WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

FEBRUARY 1954

VOL. 31 No. 2 THREE SHILLINGS AND SIXPENCE

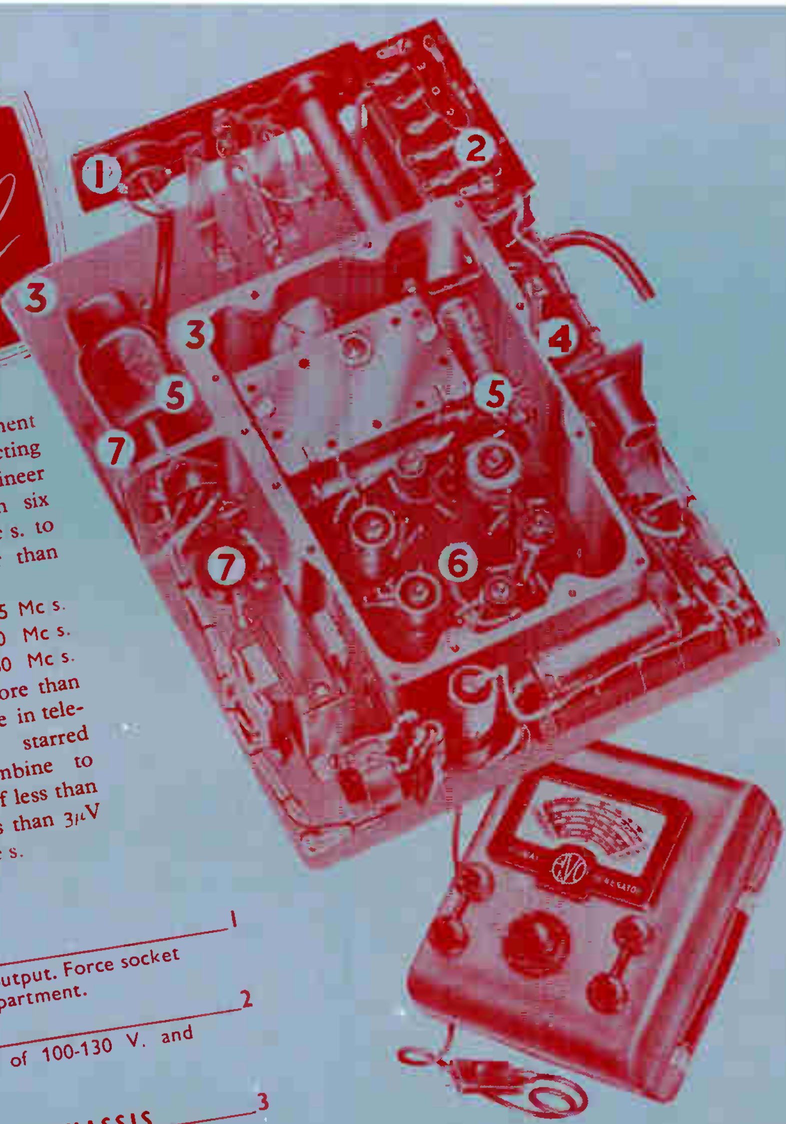
World Radio History

WIDE RANGE Signal GENERATOR

An inexpensive yet precision instrument designed specially to meet the exacting needs of the modern service engineer and laboratory technician. With six frequency ranges covering 50 Kc/s. to 80 Mc/s., its accuracy is better than ± 1% of the scale reading.

50 Kc/s.-150 Kc/s.
150 Kc/s.-500 Kc/s.
500 Kc/s.-1·5 Mc/s.
1·5 Mc/s.-5·5 Mc/s.
5·5 Mc/s.-20 Mc/s.
20 Mc/s.-80 Mc/s.

Scale sub-divisions provide more than adequate discrimination for use in television circuits. Note the starred features below, which combine to maintain a minimum signal of less than 1μV up to 20 Mc/s. and less than 3μV between 20 Mc/s. and 80Mc/s.



★ **OUTPUT** 1
Co-axial socket for attenuated output. Force socket located totally within H.F. compartment.

MAINS TRANSFORMER 2
Marked tagboard for inputs of 100-130 V. and 200-260V., A.C. 50/60 c/s.

★ **CAST ALUMINIUM H.F. COMPARTMENT and CHASSIS** 3
Large number of fixing holes for H.F. compartment cover ensures excellent electrical bonding and good screening.

4

FUSE 5
Easily accessible when replacement is necessary.

VALVES 6
Standard types run at a rating to ensure long life.

TURRET COIL SWITCHING 7
Standard "AVO" practice.

★ **ATTENUATOR SYSTEM**
Employs close tolerance, high stability midget carbon resistors, low reactance rotary potentiometer modified for H.F. operation with carefully designed screening.

Other features include:

ILLUMINATED SPOT RANGE SELECTOR
Gives rapid identification of operational band with intensified lighting round precise frequency. Fine hair line gives close discrimination, particularly on high frequencies.

STOPS
Separate stops prevent turning of dial with respect to condenser.

★ **MAINS FILTER SYSTEM**
This is screened from main electrical assembly.

BUSHING PLATES
provide additional rigidity for rotary controls

SLOW MOTION DRIVE
Substantially free from backlash.

MAINS MODEL 100—130 V. and 200—260 V. A.C., 50—60 c/s.
OR BATTERY MODEL ..... £30.

Sole Proprietors and Manufacturers:—

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S.G.2

World Radio History

'VARIAC' voltage regulating transformers

Reg'd Trade Mark

With a 'VARIAC' voltages are instantly and minutely adjustable from 0-Line Voltage, or in some cases up to 17% above line voltage. Type 50-B 'VARIAC,' as illustrated left, is often operated in a 3-gang assembly on 3-phase work to control 21kVA.

Type 200 C.U.H. 'VARIAC'

Type 100-R 'VARIAC'

SERIES 50 'VARIAC' TRANSFORMERS.

SPECIFICATIONS

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

All 'VARIAC' prices plus 20% as from 23rd Feb. 1952

REQUEST ALSO OUR 20-PAGE SUPPLEMENTARY CATALOGUE GIVING COMPLETE INFORMATION ON OUR NEW AND COMPLETE RANGE OF AC AUTOMATIC VOLTAGE STABILISERS: THESE RANGE FROM 200 VA TO 25 kVA. PERFORMANCE IS EXCELLENT, FROM NO-LOAD TO FULL LOAD, AND STABILITY IS QUITE UNAFFECTED BY FREQUENCY VARIATIONS.

PRICES ARE EXCEPTIONALLY LOW.

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

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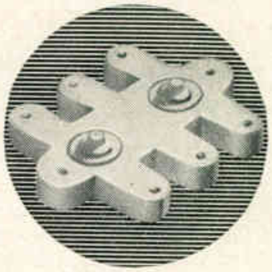

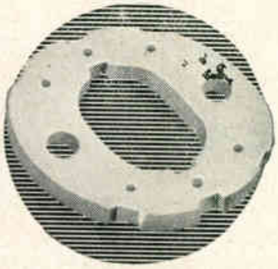

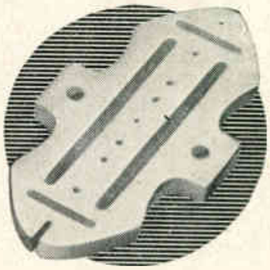

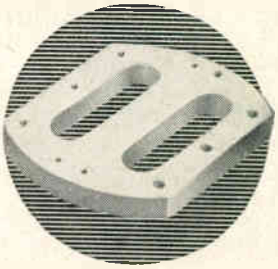

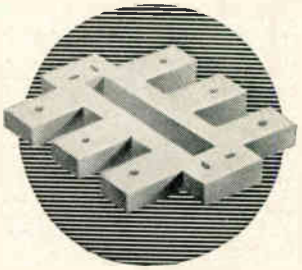

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SP87

*Mullard Ferroxcube being extruded into rods for H.F. cores.*

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.

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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.

World Radio History

from 10 to 310 mc/s

Within the small compass of $14\frac{1}{4}'' \times 12\frac{3}{4}'' \times 8''$, this generator provides facilities as are normally available only in instruments of much greater size and weight—and with an accuracy which suggests something far more costly. Outstanding features include: Frequency calibration ± 1% • Max. attenuation error at 300 Mc/s., ± 4 db. • Modulation (a) 30% sine wave at 1,000 c/s., (b) approximately 50/50 square wave at 1,000 c/s. • Negligible stray field • Weight 34 lb.

Fullest details contained in leaflet V6 sent on request.

D1

Advance

V.H.F. SIGNAL GENERATOR

ADVANCE COMPONENTS LIMITED

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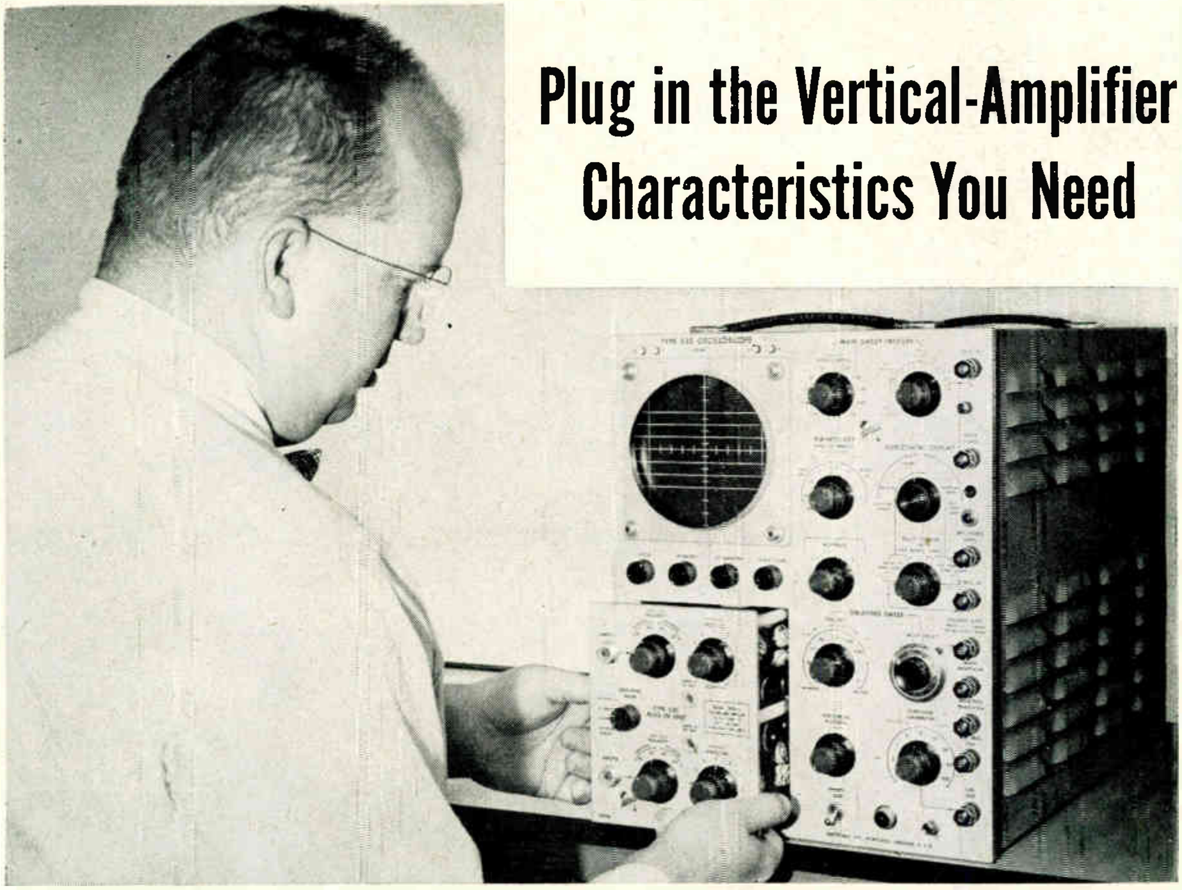
Plug in the Vertical-Amplifier Characteristics You Need



...with this new Tektronix Oscilloscope

No need to switch oscilloscopes when your requirements change. An extremely wide range of work is now handled by one oscilloscope—the Tektronix Type 535—with its moderately-priced plug-in units.

WIDE-BAND PLUG-IN PREAMPLIFIER. Bandpass dc to 10 mc, risetime 0.035 μsec, calibrated sensitivity to 0.05 v/cm, two signal inputs with more than 60 db isolation.
Type 53A Wide-band Plug-in Unit—$85

HIGH-GAIN PLUG-IN PREAMPLIFIER. 1 millivolt/cm sensitivity dc to 250 kc with bandpass increasing to dc to 750 kc at 50 mv/cm sensitivity and lower, differential input.
Type 53D High-gain Plug-in Unit—$145

DUAL-TRACE PLUG-IN PREAMPLIFIER. Two identical amplifier channels, dc to 8.5 mc, 0.04 μsec risetime, calibrated sensitivity to 0.05 v/cm, triggered or 100 kc switching, polarity reversal switches. Type 53C Dual-trace Plug-in Unit—$275

The use of plug-in preamplifiers providing this wide range of facilities is made possible by the broad basic specifications of the Type 535.

600,000,000 TO 1 TIME-BASE RANGE
0.02 μsec/cm to 12 sec/cm.

10 KV ACCELERATING POTENTIAL
Brighter display at low repetition rates.

NEW FLEXIBLE SWEEP DELAY
Accurate, jitter-free, 5 μsec to 20,000 μsec.

Type 535 Oscilloscope—$1300 plus price of desired plug-in unit. Prices f.o.b. Portland, Oregon

Please write
for complete
specifications

Tektronix, Inc.

P. O. Box 831D • Portland 7, Oregon • Cable: TEKTRONIX

World Radio History

TYPE D-650-A

The *NEW* Muirhead-Wigan decade oscillator

THIS precision laboratory oscillator, which covers a range of 1 to 111,100c/s with an overall frequency accuracy of ±0.2% or ±0.5c/s, employs the decade tuning system, by means of which the frequency can be set quickly and accurately on four decade dials and a range switch. This system of tuning ensures the highest possible frequency accuracy and stability. It also enables a given frequency setting to be repeated exactly, and permits the addition or subtraction of a fixed number of cycles per second, thus giving an incremental accuracy of an extremely high order. No other type of oscillator possesses all these advantages.

FEATURES

Frequency range: 1-11,110c/s and 10-111,100c/s.
Frequency accuracy: ±0.2% or ±0.5c/s.
Hourly frequency stability: ±0.02% over most of range.
Maximum output:
  2W into 8000 ohms above 20c/s.
  50mW into 8000 ohms below 20c/s.
Harmonic content: 1% at 1W output.
Hum level: —80db relative to maximum output at 1000c/s.
Power supply: 200-250V, 50c/s; 90W. or 95-125V, 60c/s; 90W.
Dimensions: 17¼ in. wide x 10½ in. high x 13 in. deep. (43·8 cm x 26·7 cm x 33 cm).
Weight: 83 lb. (38 kg).

MAIL THIS COUPON FOR DESCRIPTIVE BROCHURE

NAME

POSITION__________________

COMPANY__________________

ADDRESS to which BROCHURE should be sent

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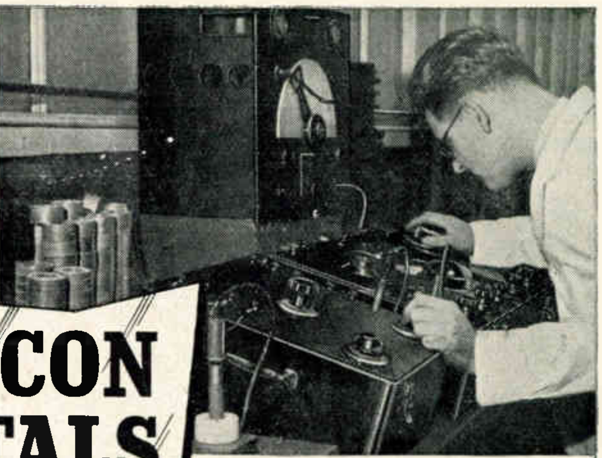
Technical Control

Close technical control of production is an all-important factor in the manufacture of Telcon Metals. Accurate tests and measurements are made at various stages in the course of production and the illustrations show two of the many routine examinations conducted in our well-equipped laboratories.



Precision measurement of magnetic characteristics of toroidal Mumetal cores by the Ferrometer.

TELCON METALS

Routine Factory testing of Mumetal toroidal cores.

MAGNETIC ALLOYS — Mumetal, Radiometal, H.C.R., Rhometal, Permendur, R2799, 36/64, Dust.
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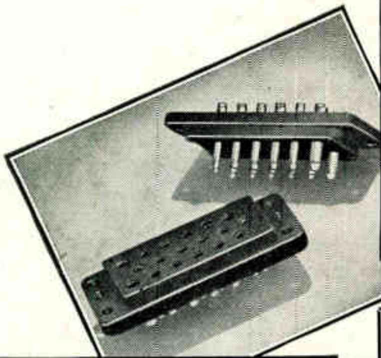
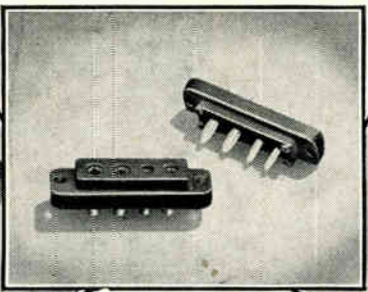
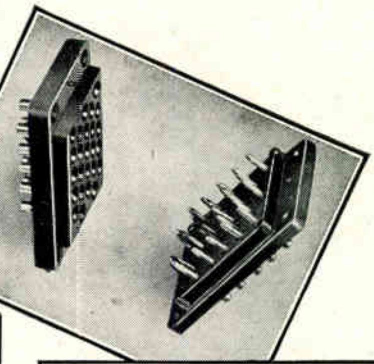
World Radio History

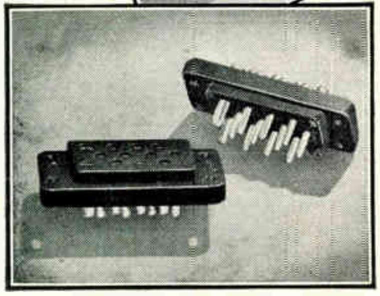
'UNITORS'

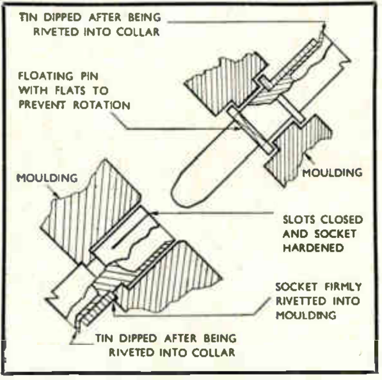
A range of miniaturised connectors by "Belling-Lee"

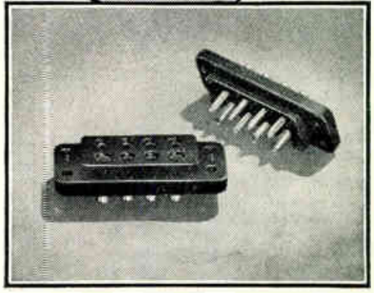












4 to 25 WAY FROM STOCK

"Unitors" are links in the chain of electronic events. Any weakness means failure, and perhaps disaster. "Belling-Lee" Unitors are approved by A.I.D. and A.R.B., and have Joint Service Approval.

In recent independent tests, five pairs of 12-way "Unitors" made 16,335 insertions and withdrawals and were still serviceable.

The test apparatus was rigged in such a way that the plug portion was offered up to the socket with the pins at the maximum limit of float, and individual pins approached the relevant socket at various angles.

A coupling comprises a block of plugs and a complementary block of sockets, arranged so as to be non-reversible. Round pins are employed, turned from high grade brass, silver plated. The normal pins carry 3 amp., but each block has two large pins or sockets to carry 10 amp. All pins are fully floating, and the method of assembly is the subject of a patent.

Resilient sockets are of differentially hardened beryllium copper. All contacts, plugs and sockets are numbered on the face and reverse sides of the body. The distance between flanges when plugged together is 0·281 in.

U.K. Pat. No.
649739

Swiss Pat. No.
277799

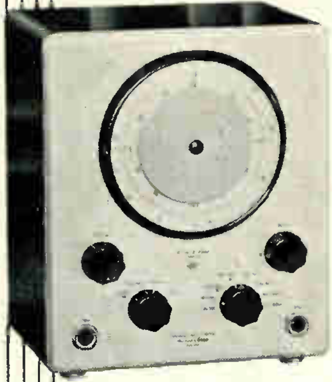
A cable cover for line connection is available, together with retainer for chassis mounting.

LIST NO.	PINS
L.653/P & S	4
L.654/P & S	8
L.655/P & S	12
L.656/P & S	18
L.657/P & S	25

BELLING & LEE LTD
GREAT CAMBRIDGE ROAD, ENFIELD, MIDDX., ENGLAND

FOR MEASURING FREQUENCY and DISTORTION

The model 1602 **Frequency and Distortion Measuring Bridge** is a simply operated blocking network, tuneable through the range from 47 to 12.000 c/s and attenuating the fundamental frequency 120 db.



type 1602
Tuneable 120 db attenuator

Wherever an interfering frequency must be blocked out, such as a hum voltage, the sharp attenuation provided by the instrument assures the complete elimination of the unwanted signal. Harmonic components may be measured in conjunction with the **Frequency Analyzer** model 2105. This versatile frequency-selective V.T. voltmeter, used over the whole field of acoustical and electro-acoustical measurements, gives in this case the harmonics as percentages of the amplitude of the fundamental note down to 0·01%.

type 2105
Multipurpose Audio Frequency Analyzer

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Full information will be supplied on request.

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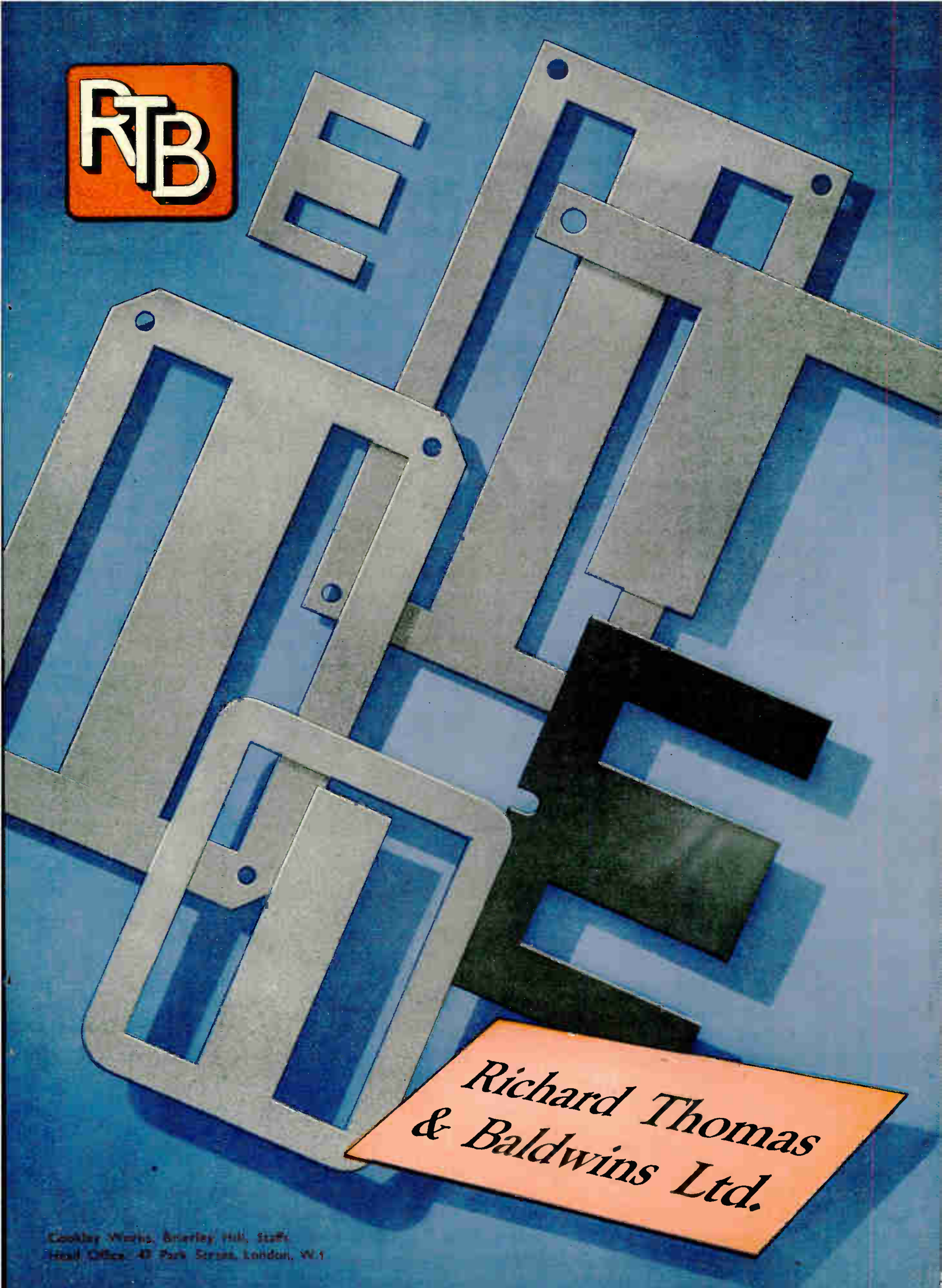

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Head Office: 47 Park Street, London, W.1

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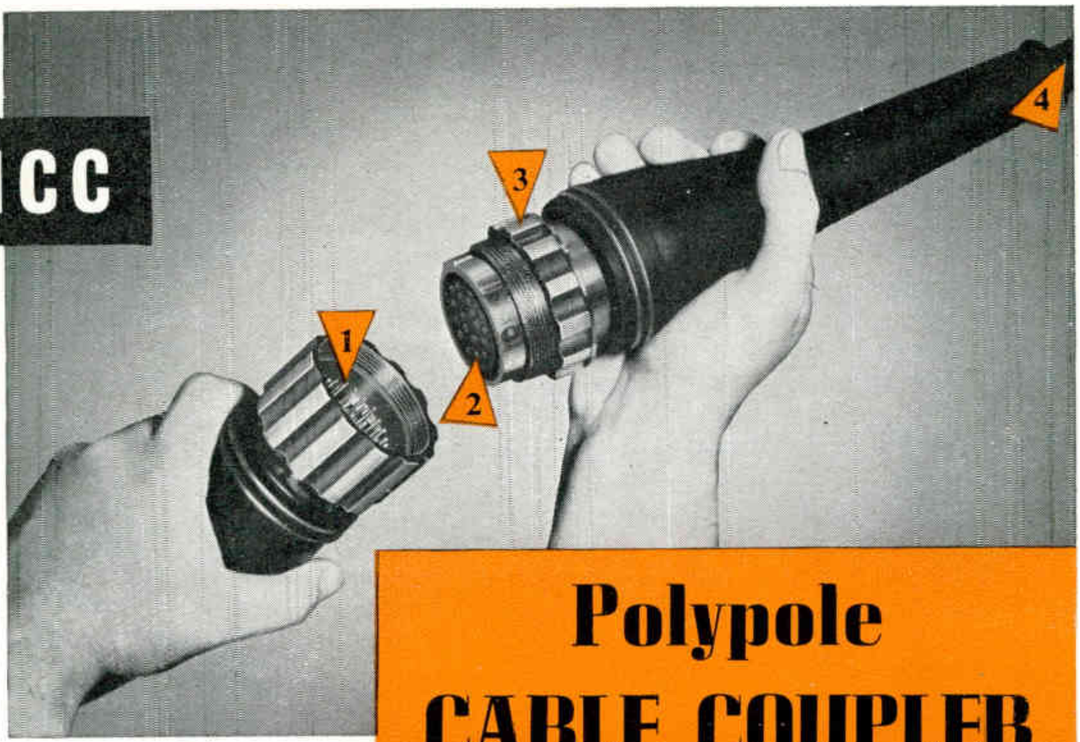


Polypole CABLE COUPLER

For- ***specialised remote control—centimetre radio links—ground radar—outside broadcast television***

BICC Couplers and Cables are intended for the outdoor inter-connection of equipment, such as that mentioned above. Each application calls for composite trailing cables containing both R.F. units and other polythene insulated conductors.

BICC Polypole Mark III Couplers are available in two versions, designed for use with two standard types of BICC outdoor trailing cables. The Mark IIIA cable and coupler incorporates three coaxial circuits, and the Mark IIIB three screened twin circuits. In addition, both cables contain three triplets and 21 other conductors.

The couplers are permanently moulded to the ends of the cable in the factory. This technique provides a remarkably robust coupler which is virtually free from the hazards of conductor breakages near to, or within the coupler.

If you are interested in the uses of BICC Polypole Cable Couplers, we will be pleased to send you further information.

Note these important features

▶ The couplers are assembled with the conductors in tension to ensure that they each contribute their share of the total strength.

▶ Polythene injection moulding permits a watertight assembly.

▶ Screwed lock rings provide forced engagement and withdrawal. The overall metal housing can also be easily replaced should it become damaged.

▶ The cable itself is designed with a symmetrical cross section to provide the greatest reliability under severe handling.

BRITISH INSULATED CALLENDER'S CABLES LIMITED
21, BLOOMSBURY STREET, LONDON, W.C.1.

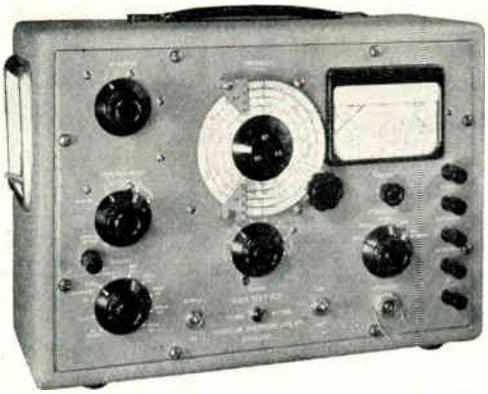
World Radio History

Marconi V.H.F. Test Set Type TF 982

For Mobile Transceivers

For the overall checking of a.m. transmitters and receivers, particularly of the mobile type, the Test Set is primarily a v.h.f./i.f. signal generator with 1,000 c/s modulation facilities; it may also be used as an a.f. and r.f. power meter, a variable-level a.f. source, an r.f. local field detector and a five-range a.c./d.c. test meter.

The signal generator section provides four v.h.f. ranges covering from 60 to 200 Mc/s and four i.f. ranges, each having a bandwidth of 250 kc/s, centred at 1.6, 2.1, 4.86 and 5.0 Mc/s respectively. Facilities are provided for crystal standardisation at the centre frequency of each i.f. range. The v.h.f./i.f. output is derived via a step attenuator and terminating unit giving calibrated outputs from 2μV to 2 mV at 52 and 75 ohms; uncalibrated outputs up to a maximum of 400 mV are also available.



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Signal Generators · Bridges · Valve Voltmeters · Q. Meters · Wavemeters
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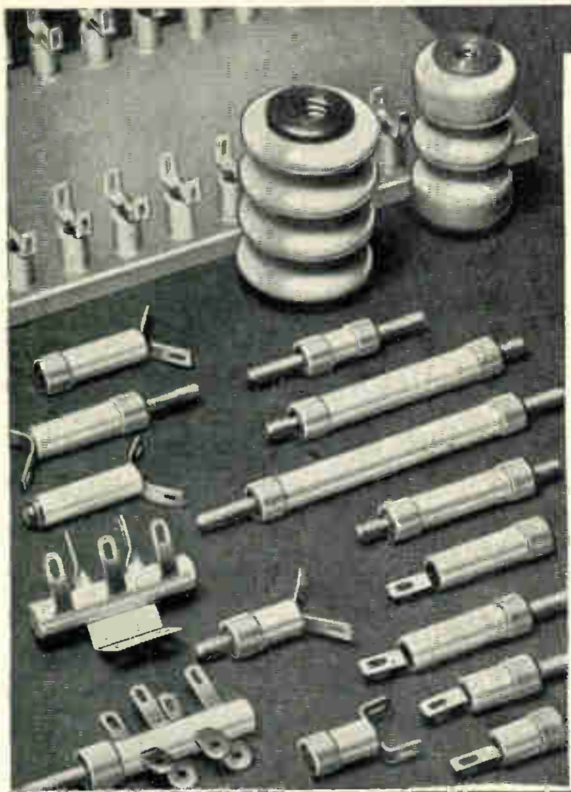

Here's quick, safe anchorage!

U.I.C. "Cactus" and "Porcupine" Tags and the almost limitless variety of Stand-off Insulators will solve all your anchorage problems quickly, easily and efficiently.
These latest aids to neat and economical wiring and component assembly are tough, fireproof, and constructed entirely without solder. Only low-loss ceramics and electro-plated brass are used in the manufacture of these best of all anchorages.

Unique design

Insulation perfection

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Three-Range PROBE MILLIVOLTMETER

Model VM6451

SELF-CONTAINED STABILISED POWER PACK

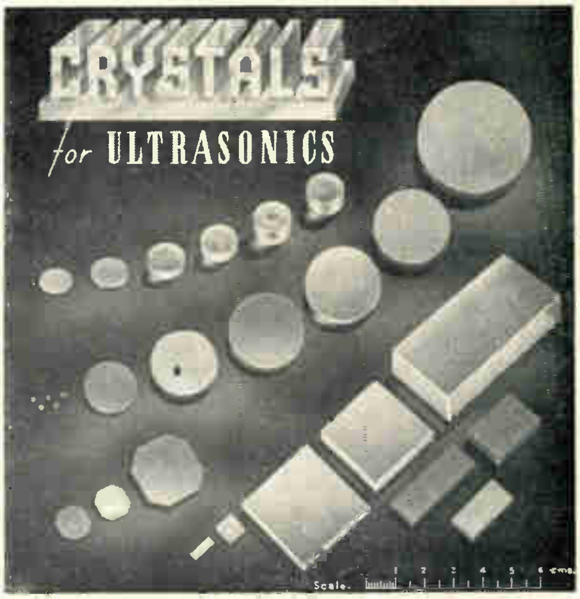
ACCURACY TO ± 5% OF FULL SCALE DEFLECTION

AUTOMATIC OVERLOAD PROTECTION

Designed to provide direct readings for A.C. voltages from 10 millivolts to 2 volts. Three ranges are provided and readings are accurate within 1db from 50 cycles to 150 megacycles. The double triode measuring valve is detachable from the cabinet. This instrument can also be used for modulation carrier detection with the use of headphones. Write for full specification.

BRITISH PHYSICAL LABORATORIES
Radlett HERTS *Tel: RADLETT 5674-5-6*

dmBP15



Quartz Crystals of any shape and size cut and ground precisely to specification and coated, if required, with Gold, Silver, Aluminium or Rhodium, etc.

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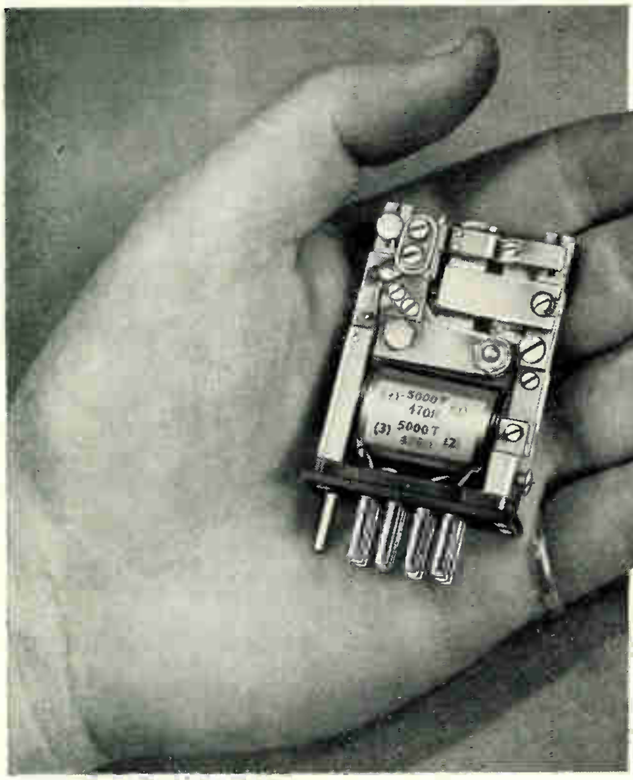
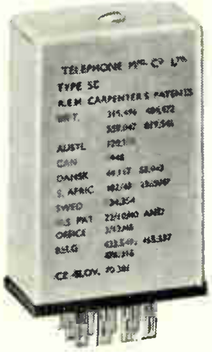


small *and* sensitive

Considering it is only the size of a matchbox the TYPE 5 CARPENTER POLARIZED RELAY is capable of a surprisingly high performance providing answers to problems in many fields of electrical engineering. Outstanding features of the Type 5 include:



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

Plug or solder tag base optional.

Dimensions — (*With cover, excluding connecting pins.*) $2\frac{3}{16}$ *ins. high.* $1\frac{7}{16}$ *ins. wide.* $\frac{3}{4}$ *in. deep.* Weight (*including socket*) 4.8 *oz.* (137 *gm.*). *Complete specification and further details of the complete range of Carpenter Relays may be had on request.*

TMC

CARPENTER POLARIZED RELAY TYPE 5

Manufactured by the Sole Licensees:

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Contractors to Governments of the British Commonwealth and other Nations

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G.E.C.

QUARTZ CRYSTAL UNITS

for Long Term Stability

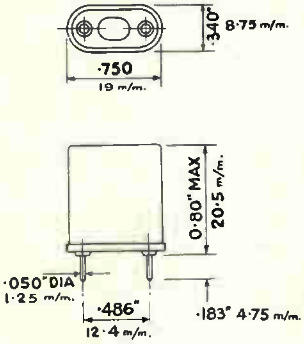
Q.C. 327

Frequency range 6,000 Kc/s to 16,000 Kc/s
Tolerance ± 0.01% or ± 0.005%

Type BA,
frequency change not exceeding 0.01% from 0°C to +70°C

Type DA,
frequency change not exceeding 0.01% from −30°C to +45°C

Type EA,
frequency change not exceeding 0.002% from +65°C to +80°C



Gross weight 3.5 ozs (99 gms)
Nett weight 0.15 oz (4.25 gms)

This style holder corresponds to Inter Services style D and the U.S. style H.C./6 U.

For further details please apply to:-

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World Radio History

WIRELESS ENGINEER

The Journal of Radio Research and Progress
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transistors for circuit experiments

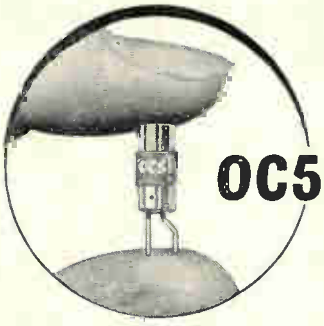
OC50

a choice of two point-contact types

In the OC50 and OC51 point-contact transistors Mullard have varied point spacing to produce two transistors of markedly different characteristics. This choice of point-contact transistors now offered by Mullard will greatly assist electronic engineers to adapt to their own needs the circuits described in existing literature, and also to create new circuits of their own design.

Although, at the present state of development, some transistor parameters tend to be temperature-dependent and to vary between transistors of the same type, these effects can be largely overcome by suitable circuit design. Circuit engineers will find that they are able to achieve good results when they take the unfamiliar characteristics of the transistors fully into account. The Mullard circuit research and development organisation is actively exploring transistor circuit techniques, and designers interested in the OC50 and OC51 are invited to avail themselves of the assistance of the Industrial Technical Service Department at the address below.

- *The OC50 and OC51 are readily available for experimental purposes at a price comparable with that of subminiature valves.*



OC51

Point-contact transistor type No.		OC50	OC51
Max. negative collector-to-base voltage	(V)	30	50
Max. collector current	(mA)	–12	–15
Max. dissipation	(mW)	120	100
Max. emitter current	(mA)	10	12
Max. ambient temperature	(°C)	40	55
Max. frequency (for α 3db down)	(Mc/s)	1.0	1.5
"Full-on" voltage across transistor		★	
Collector "cut-off" current			★

★ Superior type for this characteristic

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Constant-H.T.-Current Amplifier

When an amplifier is required to have a response extending down to zero frequency, difficulty often arises because of the internal impedance of the h.t. supply. In some cases this impedance must be made negligibly small through the use of a suitably stabilized supply, but a well-known alternative is to design each stage of the amplifier so that it draws only a constant current from the h.t. supply. The usual way of doing this is by using push-pull stages.

It is not always realized that there is an alternative to push-pull. Two valves, whose changes of current are equal and opposite are still needed, but they are in cascade, not in push-pull. The circuit is shown in Fig. 1 in its simplest form and comprises merely a triode amplifier directly-coupled to a cathode follower. An increase of current i_{a1} in V_1 increases the voltage drop across R_1 and so changes the grid potential v_2 of V_2 negatively. This reduces the current i_{a2} in V_2 and the output voltage v_0 across R_2 changes negatively. If the fall of current in V_2 equals the rise of current in V_1, the total current drawn by the two valves is unaltered, and any impedance in the h.t. supply has no effect.

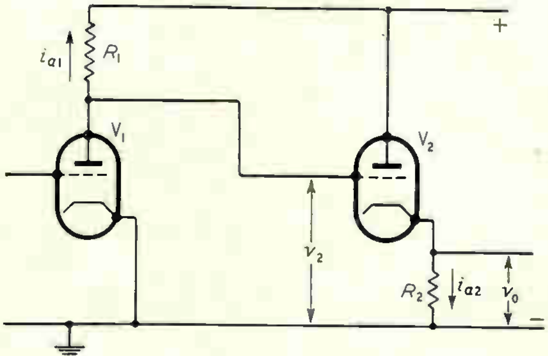

Fig. 1.

If the cathode follower were perfect so that the change of output voltage equalled the change of grid voltage, the only requirement for the constancy of total anode current would be the very simple one of making R_1 and R_2 equal. Equal changes of voltage across equal resistances require equal changes of current in them. In practice, the cathode follower is not perfect and, as is well known, it has the 'amplification'

$$A_2 = \frac{A}{1 + A} \quad \text{where } A = \frac{g_{m2} r_{a2} R_2}{r_{a2} + R_2},$$

the basic amplification without the cathode feedback.

The anode current of V_2 is $i_{a2} = v_0/R_2$ and the grid voltage is $v_2 = v_0/A_2 = i_{a2}R_2/A_2$. The anode current of V_1 is $i_{a1} = v_2/R_1$, hence

$$i_{a1} = i_{a2}\frac{R_2}{A_2 R_1}$$

The anode currents are thus equal, and the supply current is zero, when

$$R_1 = R_2(1 + 1/A)$$

In the circuit of Fig. 1, the attainment of the proper operating conditions for V_2 demands that the anode voltage of V_1 be less than the cathode voltage of V_2. These proper conditions are easily found if the two valves are alike and if the mutual conductance is high enough for the amplification A_2 of V_2 to be negligibly different from unity.

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Then R_1 and R_2 are equal, both valves require the same grid–cathode bias and they each pass the same standing anode current. For the grid of V_2 to be negative to its cathode, the voltage drops across R_1 and R_2 (or, since the drops across R_1 and R_2 are equal, twice the voltage drop across R_1) must equal the h.t. supply voltage plus the required bias.

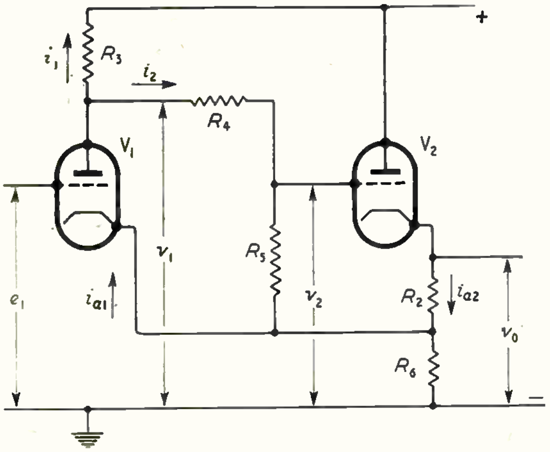

Fig. 2.

To a first approximation the grid bias is independent of the load and is about one-third of the way between the limiting values set by grid current on the one hand and anode-current cut-off on the other. From the valve curves, and the known h.t. supply voltage, therefore, we can choose a grid-voltage curve upon which the operating point must lie; twice the voltage drop across R_1 must equal the supply voltage plus the bias voltage, so we can calculate the voltage drop across R_1. The anode–cathode voltage is the h.t. supply voltage less this voltage drop and so we find the operating point. The load line can be drawn in and R_1 and R_2 evaluated.

The resulting values for R_1 and R_2 are sometimes too high for other requirements, such as high-frequency response, and the modified circuit of Fig. 2 permits more latitude in the choice of operating conditions. In this circuit, the anode current of V_1 divides between R_3 and $R_4 + R_5$ and it is only the part in R_3 which flows in the h.t. supply. If $n = R_5/(R_4 + R_5)$, we have

$$v_2 = nv_1 = ni_1R_3 = i_{a2}R_2/A_2$$

and for equality of i_1 and i_{a2}

$$R_3 = \frac{R_2}{n}\left(1 + \frac{1}{A}\right)$$

So far, R_6 has not been considered. This is a bias resistor for V_1. With the connection of R_5 to the cathode of V_1, only the supply current flows in R_6 and its presence there has no effect on the signal conditions.

It appears at first as if the presence of the potential divider R_4, R_5 would reduce the amplification. This is not necessarily the case, however. If the voltages and currents of V_2 are kept constant, i_1 must be constant whatever the value of n. But $v_2/i_1 = R_3n$ and is a constant. Now the amplification of V_1 is

$$A_1 = \frac{v_1}{e_1} = \frac{\mu_1 n \dfrac{R_3(R_4 + R_5)}{R_3 + R_4 + R_5}}{r_{a1} + \dfrac{R_3(R_4 + R_5)}{R_3 + R_4 + R_5}}$$

substituting for R_3 and re-arranging, we get

$$A_1 = \frac{g_{m1}v_2/i_1}{1 + \dfrac{v_2/i_1}{n}\left(\dfrac{1}{r_{a1}} + \dfrac{1}{R_4 + R_5}\right)}$$

If $r_{a1} \rightarrow \infty$, as with a pentode, $A_1 \rightarrow g_{m1}\, v_2/i_1$ and is independent of n. If $r_{a1} \rightarrow 0$, $A_1 \rightarrow \mu_1 n$. The normal triode condition is intermediate between these extremes, and the use of the potential divider does result in some decrease of amplification.

As shown, the circuit is best suited to low-frequency operation where triodes are suitable. If the stage is also to work at higher frequencies, complications ensue because of valve and other stray capacitances. A pentode becomes necessary for V_1 to avoid Miller effect and a compensated coupling is needed between the valves so that the circuit takes the form shown in Fig. 3.

For the purposes of calculation we can let $R_{3a} + R_{3b} = R_3$ of Fig. 2 and ignore C_1 and C_2, if we make $R_{3a}/R_{3b} = R_5/R_4$ and $C_1R_4 = C_2R_{3b}$, the usual relation for this form of compensated

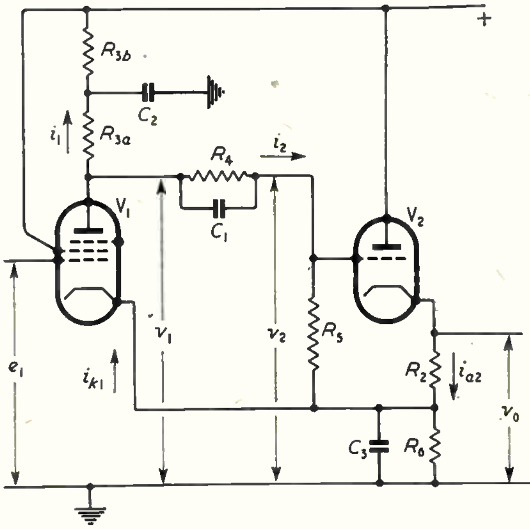

Fig. 3.

coupling. The load on V_1 falls with increasing frequency but the effective potential-divider ratio changes equally and for a given current from V_1 the grid voltage of V_2 is constant at all frequencies.

A discrepancy arises because of the screen current of V_1. To correct for this R_3 must be increased in the ratio i_{k1}/i_{a1}. If a screen dropping resistor is used for V_1 the matter becomes still more complicated. It must not be by-passed and feedback occurs because of it. Because of valve capacitance the feedback will change and Miller effect may occur at high frequencies. It is, therefore, desirable to feed the screen from a constant-voltage point as shown in Fig. 3.

While the proper conditions for balance are easily determined, as has been shown, it is a nice problem in design to choose values for the resistors which adhere to the balance relations and, at the same time, give the proper operating conditions for the valves.

It is to be noted as a great merit of the circuit that, because of the heavy negative feedback in V_2, this stage is very nearly linear, hence the anode-current waveforms of the two valves must be very nearly alike. Distortion in V_1 does not affect the matter and the characteristics of V_1 do not affect the balance. Because of the feedback, large changes in the characteristics of V_2 have only a small effect on the balance and, in practice, it is resistor values only which have a large effect. For good and well-maintained balance, close-tolerance and stable resistors must be used.

When V_1 is a pentode, a change of valve may affect the balance somewhat, since the ratio of anode to screen currents may not be exactly the same for all specimens. W. T. C.

TRANSMISSION-LINE MATCHING SYSTEM

Properties of Two Quarter-Wave Transformers

By **R. E. Collin**, B.Sc., and **J. Brown**, M.A., A.M.I.E.E.

(Department of Electrical Engineering, Imperial College of Science and Technology, London)

SUMMARY.—The two-section quarter-wave transformer is analysed in detail. It is shown that by tolerating a certain mismatch at the centre of the band it is possible to obtain a perfect match at two frequencies located symmetrically about the centre frequency. This arrangement gives an increase of 20–45% in bandwidth over the commonly-used binomial transformer. The binomial transformer is shown to be a special case of the above transformer, obtained when the two frequencies at which a perfect match occurs coincide at the centre frequency. A simple design procedure and performance curves are also given.

Introduction

WHEN a transmission line is to be terminated in a resistive load differing from the characteristic impedance of the line, it is usual to use an intermediate section of transmission line, a quarter of a wavelength long and of characteristic impedance equal to the geometric mean of the load resistance and the characteristic impedance of the main line. For such a single-section quarter-wave transformer a perfect match is obtained at one frequency only and the overall bandwidth is usually small. If a wider bandwidth is required a two-section matching transformer is used. It is usual to arrange the impedances in a binomial progression[1,2], and the two-section transformer is then termed a binomial transformer. Thus $Z_1 = R^{\frac{1}{4}}$, $Z_2 = R^{\frac{3}{4}}$, where Z_2 is the characteristic impedance of the section of transmission line adjacent to the load, R is the load impedance and all impedances are normalized with respect to the characteristic impedance of the main line. It is usually thought that this arrangement provides the maximum bandwidth for the match which can be obtained from two transformer sections. No proof of this has, however, been given and in seeking such a proof it has been found that an alternative arrangement can give a greater bandwidth.

The binomial transformer corresponds to a maximally-flat band-pass filter in filter theory. By tolerating a certain mismatch at the centre frequency it is possible to match a two-section quarter-wave transformer at two frequencies located symmetrically on either side of the centre frequency. This corresponds to the case of an overcoupled circuit and gives a much wider usable bandwidth. It is found that from 20% to 45% increase in bandwidth over the binomial transformer can usually be obtained. In this paper the optimum bandwidth two-section transformer is analysed in detail. The design formulae are given and a comparison with the two-section binomial transformer is made. This technique has

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been applied to the 4-window directional coupler used in waveguide work.[3]

The circuit to be studied is shown in Fig. 1, in which the resistive load R is to be matched to a transmission line whose characteristic impedance is taken for convenience as unity. The matching section consists of the two sections of transmission line 1 and 2, whose lengths are L_1 and L_2 respectively, with characteristic impedances Z_1 and Z_2. The problem being considered is the determination of the four parameters L_1, L_2, Z_1 and Z_2 so that the complete termination is as well matched as possible over the widest possible frequency range. More precisely, the parameters will be calculated to maximize the bandwidth within which the standing-wave ratio does not exceed a specified value, S_0. It is found to be extremely difficult to tackle the problem in its complete generality and one restriction will be imposed; i.e.,

$$\frac{L_1}{V_1} = \frac{L_2}{V_2} = p, \quad \cdots \quad (1)$$

where V_1, V_2 are respectively the phase velocities for lines 1 and 2. The phase velocities and the various impedances will be assumed independent of frequency over the frequency band for which the system is to be matched. In view of Equ. (1) the phase-shift across either line 1 or line 2 will be

$$\theta = 2\pi f p \quad \cdots \quad (2)$$

for any frequency f. The phase angle θ is therefore directly proportional to frequency.

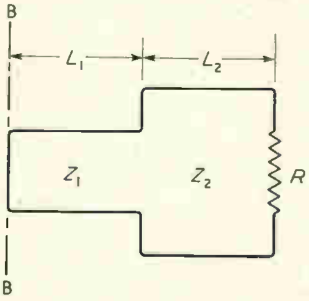

Fig. 1. *Two sections of line of length L_1 and L_2 and normalized impedances Z_1 and Z_2 used to match a normalized load R.*

The input impedance of the structure to the right of B in Fig. 1 can be calculated from ordinary transmission-line theory and is found to be

$$Z_{in} = \frac{Z_1R(Z_2 - Z_1t^2) + jZ_1Z_2(Z_1 + Z_2)t}{Z_2(Z_1 - Z_2t^2) + jR(Z_1 + Z_2)t} \quad \cdots (3)$$

where $t = \tan\theta = \tan 2\pi f p$.

The complex reflection coefficient ρ at the plane B is given by

$$\rho = \frac{Z_{in} - 1}{Z_{in} + 1} \quad \cdots \quad (4)$$

The modulus of the reflection coefficient r, can now be calculated as a function of frequency by substituting in the above equation for Z_{in}. The problem reduces to determining the values of Z_1, Z_2 and p so that the standing-wave ratio, S, is less than S_0 over as wide a range of frequencies as possible. When stated in this form the problem becomes very similar to that of designing a flat-topped band-pass filter and so a similar procedure can be used. Inspection of the expression for Z_{in} shows that it is a symmetrical function of frequency about the frequency $1/4p$ at which $\tan\theta$ becomes infinite. This suggests that $1/4p$ be made equal to f_0, the mid-frequency of the band for which the system is to be matched. Then

$$\theta = 2\pi f p = \pi f/2f_0 \quad \cdots \quad (5)$$

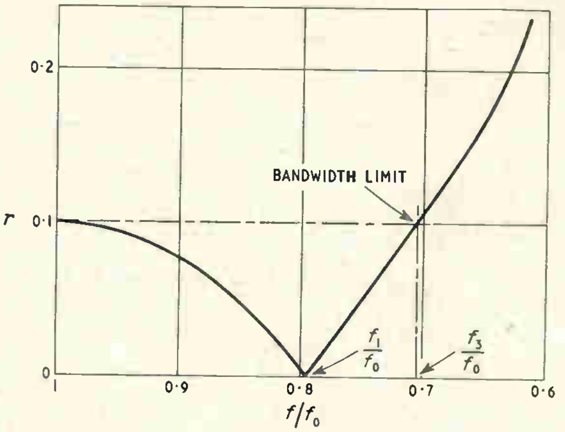

Fig. 2. *Form of reflection-coefficient curve; this curve is drawn for $R = 5$, $r_0 = 0{\cdot}1$.*

It is possible to select Z_1 and Z_2 so that ρ becomes zero for the midband frequency f_0, the necessary condition being $Z_1^2R = Z_2^2$. For a maximum bandwidth this gives the binomial transformer, as will be shown later. A wider band can be achieved by making r zero at some frequency f_1 less than f_0. From the symmetry of the expression for r with respect to frequency it follows that r will also be zero at a frequency f_2 equal to $2f_0 - f_1$.

Let θ_1 be the value of θ corresponding to f_1 so that $\theta_1 = \pi f_1/2f_0$. The condition that r equals zero is that Z_{in} must be unity so that from Equ. (3)

$$Z_1R(Z_2 - Z_1t_1^2) = Z_2(Z_1 - Z_2t_1^2)$$

and

$$Z_1Z_2(Z_1 + Z_2)t = R(Z_1 + Z_2)t$$

where $t_1 = \tan\theta_1$.

The above equations give

$$Z_1Z_2 = R \quad \cdots \quad (6)$$

$$t_1^2 = \frac{Z_1Z_2(R-1)}{Z_1^2R - Z_2^2} = \frac{R(R-1)}{Z_1^2R - R^2/Z_1^2}$$

$$= \frac{Z_1^2(R-1)}{Z_1^4 - R}. \quad \cdots \quad (7)$$

This provides a unique relation between Z_1 and

Z_2 so that if Z_1 is found, Z_2 follows immediately. The next step is to select a suitable value of the frequency f_1, for which the reflection coefficient is made zero. An examination of the frequency dependence of the reflection coefficient shows that it is always of the form shown in Fig. 2, there being a maximum value of r at the midband frequency f_0. As the frequency approaches f_0, t tends to infinity and so from Equ. (3) Z_{in} becomes the pure resistance Z_1^2R/Z_2^2; i.e., Z_1^4/R at the frequency f_0. The reflection coefficient is therefore

$$r' = \frac{Z_1^4 - R}{Z_1^4 + R} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

It is convenient to restrict the analysis at this point to the case when R exceeds unity, so that $Z_1^4 - R$ is positive, as may be seen from Equ. (7) since t_1^2 must be positive. The modification required when R is less than unity can easily be made to the remainder of the analysis. When R exceeds unity, r' in Equ. (8) is a positive real quantity and equals the modulus of the reflection coefficient, r'. It appears reasonable from Fig. 2 to suppose that the greatest bandwidth will be obtained if the reflection coefficient at f_0 is made equal to the maximum tolerable reflection coefficient r_0. This result can be justified analytically. The required value of Z_1 is now obtained by letting r' equal r_0 when from Equ. (8)

$$Z_1^4 = R\,\frac{1 + r_0}{1 - r_0} = RS_0 \quad \ldots \quad \ldots \quad (9)$$

where S_0 is the corresponding voltage standing-wave ratio (taken greater than unity).

Also from (6)

$$Z_2 = \frac{R}{Z_1} = \frac{R^{3/4}}{S_0^{1/4}} \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

Substitution for Z_1 and Z_2 in Equ. (3) gives

$$Z_{in} = \frac{R^{5/4}S_0^{1/4}(R^{3/4}/S_0^{1/4} - R^{1/4}S_0^{1/4}t^2) + jR(R^{1/4}S_0^{1/4} + R^{3/4}/S_0^{1/4})t}{R^{3/4}/S_0^{1/4}(R^{1/4}S_0^{1/4} - R^{3/4}/S_0^{1/4}t^2) + jR(R^{1/4}S_0^{1/4} + R^{3/4}/S_0^{1/4})t}$$

$$= \frac{R^{3/2}S_0^{1/2}(R^{1/2} - S_0^{1/2}t^2) + jR^{5/4}S_0^{1/4}(S_0^{1/2} + R^{1/2})t}{R(S_0^{1/2} - R^{1/2}t^2) + jR^{5/4}S_0^{1/4}(S_0^{1/2} + R^{1/2})t}.$$

Hence $$\rho = \frac{R(R-1)\sqrt{S_0} - R^{3/2}(S_0 - 1)t^2}{R(R+1)\sqrt{S_0} - R^{3/2}(S_0 + 1)t^2 + 2jtR^{5/4}S_0^{1/4}(\sqrt{S_0} + \sqrt{R})},$$

and $$r^2 = |\rho|^2 = \frac{[(R-1)\sqrt{S_0} - \sqrt{R}(S_0 - 1)t^2]^2}{[(R+1)\sqrt{S_0} - \sqrt{R}(S_0 + 1)t^2]^2 + 4\sqrt{S_0}(\sqrt{S_0} + \sqrt{R})^2\sqrt{R}t^2}. \quad \ldots \quad \ldots \quad (11)$$

The bandwidth of the matched system is obtained from the frequency f_3 for which r again equals r_0 (see Fig. 2). If the corresponding value of t is t_3, then from (11)

$$\begin{aligned}(S_0 - 1)^2[(R+1)\sqrt{S_0} - \sqrt{R}(S_0+1)t_3^2]^2 \\ + 4\sqrt{S_0}\sqrt{R}(S_0 - 1)^2(\sqrt{S_0} + \sqrt{R})^2t_3^2 \\ = (S_0 + 1)^2[(R-1)\sqrt{S_0} - \sqrt{R}(S_0 - 1)t_3^2]^2\end{aligned}$$

since

$$r_0 = \frac{S_0 - 1}{S_0 + 1}.$$

This equation simplifies to a linear equation in t_3^2 whose solution is

$$2t_3^2 = \frac{R-1}{\sqrt{R}}\,\frac{\sqrt{S_0}}{S_0 - 1} - 1, \quad \ldots \quad \ldots \quad (12)$$

The frequency f_3 which defines the lower limit of the frequency band within which $r \leqslant r_0$ is given by $2f_0/\pi \tan^{-1}t_3$. There is a very simple relation between t_3 and t_1, the value of $\tan\theta$ corresponding to the frequency f_1 at which r becomes zero. From Equs. (7) and (9)

$$t_1^2 = \frac{R-1}{\sqrt{R}}\,\frac{\sqrt{S_0}}{(S_0 - 1)}, \quad \ldots \quad \ldots \quad (13)$$

and hence from Equ. (12) it follows that

$$t_3^2 = \tfrac{1}{2}(t_1^2 - 1). \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

The Binomial Transformer

A two-section binomial transformer may be designed in one of two ways.[2] Only one need be considered and its properties are most easily obtained as a special case of the previous analysis. Suppose the two frequencies at which the reflection is zero are made to become closer together, eventually coinciding at the design frequency f_0. It follows at once from equation (7) that

$$Z_1 = R^{1/4},\ Z_2 = R^{3/4}.$$

The reflection coefficient has a double zero at the design frequency and so its first derivative with respect to frequency will also be zero. The binomial transformer so obtained has therefore a similar behaviour to a maximally-flat band-pass filter. The bandwidth of this arrangement is obtained, as before, by finding the frequency for which the reflection coefficient equals r_0.

For the binomial transformer

$Z_1 = R^{1/4}$, $Z_2 = R^{3/4}$ and therefore

$$Z_{in} = \frac{R\,(R - \sqrt{R}t^2) + jR\,(R^{1/4} + R^{3/4})t}{R - R^{3/2}t^2 + jR\,(R^{1/4} + R^{3/4})\,t}.$$

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with $$\rho = \frac{Z_{in} - 1}{Z_{in} + 1} = \frac{R(R-1)}{R^2 + R - 2R^{3/2}t^2 + 2jR^{5/4}(1+\sqrt{R})t}.$$

The corresponding value of r^2 is given by

$$r^2 = |\rho|^2 = \frac{(R-1)^2}{(1 - 2\sqrt{R}t^2 + R)^2 + 4\sqrt{R}(1+\sqrt{R})^2 t^2}$$
$$= \frac{(R-1)^2}{(1+R)^2 - 4\sqrt{R}t^2(1 + R - 1 - 2\sqrt{R} - R) + 4Rt^2}.$$

When $r = r_0$ let $t = t_B$, where t_B defines the bandwidth limit of the binomial transformer, and it follows that

$$4R(t_B^2 + 1) + (R-1)^2 = \frac{(R-1)^2}{r_0^2}$$

and therefore

$$t_B^2 = t_1^2 - 1 \quad \ldots \quad (15)$$

From the above equation it is seen that there is a unique relation between the bandwidth of the binomial transformer and that based on the alternative design given above. The improvement resulting from the use of this design is illustrated in Fig. 3, in which the ratio of optimum bandwidth to that of the binomial bandwidth is plotted against binomial bandwidth. It is seen that a maximum improvement of about 45% is possible. In practice an increase of 30% or more is usually obtained. In this paper the bandwidth is expressed as a fraction of the centre frequency f_0, so that for the above designed transformer the bandwidth is taken as $2\frac{f_0 - f_3}{f_0}$.

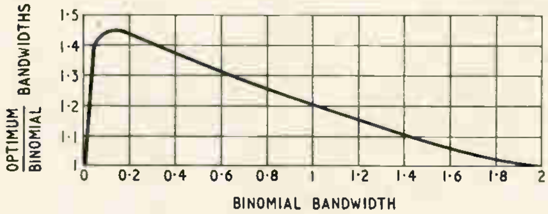


Fig. 3 (above). *This curve shows the ratio of the bandwidths obtainable with the two forms of matching transformer.*

Fig. 4 (right). *Optimum fractional bandwidth as a function of R for various standing-wave ratios S_0.*

Design Procedure

Case 1: Maximum Value of Tolerable Voltage Standing-Wave Ratio given

When S_0, the maximum tolerable voltage standing-wave ratio is given then Z_1 is determined by Equ. (9) as $Z_1 = (RS_0)^{1/4}$.

The corresponding value of Z_2 is found from the relation $Z_2 = R/Z_1 = R^{3/4}/S_0^{1/4}$.

The bandwidth is determined from Equs. (13) and (14) which, when combined, give

$$t_3^2 = \tfrac{1}{2}\left[\frac{R-1}{\sqrt{R}}\frac{\sqrt{S_0}}{S_0 - 1} - 1\right]$$

$$\text{Fractional bandwidth} = 2\frac{f_0 - f_3}{f_0}$$

where $f_3 = \frac{2f_0}{\pi}\tan^{-1} t_3$.

Case 2: Required Bandwidth given

If the required bandwidth is given then f_3 is fixed and this in turn fixes t_3 and t_1.

Thus $t_3 = \tan\frac{\pi f_3}{2f_0}$ and from Equ. (14)

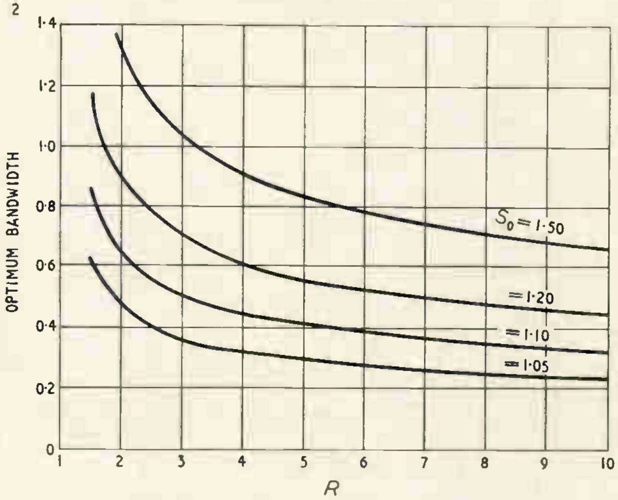
$$t_1^2 = 2t_3^2 + 1.$$

This value of t_1^2 can be used in equation (13) to obtain the value of S_0, thus

$$\frac{S_0}{(S_0 - 1)^2} = \frac{R}{(R-1)^2}t_1^4 = a,$$

and hence

$$S_0 = \left(1 + \frac{1}{2a}\right) + \sqrt{\left(\frac{2a+1}{2a}\right)^2 - 1}$$



Since S_0 must exceed unity, only the positive sign is applicable.

Alternatively Z_1 may be obtained from Equ. (7) as

$$Z_1 = \left[\sqrt{\left(\frac{R-1}{2t_1^2}\right)^2 + R} - \frac{R-1}{2t_1^2}\right]^{1/2}.$$

The corresponding value of Z_2 is R/Z_1.

The above analysis is for the case when R exceeds unity. When R is less than unity the only alteration required in the above design formulae is to replace R by $1/R$. Z_1 by $1/Z_1$ and Z_2 by $1/Z_2$.

In Fig. 4 is plotted a family of curves giving the optimum fractional bandwidth as a function of R for four values of S_0. The performance for any particular case can be obtained from these curves.

Conclusion

It has been shown that the binomial transformer does not give the maximum usable bandwidth. A simple design procedure has been worked out whereby a two-section transformer can readily be designed if the maximum tolerable voltage standing-wave ratio or required bandwidth is given. Although the lengths of the transformer sections were chosen as a quarter-wave long at the frequency f_0, it does not seem logical to expect any significant improvement in bandwidth by staggering the lengths since it is only possible to make ρ zero at two frequencies. There are four adjustable parameters and each zero requires two, one to adjust the modulus of Z_{in} to unity and one to bring the phase angle of Z_{in} to zero.

The design procedure which has been illustrated in this paper may obviously be extended to a matching network using n quarter-wave transformers. The reflection coefficient can then be made zero at n different frequencies.

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EXPERIMENTAL INVESTIGATION OF GRID NOISE

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SUMMARY.—Results are given of a detailed investigation of triode noise factor, with particular reference to correlation of induced grid noise with shot noise. It is deduced that correlation is very slight and that, although the optimum value of noise factor can be calculated fairly accurately from the values of shot noise and optimum source resistance, the latter must be found by experiment and therefore the theory is not of major practical importance.

1. Introduction

THE first published papers[1,2] on this subject appeared almost simultaneously, and since then there have been few papers published which give satisfactory experimental evidence of the validity of the theories. The possibilities of phase-correlation effects were first brought to the notice of one of us (N. Houlding) in 1944 by an unpublished paper by Peterson, who later published a different paper[3] on his theories of methods of compensating noise fluctuations by transit-time effects. Preliminary experiments in 1944 on detuning the input stage of a common-grid circuit were disappointing, but experiments with common-cathode triode circuits showed that the first result was due to a fortuitous optimization of the input stage with the practical method of adjustment adopted.[4] A series of experiments was made in 1946-7 with the object of gaining useful practical data, and possibly throwing further light on the subject.

Since that date, other papers on transit-time noise effects and the correlation with shot noise have appeared.[5,6,7] An excellent paper with a clear physical explanation is that by W. A. Harris,[8] which will probably become as widely referred to as the series by Thompson, North and Harris,[9] although his tables of comparative performance with different valves are not backed by experiment.

The outstanding difficulty in an exact analysis is the calculation of the effect for the whole range of different velocity classes of electrons. A critical discussion of the problem is given in a paper by Campbell, Francis and James,[10] who point out that the existing formula for induced grid noise is dependent on valve theory which does not take transit-time effects into account. In fact, the phenomena of space-charge limitation and space-charge smoothing only occur because of the different velocities of emission, and it is remarkable that so much progress has been made with theories which neglect the velocity distribution.

The results of our experiments were in disagreement with the simplified theory, in particular in respect of correlation effects, and since papers by

MS accepted by the Editor, March 1953

Bell[7] and A. I. Harris[11] have appeared, we decided to publish our evidence.

In what follows, it is perhaps necessary to apologize to some readers for the treatment in which all noise sources are referred to the grid, sometimes with 'transformation' from other terminals which is based on physical argument rather than rigorous algebra. This is a convention which has become common in analysis of noise, and will be familiar to most, and easier to follow than a rigorous network analysis with cumbersome expressions.

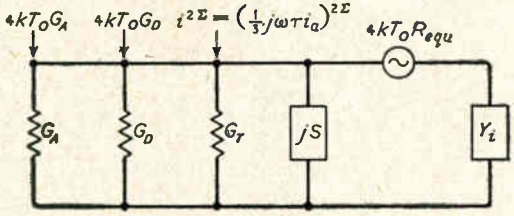

Fig. 1. *Equivalent noise circuit of triode;* Y_i *= input admittance due to feedback. Arrows indicate current generators.*

2. Noise Factor with Fully Correlated Induced Grid Noise

From the theory[1] that induced grid noise is given by $\delta i_g = \frac{1}{3} j\omega\tau\delta i_a$, where τ is the cathode–grid transit time and δi_g and δi_a are grid and anode current fluctuations, the following expression for noise factor of a triode can be derived. (Fig. 1.)

$$n = 1 + \frac{G_D}{G_A} + \frac{(G_A + G_D + G_T)^2}{G_A} R_{equ} + \frac{(S + \frac{1}{3}\,\omega\tau\, g_m)^2}{G_A} R_{equ} \quad \ldots \quad (1)$$

where n = single frequency noise factor at mid-band
S = net susceptance between grid and cathode excluding that due to feedback
G_D = input circuit loss conductance at grid
G_A = source conductance at grid
G_T = transit-time input conductance
g_m = mutual conductance (negative)
R_{equ} = shot noise equivalent resistance (See Ref. 4 for terminology)

Hence, when $S = +\left|\frac{1}{3}\,\omega\tau\, g_m\right|$, the noise factor should be given by:—

$$n = 1 + \frac{G_D}{G_A} + \frac{(G_A + G_D + G_T)^2}{G_A} R_{equ} \quad (2)$$

and, the noise factor will have an optimum value given by:—

$$n_{opt} = 1 + 2R_{equ}(G_D + G_T) + 2G_0R_{equ} \quad \ldots \quad (3)$$

with

$$G_A{}^2 = G_0{}^2 = \frac{G_D}{R_{equ}} + (G_D + G_T)^2 \text{ or } G_0 \approx \sqrt{\frac{G_D}{R_{equ}}}$$

The theoretical detuning required is, on some arguments, equal to the capacitance change due to space-charge (though this is critically discussed by A. I. Harris[11]). Hence the net result would be that the space-charge capacitance effect on noise factor is exactly similar to any other susceptance effects due to feedback. In other words, correct tuning of the input is obtained provided $g_m = 0$. The analogy between transit-time effects on noise and input admittance, and external feedback effects on noise and input admittance, particularly cathode-lead effects, is very appealing in its simplicity.

3. Outline of the Experiments

All our preliminary experiments were made with hope of finding full correlation of induced grid noise because of the extreme importance of such a result, if it could be applied to amplifiers at, say, 1,000 Mc/s. This is important to state, because the subtleties of bias in experimental work are often more than many of us like to confess.

When it was found that detuning the input circuit did not give the full improvement in noise factor predicted by simple theory, the emphasis was changed to try and establish reliable experimental data from which noise factor could be calculated. The theoretical expression[1,2] for induced grid noise in terms of transit time conductance G_T, namely*

$$i_g{}^{2\Sigma} = \frac{80}{9}\left(1 - \frac{\pi}{4}\right) 4kT_cG_T$$

(where T_c = cathode temperature)

is of little practical use, because G_T is seldom known with any accuracy, and the separation of G_T from the effects of cathode-lead inductance is too difficult. Above all, the correlation with shot noise is not disclosed.

A direct measurement of $i_g{}^{2\Sigma}$ is also fraught with experimental error due to the effects of lead inductances, and although it should be possible to make an accurate measurement of the noise temperature of the total input conductance, this would still be referring back the problem to a separation of the component parts of the input conductance even though the noise temperature of the conductance due to the cathode lead could be calculated.

It was decided, therefore, to measure the noise factor of a triode as a function of frequency and input circuit conditions. Unfortunately, no way out of the dilemma caused by valve lead inductances was found, and it is believed that they play a part in the transformation of the external admittances. It was argued that errors due to the transformation in source admittance would be less than the errors working the reverse way (i.e.,

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* $i_g{}^{2\Sigma}$ is the mean-square grid current.

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measuring $i_g^{2\Sigma}$, etc.), since theoretically the grid-cathode source admittance *excluding effects of feedback* (i.e., effects of anode current in the cathode lead), is the admittance determining the noise factor. Taking as typical values, $L = 0{\cdot}01$ μH, $C = 10$ pF, the transformation should give no more than 2% effect on source admittance. The possibility of working with resonant leads was discarded on the grounds of uncertainty. In addition to valve leads, the lead lengths used in wiring and measurement may cause significant error.

A very careful investigation with pentodes was ruled out because of the extreme complexity of the noise problem with partition noise effects and still further complexities due to lead inductances, but even more because there is no application to low-noise amplifiers.

The methods of measurement have been described in detail in a companion paper.[12] The inductance-neutralized triode circuit was used for the main tests with a CV139 common-grid second stage with an unequal Q coupling to a CV138 pentode feeding the main amplifier-detector. The bandwidth, determined by the last stage of the main amplifier was 120 kc/s.

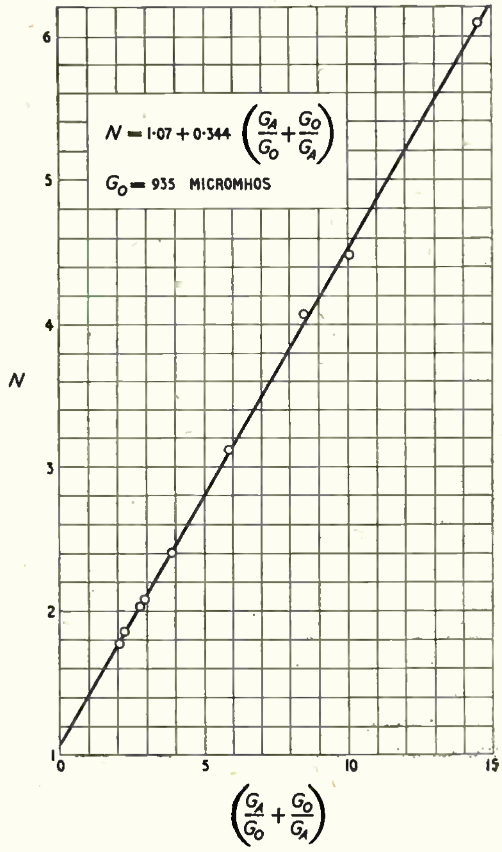

Fig. 2. *CV139 at 12-Mc/s 'tuned' condition.*

The general precautions and corrections outlined in Ref. 12 were made, and in addition a conducting screen was wound round the bulb of the valve and a large negative potential applied to eliminate bulb-charge effects. Input circuit resistances were measured in situ at the grid terminals to offset any change when soldering into the circuit and to minimize errors due to leads used in wiring, and the circuit was operated throughout with the neutralizing coil resonant with the anode-grid capacitance. No particular pains were taken with coil design to achieve high Q coils. The heater voltage was carefully set for all measurements and the results for valve parameters were accurately the same for two separate measurements, within a few weeks, using different observers.

A series of measurements was taken to determine:

(a) Tuned noise factor n_t as a function of source resistance with input circuit resonant including space-charge capacitance.

(b) Detuned noise factor n_d as a function of input circuit susceptance for different values of source conductance.

All the above measurements were made at frequencies of 12, 30, 45 and 60 Mc/s.

The CV139 was chosen for the main investigation because it was known to exhibit larger transit-time effects than the 6AK5, 6J4 or VX3052 (experimental version of the CV408—Osram A1714).

4. Experimental Results

4.1. *Main Programme*

(a) From the measurements in (a) above, it is possible to draw curves of the form

$$n_t = A + BG_A + DG_A^{-1} \quad .. \quad (4)$$

where G_A is the source conductance and A, B and D are constants for any particular valve at one frequency.

If the points are plotted with n_t on linear scale and G_A on logarithmic scale, a symmetrical curve is obtained. The determination of the axis of symmetry, G_0, was improved in accuracy by a check of the equation

$$n_t = A + \sqrt{BD}\left(\frac{G_A}{G_o} + \frac{G_o}{G_A}\right) \quad .. \quad (5)$$

for if G_0 is chosen accurately a plot of n_t against $\left(\frac{G_A}{G_o} + \frac{G_o}{G_A}\right)$ gives a straight line.

(b) From the measurements in (b) above, we can draw curves of the form

$$n_d = E + F(C - C_o)^2 \quad .. \quad (6)$$

where C is the capacitance change from the tuned condition and C_0 is the change for optimum noise factor. The axis of symmetry was obtained in the simple way, giving more prominence to the points remote from the minimum than those close to. Having determined C_0 a plot of n_d against $(C - C_0)^2$ gives a straight line from which E and F can be found.

These were the graphical methods and Figs. 2, 3 and 4 are examples of the detailed analysis, which was made before calculating the values for R_{equ} from direct measurement to avoid prejudice.

The complete results are given in Tables 1, 2 and 3.

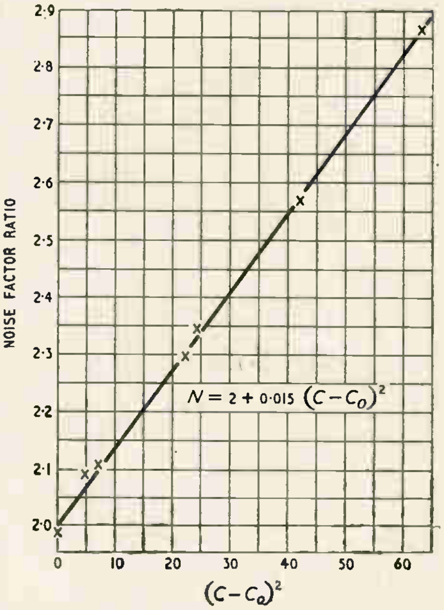

Fig. 3 (above). *CV139 at 45-Mc/s detuning experiment;* $G_A = 2095$ *micromhos.*

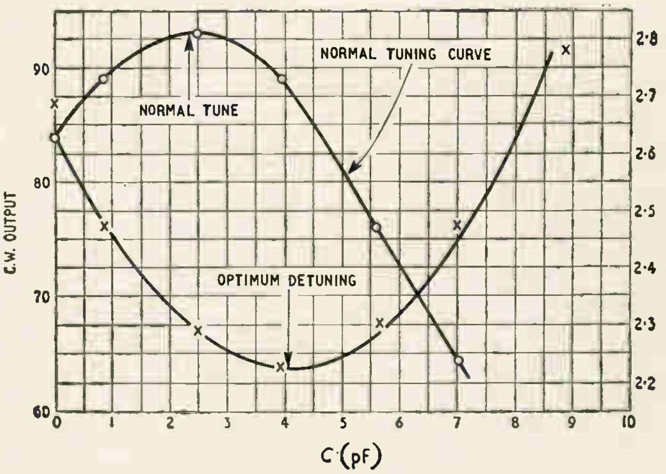

Fig. 4 (right). *CV139 at 60 Mc/s;* $G_A =$ 2390 *micromhos;* $X =$ *experimental points from which full-line curve* $N = 2{\cdot}225 + 0{\cdot}025\ (C - 4{\cdot}05)^2$ *has been deduced.*

4.2. *Supplementary Experiments*

During the writing of this paper some incidental qualitative experiments were made.

(a) Using a direct-reading noise-factor test set[12] at 45 Mc/s, the capacitance detuning required for optimum noise factor has been measured on a large number of valves of various types. The experimental accuracy in determining the detuned conditions is very good with this equipment, and on all valves tested (except one sample* of CV408) the detuning required was significantly less than the space-charge capacitance.

(b) Measurements of the effect of stray wiring leads in transformation of admittance were made at 45 Mc/s. These showed that leads of ¾ in. could cause a 10 or 20% error in the conductance term with the typical values used at 45 Mc/s. In other words, the source conductance at the grid terminal might be in error by such an amount unless measured at that terminal.

(c) The effect of cathode-lead inductance on noise factor was checked at 45 Mc/s on a unit using a 6AK5 with cathode-lead inductance to give an input conductance of 500 micromhos. With a constant source conductance of 500 micromhos, the cathode lead gave about 5% increase in first-stage noise factor and a similar further increase in noise factor due to the second stage.

(d) Using the direct-reading unit, the effect of feedback on noise factor has been investigated with a capacitance-neutralized circuit. It was found that minimum noise factor was obtained when the neutralizing was detuned to compensate the grid-cathode detuning, although the change in noise factor from the value with normal neutralization was very small. With 'tuned' input circuit, the neutralized condition gives minimum noise factor.

When the neutralizing capacitance was detuned in either sense from this position leaving the input circuit tuning unchanged, the noise factor was degraded, perhaps by as much as 1 db before the first stage went into oscillation.

This increase in noise factor due to anode-grid feedback was not due to increase in second-stage noise.

5. Discussion of Results

If we express the induced grid noise as equivalent to a correlated part $\{(a + jb)i_a\}^{2\Sigma}$ where

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*Or, rather one measurement.

TABLE 1

VALVE PARAMETERS

Valve Type	V_A (V)	I_A (mA)	g_m (μA/V)	R_g (kΩ)	R_{equ} (Ω) (at 45 Mc/s)
CV139	250	10	9460	9·7	372
6AK5	110	8	5930	4·8	632
*VX3052	150	10	7250	7·5	544

* This early development sample had thicker grid wires, etc., than the CV408 (A1714).

TABLE 2

'TUNED' NOISE FACTOR ANALYSIS

							Uncorrelated Term		
Valve Type	Freq. (Mc/s)	A	B (Ω)	D	$G_D + G_V$	G_N	$D - (G_D + G_V + G_N + R_{equ}b^2g_m{}^2)$	† $G_T + G_K$ (measured)	G_o
				mhos × 10^{-6}					
CV139	12	1·07	368	322	35	2	250	34	935
CV139	30	1·05	427	482	27	4	310	80	1060
CV139	45	1·05	366	513	— 83 —		270	92	1180
CV139	60	1·06	360	802	110	14	530	445	1490
6AK5	45	1·02	607	135	G_D = 33? (see text)	3		63	470
VX3052	45	1·05	567	401	72	3	305	77	770

†Much of the variation would be due to differences in cathode decoupling. G_K is the conductance due to cathode-lead inductance.

TABLE 3

'DETUNED' NOISE FACTOR ANALYSIS

								Correlated Term
Valve Type	Freq. (Mc/s)	G_A Source Conductance (mhos × 10^{-6})	n_o (E)	C_o (pF)	ΔC (measured) (pF)	$F \times 10^{24}$	$\frac{FG_A}{\omega^2}$ (Ω)	$C_o{}^2FG_A$ (mhos × 10^{-6})
CV139	12	77·5	4·77	3·1	3·1	·027	380	20
	12	410	1·98	3·4		·0064	465	30
CV139	30	320	2·33	2·8	3·3	·048	435	120
	30	539	2·00	$3{\cdot}0_5$		·032	490	161
	30	1310	1·93	3·0		·011	410	130
CV139	45	248	2·5	2·1	2·9	·127	400	149
	45	920	1·81	2·3		·038	440	182
	45	2095	2·00	2·2		·015	390	152
	45	3390	2·38	1·9		·0079	326	111
CV139	60	335	3·2	$1{\cdot}5_5$	3·2	·192	453	154
	60	834	2·31	1·6		·075	440	160
	60	2390	2·22	1·7		·025	422	163
6AK5	45	221	1·54	·7	1·0	·19	530	20·5
	45	897	1·66	·7		·047	530	21
VX3052	45	226	2·18	·8		·163	460	24
	45	330	2·05	·9	1·4	·123	510	31
	45	915	1·83	·9		·044	500	35
	45	1360	2·11	1·1		·023	390	36

ΔC = Measured increase in capacitance due to space-charge.

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$i_a^{2\Sigma}$ is the anode noise current, and an uncorrelated term $t4kT_0G_T$, then we get (Fig. 5)

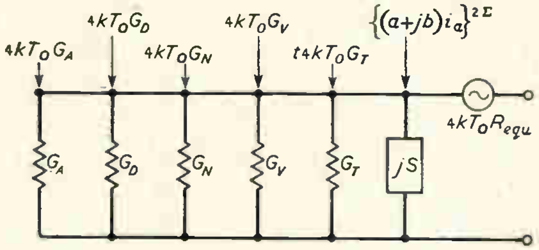

Fig. 5. *Equivalent noise circuit with induced grid noise split into correlated and uncorrelated parts.*

$$n = 1 + \frac{G_D + G_N + G_V + tG_T}{G_A} + \frac{R_{equ}}{G_A}$$
$$\{(G_A + G_D + G_N + G_V + G_T + ag_m)^2 + (S + bg_m)^2\} \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

where G_A = source conductance
G_D = input coil conductance
G_V = valve input losses not due to electronic emission, and assumed at temperature T_0
G_T = induced grid noise equivalent conductance not correlated wth shot noise
t = noise temperature ratio of G_T
G_N = neutralizing-coil conductance
S = input circuit susceptance excluding any susceptance due to feedback
R_{equ} = shot noise equivalent resistance, but including small terms to allow for second-stage noise and noise due to G_N generated between anode and cathode.
g_m = mutual conductance.

On re-arranging the terms and equating with the experimental expressions, we get:—

When $S = 0$ ('Tuned' noise factor)

$$A = 1 + 2R_{equ}(ag_m + G_D + G_N + G_V + G_T)$$
$$B = R_{equ}$$
$$D = G_D + G_N + tG_T + G_V + R_{equ}\{(G_D + G_N + G_V + G_T + ag_m)^2 + b^2g_m^2\}$$
$$\approx G_D + G_N + tG_T + G_V + R_{equ}b^2g_m^2$$

Deduced from the experimental results for $A - 1$

Hence $tG_T = D - (G_D + G_N + G_V + R_{equ}b^2g_m^2)$.

When $S = -bg_m$ ('Detuned' noise factor)

$$C_0 = \frac{-bg_m}{\omega}; \quad F = \frac{R_{equ}\omega^2}{G_A}$$

Therefore $R_{equ} = \dfrac{FG_A}{\omega^2}$; $C_0^2FG_A = R_{equ}b^2g_m^2$

The accuracy of the experimental fit is very good for the majority of the results. The CV139 results at 30 Mc/s were suspected of being faulty due to a noisy second stage, but a check-back on the unit used, after a long lapse of time, showed that this was not the cause of the discrepancy in the value of B at this frequency. In view of the discrepancy in the tuned noise factor results at 30 Mc/s (Table 2), the other results at 30 Mc/s should be ignored. At 60 Mc/s, the value obtained for A seems too small, and is too small with the 6AK5 at 45 Mc/s.

Some of the possible causes of discrepancies are:—

(1) The effect of G_N on R_{equ} will be to give a term which is correlated exactly with the other term due to G_N. This will give very small error.
(2) The effect of the second stage is not exactly equivalent to a constant increase in the shot noise because of the dependence of the first stage output impedance on the source impedance with the coil-neutralized circuit. This could cause no more than about 5 ohms variation in R_{equ}. It would have been better to measure the noise factor of the first stage only.
(3) The supplementary results show that there is a significant change in noise factor with large values of lead inductance. This causes some doubts about errors due to neglect of cathode-lead inductance at the highest frequency.
(4) There is probably some significant error in the measurement of G_A for small values at the higher frequencies.
(5) The coils and valve cold losses are assumed to generate thermal noise equivalent to 290°K. The coils were in fact close to ambient temperature, but the valve losses may be at a much higher temperature.
(6) Due to an oversight, the input losses were not separated, and at 45 Mc/s, although the same input coil was used for the three valves, there was no separate measurement on the 6AK5. A separate measurement was made of the coil, giving 33 micromhos, but this was not in situ and was probably lower than the value when connected in the circuit.

It is doubtful whether a more detailed analysis would be of practical value in view of the experimental limitations. In qualitative terms, the following points have been considered.

(7) The effect of cathode-lead inductance does not give feedback of noise sources between grid and earth, anode and cathode, and grid and cathode, in exactly the same ratio. See Fig. 6.
(8) The correlated part of induced grid noise is strictly equivalent to the transit-time effects of all electrons which induce noise at both grid and anode during their flight, and the

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strict representation should include a generator between grid and anode. However, this grid–anode generator can be replaced by equivalent correlated generators, one between anode and cathode and the other between grid and cathode. The analysis has allowed for this, but not for the input admittance due to the correlated component.

Some features of the results are:—

(a) The large value of uncorrelated noise relative to the correlated term.

(b) C_0 is a function of frequency, and is nearly equal to the space-charge capacitance at low frequencies.

(c) That the correlated, uncorrelated and total induced grid noise components do not obey the theoretical law in relation to frequency ($\propto f^2$).

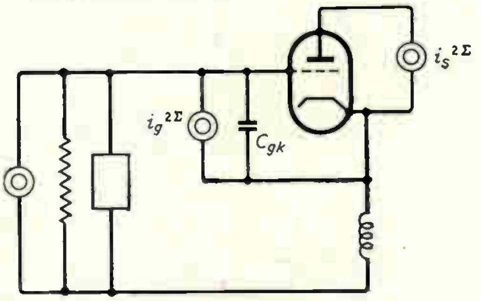

Fig. 6. *Cathode-lead inductance affects the feedback of noise sources differently, according to their positions.*

The results do not show striking agreement with the simple theory of correlation outlined, and for which R. L. Bell[7] has obtained close experimental agreement. The complexity of the theoretical expressions and the experimental work (together with the lack of detailed information about the experimental methods used by Bell) hardly permit much inference from the discrepancies noted.

It appears that the advantages to be obtained by detuning will be very small at frequencies much higher than those investigated, and cathode-lead inductance may well be part of the cause. On the other hand, reduction of frequency does not appear to give such a large reduction of induced grid noise as would be expected. This may be due to other grid–cathode losses. Some confirmation of the limited improvement at lower frequencies is given by other work. Even with valves giving 1·5 db noise factor at 45 Mc/s, a noise factor better than 1·0 db has not been achieved at 10 Mc/s, despite the use of very large low-loss coils.

6. Conclusion

The discrepancy between simple approximate theory and practice (neglecting correlation) noted elsewhere[4] seems to be due to the fact that the approximations made there were more serious than might be thought. Most probably, the value of source conductance giving optimum noise factor was greater than deduced from simple estimates. From the present results the fit with theoretical expressions is very good, having taken precautions to measure G_A accurately, but the constants for induced grid noise do not agree with theory.

There seems little hope of eliminating the effects of induced grid noise with conventional valves except by direct improvement of the valves. An easing of the problem of close spacings may perhaps be obtainable with the space-charge grid valve reported by Peterson[14] and tried by Neher[15] at 3,000 Mc/s. This valve gives a virtual emission of faster electrons, and a high mutual conductance.

A more detailed investigation of noise factor at the lower frequencies seems to be required. Although Wallmann, Macnee and Gasden[16] have reported a noise factor of ¼ db (1·06) at 6 Mc/s with a 6AK5, a more complete understanding of the reasons for the virtues of this valve (if substantiated) might point the way for further progress.

We close with a quotation from North[17] on the subject of transit-time effects on noise:—

"Although there is every need for an understanding of shot fluctuations at ultra-high frequencies, it comes not on the wings of the morning, ..."

7. Acknowledgment

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APPENDIX

Calculation of Noise Factor with Correlation

A. $$n = \frac{\text{Available Power}}{\text{Power available from source}}$$

If in Fig. 5, $G = G_A + G_D + G_N + G_V + G_T$,

Then voltage² due to correlated induced grid noise and shot noise per unit frequency interval

$$= \left[\frac{(a + jb)i_a}{G + jS} + \frac{i_a}{g_m}\right]^{2\Sigma}$$

$$= \left[\frac{\{g_m(a + jb) + (G + jS)\}\, i_a}{g_m(G + jS)}\right]^{2\Sigma}$$

$$= \frac{\{(ag_m + G)^2 + (S + bg_m)^2\}\, i_a^{2\Sigma}}{g_m^2(G^2 + S^2)}$$

Available power due to this term $$= \frac{\{(ag_m + G)^2 + (S + bg_m)^2\}\, i_a^{2\Sigma}}{4g_m^2 G}$$

$$= \frac{\{(ag_m + G)^2 + (S + bg_m)^2\}\, 4kT_o R_{equ}}{4G}$$

But, since available power from $G_A = \dfrac{4kT_oG_A}{G}$, the term due to shot noise in the expression for noise factor is

$$\frac{\{(ag_m + G)^2 + (S + bg_m)^2\}\, R_{equ}}{G_A}$$

The other terms are obtained very easily.

B. The input admittance due to cathode-lead inductance is given by:—

$$Y_K = \frac{\omega^2 L_K C_{gk} g_m + j\omega C_{gk}(1 - \omega^2 L_k C_{gk})}{(1 - \omega^2 L_k C_{gk})^2 + \omega^2 L_k{}^2 g_m{}^2}$$

Inserting approximate values for g_m, C_{gk}, L_k gives values for change of input capacitance of less than 2% at the frequencies used. By calculating the value of L_k required to give an input conductance of 500 micromhos at 45 Mc/s with a 6AK5, it is deduced that the change of input capacitance is about -25% of C_{gk}, or taking $C_{gk} = 3$ pF, about $-0{\cdot}75$ pF. This is closely equal to the capacitance detuning required for optimum noise factor.

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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.

Matching Discontinuities in Waveguides

Sir,—In his paper in the October 1953 issue of *Wireless Engineer* (p. 243), Mr. Parr states "Further, it is usually impossible to reduce the standing-wave ratio of an unmatched component to zero (i.e., to match the component) if imperfect measuring equipment is used."

I would point out that, in the matched condition, the standing-wave ratio is unity, not zero. The latter condition corresponds to perfect reflection.

Prem Swarup.

Dept. of Physics,
University of Allahabad, India.
5th December 1953.

[The author writes to say in reply that he agrees with Mr. Swarup's comment and that he inadvertently wrote 'standing-wave ratio' instead of 'reflection coefficient'.—Ed.]

NEW YEAR HONOURS

In the New Year Honours List, W. G. Radley (Engineer-in-Chief, G.P.O.) received a knighthood and N. C. Robertson (Deputy Managing Director, E. K. Cole; until recently, Director-General of Electronics Production, Ministry of Supply) becomes a Companion of the Order of St. Michael and St. George, while Commander S. S. C. Mitchell, R.N.(Ret.) (Controller of Guided Weapons and Electronics, Ministry of Supply), becomes a Knight-Commander of the British Empire.

G. Darnley Smith (Managing Director, Bush Radio), and G. J. S. Little (Assistant Engineer-in-Chief, G.P.O.) were appointed Commanders of the Order of the British Empire.

T. H. Baines (Deputy Director of Radio Equipment Production, Admiralty), A. S. Mitson (Assistant Director, Electronic Production, Ministry of Supply) and M. J. L. Pulling (Senior Superintendent Engineer, Television, B.B.C.) become Officers of the Order of the British Empire.

O. H. Barron (Engineer, Planning & Installation Department, B.B.C.), W. H. F. Griffiths (Chief Engineer, H. W. Sullivan), H. J. Harbour (Test Controller, E. K. Cole) were appointed Members of the Order of the British Empire.

I.E.E.

The Council of the Institution of Electrical Engineers has made the 32nd award of the Faraday Medal to Isaac Shoenberg "for his distinguished work in electrical engineering, in particular the outstanding contributions which he has made to the development of high-definition television in this country". Mr. Shoenberg joined E.M.I., Ltd., in 1931 as Director of Research and was the leader of the team of scientists which developed the television system adopted by the B.B.C. in 1936. Born in Russia in 1880, he came to this country in 1914 to take up an appointment with Marconi's Wireless Telegraph Company.

NEW APPOINTMENTS

A. H. Mumford, O.B.E., B.Sc.(Eng.), M.I.E.E., has been appointed Deputy Engineer-in-Chief of the G.P.O. Engineering Department in succession to H. Faulkner, C.M.G., B.Sc., M.I.E.E., F.I.R.E., who is retiring from the Post Office after 40 years' service.

Mr. Faulkner has been appointed a Director of the Telecommunication Engineering & Manufacturing Association.

EXHIBITIONS

The 38th Annual Exhibition of the Physical Society will be held at the Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7, from Thursday, 8th April to Tuesday, 13th April. Applications for tickets should be made to the Secretary-Editor, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

The exhibition of components, organized by the Radio & Electronic Component Manufacturers' Federation, will be held at Grosvenor House, Park Lane, London, W.1, from Tuesday 6th April to Thursday 8th April. Applications for tickets should be made to the Federation at 22 Surrey Street, Strand, London, W.C.2.

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NORMALIZED IMPEDANCE AND REFLECTION COEFFICIENT

Graphical Representation of their Relationship

By P. A. Lindsay, Ph.D., D.I.C., A.C.G.I.

(Communication from the Staff of the Research Laboratories of The General Electric Co., Ltd., Wembley, England)

IN the circuit analysis of most transmission systems, such as cables, waveguides, aerials, etc., it is often desirable to express the circuit characteristics of terminating or load impedances $\mathbf{Z}$ in terms of the voltage coefficient of reflection $\boldsymbol{\rho}$. The relationship between $\mathbf{Z}$ and $\boldsymbol{\rho}$ can be derived quite simply from the expression for the impedance $\mathbf{Z}$ at the end of a transmission line of length l and propagation constant $\mathbf{P}$,

$$\mathbf{Z} = \mathbf{Z}_0 \frac{\mathbf{A} \exp(-\mathbf{P}l) + \mathbf{B} \exp \mathbf{P}l}{\mathbf{A} \exp(-\mathbf{P}l) - \mathbf{B} \exp \mathbf{P}l}$$

where $\mathbf{Z}_0$ is the characteristic impedance of the line (see for example Ref. 1, p. 154 et seq.).

If we define $\boldsymbol{\rho}$ as the ratio $\{\mathbf{B} \exp \mathbf{P}l\}/\{\mathbf{A} \exp(-\mathbf{P}l)\}$ of the reflected to the incident voltage at the end of a transmission line, we get from the equation for $\mathbf{Z}$ the following expressions for the relationship between $\mathbf{Z}$ and $\boldsymbol{\rho}$:

$$\mathbf{z} = \frac{1 + \boldsymbol{\rho}}{1 - \boldsymbol{\rho}} \quad (1) \qquad \mathbf{y} = \frac{1 - \boldsymbol{\rho}}{1 + \boldsymbol{\rho}} \quad (2)$$

$$\boldsymbol{\rho} = \frac{\mathbf{z} - 1}{\mathbf{z} + 1} \quad (3) \qquad \boldsymbol{\rho} = \frac{1 - \mathbf{y}}{1 + \mathbf{y}} \quad (4)$$

where $\mathbf{z} = r + jx$ = normalized load impedance $\mathbf{Z}/\mathbf{Z}_0$

$\mathbf{y} = g + jb$ = normalized load admittance $\mathbf{Y}/\mathbf{Y}_0$

$\boldsymbol{\rho} = \rho \exp j\phi$ = voltage coefficient of reflection.

$\mathbf{Z}_0$ and $\mathbf{Y}_0$ being the characteristic impedance and admittance of the line.

Expressions (1) – (4) refer to complex quantities and belong to the bi-linear group of conformal transformations. Ideally they require four dimensions for full representation of the variables r, x, ρ and ϕ (or g, b, ρ and ϕ) along four orthogonal axes. Fortunately, expressions (1) – (4) can also be represented in two dimensions, although with some loss of clarity, either by perspective drawings of a pair of three-dimensional surfaces, one pair for each equation, or by a simultaneous projection of the contours of each pair of surfaces on to a plane. The contour representation of the functions $\boldsymbol{\rho}$, $\mathbf{z}$ and $\mathbf{y}$ was originally suggested by Smith,[2] in his paper on circle diagrams. This method, although excellent for computational purposes, does not appeal very strongly to our visual imagination. For a beginner it is of little help in tracing the intricate relationships which exist between the six quantities.* Yet in spite of some excellent examples from other fields[3] no perspective drawings of the surfaces representing the important functions $\boldsymbol{\rho}$, $\mathbf{z}$ and $\mathbf{y}$ are available in literature. It seems to the author that this gap should be filled in order to assist those who prefer pictorial to purely algebraic representation of the functions (1) – (4).

The first step in representing expressions (1) – (4) graphically is to split $\boldsymbol{\rho}$, $\mathbf{z}$ and $\mathbf{y}$ into their real and imaginary parts. From equation (1) we get, after multiplying numerator and denominator by $1 - \rho \exp(-j\phi)$,

$$\begin{aligned} \mathbf{z} &= \frac{1 + \boldsymbol{\rho}}{1 - \boldsymbol{\rho}} \\ &= \frac{1 + \rho \exp(j\phi)}{1 - \rho \exp(j\phi)} \cdot \frac{1 - \rho \exp(-j\phi)}{1 - \rho \exp(-j\phi)} \\ &= \frac{1 - \rho^2 + j2\rho \sin \phi}{1 + \rho^2 - 2\rho \cos \phi} \end{aligned}$$

or remembering that $\mathbf{z} = r + jx$

$$r = \frac{1 - \rho^2}{1 + \rho^2 - 2\rho \cos \phi} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

$$x = \frac{2\rho \sin \phi}{1 + \rho^2 - 2\rho \cos \phi} \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Similarly from equation (2) and from the relation $\mathbf{y} = g + jb$ we get:

$$g = \frac{1 - \rho^2}{1 + \rho^2 + 2\rho \cos \phi} \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

$$b = \frac{-2\rho \sin \phi}{1 + \rho^2 + 2\rho \cos \phi} \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

In all four cases we get $\mathbf{z}$ or $\mathbf{y}$ in terms of the polar components of $\boldsymbol{\rho}$. For the reverse transformation we rationalize the right-hand side of equation (3) and get:

$$\boldsymbol{\rho} = \frac{\mathbf{z} - 1}{\mathbf{z} + 1} = \frac{r - 1 + jx}{r + 1 + jx} = \frac{r^2 + x^2 - 1 + j2x}{(r + 1)^2 + x^2}$$

which leads to

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* It was brought to my notice by Dr. Bloch that the approach to circle diagrams suggested in his paper[4] provides a form of graphical representation which could also appeal to our visual imagination.

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$$\rho = \sqrt{\frac{(r-1)^2 + x^2}{(r+1)^2 + x^2}} \quad \cdot\cdot \quad \cdot\cdot \quad \cdot\cdot \quad (9)$$

$$\phi = \tan^{-1}\frac{2x}{r^2 + x^2 - 1} \quad \cdot\cdot \quad \cdot\cdot \quad \cdot\cdot \quad (10)$$

By a similar process we get from equation (4):

$$\rho = \sqrt{\frac{(1-g)^2 + b^2}{(1+g)^2 + b^2}} \quad \cdot\cdot \quad \cdot\cdot \quad \cdot\cdot \quad (11)$$

$$\phi = \tan^{-1}\frac{2b}{g^2 + b^2 - 1} \quad \cdot\cdot \quad \cdot\cdot \quad \cdot\cdot \quad (12)$$

It is worth noting at this point that because of the simple inverse relationship between **z** and **y** the number of different representations of the functions (5) – (12) is halved and many surfaces can be obtained merely by a shift or rotation of the right set of co-ordinate axes, as shown in Figs. 1–4.

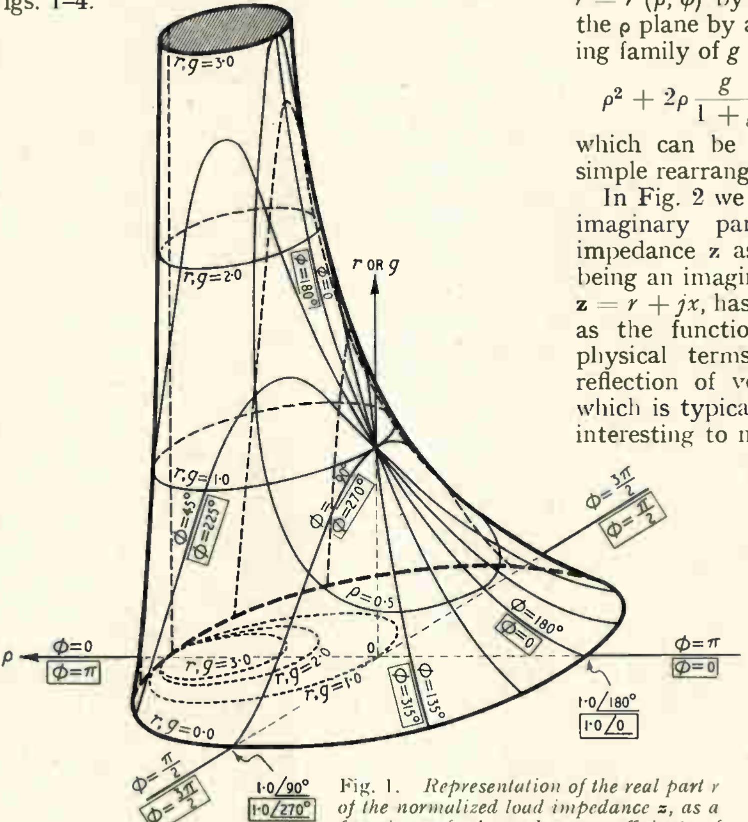

Fig. 1. *Representation of the real part r of the normalized load impedance* **z***, as a function of the voltage coefficient of reflection* **ρ**.

Let us consider now each of the surfaces in turn. We have in Fig. 1 the representation of r as a function of ρ and phase angle ϕ, where, for convenience ρ and ϕ are expressed in polar co-ordinates. For reasons which will become clear later, the function r is considered here for $\rho \leqslant 1$ only. The function r has a simple pole at $\rho = 1$, $\phi = 0$, corresponding to an open circuit, causing a total reflection at the end of the line. The thin lines on the surface $r = r\,(\rho, \phi)$ represent cross-sections along the ϕ = constant planes and along one ρ = constant cylinder. The horizontal contours, together with their dotted projections on the **ρ** plane, correspond to the r = constant curves. They can be derived from equation (5) by treating r as a parameter of a family of curves. Thus rearranging terms in equation (5) we get:

$$\rho^2 - 2\rho\frac{r}{1+r}\cos\phi = \frac{1-r}{1+r} \quad \cdot\cdot \quad \cdot\cdot \quad (13)$$

which is the equation of the r = const. family of circles in the polar form of the circle diagram. In the figure the values of the constants are marked on the corresponding contours. Further, it is shown by the boxed figures that the related $g = g\,(\rho, \phi)$ surface can be obtained from $r = r\,(\rho, \phi)$ by rotating the co-ordinate axes in the **ρ** plane by an angle of 180°. The corresponding family of g = const. curves is given by

$$\rho^2 + 2\rho\frac{g}{1+g}\cos\phi = \frac{1-g}{1+g} \quad \cdot\cdot \quad \cdot\cdot \quad (14)$$

which can be derived from equation (7) by a simple rearrangement of terms.

In Fig. 2 we have the surface representing the imaginary part x of the normalized load impedance **z** as a function of **ρ**. This function being an imaginary part of the complex variable $\mathbf{z} = r + jx$, has a discontinuity at the same point as the function r; i.e., at $\rho = 1$, $\phi = 0$. In physical terms this point represents a total reflection of voltage without change of phase, which is typical for an open-circuited line. It is interesting to note that, unlike r, the function x is different from zero for all points on the circumference of the unit circle $\rho = 1$ (except for $\phi = \pi$). The difference in the behaviour of the functions r and x is due to the fact that the magnitude of **ρ** (but not phase) remains constant and equal to one, whatever the value of the load, as long as the normalized load is purely reactive. However, as soon as the normalized load exhibits resistive components some power loss is bound to occur, and some reduction in the magnitude of **ρ** must follow, as can be shown in Fig. 1. We can also see from Fig. 2 that the function x changes sign depending on the phase of **ρ**. It is positive (inductive) for $0 < \phi < \pi$ and negative (capacitive) for $\pi < \phi < 2\pi$. For $\phi = 0$ and $\phi = \pi$ we have conditions of purely resistive normalized loads correspondingly greater and less than one.

The ρ = const. ϕ = const. and x = const. cross-sections are shown on the figure in thin

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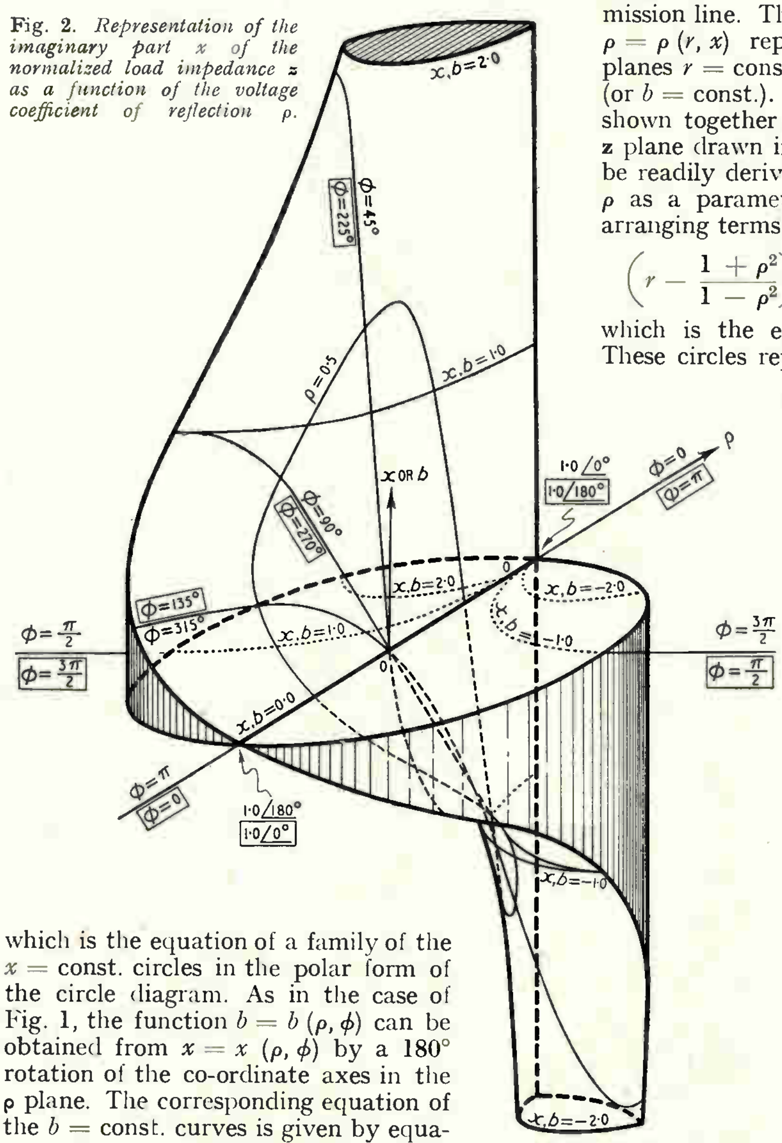
lines, and the projections of the $x =$ const. contours on to the $\boldsymbol{\rho}$ plane are dotted. The equation of the family of $x =$ const. curves can be derived from (6) by treating x as a constant parameter. Thus rearranging terms we get:

$$\rho^2 - 2\rho\left(\cos\phi + \frac{1}{x}\sin\phi\right) = -1 \quad .. \quad (15)$$

Fig. 2. *Representation of the imaginary part x of the normalized load impedance* $\mathbf{z}$ *as a function of the voltage coefficient of reflection* $\boldsymbol{\rho}$.



which is the equation of a family of the $x =$ const. circles in the polar form of the circle diagram. As in the case of Fig. 1, the function $b = b\,(\rho, \phi)$ can be obtained from $x = x\,(\rho, \phi)$ by a 180° rotation of the co-ordinate axes in the $\boldsymbol{\rho}$ plane. The corresponding equation of the $b =$ const. curves is given by equation (16),

$$\rho^2 - 2\rho\left(-\cos\phi - \frac{1}{b}\sin\phi\right) = -1 \quad .. \quad (16)$$

which can be derived from equation (8) by a simple rearrangement of terms.

Fig. 3 gives us the magnitude ρ of the voltage coefficient of reflection $\boldsymbol{\rho}$ as a function of the real and imaginary parts of the normalized load impedance $\mathbf{z}$. This function is zero only at $r = 1$, $x = 0$, which point corresponds to a matched or infinitely-long transmission line. For all other points of the $\mathbf{z}$ plane the function is $0 < \rho \leqslant 1$; i.e., some reflection must occur whenever $\mathbf{z} \neq 1$, or whenever the terminating load differs from the characteristic impedance of the transmission line. The thin lines drawn on the surface $\rho = \rho\,(r, x)$ represent the cross-section by the planes $r =$ const. (or $g =$ const.) and $x =$ const. (or $b =$ const.). The contours $\rho =$ const. are also shown together with their projections on to the $\mathbf{z}$ plane drawn in dotted lines. The contours can be readily derived from equation (9) by treating ρ as a parameter of a family of curves. Rearranging terms we get:

$$\left(r - \frac{1+\rho^2}{1-\rho^2}\right)^2 + x^2 = \left(\frac{2\rho}{1-\rho^2}\right)^2 \quad .. \quad (17)$$

which is the equation of a family of circles. These circles represent the $\rho =$ const. curves in the Cartesian form of the circle diagram. The surface shown in Fig. 3 represents both the $\rho = \rho\,(r, x)$ and $\rho = \rho\,(g, b)$ functions and similarly to equation (17) we can derive from equation (11) the following expression for the $\rho =$ const. circles in the $\mathbf{y}$ plane.

$$\left(g - \frac{1+\rho^2}{1-\rho^2}\right)^2 + b^2 = \left(\frac{2\rho}{1-\rho^2}\right)^2 \quad .. \quad (18)$$

The surface shown in Fig. 4 is more complicated than any of the others. It represents one branch of the essentially multi-valued function $\phi = \phi(r, x)$. This function becomes indeterminate at the point $r = 1$, $x = 0$, which point corresponds to a matched transmission line. It is obvious that at this point, in view of $\boldsymbol{\rho} = 0$, no meaning can be attached to the phase angle ϕ. For other values of $\mathbf{z}$, the chosen branch of the function ϕ lies between 0 and 2π. As previously, the thin lines represent the cross-sections of the surface with the $r =$ const. (or $g =$ const.) and $x =$ const. (or $b =$ const.) planes. The contours $\phi =$ const. are also shown together with their projections in dotted lines on to the $\mathbf{z}$ plane. The expression for the contours can be derived from equation (10) by treating ϕ as a parameter of a family of curves.

Rearranging terms we get from equation (10):

$$r^2 + (x - \cot\phi)^2 = \operatorname{cosec}^2\phi \qquad \text{(19)}$$

which is the equation of a family of circles representing the ϕ = const. curves in the Cartesian form of the circle diagram. The related function $\phi = \phi\,(g, b)$ can be obtained from $\phi = \phi(r, x)$ by shifting the origin by π along the ϕ axis, as shown boxed. This shift is equivalent to the 180° rotation of axes also shown boxed in Figs. 1 and 2. The family of ϕ = const. contours can now be derived from equation (12) in terms of g and b. Rearrangement of terms in equation (12) gives us

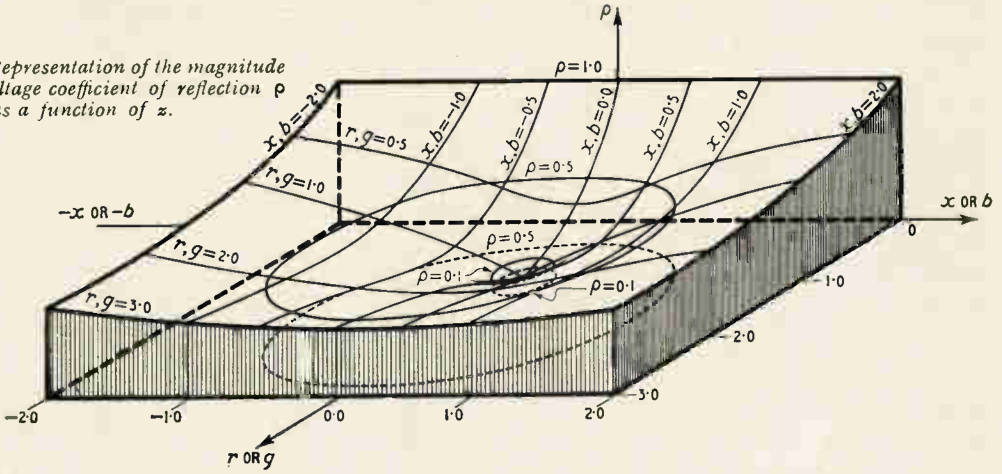


Fig. 3. *Representation of the magnitude ρ of the voltage coefficient of reflection* **ρ** *as a function of* **z**.

$$g^2 + (b - \cot\phi)^2 = \operatorname{cosec}^2\phi \qquad \text{(20)}$$

which is an equation of the family of circles representing the ϕ = const. curves in the Cartesian form of the circle diagram.

It should be added that in some cases it is necessary to consider values of r and $g < 0$ and $\rho > 1$ even for passive networks. The reason for this can be traced back to our definition of the variables **z** and **y**. Thus for instance in the case of **z** we could easily have $\mathbf{Z} = Z\underline{/-90^\circ}$ and $\mathbf{Z}_0 = Z_0\underline{/10^\circ}$ giving us $\mathbf{z} = \mathbf{Z}/\mathbf{Z}_0 = Z/Z_0\,\underline{/-100^\circ}$ which has its real part negative and leads to the values of $\rho > 1$ (in practice the reactive component of $\mathbf{Z}_0$ is normally fairly small causing ρ to be only slightly greater than one). In the case of negative r and g and ρ greater than one Figs. 1-4 still can be used, but only if we introduce an auxiliary variable

$$\boldsymbol{\rho}' = \frac{1}{\boldsymbol{\rho}^*} \qquad \text{(21)}$$

where $\boldsymbol{\rho}^* = \rho\exp(-j\phi)$ and is the complex conjugate of the voltage coefficient of reflection **ρ**. Equation (21) defines a conformal transformation which causes the whole of the **ρ** plane outside the unit circle $\rho = 1$ to be represented by the points inside the circle. The transformation is so arranged that the magnitude of **ρ** is changed, but its phase angle ϕ remains the same. Expressing equation (21) in terms of magnitude and phase we find that

$$\rho' = \frac{1}{\rho} \qquad \text{(22)} \qquad \text{and} \qquad \phi' = \phi \qquad \text{(23)}$$

as desired.

From equations (22) and (23) we can see that equation (21) can be also expressed in the form

$$\boldsymbol{\rho}'^* = \frac{1}{\boldsymbol{\rho}} \qquad \text{(24)}$$

Substituting equations (21) and (24) in equation (1) we get:

$$\mathbf{z} = \frac{\boldsymbol{\rho}'^* + 1}{\boldsymbol{\rho}'^* - 1} = \frac{\rho'^2 - 1 + j2\rho'\sin\phi'}{\rho'^2 + 1 - 2\rho'\cos\phi} \qquad \text{(25)}$$

or separating the real and imaginary parts

$$r = -\frac{1 - \rho'^2}{1 + \rho'^2 - 2\rho'\cos\phi'} \qquad \text{(26)}$$

$$x = \frac{2\rho'\sin\phi'}{1 + \rho'^2 - 2\rho'\cos\phi'} \qquad \text{(27)}$$

Similarly we get for the components g and b of the normalized admittance **y** in terms of the new variable **ρ**′

$$g = -\frac{1 - \rho'^2}{1 + \rho'^2 + 2\rho'\cos\phi'} \qquad \text{(28)}$$

$$b = -\frac{2\rho'\sin\phi'}{1 + \rho'^2 + 2\rho'\cos\phi'} \qquad \text{(29)}$$

Comparing expressions for **z** and **y** in terms of **ρ** and **ρ**′ we find that they are identical, except

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for the sign of r and g. Thus if we wish to use Figs. 1 and 2 for finding the values of **z** or **y** corresponding to a given value of ρ, where $\rho > 1$, we form first of all a new variable ρ', by putting $\rho' = 1/\rho$ and $\phi' = \phi$. Having done this we use Fig. 1 as if it were drawn originally for ρ' and not ρ, and read from it the value of r or g, adding at the same time a negative sign in front of it. Similarly we treat Fig. 2 as if it were drawn for ρ' and not ρ, and read from it directly the value of x or b, without any change of sign at all.

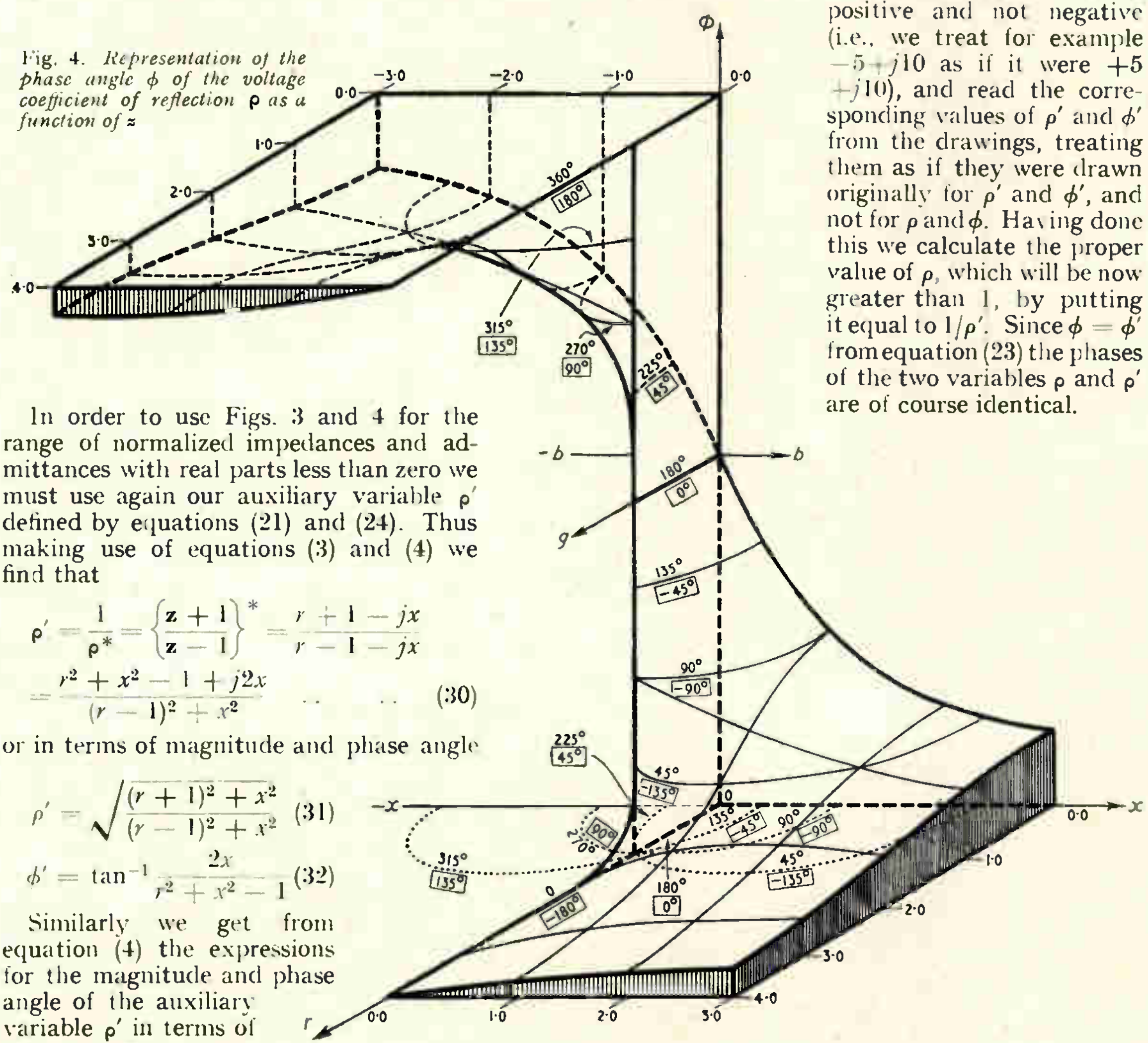

Fig. 4. *Representation of the phase angle ϕ of the voltage coefficient of reflection ρ as a function of* **z**

In order to use Figs. 3 and 4 for the range of normalized impedances and admittances with real parts less than zero we must use again our auxiliary variable ρ' defined by equations (21) and (24). Thus making use of equations (3) and (4) we find that

$$\rho' = \frac{1}{\rho^*} = \left\{\frac{\mathbf{z}+1}{\mathbf{z}-1}\right\}^* = \frac{r+1-jx}{r-1-jx}$$

$$= \frac{r^2+x^2-1+j2x}{(r-1)^2+x^2} \quad \ldots \quad \ldots \quad (30)$$

or in terms of magnitude and phase angle

$$\rho' = \sqrt{\frac{(r+1)^2+x^2}{(r-1)^2+x^2}} \quad (31)$$

$$\phi' = \tan^{-1}\frac{2x}{r^2+x^2-1} \quad (32)$$

Similarly we get from equation (4) the expressions for the magnitude and phase angle of the auxiliary variable ρ' in terms of the real and imaginary parts of the normalized admittance **y**

$$\rho' = \sqrt{\frac{(1+g)^2+b^2}{(1-g)^2+b^2}} \quad \ldots \quad \ldots \quad \ldots \quad (33)$$

$$\phi' = \tan^{-1}\frac{2b}{g^2+b^2-1} \quad \ldots \quad \ldots \quad \ldots \quad (34)$$

From equations (9), (11) and (31), (33) we find that functions ρ and ρ' satisfy the following symmetry relationship

$$\rho'(-r, x) = \rho(r, x) \quad \ldots \quad \ldots \quad \ldots \quad (35)$$

$$\rho'(-g, b) = \rho(g, b) \quad \ldots \quad \ldots \quad \ldots \quad (36)$$

the functions ϕ and ϕ' being of course identical. Thus if we wish to use Figs. 3 and 4 for finding the value of the voltage coefficient of reflection ρ for a given value of **z** or **y**, where **z** and **y** have negative real parts, we treat the variables **z** and **y** first of all as if their real parts were actually positive and not negative (i.e., we treat for example $-5+j10$ as if it were $+5+j10$), and read the corresponding values of ρ' and ϕ' from the drawings, treating them as if they were drawn originally for ρ' and ϕ', and not for ρ and ϕ. Having done this we calculate the proper value of ρ, which will be now greater than 1, by putting it equal to $1/\rho'$. Since $\phi = \phi'$ from equation (23) the phases of the two variables ρ and ρ' are of course identical.

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PHYSICAL BASIS OF THERMAL NOISE

By D. A. Bell, M.A., B.Sc., Ph.D., M.I.E.E.

ALTHOUGH very convenient, Nyquist's thermodynamic derivation of the formula for Johnson noise in a resistance under conditions of thermal equilibrium has in some ways been a misfortune for engineers: it has led so many people to ignore entirely the *mechanism* of thermal noise and to make the mistake of thinking that there is an inevitable connection between 'thermal noise' and 'thermal equilibrium'. The difficulties which have arisen in the application of the second law of thermodynamics to gases when the scale of observation is such as to show the statistical fluctuation, might perhaps be a warning against the care-free application of equilibrium arguments; and in any case there must always be a *mechanism* by means of which the equilibrium is established, and in metallic conductors the mechanism is very well established.

The Analogy with Brownian Motion

The experimental observations of Johnson[1] and the theoretical work of Nyquist[2] were published in 1928, but it had been suggested by de Haas Lorentz[3] as early as 1913 that there should be 'Brownian motion of electricity' in electric circuits. It must be noted, however, that the theory of Brownian motion, as usually expressed, describes a *total mean-square displacement*, whereas electrical engineering work from Nyquist onwards has been concerned with the *components of the disturbance in a narrow frequency band.* Thus there appears at first sight to be no relation between the formula of de Haas Lorentz,*

$$\langle i^2 \rangle = X^2/2RL \tag{1}$$

and that of Nyquist

$$\langle V^2{}_{df} \rangle = 4RkT\,df \tag{2}$$

(The de Haas Lorentz formula relates to a series L, R circuit, and X is the total electromotive force equivalent to the results of all the collisions suffered by the conduction electrons.)

But these two formulae refer in fact to different quantities and are related to each other in the same way as the well-known formulae for total fluctuation due to pure shot noise in a CR circuit,

$$\langle V^2{}_{Total} \rangle = \frac{2ie}{RC} \tag{3}$$

and the spectrum of the equivalent fluctuation current,

$$\langle I^2{}_{df} \rangle = 2iedf \tag{4}$$

Since the generalized form of (2) is

$$\langle V^2{}_{df} \rangle = 4kT\,\mathrm{Re.}(Z)df \tag{5}$$

where Re. (Z)stands for the real or resistive part of Z, one can deduce the total thermal fluctuation in a CR circuit in the form

$$\langle V^2{}_{Total} \rangle = 4kT\int_{f=0}^{f=\infty} \mathrm{Re.}\,(Z)df \tag{5a}$$

and Moullin and Ellis[1] showed that this led to the equation

$$\tfrac{1}{2}C\langle V^2{}_{Total} \rangle = \tfrac{1}{2}kT \tag{6}$$

The mean-square energy (over all frequencies) associated with the capacitance is thus the 'equipartition' value predicted by classical thermodynamic theory for any system with one degree of freedom. By taking the current-fluctuation version of Nyquist's formula,

$$\langle I^2{}_{df} \rangle = (4kT/R)df \tag{7}$$

and working in admittances, one can arrive at a corresponding formula

$$\tfrac{1}{2}L\langle I^2{}_{Total} \rangle = \tfrac{1}{2}kT \tag{8}$$

The results are readily obtained by direct integration for simple circuits consisting of one resistance and one reactance. For more complex circuits, however, one can obtain the corresponding general results by the technique which has been developed by Bode[5]: contour integration is used as a means of evaluating infinite integrals such as (5a) without using the values of the integrand at all real frequencies, as would be implied in simple integration. The method is readily applied to a passive two-terminal impedance (as distinct from a four-terminal or transfer impedance) of the type which Bode specified as a minimum-phase impedance; i.e., one free from singularities in the right-hand half of the 'p' (or 'complex frequency') plane and free from poles on the axis of real frequency. The first half of the condition requires that (a) any poles shall correspond to positive damping, thus excluding self-oscillating circuits and (b) the impedance shall be a single-valued function of frequency, a condition which may not be satisfied by the equations of distributed systems.

The process is detailed in Chapter 13 of Bode's book, and one of his results is as follows:

$$\int_0^\infty (A - A_\infty)\,d\omega = -\frac{\pi}{2}B_\infty \tag{9}$$

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* The pointed brackets < > are used to denote *mean*-squared quantities.

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with the notation that the impedance is $Z = A + jB$, where both A and B are functions of ω and, moreover, that Z is represented by a function which is analytic both at zero and infinite frequency. Then Z is to be expanded at infinite frequency in a series of inverse powers of ω:

$$Z = A_\infty + j\, B_\infty/\omega + A_1/\omega^2 + j\, B_1/\omega^3$$

The integral relation which has been quoted above means that if the real part of the impedance vanishes at infinite frequency ($A_\infty \rightarrow 0$) the infinite integral of A, the resistive part of the impedance, is equal to $-(\pi/2)\, B_\infty$. In general, a shunt capacitance will become dominant at infinite frequency, so that $j\, B_\infty/\omega$ will be $1/j\omega C_s$; i.e., $B_\infty = -1/C_s$. Under these conditions

$$\int_0^\infty \text{Re.}\ (Z)\ d\omega = \pi/2C_s$$ and the corresponding integral in *frequency* (instead of ω) will be $1/4C_s$. Then it follows that

$$< V^2{}_{Total} > =$$

$$\int_0^\infty < V^2{}_{df} > df = 4kT \int_0^\infty \text{Re.}\ (Z) df = kT/C_s \quad (10)$$

which demonstrates for the general case the result proved by Moullin and Ellis for particular cases, namely $\frac{1}{2}\, C < V^2{}_{Total} > = \frac{1}{2} kT$.

If the circuit becomes inductive at infinite frequency—for example a straight wire which would be almost a short-circuit at zero frequency—it can be treated in terms of admittance,

$$< I^2{}_{Total} > = 4kT \int_0^\infty \text{Re.}\ (Y) df = kT/L \qquad (11)$$

which is equivalent to $\frac{1}{2} L < I^2{}_{Total} > = \frac{1}{2} kT$. This is the result which was obtained by Brillouin[6] from a consideration of the detailed behaviour of the conduction electrons in a metal.

'Degrees of Freedom' of a Circuit.

Two features of these conclusions deserve further attention. It might at first be thought that if the impedance under consideration consisted of a complex structure, perhaps with several separately identifiable resonant circuits, it could be considered to have several degrees of freedom and would therefore have a mean energy of several times the equipartition value $\frac{1}{2} kT$. The answer to this is that so long as the circuit is regarded as a two-terminal impedance, its state is fully specified when *the potential difference between the two terminals* is given at all times: it is therefore a system having only *one* degree of freedom when viewed from its terminals. The second question, which was raised by Moullin and Ellis,[4] is how the individual conduction electrons combine together to form a coherent whole which we call a 'circuit' having one degree of freedom. It is by no means certain that the existence of this coherence need be assumed since the mean-square voltage $<V^2>$ at the terminals may be merely the statistical resultant of numerous independent contributions. But in the work already cited Brillouin equated the 'inductive energy' $\frac{1}{2} Li^2$ of a circuit carrying steady current i to the kinetic energy of the conduction electrons in the circuit. It turned out that for a conductor of any appreciable size the 'mechanical' kinetic energy $\frac{1}{2} mv^2$ corresponding to the rest mass m of the electron and its drift velocity v was negligible in comparison with the electrical energy associated with the drift velocity of each electron in the field due to the common motion of all the other electrons, and the latter therefore represents the inductive energy. It is thus the common magnetic field associated with the common drift velocity of the electrons which provides some measure of 'coherence'.

Mechanism in a Metallic Conductor

This relationship between total fluctuation and spectrum intensity has been stressed because historically the first thorough theoretical analysis was published by Brillouin[6] in 1937 in the form

$$< I^2 > = kT/L$$

which corresponds to our formula (8) for total fluctuation. A simple quantitative model of the mechanism was published by the author[7] in 1938, and a closely similar model was used by Weisskopf[8] in 1943. The simple model will be summarized here because it can be used to illustrate the fact that 'resistance' and 'temperature' are really secondary parameters which may, in suitable cases, be used to specify the magnitude of thermal noise arising from the random motion of individual charges. Let an electron, with charge e, travel with velocity u for time τ. The product of charge by velocity gives not a current but a 'current-element' of the form $i\delta l$, and the electron-flight just proposed produces a pulse of current-element defined by

$$\int_0^\tau (i\delta l) dt = eu\tau \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

This pulse may be analysed into a spectrum of frequencies, and if N be the number of electrons present in the conductor it is found that their spectrum is represented by

$$< I^2{}_{df} > = [2N\, e^2 u^2 \tau/(\delta l)^2] df \quad \ldots \quad \ldots \quad (13)$$

But if the resistance of the conductor is deduced from the number of electrons present and their mobility,* the latter will be found to be $e\tau/2m$ and the resistance of the conductor is

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* Mobility = mean drift velocity v acquired under steady unit field, so that current for unit field is Nev.

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$$R = \frac{2m\,(\delta l)^2}{Ne^2\,\tau} \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

Combining equations (13) and (14)

$$< I^2{}_{df} > R = 4mu^2\,df \quad \ldots \quad \ldots \quad \ldots \quad (15)$$

But if u^2 is equated to the mean-square velocity of an electron in classical thermal equilibrium,

$$mu^2 = kT \quad \ldots \quad \ldots \quad \ldots \quad (16)$$

and this leads to the standard result

$$< I^2{}_{df} > R^2 = < V^2{}_{df} > = 4\,R\,kT\,df \quad (17)$$

Now the point is that the fundamental phenomenon is described by equation (13), and it is only by means of (14) and (16) that it can be described in terms of the macroscopic parameters R and T.

The model used above is fallacious (a) because metallic conduction cannot legitimately be described by equation (14) and (b) because equation (16) is not consistent with the modern view that the conduction electrons in a metal have a Fermi-Dirac distribution, but these two deficiencies are self-compensating. It was shown by Lorentz[9] that the conductivity of a metal is proportional to $\int lu \frac{\partial}{\partial u}[f(u)]\; du$ where l is the mean free path of an electron of velocity u and $f(u)$ is the proportion of the total number of electrons which have thermal velocity u; and it has since been shown by Bakker and Heller[10] that there is a universal relationship between conductivity, calculated in this way, and the fluctuation current due to the statistical fluctuations in the distribution of thermal velocities. Hence equation (17) is derivable from the mechanism of metallic conduction, though not so simply as was suggested in equations (12) to (16).

Non-Equilibrium Systems.

It should be noted that there is here no postulate of overall thermodynamic equilibrium between the conductor and external bodies; it is only necessary to know the mean free path and the distribution function of the velocities. In fact Brillouin[6] demonstrated theoretically that the noise would not be altered by the superposition of a drift velocity due to the passage of a steady current of any value for which the resistor remained ohmic in behaviour, and in view of the i^2R heating associated with such a current there is clearly no overall equilibrium in this case. It will, of course, be argued that this is a special case in which the two effects can be separated by virtue of the principle of superposition in a linear system. It is true that the separation is rendered simple by the linearity in the case of a metallic conductor, but in principle they could just as well be separated in other and more difficult cases. Even in the thermionic valve, which has proved so controversial, the following points cannot be disputed:

(a) The apparent temperature of the conductance of a negative grid provided by electron-loading at high frequencies is directly related to cathode temperature.

(b) The 'space-charge-smoothed' shot noise can be expressed in terms of an equivalent temperature of the r_a of the valve which is a fraction of the cathode temperature, though the precise value of the fraction is still uncertain.

(c) The velocity-distribution of an electron stream is not changed by passage through an electrostatic potential barrier in a plane system, but can be changed by using a magnetic field to form a rough beta-ray spectroscope. The resulting change in noise as observed by F. C. Williams[11] was shown by the author to be readily interpretable in terms of the modified distribution of thermal velocity in the magnetically-filtered electron stream.

(d) It has recently been shown by Freeman[12] that, in the use of a temperature-limited diode at frequencies such that the transit time is appreciable, noise due to the thermal velocities of the electrons in transit can be detected.

(e) In the use of gas-discharge tubes as noise-sources at very high frequencies, it is agreed that the 'electron temperatures' are far above the temperatures of the surrounding gas molecules, yet the noise can be adequately described in thermal terms in spite of this lack of equilibrium.

The conclusion is that to calculate the random noise in a circuit one needs to know $\sum e^2\,u^2\,\tau$ where u is the random velocity and τ the time of flight of a charge-carrier. Provided this quantity can be determined in one way or another there is no need to worry about thermodynamic equilibrium.

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NEW BOOKS

Statistics for Technologists

By C. G. Paradine, M.A.(Cantab.) and B. H. P. Rivett, M.Sc.(Lond.). Pp. 288 + vii. English Universities Press, Ltd., Warwick Square, London. Price 25s.

Although statistics are usually regarded as a branch of mathematics, statistical methods must necessarily be used by practical workers in many fields. Fully-qualified statisticians are seldom available to direct the application of these methods. The subject is difficult for research workers who are not mathematicians; wrong conclusions can easily be drawn by mishandling data and by poor design of experiments, particularly subjective experiments.

Most books on statistics are either textbooks for the fully-equipped mathematician, or else they are accounts of methods only, in which the underlying theory is largely omitted. 'Statistics for Technologists' achieves a very satisfactory compromise, as might be expected when one author is a Senior Lecturer in Mathematics at Battersea Polytechnic and the other Head of the Field Investigation Group of the National Coal Board. Full details of all numerical methods used are given, with worked examples and explanations of many computational labour-saving devices. A mathematical argument, however, is not avoided when the theory underlying formulae and rules of procedure is explained. Elementary knowledge of algebra and calculus are sufficient for appreciation of the line of argument except when there is a warning asterisk. Sufficient statistical tables are provided and there are some 180 examples, with answers, at the ends of chapters. Reference is made to mathematical textbooks (notably M. G. Kendall's 'Advanced Theory of Statistics') for formal proofs involving advanced mathematics.

The first four chapters deal with frequency distributions in general, statistical parameters, probability, and the binomial, normal and Poisson distributions. The relations between these distributions, and the significance of Sheppard's corrections, moments, skewness, etc., are particularly well explained. Chapter 5 deals with sums of squares of normal variates and χ^2; Chapter 6 with the theory of small samples, variance ratio, Student's t and Fisher's z. Formulae for the probability distributions of χ, t and z are included. Quality control is discussed in Chapter 7, while Chapter 8 deals with single, double and sequential sampling inspection schemes. In Chapter 9 the theory of errors is discussed, including combinations of errors that are normally or rectangularly distributed. Chapter 10 is concerned with the method of least squares, orthogonal polynomials, Fourier series, and approximation to a continuous function. Chapter 11 deals with regression lines and correlation for two and for three variates; rank correlation is briefly mentioned. The analysis of variance (for one factor, two factors, three factors, and two factors with replications) is the subject of Chapter 12, while the principle of maximum likelihood and probit analysis are discussed in Chapter 13.

The book is very clearly printed, and only trivial misprints appear to have occurred, except in the example on page 160. Here the value 16·85 among the repeated observations must be omitted entirely and the variance of the sample is ten times too small. If the value 16·85 was intended for rejection because it is obviously abnormally large, this should have been indicated.

One minor suggestion is that, in any future edition, the Escalator method* should be added to those suggested for solving linear simultaneous equations in section 10.9.2, as this method seems to bring in during the process of calculation quantities useful for least-squares and multiple-correlation problems.

The book can be specially recommended as showing the practical worker where statistical technique is relevant to his work, and how to apply it. The subject is fundamentally mathematical, and this rather frightens many who feel that their mathematical equipment is probably inadequate. Such people should read 'Statistics for Technologists' before giving up hope of being able to master the subject sufficiently for practical purposes.

J. W. H.

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* J. Morris. "An Escalator Process for the Solution of Linear Simultaneous Equations". *Phil. Mag.*, Feb. 1946, Vol. 37, pp. 106-120.

Scintillation Counters

By J. B. Birks, B.A., Ph.D., F.Inst.P. Pp. 148 + viii. Pergamon Press Ltd., 242 Marylebone Road, London, N.W.1. Price 21s.

Following an introduction which discusses quite briefly the detection of atomic and nuclear radiation and the visual and multiplier types of scintillation counters, there are chapters on the scintillation counter, the photomultiplier tube, pulse height and time resolution. There are then three chapters on inorganic, organic crystalline, and organic plastic and solution phosphors; the final chapter covers applications of scintillation counters.

The material of the book is most clearly presented and few people with a good background of electronics will have any serious difficulty in understanding it. Mathematics is used where necessary but there is no great amount of it and, what there is, is fairly simple. The book will unquestionably be of great help to the newcomer to nuclear physics but it will also be helpful to those in related fields who find the need for some understanding of the methods used.

W. T. C.

Principles of Transistor Circuits

Edited by Richard F. Shea. Pp. 535 + xxx. Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price 88s.

This book has been written by nine authors from the Electronics Laboratory of the General Electric Company (U.S.A.), and it deals in a very comprehensive manner with transistors and their circuitry. The first chapter covers semiconductor principles while the second deals with their 'forms, types and characteristics'.

In Chapter 3, the transistor is regarded more from the standpoint of the user—as a 'black box' with three accessible terminals. Equivalent circuits for low-frequency application are deduced. The following chapters cover the basic principles of the amplifier stage, multistage amplifiers using junction transistors, bias stabilization, power amplifiers and d.c. amplifiers.

High-frequency considerations are introduced in Chapter 9 and three chapters cover the characteristics of the transistor itself, the forms of circuit, and circuit design. Video amplifiers are then treated, followed by oscillators, including multivibrators.

Chapters 14 and 15 cover circuit design by duality and circuit analysis by matrix methods, while Chapter 16 covers feedback amplifiers. There is a chapter on transient analysis and one on large-signal operation; the remaining four cover computer circuits, noise, associated semiconductor devices, and small-signal parameter measurement. The appendixes are headed: Matrix Algebra, Definition of Terms and Bibliography.

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The book includes an enormous amount of information about transistor circuits and their design and it covers point-contact transistors as well as both *n-p-n* and *p-n-p* junction types. It is invaluable as a reference book but, as a textbook, it suffers from an excess of generality. The beginner would find the going much easier if more simple circuits had been individually treated in the early stages so that he had a more gradual introduction to new ideas. It would also have been easier for him if more attention had been paid to the definitions of terms. For example, as early as page 5, the term 'minority carrier' occurs. There is no indication of its meaning in the text and it does not occur in the 'Definitions of Terms'.

If the reader does not already know the meaning, which is quite probable in such a new and specialized subject, he has to guess. The natural guess is that minority carriers are the mechanism by which a minor part of the current is carried and, therefore, that they are trivial. It is a wrong guess, however, and one that lands the reader in endless difficulties, for the 'minority' actually refers to free electrons and specifies the condition when the material contains mainly bound electrons and places in the structure holes—which can contain electrons. Conduction is considered to be mainly by the movement of these holes (although it is really by the movement of electrons into the holes to cause an apparent movement of the holes) and to a minor degree only by the movement of free electrons.

The authors are obviously so steeped in the subject that they have overlooked the beginner's difficulties. The result is, unfortunately that, in spite of the apparent simplicity of the opening, the reader does need prior knowledge of transistors before he starts this book.

One particularly valuable equivalent circuit for the transistor is to be found tucked away in the chapter on matrix methods, just where it is likely to be overlooked on account of the unfamiliarity of the mathematics. It is an equivalent circuit for the earthed-emitter transistor and is nothing more than an ordinary triode valve with two resistors—one between grid and cathode, the other between grid and anode. It is the so-called anode follower or see-saw circuit without the series grid resistor.

W. T. C.

Preferred Numbers B.S. 2045 : 1953

Pp. 10. British Standards Institution, 2 Park Street, London, W.1. Price 2s. 6d.

This booklet explains and defines preferred numbers in the Renard series which are derived from geometric series having common ratios of $\sqrt[5]{10}$, $\sqrt[10]{10}$, $\sqrt[20]{10}$, $\sqrt[40]{10}$ or $\sqrt[80]{10}$ and which are known as the R5, R10, etc., series. The series are the ones agreed internationally by the International Organization for Standardization.

It will come as a shock to radio people to find that the preferred numbers of this Standard are not the ones to which they are accustomed in dealing with resistors and capacitors. The R5 range, for instance, is 1, 1·6, 2·5, 4, 6·3, 10, instead of the familiar 1, 1·5, 2·2, 3·3, 4·7, 6·8, 10, based on $\sqrt[6]{10}$.

MEETINGS

I.E.E.

10th February. "Basic Ground-Wave Propagation Characteristics in the 50–800-Mc/s Band", by J. A. Saxton, D.Sc., Ph.D., and "Ground-Wave Field Strength Surveys at 100 and 600 Mc/s", by J. A. Saxton, D.Sc., Ph.D., and B. N. Harden, M.Sc.

11th February. "A Short Modern Review of Fundamental Electromagnetic Theory", by P. Hammond, M.A.

15th February. "The Teaching of the Subject of Insulating Materials", discussion to be opened by Willis Jackson, D.Sc., D.Phil., F.R.S., at 6 o'clock.

22nd February. "Acceptable Standards of Quality in Sound Broadcast Transmission and Reception", discussion to be opened by J. K. Webb, M.Sc.(Eng.), B.Sc.Tech.

4th March. "Submerged Telephone Repeaters for Shallow Water", by R. J. Halsey, B.Sc.(Eng.), and F. C. Wright; "The Netherlands-Denmark Submerged-Repeater System", by A. H. Roche, B.Sc.(Eng.), and F. O. Roe, B.Eng.; and "British Post Office Standard Submerged-Repeater System for Shallow-Water Telephone Cables, with special mention of the England-Netherlands System", by D. C. Walker, B.Sc.(Eng.), and J. F. P. Thomas, B.Sc.(Eng.).

These meetings will be held at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2, and will commence at 5.30 except where otherwise stated.

BRIT.I.R.E.

17th February. "Electronics in Film Making", by W. D. Kemp and B. R. Greenhead, to be held at London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, at 6.30.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Values for December 1953

Date 1953 Dec.	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 1429-1530 G.M.T.	Droitwich 200 kc/s 1030 G.M.T.	
1	− 1·3	+ 2	+ 33·1
2	− 1·3	+ 2	+ 31·4
3	− 1·3	+ 3	+ 30·4
4	− 1·5	+ 2	+ 28·6
5	− 1·4	+ 2	N.M.
6	− 1·4	+ 2	N.M.
7	N.M.	+ 2	+ 24·9
8	− 1·3	+ 1	+ 22·6
9	− 1·3	+ 2	+ 20·7
10	− 1·3	+ 2	+ 18·7
11	− 1·3	+ 2	+ 16·4
12	− 1·4	+ 3	N.M.
13	− 1·4	+ 3	N.M.
14	− 1·4	+ 2	+ 10·7
15	− 1·4	+ 3	+ 9·2
16	− 1·4	+ 3	+ 6·3
17	− 1·4	+ 3	+ 5·1
18	− 1·3	+ 3	+ 6·3
19	N.M.	+ 4	N.M.
20	N.M.	+ 3	N.M.
21	− 1·5	+ 3	+ 2·1
22	− 1·5	+ 3	− 1·3
23	− 1·5	+ 3	− 3·8
24	− 1·5	+ 4	N.M.
25	N.M.	+ 4	N.M.
26	− 1·4	+ 3	N.M.
27	− 1·4	+ 4	− 10·8
28	− 1·3	+ 4	N.M.
29	− 1·4	+ 4	− 14·5
30	− 1·4	+ 4	− 14·4
31	− 1·3	+ 4	− 16·5

The values are based on astronomical data available on 1st January 1954.

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

N.M. = Not Measured.

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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 selected list of journals abstracted, the abbreviations of their titles and their publishers' addresses.

ACOUSTICS AND AUDIO FREQUENCIES

534.21-13 **294**

Finite-Amplitude Sound Waves.—J. B. Keller. (*J. acoust. Soc. Amer.*, March 1953, Vol. 25, No. 2, pp. 212–216.) Exact solutions of the one-dimensional gas dynamic equations, representing periodic sound waves of finite amplitude, are obtained for a particular medium. The progressive wave from a vibrating piston and the standing wave in a closed tube are examined in detail.

534.213.4-13 **295**

The Theory of the Propagation of Plane Sound Waves in Tubes.—D. E. Weston. (*Proc. phys. Soc.*, 1st Aug. 1953, Vol. 66, No. 404B, pp. 695–709.) Propagation in gases within cylindrical tubes of widely differing diameters is considered. The phase velocity, attenuation and cross-section profile of particle velocity are investigated theoretically and their interrelation pointed out. The factors affecting the validity of Kirchhoff's formulae are considered and the theory is applied to Lawley's experimental results (2408 of 1952).

534.222.1 **296**

A Particular Case of the Propagation of Sound in an Anisotropic Medium.—L. M. Brekhovskikh. (*C. R. Acad. Sci. U.R.S.S.*, 11th Dec. 1952, Vol. 87, No. 5, pp. 715–718. In Russian.) A theoretical treatment of the case when the velocity of sound in the direction of the z coordinate is given by $c = c_0$ for $0 \leqslant z \leqslant h$ and $c = c_0 [1 + 2a(z - h)]^{-\frac{1}{2}}$ for $h \leqslant z < \infty$.

534.232 **297**

Transient Loading of a Baffled Strip.—J. W. Miles. (*J. acoust. Soc. Amer.*, March 1953, Vol. 25, No. 2, pp. 204–205.) The relation between the applied force and the resultant velocity variation is investigated for a plate mounted in an infinite baffle.

534.232 : 621.395.623.7 **298**

Transient Loading of a Baffled Piston.—J. W. Miles. (*J. acoust. Soc. Amer.*, March 1953, Vol. 25, No. 2, pp. 200–203.) The relation between the applied force and the resultant velocity variation of a circular piston is investigated using the Laplace transform. The results indicate that a loudspeaker system designed for critical damping in the steady state will be slightly overdamped in its initial motion, i.e. for about 10^{-3} sec.

534.26 **299**

Diffraction of Sound Waves by a Circular Aperture.—G. Bekefi. (*J. acoust. Soc. Amer.*, March 1953, Vol. 25, No. 2, pp. 205–211.) Measurements of the pressure in the aperture and in the near field, using a wavelength of about 3 cm and apertures of diameter 5λ–10λ, are reported and discussed. A new formula, which represents conditions in the field more accurately than Kirchhoff's formula, is derived theoretically.

534.321.9 + 535 **300**

Recent Developments in Ultrasonics and Optics.—(*Nature, Lond.*, 5th Sept. 1953, Vol. 172, No. 4375, pp. 443–444.) Summaries of papers read at the Summer Provincial Meeting of the Physical Society.

534.612.4 **301**

Comparison of Microphone Calibrations using Pure Tones or using a Noise Source.—P. Chavasse & L. Pimonow. (*Ann. Télécommun.*, Aug./Sept. 1953, Vol. 8, Nos. 8/9, pp. 267–270.) Microphone response curves obtained by use of pure tones and by use of white noise are reproduced and discussed. If the microphone curve obtained with pure tones is flat, or nearly so, the response to white noise, using an analyser for which $\Delta f/f$ is constant, will rise towards the higher frequencies. Apart from this difference, the response curves obtained by the two methods are very similar. It appears to be absolutely necessary to determine, for any measurement microphone, both the distortion and the maximum sound pressure that may be applied to it.

534.64 **302**

The Acoustic Waveguide: Part 1 — An Apparatus for the Measurement of Acoustic Impedance using Plane Waves and Higher-Order-Mode Waves in Tubes.—E. A. G. Shaw. (*J. acoust. Soc. Amer.*, March 1953, Vol. 25, No. 2, pp. 224–230.) Apparatus operating in the frequency range 1–3 kc/s is described. See also 2537 of 1953.

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534.64 **303**

The Acoustic Waveguide: Part 2 — Some Specific Normal Acoustic Impedance Measurements of Typical Porous Surfaces with respect to Normally and Obliquely Incident Waves.—E. A. G. Shaw. (*J. acoust. Soc. Amer.*, March 1953, Vol. 25, No. 2, pp. 231–235.) Techniques described in part 1 (302 above) were used for measurements on rock-wool, hair-felt and acoustic tile backed by a rigid wall.

534.75 **304**

Effect of Different Types of Electrodes in Electrophonic Hearing.—G. Flottorp. (*J. acoust. Soc. Amer.*, March 1953, Vol. 25, No. 2, pp. 236–245.)

534.79 **305**

The Variation of Modulation Thresholds by Masking Tones and Noises.—E. Zwicker. (*Akust. Beihefte*, 1953, No. 2, pp. 274–278. In German.) Experiments on a subject with average hearing are reported. Masking tends to raise the threshold of audibility for sound and for modulation of sounds at levels of intensity within 30 db above the new threshold. For sounds at higher intensity levels the modulation threshold is unaffected by masking.

534.833 : 532.13 : 534.321.9 **306**

Viscosity as a Factor in the Anomalous Absorption of Ultrasonic Waves in Liquids.—S. Parthasarathy & A. F. Chhapgar. (*Ann. Phys., Lpz.*, 2nd July 1953, Vol. 12, Nos. 4/6, pp. 316–320. In English.) The loss in the oscillating quartz crystal, due to internal friction and radiation of energy to the surrounding medium, was found to be proportional to $\eta^{\frac{1}{2}}$, where η is the coefficient of viscosity.

534.833.1 **307**

Notes on the Transmission of Sound through Plates.—R. D. Fay. (*J. acoust. Soc. Amer.*, March 1953, Vol. 25, No. 2, pp. 220–223.) A formula that can be readily evaluated is derived for the transmittivity of steel plates immersed in a fluid. Discrepancies between values calculated from the formula and observed values indicate that losses associated with shear waves in steel are not negligible.

534.834 **308**

Measurement of Sound Propagation in Liquid-Filled Pipes having Zero-Impedance Walls.—W. Kuhl & K. Tamm. (*Akust. Beihefte*, 1953, No. 2, pp. 303–316. In German.) Suppression of sound in pipes with a circular, a subdivided circular, or a rectangular cross-section, can be realized by means of a cellular rubber lining. Good agreement with theoretically predicted results is obtained.

534.834 **309**

Theory of Sound Attenuation in Ducts of Rectangular Cross-Section with one Absorbent Wall, and the Resulting Maximum Attenuation Factor.—L. Cremer. (*Akust. Beihefte*, 1953, No. 2, pp. 249–263. In German.) Charts are presented from which the attenuation constant can be read off directly at any one of five frequencies. These are derived from the Morse diagram noted in 680 of 1940. For a report of experimental work see 310 below.

534.834 **310**

Experimental Investigations for the Realization of the Maximum Theoretically Attainable Sound Attenuation in a Rectangular Air Duct with Absorbent Walls.—O. Gerber. (*Akust. Beihefte*, 1953, No. 2, pp. 264–270. In German.) Using a specially designed single absorption wall, attenuations up to 170–200 db/m were obtained at certain frequencies in a rectangular air duct 5 cm wide. The average attenuation over a wide frequency band was ∼ 60 db/m. Experimental details are given. The application of the results to air ventilation ducts and similar systems is noted.

534.84 **311**

Directional Distribution and Time Sequence of Sound Reflections in Rooms.—R. Thiele. (*Akust. Beihefte*, 1953, No. 2, pp. 291–302. In German.) The results are reported of comprehensive experiments performed in broadcast studios, theatres and a church, using a fixed omnidirectional sound radiator, and a directional microphone at various points. A formula is given for the 'directional diffusion', which is found from the microphone reception pattern, and has the value 100% for uniform omnidirectional reception; actual values found ranged between 13% and 66%. Oscillograms of short pulses and echoes are shown. The 'definition' of the sound at the microphone was calculated from the ratio between the energy received in the first 50 ms and the total energy received; values between 10% and 90% were found, the latter corresponding to a high intelligibility of speech.

534.846 **312**

The Acoustics of the Royal Festival Hall, London.—P. H. Parkin, W. A. Allen, H. J. Purkis & W. E. Scholes. (*J. acoust. Soc. Amer.*, March 1953, Vol. 25, No. 2, pp. 246–259.) Shortened version of paper noted in 2198 of 1953.

534.851 : 621.317.35 : 621.3.018.78 **313**

Distortion in Phonograph Reproduction.—H. E. Roys. (*RCA Rev.*, Sept. 1953, Vol. 14, No. 3, pp. 397–412.) Reprint. See 2736 of 1953.

621.395.61 **314**

Microphone Sensitivity Conversion.—L. Rosenman. (*Electronics*, Nov. 1953, Vol. 26, No. 11, p. 194.) A chart gives the relation between the values of microphone sensitivity rated according to three different commonly used methods.

621.395.61 : 546.431.824-31 **315**

Broad-Band Directional Barium-Titanate Transducers.—L. Camp. (*J. acoust. Soc. Amer.*, March 1953, Vol. 25, No. 2, pp. 297–301.) Transducers suitable for underwater operation, and having desired directional characteristics, are constructed from arrays of short thin-walled $BaTiO_3$ tubes in a fluid medium.

621.395.61 : 621.395.623.7 **316**

Loudspeaker-Microphones.—H. Gemperle. (*Elektrotech. Z., Edn B*, 21st Aug. 1953, Vol. 5, No. 8, pp. 259–263.) A discussion of the conditions to be satisfied to obtain an electroacoustic transducer operating efficiently in either direction.

621.395.616 **317**

The Sensitivity Limits for a Capacitor Microphone in a Low-Frequency Circuit.—H. Grosskopf. (*Akust. Beihefte*, 1953, No. 2, pp. 279–290. In German.) General relations are derived for the sensitivity of a microphone the dimensions of which are small compared with the wavelength of the highest frequency. The transmission coefficient of the microphone and the noise component of the amplifier input circuit are considered separately. An equivalent circuit-noise level of 10 phon can be attained with a uniform response over the a.f. range.

621.395.616 **318**

New High-Grade Condenser Microphones.—F. W. O. Bauch. (*J. audio Engng Soc.*, July 1953, Vol. 1, No. 3, pp. 232–240.) Reprint. See 1230 of 1953.

621.395.616 : 534.6 **319**

A Capacitive Velocity Pickup for Vibrations of Structures.—K. Tamm & E. Aha. (*Akust. Beihefte*, 1953, No. 2, pp. 270–273. In German.) A pickup with a frequency response level between 20 c/s and 2 kc/s is described. When used in a bridge circuit, operating with a 10-V 1·8-Mc/s input, the velocity sensitivity is 3 V/(m/sec).

621.395.616 : 534.612.2 **320**

Microphones measure High-Intensity Sound.—J. K. Hilliard. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 160–163.) Three different types of capacitor microphone are discussed, suitable for measurement of sound levels in the range 40–220 db referred to 0·0002 dyne/cm². A pistonphone for calibration is described and applications to investigations of industrial, explosion and jet noise are indicated.

621.395.623.75 **321**

An Investigation of the Air Chamber of Horn-Type Loudspeakers.—B. H. Smith. (*J. acoust. Soc. Amer.*, March 1953, Vol. 25, No. 2, pp. 305–312.) A boundary-value treatment leads to the solution of the wave equation for the general case in which the horn throat enters the air chamber in any rotationally symmetrical manner. Special cases are analysed. Design methods for eliminating undesired higher-order modes are discussed.

621.395.625.3 **322**

The Development of a Variable Time Delay.—K. W. Goff. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1578–1584.) A magnetic-drum system for acoustic studies amenable to correlation techniques is discussed. Two recording and reproducing channels are provided by using two tracks; the time difference between them can be varied from − 15 ms to + 190 ms by shifting one of the recording heads. Uniformity of the layer of magnetic material is obtained by spraying the drum with a dispersion of iron oxide. The dependence of the performance on the spacing between the head and the magnetic material is analysed. A flutter-free mechanical drive system is described.

621.395.625.3 **323**

Structure and Performance of Magnetic Transducer Heads.—O. Kornei. (*J. audio Engng Soc.*, July 1953, Vol. 1, No. 3, pp. 225–231.) The influence of various structural features and properties of the materials used on the performance of ring heads is discussed; a particular commercially available head is described.

621.395.625.3 **324**

Studies on Magnetic Recording: Part 3 — The Recording Process. Part 4 — Calculation of the Fields in and around the Tape.—W. K. Westmijze. (*Philips Res. Rep.*, Aug. 1953, Vol. 8, No. 4, pp. 245–269.) Biasing methods and the longitudinal and transverse magnetization of tape are discussed from the experimental and theoretical points of view. Part 2: 9 of January.

621.395.92 **325**

An Electronic Hearing Aid.—P. Blom. (*Philips tech. Rev.*, Aug. 1953, Vol. 15, No. 2, pp. 37–48.) Details are given of a range of models permitting adaptation for various types of hearing defect. A piezoelectric-crystal microphone is used, with the alternative of switching to a pickup coil for direct induction e.g., from a telephone receiver. Automatic volume compression at seven different levels is available. Either a magnetic or a crystal-type earphone is used.

AERIALS AND TRANSMISSION LINES

621.372 **326**

Recent Research on the Transmission of Signals along Metal and Dielectric Lines.—H. Kaden. (*Fernmeldetech. Z.*, Sept. 1953, Vol. 6, No. 9, pp. 432–438.) Theory of propagation along metal and dielectric waveguides and wires is reviewed. Measurements made at λ 12 cm on a 70-m line comprising copper helices with a pitch of 2 cm indicate marked dependence of attenuation on conditions of rain and hail, due to the formation of a nonuniform surface and consequent radiation of energy. See also 908 and 1893 of 1952.

621.372.22 : 621.372.51 **327**

The Hyperbolic Transmission Line as a Matching Section.—H. J. Scott. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1654–1657.) Coaxial-line sections in which the variation of characteristic impedance along the section is represented by a hyperbolic function are relatively insensitive to variations of frequency. The performance of such lines is described in terms of reflection coefficients. Two types are considered; in the one, the characteristic impedance varies as a hyperbolic tangent, in the other the reflection per unit length varies as the square of a hyperbolic secant.

621.372.8 **328**

Propagation of Microwaves through a Cylindrical Metallic Guide Filled Coaxially with Two Different Dielectrics.—S. K. Chatterjee. (*J. Indian Inst. Sci.*, Section B, Jan. 1953, Vol. 35, No. 1, pp. 1–16.) The field components for the TE_{01} modes are derived from Maxwell's equations; the attenuation constant for this mode is then calculated, using the Poynting vector.

621.372.8 **329**

Modification of the Electrical Field Strength in a Rectangular Waveguide excited in the Fundamental H_{10} Mode due to the Introduction of a Current-Carrying Thin Circular Wire.—R. Müller. (*Arch. elekt. Übertragung*, Sept. 1953, Vol. 7, No. 9, pp. 451–457.) The field strength is given by an infinite series involving Hankel functions corresponding to the series of superposed interfering cylindrical waves reradiated by the wire; all but one of these decay very rapidly. The single reradiated wave remaining at a little distance from the wire is of the same type as the primary wave, on which it is superposed. Hence line theory is applicable outside the limited interference region.

621.372.8 **330**

Matching Nonstandard Waveguide Sections.—A. Chlavin. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 192–193.) An experimental procedure is described for designing junctions between waveguides of different types.

621.396.67 **331**

Excitation Coefficients and Beamwidths of Tschebyscheff Arrays.—R. J. Stegen. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1671–1674.) Exact expressions are obtained for the excitation coefficients of a Tchebycheff array by equating the array space factor to a Fourier series whose coefficients are readily calculated. Curves are presented showing the variation of half-power beam width with aerial length for various side-lobe levels. An expression for beam width is derived which is exact for small values of beam width.

621.396.674.3 **332**

Radiation from a Vertical Electric Dipole over a Stratified Ground.—J. R. Wait. (*Trans. Inst. Radio Engrs*, July 1953, Vol. AP-1, No. 1, pp. 9–11.) Expressions are derived for the radiation fields at low frequencies. An 'effective numerical distance' is defined, by means of which numerical data for homogeneous ground can be applied to ground-wave propagation over plane ground with any number of parallel stratifications.

621.396.677.3.029.62 : 523.854.22 : 621.396.822 333
The Distribution of the Discrete Sources of Cosmic Radio Radiation.—B. Y. Mills. (*Aust. J. sci. Res., Ser. A*, June 1952, Vol. 5, No. 2, pp. 266–287.) The outputs from two coplanar 101-Mc/s beam aerials, 60 m or 270 m apart, were combined and recorded, the output of one aerial being reversed at 25 c/s. The aerials, each of which consisted of 24 end-fed half-wave dipoles and a similarly constructed reflector, could be tilted about an *E-W* horizontal axis. 77 sources were observed and recorded.

621.396.677.71 334
Traveling-Wave Slot Antennas.—J. N. Hines, V. H. Rumsey & C. H. Walter. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1624–1631.) The travelling-wave slot aerial may be considered as an array of $\lambda/2$ slot aerials, but is sometimes easier to design and construct than such an array. Four types are distinguished according to the mode of the wave propagated; two of these are hybrid types, giving end-fire operation. Measured propagation constants for aerials of various shapes are shown graphically. Control of radiation pattern by variation of the slot width along the aerial is discussed. A design technique is described by means of which the pattern can be predicted exactly from measurements of individually excited array elements.

621.396.677.833.2.029.64 335
A New Wide-Angle Microwave Reflector.—K. S. Kelleher. (*Tele-Tech*, June 1953, Vol. 12, No. 6, pp. 98–99 . . 169.) The characteristics and the applications of an X-band wide-angle and a medium-angle parabolic torus reflector are compared with those of the paraboloid type. The applications include simultaneous reflection of a number of beams for controlling a number of remote stations, and a marine-navigation radar scanner.

621.396.677.85 336
A Two-Dimensional Microwave Luneberg Lens.—G. D. M. Peeler & D. H. Archer. (*Trans. Inst. Radio Engrs*, July 1953, Vol. AP-1, No. 1, pp. 12–23.) Detailed description of the design and performance of a lens aerial for radar scanning. Design is based on TE$_{10}$-mode propagation by nearly parallel plates. The space between two conducting plates, of diameter 36 in., is filled with polystyrene, the thickness of which varies with the normalized radius, r, to give the desired refractive index $n = \sqrt{2 - r^2}$. The lens maintains constant gain and beam shape throughout the scan, with side-lobe level at least 18 db below peak power. A 360° scan can be effected using peripheral flares on the plates. The stacking of lenses to concentrate the beam is investigated.

AUTOMATIC COMPUTERS

681.142 337
Application Factors for Electrical Resolvers.—S. Davis. (*Elect. Mfg*, March 1953, Vol. 51, No. 3, pp. 128–133 . . 328.) The device described resembles a small motor and was originally designed for solving trigonometry problems in conjunction with analogue computers. Possible applications for control purposes in industry are discussed.

681.142 338
Magnetic Drum Design.—D. G. O'Connor. (*Electronics*, Nov. 1953, Vol. 26, No. 11, p. 196.) A chart relates the various parameters involved.

681.142 339
Step-Switch Converter Digitizes Analog Data.—R. R. Bennett & H. Low. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 164–165.)

CIRCUITS AND CIRCUIT ELEMENTS

621.314.2 340
Review of New Materials and Techniques in High-Fidelity Transformer Design.—L. W. Howard. (*J. audio Engng Soc.*, July 1953, Vol. 1, No. 3, pp. 265–267.)

621.314.7 : 621.375.4 341
Transistors: Theory and Application: Part 9—Grounded Emitter and Collector Circuits.—A. Coblenz & H. L. Owens. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 166–172.) Formulae and typical values of parameters are tabulated for various circuit arrangements for junction and point-contact transistors. Part 8: 283 of January.

621.314.7 : 621.375.4.015.3 342
Transient Analysis of Transistor Amplifiers.—W. F. Chow & J. J. Suran. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 189–191.) See 3513 of 1953.

621.316.86 : [537.311.32 + 621.396.822 343
The Electrical Conductivity and Current Noise of Carbon Resistors.—I. M. Templeton & D. K. C. MacDonald. (*Proc. phys. Soc.*, 1st Aug. 1953, Vol. 66, No. 404B, pp. 680–687.) The variation of resistance with temperature, pressure, and magnetic field in several types of carbon resistor was measured down to liquid-He temperatures. The dependence of the noise spectrum on the current intensity, temperature and magnetic field was also investigated; the $1/f$ law holds at all temperatures.

621.316.923 344
Basic Fuse Types for Electronic Equipment.—E. V. Sundt & A. J. Steele. (*Elect. Mfg*, April 1953, Vol. 51, No. 4, pp. 144–146, 366.) Types with slow, medium and fast action are described.

621.318.4 : 621.318.134 345
Tolerances and Temperature Coefficient of Coils with Ferroxcube Slugs.—H. van Suchtelen. (*Electronic Applic. Bull.*, Jan./Feb. 1953, Vol. 14, Nos. 1/2, pp. 27–32.) Extension of a previous discussion (939 of 1953). From the point of view of insensitivity to variations of core permeability and of temperature, the closed core with air-gap is best, the rod core with long coil next, and the rod core with short coil worst. See also 3636 of 1953.

621.318.42 346
A Variable Inductor.—R. E. Allison. (*J. audio Engng Soc.*, July 1953, Vol. 1, No. 3, pp. 262–264.) An a.f. inductor is described in which core hysteresis effects are eliminated, the inductance being controlled by moving a magnet in relation to the cores. Q values > 100 at 1 kc/s and > 30 at 100 c/s are possible. Experimental filters using the inductors are also described.

621.318.5 347
Current Trends in Miniature Relay Design.—I. S. Mayer. (*Elect. Mfg*, Feb. 1953, Vol. 51, No. 2, pp. 135–137 . . 364.) Design of relays for airborne electronic equipment is discussed.

621.318.572 348
The Optimum D.C. Design of Flip-Flops.—D. K. Ritchie. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1614–1617.) A simple criterion is derived by means of which it can immediately be seen whether or not a flip-flop circuit corresponding to specified requirements is realizable. A numerical example is given.

621.318.572 : 621.385.832 349
The E1T Decade Counter Tube.—(See 603.)

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621.318.572 : 621.387 **350**

Polycathode Counter-Tube Applications.—J. H. L. McAuslan & K. J. Brimley. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 138–141.) The use of dekatrons in millisecond timers, batching counters and c.r.o. time markers is described. The basic decade units are capable of counting up to 20 000 per sec. See also 3485 of 1952 and 771 of 1953 (McAuslan).

621.372 **351**

A Method of Approximate Steady-State Analysis for Non-Linear Networks.—G. R. Slemon. (*Proc. Instn elect. Engrs*, Part I, Sept. 1953, Vol. 100, No. 125, pp. 275–287.) Approximate solutions for the fundamental and third harmonic are obtained by a three-stage method involving (*a*) a first approximation to the fundamental-frequency solution, usually accurate to within 10%, (*b*) a third-harmonic solution (generally within 15%) using an equivalent circuit which is dependent on the first fundamental solution, (*c*) a correction to the fundamental solution, using third-harmonic quantities, which brings its accuracy to within about 3%. Adaptations of some standard techniques of solving linear steady-state problems for use with this method of analysis are described. Appendix by G. H. Rawcliffe.

621.372.41 : 621.396.822 **352**

Effective Circuit Bandwidth for Noise with a Power-Law Spectrum.—P. R. Karr. (*J. Res. nat. Bur. Stand.*, Aug. 1953, Vol. 51, No. 2, pp. 93–94.) Analysis is developed for a tuned *RLC* circuit, for noise with a frequency spectrum given by an arbitrary power law. The effective bandwidth is presented in terms of that for white noise.

621.372.412 **353**

The Piezoelectric Oscillations of a Quartz Crystal at its Odd, Even and Half-Odd Harmonics.—S. Parthasarathy, M. Pancholy & A. F. Chhapgar. (*Ann. Phys., Lpz.*, 16th April 1953, Vol. 12, Nos. 1/3, pp. 1–7. In English.) The results reported in *J. sci. industr. Res.*, 1944, were confirmed by observing the diffraction patterns of the oscillating quartz. See also 1619 of 1953.

621.372.412 : 621.373.421.13.029.4 **354**

Flexure Mode Quartz Oscillators.—N. J. Beane & R. C. Richards. (*Marconi Rev.*, 4th Quarter 1953, Vol. 16, No. 111, pp. 141–168.) Details are given of the modes of motion, electrode arrangements and electrical performance of the duplex, *XY* and *NT* types. Typical frequency/temperature curves and graphs of other crystal characteristics are shown. A crystal-controlled a.f. oscillator is described and the circuit diagram, including component values, is given.

621.372.5.012.029.6 **355**

Loci-Curve Theory applied to High-Frequency Networks.—E. Schelisch. (*Marconi Rev.*, 4th Quarter 1953, Vol. 16, No. 111, pp. 169–183.) The application of the method is shown for the evaluation of such response curves of four-terminal networks as are produced by the variation of one parameter. Examples are given of the calculation of (*a*) a wide-band thermistor mount, using a rectangular admittance chart, and (*b*) the variation of the input reflection coefficient with frequency of a given transformer, using a Smith chart.

621.372.51.012.3 : 621.396.67 **356**

Antenna-Matching Network Efficiency.—R. L. Tanner. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 142–143.) Charts are presented for estimating the transfer efficiency of matching networks.

621.372.54 **357**

Conformal Mappings for Filter Transfer Function Synthesis.—G. L. Matthaei. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1658–1664.) Conformal mapping provides a practical way of solving the e.s.-potential problems previously considered (1611 of 1953). Analysis in the mapped plane also yields convenient methods for predetermining the number of poles and zeros required to meet given design specifications.

621.372.54 **358**

Theory of Maximally Flat and Quasi-Tchebycheff Filters.—F. S. Atiya. (*Arch. elekt. Übertragung*, Sept. 1953, Vol. 7, No. 9, pp. 441–450.) The synthesis of a quadripole with a prescribed attenuation function is described. This function has to satisfy certain conditions. The synthesis is carried out for maximally flat and quasi-Tchebycheff low-pass filters, the results being presented in curves suitable for calculating the values of the circuit components. The treatment is extended to band-pass filters by means of a well-known frequency transformation.

621.372.54 **359**

***RLC* Lattice Networks.**—L. Weinberg. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, p. 1667.) Correction to paper noted in 3535 of 1953.

621.372.543.2 **360**

Band-Pass Filters.—F. S. Atiya. (*Wireless Engr*, Dec. 1953, Vol. 30, No. 12, pp. 307–311.) A method is presented for synthesizing constant-resistance networks to have maximally flat or Tchebycheff-type response characteristics. A numerical example of each type is calculated.

621.372.543.2 : 621.397.61 **361**

High-Frequency-Filter Problems in Television Transmitters.—W. Burkhardtsmaier. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, 1953, Vol. 5, Nos. 7/8, pp. 150–154.) Coaxial-line filters for the partial suppression of the lower sideband are discussed. Particular attention is paid to arrangements suitable for high-level modulation, in which the filter is spatially separated from the output stage and its input impedance is maintained constant over the frequency band.

621.373.4 : 621.316.726 **362**

Electrical Control of Valve-Transmitter Frequency by means of an Electrodeless Gas Discharge.—B. Koch. (*Z. angew. Phys.*, Aug. 1953, Vol. 5, No. 8, pp. 292–294.) The tuned-circuit inductor of an oscillator was wound round an argon-filled cylindrical container, in which an electrodeless discharge could be maintained. The oscillator frequency was nearly linearly proportional to the anode voltage and was also dependent on the gas pressure. See also 90 of January (Koch & Neuert).

621.373.4 : 621.396.822 **363**

Noise Properties of *LC* Oscillators.—J. van Slooten. (*Electronic Applic. Bull.*, March/April 1953, Vol. 14, Nos. 3/4, pp. 33–39.) Previous analyses based on the concepts of (*a*) forced oscillations [362 of 1953 (Lerner)] and (*b*) disturbed free oscillations (2940 of 1953) are discussed; the extent of the a.m. and the f.m. resulting from the presence of noise is examined.

621.373.421 **364**

Pseudoresonant and Phase-Shifting Quadripoles as Frequency-Determining Elements in *RC* Oscillators.—R. Hennicke. (*NachrTech.*, Aug. 1953, Vol. 3, No. 8, pp. 354–358.) *RC* oscillators with a sinusoidal output are divided into two main groups, according to the type of *RC* network they include. Equivalent circuits are obtained and simple expressions are derived for the frequency of stable oscillation and for the condition for self-excitation.

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621.373.421.1 : 621.385.3 **365**

Theory of Triode Oscillators with Coaxial Resonators.—E. Hauri. (*Bull. schweiz. elektrotech. Ver.*, 22nd Aug. 1953, Vol. 44, No. 17, pp. 761–768.) A study of disk-seal-triode oscillators. The conditions necessary for maintaining oscillations are derived. The width of the frequency range with a fixed-tuned grid circuit is calculated from the valve parameters; deviations from the theoretical value encountered under working conditions are discussed. A general criterion for mode separation is established. 35 references.

621.373.43 **366**

Pulse Generator with Variable Repetition Frequency and Pulse Width.—H. Spalding & W. Vogt. (*Fernmeldetech. Z.*, Sept. 1953, Vol. 6, No. 9, pp. 428–431.) An instrument designed around the EQ40 nonode valve is described; the principle of operation is that of the 'ϕ-detector' [505 of 1950 (Jonker & van Overbeek)]. The pulse-repetition frequency can be varied between 50/sec and 20 000/sec (or higher), the duty factor from 0 to 50% and the amplitude from 0 to 100 V. The pulse flank occupies $<$ 0·2% of the pulse period. P.a.m., p.w.m. and p.ph.m. can be used. A complete circuit diagram, including component values, is given.

621.375.2 : 621.385.15 **367**

Wide-Band Amplifiers using Secondary-Emission Tubes.—C. H. Chandler & G. D. Linz. (*RCA Rev.*, Sept. 1953, Vol. 14, No. 3, pp. 367–378.) The applications of an experimental valve, particularly at v.h.f., in r.f. or i.f. amplifiers, c.r.-tube deflection amplifiers and distributed amplifiers are described and discussed. The transconductance of this valve is 15mA/V, the input and output capacitances are 6·3 pF and 4·8 pF respectively, and the sum of anode and screen currents is 15·7 mA. The valve construction has been described by Mueller (1814 of 1950).

621.375.2.024 **368**

A Method for the Amplification of Extremely Small Thermoelectric Voltages.—W. Kroebel. (*Z. angew. Phys.*, Aug. 1953, Vol. 5, No. 8, pp. 286–291.) A more detailed account of the d.c. amplifier noted in 2276 of 1953 is given. The threshold voltage is $\sim 1\cdot5 \times 10^{-9}$ V, with a source impedance of $\sim 10\,\Omega$. A circuit diagram including component values is given.

621.375.2.029.62 + 621.385.3] : 621.396.822 **369**

Noise Factor of Conventional V.H.F. Amplifiers.—N. Houlding. (*Wireless Engr*, Nov. & Dec. 1953, Vol. 30, Nos. 11 & 12, pp. 281–290 & 299–306.) A simple treatment is presented; the various types of circuit and valve noise are indicated, the concept of available power is explained, and noise factor is defined in terms of available power gain. Analysis is given for triode input stages based on common-cathode, common-grid and common-anode connections. Experimental results are given for various amplifiers for a mid-band frequency of 45 Mc/s. Curves show the effect of source resistance on the mid-band noise factor and the variation of single-frequency noise factor over the band, and results are also tabulated for different valves and circuits. The best noise factor with a given valve can only be determined experimentally. The need for further improvement in the noise performance of valves is emphasized.

621.375.23.029.3 **370**

Multiple-Feedback Audio Amplifier.—J. M. Diamond. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 148–149.) The power output of the Williamson circuit is increased and the power-supply requirements reduced by using tetrode output valves with anode-to-grid feedback. See also 3387 of 1952 (Williamson & Walker).

621.375.232.4 **371**

Stability of a Grounded-Grid Amplifier.—W. P. Mundrashi. (*NachrTech.*, Aug. 1953, Vol. 3, No. 8, pp. 345–348. German translation of an article in *Radiotekhnika, Moscow*, 1951, Vol. 6, No. 2, pp. 64–71.) The general conditions are investigated for the self-excitation of u.h.f. grounded-grid amplifiers. The precise formula and an approximate one for the frequency, and the condition for self-excitation, are derived. The dependence of the stability of the amplifier on circuit constants is considered; the results are shown graphically.

621.375.3 **372**

Methods of Magnetic Amplifier Analysis.—L. A. Finzi & G. F. Pittman, Jr. (*Elect. Engng, N.Y.*, Aug. 1953, Vol. 72, No. 8, pp. 690–694.)

621.376.56 **373**

P.C.M. Coding System uses Special Tubes.—A. G. Fitzpatrick. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 173–175.) The system uses a ten-target ribbon-beam switching tube for sampling and a tube with ten stable positions determined by crossed electric and magnetic fields for coding. Descriptions of tubes and circuit are given.

621.396.6 **374**

Printed Circuits: Some General Principles and Applications of the Foil Technique.—P. Eisler. (*J. Brit. Instn Radio Engrs*, Nov. 1953, Vol. 13, No. 11, pp. 523–538. Discussion, pp. 538–541.) Methods of producing printed circuits are discussed from the viewpoint of the printer; the foil technique is suitable for both general and special applications. The main processes involved, namely printing, etching, fusing, mechanical patterning, transfer and multilayer technique, are described. Various characteristics of foil conductors are examined and some particular applications are indicated.

621.396.822 **375**

Johnson Noise and Equipartition.—D. A. Bell. (*Proc. phys. Soc.*, 1st Aug. 1953, Vol. 66, No. 404B, pp. 714–715.) Discussion on 2847 of 1953 (Lindsay & Sims).

GENERAL PHYSICS

535.233 **376**

The Value of the Constant in Wien's Displacement Law.—A. H. Boerdijk. (*Philips Res. Rep.*, Aug. 1953, Vol. 8, No. 4, pp. 291–303.) The observed value of the wavelength at which maximum radiation occurs for a black body at a given temperature depends on the band-pass characteristics of the instrument used; as a consequence, Wien's constant can assume different values.

535.376 **377**

Demonstration of Electroluminescence by means of a Multilayer Colour Film.—G. Wendel. (*Ann. Phys., Lpz.*, 2nd July 1953, Vol. 12, Nos. 4/6, pp. 222–226.) Contact photographs were made of electroluminescence effects in a ZnO, ZnS-Cu phosphor, at field strengths of 10–100 kV/cm and a frequency of 50 c/s. The results indicate a direct excitation process, without the intermediate step of a gas discharge.

535.42 **378**

The Diffraction of an Arbitrary Pulse by a Wedge.—I. Kay. (*Commun. pure appl. Math.*, Aug. 1953, Vol. 6, No. 3, pp. 419–434.) An extension of the conical-flow method used by Keller & Blank (2963 of 1951). The coordinates chosen are such that the characteristic cone and the two planes intersecting to form the wedge each become constant coordinate surfaces. The problem is then solved by separating variables and expanding the boundary conditions in terms of solutions of the ordinary differential equations which appear. The results are shown to apply to the special case investigated by Keller & Blank.

535.42 : 538.566 **379**

Theory of Diffraction of Electromagnetic Waves at a Perfectly Conducting Disk, and Related Problems.—J. Meixner. (*Ann. Phys., Lpz.*, 2nd July 1953, Vol. 12, Nos. 4/6, pp. 227–236.) The problem considered in 2767 of 1950 (Meixner & Andrejewski) for plane e.m. waves is solved generally for the case of spherical waves. Particular solutions are also obtained for the diffraction at an ellipsoid of revolution for a solenoidal e.m. field. A method for the numerical solution is outlined for the case of diffraction at a disk, at a circular aperture and at an ellipsoid of revolution, valid for $\lambda > 0{\cdot}6a$ approximately, where a is the radius or half the distance between the foci, as appropriate.

535.43 : 538.566 **380**

Scattering of Electromagnetic Waves at an Uneven Surface.—Yu. P. Lysanov. (*C. R. Acad. Sci. U.R.S.S.*, 11th Dec. 1952, Vol. 87, No. 5, pp. 719–722. In Russian.) Scattering of waves incident at an angle such that no part of the surface is in a shadow is considered theoretically. Application of the results to two particular cases shows that surfaces of a trochoidal form will give appreciably greater backscatter than a sinusoidal surface of the same 'amplitude' and 'wavelength'.

537.311.33 : 537.311.1 **381**

The Theory of Electronic Conduction in Polar Semiconductors.—D. J. Howarth & E. H. Sondheimer. (*Proc. roy. Soc. A*, 11th Aug. 1953, Vol. 219, No. 1136, pp. 53–74.) The present problem has been considered before by several authors [e.g., Wright (1577 of 1952)], but many of the results which have been given are either incorrect or only correct within certain limits. By solving the Boltzmann equation for the velocity distribution function of the conduction electrons in a crystal in which the scattering is due to the polarization waves of the lattice, exact expressions are obtained for the electrical conductivity and the thermoelectric power in the form of ratios of infinite determinants. Simple approximate solutions are derived and are used in the discussion of the dependence of conduction phenomena upon the temperature and upon the degree of degeneracy of the electron gas.

537.311.62 **382**

The Transient Period of the Skin Effect.—D. Zanobetti. (*R. C. Accad. naz. Lincei*, June 1953, Vol. 14, No. 6, pp. 791–795.) Analysis is given for the distribution of current in cylindrical conductors (solid or hollow) during the period between application of a voltage and attainment of a steady state.

537.311.62 **383**

Impedance of Solid and Hollow Cylindrical Conductors to Current Pulses.—D. Zanobetti. (*R. C. Accad. naz. Lincei*, Sept./Oct. 1953, Vol. 15, Nos. 3/4, pp. 200–202.) Continuation of work noted in 382 above. A quantitative solution is obtained for the initial value of the ratio between the instantaneous voltage and current.

537.52 **384**

Electrical Discharges.—F. L. Jones. (*Rep. Progr. Phys.*, 1953, Vol. 16, pp. 216–265.) Recent work on electrical discharges is surveyed under the following headings:—the breakdown of gases in static fields; high-frequency discharges; cold-emission phenomena; the regime of space charges. Breakdown is regarded as a consequence of the development of pre-breakdown ionization currents by primary and secondary processes which are themselves controlled by the nature and geometry of the cathode. The important part played by surface films in the cold extraction of electrons from electrodes is described. R.f. plasma oscillations and the generation of noise by discharges is discussed. 216 references.

537.523.4 : 537.533 **385**

Fundamental Processes of the Initiation of Electrical Discharges.—C. G. Morgan & D. Harcombe. (*Proc. phys. Soc.*, 1st Aug. 1953, Vol. 66, No. 404B, pp. 665–679.) The production of electrons initiating the spark discharge from polished and tarnished metal surfaces was investigated. The field applied was of the order of 10^5 V/cm.

537.533 : 537.534.8 **386**

Electron Emission resulting from the Impact of Ions on Molybdenum and Carbon Targets.—G. Philbert. (*C. R. Acad. Sci., Paris*, 19th Oct. 1953, Vol. 237, No. 16, pp. 882–883.) Experiments were made using normally incident polyatomic ions of energy between 1 and 2 keV. The number and energy distribution of the emitted electrons did not depend on the target material. The energy distribution of the electrons was independent of the nature and energy of the incident ions, but the number of electrons emitted per ion increased with the energy of the ions and depended on the nature of the ions.

538.3 : 537.122 **387**

A Variational Formulation of the Multi-stream Electrodynamic Field Equations.—P. N. Butcher. (*Phil. Mag.*, Sept. 1953, Vol. 44, No. 356, pp. 971–979.) "A non-relativistic approximation to Dirac's new variational formulation of the single-stream electrodynamic field equations is presented using 3-vector notation and m.k.s. units throughout. The Hamilton-Jacobi theory of a rotational space charge stream is developed. The variational formulation is generalized to the multi-stream case—both for a finite number and a non-denumerably infinite number of streams."

538.52 **388**

Induction Phenomena consequent on the Movement of Material in Primary Magnetic Fields, and their Experimental Applications: Part 2 — Translation.—H. Hinteregger. (*Acta phys. austriaca*, May 1953, Vol. 7, No. 2, pp. 129–145.) The Minkowski field equations are presented in a form to suit the particular conditions. A definition is given of apparent dielectric constant. Sommerfeld's treatment of unipolar induction is extended to magnetizable bodies. Unipolar induction in the case of translational motion is identified with e.s. induction in the material at rest. Part 1: 118 of January.

538.561 : 537.523.5 **389**

The Hissing Arc and Radio-Frequency Self-Generated Oscillations in the D.C. Carbon Arc.—B. H. List & T. B. Jones. (*Elect. Engng, N.Y.*, Aug. 1953, Vol. 72, No. 8, pp. 683–686.)

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523 : 621.396.822 **390**

Radio Astronomy: Part 1 — Methods of Observation.—W. Dieminger. (*Arch. elekt. Übertragung*, Sept. 1953, Vol. 7, No. 9, pp. 421–427.) Theory and technique of methods of observing extraterrestrial sources of r.f. radiation are reviewed.

523.72 : 621.396.822 **391**

Evidence of Harmonics in the Spectrum of a Solar Radio Outburst.—J. P. Wild, J. D. Murray & W. C.

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Rowe. (*Nature, Lond.*, 19th Sept. 1953, Vol. 172, No. 4377, pp. 533–534.) Measurements of r.f. outbursts on November 21, 1952, and May 5, 1953, show a dynamic spectrum comprising two widely spaced frequency bands having a drift with time from high to low frequencies. The ratio between frequencies of corresponding peaks was close enough to 2 to suggest a harmonic relation between the bands. The emission may take place in the corona at frequencies equal to the natural plasma frequency and its harmonics.

523.752 : 523.72 : 621.396.822 **392**

Radio Observations at the Time of an Ascending Solar Prominence.—R. D. Davies. (*Nature, Lond.*, 5th Sept. 1953, Vol. 172, No. 4375, pp. 447–448.) The solar prominence reported by Das & Sethumadhavan (393 below) was observed in Sydney, and records of radiation on 62, 98, 200, 600, 1 200, 3 000 and 9 400 Mc/s were obtained. Noise bursts preceding and following the eruption were also recorded.

523.752 : 621.396.822 **393**

Eruptive Prominence of February 26, 1953, and Associated Radio Noise-Burst.—A. K. Das & K. Sethumadhavan. (*Nature, Lond.*, 5th Sept. 1953, Vol. 172, No. 4375, pp. 446–447.) Three bursts of noise associated with the prominence were recorded at Kodaikanal, with a radio telescope working on 100 Mc/s. These occurred when the topmost parts of the prominence were at about 50 000, 140 000 and 184 000 km respectively above the limb, though present-day theory indicates that at 100 Mc/s radiation cannot ordinarily escape from the sun unless generated at a height > 100 000 km. No active sunspot group was observed in the vicinity of the prominence.

523.8 : 621.396.822 **394**

Radio Radiation from the Supergalaxy.—J. D. Kraus & H. C. Ko. (*Nature, Lond.*, 19th Sept. 1953, Vol. 172, No. 4377, pp. 538–539.) A low-intensity source was observed in March 1953 on 250 Mc/s with position corresponding approximately to the plane of the local supergalaxy described by de Vaucouleurs.

523.85 : 621.396.822 **395**

The Galaxy Explored by Radio Waves.—H. C. van de Hulst. (*Observatory*, Aug. 1953, Vol. 73, No. 875, pp. 129–139.) The full text of the Halley Lecture for 1953. This includes a short account of radio astronomy and of the results of observations made at 21·1049 cm and other wavelengths.

523.852.21 : 621.396.822 **396**

A Search for Radio Emission from the Orion Nebula.—J. E. Baldwin. (*Observatory*, Aug. 1953, Vol. 73, No. 875, pp. 155–157.) Short report of interferometer observations at a frequency of 210 Mc/s.

523.854 : 621.396.822.029.55/.63 **397**

A Model of the Radio-Frequency Radiation from the Galaxy.—R. H. Brown & C. Hazard. (*Phil. Mag.*, Sept. 1953, Vol. 44, No. 356, pp. 939–963.) The model has been designed to give agreement both with the observed values of equivalent aerial temperature and with the observed isophotes over the frequency range 18·3 Mc/s–1·2 kMc/s. The actual mechanism of generation of radio energy is not discussed.

523.854.22 : 621.396.822 : 621.396.677.3.029.62 **398**

The Distribution of the Discrete Sources of Cosmic Radio Radiation.—Mills. (See 333.)

550.38 **399**

The South Magnetic Pole in 1952 and the Comparative Displacements of the North and South Poles from 1842 to 1952.—P. N. Mayaud. (*Ann. Géophys.*, July/Sept. 1953, Vol. 9, No. 3, pp. 266–276.)

550.38 **400**

Recording the Geomagnetic Field at Port Martin.—P. N. Mayaud. (*Ann. Géophys.*, July/Sept. 1953, Vol. 9, No. 3, pp. 256–265.) The records were obtained by the Adélie Land expedition during the period April 1951–January 1952. Details are given of methods and results.

550.384 : 621.317.7 **401**

Electromagnetic Variometer for the Vertical Component [of the geomagnetic field].—I. Özdogan. (*Ann. Géophys.*, April/June 1953, Vol. 9, No. 2, pp. 161–163.) An instrument for studying rapid field variations is described; it operates on the same principles as the electromagnetic seismograph.

551.510.534 : 523.38 **402**

Further Determinations of the Vertical Distribution of Ozone during Eclipses of the Moon.—H. K. Paetzold. (*Z. Naturf.*, May 1952, Vol. 7a, No. 5, pp. 325–328.)

551.510.535 **403**

Propagation Measurements in the Ionosphere with the Aid of Rockets.—J. C. Seddon. (*J. geophys. Res.*, Sept. 1953, Vol. 58, No. 3, pp. 323–335.) Measurements made at White Sands are reported. Continuous waves with harmonically related frequencies, namely 4·274 and 25·644 Mc/s, were radiated from the rocket to two ground stations. The higher-frequency wave is practically unaffected by the E layer, and serves as a reference. The ordinary and extraordinary components of the lower-frequency wave, with frequency multiplied by 6, are separately heterodyned with the reference wave. The refractive indices of the medium are determined from the resulting beat frequencies together with a determination of the geomagnetic field and of the electron collision frequency at one altitude; the Lorentz polarization term can be neglected. Results are given and discussed.

551.510.535 **404**

The Reflection Coefficient of the Long Wave.—T. Sato. (*Rep. Ionosphere Res. Japan*, June 1953, Vol. 7, No. 2, pp. 69–70.) The propagation equation is solved and the reflection coefficient deduced for long waves incident vertically on a region of low electron concentration such as that situated below the E layer. Results are given for two cases based on different assumptions regarding the vertical gradient of concentration; comparison of these calculated results with observations on 16-kc/s and 150-kc/s waves indicates that there is a considerable gradient of electron concentration in the layer.

551.510.535 **405**

Dissociative Recombination in the E Layer.—E. Gerjuoy & M. A. Biondi. (*J. geophys. Res.*, Sept. 1953, Vol. 58, No. 3, pp. 295–303.) An examination is made of the consequences of assuming that electrons in the E layer disappear mainly by dissociative recombination. It is shown that this assumption provides a far more satisfactory basis for explaining actual E-layer observations than ion-ion recombination, and that most of the atomic processes involved are amenable to accurate laboratory measurement.

551.510.535 **406**

Ionosphere Observations in the Kerguelen Islands.—J. Le Gall, B. Mongin & H. Munier. (*C. R. Acad. Sci., Paris*, 19th Oct. 1953, Vol. 237, No. 16, pp. 927–928.) An ionosphere station has been established by the S.P.I.M. at Port aux Français (49·6°S, 70°E); regular observations started in February 1953. Monthly mean

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values of f_0F_2 and f_0E_s for six months are tabulated; the results demonstrate the great influence of the geomagnetic field.

551.510.535 **407**

Some Regularities of the Ionospheric F Region.—B. Chatterjee. (*J. geophys. Res.*, Sept. 1953, Vol. 58, No. 3, pp. 353–362.) The F_2-layer regularities observed by Ratcliffe (1294 of 1952) are confined to a few stations only, and disappear when the bifurcation of the F layer is large. If the ion content of the F_1 and F_2 layers is considered as a whole, the regularities become much more marked and are observed at Slough, Falkland Islands and Singapore, even when the bifurcation is large. Peaks observed in the monthly mean values are attributed to tidal effects. The results are in conformity with the view that the F_1 and F_2 layers constitute a single ionization region.

551.510.535 : 525.624 **408**

Lunar Tidal Variations in the Sporadic-E Region.—S. Matsushita. (*Rep. Ionosphere Res. Japan*, June 1953, Vol. 7, No. 2, pp. 45–52.) Lunar tidal variations in the E_s layer are deduced from a statistical study of records from various stations. The maximum amplitude of the lunar semidiurnal variation of fE_s for a period of a year resembles that of the F_2 layer; in summer it is larger than that of the F_2 layer, especially in middle latitudes. The magnitude of the height variation is similar to that of the F_1 layer. The maximum height variation occurs about six hours after the lunar culminations, and the maximum value of fE_s two or three hours later. Possible explanations of the phenomena are discussed.

551.510.535 : 550.384 **409**

The Distribution of the Ionospheric Disturbances during the Geomagnetic Bay.—H. Kamiyama. (*Rep. Ionosphere Res. Japan*, June 1953, Vol. 7, No. 2, pp. 70–71.) A statistical analysis based on ionospheric data obtained at 35 widely distributed stations.

551.510.535 : 550.384 **410**

On a Change in Geomagnetic Declination accompanying Intense Sporadic-E-layer Ionization.—H. Hojo & T. Yonezawa. (*Rep. Ionosphere Res. Japan*, June 1953, Vol. 7, No. 2, pp. 61–67.) Analysis of geomagnetic and ionospheric data obtained at Kakioka and Kokubunji respectively indicate that the geomagnetic declination exhibits increased diurnal variation a few hours after the appearance of an intense E_s layer. It is inferred that the E_s-layer ionization is probably due to the incidence of particles.

551.510.535 : 551.594.12 **411**

A Procedure for the Determination of the Vertical Distribution of the Electron Density in the Ionosphere.—D. H. Shinn. (*J. geophys. Res.*, Sept. 1953, Vol. 58, No. 3, pp. 416–418.) Comment on 409 of 1953 (Kelso). See also 1997 of 1953 (Manning).

551.510.535 : 621.396.11 **412**

Optic Axes and Critical Coupling in the Ionosphere.—N. Davids. (*J. geophys. Res.*, Sept. 1953, Vol. 58, No. 3, pp. 311–321.) The similarity between the phenomena of double refraction in crystals and in the ionosphere is discussed [2868 of 1952 (Lange-Hesse)]. The ionosphere problem is studied by introducing a reference system based on the principal directions of the three-dimensional dielectric ellipsoid; these depend only on the direction of the earth's field, and are essentially constant over the ionosphere. Optic axes can exist in the ionosphere in the presence of collisions, and this is precisely the condition for critical coupling between the ordinary and extraordinary modes. The analysis is illustrated by reference to a possible set of ionospheric conditions.

551.578.1 : 551.594.25 **413**

Raindrop Charge and Electric Field in Active Thunderstorms.—R. Gunn & C. Devin, Jr. (*J. Met.*, Aug. 1953, Vol. 10, No. 4, pp. 279–284.) Measurements on over 7 000 drops are reported; the average charge was 0·022 e.s.u. for positively charged drops and 0·031 e.s.u. for negatively charged drops.

551.578.4 : 551.594.6 **414**

On the Electrification of Snow.—H. Norinder & R. Siksna. (*Tellus*, Aug. 1953, Vol. 5, No. 3, pp. 260–268.) An account is given of experimental investigations of the charging produced by (*a*) pouring snow from a vessel into a funnel, and (*b*) blowing snow on to an insulated target. The results are relevant to problems of precipitation static.

551.578.7 : 621.396.96 **415**

Radar Echoes from a Growing Thunderstorm.—R. Wexler. (*J. Met.*, Aug. 1953, Vol. 10, No. 4, pp. 285–290.) The growth of hail in cumulus clouds is studied theoretically in relation to the first appearance of radar echoes. The results are in good agreement with earlier observations.

551.594.5 **416**

Auroral Radio-Echo Table and Diagram for a Station in Geomagnetic Latitude 56°.—J. C. Cain. (*J. geophys. Res.*, Sept. 1953, Vol. 58, No. 3, pp. 377–380.)

551.594.5 : 621.396.822 **417**

Radio Noise from Aurora.—R. P. Chapman & B. W. Currie. (*J. geophys. Res.*, Sept. 1953, Vol. 58, No. 3, pp. 363–367.) Failure of attempts made during 1951 and 1952 to detect 10-cm auroral radiation observed in 1949 [3139 of 1949 (Forsyth et al.)] is attributed to the decreased intensity of auroral displays and of sunspot activity.

551.594.6 : 551.555.6 **418**

Electrical Properties of the Blizzard.—M. Barré. (*Ann. Géophys.*, April/June 1953, Vol. 9, No. 2, pp. 164–183.) The programme of the 1951 expedition to Adélie land was not intended to cover the study of blizzards, but the interference with radio reception due to this cause was found to be so bad that an investigation was instituted. When a meter was connected between the aerial feeder of the atmospherics receiver and earth, a current of 30–50 μA was observed, varying with the intensity of the wind; some days later, in identical weather conditions, the same current intensities were measured, but with reversed sign. To explain this result, extended measurements were made of the charge collected, using horizontal aerials arranged at right angles to the wind. The r.f. noise spectrum of the blizzard was also studied, using a receiver with a frequency range of 4–15 Mc/s. Records were also made of reception of WWV and WWVH on 5, 10, 15 and 20 Mc/s, for correlation with anemometer and charge records. The results indicate that the sign of the charge collected depends on the temperature of the blizzard, reversal occurring at about − 15°C. The r.f. noise is closely related to the wind and intensity of the blizzard.

551.594.6 : 621.396.11 **419**

Audio-Frequency Spectrum of Atmospherics.—F. W. Chapman & W. D. Matthews. (*Nature, Lond.*, 12th Sept. 1953, Vol. 172, No. 4376, pp. 495–496.) Results are reported of simultaneous recordings of the frequency components in the band 40 c/s–16 kc/s. The frequency of the largest component in the 'slow tail' decreases as source distance increases and is higher at night than by day, while for the oscillatory part the opposite effect occurs. Selective attenuation at frequencies around 2 kc/s is indicated.

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551.594.6 : 621.396.11 420

The Variation with Distance in the Range 0–100 km of Atmospheric Waveforms.—R. B. Morrison. (*Phil. Mag.*, Sept. 1953, Vol. 44, No. 356, pp. 980–986.) Records of the electric-field variation of a violent thunderstorm, made at distances of 10–100 km, are analysed over portion (*b*), which covers the large and rapid increase in field strength corresponding to the return stroke of the lightning discharge. Theoretical and experimental results for the waveform, the ratio of the maximum e.s. field to the net e.s. change, and the current in the discharge, are in fair agreement.

551.510.535 421

Die Ionosphäre. [Book Review]—K. Rawer. Publishers: P. Noordhoff N. V., Groningen, 1952, 189 pp., 14·50 florins. (*Nature, Lond.*, 19th Sept. 1953, Vol. 172, No. 4377, p. 514.) ". . . intended primarily for the physicist who wishes to make a rapid survey of ionospheric physics . . . Space has been found, in most cases, not only for a brief review of the background but also for an indication of more recent developments."

LOCATION AND AIDS TO NAVIGATION

621.396.91 : 551.508.1 422

A New Radio Theodolite.—V. Väisälä. (*Proc. Indian Acad. Sci. A*, Feb. 1953, Vol. 37, No. 2, pp. 223–228.) A preliminary account is given of a fixed-aerial system developed for tracking the Finnish Väisälä-7 radiosonde, which uses a wavelength of 12·5 m.

621.396.932 : 621.396.96 423

An Improved Marine Radar Set.—(*Engineer, Lond.*, 21st Aug. 1953, Vol. 196, No. 5091, pp. 248–249; *Engineering, Lond.*, 21st Aug. 1953, Vol. 176, No. 4569, pp. 236–237.) Description of the Kelvin Hughes Type-2C equipment, which has a 12-in. p.p.i. with four scale ranges, with a maximum range of 50 miles.

621.396.96 : 551.578.12 424

Utility of Radar in Measuring Areal Rainfall.—G. E. Stout & J. C. Neill. (*Bull. Amer. met. Soc.*, Jan. 1953, Vol. 34, No. 1, pp. 21–27.) A comparison was made of rainfall estimates for a 50-square-mile area obtained from (*a*) radar observations and (*b*) a network of 33 rain gauges. The radar determination was, in the least satisfactory case, as accurate as that obtained with a network of 1 gauge/200 square miles; in other cases it was considerably more accurate.

621.396.96 : 621.397.26 425

Radar Relay.—F. Kirschstein. (*Fernmeldetech. Z.*, Aug. 1953, Vol. 6, No. 8, pp. 389–395.) Several systems suitable for the transmission of p.p.i. displays are considered theoretically and an estimate is made of the bandwidths required. The usefulness of such systems for air-traffic-control is noted.

621.396.963.3 + 621.396.932 426

Recent Maritime Radio and Radar Developments.—Byrnes. (See 531.)

MATERIALS AND SUBSIDIARY TECHNIQUES

531.788.7 427

Sorption and Desorption of Gas in the Cold-Cathode Ionization Gauge.—J. H. Leck. (*J. sci. Instrum.*, Aug. 1953, Vol. 30, No. 8, pp. 271–274.) The rate of clean-up was measured for several gases and vapours, including N, A and water vapour, at pressures between 10^{-6} and 10^{-4} mm Hg; an estimate is made of the influence of the process on the accuracy of the gauge.

531.788.7 428

Wide-Range Vacuum Gage.—C. B. Sibley & J. R. Roehrig. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 176–177.) A development of the gauge described by Mellen (1867 of 1946), covering the range 10^{3}–10^{-4} mm Hg.

535.37 429

The Chemistry of Traps in Zinc Sulfide Phosphors.—W. Hoogenstraaten. (*J. electrochem. Soc.*, Aug. 1953, Vol. 100, No. 8, pp. 356–365.) By varying the coactivators in ZnS-Cu, the trap depth could be varied between 0·37 eV and 0·74 eV. The coactivators investigated were Cl, Br, Al, Sc, Ga and In ions. Additional glow peaks and traps were produced by oxygen and the killers Co and Ni. The formation of mixed crystals with CdS and ZnSe generally resulted in a shift of the glow curves towards lower temperatures.

535.37 430

Some Properties of Zinc Sulfide Activated with Copper and Cobalt.—W. Hoogenstraaten & H. A. Klasens. (*J. electrochem. Soc.*, Aug. 1953, Vol. 100, No. 8, pp. 366–375.) The thermal glow, decay and build-up of fluorescence, temperature dependence and the light sum for ZnS-Cu-Co phosphors excited by 3 650 Å radiation, were investigated experimentally. Most of the results are explained by means of a model in which Co levels act both as 0·5-eV electron traps and as acceptors for holes ejected thermally from Cu centres with an activation energy of 1·1 eV.

535.37 : 621.385.832 431

The Efficiency of Fluorescence in Cathode-Ray Tubes.—A. Bril & H. A. Klasens. (*Philips tech. Rev.*, Aug. 1953, Vol. 15, No. 2, pp. 63–72.) See 3607 of 1953.

537.311.33 432

Conduction Mechanisms in Semiconductors.—H. Krömer. (*Fernmeldetech. Z.*, Sept. 1953, Vol. 6, No. 9, pp. 438–443.) The first paper of a series on transistors, intended for engineers.

537.311.33 : 538.632 433

On the Theory of the Isothermal Hall Effect in Semiconductors.—P. C. Banbury, H. K. Henisch & A. Many. (*Proc. phys. Soc.*, 1st Aug. 1953, Vol. 66, No. 404A, pp. 753–758.) "The theory of the isothermal Hall effect is re-examined, taking into account the finite dimension of the specimen in the direction of the Hall e.m.f. This involves consideration of concentration gradients, space charges, recombination processes and floating potential at the Hall electrodes. The analysis leads to recommendations concerning experimental technique."

537.311.33 : 546.281.26 434

Semiconductor Complexes forming Nonlinear Resistors: Recent Improvements.—S. Teszner, P. Seguin & J. Millet. (*Ann. Télécommun.*, Aug./Sept. 1953, Vol. 8, Nos. 8/9, pp. 271–298.) The properties of semiconductors and the nature of their departures from Ohm's law are discussed. A description is given of the preparation of materials with a SiC base; their electrical properties are described and a tentative theory of the mechanism of conduction is presented. Investigations are described with a view to the development of materials with more pronounced nonlinear characteristics. Two types of complex were developed. Type 1 incorporated BeO or MgO, the best results being obtained with 65–66% SiC, 29–31% clay and 4–5% BeO or MgO. Type 2 received special thermal treatment, some containing 65% SiC, 30% clay and 5% MgO, others consisting of 65% SiC, 31% clay and 4% of a Ni-Be or Ni-Mg alloy. The results obtained with Type-1 materials show that the introduction of MgO or BeO increases considerably the l.v.

resistance. In Type-2 materials the initial resistance on application of a high voltage is very great compared with the final resistance, the ratio being much greater than in the case of materials without the MgO or alloy additions. Various possible applications of these new materials are suggested.

537.311.33 : 546.289 **435**

On the Thermal Conversion of Germanium.—F. van der Maesen, P. Penning & A. van Wieringen. (*Philips Res. Rep.*, Aug. 1953, Vol. 8, No. 4, pp. 241–244.) Experimental results indicate that conversion of *n*-type into *p*-type Ge at 800°C is due to the presence of acceptor impurities on the Ge surface prior to heating. Heating *n*-type Ge in contact with Cu or Ni resulted in a conversion; no conversion was observed with Mg, Fe or Ag.

537.311.33 : 546.561-31 **436**

The Semiconductor Properties of Cu_2O: Part 4 — Conductivity Measurements at High Temperatures.—O. Böttger. (*Ann. Phys., Lpz.*, 16th April 1953, Vol. 12, Nos. 1/3, p. 160.) Correction to paper abstracted in 1386 of 1953.

537.311.33 : 546.561-31 **437**

The Semiconductor Properties of Cu_2O: Part 6 — The Temperature Dependence of the Electrical Conductivity at Temperatures between + 20°C and — 190°C.—G. Blankenburg & G. Schubart. (*Ann. Phys., Lpz.*, 2nd July 1953, Vol. 12, Nos. 4/6, pp. 281–296.) The results indicate the importance of the controlled cooling of semiconductors pre-treated at high-temperature, to obtain uniform, reproducible properties. Part 5: 1387 of 1953 (Blankenburg & Böttger).

537.311.33 : 546.561-31 **438**

The Semiconductor Properties of Cu_2O: Part 7 — The Hall Effect below Room Temperature.—H. Nieke. (*Ann. Phys., Lpz.*, 2nd July 1953, Vol. 12, Nos. 4/6, pp. 297–308.) Hall-effect measurements at + 50°C to − 150°C are reported. The influence of the oxygen pressure during the cooling from the pretreatment temperature of 960°C was investigated. Part 6: **437** above.

537.311.33 : [621.314.632 + 621.314.7 **439**

Semiconductor Circuit Elements.—J. S. Blakemore, A. E. De Barr & J. B. Gunn. (*Rep. Progr. Phys.*, 1953, Vol. 16, pp. 160–215.) Theory of the conduction mechanism in semiconductors and semiconductor/metal systems is reviewed, mainly in relation to materials such as Ge and Si, whose special properties depend on the simultaneous flow of electrons and holes. Magnetic and optical effects and noise are discussed. Rectification and transistor action at semiconductor/metal contacts and *p-n* junctions are considered, and the properties of crystal diodes and transistors are described. 105 references.

537.311.33 + 621.385.032.21] : 621.396.822 **440**

Note on Shot Effect in Semi-Conductors and Flicker Effect in Cathodes.—van der Ziel. (See 605.)

537.311.33 + 621.385.032.21] : 621.396.822 **441**

Theory of the Flicker Effect.—Tomlinson & Price. (See 606.)

538.213 **442**

Complex Magnetic Permeability of Spherical Particles.—J. R. Wait. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1664–1667.) Calculations are made of the effective permeability for an array of conducting particles embedded in a dielectric. The relations between conductivity, permeability, permittivity, particle radius and frequency are shown in curves.

538.221 **443**

Ferromagnetic Resonance in Colloidal Suspensions.—D. M. S. Bagguley. (*Proc. phys. Soc.*, 1st Aug. 1953, Vol. 66, No. 404A, pp. 765–767.) Measurements have been made of the absorption at 290°K and λ 3·14 cm and 1·20 cm, using suspensions of ferromagnetic particles in paraffin wax. The results indicate that the method is useful for investigating the properties of ferromagnetic alloy systems.

538.221 **444**

The Dependence of Ferromagnetic Resonance in Parallel Wires on the Tension.—A. G. Kotov. (*C. R. Acad. Sci. U.R.S.S.*, 1st Dec. 1952, Vol. 87, No. 4, pp. 531–533. In Russian.) The variation of the magnitude of the ferromagnetic-resonance effect in hardened Ni and Fe wires with the tensile stress and the axial magnetic field is shown graphically.

538.221 **445**

The Effect of Small Elastic Tensions on the Initial Susceptibility of Ferromagnetic Materials.—Ya. S. Shur & D. D. Mishin. (*C. R. Acad. Sci. U.R.S.S.*, 1st Dec. 1952, Vol. 87, No. 4, pp. 543–546. In Russian.) The initial susceptibility/tensile-stress characteristics of permalloy and various other steels depend on the previous magnetic history and on the crystallographic structure of the specimen. The susceptibility/tensile-stress curves for several specimens are shown.

538.221 **446**

Comparison of the Effects of Tension and Compression on the Magnetic Characteristics of Mild Steel.—G. Vidal & P. Lanusse. (*C. R. Acad. Sci., Paris*, 19th Oct. 1953, Vol. 237, No. 16, pp. 902–904.) The following sequence of operations was used for the tests:—(*a*) application of stress, (*b*) demagnetization, (*c*) application of magnetizing field, (*d*) measurement of induction. Results are presented graphically.

538.221 **447**

Secondary Recrystallization Textures in Soft Iron.—R. Guihaumé, M. Sternberg & P. Lacombe. (*C. R. Acad. Sci., Paris*, 19th Oct. 1953, Vol. 237, No. 16, pp. 904–906.) An account of experiments in which large crystals were found to develop in armco specimens after cold working followed by heat treatment.

538.221 **448**

Recent Investigations of Magnetic-Reversal Domains.—C. Greiner. (*Ann. Phys., Lpz.*, 16th April 1953, Vol. 12, Nos. 1/3, pp. 89–100.)

538.221 **449**

Magnetic Measurements on Iron Amalgam with Reference to the Problem of Ferromagnetism and Grain Size.—A. Mayer & E. Vogt. (*Z. Naturf.*, May 1952, Vol. 7a, No. 5, pp. 334–340.)

538.221 **450**

The Barkhausen Effect in Single Crystals.—R. S. Tebble & V. L. Newhouse. (*Proc. phys. Soc.*, 1st Aug. 1953, Vol. 66, No. 404B, pp. 633–641.) The results of measurements on single crystals of Si/Fe and Ni show that the Barkhausen effect is small and the magnetization process is mainly reversible, if the demagnetization factor of the specimen is large. It is suggested that the Barkhausen effect is associated with the movement of 180° rather than 90° boundaries.

538.221 **451**

Ferromagnetic Domain Processes in Single Crystal Disc Specimens of Silicon Iron.—D. H. Martin. (*Proc. phys. Soc.*, 1st Aug. 1953, Vol. 66, No. 404B, pp. 712–714.)

World Radio History

Changes in the domain structure of the surface layer due to changes in the direction of application of a magnetic field were observed and photographed.

538.222 : 539.15 **452**

Paramagnetic Resonance.—B. Bleaney & K. W. H. Stevens. (*Rep. Progr. Phys.*, 1953, Vol. 16, pp. 108–159.) An account is given of the principal phenomena associated with electronic magnetic resonance. Problems involved in its detection are reviewed. The theory of paramagnetism of the solid state is outlined and the spin-Hamiltonian is derived. The ions of the iron (3d) group and the rare-earth (4f) group are examined in terms of the spin-Hamiltonian. The influence of exchange interaction is discussed, and resonance in gases and other special compounds is treated briefly. 103 references.

538.245.002.2 **453**

Recent Progress in the Manufacture of Magnetic Materials: Ferronickels with Oriented Structure.—É. Josso. (*Ann. Télécommun.*, Aug./Sept. 1953, Vol. 8, Nos. 8/9, pp. 262–266.) Various methods of manufacturing oriented Ni-Fe materials are mentioned, the rectangular types of hysteresis curve for such materials are described and the magnetic characteristics are tabulated for a 50/50 Ni-Fe alloy (rectimphy) with a maximum permeability at 0·1 oersted of $8–14 \times 10^4$ and saturation induction of $15–16 \times 10^3$ gauss, and also for an alloy (permafix) with a constant permeability of 90–125, depending on heat treatment.

546.289 **454**

Theoretical Resistivity and Hall Coefficient of Impure Germanium near Room Temperature.—P. G. Herkart & J. Kurshan. (*RCA Rev.*, Sept. 1953, Vol. 14, No. 3, pp. 427–440.) The temperature variation of resistivity ρ over the range − 100°C to + 140°C has been calculated and plotted for both *n*-type and *p*-type Ge with varying impurity content corresponding to a resistivity range of 0·1–60Ω.cm at 25°C. The relations between ρ, impurity concentration and the Hall coefficient at 25°C are shown graphically. The mol-fraction of impurity is approximately $3{\cdot}8 \times 10^{-8}/\rho$ for *n*-type and $8{\cdot}1 \times 10^{-8}/\rho$ for *p*-type Ge over the range $0{\cdot}1 < \rho < 20\Omega$.cm.

546.289 + 546.92] : 621.357.13 **455**

Electrolytic Polishing of Germanium and Platinum in the Presence of F^- or Cl^- Ions.—P. Brouillet & I. Épelboin. (*C. R. Acad. Sci., Paris*, 19th Oct. 1953, Vol. 237, No. 16, pp. 895–897.) Previous research on electrolytic polishing is applied to the cases of Ge and Pt. Details are given of ClNa-ClK and FNa-FK mixtures suitable for revealing the structure of Ge.

548.0 : 53 **456**

Physical Properties and Atomic Arrangements in Crystals.—W. A. Wooster. (*Rep. Progr. Phys.*, 1953, Vol. 16, pp. 62–82.) A survey is made of the relation between the structure of crystals and their magnetic, optical, piezoelectric and elastic properties. Recent work on paramagnetic resonance absorption at high frequencies is discussed in connection with the spinels. The spontaneous electric polarization of Rochelle salt and KH_2PO_4 is attributed to cooperative movements of hydrogen ions.

548.0 : 53 **457**

The Physical Properties of Crystals and their Symmetry.—M. Tournier. (*Cah. Phys.*, July 1953, No. 44, pp. 44–73.) Certain properties of crystals can be predicted from the elements of symmetry in the cause-and-effect relations of the phenomena associated with them. Tensor and matrix methods are used to express the pyroelectric, dielectric, piezoelectric and elastic processes. Various crystalline systems are examined, and an indication is given of the properties to be expected of them according to this analysis.

548.1 : 537.1 **458**

Interface Area, Edge Length, and Number of Vertices in Crystal Aggregates with Random Nucleation.—J. L. Meijering. (*Philips Res. Rep.*, Aug. 1953, Vol. 8, No. 4, pp. 270–290.)

548.5 : 549.514.51 **459**

Hydrothermal Synthesis of Quartz Crystals.—A. C. Walker. (*J. Amer. ceram. Soc.*, 1st Aug. 1953, Vol. 36, No. 8, pp. 250–256.) The method and the autoclave used to grow crystals, weighing over 1 lb each, in less than 60 days are described.

548.55 : 537.311.33 : [546.28 + 546.289 **460**

Apparatus for Crystal Pulling in Vacuum using a Graphite Resistance Furnace.—K. Lehovec, J. Soled, R. Koch, A. MacDonald & C. Stearns. (*Rev. sci. Instrum.*, Aug. 1953, Vol. 24, No. 8, pp. 652–655.) Apparatus suitable for producing large single crystals of Ge or Si is described. Independent rotation of crucible and crystal is provided. The crystal is withdrawn at a rate of up to 6 in./hour.

548.73 : 549.731.11 **461**

Physical and Crystallographical Properties of Some Spinels.—F. C. Romeijn. (*Philips Res. Rep.*, Aug. & Oct. 1953, Vol. 8, Nos. 4 & 5, pp. 304–320 & 321–342.) X-ray measurements on simple and complex spinels indicated regularities in ionic distribution and lattice constants. These are explained by a calculation of the Madelung potential, by geometrical considerations, and by the properties of the constituent ions. The calculated relation between the ionic distribution and the oxygen parameter u was confirmed. Some physical properties of the compounds investigated have been correlated with the ionic distribution.

621.314.632.1 **462**

Cuprous Oxide Rectifier Characteristics.—J. Lees. (*Proc. phys. Soc.*, 1st Aug. 1953, Vol. 66, No. 404B, pp. 622–632.) The current/voltage and the capacitance/reverse-voltage characteristic were determined at 0, 30 and 70°C; the latter was independent of temperature in this range. The assumption of a Schottky barrier is not compatible with the results obtained. A method of predicting the reverse current/voltage characteristic, giving results in good agreement with the experimental results, is derived.

621.315.612.4 **463**

Phase Equilibria in the System MgO-TiO_2.—L. W. Coughanour & V. A. DeProsse. (*J. Res. nat. Bur. Stand.*, Aug. 1953, Vol. 51, No. 2, pp. 85–88.) Report of an investigation in connection with the study of ceramic dielectrics.

621.315.612.4 : 537.226.2-972 **464**

Investigations in the Tenth-Millimetre Wavelength Region.—R. Meier. (*Ann. Phys., Lpz.*, 16th April 1953, Vol. 12, Nos. 1/3, pp. 26–34.) Types of grating used in the wavelength range 0·15–0·6 mm are described. The absorption bands of water vapour were partially resolved into absorption lines. The dielectric constants of Condensa N and F and Epsilan 900 and 7000 were determined from reflection-coefficient measurements; the results are shown graphically.

621.315.613.1 **465**

Alternatives to Mica.—E. R. Haines. (*Elect. Rev., Lond.*, 28th Aug. 1953, Vol. 153, No. 9, pp. 437–441.)

World Radio History

The electrical and mechanical properties of mica and various types of micanite are compared with those of materials of the glass-fibre and asbestos types. A material consisting of glass cloth backed with asbestos paper and fully impregnated with a plasticized-shellac varnish was found to have excellent electrical properties and, from the point of view of moulding, was superior to any mica-type material.

621.375.3.042 **466**

Evaluation of Core Materials for Magnetic Amplifiers.—D. C. Dieterly. (*Elect. Mfg*, Jan. & Feb. 1953, Vol. 51, Nos. 1 & 2, pp. 68–73 . . 276 & 124–127, 380.)

MATHEMATICS

517.947.5 **467**

Self-Oscillation in Essentially Nonlinear Quasi-conservative Systems.—G. V. Savinov. (*C. R. Acad. Sci. U.R.S.S.*, 21st April 1953, Vol. 89, No. 6, pp. 995–997.) Systems are considered which can be represented by the equation $\ddot{x} + g(x) = \mu f(x, \dot{x}, \mu)$, where μ is a small magnitude characterizing the degree of quasi-conservativeness. This class includes physical systems containing $BaTiO_3$ capacitors or permalloy-cored inductors.

518.5 : 621.3.011 **468**

Pocket Reactance and Resonance Calculator.—V. J. Tyler. (*Wireless World*, Dec. 1953, Vol. 59, No. 12, pp. 560–562.) A simple calculator comprising six concentric disks and covering twelve decades without ambiguity.

MEASUREMENTS AND TEST GEAR

529.78(083.74) **469**

Pendulum, Quartz and Atomic Clocks as Time Standards.—A. Scheibe. (*Z. angew. Phys.*, Aug. 1953, Vol. 5, No. 8, pp. 307–317.) A survey of the development of standard-time clocks from 1932 to date is given. Comparison of the several types indicates the superiority of the quartz clock, although a Cs resonator may be developed for short-period accuracy checking. 37 references.

529.786 + 621.3.018.4(083.74)] : 621.372.412 **470**

Underearth Quartz Crystal Resonators.—T. A. Pendleton. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1612–1614.) Precision quartz resonators are used in conjunction with oscillators for primary standards of frequency and time. Stable ambient conditions for such resonators are provided by locating them underground. A method is described for measuring resonator-frequency drift to within 2 parts in 10^{10}, using a direct voltage.

621.317 : 621.396.823 **471**

Measurement of Radio Interference generated by High-Voltage Lines.—D. Renaudin. (*Bull. Soc. franç. Élect.*, July 1953, Vol. 3, No. 31, pp. 425–431.) Discussion of the principles of measurement based on a statistical analysis of interference pulse trains due to brush discharges, and on the response of a receiver to this type of interference, taking account of bandwidth, circuit time-constants and type of detection. Specifications for a standard receiver for measurement purposes and the method of calibration by means of a special noise source are noted.

621.317.3 : 621.396.822 **472**

Fluctuation Theory in Physical Measurements.—C. W. McCombie. (*Rep. Progr. Phys.*, 1953, Vol. 16, pp. 266–320.) An elementary account is given of the ways in which fluctuation theory has been applied to some of the simpler types of physical measurement. Uncertainties in measurements involving suspended systems are discussed on the basis of simple correlation-function arguments, and consideration is given to the methods of measurement appropriate when there are various practical limitations on the parameters of the suspended system. The circumstances under which there is an absolute limit to the attainable accuracy are discussed; the use of feedback may enable such limits to be attained in practice. Some results are established concerning the optimum characteristics of an instrument used to follow a varying signal in the presence of noise. 78 references.

621.317.3.018.78 : 621.395.625.3 **473**

'Wow' Measurement.—D. W. Thomasson. (*Wireless World*, Dec. 1953, Vol. 59, No. 12, pp. 579–580.) A laboratory method for detecting 'wow' in tape recorders is described in which the output obtained on playing a test recording (e.g., of a 1-kc/s sine wave) is observed oscillographically. For production testing a further method is mentioned, using a frequency-measuring circuit in which a capacitor is charged and discharged during each signal cycle, the average discharge current being proportional to signal frequency.

621.317.33 **474**

The Measurement of the Electrical Resistance of Powders.—H. v. Wartenberg. (*Z. angew. Phys.*, Aug. 1953, Vol. 5, No. 8, pp. 291–292.) The concentration of an electrolyte is adjusted until an addition of the powder has no effect on the conductivity. The resistivities of the powder and electrolyte are then equal. Precautions against the formation of surface layers are outlined.

621.317.34.029.5/.63 **475**

Filter Insertion Loss in the 10–1000-Mc/s Range.—S. Shive. (*Tele-Tech*, June 1953, Vol. 12, No. 6, pp. 95–97 . . 184.) Standard attenuation-measurement technique is described. The importance of correct impedance matching, in order to avoid standing waves in the generator-filter-detector line, is pointed out.

621.317.35 : 621.3.018.78 : 534.851 **476**

Distortion in Phonograph Reproduction.—H. E. Roys. (*RCA Rev.*, Sept. 1953, Vol. 14, No. 3, pp. 397–412.) Reprint. See 2736 of 1953.

621.317.42 **477**

Three Methods of Measuring Magnetic Fields: Part 1 — Measurement based on the Generator Principle.—B. F. Jürgens. **Part 2 — Measurement of the Field on the Axis of Magnetic Electron Lenses.**—A. C. van Dorsten & A. J. J. Franken. **Part 3 — Measurement by the Proton Resonance Method.**—H. G. Beljers. (*Philips tech. Rev.*, Aug. 1953, Vol. 15, No. 2, pp. 49–62.) The principles of the first two of these methods are well known. In the third method, a small vessel of water is placed in the field to be measured. Application of a weak alternating field at right angles to this field causes the hydrogen nuclei to resonate; the resonance frequency is proportional to the strength of the field to be measured. A model with a range up to 14 000 gauss has been made. The error is $< 0{\cdot}01\%$.

621.317.7 : 621.396.82.029.62/.63 **478**

Measuring Equipment for Radio Interference in the U.S.W. Range.—H. Leingang. (*Rohde & Schwarz Mitt.*, May 1953, No. 3, pp. 120–125.) Equipment for measurement of continuous and discontinuous line and radiated interference in the frequency ranges 30–180 Mc/s and 85–330 Mc/s is described and illustrated. Calibration of the instruments is discussed. A graph showing the difference of the indicated interference level between British and German standard equipment is given.

World Radio History

621.317.73.029.6 **479**

Improved Accuracy and Convenience of Measurements with Type 1602-B Admittance Meter in V.H.F. and U.H.F. Bands.—R. A. Soderman. (*Gen. Radio Exp.*, Aug. 1953, Vol. 28, No. 3, pp. 1–6.) A modified model of the instrument noted in 163 of 1951 (Thurston) is described. The ranges have been extended to 10^{-4}–1 Ω^{-1} for measurement of conductance and susceptance at frequencies from 41 Mc/s to 1 kMc/s.

621.317.733 : 621.314.7 **480**

Bridges measure Transistor Parameters.—L. J. Giacoletto. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 144–147.) See 3359 of 1953.

621.317.755 : 621.375.221 : 621.376.3 **481**

A Method of Band-Pass Amplifier Alignment.—J. J. Hupert & A. M. Reslock. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1668–1671.) The second-harmonic distortion is displayed on a c.r.o. as a function of the deviation of the carrier frequency from the centre of the pass band. The method is particularly useful for cases where linear variation of phase with frequency is required, e.g., in i.f. amplifiers for f.m. receivers. See also 3550 of 1953 (Hupert).

621.317.755 : 621.385 **482**

Determination of the Slope of an Electronic-Valve Characteristic by Time-Differentiation of the Anode Current.—R. Counord. (*C. R. Acad. Sci., Paris*, 19th Oct. 1953, Vol. 237, No. 16, pp. 879–881.) The method presented makes use of differentiators described by Rateau (1688 of 1952). The grid of the valve under test is fed with linearly increasing voltages from a sawtooth oscillator, and the anode current is passed through a differentiating circuit, the output of which is displayed on a c.r.o. whose timebase is derived from the same oscillator.

621.317.763.029.64 : 621.372.413 **483**

Construction and Calibration of a Cavity-Wavemeter for Physical Measurements.—J. C. van den Bosch & F. Bruin. (*Physica*, Aug. 1953, Vol. 19, No. 8, pp. 705–718.) The wavemeter described is constructed according to the design of Bleaney et al. (3187 of 1947) and operates in the 12·5-mm wavelength range. Using ammonia absorption lines for calibration, the resonance frequencies are determined to within 1 part in 10^4. Temperature dependence and compensation are discussed.

621.317.772 **484**

Zero-Intercept Phase Comparison Meter.—Y. P. Yu. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 178–180.) Two waveforms to be compared are fed to two separate circuits and a pulse is produced in each circuit when its input voltage crosses the zero axis. The first pulse initiates generation of a sawtooth voltage, while the second cuts off the sawtooth generator. The amplitude of the sawtooth is measured with a calibrated valve voltmeter which gives the phase angle between the two waveforms.

621.317.772 : 621.317.727 **485**

Electronic A.C. Potentiometer.—L. Tasny-Tschiassny. (*Wireless Engr*, Dec. 1953, Vol. 30, No. 12, pp. 295–298.) A simple arrangement for measuring phase differences is based on comparison between an unknown voltage and an adjustable known fraction of a reference voltage; operation is independent of frequency. A square-law detector is used. The apparatus is built from standard radio components.

621.373.4.029.63/.64 **486**

S-Band Sweep Generator and Test Set.—R. E. Larson. (*Tele-Tech*, June 1953, Vol. 12, No. 6, pp. 116–118 . . 164.) See 3671 of 1953 (Kluck & Larson).

621.373.42 **487**

A Novel Audio Sweep Generator.—P. Pohl & H. Wolcott. (*J. audio Engng Soc.*, July 1953, Vol. 1, No. 3, pp. 244–245.) Description of equipment for use with a c.r.o. to display a response curve. A frequency sweep between any two limits within the range 20 c/s–200 kc/s is available.

621.373.421.13 : 621.317.361.029.6 **488**

Microwave Frequency Standard.—L. C. Hedrick. (*Rev. sci. Instrum.*, Aug. 1953, Vol. 24, No. 8, pp. 565–568.) Details are given of a highly stable signal generator in which the final frequency of 810 Mc/s is derived in five stages of multiplication from the output of a 5-Mc/s crystal oscillator. An unknown microwave frequency to be measured is heterodyned against harmonics from this generator, and the resulting beat-frequency signal is fed to a calibrated communication receiver.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.768 : 546.431.824-31 **489**

Symposium on Barium Titanate Accelerometers.—(*Tech. News Bull. nat. Bur. Stand.*, Aug. 1953, Vol. 37, No. 8, pp. 125–126.) Brief note indicating the scope of the discussions at the symposium held in Washington, May 1953.

537.528 : 534.88 : 526.956.5 **490**

The Under-Water Spark as Sound-Pulse Generator.—H. Drubba & H. H. Rust. (*Arch. elekt. Übertragung*, Sept. 1953, Vol. 7, No. 9, pp. 429–440.) The discharge of a capacitor through an under-water spark gap was investigated, using inductance-free capacitors of 0·75, 1·25, 2·25, 4·25 and 6·25 μF with voltages up to 5 kV and electrode spacings of 0·1 and 0·3 mm. Oscillographic records were obtained of the current/time curve, discontinuous increases being observed. The duration and shape of the pulses are interpreted on the assumption that the pulse traverses a gas/water boundary close to the spark channel. Photographs of the electrodes showing the effect of the spark, and photographs of the spark region taken 10^{-5}–10^{-4} sec after the breakdown are included. 138 references. See also 223 of January.

550.837 **491**

Principle of the Magneto-telluric Method, a New Method for Geophysical Prospecting.—L. Cagniard. (*Ann. Géophys.*, April/June 1953, Vol. 9, No. 2, pp. 95–125.) The method is based on quantitative relations existing between the horizontal components of the electric field and the magnetic field when current flows in the subsoil.

550.837.6 **492**

Modelling of Alternating Electromagnetic Fields for Geophysical Prospecting.—A. G. Tarkhov. (*Bull. Acad. Sci. U.R.S.S., sér. géophys.*, June/Aug. 1953, No. 4, pp. 318–323. In Russian.) The effect of conducting bodies in the upper layers of the earth on the magnetic field of an h.f. e.m. field was investigated experimentally by means of a scale model. The scaling-down factors for the conductivity γ and dielectric constant ϵ of the medium, the frequency f and the linear dimension l, were calculated from the equations $\gamma_1 f_1 l_1^2 = \gamma_2 f_2 l_2^2$ and $\epsilon_1 f_1^2 l_1^2 = \epsilon_2 f_2^2 l_2^2$. The observed distribution of the vertical component of the magnetic field is shown graphically.

621.383.2 : 536.521 **493**

A New Photoelectric Pyrometer.—A. Peuteman. (*C. R. Acad. Sci., Paris*, 28th Oct. 1953, Vol. 237, No. 17, pp. 975–977.) The vacuum-type photocell used has a Cs-Ag cathode and metal-cylinder anode; it is rendered effectively monochromatic ($\lambda \sim 680 \text{ m}\mu$) by means of optical filters. An a.c. amplifier is used, the incident radiation being interrupted at about 600 c/s. The sensitivity is 1 mV for 5° at 1 600°C.

621.384.611 **494**
The Design and Operation of a 4·5 MeV Microtron.—C. Henderson, F. F. Heymann & R. E. Jennings. (*Proc. phys. Soc.*, 1st Aug. 1953, Vol. 66, No. 404B, pp. 654–664.) Description of a machine similar to that described by Redhead et al. (1472 of 1950), and operating with a r.f. accelerating field generated by a 500-kW peak microwave source at 3 kMc/s.

621.384.611 **495**
The Theory of the Fixed Frequency Cyclotron.—B. L. Cohen. (*Rev. sci. Instrum.*, Aug. 1953, Vol. 24, No. 8, pp. 589–601.)

621.384.612 **496**
Oscillator Switching for Variable Frequency Synchrotron Control.—D. E. Caro & L. U. Hibbard. (*Phil. Mag.*, Sept. 1953, Vol. 44, No. 356, pp. 964–970.)

621.384.622.2 **497**
Effect of Anomalous Attenuation in a Linear Accelerator.—C. W. Miller & G. Saxon. (*Nature, Lond.*, 5th Sept. 1953, Vol. 172, No. 4375, p. 463.)

621.385.833 **498**
Double Focusing of Charged Particles by a System of Two Magnets with Nonuniform Fields.—R. M. Sternheimer. (*Rev. sci. Instrum.*, Aug. 1953, Vol. 24, No. 8, pp. 573–585.)

621.385.833 : 530.145.6 **499**
Electron-Optical Image Formation based on Wave Mechanics.—W. Glaser & P. Schiske. (*Ann. Phys., Lpz.*, 2nd July 1953, Vol. 12, Nos. 4/6, pp. 240–280.)

621.387.422 **500**
On Energy Resolution with Proportional Counters.—G. S. Hurst & R. H. Ritchie. (*Rev. sci. Instrum.*, Aug. 1953, Vol. 24, No. 8, pp. 664–668.) Investigation of the dependence of the height of the output pulse on the orientation of the ionizing track and on the amplifier time constant.

621.387.424 **501**
Recent Developments in the Production of Halogen-Quenched Geiger-Müller Counting Tubes.—L. B. Clark, Sr. (*Rev. sci. Instrum.*, Aug. 1953, Vol. 24, No. 8, pp. 641–643.) G-M tubes have been constructed using transparent nonmetallic electrically conducting films as cathodes. Advantages of this construction are indicated.

621.387.424 **502**
The Starting Potential of Counter Tubes.—K. H. Lauterjung. (*Z. Naturf.*, May 1952, Vol. 7a, No. 5, pp. 344–351.)

PROPAGATION OF WAVES

621.396.11 : 551.510.52] : 061.3 **503**
The 1953 Symposium on Tropospheric Wave Propagation within the Horizon at the U.S. Navy Electronics Laboratory.—W. C. Hoffman. (*Trans. Inst. Radio Engrs*, July 1953, Vol. AP-1, No. 1, pp. 28–30.) Report of the symposium held 30th March–2nd April, outlining papers read.

621.396.11 : 551.510.535 **504**
The Effect of Ions on Magneto-ionic Characteristic Polarization.—W. Snyder. (*Trans. Inst. Radio Engrs*, July 1953, Vol. AP-1, No. 1, pp. 23–27.) A general formula for polarization in a mixture of ions and electrons is derived. The predicted polarization of a 100-kc/s and 300-kc/s downcoming wave component in a neutral mixture of oxygen ions, nitrogen ions and electrons is plotted as a function of Goubau's mixture coefficient *k* (3751 of 1935). The plots show that, in a mixture, (*a*) polarizations are possible that cannot occur when only electrons are present, (*b*) a given polarization does not uniquely determine *k*, and (*c*) polarization depends on relative numbers of each type of charged particle but not on actual charge density when the proportion of electrons is small.

621.396.11 : 551.510.535 **505**
Optic Axes and Critical Coupling in the Ionosphere.—Davids. (See 412.)

621.396.11 : 551.594.6 **506**
Audio-Frequency Spectrum of Atmospherics.—Chapman & Matthews. (See 419.)

621.396.11 : 551.594.6 **507**
The Variation with Distance in the Range 0–100 km of Atmospheric Waveforms.—Morrison. (See 420.)

621.396.11.029.6 : 550.38 **508**
Influence of the Geomagnetic Field on the Propagation of Short Waves. Application to the Calculation of Maximum Usable Frequency.—É. Argence. (*Ann. Géophys.*, July/Sept. 1953, Vol. 9, No. 3, pp. 227–244.) The theory presented is developed from a more general method previously noted (2315 of 1952). Approximate expressions for the refractive index are used for calculating s.w. propagation paths, a plane earth and ionosphere being assumed. Three special cases are examined in detail, viz., (*a*) propagation at the equator, (*b*) east-west propagation at any geomagnetic latitude, (*c*) propagation in the plane of the magnetic meridian; both ordinary and extraordinary rays are calculated. Various methods are discussed for using the results to simplify m.u.f. calculations. The effect of curvature of earth and ionosphere is discussed briefly. The method enables the wave polarization to be determined at any point in the path.

621.396.11.029.62 **509**
Long-Distance Propagation of Metre Waves.—B. Sadoun. (*Ann. Télécommun.*, Aug./Sept. 1953, Vol. 8, Nos. 8/9, pp. 299–308.) Since November 1952 records have been obtained at the Laboratoire National de Radioélectricité of the field strengths of f.m. broadcasting transmitters operating at frequencies of 88–100 Mc/s and at distances of 300–700 km from Paris. The method of measurement is described and typical records are reproduced. The results obtained show that, in addition to abnormal propagation phenomena of a sporadic nature, there exists at great distances a permanent field whose mean value is the more stable as the distance from the transmitter increases. This field strength is much greater than that calculated from wave diffraction round the earth. A tentative explanation is that a scattering of radio waves takes place in the troposphere. The records obtained during eight months show no marked diurnal effects; the variations observed during the day are often quite different from one day to another. Seasonal effects also are not very noticeable.

621.396.11.029.62 **510**
Note on the Frequency Bandwidth Usable for Long-Distance U.S.W. Transmissions.—J. Voge. (*Ann. Télécommun.*, Aug./Sept. 1953, Vol. 8, Nos. 8/9, pp. 308–311.) The results of Rice's theory (1473 of 1953) are applied to the transmission path between Wrotham and Bagneux, one of the paths studied by Sadoun (509 above).

The maximum usable bandwidth is found to be of the order of 100 kc/s at a distance of 300 km. This value is independent of the carrier frequency and varies inversely with the distance. This result has not yet been tested experimentally, but it should be noted that the application of Rice's formulae gives values in satisfactory agreement with the results obtained for the periods of fading and the dimensions of the volume in which scattering takes place.

621.396.81.029.64 **511**

Measurement of Path Loss between Miami and Key West at 3675 Mc/s.—R. L. Robbins. (*Trans. Inst. Radio Engrs*, July 1953, Vol. AP-1, No. 1, pp. 5–8.) Report of measurements made of the received field strength using 1·5-μs pulses transmitted over five transmission paths about 130 miles long, largely water-covered. Path loss and fading characteristics were similar to those for mountainous paths elsewhere [1114 of 1953 (Bullington)]. No differences were observed due to different terrain in front of the aerial.

621.396.812.3 : 551.510.535 **512**

Studies on Mechanism and Distribution of Short-Period Fading Reflected from Turbulent Ionosphere.—F. Minozuma & H. Enomoto. (*Rep. Ionosphere Res. Japan*, June 1953, Vol. 7, No. 2, pp. 53–59.) Fading phenomena are discussed in terms of the variations of optical paths produced by turbulence of the ionosphere. A simple model is proposed which fits observations of field strength made on 4-Mc/s and 8-Mc/s standard-frequency transmissions over distances of 90–830 km.

621.396.812.3.029.55 **513**

Statistical Investigations of Short-Wave Transmission Paths.—J. Grosskopf. (*Fernmeldetech. Z.*, Aug. 1953, Vol. 6, No. 8, pp. 373–378.) The statistical distribution of the signal amplitudes was determined for WWV signals received at Darmstadt; it is represented by a log-normal distribution curve. The fading characteristics at 10, 15 and 20 Mc/s were analysed statistically; the hourly scatter of the instantaneous field-strength values was 7 db and the monthly scatter of the hourly median values was 14 db. The device used for counting the frequency of occurrence of the various amplitudes is described.

RECEPTION

621.396.621 **514**

Development of German Broadcast Receivers from 1945 to 1953.—O. Limann. (*Elektrotech. Z.*, *Edn B*, 21st Aug. 1953, Vol. 5, No. 8, pp. 246–251.) As a result of Germany's post-war frequency allocation, work has been largely concentrated on u.s.w. receivers. Models briefly described include modern a.m./f.m. superheterodyne sets with built-in aerial.

621.396.621 **515**

Circuit Refinements of 1953/54 [West German] **Broadcast Receivers.**—W. W. Diefenbach. (*Funk-Technik, Berlin*, Aug. 1953, Vol. 8, No. 15, pp. 456–457 . . 471.)

621.396.621 **516**

Improvements to the Communications Receiver BRT 400.—C. W. M. Read. (*G.E.C. Telecommun.*, April 1953, No. 16, pp. 40–47.) Modifications to the receiver noted in 2310 of 1949 include an extension of the adjustable i.f. bandwidth to 13 kc/s and improved oscillator stability for frequency-shift reception. A valve phase changer is used for cancelling the d.c. ripple, so that electrolytic smoothing capacitors can be dispensed with.

621.396.621 : 621.396.8 **517**

Figure of Merit of Broadcast [receiving] **Installations and Conditions for Undisturbed Reception.**—H. Schmalbruch. (*Z. Ver. dtsch. Ing.*, 11th Aug. 1953, Vol. 95, No. 23, pp. 774–776.) Aerial requirements in respect of height and interference-free location, and advantages of common-aerial reception are indicated. Criteria for estimating receiver performance as regards hum pickup, radiation, selectivity, etc., are given; an overall figure of merit for the installation is obtained by combining these assessments.

621.396.621.54 : 621.396.91 **518**

Radio Receiver for recording Time Signals.—A. Godefroy. (*Ann. Géophys.*, July/Sept. 1953, Vol. 9, No. 3, pp. 245–247.) A stable highly selective 90·9-kc/s receiver is described. A double-heterodyne system is used, oscillations from a single quartz-controlled local oscillator beating (*a*) with the incoming signal to give an i.f., and (*b*) with the i.f. to give the a.f.

621.396.823 + 621.397.823 **519**

Effect of Radio Interference generated by High-Voltage Lines on the Reception of Broadcast and Television Transmissions.—P. Passerieux. (*Bull. Soc. franç. Élect.*, July 1953, Vol. 3, No. 31, pp. 432–444.) Detailed results of measurements on different power lines are presented, showing the influence of the arrangement, voltage and surface condition of the conductors on the noise level due to corona discharge, and the effect of coupling between parallel lines on the propagation of a disturbance. Three types of interference trace on a television screen were identified; the number of these traces was very small at normal line voltages but increased greatly at excessive line voltages.

621.396.823 : 621.315.1.027.8 **520**

Experimental and Theoretical Study of the Mechanism of Propagation and Radiation of Interference from High-Voltage Lines.—J. Fabre. (*Bull. Soc. franç. Élect.*, July 1953, Vol. 3, No. 31, pp. 419–424.) Investigation of the field distribution and the spectrum of interference shows that receiver noise due to direct radiation from corona discharge is negligible compared with that due to propagation of the disturbance between line and earth. Frequency spectra of interference from short and long lines are compared. Attenuation as a function of distance along the line is calculated for 400- and 127-kV lines.

621.396.823 : 621.315.1.027.8 **521**

Radio Interference from Very-High-Voltage Lines.—R. Pélissier. (*Bull. Soc. franç. Élect.*, July 1953, Vol. 3, No. 31, pp. 409–418.) The mechanism of corona discharge and the propagation of a disturbance along the lines are discussed with reference to measurements made on different power lines, particularly at a 500-kV experimental station at Chevilly. Received-noise spectra are analysed. A relation between effective noise power and the ratio applied-voltage/critical-voltage is derived by which the maximum noise field strength close to a projected line can be estimated.

621.396.823 : 621.317 **522**

Measurement of Radio Interference generated by High-Voltage Lines.—Renaudin. (See 471.)

621.396.828 **523**

Progress in Radio-Interference Suppression.—W. Scholz. (*Fernmeldetech. Z.*, Aug. 1953, Vol. 6, No. 8, pp. 385–388.) The measurement of interference at frequencies between 150 kc/s and 328 Mc/s is briefly described (see also 478 above). The generation of interference and its suppression by suitable design, with or without additional suppressors, is discussed; in particular, radiation from fractional-horse-power motors, fluorescent lamps, h.f. generators and radio and television receivers is considered.

World Radio History

621.396.828 **524**

A Codan for A.M. Receivers.—J. B. Rudd. (*J. Brit. Instn Radio Engrs*, Nov. 1953, Vol. 13, No. 11, pp. 558–568.) Reprint. See 2132 of 1953.

STATIONS AND COMMUNICATION SYSTEMS

621.396.333 **525**

Frequency Shift Keying Radio Telegraph Equipment.—D. A. Brooke. (*Telecommun. J. Aust.*, June 1952, Vol. 9, No. 1, pp. 42–51.) A brief survey of the historical development of frequency-shift technique is presented and a description is given of the equipment used on a typical circuit working between Perth and Melbourne; results of some performance tests are discussed.

621.396.5 : 621.396.932 **526**

Admiralty Radio-Telephone Equipment Type 619.—(*Elect. J.*, 7th Aug. 1953, Vol. 151, No. 6, pp. 419–420.) An outline description is given of the receiver (60 kc/s–32 Mc/s), the h.f. transmitter (1·5–16 Mc/s), the m.f. transmitter (330–550 kc/s) and the power unit for operation from 100–125-V or 200–250-V 50–60-c/s mains. The radiated field from the superheterodyne receiver is < 0·1 μV/m at a distance of one nautical mile.

621.396.5.029.62 : 621.396.931 **527**

U.S.W. Radiotelephony for Mobile Services.—H. v. Kobierski. (*Fernmeldetech. Z.*, Aug. 1953, Vol. 6, No. 8, pp. 379–384.) A survey and discussion of specifications for mobile R/T equipment.

621.396.65.029.62 + 621.397.26.029.62 **528**

Operational and Technical Structure of the Höhbeck V.H.F. Relay Station.—Heuser & Pietz. (See 539.)

621.396.712.3 **529**

New Studio Installation at Radio Luxemburg.—H. Petzoldt. (*Elektrotech. Z., Edn B*, 21st Aug. 1953, Vol. 5, No. 8, pp. 263–265.) A brief illustrated description of the a.f. equipment and layout.

621.396.721 **530**

Two-Band Transmitter-Receiver.—G. P. Anderson. (*Wireless World*, Dec. 1953, Vol. 59, No. 12, pp. 593–598.) A detailed description is given of low-power equipment for a fixed or portable station providing telephony and c.w. operation in the 160-m and 80-m bands. Transmitter and receiver are housed in identical boxes 8 in. × 4 in. × 5 in., with a separate unit for power supply. The audio stages of the t.r.f. receiver are used for modulating the transmitter.

621.396.932 + 621.396.963.3 **531**

Recent Maritime Radio and Radar Developments.—I. F. Byrnes. (*RCA Rev.*, Sept. 1953, Vol. 14, No. 3, pp. 305–317.) An outline description of telegraphy and telephony equipment for cargo and passenger ships complying with F.C.C. requirements, the specifications of the Safety of Life at Sea Convention (London, 1948) and the 1947 Atlantic City Conference Radio Regulations. A surface-search radar with a 16-in. p.p.i. display is also described.

621.396.97.029.6 + 621.397.743.029.6 **532**

Planning the U.S.W. Broadcasting Network for Sound and Television.—F. Gutzmann, W. Knöpfel & W. Stepp. (*Fernmeldetech. Z.*, Aug. 1953, Vol. 6, No. 8, pp. 353–372.) A survey is made of the development of the transmitter networks in the Federal German Republic before and after the Stockholm Conference [3560 of 1952 (Stepp)]. Frequency allocation, optimum transmitted power, transmitter siting, interference, etc., are discussed. Complete lists are given of the v.h.f. sound and television transmitters, and their geographical position, frequency and radiated power. Field-strength contour and service-area maps are also given. To obtain complete television coverage it will be necessary to provide some u.h.f. transmitters.

SUBSIDIARY APPARATUS

621-526 **533**

Design Charts for an On/Off Control System.—W. T. Bane. (*Trans. Soc. Instrum. Technol.*, June 1953, Vol. 5, No. 2, pp. 52–70. Discussion, pp. 70–71.) A simple and rapid method is presented for determining the step-function response of an on-off system consisting of a pure time delay (or distance-velocity lag), an exponential time constant and an integration.

621.314.57 **534**

Self-Excited Two-Phase Thyratron Inverter.—H. Hertwig. (*Electronic Applic. Bull.*, March/April 1953, Vol. 14, Nos. 3/4, pp. 54–58.) Details are given of a unit providing an output of 30 W at 220 V 50 c/s from a 220-V d.c. input.

TELEVISION AND PHOTOTELEGRAPHY

621.397.2 : 621.396.662.029.63 **535**

The Selection and Amplification of U.H.F. Television Signals.—W. P. Boothroyd & J. Waring. (*Trans. Inst. Radio Engrs*, June 1953, No. PGBTR-3, pp. 5–14.) Maps showing the distribution and coverage of television stations in various parts of the U.S.A. are used to illustrate receiver selectivity problems. The design principles and features of some u.h.f. tuners are described.

621.397.24 : 535.623 **536**

Color-Television Converter for Cable Networks.—J. G. Reddeck & H. C. Gronberg. (*Electronics*, Nov. 1953, Vol. 26, No. 11, pp. 132–134.) In the N.T.S.C. colour system the colour information is located towards the upper end of the video-signal spectrum, which extends over a band of 4 Mc/s. In order to be able to transmit this information over the long-distance L-1 coaxial cable, which has a bandwidth of about 2·7 Mc/s, the video signal is split into two bands, one covering 0–2 Mc/s and the other covering the colour subcarrier ± 0·3 Mc/s; the latter is heterodyned down close to the former to give a compressed video signal of width 2·7 Mc/s.

621.397.26 : 621.396.65 **537**

Mobile Outside-Broadcast Decimetre-Wave Equipment for Television Transmission.—H. Röschlau. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, 1953, Vol. 5, Nos. 7/8, pp. 144–147.) Equipment for operation on a wavelength of 21 cm is described. The mobile transmitter has an aerial reflector of diameter 1·1 m, giving a beam width of 16°; the stationary receiver has a reflector of diameter 2·4 m, giving a beam width of 12°. The modulation system is d.s.b. a.m. Noise-free pictures have been transmitted over distances > 40 km.

621.397.26 : 621.396.65 **538**

The Equipment of the Cologne-Frankfurt-Neustadt Decimeter-Wave Television-Relay Link.—O. H. Appelt, K. Christ & K. Schmid. (*Fernmeldetech. Z.*, Aug. 1953, Vol. 6, No. 8, pp. 406–410.) The design principles are noted and brief descriptions are given of the equipment and installations at the relay and terminal stations. The methods used for the determination of receiver sensitivity and signal/noise ratio, and overall distortion, are described.

World Radio History

621.397.26.029.62 + 621.396.65.029.62 **539**

Operational and Technical Structure of the Höhbeck V.H.F. Relay Station.—H. Heuser & H. Pietz. (*Fernmeldetech. Z.*, Sept. 1953, Vol. 6, No. 9, pp. 416–421.) Television, radio programme and R/T relay services are provided for the Berlin-Hamburg v.h.f. link. The equipment, installation and the relay system of operation are described. Frequencies in the 174–216-Mc/s band are used for television and in the 41–68-Mc/s band for sound.

621.397.3 **540**

The Television Picture.—P. Lindner. (*NachrTech.*, Aug. 1953, Vol. 3, No. 8, pp. 359–364.) Perspective, contrast, definition, geometry, and the monochrome reproduction of coloured objects, are discussed.

621.397.5 **541**

Amateur Television Progress.—M. Barlow. (*Wireless World*, Dec. 1953, Vol. 59, No. 12, pp. 589–592.) The total number of active amateur experimenters is estimated to be about 500, the number of amateur stations ≯ 25. Most of the work is done on the 430-Mc/s band. Some details are given of the apparatus used.

621.397.5 : 535.623 **542**

Optimum Utilization of the Radio Frequency Channel for Color Television.—R. D. Kell & A. C. Schroeder. (*Trans. Inst. Radio Engrs*, June 1953, No. PGBTR-3, pp. 33–39.) See 3431 of 1953.

621.397.5 : 535.623 **543**

Transient Considerations in the N.T.S.C. Color System.—B. S. Parmet & L. M. Kaminsky. (*Trans. Inst. Radio Engrs*, June 1953, No. PGBTR-3, pp. 47–67.) A discussion of methods of reducing picture-signal distortion caused by bandwidth limitations. Fourier-integral analysis is used to determine the amount by which a unit step signal is distorted when the bandwidth and rates of cut-off of the filters are adjusted in accordance with N.T.S.C. specifications. Results are shown graphically.

621.397.5 : 535.623 **544**

Technical Signal Specifications Proposed as Standards for Color Television.—(*RCA Rev.*, Sept. 1953, Vol. 14, No. 3, pp. 359–366.) N.T.S.C. revised specifications of July 1953. These embody minor modifications to the February 1953 specifications noted in 3428 of 1953 (Brown & Luck).

621.397.5 : 535.623 **545**

Band-1 Colour Television.—(*Wireless World*, Dec. 1953, Vol. 59, No. 12, p. 599.) A note indicating the advantage from the point of view of compatibility, of transmitting the colour signal by the adjacent-channel system rather than by the N.T.S.C. subcarrier system.

621.397.61 : 621.372.543.2 **546**

High-Frequency-Filter Problems in Television Transmitters.—Burkhardtsmaier. (See 361.)

621.397.611.2 **547**

Image Orthicon Camera Tubes.—G. B. Banks, K. Frank & E. D. Hendry. (*J. Telev. Soc.*, July/Sept. 1953, Vol. 7, No. 3, pp. 92–104.) Detailed description of construction and operation; various manufacturing stages are illustrated.

621.397.611.2 **548**

A Survey of the Development of Television Pickup Devices.—H. A. McGhee. (*J. Brit. Instn Radio Engrs*, Nov. 1953, Vol. 13, No. 11, pp. 543–557.) The survey includes the image dissector and c.r.-tube flying-spot scanner, and camera tubes of both anode-potential-stabilized and cathode-potential-stabilized types. The method of improving the operation of the image iconoscope by flooding the target with low-velocity photoelectrons is described.

621.397.62 **549**

The Design of Television Receivers utilizing Non-synchronous Power.—G. D. Hulst. (*Trans. Inst. Radio Engrs*, June 1953, No. PGBTR-3, pp. 15–24.) An examination of problems involved in the design of sets to receive standard U.S.A. television broadcasts without adverse effects on the picture while using power supplies at frequencies other than 60 c/s. Location of the power transformer and precautions regarding heater wiring are discussed particularly. Details are given of the performance of two commercial receivers.

621.397.62 **550**

German Television Receivers.—H. K. Ibing. (*Z. Ver. dtsch. Ing.*, 11th Aug. 1953, Vol. 95, No. 23, pp. 769–773.) A review of current trends. Features mentioned include provision of high anode voltage, giving brighter pictures; ion traps; ten frequency channels; reduced number of valves; use of Ge diodes. There is little variety as regards i.f. amplifiers, but individuality is shown in the demodulating, filtering and timebase circuits.

621.397.62 **551**

German Television-Receiver Circuits, 1953/54.—W. W. Diefenbach. (*Funk-Technik, Berlin*, Aug. 1953, Vol. 8, No. 16, pp. 485–489.) Features noted in this survey include multichannel reception, larger picture screens, improved sensitivity achieved by use of cascode input circuits, use of Ge diodes, good stability, and improved facilities for servicing.

621.397.62 **552**

The Importance of the D.C. Component.—D. C. Birkinshaw. (*J. Telev. Soc.*, July/Sept. 1953, Vol. 7, No. 3, pp. 105–114.) A description is given of various undesirable effects produced at the receiver if the brightness of the picture is not controlled at the transmitter, i.e. by transmitting the d.c. component; the effects are illustrated by photographs. In some modern receivers the d.c. component is deliberately attenuated to suit other design requirements and to avoid brightness flutter due to passing aircraft; alternative methods of solving these problems are indicated.

621.397.62 : 621.396.662 **553**

A V.H.F.-U.H.F. Television Turret Tuner.—T. Murakami. (*RCA Rev.*, Sept. 1953, Vol. 14, No. 3, pp. 318–340; *Trans. Inst. Radio Engrs*, Oct. 1953, No. PGBTR-4, pp. 38–52.) Channels 2–83 are covered by using six different types of subassembly (channel strip) consisting of the r.f. amplifier, oscillator and mixer circuits. Sixteen channel strips are mounted on a turret-type channel selector and a variable impedance in the anode circuit of the oscillator is used to provide a fine tuning control. The vision i.f. is 45·75 Mc/s, the sound i.f. 41·25 Mc/s. Circuits and performance characteristics are described.

621.397.62 : 621.396.665 **554**

A Keyed Minimum-Signal Detector for Television Receiver Impulse-Noise Immunity.—A. Macovski. (*RCA Rev.*, Sept. 1953, Vol. 14, No. 3, pp. 389–396.) The minimum, instead of the maximum, of a positive synchronizing pulse is used for the synchronizing-signal-separator and the a.g.c. reference voltages. Circuits are described of a minimum-signal detector, separator and a.g.c. systems, diode clipper and noise inverter.

World Radio History

621.397.62 : 621.396.665 555

A Level-setting Sync and Automatic-Gain-Control System for Television Receivers.—E. O. Keizer & M. G. Kroger. (*RCA Rev.*, Sept. 1953, Vol. 14, No. 3, pp. 379–388.) The self-biased synchronizing-signal separator, which charges up on noise pulses, is replaced by a direct-coupled separator, biased by voltage obtained from the i.f. amplifier stage. This circuit also provides the a.g.c. amplification; the a.g.c. voltage is protected from noise pulses by clipping in the separator stage. A television receiver embodying the system is described.

621.397.62.002.2 556

Approach to Mechanized Assembly of Electronic Equipment Applicable to TV Receivers.—R. F. Newton & L. K. Lee. (*Trans. Inst. Radio Engrs*, June 1953, No. PGBTR-3, pp. 25–32.) A study of the immediate possibilities of mechanizing the production of television receivers. Flexibility of operation can be achieved by building up the automatic production line from machine units, individual members of which can be removed as required. Special-purpose machines, such as one for attaching resistors and capacitors, are discussed.

621.397.621 : 621.311.6 557

Ringing-Choke E.H.T. Unit.—D. M. Melluish. (*Wireless World*, Dec. 1953, Vol. 59, No. 12, pp. 603–604.) Description of a circuit suitable for operating a 6-in. c.r. tube, and capable of providing a voltage of 2–3 kV at 250 μA from a 350-V 10-mA supply.

621.397.621.018.75 558

Pulse-Regeneration Equipment for Television Signals.—G. Dröscher. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, 1953, Vol. 5, Nos. 7/8, pp. 148–149.) A circuit for use in relaying television is described and illustrated. Synchronizing pulses are separated from the incoming picture signal, the slope of the flanks is increased in two overmodulated amplifier stages, and the pulses are then recombined with the picture signal.

621.397.621.2 : 535.623 559

A Four-Gun Tube for Color Television Receivers.—J. L. Rennick & C. H. Heuer. (*Trans. Inst. Radio Engrs*, June 1953, No. PGBTR-3, pp. 40–46.) The tube is similar to the three-gun aperture-mask type described by Law (844 of 1952), but each group of phosphor dots on the screen includes a fourth dot giving white fluorescence. The signal waveforms required for operating the system are indicated, and the implications of the modification as regards convergence and gamma correction are discussed.

621.397.7 560

New Directional Radio Links and Television Transmitters in the German Democratic Republic.—(*Nachr-Tech.*, Aug. 1953, Vol. 3, No. 8, p. 337.) A note on the inauguration of the Berlin-Leipzig u.h.f. television link and the Leipzig transmitter. The vision transmitter frequency is 59·25 Mc/s (s.s.b. transmission), the f.m. sound transmitter frequency is 65·75 Mc/s.

621.397.7 561

Special Effects for Television Studio Productions.—A. M. Spooner & T. Worswick. (*Proc. Instn elect. Engrs*, Part I, Sept. 1953, Vol. 100, No. 125, pp. 288–296. Discussion, pp. 296–299.) Three methods of producing special effects are described, viz. (*a*) optical-image back projection for providing scenery, (*b*) inlay, in which a picture from one camera is substituted by electronic means for part of the picture from a second camera, (*c*) overlay, in which a result similar to back projection is obtained by electronic means. Advantages and operational difficulties associated with these processes are discussed.

621.397.7 562

The 10-kW Television Transmitter Station on the Feldberg (Taunus).—(*Fernmeldetech. Z.*, Aug. & Sept. 1953, Vol. 6, Nos. 8 & 9, pp. 396–405 & 449–454.) Technical details are given of the sound and vision transmitters and of the slotted-cylinder aerial. A power gain of 12, obtained by feeding the common wide-band aerial via a diplexer, results in effective radiated powers of 36 and 120 kW respectively for sound and vision. The present sound and vision transmission frequencies are 201·75 and 196·25 Mc/s respectively. The account comprises four papers, as follows:—

A. Picture and Sound Transmitters.—E. Heinecke & H. Hornung.
B. Modulation Amplifier and Video Frequency Monitoring Equipment.—R. Urtel & K. Jekelius.
C. Aerial Diplexer and Single-Sideband Filter.—A. Linnebach.
D. Slotted-Cylinder Aerial for the 174–216-Mc/s Television Band.—H. Bosse & W. Crone.

621.397.7 563

The New Television Building in Hamburg-Lokstedt.—W. Nestel. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, 1953, Vol. 5, Nos. 7/8, pp. 125–127.) The considerations underlying the structural design and technical equipment of this studio centre are discussed. See also *Funk-Technik, Berlin*, Nov. 1953, Vol. 8, No. 21, pp. 670–671.

621.397.7 564

Architectural Aspects of the New Television Building in Hamburg-Lokstedt.—K. Heinemann & K. Langer. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, 1953, Vol. 5, Nos. 7/8, pp. 128–133.)

621.397.7 565

Heating, Ventilating, Air-Conditioning and Refrigerating Installations in the New Television Building at Lokstedt.—O. H. Brandi. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, 1953, Vol. 5, Nos. 7/8, pp. 134–135.)

621.397.7 566

The Television Switching Equipment at the Lokstedt Studio.—F. Below. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, 1953, Vol. 5, Nos. 7/8, pp. 137–139.) The facilities described correspond to an interim stage in which four studios are available. The circuits from the control cubicles and the film-scanning room are routed via a main control room.

621.397.7 : 534.861.1 567

The Problems of the Acoustics of a Television Studio.—H. Kösters. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, 1953, Vol. 5, Nos. 7/8, pp. 135–136.) Acoustics problems associated with the need for frequent changes of scene are discussed.

621.397.712 568

Picture-Mixing Desk for Transmission Truck.—H. Fünfstück. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, 1953, Vol. 5, Nos. 7/8, pp. 140–143.) A four-channel mixer is described in which the video-amplitude controls are lever actuated. A black-level-control diode prevents undesirable effects in the amplifier during cross-fades.

621.397.743.029.6 + 621.396.97.029.6 569

Planning the U.S.W. Broadcasting Network for Sound and Television.—Gutzmann, Knöpfel & Stepp. (See 532.)

621.397.8 : 621.397.5 : 535.623 570

A Comparison of Monochrome and Color Television with Reference to Susceptibility to Various Types of Interference.—G. L. Fredendall. (*RCA Rev.*, Sept. 1953, Vol. 14, No. 3, pp. 341–358.) The types of interference used in this series of subjective tests included co-channel, adjacent-channel, random-noise, sine-wave, impulse-noise and multipath interference. Colour is more susceptible (by 6–8 db) than monochrome to upper-adjacent-channel interference, and slightly more susceptible to some of the other types.

621.397.823 + 621.396.823 571

Effect of Radio Interference generated by High-Voltage Lines on the Reception of Broadcast and Television Transmissions.—Passerieux. (See 519.)

621.397.828 572

Ignition Interference with Television Reception.—A. H. Ball & W. Nethercot. (*Proc. Instn elect. Engrs*, Part 1, Sept. 1953, Vol. 100, No. 125, pp. 299–300.) Oscillograms are shown of the discharge of a typical ignition circuit with and without an interference-suppressing resistor; in the latter case the discharge is oscillatory and the peak value of the current is $\sim$ 220 A; in the former case the discharge is unidirectional and the peak value of the current is 0·8 A. Tests indicate that suppressors have no adverse effect on normal engines under normal operating conditions.

621.397.5 573

Television. [Book Review]—F. Kerkhof & W. Werner. Publishers: Cleaver-Hume Press, London, & Elsevier Press, New York, 1952, 434 pp., 50s. (*Nature, Lond.*, 12th Sept. 1953, Vol. 172, No. 4376, pp. 471–472.) "As the first full modern study of the basic aspects of the subject, this work can be recommended with confidence both for general reading and, with the aid of the excellent bibliography provided, as a constant source of reference for more detailed study." For a review of the German edition see 2643 of 1952.

TRANSMISSION

621.396.61.029.55 574

A New 5-Kilowatt H.F. Multichannel Transmitter.—F. R. Hill. (*Proc. Instn Radio Engrs, Aust.*, Sept. 1953, Vol. 14, No. 9, pp. 219–227.) A detailed description is given of a telegraphy transmitter comprising four separate crystal-controlled r.f. units, with a r.f. output of 5 kW each at 3–25 Mc/s, a single modulator and a power and power-switching unit. Independent c.w. transmission, or common m.c.w. transmission, on up to four channels is obtained by a simple power-switching operation. With a different modulator the same r.f. units could be used for broadcasting.

621.396.662.6 : 621.396.933 575

Increasing Mean Modulation Depth by Peak Speech Clipping.—(*Marconi Rev.*, 4th Quarter 1953, Vol. 16, No. 111, p. 184.) In normal speech the peak power of the average vowel is considerably greater than that of the average consonant, hence a carrier modulated 100% by vowel sounds is modulated much less by consonants. Improved intelligibility is obtained by speech clipping, i.e. reducing this intensity difference before modulation. For 100% modulation by peak vowel sounds, the mean modulation depth is 35% with no clipping, 70% with 12 db of clipping and 95% with 24 db of clipping. The technique is used in air-to-ground communications.

VALVES AND THERMIONICS

537.533 576

Field Electron Emission and Gas Adsorption.—F. Kirchner & H. Kirchner. (*Z. angew. Phys.*, Aug. 1953, Vol. 5, No. 8, pp. 281–283.) The variation with temperature of the field emission from a tungsten point with a layer of adsorbed oxygen was investigated experimentally. A critical temperature was found at which an abrupt change occurred in the electron emission; the observed effects indicate that above this temperature the oxygen forms only an incomplete coating.

621.314.632 + 621.314.7] : 537.311.33 577

Semiconductor Circuit Elements. Blakemore, De Barr & Gunn. (See 439.)

621.314.632 : 546.289 578

Point-Contact Germanium Rectifiers.—R. T. Lovelock. (*Wireless World*, Nov. & Dec. 1953, Vol. 59, Nos. 11 & 12, pp. 511–514 & 600–602.) A simple exposition of semiconductor theory is given as a basis for a discussion of factors affecting the performance and reliability of Ge rectifiers. The influence of temperature and humidity is examined.

621.385.029.6 : 621.396.822 579

Noise in C.W. Magnetrons.—D. Middleton, W. M. Gottschalk & J. B. Wiesner. (*J. appl. Phys.*, Aug. 1953, Vol. 24, No. 8, pp. 1065–1066.) Measurements were made to determine whether the magnetron output should be regarded as carrier plus noise, carrier amplitude-modulated by noise, or carrier phase-modulated by noise; the last of these alternatives appears to fit the experimental results best. The frequency deviations observed could be accounted for by fluctuations in the density of the magnetron space charge due to cathode noise effects or to the presence of gas ions.

621.385.029.63 580

Design and Performance of a High-Power Pulsed Klystron.—M. Chodorow, E. L. Ginzton, I. R. Neilsen & S. Sonkin. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1584–1602.) Development work at Stanford University on 3-cavity klystrons for operation at 3 Mc/s in the voltage range 100–400 kV, and delivering power of about 20 MW, is discussed. At the voltages used, relativity effects on the electron velocities must be taken into account. Problems connected with the magnetic focusing of the beam, the cathode design, the avoidance of voltage breakdown, and the generation and transformation of the pulses are examined. The collector is shaped so as to receive the beam over a large area, thus ensuring that the temperature rise is not too great. Details are given of the construction of a particular klystron giving pulses of duration 1–2 μs with a beam voltage of 400 kV and a beam current of 250 A. The longest life so far recorded is 200 hours at 17 MW output and $>$ 460 hours at 8 MW output, but it is considered that a life of $>$ 1 000 hours could be attained with an operating voltage of about 300 kV.

621.385.029.63/.64 581

Influence of Secondary Electrons on Noise Factor and Stability of Traveling-Wave Tubes.—R. W. Peter & J. A. Ruetz. (*RCA Rev.*, Sept. 1953, Vol. 14, No. 3, pp. 441–452.) The noise factor and stability of the experimental 3-kMc/s travelling-wave valve [277 of 1953 (Peter)] were improved by using a magnetically shielded collector, thus preventing secondary electrons emitted by the collector from reaching the helix. Experimental details are given.

621.385.029.63/.64 582

Measurement of the Cross-Sectional Nonuniformity of the Electron Beam in a Helix-Type Travelling-Wave Valve.—H. Schnitger. (*Arch. elekt. Übertragung*, Sept. 1953, Vol. 7, No. 9, pp. 415–420.) As a result of radial components in the initial velocity of the electrons, the beam diameter varies periodically along its length. Using theory given by Wang (1395 of 1950), a relation is established between (*a*) the distance separating successive beam-radius minima (the 'wavelength'), and (*b*) the ratio of maximum to equilibrium radius. The cross-

World Radio History

sectional nonuniformity can then be determined from measurements of this 'wavelength'. The method used is to measure the helix current as a function of the position of a short double coil which is moved coaxially along the valve and whose windings carry equal and opposite currents.

621.385.029.63/.64 **583**

On the Excitation of Different Space-Charge Wave Modes in Travelling-Wave Tubes.—O. E. H. Rydbeck. (*Arch. elekt. Übertragung*, Sept. 1953, Vol. 7, No. 9, pp. 409–414. In English.) Analysis is given for beams of moderate current density. The characteristic equation for the travelling-wave valve is shown to comprise two coupled equations, one associated with the beam and the other with the helix. These equations are used to investigate the excitation of the space-charge waves and their transformation into waves characteristic of travelling-wave valves. All the transformed space-charge waves have practically the same propagation constants, and hence the same gain. Space-charge modes whose wavelength is $\sqrt{2}$ times that for an infinitely wide beam are most easily transformed. It is probable that no transformations of this kind occur at very high beam current density.

621.385.029.63/.64 **584**

Traveling-Wave-Tube Helix Impedance.—Ping King Tien. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1617–1623.) Helix impedance K is given by the formula $K = E_z^2(0)/2\beta^2 P$, where $E_z(0)$ is the maximum value of the longitudinal field on the axis, P is the power in the wave carried by the helix, and β the phase constant. The value of K is found by calculation to be smaller for the 'tape-helix' model than for the 'sheath-helix' model, and to decrease as the ratio of helix circumference to free-space wavelength increases. Conditions are analysed for a tape helix surrounded by a dielectric. The theory indicates that the design of travelling-wave valves can be improved (*a*) by means of suitably designed dielectric supports for the helix, and (*b*) by reducing the space-harmonic component fields.

621.385.029.63/.64 **585**

Prediction of Traveling-Wave-Magnetron Frequency Characteristics: Frequency Pushing and Voltage Tuning.—H. W. Welch, Jr. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1631–1653.) 'Frequency pushing' is defined as the frequency variation associated with change of anode direct current when the anode voltage is varied, the resonator temperature being held constant. 'Voltage tuning' is defined as the frequency variation associated with change of anode direct voltage when anode direct current, load impedance, magnetic field and resonator temperature are held constant. Formulae are derived expressing the relations involved, based on an approximate determination of the distribution of space charge for high r.f. voltage. Calculated characteristics for typical design parameters are presented. Theoretical and experimental results are compared.

621.385.029.64/.65 **586**

Backward-Wave Tubes.—R. Kompfner & N. T. Williams. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1602–1611.) Experiments with travelling-wave valves of the type described by Millman (547 of 1952) show that oscillations can be generated in modes such that r.f. power output is obtained at the gun end of the valve. The first and second spatial-harmonic modes were excited with voltages of 1·6–4 kV and 600–900 V respectively on the electron beam constituting the feedback path; the corresponding wavelength ranges were 6–7·5 mm and 5·9–6·4 mm. A frequency band of 10 kMc/s is thus covered by purely electronic tuning. Power output of about 10 mW was obtained at 6·4 mm λ. The operation of the valves as amplifiers was also studied. Theory is given.

621.385.029.64/.65 : 621.373.423 **587**

Backward-Wave Tube.—H. Heffner. (*Electronics*, Oct. 1953, Vol. 26, No. 10, pp. 135–137.) An explanation is given of the production of the backward wave in a travelling-wave valve, and the conditions for oscillation are indicated. Continuous tuning over a 3 : 1 range is possible.

621.385.029.65 **588**

A Hairpin-Tube Backward-Wave Oscillator.—G. E. Helmke. (*Bell Lab. Rec.*, Aug. 1953, Vol. 31, No. 8, pp. 286–291.) The construction of an experimental valve and, in particular, of the interdigital waveguide section containing the wire loops which resemble a row of hairpins, is described. The frequency of oscillation may be varied between 43 and 63 kMc/s by varying the beam voltage between 500 and 2 500 V.

621.385.032.213.2 **589**

The Emission Constants of Metal Capillary Cathodes.—H. Benda. (*Frequenz*, Aug. 1953, Vol. 7, No. 8, pp. 226–232.) Continuation of work noted in 1155 of 1952 (Katz & Rau). The emission constants of W-BaCO$_3$ + Si cathodes were determined experimentally by measuring the current collected by the metal capillary cathode when connected as anode in relation to a heated counter-electrode; this current depends on the work function of the metal capillary cathode. The arithmetic mean of the work function over a period of aging at about 950°C is 2 eV. The value thus found for the Richardson constant A is of the order of 10^2; the discrepancy between this value and that found by other methods is discussed.

621.385.032.216 **590**

Diffusion of Barium in an Oxide-Coated Cathode.—R. S. Bever. (*J. appl. Phys.*, Aug. 1953, Vol. 24, No. 8, pp. 1008–1010.) Measurements of the diffusion of BaO through activated BaO-SrO cathode coatings, using a technique similar to that described by Redington (432 of 1953), indicated that the law of temperature variation of diffusion was similar to that for Ba in BaO single crystals. The activation energy was 4·1 ± 0·6 eV above 1 280°K and 0·40 ± 0·07 eV below that temperature.

621.385.032.216 **591**

Space-Charge Effect in the Oxide-Cathode Layer: Part 2.—T. Shindo. (*J. phys. Soc. Japan*, July/Aug. 1953, Vol. 8, No. 4, pp. 494–499.) The theory previously given (2082 of 1952) is extended to include the retarding-field region. The emission characteristics for a planar diode are calculated.

621.385.032.216 **592**

A Theoretical Study of the Chemistry of the Oxide Cathode.—E. S. Rittner. (*Philips Res. Rep.*, June 1953, Vol. 8, No. 3, pp. 184–238.) A comprehensive analysis, based on thermochemistry and on the theory of diffusion, is presented. The treatment is based on the assumption that excess Ba is required to activate the coating. Metals with sufficient reducing power to act as activators include Th, Mg, Be, Hf, Sc, Y, Sm, Nd, Pr, La, Zr, U, Al, Si, C and possibly Ti and Ce. The most favourable reaction mechanism for the generation of free Ba is that in which the reaction speed is limited by the rate of diffusion of the activator in the core metal. The free Ba penetrates the oxide crystals by Knudsen vapour flow and volume diffusion, and hence the coating should be porous.

621.385.15 : 621.375.2 **593**

Wide-Band Amplifiers using Secondary-Emission Tubes.—Chandler & Linz. (See 367.)

World Radio History

621.385.15 : 621.385.5 **594**

Electron Multiplier Valve.—A. Lempicki. (*Wireless Engr*, Dec. 1953, Vol. 30, No. 12, pp. 312–317.) The multiplier valve considered is similar in construction to an ordinary r.f. pentode, the multiplier anode being of grid form and occupying the position of the usual suppressor, while the secondary emitter occupies the position of the usual anode; the performance of these two valves is compared. The multiplier type is recommended for wide-band operation, but the overall multiplication factor should be not greater than about 10. Upper frequency limits due to electron transit times in the various sections of the valves are discussed, and noise is considered.

621.385.2 : 621.316.722.1 **595**

Characteristics of the Temperature-Limited Diode Type 29C1.—F. A. Benson & M. S. Seaman. (*Electronic Engng*, Nov. 1953, Vol. 25, No. 309, pp. 462–464.) Static characteristics and long-term test results are given for the diode used in the stabilizer described by Richards (1742 of 1952) and in the differential voltmeter described by Attree (3501 of 1952).

621.385.2.032.21 **596**

Diode Characteristic of a Hollow Cathode.—M. L. Babcock, D. F. Holshouser & H. von Foerster. (*Phys. Rev.*, 1st Aug. 1953, Vol. 91, No. 3, p. 755.) Very much higher currents, particularly for small potentials, are obtained than would be expected from the I/V curve for the equivalent planar diode.

621.385.3 + 621.385.5 **597**

Performance Evaluation of "Special Red" Tubes.—H. J. Prager. (*RCA Rev.*, Sept. 1953, Vol. 14, No. 3, pp. 413–426.) The term 'Special Red' refers to some small receiving-type valves specially selected for industrial applications. The results of life-tests are presented graphically and discussed. Both electrical and mechanical tests were made.

621.385.3 **598**

Variations of Triode Characteristics with Heater Voltage.—F. A. Benson, G. V. G. Lusher & M. S. Seaman. (*Elect. J.*, 14th Aug. 1953, Vol. 151, No. 7, pp. 481–483.) The I_a/V_g characteristic of a triode is modified by a deviation of the filament voltage from normal. It can be expressed by the equation $V_a = r_a I_a - \mu V_g - c_2 r_a$ where r_a is the anode resistance, μ the amplification factor and c_2 a constant which is a function of the applied filament voltage and is important in the design of stabilizers and d.c. amplifiers.

621.385.3 : 621.387 **599**

Control of the Discharge Current in Gas-Filled Valves with Grids by means of Small Alternating Voltages.—A. Székely. (*Acta phys. austriaca*, May 1953, Vol. 7, No. 2, pp. 164–180.) Measurements were made on a Philips Type-4690 triode with the grid connected to the cathode via a high resistance. Application of a small alternating voltage to the grid or anode causes the mean grid potential to become negative with respect to the cathode, thereby raising the ignition voltage. If the circuit is tuned to the applied voltage, this rise in ignition voltage is eliminated. The true variation of ignition voltage with frequency is observed by tuning the circuit to a frequency very different from that of the applied voltage. Results are shown graphically. Application of small alternating voltages can also be used for extinguishing discharges.

621.385.3 : 621.396.662 **600**

The DM 70 and DM 71 Tuning Indicators.—(*Electronic Applic. Bull.*, Jan./Feb. 1953, Vol. 14, Nos. 1/2, pp. 1–11.) These two subminiature valves are identical except for the external connecting arrangements. They have a straight directly heated filament (1·4 V, 0·025 A), a long flat control electrode with an aperture shaped like an exclamation mark, and a luminescent anode beyond the control electrode. Lowering of the potential of the control electrode reduces the length of the luminescent bar. Construction, characteristics and circuits are described. For another account see 3456 of 1953 (White).

621.385.3 + 621.375.2.029.62] : 621.396.822 **601**

Noise Factor of Conventional V.H.F. Amplifiers.—Houlding. (See 369.)

621.385.5 **602**

The EL84 Power Pentode.—P. J. Tijssen. (*Electronic Applic. Bull.*, March/April 1953, Vol. 14, Nos. 3/4, pp. 40–53.) Design, construction and performance details are given of a 12-W output pentode.

621.385.832 : 621.318.572 **603**

The E1T Decade Counter Tube.—(*Electronic Applic. Bull.*, Jan./Feb. 1953, Vol. 14, Nos. 1/2, pp. 13–26.) See 3762 of 1953 (van Overbeek et al.).

621.396.822 **604**

Johnson Noise and Equipartition.—D. A. Bell. (*Proc. phys. Soc.*, 1st Aug. 1953, Vol. 66, No. 404B, pp. 714–715.) Discussion on 2847 of 1953 (Lindsay & Sims).

621.396.822 : [537.311.33 + 621.385.032.21 **605**

Note on Shot Effect in Semi-Conductors and Flicker Effect in Cathodes.—A. van der Ziel. (*Physica*, Aug. 1953, Vol. 19, No. 8, pp. 742–744.) A limitation of the theory previously given (3035 of 1950) is pointed out. It is shown that flicker effect due to emission centres can be treated in the same way as shot noise in semiconductors.

621.396.822 : [621.385.032.21 + 537.311.33 **606**

Theory of the Flicker Effect.—T. B. Tomlinson & W. L. Price. (*J. appl. Phys.*, Aug. 1953, Vol. 24, No. 8, pp. 1063–1065.) Theories on the low-frequency fluctuation of emission current from oxide cathodes and on the similar effect of contact noise in semiconductors are critically reviewed. A modification to Macfarlane's theory (910 of 1951) is discussed which takes account of conditions in retarding-field operation.

621.385.029.6 **607**

Atomic Energy Research Establishment Report A.E.R.E. X/R 608, Mode-Separation Theory for Heavily Strapped Magnetrons. [Book Notice]—A. W. Aikin. Publishers: H.M. Stationery Office, London, 1950, 2s. (*Govt Publ.*, Aug. 1953, p. 20.)

MISCELLANEOUS

6 : 061.4 **608**

The British Instrument Industries Exhibition.—(*Engineer, Lond.*, 3rd–17th July 1953, Vol. 196, Nos. 5084–5086, pp. 20–21, 53–54 & 71–73.) Description of some of the exhibits.

621.38/.39 : 629.13.018 **609**

Aviation Electronics.—A. Van Dyck. (*Proc. Inst. Radio Engrs*, Nov. 1953, Vol. 41, No. 11, pp. 1572–1578.) Special problems introduced by the complexity and unreliability of aircraft electronic apparatus are discussed. The solution depends not only on increasing the reliability of valves and components, but also on improved planning and specifications and on closer cooperation between the electronic engineers and the other personnel concerned.

621.39 : 061.4 **610**

The Leipzig Fair 1953.—(*NachrTech.*, Aug. & Sept. 1953, Vol. 3, Nos. 8 & 9, pp. 338–342 & 402–406.) A survey of communication equipment, amplifiers, valves and test equipment exhibited by manufacturers in the German Democratic Republic.

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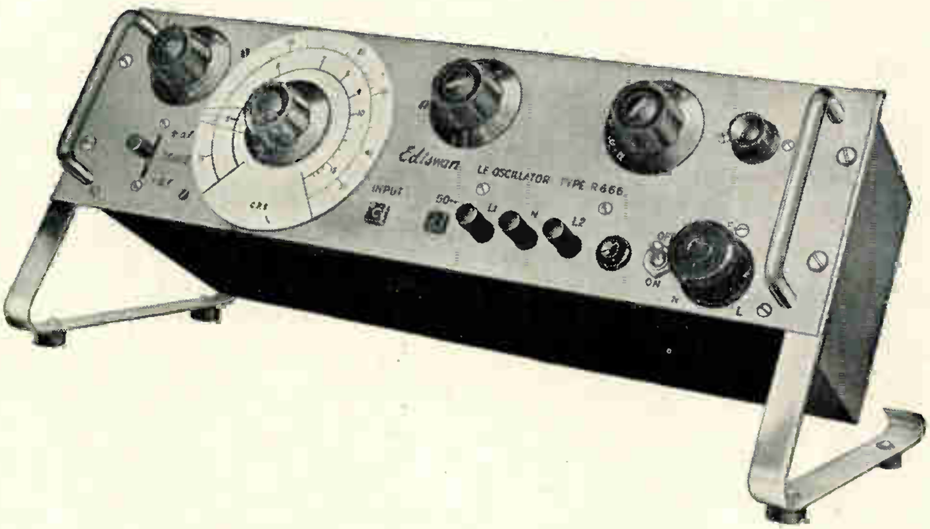

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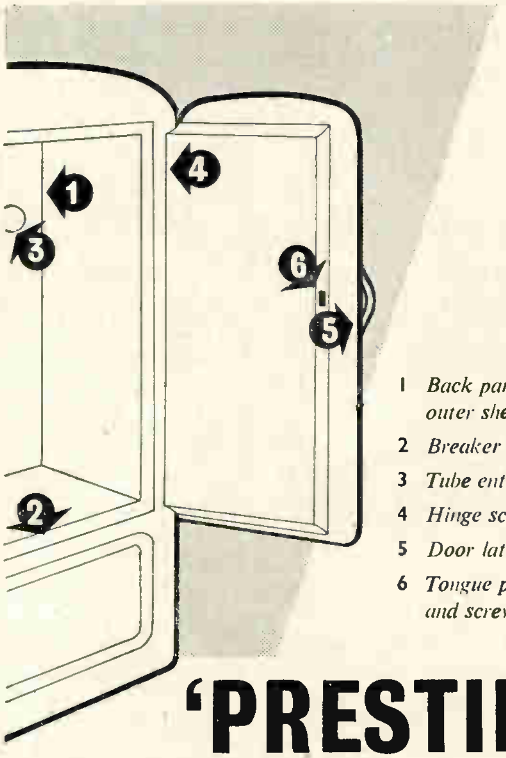

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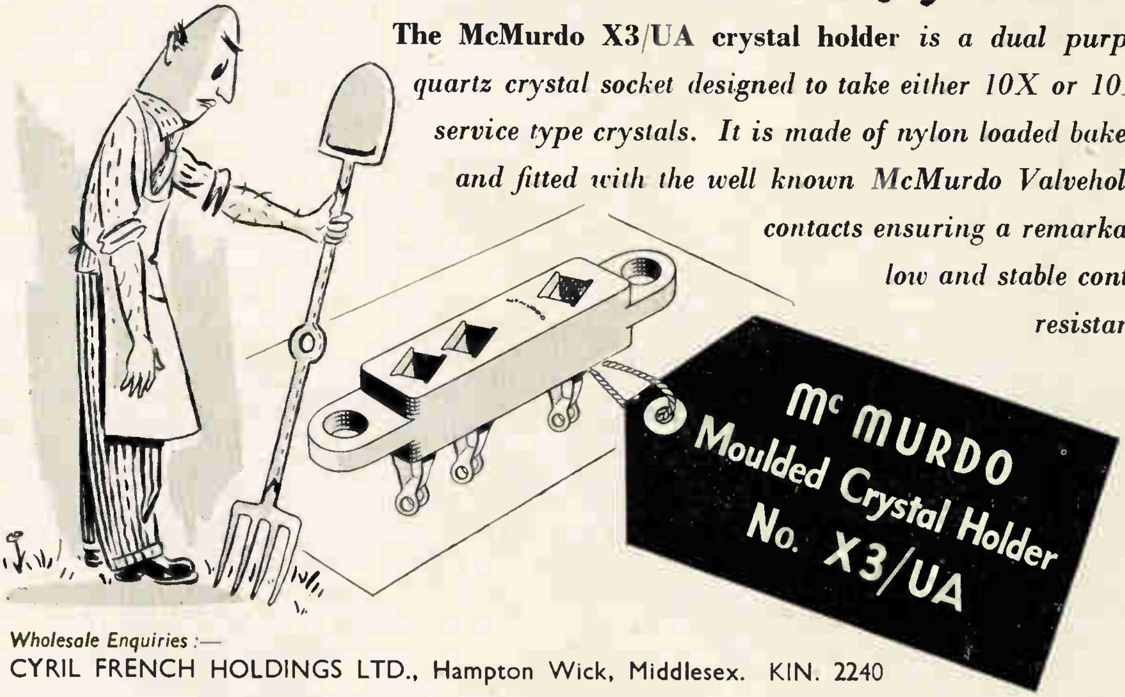

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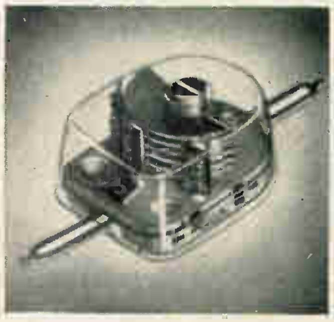

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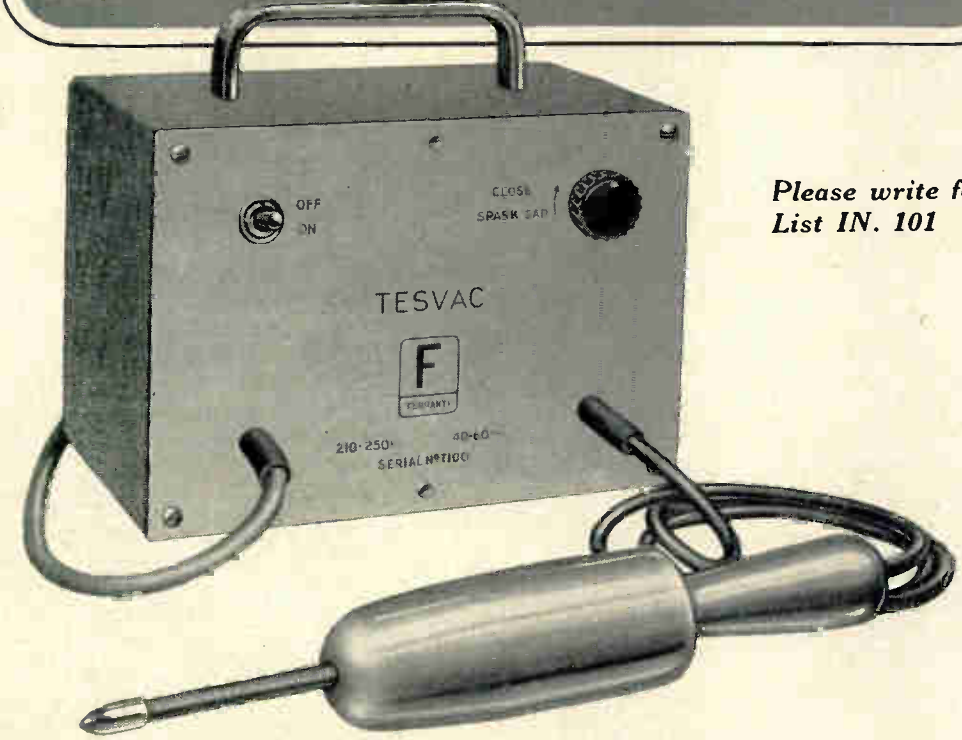

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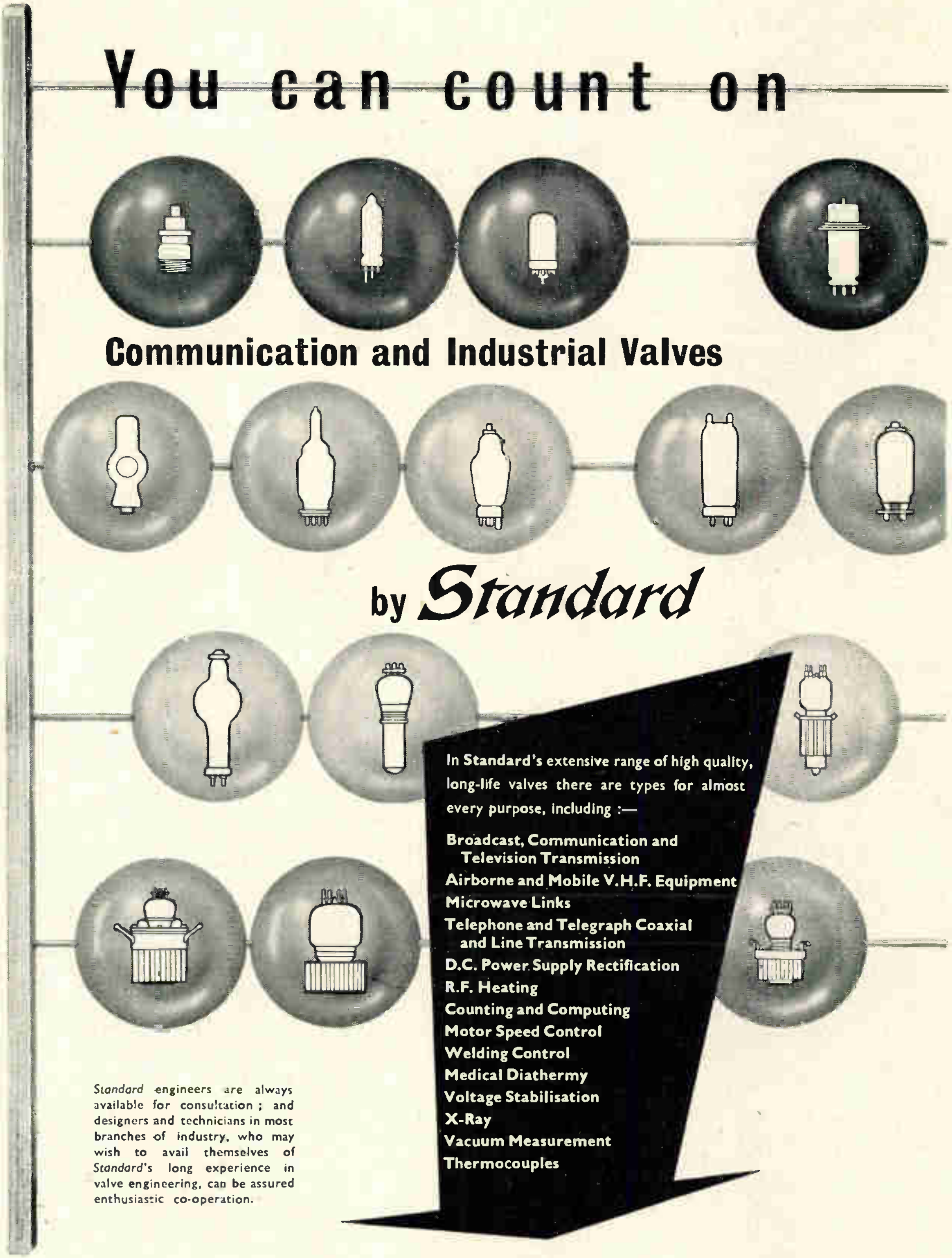

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Duties.—Responsible for the development of various types of precision mechanical recording instruments for the instrumentation of guided missile tests and trials.

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Position No. 7 MATHEMATICS

Duties.—Advise Research Groups on the most suitable mathematical and numerical methods to be employed in the solution of problems, and to undertake the solution of problems requiring specialised mathematical and numerical techniques.

Qualifications.—Degree of high standard in Mathematics, together with experience in allied duties, or equivalent qualifications.

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Duties.—Responsible for a Section concerned with the development of Electronic Systems, for the instrumentation of missiles in flight.

Qualifications.—A degree of high standard in Science or Engineering, together with extensive experience in electronic development work or equivalent qualifications; experience in the design of radars, or other electronic aids, is desirable.

The Headquarters of the Long Range Weapons Establishment is situated at Salisbury, 16 miles from Adelaide in South Australia, where approximately 200 scientists and engineers, with appropriate ancillary staffs, are engaged in this Joint Australia United Kingdom Project. General research and development work is carried out in laboratories established there in the fields of aerodynamics, control and guidance of missiles, design of optical and electronic equipment required for trials, and computation and analysis of trials results.

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Further details of Adelaide and its surroundings can be obtained from the office of:—

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LONDON, W.1.

Further information, including details regarding the nature of the work and application forms, may be obtained from:—

Senior Representative (A.P.5).
Department of Supply.
Australia House.
The Strand, LONDON, W.C.2.

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Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C 29100 WJ.

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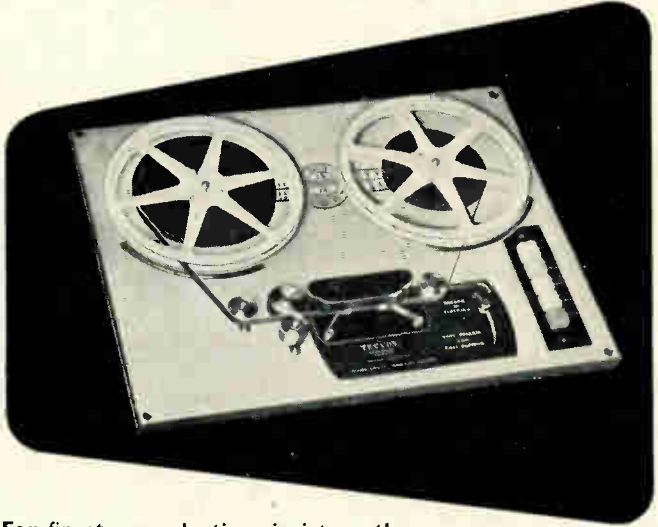

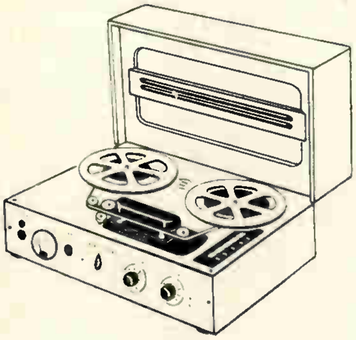

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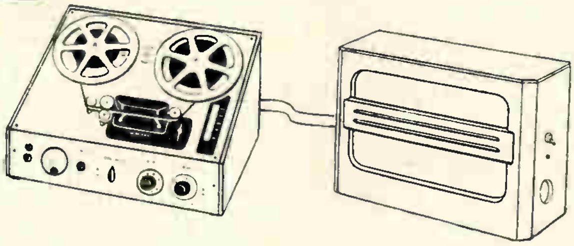

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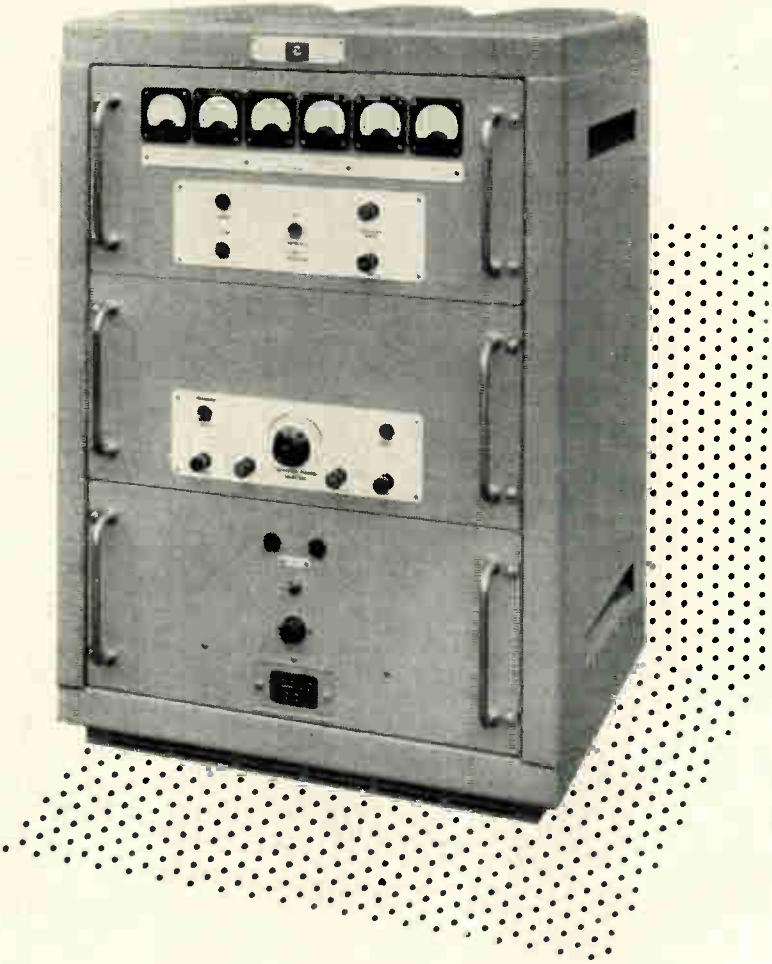

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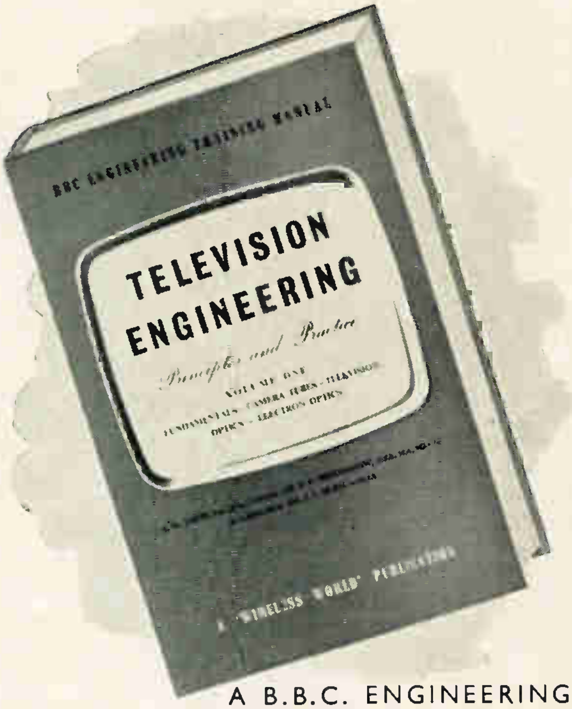

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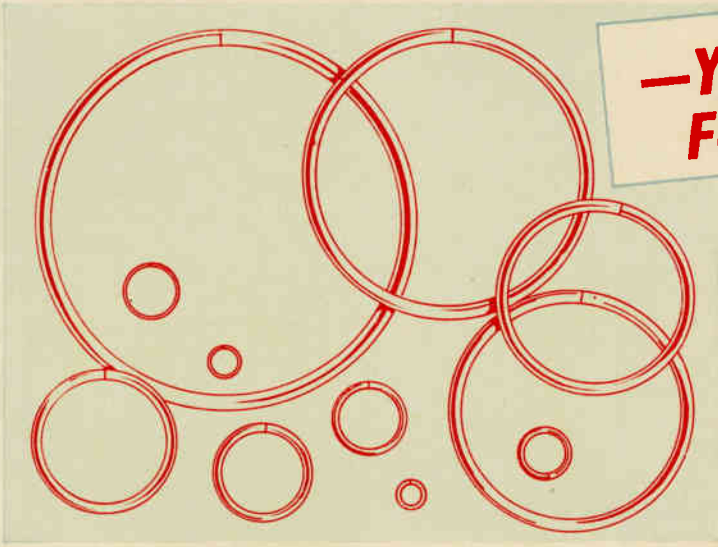

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COMSOL Silver/Tin/Lead. Made by arrangement with Johnson, Matthey & Co. Ltd., of Hatton Garden, this type of Ersin Multicore Solder provides a high melting point of 296 C. and is particularly suitable for those soldering processes where a cored solder is required with a melting point well in excess of those normally associated with soft solders.

PURE TIN. Particularly suitable for work where a lead-free solder is required.

T.L.C. Tin/Lead/Cadmium. A special type of Ersin Multicore Solder having a liquidus of 145°C. which is little above the melting point of the flux. Used where a specially low melting point cored solder is required.

FLUXES incorporated in Ersin Multicore Solder.

All types of Ersin Multicore Solder contain non-corrosive Ersin Fluxes specially formulated for specific soldering purposes. Publication "Flux Facts" ref. FF. 453, gives full details of the types available and the percentages of flux incorporated in the various specifications of Ersin Multicore Solder.

***TYPE 362 FLUX.** Limited supplies of Ersin Multicore Solder are now available incorporating this new Pentacol derivative. This latest development of Multicore Research Laboratories provides an A.I.D. approved flux suitable for highly tarnished components. Ersin Multicore Solder incorporating this type of flux may be considered too fast for general production processes, for, owing to its great speed, it may flow along flexibles and down the tags of valve holders. Advance samples are already available in the usual grades of 60/40, 45/55, and 40/60 alloys.

SEPARATE FLUXES

***ERSIN LIQUID FLUX TYPE 362/5.** This Liquid Flux is available in 10-oz. and 1-gallon tins. It conforms to A.I.D. requirements and is considerably stronger than the Ersin Liquid Flux previously supplied.

***ERSIN NON-CORROSIVE JELLY FLUX.** For some soldering purposes, it is preferable to use a separate flux of a high viscosity jelly consistency. Hitherto, apparently no flux of this consistency had been available which would satisfy A.I.D. requirements for halide content of the D.T.D. 599 specification. A jelly flux of the Ersin type with suitable halide content has now been developed. Please ask for Ersin Jelly Flux.

ARAX MULTICORE SOLDER

ARAX LIQUID FLUXES. Arax Multicore Solder, with its washable flux residue, will be found suitable in those processes where it is not essential to use a non-corrosive flux, e.g. jointing of metals, soldering stainless steel, etc.

*Products which have been recently introduced.

Manufacturers are invited to write for special booklet Ref. M52 and reprint of "Considerations of Soldering Technique" Ref. M53, samples and comprehensive literature.

ERSIN MULTICORE SOLDER

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