Reggia & R. W. Beatty. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 93–100.) The design of the field-controlled attenuator previously described by Reggia (1237 of 1952) is discussed, and performance data are given for attenuators using various ferromagnetic materials.

621.395.665.1 : 534.86 **965**

New Principle for Electronic Volume Compression.—H. E. Haynes. (*Radio & Telev. News, Radio-Electronic Engng Section*, Nov. 1952, Vol. 48, No. 5, pp. 7–9, 29.) Reprint. See 2152 of 1952.

621.396.611.21 **966**

Loading of Quartz Oscillator Plates.—L. T. Sogn & P. A. Simpson. (*J. Res. nat. Bur. Stand.*, Nov. 1952, Vol. 49, No. 5, pp. 325–327.) An investigation was made of the effectiveness of mechanical loading for eliminating unwanted modes of vibration and adjusting the oscillation frequency towards the value corresponding to greatest activity. The loading was done by applying various amounts of Wood's metal to different parts of the plate surfaces. For concave thickness-shear-mode and X-cut plates, improvement was obtained when the loading was applied at or near the active central area; for flat or convex X-cut plates with an extensional mode of vibration improvement was obtained when the loading was applied near the periphery. For both types, loading increased the Q factor.

621.396.611.4 **967**

Microwave Cavity Resonators as Circuit Elements.—S. K. Chatterjee. (*J. Indian Inst. Sci.*, Section B, Oct. 1952, Vol. 34, No. 4, pp. 99–112.) The differential equation for the equivalent circuit of a double-loop-coupled cavity resonator is derived by using Lagrange's equation and Maxwell's equations. The losses in the walls and the Q of the cavity operating in the TE_{11n} mode are evaluated.

621.396.615 **968**

Power Spectrum of a Nonlinear Oscillator with a Frequency/Amplitude Law, Perturbed by Noise.—A. Blaquière. (*C. R. Acad. Sci., Paris*, 17th Nov. 1952, Vol. 235, No. 20, pp. 1201–1203.) Discussion for the case where the dependence of the frequency ν on the amplitude a is represented by the formula $\nu = \nu_0 (1 + 3\mu a^2/8)$. The power spectrum is determined and can be represented as a single line with a superposed noise spectrum resulting from the amplitude and phase fluctuations. The methods previously developed (2162 and 2486 of 1952) enable the noise spectrum to be resolved into a continuous band and a periodic line component.

621.396.615 **969**

Multiple-Feedback Oscillators.—(*Electronics*, Jan. 1953, Vol. 26, No. 1, pp. 200..208.) The use of several feedback circuits in connection with a single tank circuit makes it possible to construct oscillators capable of operation over a wide frequency range, the LC value of the tank circuit remaining fixed. Such oscillators, and the theory on which they are based, are described by M. Morrison in U.S.A. patent No. 2 587 750. Important points of the theory are here given and two typical oscillator circuits are described. In the second of these a special current transformer, with a 10 : 1 ratio, is used to effect phase alteration of the feedback current. The transformer, with a variable capacitor across the output terminals, is adjusted to provide feedback current in phase with the a.c. component of the anode load current, so that the proper grid-voltage angle is obtained for maintaining oscillation at the desired frequency.

621.396.615 **970**

Constant-Amplitude Oscillator.—(*Tech. News Bull. nat. Bur. Stand.*, Nov. 1952, Vol. 36, No. 11, pp. 172–173.) A circuit developed by N. C. Hekimian comprises a conventional oscillator whose rectified output is applied as a positive voltage to the grid of a clamp valve which shares the voltage-dropping resistance in the oscillator anode-supply lead. For a more detailed account see *Electronics*, July 1951, Vol. 24, No. 7, p. 164.

621.396.615 : 517.941.91 **971**

On an Equation connected with the Theory of Triode Oscillations.—R. A. Smith. (*Proc. Camb. phil. Soc.*, Oct. 1952, Vol. 48, Part 4, pp. 698–717.) Detailed discussion of the periodic solutions of the differential equation

$$\ddot{x} + k\dot{x}f(x) + x = pk\lambda \cos(\lambda t + \alpha),$$

in which the parameter k is small. The equation is concerned with the forced oscillations in a simple electrical circuit containing a triode. Van der Pol has treated the case where $f(x) = x^2 - 1$, and an extensive theory of triode oscillations has been built up for this case. In practice, however, the graph of $f(x)$ has a much flatter bottom than that of the function $(x^2 - 1)$, and Cartwright (2740 of 1948 and 1417 of 1951) has raised the question whether this flattening will alter the performance of the circuit near resonance. The main part of this paper is an attempt to answer this question. An estimate is made of the permissible degree of flattening of the $f(x)$ curve without the detuning diagram losing any of its significant properties. Various pertinent theorems are established and the possible periodic solutions of the equation are discussed in relation to the detuning diagram. Particular results include the following:—(*a*) if k is small enough and the value of λ lies in a certain small range near 2, forced oscillations with half the applied frequency are possible; two of these have amplitudes very large compared with that of the applied e.m.f., one mode being stable and the other unstable; (*b*) only when the graph of $f(x)$ is asymmetrical can there be an appreciable range of values of λ for which subharmonic oscillations of order $\frac{1}{2}$ take place.

621.396.615 : 621.316.729 **972**

Pull-In of Nonlinear Oscillators with Filtered Output.—G. Cahen & J. Loeb. (*Ann. Télécommun.*, Oct. 1952, Vol. 7, No. 10, pp. 411–413.) The effect is considered of applying a small voltage δV, of frequency $f + \delta f$, to an oscillator whose fundamental frequency f has been freed from harmonics by filtering. A general formula is derived which gives the maximum value of δf for pull-in to occur. For the particular case of an oscillator with a single oscillatory circuit, the formula reduces to the known expression $\delta f/f = 1/(2Q.\ \delta V/V)$, Q being the quality factor of the circuit and V the voltage amplitude of the free oscillations. A formula is also given for the threshold value of δV below which pull-in is not possible.

621.396.615.142.2 : 621.392.54 : 538.69 **973**

An X-Band Sweep Oscillator.—I. D. Olin. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 10–13.) A generator which sweeps through the frequency band 8·5–9·5 kMc/s in 1·5 sec is described; a mechanically tuned klystron is used. The output level is maintained constant to within ±0·1 db by means of an automatic control circuit including a variable attenuator with ferrite rotator unit (964 above), which also provides a.m. at 1 kc/s.

621.396.615.17 **974**

Production of Standard Waves with a 3 000-kV Impulse Generator.—N. Narayan & K. S. Prabhu. (*J. Indian Inst. Sci.*, Section B, Oct. 1952, Vol. 34, No. 4, pp. 113–122.) Equipment installed at Bangalore is discussed. The characteristics of the generator were determined experimentally; a method of setting it up to produce a desired standard waveform is described.

621.396.615.17 **975**

Multichannel Crystal Control of V.H.F. and U.H.F. Oscillators.—A. Hahnel. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 79–81.) The frequencies of a number of channels are controlled by a single crystal, using an oscillator whose phase is varied periodically by application of pulses; the oscillator output comprises a spectrum of harmonically related frequencies whose fundamental is the crystal-controlled pulse frequency. A particular triode oscillator covers the range 250–850 Mc/s with fundamental in the range 1–10 Mc/s. By appropriately tuning the tank circuit any desired harmonic can be emphasized by an amount up to 40 db.

621.396.645 : 621.396.822 **976**

Methods of Reducing the Ratio of Noise to Signal at the Output Terminals of Amplifiers.—M. J. O. Strutt. (*Elektrotech. Z., Edn A*, 11th Oct. 1952, Vol. 73, No. 20, pp. 649–653.) A summarized account of earlier work by the author alone or in collaboration with A. van der Ziel. See 3041 of 1942, 1075, 2088 and 2089 of 1943, 749 and 750 of 1945, 2843, 2844 and 3740 of 1946, 1573 and 3067 of 1947, 1599, 2074 and 3358 of 1948, 1332, 1487, 1631 and 2312 of 1949.

621.396.645 : 621.397.24 **977**

The Design of Amplifiers for the Birmingham-Manchester Coaxial Cable.—W. T. Duerdoth. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 385–393. Discussion, pp. 472–478.) Description, with schematic circuit diagrams, of (*a*) a line amplifier suitable for the transmission of 405-line television signals on a 1-Mc/s carrier, or for 16 telephony channel groups, on ⅜-in. diameter coaxial cables, (*b*) a constant-gain amplifier for the transmitting terminal. Practical difficulties which limit the performance of the amplifiers and associated transformers are discussed and possible improvements for future designs are suggested.

621.396.645.029.3 **978**

The Maestro — a Power Amplifier.—D. Sarser & M. C. Sprinkle. (*Audio Engng*, Nov. 1952, Vol. 36, No. 11, pp. 19–21 . . 89.) Description, with complete circuit details, of a new version of the 'musician's amplifier' (70 of 1950) with an output of 90 W. A pair of R.C.A. Type-6146 beam power valves, operated in class AB, are used with a specially designed Peerless output transformer, Type S-268-Q. Power-supply circuits are also described.

621.396.645.029.3 **979**

New Medium-Cost Amplifier of Unusual Performance.—G. L. Werner & H. Berlin. (*Audio Engng*, Nov. 1952, Vol. 36, No. 11, pp. 30–31, 71.) Description, with circuit details, of an amplifier with the necessary flexibility and performance for most high-fidelity applications; only standard, readily available valves are used.

621.396.645.029.33 : 621.3.018.78 **980**

Essential Similarity and Relations between Amplitude and Phase Distortions in Video Amplifiers.—F. J. Tischer. (*Arch. elekt. Übertragung*, Nov. 1952, Vol. 6, No. 11, pp. 452–459.) In the complex method of representation, the transmission function of a video amplifier for steady oscillations can be regarded as the sum of an ideal transmission function and an error function. The error function is applied in investigating the relations between an arbitrary transmission function with superposed amplitude and phase errors and the associated distortions, for the minimum-phase-shift condition. The investigation gives an insight into the physical relation between the distortions. The formulae derived are applied to determine the distortions for a system with a Tchebycheff-type transmission function; these distortions are then compared with those for a system with a steady fall of amplitude near the cut-off frequency.

621.396.645.35 **981**

The Direct-Voltage Valve Amplifier.—G. Kessler. (*Arch. tech. Messen*, July & Sept. 1952, & Jan. 1953, Nos. 198, 200 & 204, pp. 163–166, 211–214 & 19–22.) Effects of valve and circuit noise, fluctuations of the current source and temperature changes are evaluated. A review of basic amplifier circuits for measurement purposes illustrates different directly-coupled interstage and output arrangements and methods of compensating the above effects. Methods of amplification involving modulation are noted. 107 references.

621.396.645.35 **982**

The Parallel-T D.C. Amplifier: A Low-Drift Amplifier with Wide Frequency Response.—P. S. T. Buckerfield. (*Proc. Instn elect. Engrs*, Part II, Oct. 1952, Vol. 99, No. 71, pp. 497–506.) The frequency response of a modulated d.c. amplifier is broadened by the parallel addition of a conventional a.c. amplifier, which has inherently a response capable of being made complementary to that of the d.c. amplifier. The result is a homogeneous design without excessive phase shift. Circuit details are given of an amplifier designed for use with a high-speed pen recorder in the frequency range 0–90 c/s. The avoidance of direct coupling renders the use of electrometer valves unnecessary.

621.396.645.37 **983**

Feedback-Amplifier Design.—R. J. D. Reeves. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 383–389.) Discussion of the pole pattern required for a low-pass amplifier with overall feedback. Analysis is presented for an amplifier whose gain function contains no internal zeros and for which the feedback fraction is independent of frequency. A general solution, applicable to any number of poles, is obtained for the case of critical damping. For amplifiers with maximally flat response curves [3013 of 1941 (Landon)] graphical solutions are given for systems with n poles, where n ranges from 1 to 6. The synthesis of a prescribed pole pattern is considered and the method of realizing conjugate poles by feedback pairs is described.

621.396.645.371 : 621.397.24 **984**

Two Simple Types of Feedback Amplifier for the Relaying of Television Signals over Coaxial Cables.—F. G. Clifford. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 367–373. Discussion, pp. 472–478.) A method is described for applying negative feedback to flatten the gain/frequency characteristic of 3-stage amplifiers using tuned-anode intervalve couplings resonant at the mid-band frequency. Two typical amplifiers are described.

GENERAL PHYSICS

061.3 : 538.56.029.6 **985**

Summarized Proceedings of a Conference on Microwave Physics — Oxford, July 1952.—D. A. Wright. (*Brit. J. appl. Phys.*, Nov. 1952, Vol. 3, No. 11, pp. 337–341.) Summaries are given of the papers presented and of the subsequent discussions.

534.26 + 535.42 **986**

Diffraction of a Shock or an Electromagnetic Pulse by a Right-Angled Wedge.—J. B. Keller. (*J. appl. Phys.*, Nov. 1952, Vol. 23, No. 11, pp. 1267–1268.) Solutions given in a previous paper [2963 of 1951 (Keller & Blank)] are used as a basis for calculating the field distribution; comparison with measurements made for the acoustic case shows satisfactory agreement.

535.223 **987**

Precision Determination of the Velocity of Light derived from a Band-Spectrum Method.—D. H. Rank, R. P. Ruth & K. L. Vander Sluis. (*J. opt. Soc. Amer.*, Oct. 1952, Vol. 42, No. 10, pp. 693–698.) Detailed report of the work noted in 3053 of 1952. The value obtained for the velocity is 299 776 ± 6 km/sec.

537 : 531].001.362 **988**

Extension and More Exact Statement of the Analogies between Electrical and Mechanical Devices.—G. Lander. (*Frequenz*, Aug. & Sept. 1952, Vol. 6, Nos. 8 & 9, pp. 235–246 & 257–266.)

537 : 531].001.362 **989**

Electrical and Mechanical Analogies.—F. Raymond. (*Rev. gén. Élect.*, Oct. 1952, Vol. 61, No. 10, pp. 465–475.) An introduction to the study of general problems concerning electrical networks and mechanical systems whose operation is governed by linear laws. Matrix symbolism is explained by examples and a table of elementary electrical and mechanical analogues is given. Application of the theory is made to discussion of the characteristics of transducers such as loudspeakers and piezoelectric or magnetostrictive generators.

537.122 **990**

Dirac's New Classical Theory of the Electron.—G. Höhler. (*Ann. Phys., Lpz.*, 15th Feb. 1952, Vol. 10, No. 3, pp. 196–200.) Dirac's new theory (1574 and 3059 of 1952) is shown to arise as a limiting case for both the particle and wave theories; for continuously distributed charge it is equivalent to the Maxwell-Lorentz theory.

537.122 : 538.21 : 511.61 **991**

Number Theory and the Magnetic Properties of an Electron Gas.—M. F. M. Osborne. (*Phys. Rev.*, 1st Nov. 1952, Vol. 88, No. 3, pp. 438–451.)

537.122 : 538.21 : 511.61 **992**

Application of the Theory of Numbers to the Magnetic Properties of a Free Electron Gas.—M. C. Steele. (*Phys. Rev.*, 1st Nov. 1952, Vol. 88, No. 3, pp. 451–464.)

537.221 **993**

A Direct Comparison of the Kelvin and Electron-Beam Methods of Contact Potential Measurement.—P. A. Anderson. (*Phys. Rev.*, 1st Nov. 1952, Vol. 88, No. 3, pp. 655–658.)

537.226 : 537.1 **994**

The Poisson-Kelvin Hypothesis and the Theory of Dielectrics.—W. B. Smith-White. (*J. roy. Soc. N.S.W.*, 23rd May 1952, Vol. 85, Part 3, pp. 82–112.) A comprehensive critical review of fundamental mathematical theory. Electrostatics only is considered, but the treatment indicates that a complete reconstruction of electrodynamic theory is essential.

537.226.1 + 538.213 **995**

An Optical Method for determining the Complex Dielectric Constant ϵ and the Magnetic Permeability μ.—H. Falkenhagen & G. Kelbg. (*Ann. Phys., Lpz.*, 15th Feb. 1952, Vol. 10, No. 3, pp. 170–176.) A method applicable in the cm and mm wave ranges is described which depends on determination of the normal-incidence reflection and transmission factors of a plane-parallel plate. The calculation is based on the general matrix equations of the field as derived from Maxwell's equations.

537.311.1 : 546.87-1 **996**

The Mean Free Path of Conduction Electrons in Bismuth.—A. B. Pippard & R. G. Chambers. (*Proc. phys. Soc.*, 1st Nov. 1952, Vol. 65, No. 395A, pp. 955–956.) Experimental results for Bi single crystals are given from which it is concluded that, in agreement with the suggestion of Sondheimer (2190 of 1952), the mean free path of the conduction electrons in Bi is much longer than in normal metals, and that, for electrons travelling perpendicular to the triad axis, the path length is probably in the range 2–4 μ at room temperature.

537.523/.525 **997**

Secondary Processes Active in the Electrical Breakdown of Gases.—L. B. Loeb. (*Brit. J. appl. Phys.*, Nov. 1952, Vol. 3, No. 11, pp. 341–349.) Results of recent investigations indicate the complexity of gas-breakdown mechanisms. Three cathode mechanisms and two anode mechanisms are analysed and their relative importance and the conditions for their occurrence are discussed. They lead to the same type of generalized threshold breakdown condition, subject to statistical fluctuations and to space-charge effects. This condition masks the active processes and renders analysis difficult. The various factors affecting the discharge are considered, and proper methods of discharge investigation are indicated. 49 references.

537.533.8 998

The Mechanism of Field-Dependent Secondary Emission.—H. Jacobs, J. Freely & F. A. Brand. (*Phys. Rev.*, 1st Nov. 1952, Vol. 88, No. 3, pp. 492–499.) An account of experiments made to test the theory that the mechanism of field-dependent secondary emission is similar to that of the 'Townsend avalanche' in gas discharges. Special tubes were used having dynodes with a porous MgO coating. The results indicate that the high yield of secondaries is independent of the base material. The variation of secondary current with field strength was in accordance with the gas-discharge equations; this was confirmed by retarding-field measurements of the energies and mean free paths of the secondaries. The time required for the surface to become charged was determined by using pulsed bombarding currents, and was found to be consistent with the theory.

537.568 999

Recombination of Gaseous Ions.—H. S. W. Massey. (*Advances Phys.*, Oct. 1952, Vol. 1, No. 4, pp. 395–426.) Recombination between positive ions and electrons and between positive ions and negative ions are considered separately, since the nature of the processes involved and the experimental techniques for observing them are quite different in the two cases. Although there is still little information about the rate of recombination of positive and negative ions at low pressure, there has been substantial clarification of the processes of electron-ion recombination during the last two years due to the application of microwave techniques. The knowledge of the mechanism of electron-ion recombination derived from both theory and experiment is reviewed in detail, and a shorter account given of present knowledge of ion-ion recombination at pressures less than that of the atmosphere. Recombination phenomena in the ionosphere, in the solar corona, and in interstellar gas, are also discussed briefly. 80 references.

538.113 1000

Antiferromagnetism and Ferrimagnetism.—L. Néel. (*Proc. phys. Soc.*, 1st Nov. 1952, Vol. 65, No. 395A, pp. 869–885.) The 7th Holweck Lecture, May 1952, reviewing the present state of knowledge of antiferromagnetism, including ferrimagnetism, and describing interesting phenomena related to the magnetic properties of certain ferrites and of pyrrhotite.

538.114 1001

Spin Degeneracy and the Theory of Collective Electron Ferromagnetism.—A. B. Lidiard. (*Proc. phys. Soc.*, 1st Nov. 1952, Vol. 65, No. 395A, pp. 885–893.) A model is discussed for which the results obtained by neglecting or taking account of spin degeneracy are identical. The model can be treated exactly and leads to equations for the free energy, magnetization, etc., which are a generalization of those of Stoner's theory of collective electron ferromagnetism (2548 of 1939).

538.114 1002

Zener's Treatment of Ferromagnetism.—A. Teviotdale. (*Proc. phys. Soc.*, 1st Nov. 1952, Vol. 65, No. 395A, pp. 957–958.) A critical review of Zener's theory.

538.114 1003

The Theory of Ferromagnetism and Heisenberg's Model.—J. Yvon. (*J. Phys. Radium*, Oct. 1952, Vol. 13, No. 10, pp. 488–489.)

538.221 1004

Some Magnetic Properties of Metals: Part 3—Diamagnetic Resonance.—R. B. Dingle. (*Proc. roy. Soc. A*, 8th April 1952, Vol. 212, No. 1108, pp. 38–47.) E.m. radiation incident on a large system of electrons moving in a constant magnetic field H in a metal is strongly absorbed near a frequency $\nu = eH/2\pi mc$, where m is the effective mass. The resonance absorption is of the same order of magnitude as the absorption due to skin effect. Part 2: 2490 of 1952.

538.221 1005

Some Magnetic Properties of Metals: Part 4—Properties of Small Systems of Electrons.—R. B. Dingle. (*Proc. roy. Soc. A*, 8th April 1952, Vol. 212, No. 1108, pp. 47–65.) A calculation is made of the magnetic properties of a system of electrons within a cylinder of very small radius with its axis parallel to the field direction. The expressions obtained for magnetic susceptibility, thermodynamic potential and specific heat contain a steady term which remains of significant magnitude at all temperatures, together with terms periodic in the field which are significant only at very low temperatures. The influence of electron spin is discussed. Similar calculations are made for a small spherical system.

538.566 1006

The Limits of Total Reflection: Part 2—Rigorous Wave-Theory Calculation.—H. Maecker. (*Ann. Phys., Lpz.*, 15th Feb. 1952, Vol. 10, No. 3, pp. 153–160.) The variation of intensity in the region of the critical reflection angle is calculated numerically for a particular case previously considered by Ott (18 of 1943). The curve obtained indicates a continuous variation from the region of partial to that of total reflection.

538.566 1007

Propagation of a Wave Front in Anisotropic Dispersive Media.—M. Marziani. (*R. C. Accad. naz. Lincei*, Sept./Oct. 1952, Vol. 13, Nos. 3/4, pp. 127–131.) Extension of work previously noted (390 of February) to the case of anisotropic media. Expressions are derived for the velocity of propagation and for the field in the vicinity of the wave front.

539.152.2 1008

Determination of Nuclear Moments from Hertzian Spectra.—G. J. Béné. (*J. Phys. Radium*, Oct. 1952, Vol. 13, No. 10, pp. 473–479.) Discussion of the interaction between nucleus and electron, and an account of the principal methods, apart from resonance methods, of applying microwave spectroscopy to the determination of nuclear moments.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.5 1009

The Velocity Distribution of Sporadic Meteors: Part 2.—M. Almond, J. G. Davies & A. C. B. Lovell. (*Mon. Not. R. astr. Soc.*, 1952, Vol. 112, No. 1, pp. 21–39.) Extension of the work noted in part 1 (1899 of 1952) to the investigation of fainter meteors; similar results are obtained.

523.5 : 621.396.9 1010

The Velocity Distribution of Sporadic Meteors: Part 3—Calculation of the Theoretical Distributions.—J. A. Clegg. (*Mon. Not. R. astr. Soc.*, 1952, Vol. 112, No. 4, pp. 399–413.) A general method is described for estimating the field of view of any aerial system, and hence of predicting the ratio of true to observed hourly numbers for particles of different velocity and flight direction. Part 2: 1009 above.

523.72 : 550.38 1011

Relation between Geomagnetic Activity and Solar Radio Activity.—J. F. Denisse. (*Ann. Géophys.*, Jan./March 1952, Vol. 8, No. 1, pp. 55–64.) A fuller account of work noted previously [2983 of 1951 (Denisse, Steinberg & Zisler)].

550.384.3 **1012**

The Representation of the Main Geomagnetic Field and of its Secular Variation by means of Two Eccentric Dipoles.—H. G. Macht. (*Trans. Amer. geophys. Union*, Aug. 1951, Vol. 32, No. 4, pp. 555–562.) A model comprising two dipoles is suggested to account for the second-order terms in the expansion representing the geomagnetic potential. The systematic displacement of the dipoles with time explains certain features of the geomagnetic secular variation. The model provides a generally improved approximation to the actual surface geomagnetic field.

550.385 + 551.594.5 **1013**

Theories of Magnetic Storms and Aurorae.—J. W. Dungey. (*Nature, Lond.*, 8th Nov. 1952, Vol. 170, No. 4332, p. 795.) Discussion of theories advanced by Alfvén (2777 of 1950) and Martyn (1374 of 1951).

551.510.3 : 535.325 : 538.56 **1014**

Slide Rule computes Radio Refractive Index of Air.—S. Weintraub. (*Electronics*, Jan. 1953, Vol. 26, No. 1, pp. 182..198.) Details are given of methods developed at the National Bureau of Standards for computing atmospheric r.f. refractive indices from radiosonde meteorological data, using special types of straight or circular slide-rule. The methods give adequate accuracy for almost any conditions likely to be encountered in the troposphere.

551.510.41 : 546.214 **1015**

Ozone in the Earth's Atmosphere.—G. M. B. Dobson. (*Endeavour*, Oct. 1952, Vol. 11, No. 44, pp. 215–219.) General discussion of processes involved in the formation of ozone, methods of measuring ozone content and its vertical distribution in the atmosphere, and variations of ozone content with meteorological conditions.

551.510.535 "1952" : 621.396.11 **1016**

Ionosphere Review: 1952.—T. W. Bennington. (*Wireless World*, Feb. 1953, Vol. 59, No. 2, pp. 59–60.) Curves are given for the period 1947–1952 showing (*a*) monthly mean values, (*b*) 12-month running averages of sunspot numbers and noon and midnight F_2 critical frequencies. From these it appears probable that both sunspot numbers and critical frequencies will continue to decrease slightly during 1953.

551.594.5 : 551.510.535 **1017**

Recent Advances in Auroral Spectroscopy and in our Knowledge of the Upper Atmosphere.—L. Vegard. (*Ann. Géophys.*, Jan./March 1952, Vol. 8, No. 1, pp. 91–99.)

551.594.5 : 621.397.8 **1018**

Auroral Effects on Television.—Thayer. (See 1173.)

551.594.6 : 621.396.11 **1019**

The Propagation of a Radio Atmospheric: Part 2.—Budden. (See 1108.)

LOCATION AND AIDS TO NAVIGATION

621.396.9 : 551.594.221 **1020**

Recent Developments in Radio Location of Thunderstorm Centers.—W. J. Kessler & S. P. Hersperger. (*Bull. Amer. met. Soc.*, April 1952, Vol. 33, No. 4, pp. 153–157.) Short account of the triangulation method used by the U.S. air forces during the war, and of the single-station technique being investigated at the University of Florida.

621.396.9 : 621.396.677 **1021**

Wide-Angle-Scan Radar Antenna.—Chait. (See 938.)

621.396.932 **1022**

Radar Chart-Matching Devices.—J. H. Dickson. (*J. Inst. Nav.*, Oct. 1952, Vol. 5, No. 4, pp. 331–341. Discussion, pp. 341–344.) For navigation at sea, chart-matching-devices are used enabling a p.p.i. presentation and a chart to be viewed in coincidence; three main classes of device are distinguished, viz., (*a*) reflecting devices without magnification, (*b*) optical instruments involving lenses, and (*c*) projection devices. Descriptions are given of the U.S. Navy virtual-position reflectoscope, and of a simplified reflectoscope, both using a 45° semireflecting mirror; these have the disadvantage of requiring specially prepared charts. Standard navigational charts can be used with the Admiralty Research Laboratory chart-comparison unit, the construction and performance of which are described in some detail. This has a telescopic optical system and is viewed through an eyepiece, the p.p.i. face being screened from external light. Experimental projection methods using forms of the Schmidt optical system or c.r. tubes of special construction are also briefly described. For a shorter account see *J. R. Soc. Arts*, 31st Oct. 1952, Vol. 100, No. 4885, pp. 825–830.

621.396.932 **1023**

Navigational Work in Ocean Weather Ships.—C. E. N. Frankcom. (*J. Inst. Nav.*, Oct. 1952, Vol. 5, No. 4, pp. 351–361.) Equipment carried by the British weather ships includes loran (type DA52), and radar for taking upper-wind observations, for obtaining fixes of aircraft and for navigation. An ordinary radio receiver is used for consol bearings. Navigation aids between ship and aircraft include m.f. beacon, v.h.f. and m.f. d.f. and a eureka responder. Facilities for m.f., h.f. and v.h.f. communications are provided.

621.396.933 : 656.7 **1024**

The Use of Radio in the Navigation and Operation of Civil Aircraft.—D. H. C. Scholes. (*J. Brit. Instn Radio Engrs*, Dec. 1952, Vol. 12, No. 12, pp. 595–623.) "Systems of navigation and communication for landing, traffic control and en-route communication and navigation are described in sufficient technical detail to enable their functions and capabilities to be appreciated, but the general purpose of the paper is to indicate the contributions made by radio to the solution of operational problems."

621.396.933.088 **1025**

An Examination of Some Site and Transmission-Path Errors of the Decca Navigator System when used over Land.—L. G. Reynolds. (*Proc. Instn elect. Engrs*, Part III, Jan. 1953, Vol. 100, No. 63, pp. 29–35.) The results of measurements of the Decometer errors near obstacles such as trees and telegraph wires are described and discussed. Vertical obstacles were found to show some uniformity as regards their effect, but the effects of long horizontal conductors were very variable. Errors determined at good sites on the base-line extensions of the red and green lattices are shown graphically and exhibit the effects of the near-field components and the finite conductivity of the ground. Good agreement is obtained between the mean of the observations and a composite theoretical curve based on Norton's plane-earth theory and Bremmer's curved-earth theory of ground-wave propagation.

MATERIALS AND SUBSIDIARY TECHNIQUES

535.37 : 546.482.21 **1026**

The Electrical Conductivity connected with the Phosphorescence of Cadmium-Sulphide Crystals.—I. Broser & R. Warminsky. (*Z. Phys.*, 2nd Oct. 1952, Vol. 133, No. 3, pp. 340–361.)

537.311.31 : 669-124.2 **1027**

The Effect of Temperature of Deformation on the Electrical Resistivity of Cold-Worked Metals and Alloys.—T. Broom. (*Proc. phys. Soc.*, 1st Nov. 1952, Vol. 65, No. 395B, pp. 871–881.) Special apparatus was used to draw wires of various metals at temperatures between −183°C and +100°C, and to measure their resistivities at the temperature of drawing. The increase of resistivity with deformation was found to depend on the difference between the deformation and recrystallization temperatures. A unified theory of the effect of deformation on the resistivity of both pure metals and alloys can possibly be based on stacking faults in the crystal lattice.

537.311.32/.33 : 546.561.221 **1028**

Electrical and Optical Properties of Copper Sulphides.—L. Eisenmann. (*Ann. Phys., Lpz.*, 15th Feb. 1952, Vol. 10, No. 3, pp. 129–152.) The sulphur content of thin copper-sulphide layers was varied and measurements were made of the resistance at temperatures down to 14°K, and the absorption for wavelengths from 0·4 to 3 μ. The structure of the layers was examined. Cu_2S can take up S until CuS is formed. Cu_2S, the two-phase Cu_2S-$Cu_{1.8}S$ and the compound $Cu_{1.8}S$ have semiconductor properties; CuS has the properties of a metal, its conductivity being comparable with that of Hg. Two alternative interpretations of the observations are discussed.

537.311.33 : 538.21 **1029**

Magnetodynamics of Semiconductors.—P. M. Prache & H. Billottet. (*Câbles & Transm.*, Oct. 1952, Vol. 6, No. 4, pp. 317–332.) The variation with frequency of the apparent permeability of ferrite cores is very different from that of ferromagnetic metal cores. Experimental work in this field is reviewed and test methods used by the authors for the range 0–40 Mc/s are described. In this frequency range the conductivity can be considered, to a first approximation, as the sum of a constant term and one proportional to the frequency. The permittivity increases with frequency very rapidly at first and then more slowly. A surprising result is the rapid rise of the parameter $\lambda/\omega\mu_0$ (λ being related to surface resistivity), accompanied by a permeability decrease, for frequencies > 1 Mc/s. Results of measurements of the variation with temperature of the permeability, conductivity and permittivity of the ferrite samples investigated are presented and discussed.

537.311.33 : 546.289-1 **1030**

Resistance of Germanium Contacts.—J. B. Gunn. (*Proc. phys. Soc.*, 1st Nov. 1952, Vol. 65, No. 395B, pp. 908–909.) Previous attempts to explain the h.v. I/V characteristics of Ge point contacts have not taken account of the very high current densities which normally occur near the contact, and which give rise to electric fields far greater than those which Ryder & Shockley (1398 of 1951) found to cause nonlinear mobility effects of the type discussed by Shockley (1011 of 1952). A tentative theory is presented which shows that these effects, together with the Zener current observed by McAfee et al. (164 of 1952), can account for the observed I/V characteristics, and in particular for the high resistances recently noted in *p-p* Ge-Ge contacts by Granville et al. (117 of January).

537.311.33 : 546.47-31 : 539.231 **1031**

Effect of Dissolved Oxygen on the Electrical Conductivity of Zinc Oxide.—H. Fritzsche. (*Z. Phys.*, 2nd Oct. 1952, Vol. 133, No. 3, pp. 422–437.) ZnO layers with reproducible characteristics are obtained by cathodic sputtering of the metal in an atmosphere containing oxygen. Measurements of the conductivity of such layers in vacuo give results which can be explained by the assumption that dissolved oxygen acts as an electron trap, and at higher temperatures diffuses out of the ZnO lattice.

538.221 **1032**

Results of Measurements on High-Permeability Ferrite Cores: Part 2.—M. Kornetzki, J. Brackmann, J. Frey & W. Gieseke. (*Z. angew. Phys.*, Oct. 1952, Vol. 4, No. 10, pp. 371–374.) Continuation of work noted in 2736 of 1951 (Kornetzki). Measurements of after-effect losses are reported; the loss factor is nearly constant at low frequencies and increases steeply near a frequency related to the gyromagnetic critical frequency. For a given value of permeability there exists an optimum ferrite composition; for Ni-Zn optimum ferrites the loss tangent at low frequencies is about 7°/₀₀, for Mn-Zn optimum ferrites it is about 2·5°/₀₀.

538.221 : 538.24.096 **1033**

The Temperature Variation of the Magnetization of Nickel in Low and Moderate Fields.—R. S. Tebble, J. E. Wood & J. J. Florentin. (*Proc. phys. Soc.*, 1st Nov. 1952, Vol. 65, No. 395B, pp. 858–871.) An account of measurements on the reversible changes of magnetization accompanying change of temperature of annealed Ni, with discussion of the results in relation to the work of Bates (914 of 1951), Stoner (2689 of 1951) and others on the magneto-caloric effect.

538.221 : 546.72-1 **1034**

Effect of Oxygen in Solid Solution in High-Purity Iron on Certain Magnetic Properties in Weak Alternating Fields.—J. Bourrat, G. Chaudron & I. Épelboin. (*C. R. Acad. Sci., Paris*, 24th Nov. 1952, Vol. 235, No. 21, pp. 1290–1292.) Measurements on four samples of iron, of different degrees of chemical purity, show that metallic impurities have a preponderating effect on initial permeability when the quantity of dissolved oxygen is small. This effect decreases rapidly with increase of oxygen content and practically disappears for an oxygen content of about 0·013%.

538.221 : 621.318.2 **1035**

A New Permanent Magnet from Powdered Manganese Bismuthide.—E. Adams, W. M. Hubbard & A. M. Syeles. (*J. appl. Phys.*, Nov. 1952, Vol. 23, No. 11, pp. 1207–1211.) A method is described for preparing the magnet material, known as 'bismanol', by hot-pressing in the presence of a strong magnetic field finely powdered MnBi crystals obtained from a mixture of Mn (16·65%) and Bi (83·35%). Specimens have been obtained with BH_{max} value as high as $4{\cdot}3\times10^6$ gauss-oersted, coercive force of 3 400 oersted and remanence of 4 300 gauss. In addition to its importance as a substitute for Co alloys, the material is particularly useful for applications where a high coercive force is required.

538.221 : 621.318.2 **1036**

Preferred Crystal Orientation in Ferromagnetic Ceramics.—A. L. Stuyts, G. W. Rathenau & E. W. Gorter. (*J. appl. Phys.*, Nov. 1952, Vol. 23, No. 11, p. 1282.) The use of $BaFe_{12}O_{19}$ in permanent-magnet materials has been described previously [2824 of 1952 (Went et al.)]. By orienting the crystals of this oxide in a magnetic field before sintering, it is possible to obtain a material with BH_{max} value as high as 3×10^6 gauss-oersted.

538.221 : 669.14.018.58 : 539.431 **1037**

Effect of Fatigue on the Magnetic Properties of Steels.—A. Kovacs & P. Laurent. (*C. R. Acad. Sci., Paris*, 17th Nov. 1952, Vol. 235, No. 20, pp. 1224–1226.) Permeability measurements were made at intervals during vibratory fatigue tests of Ni-Cr steels. The results obtained are shown in curves and discussed.

538.652 : 546.74-1 **1038**

Magnetostrictive Effect and the Δ-E Effect in Nickel.—H. Nödtvedt. (*Nature, Lond.*, 22nd Nov. 1952, Vol. 170, No. 4334, pp. 884–885.) An account of experiments demonstrating the connection between the two effects.

539.234 : 546.72 **1039**

Influence of a Magnetic Field on the Electrical Resistance of Iron Films.—B. Franken, A. van Itterbeek, G. J. van den Berg & D. A. Lockhorst. (*Physica*, Oct. 1952, Vol. 18, No. 10, pp. 771–779.) Continuation of work noted in 2828 of 1952 (van Itterbeek et al.). It has been previously assumed that the coercive force is given by the value of field strength for which the resistance/magnetizing-field curve shows a turning point. Low-temperature measurements to test the validity of this assumption are reported and discussed.

546.212 + 621.315.613.1] : 537.226.2 **1040**

Dielectric Constant of Water Films.—L. S. Palmer, A. Cunliffe & J. M. Hough. (*Nature, Lond.*, 8th Nov. 1952, Vol. 170, No. 4332, p. 796.) Continuation of the investigations previously reported [2793 of 1952 (Cownie & Palmer) and 99 of January (Palmer)]. Measurements were made at 2 and 3 Mc/s, using thin mica plates separated by films of water; the dielectric constant of the water varied from > 20 for films about 5 μ thick to < 10 for films about 2 μ thick. Measurements on composite mica/water blocks at 2 Mc/s and at 2·5 kc/s indicated that the water films have the properties of 'liquid ice' rather than of solid water.

546.26-1 **1041**

Electrical Resistivity of Artificial Graphite.—J. Okada & T. Ikegawa. (*J. appl. Phys.*, Nov. 1952, Vol. 23, No. 11, pp. 1282–1283.) Report of an investigation of the influence on the graphite resistivity of the temperature at which the raw coke is calcined.

546.431.824-31 : 537.228.1 **1042**

Electromechanical Properties of $BaTiO_3$ Compositions showing Substantial Shifts in Phase Transition Points.—D. A. Berlincourt & F. Kulcsar. (*J. acoust. Soc. Amer.*, Nov. 1952, Vol. 24, No. 6, pp. 709–713.) Measurements of the dielectric and piezoelectric properties over the temperature range −40° to 120°C are reported for $BaTiO_3$ ceramics containing $CaTiO_3$, Y_2O_3 and $PbTiO_3$. The composition containing 5% $CaTiO_3$ combines high piezoelectric response with good temperature stability.

546.431.824-31 : 621.3.011.5.001.572 **1043**

Statistical Model of Barium Titanate at Room Temperature.—R. Hagedorn. (*Z. Phys.*, 2nd Oct. 1952, Vol. 133, No. 3, pp. 394–421.) A simple model of the structure of a $BaTiO_3$ single crystal is discussed which may serve to explain the properties of the material at ordinary temperatures.

548.0 : 53 : 546.391.85 **1044**

The Piezoelectric, Dielectric, and Elastic Properties of $ND_4D_2PO_4$ (Deuterated ADP).—W. P. Mason & B. T. Matthias. (*Phys. Rev.*, 1st Nov. 1952, Vol. 88, No. 3, pp. 477–479.) Heavy-water ADP crystallizes in the same form as normal ADP but has a transition at −31°C, whereas normal ADP has a transition at −125°C. At temperatures below the transition the crystals are antiferroelectric, with one of the '*a*' crystal axes as the antiferroelectric axis. Measurements were made on the material at temperatures from 80°C down to the transition temperature; results are shown in graphs. The crystal has zero temperature coefficient of frequency at 0°C, and may be useful for transducers and mechanical filters.

548.0 : 53 : 546.391.85 **1045**

Properties of a Tetragonal Antiferroelectric Crystal.—W. P. Mason. (*Phys. Rev.*, 1st Nov. 1952, Vol. 88, No. 3, pp. 480–484.) Theory explaining the properties of deuterated ADP is developed in terms of thermodynamics. Observed changes of crystal structure and dielectric constant at the transition temperature are related to the occurrence of spontaneous polarization. Use is made of the results given in 1044 above.

548.0 : 534/539].001.8 **1046**

Recent Applications of Synthetic Crystals.—J. Chapelle. (*Ann. Télécommun.*, Oct. 1952, Vol. 7, No. 10, pp. 398–407.) Review of applications in microphones, ultrasonic transducers, optical and electrical filters, Kerr cells, etc.

621.314.6 : 621.396.822 **1047**

Flicker Effect in Crystal Detectors.—N. Nifontoff. (*C. R. Acad. Sci., Paris*, 10th Nov. 1952, Vol. 235, No. 19, pp. 1117–1118.) Continuing work previously reported (2827 of 1952 and back references), results are now given for the resistance variations and flicker effect in Si and Ge crystal rectifiers as functions of the current in the forward and reverse directions. Similar curves were obtained in all cases. The results were identical for increasing or decreasing current except for Ge, which exhibits a little hysteresis.

621.315.612.4 **1048**

A New Dielectric Material.—L. Nicolini. (*Nature, Lond.*, 29th Nov. 1952, Vol. 170, No. 4335, p. 938.) Short note on a material prepared by heating pure TiO_2 to 1 400°C. X-ray analysis gives the same Debye-Scherrer pattern as for rutile, with an axis ratio 1 : 0·911. The dielectric constant varies from over 10^4 at 10 c/s to an asymptotic value of about 100 for frequencies above about 100 kc/s. Tan δ has a pronounced maximum at about 30 kc/s.

MATHEMATICS

681.142 **1049**

The C.S.I.R.O. Differential Analyser.—D. M. Myers & W. R. Blunden. (*J. Instn Engrs Aust.*, Oct./Nov. 1952, Vol. 24, Nos. 10/11, pp. 195–204.) Description of the analyser installed by the Commonwealth Scientific and Industrial Research Organization in the University of Sydney, and of its use in solving the differential equations relating to various technical problems.

681.142 **1050**

An Electronic Computer.—M. Beard & T. Pearcey. (*J. sci. Instrum.*, Oct. 1952, Vol. 29, No. 10, pp. 305–311.) Description of the C.S.I.R.O. Mark I binary digital computer. Mercury-filled ultrasonic delay tubes are used for the main high-speed store and a magnetic drum for the low-speed intermediate store; the total capacity is 40 960 binary digits. The command code specifies a source and a destination. Programmes are placed in the main store and commands are adopted sequentially at a rate of 500 per sec. Manual controls provide for variation of operation.

681.142 **1051**

Multiplication in the Manchester University High-Speed Digital Computer.—A. A. Robinson. (*Electronic Engng*, Jan. 1953, Vol. 25, No. 299, pp. 6–10.)

681.142 : 003.62 **1052**

On Optimum Relations between Circuit Elements and Logical Symbols in the Design of Electronic Calculators.—A. D. Booth. (*J. Brit. Instn Radio Engrs*, Dec. 1952, Vol. 12, No. 12, pp. 587–594.) The functions of the main units of a high-speed calculator are discussed, possible means of representing typical units by logical symbols are considered, and methods by which such symbols can be transformed into engineering details are examined. A logical notation for computer elements is suggested which is such that a small number of basic standard 'building blocks' can be combined to form units of any desired functional complexity that will operate in a reliable manner.

681.142 : 621.315.612.4 **1053**

Ferroelectric Storage Elements for Digital Computers and Switching Systems.—J. R. Anderson. (*Elect. Engng, N.Y.*, Oct. 1952, Vol. 71, No. 10, pp. 916–922.) Revised text of paper presented at the A.I.E.E. Fall General Meeting, October 1952. The advantages of ferroelectric materials, $BaTiO_3$ in particular, for information storage are discussed and practical storage devices are described which are capable of storing 2 500 'bits' of information per square inch on the surface of a material only a few thousandths of an inch thick, using pulses of duration < 1 µs.

681.142 : 621-526 **1054**

The Design and Testing of an Electronic Simulator for a Hydraulic Remote-Position-Control Servomechanism.—F. J. U. Ritson & P. H. Hammond. (*Proc. Instn elect. Engrs*, Part II, Dec. 1952, Vol. 99, No. 72, pp. 533–548. Discussion, pp. 549–552.)

681.142 : 621-526 **1055**

An Analogue Computer for Use in the Design of Servo Systems.—E. E. Ward. (*Proc. Instn elect. Engrs*, Part II, Dec. 1952, Vol. 99, No. 72, pp. 521–532. Discussion, pp. 549–552.)

681.142 : 621.396.645 **1056**

A Source of Computing Voltage with Continuously Variable Output.—R. W. Williams & G. M. Parker. (*J. sci. Instrum.*, Oct. 1952, Vol. 29, No. 10, pp. 322–324.) For use as an a.c. voltage source in an analogue computer, the resistance potentiometer has the disadvantage that its output does not vary smoothly. As an alternative in which this difficulty is overcome, a circuit is described using a magslip feedback resolver [235 of 1952 (Bell)].

MEASUREMENTS AND TEST GEAR

538.632 : 537.311.33 **1057**

Sensitive Recording Alternating-Current Hall-Effect Apparatus.—E. M. Pell & R. L. Sproull. (*Rev. sci. Instrum.*, Oct. 1952, Vol. 23, No. 10, pp. 548–552.) Apparatus is described capable of measuring mobilities of 10^{-2} cm/sec per V/cm or less in semiconductors; it is especially suitable for measuring Hall effect in samples of very low conductivity. Independent units are used for the magnetic field, current source and detector circuit. An amplidyne control circuit is used for regulating the magnet current and reducing the time required to reverse the magnetic field.

621.3.018.41(083.74) : 621.317.361 : 529.77 **1058**

The Estimation of Absolute Frequency in 1950–51.—H. M. Smith. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 273–278.) Full paper. See 153 of January.

621.317(083.74) + 537.71 **1059**

Units and Standards of Electrical Measurement. A Review of Progress.—L. Hartshorn. (*Proc. Instn elect. Engrs*, Part I, Nov. 1952, Vol. 99, No. 120, pp. 271–279.) The functions of the various international organizations concerned with electrical standards are noted and an account is given of their work since 1942 and of the consequent redefinition of British legal standards. Experimental work has shown that over a 10-year period standard manganin resistors are stable to within ± 1 part in 10^6, while Weston cells may vary by as little as ± 5 parts in 10^6, with capacitors and inductors showing relatively greater drift. The precision and convenience of Wenner's method for the absolute determination of the ohm is pointed out. Progress in frequency standards is noted, and consideration given to the possible choice of the magnetic moment of the proton, or other atomic constant, as the primary electrical unit.

621.317.3 : 621.396.615.141.2 : 621.396.619.11 **1060**

Measurements of some Operational Characteristics of an Amplitude-Modulated Injection-Locked U.H.F. Magnetron Transmitter.—L. L. Koros. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 4–10.) The loop impedance looking towards the magnetron, which is important for determining the position of the injection junction, is computed from the voltage s.w.r. and the position of the minimum-voltage plane of the injection current reflected from the magnetron output loop. The loop-impedance changes are observed as the anode voltage is varied. The phenomena occurring in the output transmission line are described, loads of various types being used. The load impedance as seen from the magnetron varies with the power level during the modulation cycle; this is shown on a special circular diagram. At the low-power end of the modulation cycle the value of the load, for a given type of magnetron and setting of tuner, depends only on the carrier frequency.

621.317.328 : 621.396.615(083.74) **1061**

Signal-Generator System for Low Output Levels.—J. W. Herbstreit. (*Electronics*, Jan. 1953, Vol. 26, No. 1, pp. 218..224.) For measuring signal levels far below that useful for communications, a method similar to that described by Gainsborough (3202 of 1947) was adopted in which two standard signal generators were used with a crystal mixer, the desired frequency being either the sum or difference frequency of the two generators. Details are given of the procedure, and other applications of the heterodyne principle are suggested.

621.317.332 **1062**

A Modified Wide-Range Shunted-T Circuit for the Measurement of Impedance in the A.F., R.F. and V.H.F. Ranges.—D. Karo. (*Proc. Instn elect. Engrs*, Part III, Jan. 1953, Vol. 100, No. 63, pp. 25–28.) The T circuit is connected across the lower-voltage section of a voltage divider connected across the source, the shunt also being across the source. A variable multiplication ratio is thus obtained and hence a much greater range for a given set of standards. Tests are described at frequencies from 1 kc/s to 50 Mc/s. By using an additional standard the frequency can be eliminated from the balance equations.

621.317.335.029.64 **1063**

Dielectric Constants of Gases in the Microwave Region.—A. Gozzini. (*Nuovo Cim.*, 1st June 1951, Vol. 8, No. 6, pp. 361–368.) A method of measurement is described which makes use of reflections in mismatched waveguides. Results are given for H_2, air and CO_2.

621.317.34 : 621.397.2 **1064**

Apparatus for the Measurement of Nonlinearity in Television Trunk Systems.—G. W. S. Griffith. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 394–397. Discussion, pp. 472–478.) Defects of methods of measurement using sawtooth or stepped waveforms are noted and two methods are described which avoid such difficulties. In the 2-frequency method used for the London–Birmingham television radio-relay link, a 250-c/s signal, with an amplitude covering almost the whole amplitude characteristic of the system, is transmitted together with a 50-kc/s signal whose amplitude is about one-fiftieth of that of the 250-c/s signal. The small signal is thus made to examine, 250 times per second, the whole amplitude characteristic of the transmission system. At the receiving end the signals are separated and used respectively for the horizontal and vertical deflection of a c.r.o. beam. For a perfectly linear system a rectangular display pattern is obtained. Use of a clamp circuit for the vertical (50-kc/s) deflection results in a pattern with a horizontal base line and with ordinates representing the slope of the amplitude characteristic of the system under test. For investigation of the effect of the d.c. component in a television waveform, a test signal with waveform essentially of the television type must be used. Such a waveform can also be used to measure synchronization-pulse compression.

621.317.34 : 621.397.6 **1065**

The Transient Testing of Television Apparatus.—V. J. Cooper. (*Marconi Rev.*, 1st Quarter 1953, Vol. 16, No. 108, pp. 1–7.) The relative merits of spike and step waveforms for estimating the response characteristics of television equipment are briefly considered. A limited-spectrum test waveform approximately represented by a sine-squared step function has been found amenable to mathematical analysis. Results thus obtained by Skwirzynski (1066 below) are summarized.

621.317.34 : 621.397.6 **1066**

The Response of a Vestigial Side-Band System to a "Sine-Squared" Step Transition.—J. K. Skwirzynski. (*Marconi Rev.*, 1st Quarter 1953, Vol. 16, No. 108, pp. 8–24.) The transient response to a 'sine-squared' step function is determined for a transmission system which can be represented by a triply tuned circuit with a maximally flat admittance function and arbitrarily placed carrier frequency. The problem is solved by means of the zero-frequency carrier method due to Wheeler (3297 of 1941). Response curves for various transition times of the sine-squared function are shown for (*a*) the double-sideband system with 100% modulation, (*b*) the vestigial-sideband system with 100% modulation, (*c*) the vestigial-sideband system with modulation from 30% to 100% of the carrier level. The results obtained are discussed; they can be used to estimate the change of transient distortion resulting from slight changes in the position of the carrier frequency in relation to the filter characteristics (e.g. temperature drift, etc.)

621.317.35 : 519.272.1 **1067**

A Microwave Correlator.—R. M. Page, A. Brodzinsky & R. R. Zirm. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 128–131.) The spectrum of a wide-band u.h.f. signal is converted to a form more convenient for correlation computations by a method which involves local generation of a line spectrum and summation of the resulting frequency differences into a narrower band while retaining the original correlative characteristics. Analysis is presented together with experimental results obtained on a noise signal of bandwidth 200 Mc/s centred at 1·1 kMc/s.

621.317.352 : 621.392.26 **1068**

Experimental Study and First Results of Measurements of the Attenuation of TE$_{01}$ (H$_{01}$) Waves in Short Sections of Straight Circular Waveguide.—G. Comte & A. Ponthus. (*Câbles & Transm.*, Oct. 1952, Vol. 6, No. 4, pp. 333–352.) The propagation of TE$_{01}$ waves in an infinitely long circular waveguide and their reflection at a conducting piston are analysed, and resonance phenomena in a section limited by two conducting pistons are discussed. Measurements of the propagation constants, in particular the attenuation, are described which are based on such resonance effects. The attenuation produced by coupling a receiver to the waveguide is calculated. The construction of a differential wavemeter for wavelengths arouud 3 cm is described, and attenuation and *Q*-factor measurements are reported in detail for the following waveguide materials: (*a*) red Cu, Cu polished with emery, Cu electrolytically polished, (*b*) Al alloy polished with emery, (*c*) mild steel, well polished after turning.

621.317.361 **1069**

Precision Frequency Measurements.—K. Gosslau. (*Frequenz*, Sept. 1952, Vol. 6, No. 9, pp. 249–255.) Precision methods depend on a comparison between the unknown frequency and a standard. A standard-frequency quartz-oscillator circuit is described in which the crystal is only lightly loaded; this is incorporated in an equipment which covers the range 500 c/s–70 Mc/s, making use of harmonics. The relative uncertainty is ± 1 part in 10^8 and the absolute uncertainty ± 0·2 c/s. Operation is simple compared with other instruments of similar precision.

621.317.37 **1070**

The Measurement of High Standing-Wave Ratios.—T. J. Buchanan. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 372–375.) The rate of change of phase at a minimum in a standing-wave pattern increases as the s.w.r. increases, becoming infinite in the case of a full standing wave. The apparatus described enables measurements by a phase and amplitude balance method to be made of the phase difference between two points close to and equidistant from a minimum. A comparison is made with the Roberts-von Hippel method and a modification of this method is described.

621.317.382.029.6 **1071**

A General Method for the Absolute Measurement of Microwave Power.—A. L. Cullen. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 429–430.) Discussion on 2850 of 1952.

621.317.444.029.64 : 538.614 **1072**

A Microwave Magnetometer.—P. J. Allen. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 100–104.) The phenomenon of Faraday rotation in ferrites is used to obtain a magnetometer of high sensitivity giving a voltage output proportional to the applied magnetic field. Dominant-mode rectangular waveguides, aligned axially and with crossed electric planes, are used as polarizer and analyser; the rotator is a ferrite cylinder enclosed in a circular waveguide. Response curves obtained with rotators of two different lengths are shown. Variations as small as 1 gamma have been detected.

621.317.7.029.63/.64 : 621.392.43 **1073**

A U.H.F. and Microwave Matching Termination.—R. C. Ellenwood & W. E. Ryan. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 104–107.) The unit comprises two low-loss dielectric slugs and a lossy dielectric load which are slid inside a waveguide or coaxial line by means of bakelite rods parallel to the axis. Matching is accomplished by altering the distances between the dielectrics. Wide frequency ranges are covered.

621.317.7.088 **1074**

The Error of a Measurement Instrument, and its Probability.—W. Hasselbeck. (*Funk u. Ton*, Aug. 1952, Vol. 6, No. 8, pp. 400–405.) The greater the number of possible causes of error, the less is the probability of their superposition to produce the maximum possible error. Known statistical methods are used to calculate the probability of an error of given magnitude.

621.317.714.029.62/.63 **1075**

Calibrating Ammeters above 100 Mc/s.—H. R. Meahl & C. C. Allen. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 152–159.) Methods of measuring currents at frequencies >100 Mc/s are reviewed, types of vacuum thermocouple available for low-current work are described, and methods of calibration are compared. The electrodynamic method (2832 of 1950) is suitable for large currents, the calorimeter method for medium currents, and the thermistor-bridge for small currents. Attention is drawn to the importance of obtaining agreement between at least two methods based on different principles.

621.317.74 : 621.397.2 **1076**

Group-Delay Distortion-Measuring Equipment.—G. J. Hunt & L. G. Kemp. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 411–414. Discussion, pp. 472–478.) Equipment is described for measuring changes in the slope of the phase/frequency characteristic of a transmission system in the range 200 kc/s–5 Mc/s. A continuously variable a.m. test frequency is used, the sidebands serving for measurement of the slope of the phase-distortion characteristic relative to the slope at a datum frequency. Direct readings of group-delay distortion are given by a c.r.o. display calibrated in intervals of 10 mμs.

621.317.755 **1077**

The Presentation of Frequency Markers and Frequency Scales for Visible-Indication Instruments.—A. Scholz & G. Stuwe. (*Funk u. Ton*, Sept. 1952, Vol. 6, No. 9, pp. 470–480.) A description is given of a multipurpose c.r.o. using a sine-wave deflection voltage with blanking of the return stroke. The frequency scale is provided by dark spots on a line parallel to that on which the required curve is based; a single-beam tube is used with beam switching.

621.317.757 **1078**

Theory and Construction of a Harmonic-Distortion Meter.—G. E. Jones, Jr. (*Audio Engng*, Nov. 1952, Vol. 36, No. 11, pp. 22–23, 79.) Description, with circuit details, of a relatively simple meter for measuring harmonics of fundamental frequencies in the range 16 c/s–20 kc/s. The instrument is only suitable for measuring harmonics with amplitudes ≮1% of that of the fundamental.

621.317.761.029.424/.45 **1079**

Reed-Type Frequency Meter.—H. Behrmann. (*Z. Ver. dtsch. Ing.*, 21st Oct. 1952, Vol. 94, No. 30, pp. 992–994.) Details are given of a meter using a reed of variable length for the measurement of the frequency of mechanical vibrations or electrical oscillations in the ranges 5–45 and 30–270 c/s. For measurements of a.c. frequency a small electromagnet is used to excite the reed.

621.317.772 **1080**

A Precision Phase Comparator for Use at Low Radio Frequencies.—B. G. Pressey, C. S. Fowler & R. W. Mason. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 318–325.) Full paper. See 483 of February.

621.317.784 : 621.319 **1081**

The Design and Application of a Portable Electrostatic Wattmeter.—F. R. Axworthy & J. K. Choudhury. (*Trans. Soc. Instrum. Technol.*, June 1952, Vol. 4, No. 2, pp. 57–63. Discussion, pp. 64–66.) Description of an instrument of the quadrant-electrometer type, using a mica vane coated with Al by evaporation and suspended by a phosphor-bronze strip. Methods of eliminating the error due to power loss in the shunt are described and applications of the wattmeter to the measurement of iron losses are discussed, with illustrative examples.

621.317.784.029.64 **1082**

A Torque-Operated Wattmeter for 3-cm Microwaves.—A. L. Cullen & I. M. Stephenson. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 294–301. Digest, *ibid.*, Part II, Oct. 1952, Vol. 99, No. 71, pp. 516–517.) Power measurements are made in a waveguide by observation of the torque exerted by the e.m. field in the waveguide on a small vane suspended by a quartz fibre, the vane deflection being measured optically. Pulsed microwave power in the range 10–60 W can be measured to within about ±1·5%. Theory of a standing-wave method of calibration has previously been given [1052 and 2850 of 1952 (Cullen)].

621.396.611.21(083.74) **1083**

High-Stability 100-kc/s Crystal Units for Frequency Standards.—J. P. Griffin. (*Bell Lab. Rec.*, Nov. 1952, Vol. 30, No. 11, pp. 433–437.) Short account of the development of the latest type of wire-supported quartz-crystal units, such as those used for the loran system of the U.S. Navy.

621.396.615.029.55/.63(083.74) **1084**

Three Generators of Standard Signals in the Frequency Band 20–1 200 Mc/s.—P. Herreng, G. Couanault & G. Plottin. (*Câbles & Transm.*, Oct. 1952, Vol. 6, No. 4, pp. 353–367.) A detailed description is given of generators with ranges of 20–250 Mc/s, 150–500 Mc/s and 500–1 200 Mc/s respectively. The general characteristics are the same for all three, but different techniques are used in the oscillatory circuits, attenuator networks, modulators, etc. Schematic circuit diagrams and photographs of the complete instruments are given.

621.396.615.14 : 535.325 : 546.217 **1085**

A Highly Stable Microwave Oscillator and its Application to the Measurement of the Spatial Variations of Refractive Index in the Atmosphere.—L. Essen. (*Proc. Instn elect. Engrs*, Part III, Jan. 1953, Vol. 100, No. 63, pp. 19–24.) For frequencies >3 kMc/s the type of oscillator described by Pound (2865 of 1948, in which please read 'Volume 11' instead of 'Volume 2') is particularly suitable. An oscillator of this type, using an invar cavity resonator as the control element, is described and its performance discussed. The factors affecting frequency stability are analysed. It is possible to obtain a bandwidth of 1 part in 10^{10} at a frequency of 9·2 kMc/s, with a stability to within 1 part in 10^8 per hour. A heterodyne method was used to demonstrate the variation of the refractive index of air drawn through the resonator. Erratic variations were observed when the indrawn air passed over a dish of water, thus changing its moisture content. Variations of 1 part in 10^6 were found fairly general, even inside a laboratory.

621.396.615.16/.17].015.7 **1086**

High-Power Square-Pulse Generator.—W. E. Williams, Jr. (*Electronics*, Oct. 1952, Vol. 25, No. 10, pp. 144–145.) Short description, with detailed circuit diagram, of a generator providing current pulses up to several amperes at voltages adjustable up to 1·2 kV. The pulse recurrence frequency is variable in steps of 10 from 10 to 60/sec, the duty cycle being constant at 1%. Designed primarily for testing cathode emission under pulsed operation, the generator may have other applications. Overshoot at the beginning and end of each pulse is negligible. See also *Tech. News Bull. nat. Bur. Stand.*, Dec. 1952, Vol. 36, No. 12, p. 181.

621.396.615.17 : 621.317.34 : 621.397.2 **1087**

A Waveform Generator and Display Unit for the Testing of a Television Channel.—P. E. Ackland-Snow & G. A. Gledhill. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 332–337. Discussion, pp. 472–478.) Description, with block diagrams, of a generator providing six different television-type waveforms for testing a communication channel, together with a c.r. display unit for examination of the channel output waveform.

621.396.615.17.015.33.027.4 **1088**

Generators of Repeated Surge Waves.—M. Teissié-Solier & J. Lagasse. (*Rev. gén. Élect.*, Oct. 1952, Vol. 61, No. 10, pp. 425–429.) Description of a generator suitable for tests on electrical material, particularly transformers, and furnishing 200–400-V steep-fronted pulses with repetition frequency equal to the mains frequency and with variable rise time. Various applications are suggested.

621.396.615.17.018.75 : 621.397.62 **1089**

A Testing Pulse for Television Links.—I. F. Macdiarmid. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 436–444. Discussion, pp. 472–478.) The advantages of the 'sine-squared' pulse waveform for testing the characteristics of a television link are discussed and a pulse generator is described which produces such pulses having a half-amplitude width of 0·17 μs, the normal repetition frequency being 10^4/sec. The very short pulses required for driving the generator are produced by a triggered blocking oscillator and have an amplitude of about 40 V, with a half-amplitude width of 0·035 μs. The circuits described are stable and easily reproducible.

621.396.645.35 : 621.314.5 **1090**

High-Speed D.C. Amplifier.—F. Y. Masson. (*Elect. Mfg*, May 1951, Vol. 47, No. 5, pp. 118, 120.) Description of an instrument using a moving-coil galvanometer, with 200-kc/s alternating field superposed on a permanent magnet field, for converting d.c. to a.c. for high-gain amplification. An energy gain of 10^8 is achieved and the amplifier develops sufficient power to operate a d.c. moving-coil recorder. Response time is $<0{\cdot}1$ sec, so that the instrument is very suitable for rapid production testing of components such as resistors.

621.396.65.001.4 : 621.396.11.029.64 **1091**

A Technique for 4 000-Mc/s Propagation Testing for Radio-Relay Systems.—W. J. Bray & R. L. Corke. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 281–289. Discussion, pp. 310–312.) Simple technique is described for measurement of the path attenuation of radio-relay systems operating at frequencies of the order of 4 kMc/s. A coaxial-line oscillator, with a.m. at 1 kc/s, is used as transmitter. The receiver comprises a Si-crystal detector followed by a 1-kc/s high-gain narrow-band amplifier and diode rectifier operating a meter. With a transmitter output of 1 W, path attenuations up to 95 db can be measured to within 0·5 db. A method of measuring the path attenuation is described. The results of tests on typical paths over land and over sea are shown graphically.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

526.956 : 534.321.9 : 538.652 **1092**

Echo Sounding Equipment with New Indicating Instrument.—W. Krzikalla. (*Arch. elekt. Übertragung*, Nov. 1952, Vol. 6, No. 11, pp. 473–477.) Description of magnetostrictive equipment operated at a frequency of 30 kc/s by a pulse of current from a capacitor discharge. Depth measurement is effected by measurement of the time interval between the transmitted ultrasonic pulse and the echo, using a relaxation-circuit timer with a direct-reading indicator, which can be compensated for measurements in either sea or fresh water.

538.569.2.047 **1093**

Possible Industrial Hazards in the Use of Microwave Radiation.—H. M. Hines & J. E. Randall. (*Elect. Engng, N.Y.*, Oct. 1952, Vol. 71, No. 10, pp. 879–881.) Revised text of paper presented at the A.I.E.E. Summer General Meeting, June 1952.

621-578 : 538.3 **1094**

A "Loudspeaker" Clutch.—(*Tech. News Bull. nat. Bur. Stand.*, Nov. 1952, Vol. 36, No. 11, pp. 161–163.) A fast-acting clutch developed by J. Rabinow is actuated by passing d.c. through a coil located in a constant magnetic field. Possible uses in magnetic recorders, electronic computers etc. are indicated.

621.314.3.001.8† **1095**

Industrial Applications of Magnetic Amplifiers.—R. W. Moore. (*Elect. Engng, N.Y.*, Oct. 1952, Vol. 71, No. 10, pp. 912–916.) Typical examples of the use of Westinghouse 'Magamps' are described.

621.316.71 : 621.383 : 67 **1096**

Photoelectric Register-Control Devices.—R. Kretzmann. (*Electronic Applic. Bull.*, June 1952, Vol. 13, No. 6, pp. 81–87.) Description of the application of photocell equipment for register control, (*a*) in a wrapping machine, (*b*) of the position of a strip of paper or fabric passing through a processing machine.

621.317.083.7 : 621.394.324 **1097**

Multipoint Telemetering System using Teletype Transmission.—A. J. Hornfeck & G. R. Markow. (*Elect. Engng, N.Y.*, Oct. 1952, Vol. 71, No. 10, pp. 929–935.) Essentially full text of paper presented at the A.I.E.E. Summer General Meeting, June 1952. Description of a system developed for remote monitoring of pumping stations on a pipe line, to permit automatic operation from a central office. The measured variable quantities are converted to pulses of proportionate duration, and the teletype equipment prints a succession of identical letters (coded for each variable), whose number indicates the measure of the particular variable in question.

621.383.001.8 : 621.386 **1098**

Electronic Intensification of Fluoroscopic Images.—M. C. Teves & T. Tol. (*Philips tech. Rev.*, Aug. 1952, Vol. 14, No. 2, pp. 33–43.) The intensifier unit consists essentially of an evacuated tube having a fluoroscopic screen mounted in contact with a photocathode of suitably chosen material. A potential of 25 kV applied between the photocathode and the perforated anode produces an image about 1 000 times brighter on a viewing screen of linear dimensions $\frac{1}{9}$ those of the fluoroscopic screen. This image is optically enlarged to its original size.

621.384.621.1 **1099**

A Versatile Focusing System for Van de Graaff Accelerating Tubes.—P. Howard-Flanders. (*Nature, Lond.*, 1st Nov. 1952, Vol. 170, No. 4331, pp. 744–745.) By means of a resistor-type voltage divider, the e.s. field is kept low in a short initial section of the accelerating tube and is maintained at a uniform high value throughout the remaining length. This arrangement acts like a lens situated at the point where the field changes. Suitable adjustment of the potentials of the accelerating electrodes brings injected particles to a focus on the target at the end of the tube. Good focusing has been obtained over a wide range of voltage and current for both electrons and positive ions.

621.385.833 **1100**

Calculation of Spherical Aberration for the Electrostatic Electron Lens.—D. W. Shipley. (*Sylvania Tech-*

nologist, Oct. 1952, Vol. 5, No. 4, pp. 87–93.) Methods of successive approximation and numerical integration are applied to check electrolyte-tank measurements of the spherical aberration of an e.s. unipotential lens consisting of three coaxial cylinders.

621.385.833 **1101**

Spherical Aberration of Grid-Type Electron Lenses.—M. Bernard. (*C. R. Acad. Sci., Paris*, 10th Nov. 1952, Vol. 235, No. 19, pp. 1115–1117.) Analysis for the case where the grid can be regarded as a continuous membrane, transparent to electrons.

621.385.833 **1102**

Calculation of the Potential Distribution on the Axis of an Electrostatic Immersion Objective with Thick Electrodes.—A. Septier. (*C. R. Acad. Sci., Paris*, 17th Nov. 1952, Vol. 235, No. 20, pp. 1203–1206.)

621.387.4 : 535.37 **1103**

The Phosphor-Phototube Radiation Detector.—D. P. Cole, P. A. Duffy, M. E. Hayes, W. S. Lusby & E. L. Webb. (*Elect. Engng, N. Y.*, Oct. 1952, Vol. 71, No. 10, pp. 935–939.) Description of the development of a portable photocell-phosphor combination, Type AN/PDR-18, which uses the average current from the photocell to indicate radiation intensities from about 0·05 to 500 röntgen/hr in four linear-scale decades.

PROPAGATION OF WAVES

538.566.3 : 535.51 **1104**

The Theory of the Limiting Polarization of Radio Waves Reflected from the Ionosphere.—K. G. Budden. (*Proc. roy. Soc. A*, 25th Nov. 1952, Vol. 215, No. 1121, pp. 215–233.) The coupling between the ordinary and extraordinary waves which occurs in the lower part of the ionosphere is discussed. There is a 'limiting' region where a downcoming characteristic wave acquires the limiting polarization observed at ground level. Booker (3277 of 1936) has given an approximate specification for the level of the limiting region. A more exact specification is here given and a method is developed for calculating the limiting polarization of a downcoming characteristic wave. The theory is based on Försterling's coupled-wave equations (1884 of 1942), which apply only to vertical incidence. These equations contain a coupling parameter ψ which depends on the gradients of electron density and collision frequency. The level of the limiting region is specified in terms of ψ and the refractive indices for the characteristic waves. For frequencies greater than about 1 Mc/s the limiting polarization, in the case of a specific model of the ionosphere, is that given by the magneto-ionic theory for a certain limiting point at a definite height. This height, in practical cases, corresponds to low values of electron density and collision frequency, so that at high frequencies the limiting polarization is determined only by the magnitude and direction of the geomagnetic field in the ionosphere.

621.396.11 + 621.396.812.3 **1105**

Waves and Fluctuations.—E. C. S. Megaw. (*Proc. Instn elect. Engrs*, Part III, Jan. 1953, Vol. 100, No. 63, pp. 1–8.) Chairman's address to the Radio Section of the I.E.E., discussing the effects of turbulence and fluctuations of refractive index on the transmission of waves through the earth's atmosphere, wave propagation through slightly inhomogeneous media, intensity fluctuation or scintillation, and long-range propagation of radio waves by atmospheric scattering.

621.396.11 **1106**

Toward a Theory of Reflection by a Rough Surface.—W. S. Ament. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 142–146.) The reflection of e.m. waves by the surface of the sea is investigated theoretically by combining a statistical description of the surface with Maxwell's equations. Formulae are thus derived from which the average specular-reflection coefficient can be determined from the average surface currents when methods of evaluating certain integrals have been found.

621.396.11 **1107**

Can Prediction be Simplified?—R. Gea Sacasa. (*Rev. Telecomunicación, Madrid*, Sept. 1952, Vol. 8, No. 29, pp. 6–21.) N.B.S. prediction procedure, described in Ebert's paper (1476 of 1951) on the reception in Switzerland of signals from WWV, is discussed in detail and compared with the 'Spanish method' (1404 of 1952). Graphs are given showing predicted optimum working frequency against hour of day for the two methods. The 'Spanish method' gives results in good agreement with observations, and is much simpler than the N.B.S. method.

621.396.11 : 551.594.6 **1108**

The Propagation of a Radio Atmospheric: Part 2.—K. G. Budden. (*Phil. Mag.*, Nov. 1952, Vol. 43, No. 346, pp. 1179–1200.) In part 1 (1652 of 1951) one of the modes of propagation of atmospherics considered was by means of a duct formed between the ionosphere and the earth, for which a theory was outlined. Part 2 gives the full mathematical theory and shows how the characteristics of the waveguide modes can be determined in the most general case, provided the reflecting properties of the earth and the ionosphere are known as functions of the angle of incidence. The waveguide modes are found to be of two types, which are termed quasi-transverse magnetic and quasitransverse electric. The particular case is discussed in which the earth is perfectly conducting and the ionosphere a homogeneous ionized medium. The results of numerical calculations for a few special cases are presented in curves which show (*a*) the attenuation in the various modes as a function of frequency, (*b*) the polarization characteristics of the wave in typical modes, (*c*) the amplitudes of the waves excited in typical modes by a vertical electric-dipole source.

621.396.11 : 621.397.8 **1109**

A Survey of British Research on Wave Propagation with Particular Reference to Television.—R. L. Smith-Rose. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 270–280. Discussion, pp. 310–312.) Theoretical and experimental investigations of e.m. wave propagation over distances up to about 100 km, and the effects of terrain irregularities, atmospheric refraction, diffraction and scattering, are discussed. Investigations for the metre waveband for distances of a few hundred kilometres show the preponderating effect of meteorological conditions. Apart from the use of radio links at frequencies in the region of 900 Mc/s, comparatively little has been done regarding the study of propagation in the 470–960-Mc/s television band, but at frequencies between 3 and 10 kMc/s considerable work has been done in connection with radar developments. It seems likely that the use of such high frequencies in a television service will be confined to radio links for point-to-point distribution. 55 references.

621.396.11 : 621.397.8 **1110**

Long-Distance Propagation in Relation to Television in the United Kingdom.—J. A. Saxton. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 294–299. Discussion, pp. 310–312.) A review is given of the effects of irregularities in the terrain and of non-standard refraction in the troposphere on radio field-strength characteristics in the v.h.f. band. The results of an analysis of existing data on long-range transmission in this band in the United Kingdom are then applied to the problem of determining the spacing required between two transmitters working on a common frequency when the degree of interference in each local service area caused by signals from the more distant transmitter must not exceed various specified limits. The effects of non-standard tropospheric refraction, in particular, are such as to make this spacing much greater than it would be if such departures from standard did not exist.

621.396.8 **1111**

Transmission Loss in Radio Propagation.—K. A. Norton. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 146–152.) 'Transmission loss' is defined as the ratio of radiated power to signal power available from a loss-free receiving aerial, thus including only losses occurring in the aerials and the intervening medium. The measurement and calculation of this quantity are discussed. The time variations to be expected in cases of ionospheric or tropospheric propagation are investigated with reference to Rayleigh's distribution theory of random vibrations. The transmission-loss concept is useful for estimating the maximum effective range of a radio system subject to interference from both noise and unwanted signals.

621.396.81 **1112**

Prediction of the Nocturnal Duct and its Effect on U.H.F.—L. J. Anderson & E. E. Gossard. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 136–139.) Predictions, based on meteorological data covering 3½ years, are made of the probability distribution of diurnal variations in field strength for two 98-mile C.R.P.L. links in Colorado, operating respectively on 100 Mc/s and 1 kMc/s. Agreement between predicted and measured values is encouraging.

621.396.81 **1113**

Field Strength of KC2XAK, 534.75 Mc/s, recorded at Riverhead, N.Y.—G. S. Wickizer. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 140–142.) Analysis of field strengths recorded during 22 months for transmission over a nonoptical path of length 33 miles. Overall variation was about 12 db in winter and 33 db in summer; variation of the median level was relatively small. Fading 10 db or more below the median level occurred during summer.

621.396.81.029.62/.64 **1114**

Radio Transmission Beyond the Horizon in the 40- to 4 000-Mc/s Band.—K. Bullington. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 132–135.) Tests using frequencies of 3·7 kMc/s, 535 Mc/s and 460 Mc/s are reported; reliable signals have been received at distances of several hundred miles. Median signal levels are 50–90 db below the free-space values but are hundreds of decibels higher than values predicted from classical theory. At points far beyond the horizon the received power is relatively independent of aerial height, meteorological factors and frequency over the range 40 Mc/s–3·7 kMc/s. No long-delay echoes have been observed. A shorter account was noted in 3216 of 1952.

RECEPTION

621.396.621 : 517.432.1 **1115**

Theory of the Impulse Response of Receivers.—R. Kitai. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 279–288. Discussion, p. 430.) Full paper. See 2879 of 1952.

621.396.82 + 621.397.82 **1116**

Current Radio-Interference Problems.—Lee. (See 1179)

621.396.82 : 621.315.14.027.8 **1117**

Radio Noise in Relation to the Design of High-Voltage Transmission Lines.—Rörden & Gens. (See 927.)

STATIONS AND COMMUNICATION SYSTEMS

621.39 : 358.236(494) **1118**

The Evolution of Electrical Communication in the [Swiss] Army.—M. Nüscheler. (*Bull. schweiz. elektrotech. Ver.*, 4th Oct. 1952, Vol. 43, No. 20, pp. 820–824.) History of developments since 1852.

621.39(689) **1119**

Telecommunications in Nyasaland.—C. R. Dickenson. (*Overseas Engr*, Oct. 1952, Vol. 26, No. 298, pp. 76–77.) An outline description of present facilities and proposed developments, including multichannel R/T links operating in the v.h.f. bands.

621.395 + 621.396.5] : 061.31 **1120**

The 16th Plenary Assembly of the Comité Consultatif International Téléphonique (C.C.I.F.), October 1951, Florence.—R. Sueur. (*Câbles & Transm.*, Oct. 1952, Vol. 6, No. 4, pp. 281–284.) Review of the proceedings.

621.395.44 **1121**

Terminal Equipment of Modern Carrier-Frequency Telephony Systems.—J. Bauer. (*Bull. schweiz. elektrotech. Ver.*, 4th Oct. 1952, Vol. 43, No. 20, pp. 824–829.) Description of basic groups and of equipment suitable for symmetrical lines and for coaxial cables.

621.396 : 656.2(54) **1122**

Radio on Indian Railways.—H. C. Towers. (*Elect. J.*, formerly *Electrician*, 24th Oct. 1952, Vol. 149, No. 3880, pp. 1241–1243.) An outline of recent developments in the installation of 20-W and 500-W radiocommunication sets, and of experiments on various applications of v.h.f. mobile equipment.

621.396(494) : 061.2 **1123**

Growth, Organization and Activities of the Swiss Radiocommunication and Broadcasting Organizations.—F. Rothen. (*Bull. schweiz. elektrotech. Ver.*, 4th Oct. 1952, Vol. 43, No. 20, pp. 815–820.)

621.396.1 **1124**

Recent International Conferences and the Radio-frequency Spectrum.—(*Rev. telegr. Electronica, Buenos Aires*, July 1952, Vol. 40, No. 478, pp. 415–419, 424.) A report of work done from 1946 to 1951, with particular reference to frequency allocations for the American continent.

621.396.619.16 **1125**

Experimental System of Multifrequency Code Modulation.—A. Pinet. (*Câbles & Transm.*, Oct. 1952, Vol. 6, No. 4, pp. 285–300.) The basic principles of code modulation are outlined and a detailed description is given of the first experimental system of this type developed in the research laboratories of the French P.T.T. The coding equipment is of the parallel type previously considered [2331 of 1952 (Libois)]. Somewhat complex circuits were found necessary to obtain a satisfactory signal/noise ratio, particularly at low modulation levels, so that the number of valves for each of the 12 channels is about 15, whereas for a similar delta-modulation system [2330 of 1952 (Libois)] only about 6 valves per channel are required. Control equipment for adjusting and testing the various sections of the system is noted.

621.396.65.029.63/.64 **1126**

U.H.F. Radio-Relay-System Engineering.—J. J. Egli. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 115–124.) Abacs are presented for finding required path clearances from path parameters and operating frequency. Methods of minimizing fading are discussed; formulae are derived for determining for a given path profile the required spacing of receiving aerials for space-diversity reception. The power levels at various points of a single-hop system are evaluated, and the performance and reliability of a multi-hop system are discussed.

621.396.65.029.64 : 621.396.619.13 **1127**

An F.M. Microwave Radio Relay.—R. E. Lacy & C. E. Sharp. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 125–128.) 1952 I.R.E. National Convention paper. A transportable unit for military purposes, operating with 50 channels in the frequency range 8–8·5 kMc/s, uses a common aerial for transmitter and receiver, with duplexing by means of a waveguide magic T. The aerial system comprises a paraboloidal reflector fed by an off-centre horn. The tuned c.w. magnetron gives >50 W carrier power. Frequency is stabilized by the method previously described by Bruck (1569 of 1948).

621.396.712 **1128**

Transmitting Equipment at the Wavre-Overijse Centre.—G. Hansen. (*HF, Brussels*, 1952, Vol. 2, No. 4, pp. 81–96.) A general description is given of the high-power transmitters, aerial systems, aerial-switching arrangements and control consoles at this new centre for broadcasting in French and Flemish the national programmes on medium wavelengths, and for s.w. transmission of the 'colonial' programme to the Belgian Congo and of the 'world' programme to other parts of the world. Detailed descriptions are included of the output stages, h.v. rectifier system, s.w. aerial-switching system and heat-recovery system.

621.396.931 **1129**

Synchronous F.M. System.—(*Wireless World*, Feb. 1953, Vol. 59, No. 2, pp. 77–78.) Operation of a v.h.f. communication system in a hilly, and in some parts mountainous, area such as Ayrshire is found impractical with a single central station. A master station controlling two slave stations has consequently been adopted. The master station broadcasts at 97·5 Mc/s, and the link transmitters feeding the satellites operate at 146·25 Mc/s, both frequencies being controlled by a master crystal with a frequency of 1·35416 Mc/s. A process of frequency multiplication and division restores the frequency of 97·5 Mc/s for transmission by the satellites, time delay circuits ensuring simultaneous speech radiation from the master and slave stations.

SUBSIDIARY APPARATUS

621-526 : 621.3.015.3 **1130**

Transients in Nonlinear Servomechanisms with Filters.—J. Loeb. (*Ann. Télécommun.*, Oct. 1952, Vol. 7, No. 10, pp. 408–410.) Continuing previous work (2041 of 1952), equations are derived for amplitude x and elongation y (a complex function of time t) for the case of small damping, and a new construction for point-to-point tracing of the x/t curve is indicated which furnishes a new criterion of stability of steady states of oscillation.

621-526 : 621.3.015.7 **1131**

The Pulse Transfer Function and its Application to Sampling Servo Systems.—R. H. Barker. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 302–317. Digest, *ibid.*, Part II, Oct. 1952, Vol. 99, No. 71, pp. 302–317.) A method of analysis of sampling in a linear system is described which is based on a sequence transformation closely analogous to the Laplace transform. The pulse transfer function relates a sequence of samples at the output of the system to the input sequence of pulses producing it. Servo systems with a finite time-delay in the feedback loop are particularly considered. A list of transforms is provided in an appendix.

621-526 : 681.142 **1132**

The Design and Testing of an Electronic Simulator for a Hydraulic Remote-Position-Control Servomechanism.—F. J. U. Ritson & P. H. Hammond. (*Proc. Instn elect. Engrs*, Part II, Dec. 1952, Vol. 99, No. 72, pp. 533–548. Discussion, pp. 549–552.)

621.311.6 : 621.316.72 **1133**

Exceptionally Stable Regulated Power Supply for Electrometer Tubes.—W. P. Senett & R. W. Pierce. (*Rev. sci. Instrum.*, Oct. 1952, Vol. 23, No. 10, pp. 534–537.) Description of a two-stage regulator circuit delivering about 100 mA at 80 V with the output regulated to within several parts per million for line-voltage changes of $\pm 10\%$. Drift of the output voltage is about 5 parts per million per hour. Theory, construction details and results of performance tests are given.

621.311.6 : 621.316.72 **1134**

Radiofrequency Power Supply.—E. M. Reilley, R. S. Bender & H. J. Hausman. (*Rev. sci. Instrum.*, Oct. 1952, Vol. 23, No. 10, pp. 572–573.) Brief description of a circuit designed for a maximum current output of 500 μA, an output voltage of 500–3 000 V being provided by means of a chain of wire-wound resistors. The variation of the d.c. output voltage, measured over a period of 48 hours, was < 2 parts in 10^4.

621.316.7.076.12 **1135**

Compensation of Feedback-Control Systems subject to Saturation.—G. C. Newton, Jr. (*J. Franklin Inst.*, Oct. & Nov. 1952, Vol. 254, Nos. 4 & 5, pp. 281–296 & 391–413.) "A theory for the design of compensating networks for feedback-control systems and filters is developed . . . The novel feature of this theory is its consideration of saturation and transient performance in addition to the usual steady-state behaviour. This theory is essentially an extension of the researches of Wiener and Lee in statistical methods for filter design. Saturation is handled by limiting the r.m.s. signal levels at critical points in the linear model used as the design basis for the physical system. Transient performance is handled by limiting the integral-square errors to a set of transient test signals."

621.316.722.1 : 621.387 **1136**

Corona Discharge Tubes for Voltage Stabilization.—E. E. Shelton & F. Wade. (*Electronic Engng*, Jan. 1953, Vol. 25, No. 299, pp. 18–21.) The mechanism of the corona discharge is briefly described by reference to the current/voltage characteristic of the glow-discharge tube. The construction, processing and performance of experimental coaxial types of tube are discussed. The data presented are sufficient for the design of tubes with regulating voltages between 400 and 1 000 V operating at currents up to at least 100 μA. Such tubes can be made with characteristics stable for over 1 000 hours.

621.316.726.087.9 **1137**

The Importance of Frequency Rate Indication in the Control of the National Grid.—(*Muirhead Technique*, Oct. 1952, Vol. 6, No. 4, pp. 27–29.) Description of the construction and use of equipment indicating time error, mains-frequency error and rate of change of mains frequency. The unit comprises a mains-driven and a tuning-fork controlled motor, both coupled to a differential gear whose output shaft moves only when the mains frequency differs from 50 c/s. Systems of differentiators and geared counters operate the indicating instruments.

TELEVISION AND PHOTOTELEGRAPHY

621.397.2 **1138**

Radio Facsimile Weather Map Transmissions.—(*Muirhead Technique*, Oct. 1952, Vol. 6, No. 4, p. 29.) Details of transmission times and frequencies for the stations Washington, Port Lyautey, Balboa and Frankfort.

621.397.2 : 621.317.34 **1139**

Apparatus for the Measurement of Nonlinearity in Television Trunk Systems.—Griffith. (See 1064.)

621.397.2 : 621.317.74 **1140**

Group-Delay Distortion-Measuring Equipment.—Hunt & Kemp. (See 1076.)

621.397.2 : 621.396.615.17 : 621.317.34 **1141**

A Waveform Generator and Display Unit for the Testing of a Television Channel.—Ackland-Snow & Gledhill. (See 1087.)

621.397.2 : 621.396.65 **1142**

Permanent Point-to-Point Links for Relaying Television.—H. Faulkner. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 313–322. Discussion, pp. 472–478.) An account of the various cable and radio relay links for the transmission of television signals, with a video-frequency bandwidth of at least 3 Mc/s, between London and other stations in the United Kingdom network. See also 820 (Clayton et al.), 2342 and 2625 (Kilvington et al.) of 1952.

621.397.24/.26 **1143**

Temporary Linkages for Outside Broadcasting Purposes.—A. R. A. Rendall & W. N. Anderson. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 323–331. Discussion, pp. 472–478.) Discussion of the relative merits of metre-wave and centimetre-wave equipment for use on television outside-broadcasting links shows that both can be usefully employed. A general description is given of the arrangements adopted by the B.B.C. in conjunction with the G.P.O. to provide links between pickup point and transmitter giving satisfactory picture quality. Examples are given of typical links, with performance data.

621.397.24/.26 **1144**

Operating Television O.B. Units.—J. F. Hartwright. (*Wireless World*, Feb. 1953, Vol. 59, No. 2, pp. 74–76.) A short account of the functions of the various members of the team required to operate the different units of the equipment for an outside television broadcast, and of the procedures adopted under various operating conditions.

621.397.24 **1145**

Cable Links for Television Outside Broadcasts.—T. Kilvington. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 415–420. Discussion, pp. 472–478.) An outline of the methods used for the transmission of television signals over (*a*) special low-loss balanced-pair cable, (*b*) coaxial cable, or (*c*) pairs in the ordinary telephone network. For (*a*) and (*c*) transmission is direct; for (*b*) a carrier system is used.

621.397.24 : 621.3.018.78 : 621.315.212 **1146**

Some Factors affecting the Performance of Coaxial Cables for Permanent Television Links.—H. Ashcroft, W. W. H. Clarke & J. D. S. Hinchliffe. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 350–356. Discussion, pp. 472–478.)

621.397.24 : 621.315.212.4 **1147**

The Birmingham–Manchester–Holme-Moss Television-Cable System.—R. J. Halsey & H. Williams. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 398–410. Discussion, pp. 472–478.) Description of the specification for, and the construction and performance characteristics of the system. See also 2342 of 1952.

621.397.24 : 621.395.521.3 **1148**

The Delay Equalization of the London–Birmingham Television Cable System.—J. W. Allnatt. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 338–349. Discussion, pp. 472–478.) A systematic method of equalizer design is outlined and a description is given of the units developed for the London–Birmingham cable link, together with performance figures. See also 2625 of 1952 (Kilvington et al.).

621.397.24 : 621.396.619.24 **1149**

Television Frequency-Translating Terminal Equipment for the Birmingham–Holme-Moss Coaxial Cable.—A. H. Roche & L. E. Weaver. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 455–463. Discussion, pp. 472–478.) Factors affecting the performance of vestigial-sideband systems are discussed and reasons are given for the choice of carrier frequency and sideband width for the Birmingham–Manchester television link, which uses standard ⅜-in. diameter coaxial cable. A description is given of the double-modulation method by which the vision signal is converted into a modulated wave with a carrier frequency of 1·056 Mc/s and a vestigial-sideband width of 500 kc/s. At the receiving terminal the procedure is reversed and the vision signal restored to its original place in the frequency spectrum. Electrical and mechanical details of the equipment are described, with special attention to the design of the modulators and band-shaping filters.

621.397.24 : 621.396.645 **1150**

The Design of Amplifiers for the Birmingham–Manchester Coaxial Cable.—Duerdoth. (See 977.)

621.397.24 : 621.396.645.371 **1151**

Two Simple Types of Feedback Amplifier for the Relaying of Television Signals over Coaxial Cables.—Clifford. (See 984.)

621.397.26.029.63 : [621.318.57 + 621.392.52 **1152**

Ultra-High-Frequency Switches and Filters.—Small. (See 951.)

621.397.335 **1153**

Synchronization and Pulse Technique in Television.—J. Günther. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, Sept./Oct. 1952, Vol. 4, Nos. 9/10, pp. 161–175.) The proposed C.C.I.R. standard composite signal for 625-line television is discussed and possible synchronization faults and the corresponding necessary precautions are indicated. Technical terms which have newly gained acceptance in the German television sphere are listed together with their English equivalents.

621.397.5 **1154**

Some Possibilities for the Compression of Television Signals by Recoding.—E. C. Cherry & G. G. Gouriet. (*Proc. Instn elect. Engrs*, Part III, Jan. 1953, Vol. 100, No. 63, pp. 9–18.) Discussion with reference to communication theory.

621.397.5 : 535.88 **1155**

An Experimental System for Slightly-Delayed Projection of Television Pictures.—P. Mandel. (*J. Brit. Instn Radio Engrs*, Nov. 1952, Vol. 12, No. 11, pp. 567–575.) For another account of the system see 241 of January.

621.397.6 : 621.317.34 1156

The Transient Testing of Television Apparatus.—Cooper. (See 1065.)

621.397.6 : 621.317.34 1157

The Response of a Vestigial Side-Band System to a "Sine-Squared" Step Transition.—Skwirzynski. (See 1066.)

621.397.6 : 621.396.65 1158

Portable Equipment for a Microwave Television Link.—G. Dawson. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 379–384. Discussion, pp. 472–478.) Description of transmitting and receiving equipment for a link operating in either the 3·6–4·2 or the 4·4–4·8-kMc/s band. A coaxial-line v.m. oscillator valve [1211 below (Lambert)] was found so stable in operation that no a.f.c. system was required. With paraboloidal aerials 4 ft in diameter, satisfactory operation is obtained under normal conditions over paths of length up to 40 miles.

621.397.6 : 621.396.65 1159

A Mobile High-Power Microwave Link for Vision and Sound.—F. W. Cutts. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 374–378. Discussion, pp. 472–478.) Description of equipment for transmitting one video and two audio signals from an outside-broadcast site back to base. Paraboloid reflectors 4 ft in diameter, with waveguide feed from a Type-R5081 reflex klystron for the 3·9–4·2-kMc/s band or from a Type-R6010 klystron for the 4·4–4·8-kMc/s band, provide an output power of 4 W. Double f.m. is used for the audio signals to reduce cross modulation. Performance test results are in good agreement with theory. For a description of the Type-R5081 valve see 1214 below (Pearce & Mayo).

621.397.6 : 621.396.67.029.63 1160

Hinged Tubular Mast for Decimetre Television Mobile Transmitter.—H. Käding. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, Sept./Oct. 1952, Vol. 4, Nos. 9/10, pp. 181–183.) Details are given of a four-section mast which when erected carries the aerial at a height of 17 m, and of the trailer on which it is supported.

621.397.61 1161

High-Power Television-Transmitter Technique, with Particular Reference to the Transmitter at Holme Moss.—V. J. Cooper. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 231–242. Discussion, pp. 264–269.) Performance requirements for television transmitters are discussed. Comparison of high-level and low-level modulating systems indicates that high-level systems are preferable. The design features of a B.B.C. 50-kW transmitter are discussed, with special reference to shunt-regulated amplifiers, pulse-stabilization methods and black-level control. Transmitter testing methods are considered briefly. See also 567 of February.

621.397.61 : 621.392.52 : 621.396.67 1162

A Combining Filter for Vision and Sound Transmission.—B. M. Sosin. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 253–264. Discussion, pp. 264–269.) Possible methods of combining sound and vision signals and feeding them into a common aerial are reviewed. Use of the Maxwell bridge leads to a compact design with good performance. Detailed analysis of this type of combining filter is presented. A coaxial unit is described and its equivalent circuit given, performance measurements being shown graphically. Two types have been designed, one for the high-power transmitter at Holme Moss (50-kW video and 12-kW sound), the other for medium-power transmitters (5-kW video and 2-kW sound).

621.397.61 : 621.396.619.2 1163

Television Modulation.—F. C. McLean : E. Green. (*Wireless World*, Feb. 1953, Vol. 59, No. 2, p. 63.) Critical comments on paper noted in 568 of February.

621.397.611 : 628.9 1164

Illumination in Television Studios.—J. Sánchez Cordovés. (*Rev. Telecomunicación, Madrid*, Sept. 1952, Vol. 8, No. 29, pp. 39–43.) Discussion of the factors to be considered in determining correct illumination in relation to the characteristics of the camera tube used.

621.397.611.2 1165

Some Problems of Television Pickup Technique.—H. Hewel. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, Sept./Oct. 1952, Vol. 4, Nos. 9/10, pp. 176–180.) The principles and design are discussed of three items of auxiliary equipment for the portable pickup set described in 2056 of 1952; they are:— (*a*) automatic aperture control of the optical system; (*b*) synchronized black-level control in the video amplifier; (*c*) electronic picture-signal mixer.

621.397.62 1166

Tuner for Complete U.H.F.-TV Coverage without Moving Contacts.—R. J. Lindeman & C. E. Dean. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 67–72.) The circuit comprises two-stage preselector, crystal mixer, triode oscillator and cascode-type first i.f. stage; the input matches a 300-Ω aerial and the output is suitable for feeding the i.f. amplifier of a conventional television receiver. The tuned circuits use balanced parallel-rod constructions, and are screened. Methods of achieving low noise figure, adequate rejection of unwanted signals, and low oscillator radiation are discussed and measurements of the performance are reported.

621.397.62 1167

Comparative Survey of Input Stages of Television Receivers.—W. Reichel. (*Funk u. Ton*, Aug. 1952, Vol. 6, No. 8, pp. 406–415.) H.f. amplifier, oscillator, mixer and tuning arrangements used in various U.S. and European receivers are compared; details are given of some interesting examples from German models.

621.397.62 : 535.88 1168

Special Problems in Television Large-Picture Installations.—E. Schwartz. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, Sept./Oct. 1952, Vol. 4, Nos. 9/10, pp. 184–194.) Arrangements using c.r. tubes with optical projection systems are surveyed, and their limitations indicated; the possibilities of systems using light valves, as in the eidophor process, are noted.

621.397.62 : 621.396.615.17.018.75 1169

A Testing Pulse for Television Links.—Macdiarmid. (See 1089.)

621.397.7 1170

Television Facilities of the Canadian Broadcasting Corporation.—J. E. Hayes. (*J. Soc. Mot. Pict. Telev. Engrs*, Nov. 1952, Vol. 59, No. 5, pp. 398–405.) Description of television broadcasting stations established in Montreal and Toronto. Operation at Montreal is on channel 2 (54–60 Mc/s) with an effective radiated power of 16 kW, and at Toronto is on channel 9 (186–192 Mc/s) with an output of 26 kW.

621.397.7 1171

Television Broadcasting Stations.—P. A. T. Bevan. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 179–214. Discussion, pp. 264–269.) A survey is made of the distribution scheme by which the B.B.C. hopes to provide the greater part of the United

Kingdom with a 405-line television service. The basic factors underlying the choice of scheme are discussed, together with the arrangements for dividing the available 41–68-Mc/s frequency band into five separate operating channels using the receiver-attenuation system of vestigial-sideband transmission. The proposals for operating two geographically separated transmitters, one of high power and one of low power, on each channel to complete a 10-station plan, and the precautions needed to minimize co-channel interference, are explained. Problems of site selection for transmitting stations are mentioned and a brief account is given of propagation phenomena which affect the estimation of service area. The scheme for linking the stations with the London studio centre is briefly described. The general planning and design of the complete transmitting equipment used at the new B.B.C. high-power television stations, and of that intended for use at the future low-power stations, are surveyed, with particular reference to the different types of vision and sound transmitter, monitoring equipment, air- and water-cooling installations, vision/sound combining circuits, transmission lines and aerial systems. For a shorter version, see *B.B.C. Quart.*, Winter 1952–1953, Vol. 7, No. 4, pp. 235–245.

621.397.7 **1172**

The Selection and Testing of Sites for Television Transmitters in the United Kingdom.—L. F. Tagholm & G. I. Ross. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 300–309. Discussion, pp. 310–312.) Discussion of the problem of providing a television service for the whole of the United Kingdom, using five high-power transmitters linked with five low-power transmitters operating at different frequencies in the 41–68-Mc/s band. Site testing and determination of service areas were carried out at various places, using an aerial supported by a balloon. Reasons for the final choice of sites are given. Experiments were made at two sites to determine the effects of re-radiation from neighbouring structures which might give rise to ghost images.

621.397.8 : 551.594.5 **1173**

Auroral Effects on Television.—R. E. Thayer. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, p. 161.) Brief illustrated report of a particular form of television interference observed in the Ithaca, New York, fringe area and attributed to auroral propagation phenomena of the type reported previously, e.g. by Moore (2002 of 1951).

621.397.8 : 621.396.11 **1174**

A Survey of British Research on Wave Propagation with Particular Reference to Television.—Smith-Rose. (See 1109.)

621.397.8 : 621.396.11 **1175**

Long-Distance Propagation in Relation to Television in the United Kingdom.—Saxton. (See 1110.)

621.397.812 **1176**

Ionospheric Influences in Television Reception.—F. A. Kitchen & K. W. Tremellen. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 290–293. Discussion, pp. 310–312.) The effects of ionospheric reflections of v.h.f. waves on television reception are reviewed. Sustained propagation via the F_2 region may occur for limited periods during years of maximum solar activity, whilst irregular and intermittent propagation via sporadic E-region clouds may occur during certain months of every year. The range of frequencies concerned includes those now used for television services in the United Kingdom and elsewhere. A summary is presented of the circumstances under which interference may be expected with the reception of television transmissions, owing to the use of common frequencies for remotely situated short-range v.h.f. systems.

621.397.813 : 621.3.018.78 **1177**

Effects of Amplitude and Phase Distortion on Limited-Spectrum Television Signals.—M. Jouguet. (*Câbles & Transm.*, Oct. 1952, Vol. 6, No. 4, pp. 301–316.) A concise exposition is given of the principles of the method of orthogonal signals developed by Oswald (210 of 1951) and Ville (2933 of 1951), and of the analogous method of 'paired echoes' described by Wheeler (3642 of 1939), for studying the effects of amplitude and phase distortion on the transmission of signals. Relations between these two methods are noted and Wheeler's method is applied to discussion of (*a*) signals of the $\cos^2\theta$ type, (*b*) simple amplitude distortion, (*c*) simple phase distortion, (*d*) a system with both amplitude and phase distortion.

621.397.813 : 621.395.521.3 **1178**

A Variable Time-Equalizer for Video-Frequency Waveform Correction.—J. M. Linke. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 427–435. Discussion, pp. 472–478.) Description of equipment operating on the time-equalizer principle, whereby a wide variety of transmission characteristics can be obtained by combining the input signal with series of (*a*) advanced, (*b*) retarded echoes (attenuated replicas) of the input signal, each echo being individually adjustable in amplitude and sign. The equipment consists essentially of a delay line with adjustable tapping devices which include arrangements for combining and amplifying the various signal components.

621.397.82 + 621.396.82 **1179**

Current Radio-Interference Problems.—E. M. Lee. (*J. Brit. Instn Radio Engrs*, Nov. 1952, Vol. 12, No. 11, pp. 551–564.) A comprehensive review of the many different sources of interference with radio and particularly television reception, with special reference to G.P.O. statistics for 1951 and methods recommended for reducing such interference. Evidence is given of the improved performance of petrol engines resulting from the fitting of suppressors in the ignition-system leads, particularly as regards starting in cold weather and increase of sparking-plug life. Legislation on the subject and specifications for suppressor units are discussed, and an outline is given of methods for the measurement of interference.

621.397.82 : 621.396.67 : 656.13 **1180**

Sensitivity of a Television Aerial to Interference from Motor Vehicles as dependent on its Vertical or Horizontal Polarization.—F. de Clerck. (*HF, Brussels*, 1952, Vol. 2, No. 4, pp. 97–98.) Tests carried out on a dipole aerial, tuned to 180 Mc/s, which could be arranged either vertically or horizontally at the top of a mast 10 m high, indicate that interference from the ignition system of a motor car is less with vertical polarization, the ratio of the interference effects in the two cases being of the order of 8 db.

TRANSMISSION

621.396.619.11 **1181**

The 'Rothman' Modulation System.—A. J. A. Coghlan. (*Rev. telegr. Electronica, Buenos Aires*, July 1952, Vol. 40, No. 478, pp. 420–422, 436.) A screen-grid modulation system is described in which a small portion of the transmitter output is rectified, demodulated and re-applied to the output stage in such a way that the change in valve operating angle due to the modulation is compensated. Greatly increased efficiency results. The power requirements of the screen grid in the modulator valve must not be an appreciable fraction of the total output power. The circuit is unsuitable for frequency-multiplier stages.

621.396.931 : 621.396.619.23 **1182**

Carrier Control with Self-Biased Clamp-Tube Modulator.—(*QST*, Nov. 1952, Vol. 36, No. 11, pp. 41–44.) Discussion of effects obtained in screen-grid modulation of the r.f. amplifier valve by a clamp-valve modulator with a Se rectifier connected between the control grid and the microphone transformer. A certain amount of carrier control is obtained, but distortion results from the clipping of the positive half of the a.f. cycle by the rectifier. Substitution of a grid-blocking capacitor for the rectifier reduces the distortion without impairing carrier control.

VALVES AND THERMIONICS

537.533 : 621.385 **1183**

Low-Noise Electron Streams.—H. W. König. (*Arch. elekt. Übertragung*, Nov. 1952, Vol. 6, No. 11, pp. 445–452.) The sinusoidal fluctuations of field strength and electron velocity in the planes of two consecutive grids, $(n-1)$ and n, are linearly related. The determinant of the system of equations is given by the ratio of the velocities in the grid planes, i.e., $D_n = v_{n-1}/v_n$. In the limiting case $D_n \rightarrow 0$, both noise components in the plane of grid n vanish. Analysis is presented for the case of an acceleration space between cathode and grid-2, with an intermediate grid-1, assuming pure velocity fluctuations at the cathode. By suitable choice of the electrode separations, the field-strength fluctuations or the velocity fluctuations in the grid-2 plane can be made to vanish. The velocity ratios can also be chosen so that both noise components in the grid-2 plane can be reduced to a fraction σ of the corresponding values for the accelerating space without the intermediate grid-1, the current density and the end velocity v_2 being the same in both cases. If Z is the noise factor of a klystron with a divided pre-acceleration space, $Z-1$ is reduced by a factor σ^2 which for $v_1 \ll v_2$ is approximately $v_1/4v_2$. The maximum reduction of $Z-1$ attainable by this method is estimated as about 20 db.

621.314.7 **1184**

High-Frequency Transistor Tetrode.—R. L. Wallace, Jr, L. G. Schimpf & E. Dickten. (*Electronics*, Jan. 1953, Vol. 26, No. 1, pp. 112–113.) See 677 of March.

621.385 : 621.396.822 **1185**

Low-Frequency Noise in Electron Tubes: C. Electrometer Tubes.—J. G. van Wijngaarden & E. F. de Haan. (*Physica*, Oct. 1952, Vol. 18, No. 10, pp. 705–713.) Noise measurements are reported on Philips Type-4060, Ferranti Type-BM4A and Victoreen Type-VX41 electrometer valves and on a normal Type-AF7 pentode. Flicker noise is important in all the electrometer types at low frequencies. There is satisfactory agreement between values of grid current measured directly and values derived from noise measurements.

621.385.029.64 **1186**

Travelling-Wave Valve with Sinuous Rectangular Waveguide.—H. Kleinwächter. (*Arch. elekt. Übertragung*, Nov. 1952, Vol. 6, No. 11, p. 460.) Theory and a sketch are given of a travelling-wave u.h.f. amplifier valve with very great bandwidth. This embodies a section of rectangular waveguide, the middle portion of which is much reduced in width and corrugated. H_{01} waves are fed through a side branch and travel through the waveguide in the same direction as the electron beam.

621.385.029.65 **1187**

Spatial Harmonic Traveling-Wave Amplifier.—S. Millman. (*Bell Lab. Rec.*, Nov. 1952, Vol. 30, No. 11, pp. 413–416.) Description of the construction of a new type of travelling-wave valve, operating at 50 kMc/s, in which the usual helix is replaced by a Cu block with three longitudinal slots, down which the main stream of electrons travels, and 100 transverse resonator slots, of width 0·0065 in. and depth 0·056 in. The dimensions of the Cu block are 2¼ × ⅜ × ¼ in. Amplification results from interaction between the electrons and the travelling wave at the successive transverse slots, the action being effectively the same as if the speeds of wave and electrons were equal, although the electrons are actually travelling more slowly, the ratio of velocities being $d/(d + \lambda)$, where d is the slot spacing and λ the wavelength of the travelling wave. The bandwidth of the amplifier is about 1·5 kMc/s, gain > 20 db, and estimated output power about 25 mW.

621.385.032.216 **1188**

Spectroscopic Investigations of Oxide Cathodes in Gas Discharges.—E. Krautz. (*Z. Naturf.*, Jan. 1951, Vol. 6a, No. 1, pp. 16–24.) Investigations were made of cathodes with pure alkaline-earth oxides, mixed crystals, and compounds including other metal oxides, over the wavelength range 2 200–7 600 Å. Spectrograms show that the destruction of the oxide layer in a low-pressure discharge is largely an atomic process. The method affords a ready means of assessing not only the composition of the surface layers but also the resistance of the cathodes to evaporation, disintegration and dissociation.

621.385.032.216 **1189**

Bariated Tungsten Emitters.—R. C. Hughes & P. P. Coppola. (*J. appl. Phys.*, Nov. 1952, Vol. 23, No. 11, pp. 1261–1262.) Methods are described for the preparation of cathodes in which BaO is dispersed in W without simultaneous oxidation of the W. Cathodes with a BaO content of 5–10% can give continuous emission >100 A/cm² and are highly resistant to damage. A typical specimen gave an emission of about 8 A/cm² at a temperature of 1 000°C, with a life >650 hours at 1 100°C. Richardson-equation constants for a moderately active cathode are $\phi = 1{\cdot}56$ eV and $A = 0{\cdot}6$ A/cm²/deg².

621.385.032.216 : 537.533 **1190**

Poisoning of Oxide-Cathode Emission by Oxygen.—A. A. Shepherd. (*Nature, Lond.*, 15th Nov. 1952, Vol. 170, No. 4333, pp. 839–840.) Experiments are described which indicate the probability that the main cause of oxygen poisoning is the adsorption of thin films of oxygen on both the outer cathode surface and the interior crystallite surfaces, with consequent reduction of both emission and coating conductivity at high temperatures. At low temperatures, such adsorption will reduce the emission from the outer surface without appreciably affecting the conductivity of the coating, since conduction at temperatures below 700°K is mainly a direct crystal-to-crystal process.

621.385.2/.3 **1191**

The Triple Diode-Triode E/U/PABC 80.—H. te Gude. (*Funk u. Ton*, Sept. 1952, Vol. 6, No. 9, pp. 449–458.) The construction and characteristics of the valve are described and its use in the demodulator and a.f. stages of an a.m./f.m. receiver is illustrated.

621.385.2/.3] : 621.396.822 **1192**

Low-Frequency Noise in Electron Tubes: A. Space-Charge Reduction of Flicker Effect.—J. G. van Wijngaarden & K. M. van Vliet. (*Physica*, Oct. 1952, Vol. 18, No. 10, pp. 683–688.) Theoretical discussion of the flicker effect in diodes and triodes under normal operating conditions. This effect can be represented by an equivalent input intensity (or input noise resistance) which is a nearly constant part of the intensity of the fluctuations in the total emission current for a given cathode temperature.

621.385.2 **1193**

Influence of Initial Velocities on Electron Transit Time in Diodes.—J. T. Wallmark. (*J. appl. Phys.*, Oct. 1952, Vol. 23, No. 10, pp. 1096–1099.) The transit-time spread due to the spread of initial velocities is calculated for the case of nonuniform velocity distribution, and is given as a function of the current for (*a*) a normal diode, and (*b*) an inverted diode, i.e., one in which the beam is reflected. The transit-time spread is also given as a function of anode voltage within certain limits. The theory is used to explain the properties of the valve previously described (1477 of 1952).

621.385.2 **1194**

Effect of Filament Voltage on the Plate Current of a Diode.—H. F. Ivey. (*J. appl. Phys.*, Nov. 1952, Vol. 23, No. 11, pp. 1254–1256.) Analysis applicable to both planar and cylindrical arrangements is given for a diode with filament directly heated, either by d.c. or by a.c. Graphs show the variation of I/I_0 with V_a/V_f for space-charge-limited conditions and with V_f/T for retarding-field conditions (I is the actual anode current and I_0 the corresponding value with equipotential cathode).

621.385.2 **1195**

Calculation of the Efficiency and Damping of Diode Rectifiers.—H. H. van Abbe. (*Funk u. Ton*, Sept. 1952, Vol. 6, No. 9, pp. 459–469.) Disadvantages of usual methods of calculation, based on the exponential initial portion of the diode characteristic, are indicated and a method is developed involving successive approximations. Divergences between calculated and measured values are $<5\%$. The effect of variations of the diode characteristic is investigated.

621.385.2 : 537.525.92 **1196**

The Space-Charge Smoothing Factor: Part 2.—C. S. Bull. (*Proc. Instn elect. Engrs*, Part IV, Dec. 1952, Vol. 99, No. 4, pp. 289–293.) Full paper. See 291 of January.

621.385.2 : [621.317.3 + 621.316.72 **1197**

Saturated-Diode Operation of Miniature Valves.—V. H. Attree. (*Electronic Engng*, Jan. 1953, Vol. 25, No. 299, pp. 27–29.) Characteristics of a typical subminiature pentode and triode operated as diodes are discussed; the filament power required for temperature-limited operation is only a few milliwatts. A small change of filament heating current produces a relatively large change of anode current. The valves are useful as amplitude-sensing devices in low-power stabilizer circuits and as substitutes for thermojunctions in r.f. measurements.

621.385.2 : 621.396.822 **1198**

On the Relation between the Conductance and the Noise Power Spectrum of Certain Electronic Streams.—J. J. Freeman. (*J. appl. Phys.*, Nov. 1952, Vol. 23, No. 11, pp. 1223–1225.) Analysis is given for diodes with temperature-limited current and for diodes with retarding field. The noise-power spectrum can be considered as the sum of two terms, viz. that due to the pure shot noise which would be produced if the electrons were emitted with zero velocity, and that due to the thermal noise, which is related to the conductance by Nyquist's law.

621.385.2.032.216 **1199**

Electrical Measurement of the Cathode Temperature of Diodes.—D. A. Bell, J. C. Cluley & H. O. Berktay. (*Brit. J. appl. Phys.*, Oct. 1952, Vol. 3, No. 10, pp. 322–323.) The slope of the retarding-field characteristic of the diode is measured in terms of the resistance, and the temperature T is found from the relation $i.r_a = i.dV/di = kT/e$. Comparison with the results of pyrometer measurements indicates that the method is reliable for oxide-coated cathodes and may be useful at temperatures below those suitable for pyrometer measurements.

621.385.3 **1200**

Transit-Time Oscillations in Triodes.—I. A. Harris: M. R. Gavin. (*Brit. J. appl. Phys.*, Nov. 1952, Vol. 3, No. 11, pp. 363–364.) Discussion on paper abstracted in 2664 of 1952 (Critchley & Gavin).

621.385.3 : 621.396.615.14 **1201**

Limiting Frequency of Triode Oscillator.—Y. Koike & S. Yamanaka. (*Technol. Rep. Tohoku Univ.*, 1951, Vol. 16, No. 1, pp. 8–16.) Report of experiments made with two types of disk-seal triodes to verify theory previously advanced (871 of 1952). Values of limiting frequency were noted for different values of anode voltage. The influence of electrode configuration is indicated. An unexpectedly high value of electron transit angle was observed; a satisfactory explanation is not yet available.

621.385.3 : 621.396.822 **1202**

Low-Frequency Noise in Electron Tubes: B. Measurements on Triodes under Normal Operating Conditions.—J. G. van Wijngaarden, K. M. van Vliet & C. J. van Leeuwen. (*Physica*, Oct. 1952, Vol. 18, No. 10, pp. 689–704.) Physical theories of the flicker effect are reviewed and measurements are reported covering the frequency range 1 c/s–5 kc/s and various types of cathode. For W cathodes, deviations from the white shot-noise spectrum were observed only at very low frequencies. W-Th cathodes exhibited flicker effect of intensity inversely proportional to frequency, ν. With oxide cathodes, flicker effect was observed with a component proportional to ν^{-1} (attributed to changes inside the oxide layer) and in some cases with a second component proportional to ν^{-2} (attributed to changes at the surface of the cathode).

621.385.3 : 621.396.822 **1203**

The Limiting Sensitivity of Amplifier Valves: Part 1—Theory of the Triode.—H. Rothe. (*Arch. elekt. Übertragung*, Nov. 1952, Vol. 6, No. 11, pp. 461–468. Correction, *ibid.*, Dec. 1952, Vol. 6, No. 12, p. 498.) Valve noise consists of a coherent part, principally due to the electrons passing through the valve, and an incoherent part mainly due to the effect of the space charge between the cathode and the point of minimum potential. The effects in the different sections of a triode are analysed, making use of equivalent circuits, and a very simple expression for the noise figure is derived which differs from the expressions hitherto given.

621.385.3.029.63 **1204**

R.F. Performance of a U.H.F. Triode.—H. W. A. Chalberg. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 46–50.) 1952 I.R.E. National Convention paper. Techniques used in evaluating the performance of the Type Z-2103 valve (the development number corresponding to production type 6AJ4) are described; both coaxial-line measuring equipment and lumped-constant test circuits were used. Values of gain and noise figure are compared with values for available v.h.f. valves; results indicate the suitability of the Z-2103 valve for use as r.f. amplifier in v.h.f.-u.h.f. television tuners.

621.385.3.029.63 **1205**

Development of a U.H.F. Grounded-Grid Amplifier.—C. E. Horton. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 73–79.) Account of the development of the 9-pin miniature triode Type 6AJ4 for operation in television receivers at frequencies up to 900 Mc/s. Methods of reducing coupling between input and output circuits are discussed, and measurement techniques are indicated.

621.385.4.029.63 **1206**

One-Kilowatt Tetrode for U.H.F. Transmitters.—W. P. Bennett & H. F. Kazanowski. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 13–19.) A forced-air-cooled tetrode capable of delivering 1·2 kW output in television service at frequencies up to 900 Mc/s has a coaxial electrode structure with metal/ceramic seals, and an indirectly heated matrix-type cathode permitting application of high anode voltages without sparking. Production techniques are described for obtaining uniform close spacings. A suitable circuit is illustrated, and performance figures are given for operation as a cathode-driven amplifier.

621.396.615.14 **1207**

Theory of the Reflex Resnatron.—M. Garbuny. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 37–42.) An account is given of the mechanism of energy interchange between the density-modulated electron beam and the h.f. field in the valve previously described [3617 of 1952 (Sheppard et al.)]. The method of Lagrangian parameters is used to determine conditions for maximum energy transfer. Efficiency, amplitude modulation and bandwidth are discussed. Theoretical and experimental results are compared for operation in the neighbourhood of 600 Mc/s; satisfactory agreement is obtained.

621.396.615.14 **1208**

An Axial-Flow Resnatron for U.H.F.—R. L. McCreary, W. J. Armstrong & S. C. McNees. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 42–46.) A design in which the electron stream is directed axially rather than radially leads to constructional simplicity and operational stability. Mechanical features are described and performance figures are tabulated and shown in graphs. The specification calls for a power output of 30 kW c.w., a tuning range of 300–600 Mc/s, a power gain of at least 10 db with a 4-Mc/s bandwidth and an anode efficiency of at least 50%, and easy replacement or adjustment of electrodes.

621.396.615.141.2 **1209**

Magnetrons.—J. Verweel. (*Philips tech. Rev.*, Aug. 1952, Vol. 14, No. 2, pp. 44–58.) An introductory article covering electron motion, oscillations, resonators, output systems and manufacturing problems.

621.396.615.141.2 **1210**

The Magnetron in the Static Cut-Off State. Experimental Study: Part 2—The Influence of the Inclination of the Magnetic Field to the Magnetron Axis.—J. L. Delcroix. (*C. R. Acad. Sci., Paris*, 3rd Nov. 1952, Vol. 235, No. 18, pp. 1018–1020.) Measurements were made of the residual current in the cut-off state for varying inclinations of the magnetic field to the magnetron axis, the inclination being produced by means of auxiliary coils providing a field perpendicular to the main magnetic field. The results confirm the existence, previously observed, of three regimes, B_0, B_1 and B_2, of which B_1 is only slightly influenced by the inclination, B_2 is critically influenced, and B_3 has intermediate properties. B_0 is the Brillouin regime, B_1 and B_2 are the first two bidromic regimes. Part 1: 3620 of 1952.

621.396.615.142 : 621.396.65 **1211**

A Coaxial-Line Velocity-Modulated Oscillator for Use in Frequency-Modulated Radio Links.—D. E. Lambert. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 421–426. Discussion, pp. 472–478.) "An outline is given of the valve requirements for frequency-modulated microwave radio links, and the design and development of suitable valves for the 3·6–5·0-kMc/s band are described."

621.396.615.142.2 **1212**

High-Power U.H.F. Klystron.—(*Tele-Tech*, Oct. 1952, Vol. 11, No. 10, pp. 60–61.) Description of the construction of the Type-V42 valve, a linear amplifier with a gain of over 23 db and an output of 15 kW in the 470–890-Mc/s band. A demountable cathode assembly permits inexpensive replacement. Tuning is effected by flexure of the thin walls of the resonators. The concentric construction gives rigidity, and freedom from vibration and shock effects. The maximum beam current is 3 A at 17 kV, and bombarder voltage 2·4 kV between cathode and filament. The overall length is 50 in., and the weight 150 lb without the 100-lb beam-focusing magnets.

621.396.615.142.2 **1213**

High-Power Klystrons at U.H.F.—D. H. Preist, C. E. Murdock & J. J. Woerner. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 20–25.) The three-cavity gridless magnetically focused klystron is discussed and a particular type, the Eimac 5-kW television klystron, is described in detail. This has the cavities partly outside the vacuum system, thus facilitating tuning. The advantages of this type of valve over conventional grid-control types are indicated.

621.396.615.142.2 : 621.396.619.13 **1214**

The Design of a Reflex-Klystron Oscillator for Frequency Modulation at Centimetre Wavelengths.—A. F. Pearce & B. J. Mayo. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 445–454. Discussion, pp. 472–478.) The factors governing the design of a reflex klystron suitable for f.m. are discussed, and the conditions are considered which give maximum linearity between the oscillation frequency and the modulating voltage applied to the reflector. Practical design problems are mentioned and a description is given of the design and construction of a new valve, Type R5081, which gave an output of about 4 W at 4 kMc/s when used as the f.m. transmitting valve in a television relay link.

MISCELLANEOUS

061.4 : 621.396 **1215**

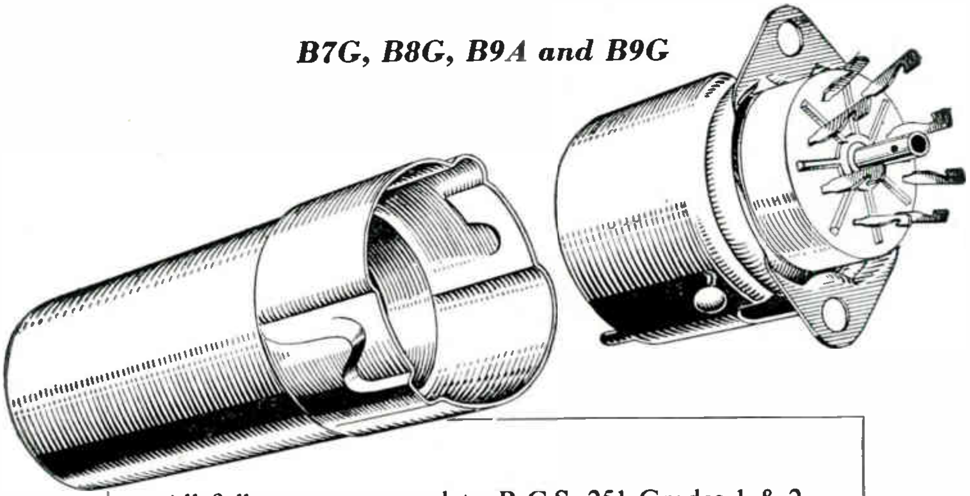
Sixth R.S.G.B. Radio Show.—(*Wireless World*, Jan. 1953, Vol. 59, No. 1, pp. 6–8.) Brief descriptions of commercial and home-constructed amateur equipment.

621.3 : 629.13 : 061.4 **1216**

S.B.A.C. [Society of British Aircraft Constructors] **Farnborough. Details of Electrical Exhibits.**—(*Electrician*, 5th Sept. 1952, Vol. 149, No. 3873, pp. 675–679.) Short descriptions of a wide variety of electrical and electronic equipment on view at the annual show, September 1952.

621.317.7 : 061.3 **1217**

'Electronic Instruments' Symposium.—(*Electrician*, 5th Sept. 1952, Vol. 149, No. 3873, pp. 689–690.) Brief summaries are given of the papers read at the symposium on 'Electronic instruments in research and industry', September 1952, arranged by the Scientific Instrument Manufacturers' Association.



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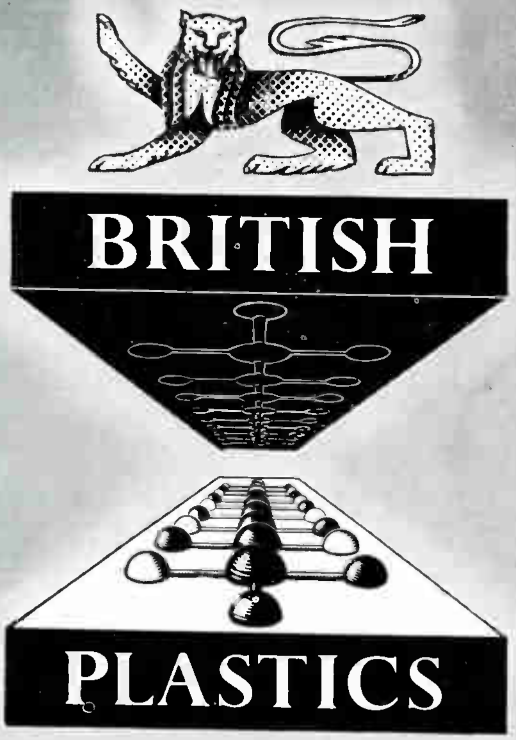

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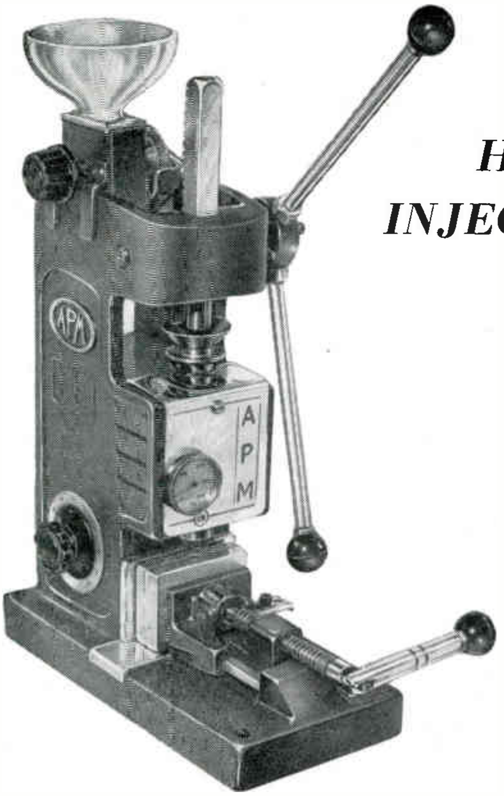
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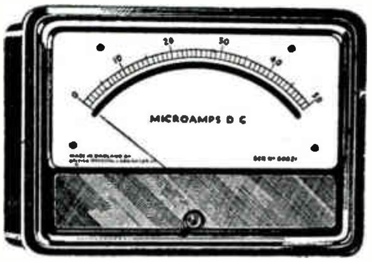
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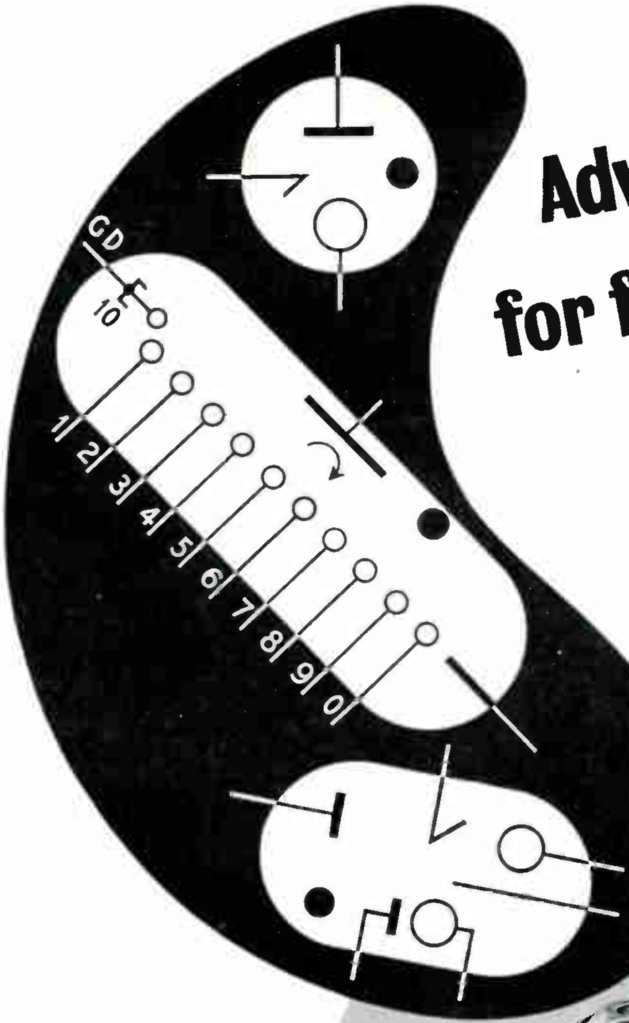

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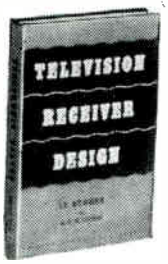

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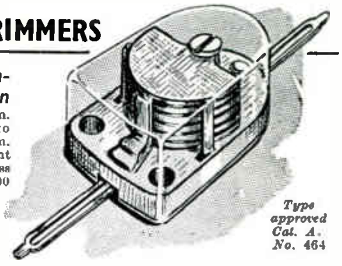

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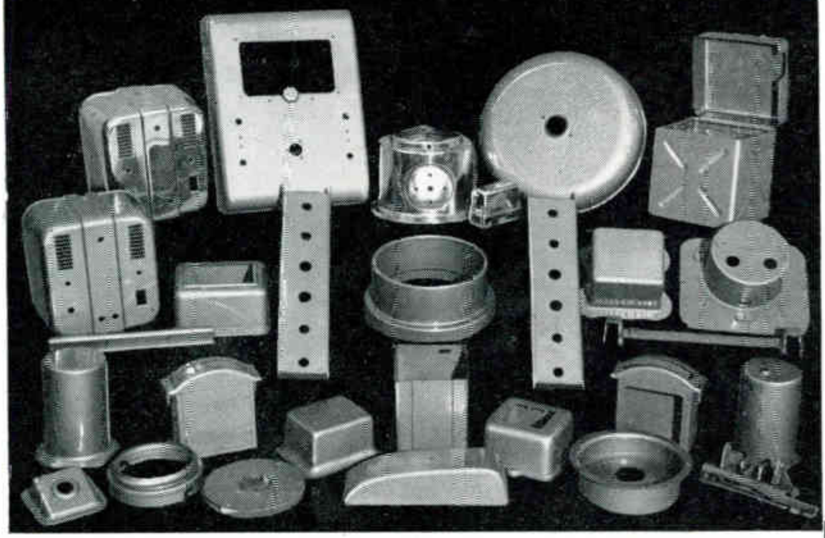

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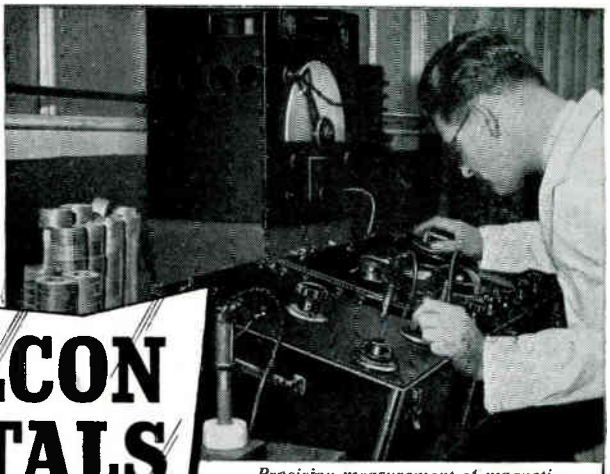

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M2N (wires) MAN (tags)	·00005-·0003	1/2
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	201-300	2/-	2/8
	301-500	2/4	3/-
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	451-500	2/4	3/-
SMAN (tags)	501-1000	2/8	3/3
	1001-2000	3/6	4/-
SM3N (wire)	200-2500	3/6	4/-
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The Finest Cored Solder in the World preferred by the leading makers of television, radio and telephone equipment, and electronic component manufacturers throughout the world

ALLOYS This table shows the Melting Points of the three principal alloys used in Electronic and Telecommunication industries. TABLE 1

Alloy	Colour Code	Sol	Liq	Bit. Temp	USES
60/40	Red	183 C	189 C	229 C	High quality work
45/55	Crimson Buff	183 C	225 C	265 C	Hand Soldering radio and electrical
40/60	Green	183 C	232 C	272 C	

GAUGES. Approximate number of feet per lb. (2.2% flux content)

Standard Wire Gauge	Diam. in Inches	Diam. in M.ms.	ALLOY Tin content is shown first 60/40	45/55	40/60
10	.128	3.251	24.5	23.3	22.7
12	.104	2.642	37.2	35.2	34.6
13	.092	2.337	47.5	45	44
14	.080	2.032	62.8	59.4	58
16	.064	1.626	98	93	91
18	.048	1.219	174.5	165	161
19	.040	1.016	251	238	232
20	.036	.914	310	294	287
22	.028	.711	512	486	474

Ersin Multicore Solder is made as standard for factory use in 6 alloys and 9 gauges, and is supplied on nominal 7 lb. reels. Other alloys and gauges can be supplied to special order. Bulk prices on application.

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ITALY. Switchboard apparatus at Autelco Mediterranea, S.A.T.A.P.

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Special Products

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For the now comparatively few soldering processes where solid wire is required instead of Multicore Solders, supplies are available to special order of Multicore precision made solid wire in all alloys and gauges.

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Ersin Multicore is available in the following solders, all containing 3 cores of Ersin Flux. The melting points are outside the range of the tin/lead alloys shown in Table 1.

TABLE 2

Reference	Composition	Solidus and Liquidus M.P.
T.L.C.	Tin Lead Cadmium	145 C
P.T.	Pure Tin	232 C
*COMSOL	Silver/Tin/Lead	296 C

* *By arrangement with Johnson Matthey & Co. Ltd. of Hatton Garden.*

SOLDER RINGS, PELLETS AND TAPE

Where electronic heating methods are being employed and in other soldering operations, it is often more convenient to use Ersin or Arax Multicore Solder in the form of slugs or pellets. They are available in a wide range of sizes in all standard tin/lead alloys incorporating the time-tested Ersin and Arax Fluxes. Tape solder, containing Ersin or Arax flux, is made in a wide range of sizes, and from .003" thick, accurate to ± .001". Where required, tape can also be supplied without flux content.

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The world-wide popularity of Ersin Multicore is based on its proven reliability over the years. Manufacturers know they can depend on Ersin Multicore because the same unvarying and consistently high quality has always been maintained.

TECHNICAL INFORMATION

Those wireless engineers and laboratory assistants who can't attend but would like fuller technical information about MULTICORE SOLDERS are invited to write for a copy of "TECHNICAL SUMMARY", Reference M.52, giving comprehensive details of the entire Multicore range, facts about flux percentages, solder action, melting points, etc.—also samples of alloys.

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