ELECTRONIC & RADIO ENGINEER

Incorporating **WIRELESS ENGINEER**

In this issue

Rhombic Aerials

Stacked Valve Circuits

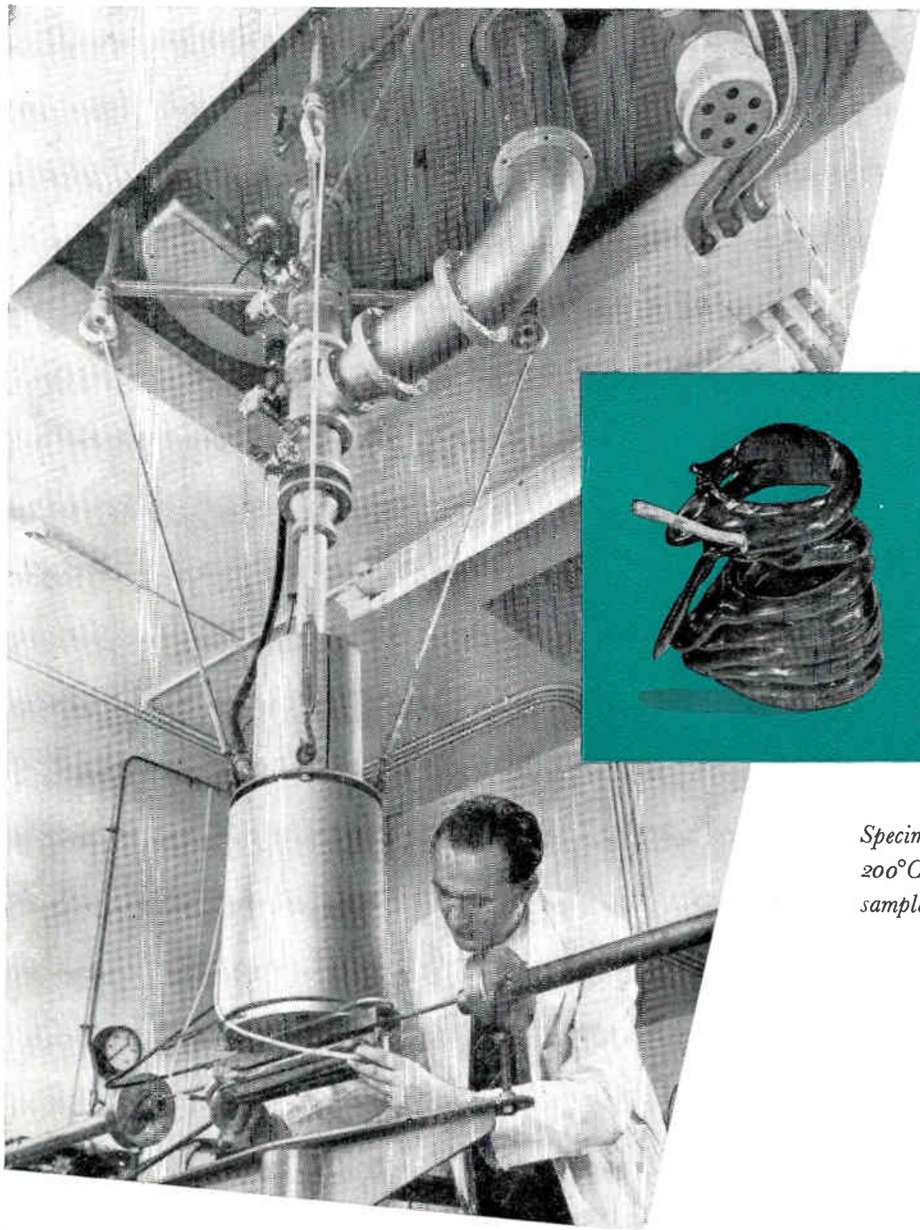
Comparison of Four Television Standards

Measuring Earth Conductivity

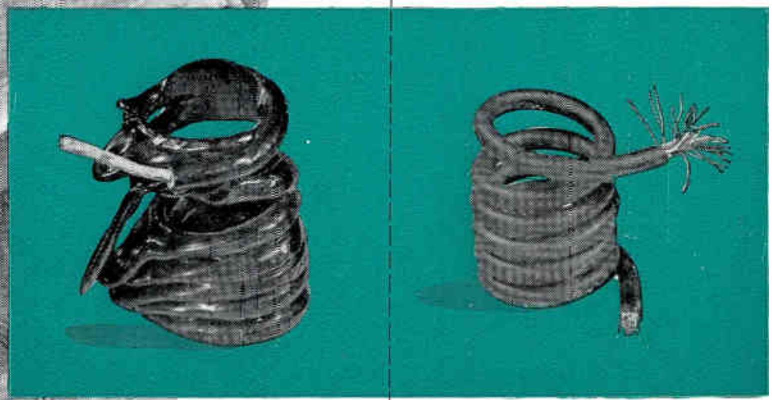
Three shillings
and sixpence

NOVEMBER 1957 Vol 34 *new series* No 11

World Radio History



Setting up polythene core ready for irradiation.



Specimens of polythene cable after heating at 200°C. Left: Normal sample. Right: Irradiated sample.

How we make good cables—better

Take polythene for instance, already noted for its excellent electrical characteristics and widely used in the cable industry.

Then make it stronger, more elastic and improve its temperature characteristics. The result, a better material still.

How do we do it? By bombarding polythene with electrons to cause a chemical change. A process known as electron irradiation and an important step forward in the general development of plastic materials for our wide range of cables.

We have a publication which tells you more about this process. May we send you a copy?

BICC IRRADIATION OF POLYTHENE

REMEMBER POPPY DAY

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

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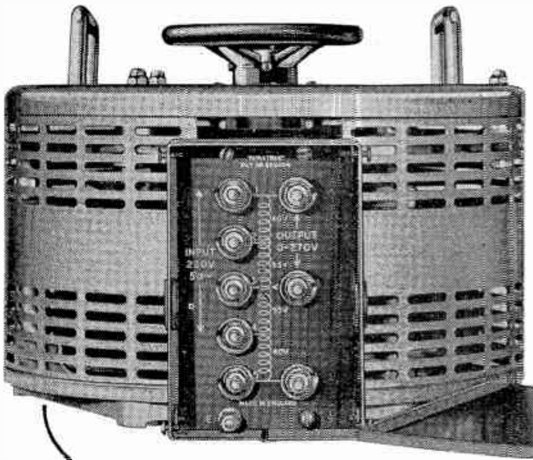

Smooth voltage control

-with 'VARIAC'

'VARIAC' (Regd. Trademark) is the *original*, continuously adjustable auto-transformer—the only one having 'DURATRAK' (Regd. U.K. Patent No. 693,406)—and it provides unrivalled smoothness of a-c voltage control for any electrical, electronic, radar or communications equipment. 'DURATRAK' is a track plated with precious metal alloy which ensures very long life, absolute reliability, much increased overload capacity, and high resistance to accidental short-circuits. Compared with the losses of resistive controls 'VARIACS' often save their initial cost within a year.

With the 'VARIAC', voltages from zero to 17% above line are obtained by a 320° rotation of the shaft and an accurately calibrated direct-reading dial is provided. 'VARIACS' are very competitively priced, and are available in many sizes from 170 VA up to 25 kilowatts including 3 gang assemblies for 3-phase working—there are many patterns for use on frequencies up to several thousand cycles/second.

Write for a well illustrated catalogue 424—U.K., and a handy pocket-sized reference Price List VSP—57/16, which give full information about the entire 'VARIAC' range.

Technical Information on the New 4 KVA 'VARIAC' type V-30-HM
(illustrated above)

The 'VARIAC' type V-30-HM effectively meets the insistent demand for a 'VARIAC' of a rating between series 100 (2.0 kVA) and series 50 (7.0 kVA). It features the latest 'rolled' core of ultra-low-loss type and 'DURATRAK' (U.K. Patent No. 693,406), a Rhodium-covered, silver-plated track surface which eliminates the possibility of deterioration due to oxidation, and greatly reduces contact resistance.

INPUT VOLTAGE: 230 (tap at 115). (Voltages above 230, but not exceeding 270, across entire winding).

OUTPUT: 0-270V, on 230V, using 'overvoltage' feature. (Alternatively, 0-Line Voltage).

OUTPUT CURRENT: 15A (rated): 17.5A (maximum).

DIMENSIONS: Only 11 in. x 11 in. x 8 in. (shielded type); depth behind panels (open type), only 6⅝ in. Weight: 48 lb.

NET PRICES: V-30-H (open style) £41.16.0, Net. V-30-HM (shielded). £42.12.6, Net.

GANGED MODELS: available at very short notice. A 3-gang, 3-phase assembly, arranged in "Star" (for example), for use on 415/3/50, will handle 12.5 kVA, and will cost £130.7.0. Net, delivered. (2-Brush, i.e.: dual-output model also available).

ONLY 'VARIAC' HAS 'DURATRAK'

Claude Lyons Ltd.

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CL38

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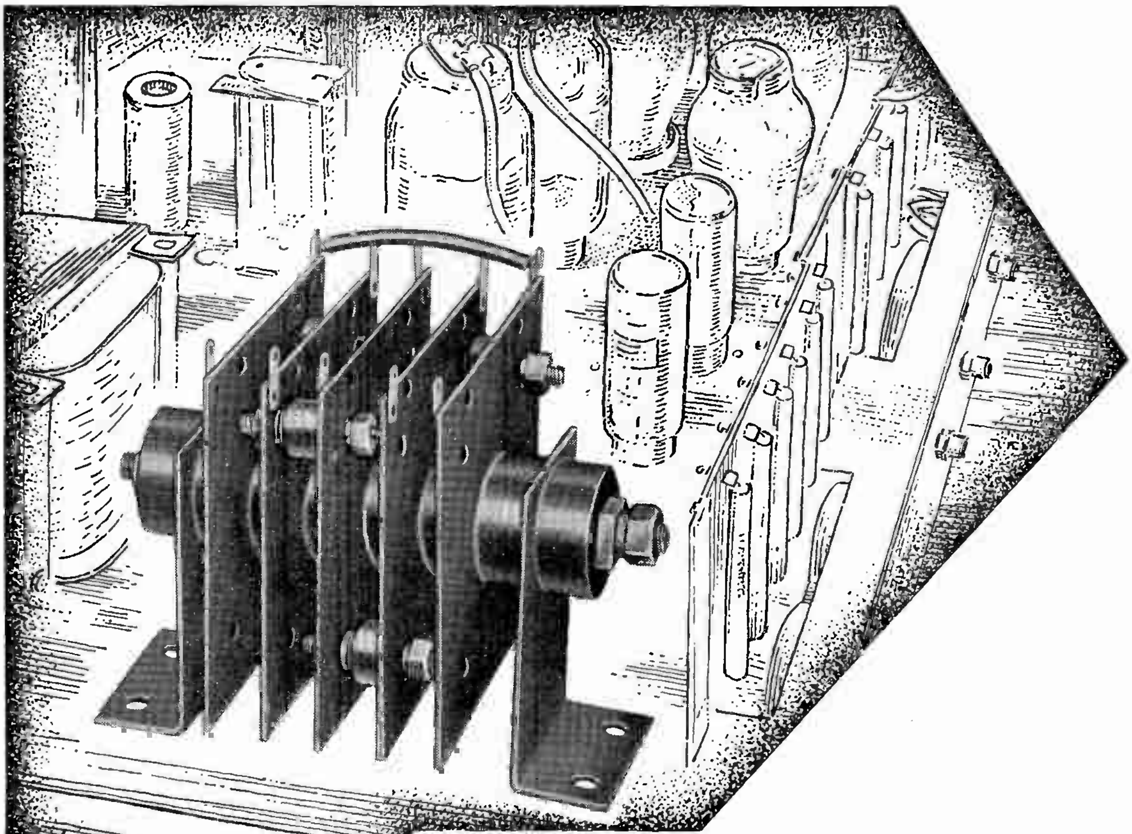
GERMANIUM JUNCTION RECTIFIERS
— finned bridge units



RATINGS FOR INDUCTIVE AND RESISTIVE LOADS

	TYPE	A.C. INPUT max. peak volts	D.C. OUTPUT max. voltage volts	D.C. OUTPUT max. current amperes	OVERALL LENGTH inches
SINGLE-PHASE	GA31-A	140	125	2·0 at 40°C	3½
	GA41-A	53	47	2·0 at 60°C	3½
	GA51-A	210	187	2·0 at 40°C	3½
	GA61-A	106	94	2·0 at 60°C	3½
	GA52-A	340	303	2·0 at 40°C	5
	GA62-A	170	151	2·0 at 60°C	5
	GA53-A	510	455	2·0 at 40°C	6½
	GA63-A	254	227	2·0 at 60°C	6½
THREE-PHASE	GB31-A	140	188	3·0 at 35°C	4⅝
	GB41-A	53	71	3·0 at 55°C	4⅝
	GB51-A	210	283	3·0 at 35°C	4⅝
	GB61-A	106	143	3·0 at 55°C	4⅝
	GB52-A	340	458	3·0 at 35°C	6¾
	GB62-A	170	229	3·0 at 55°C	6¾

The well-known range of BTH germanium junction rectifiers is now available made up into convenient bridge units ready for incorporation in your equipment.

BRITISH THOMSON-HOUSTON

THE BRITISH THOMSON-HOUSTON CO., LTD., RUGBY ENGLAND

an A.E.I. Company

A5184

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V.H.F. radio telephones

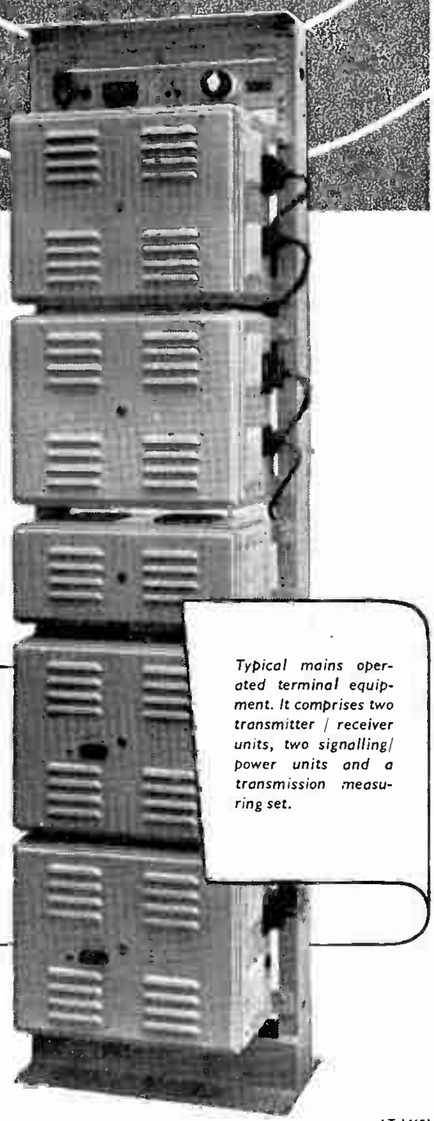
Radio links with type RL equipment are a practical, economic and reliable alternative to landlines.

V.H.F. Radio telephones are particularly suitable where contact is to be maintained between isolated communities and individual subscribers remote from main trunk routes.

A.T.E. single-channel v.h.f. equipment type RL is designed for a variety of applications where an easily installed and **simply maintained** system is required. Over any type of terrain it provides normal point to point communication or, alternatively, it can be linked in with existing telephone circuits without modification of equipment.

*** The equipment has the following characteristics**

MAINS OR BATTERY OPERATED · AMPLITUDE OR FREQUENCY MODULATED · OPERATES IN RANGE 54-186 Mc/s · TRANSMITTED POWER 0.6W-10W



Typical mains operated terminal equipment. It comprises two transmitter / receiver units, two signalling/power units and a transmission measuring set.

AUTOMATIC TELEPHONE & ELECTRIC CO. LTD.

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Strowger Works, Liverpool, 7.

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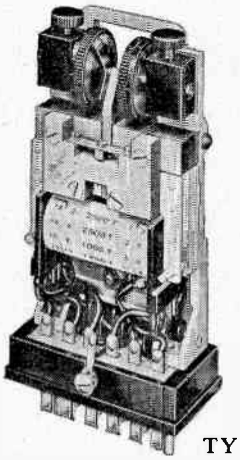
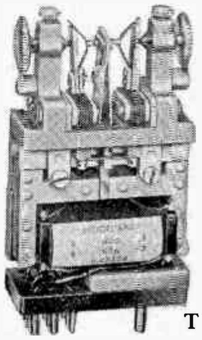
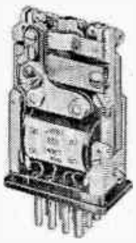
It doesn't matter whether you call it . . .



TYPE 3



TYPE 4



TYPE 5

TYPE 51

TYPE 6

5 Basic types are available each with several variations for special purposes.

the **CARPENTER** Polarized Relay

or the Carpenter **POLARIZED** Relay

or the Carpenter Polarized **RELAY**

it is the polarized relay, with the UNIQUE combination of superlative characteristics, that has solved, and is continuing to solve many problems in . . .

High speed switching · Control
Amplification · Impulse repetition

for : Industrial recording
Aircraft control and navigational equipment
Automatic machine control
Analogue computers
Temperature control
Servo mechanisms
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Theatre lighting "dimmer" and colour mixing equipment
Teleprinter working
Automatic pilots
Remote control of Radio links
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etc, etc, etc.

Therefore — if your project, whatever it may be, calls for a POLARIZED relay, with high sensitivity, high speed without contact bounce, freedom from positional error, and high reliability in a wide range of temperature variations, *you cannot do better* than use a CARPENTER POLARIZED RELAY.

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TELEPHONE MANUFACTURING CO. LTD.

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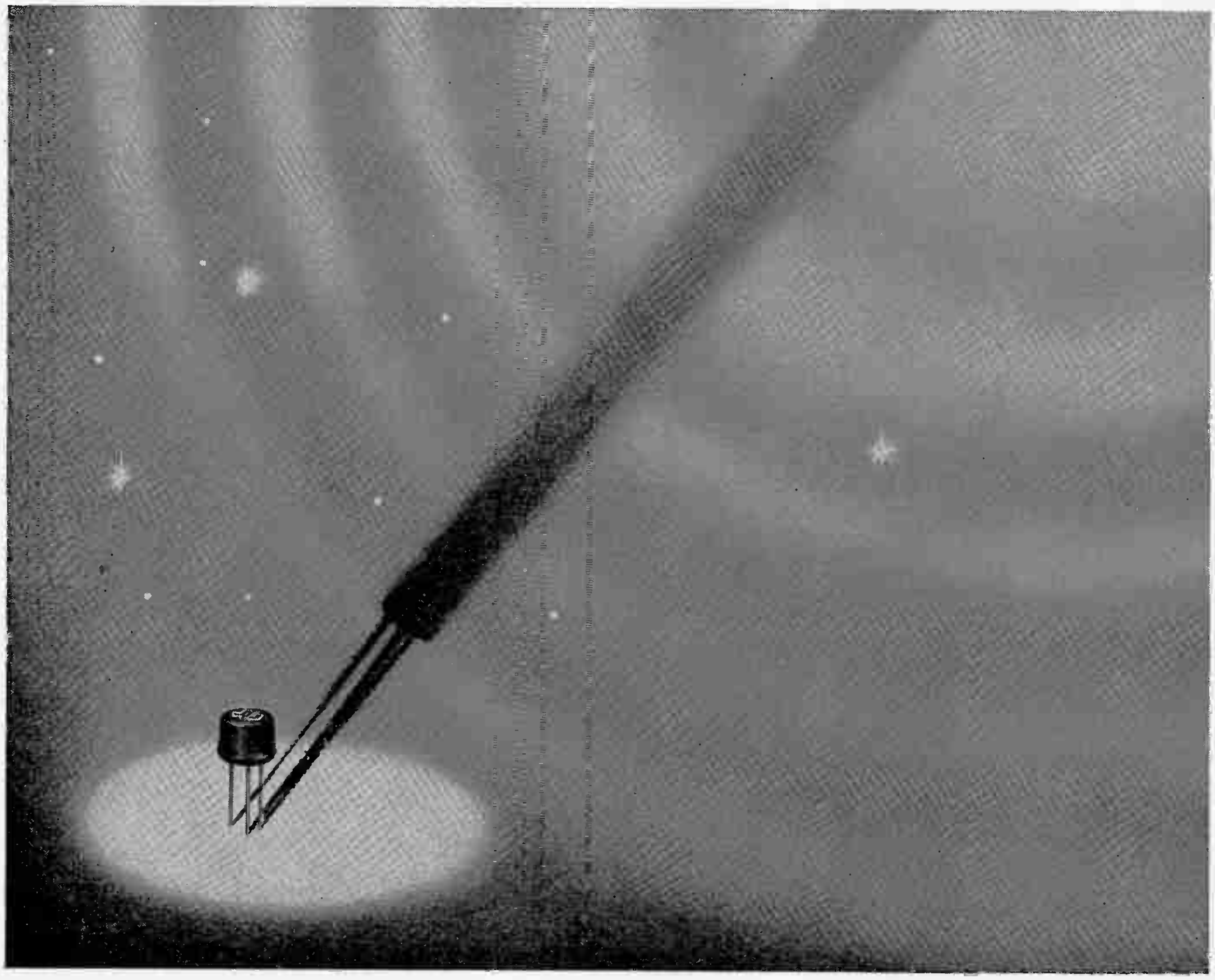

So small . . .
with so great a future
and in production NOW

You are looking at a silicon transistor. These are the only transistors that will operate in high temperatures. These are the electronic midgets, the brain cells, that can be tucked away in computers, in radar sets, in guided missiles. It is these tiny, tough devices that Texas Instruments know more about than anyone else.

BEHIND US . . . Texas Instruments are a quarter-century old in scientific experience. They are one of the pioneers of semiconductor products, and it was their foresighted skill and theirs alone that introduced silicon transistors and silicon high voltage rectifiers to industry more than three years ago. Today, with all this accumulated knowledge and experience behind them, Texas Instruments Limited has begun production in this country.

AND AHEAD . . . Texas Instruments Limited is at the service of industry. Here at Bedford, we are working today for today—and for the future. Our purpose is to design, develop and manufacture the best there are, and will be, in semiconductor products. Our skill and research are dedicated to that ideal. It is with the essential co-operation of equipment designers and users that entirely new devices will come into being. Together, we shall see their birth.

APPLICATIONS ADVICE AND DEVELOPMENT

Texas Instruments Limited wishes to co-operate with equipment designers. Highly qualified engineers in our Applications Section are ready to advise them about our semiconductor products, and their applications. Technical Data Sheets are available.

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Tel: BEDFORD 68051. *Cables:* TEXINLIM BEDFORD

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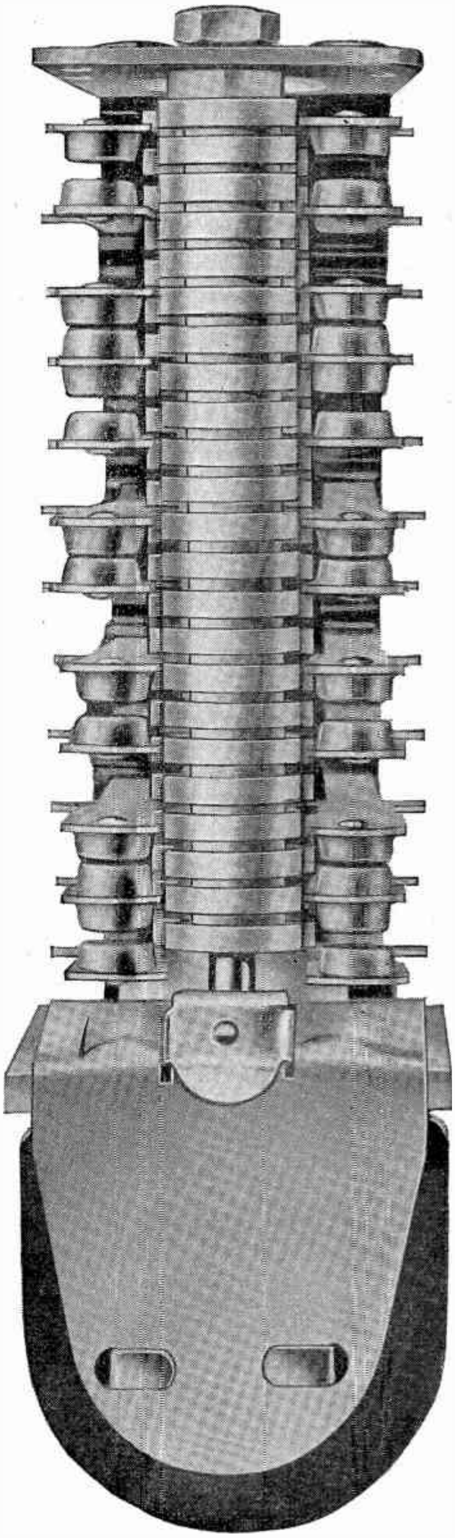

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Series 285

- Fast operating
- Negligible bounce
- Exceptional life
- Exceptional insulation

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MD 21

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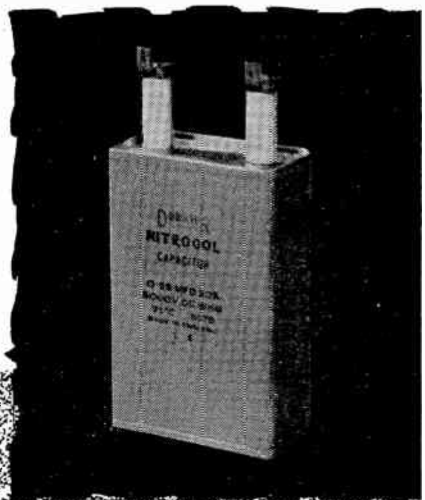
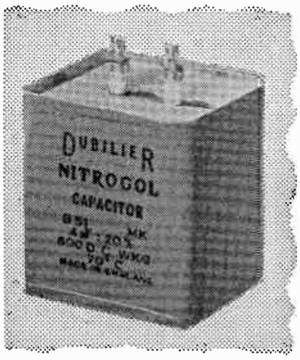
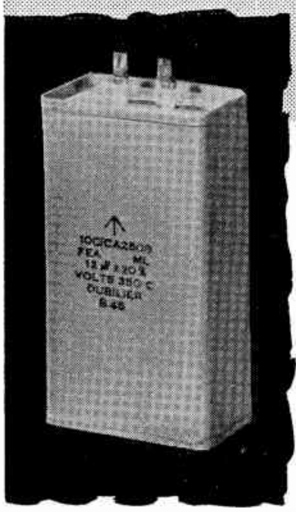
SOLID RELIABILITY







Meticulous engineering backed by the highest quality materials has resulted in a capacitor that is generally recognised to be the best available to industry today. Nitrogol capacitors are type approved for operation in temperatures up to 100°C. on D.C. and can withstand severe conditions of vibration.

For instruments and all high grade equipment where paper capacitors are used Dubilier Nitrogol will meet all the necessary requirements of safety, stability and reliability.

Available in standard capacitance values for operation up to 10,000 volts D.C. working at 71°C.

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DN.186

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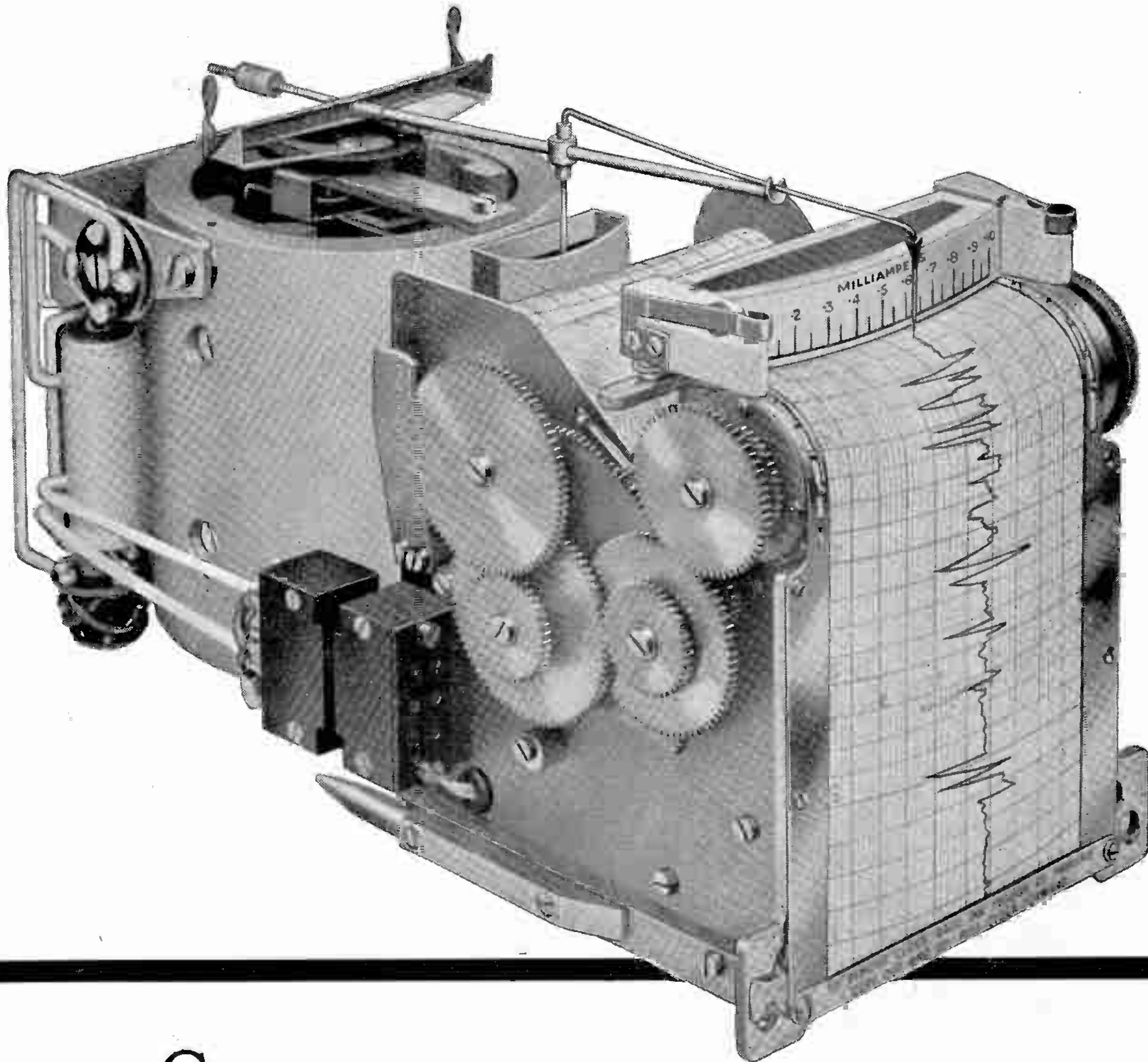
Inside story...



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*(To within 2% of indication)**

The secret of this remarkable performance lies in the generously proportioned movement which is designed to utilise every available cubic inch of a case which occupies the minimum of panel space.

A wide selection of other ranges can be quoted according to requirements, including Amperes, Volts, Watts, Vars, Frequency and R.P.M., also multi-range with Clip-on Transformer.

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Ammeters,
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Excellent electrical properties
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AT HIGH TEMPERATURES

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Bakelite Limited manufacture an extensive range of plastics materials and maintain a technical service unequalled in the industry. No matter what your plastics problems, this service is at your disposal. SLOane 0898 is the telephone number.

TGA LO1

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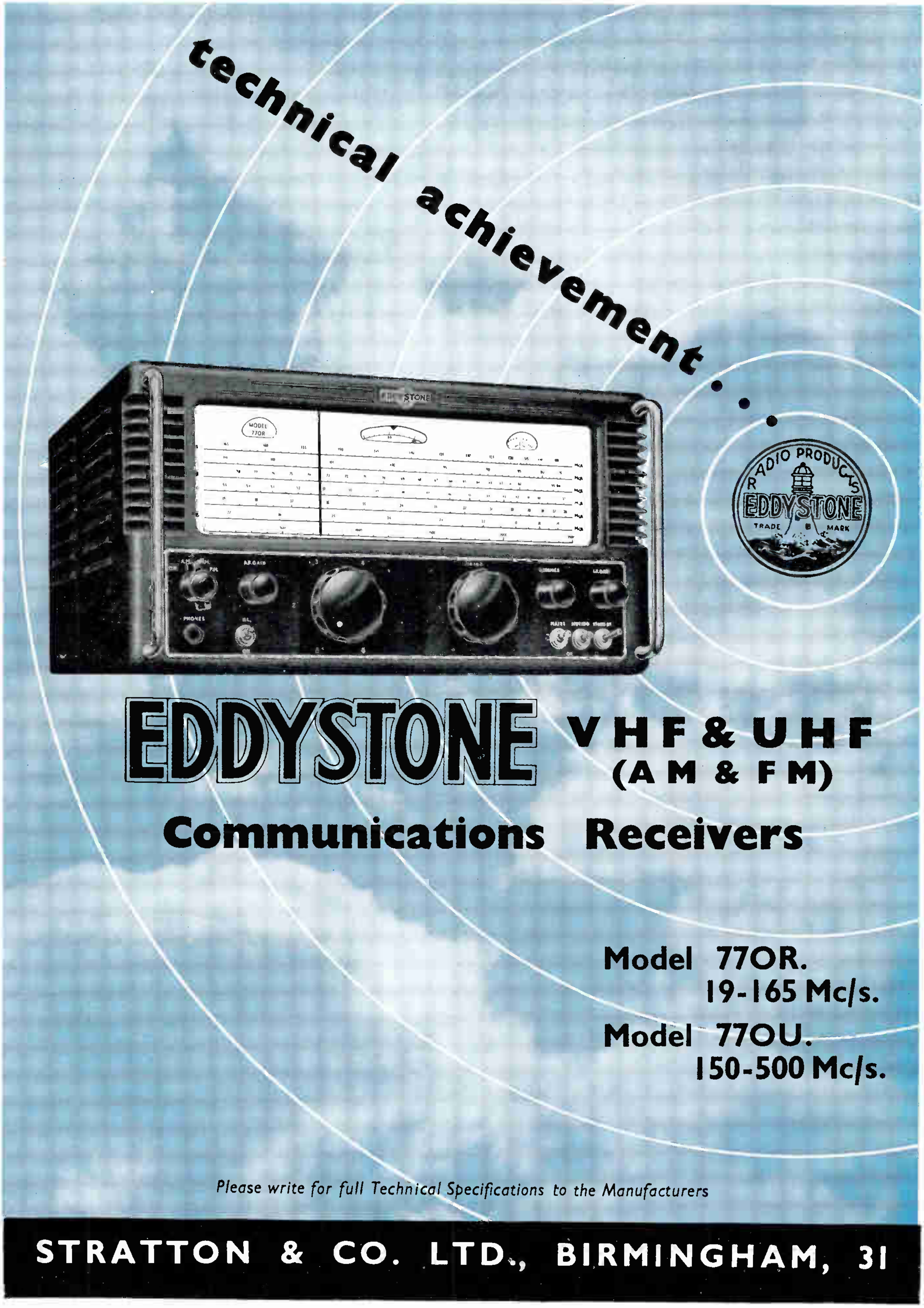

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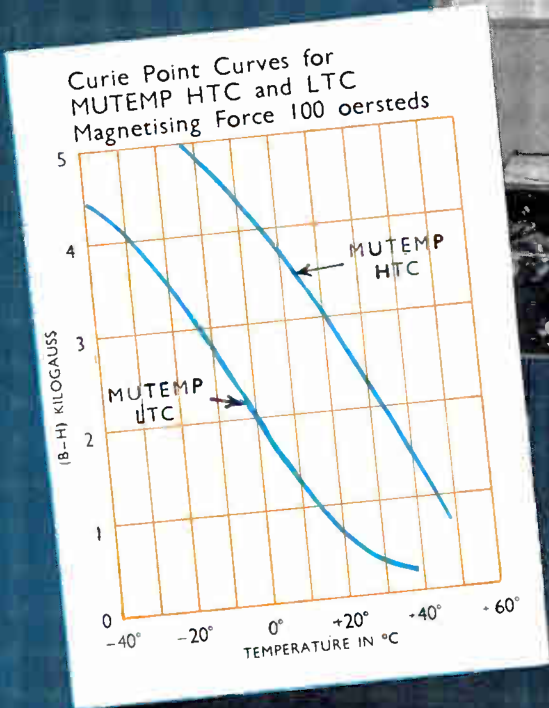
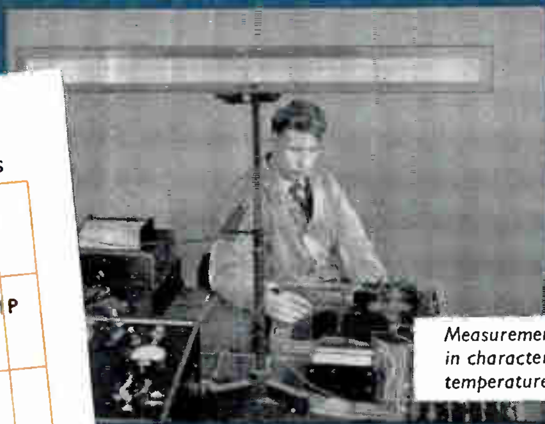
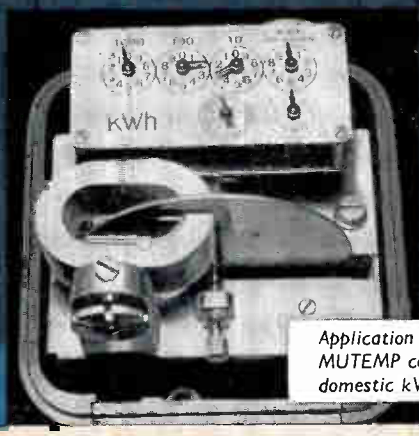




Measurement of the change in characteristics with temperature.



Application of a MUTEMP compensator to a domestic kWh meter.

MUTEMP: a temperature-compensating alloy

This alloy, for use in electric instruments subject to wide variations in temperature, is now available in two distinct grades. The two grades ensure satisfactory coverage for a wide range of temperature change. It will be seen from the curves that MUTEMP LTC has characteristics suitable for the low temperature and HTC for the higher temperature ranges. MUTEMP is supplied in hot-rolled sheets up to 18 ins. wide and in thicknesses ranging from ·125 ins. to ·020 ins.

Full details may be obtained from our current catalogue, where its temperature characteristics are set out at three standard magnetizing forces, 2, 18 and 100 oersteds.

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RTB

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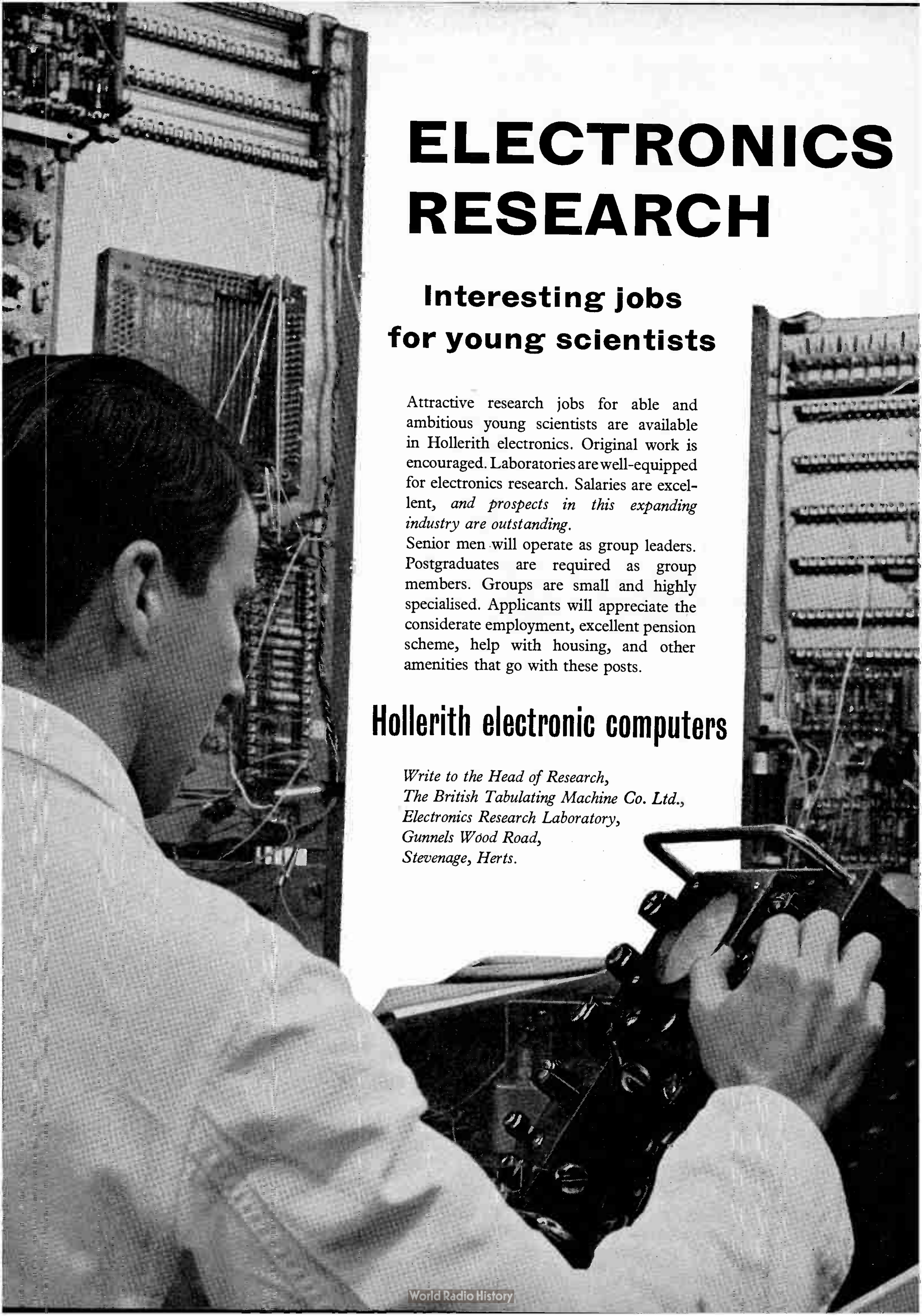

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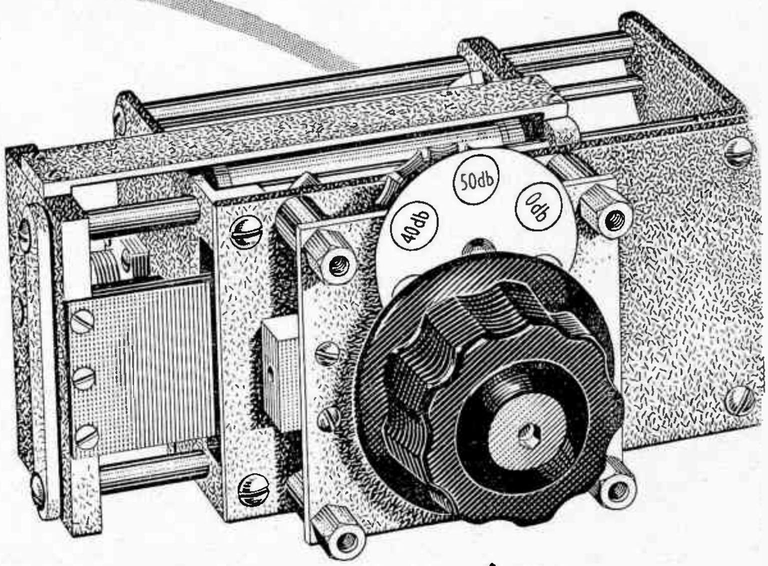
new



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dc — **3000Mc/s**

A completely co-axial attenuator unit specially designed for use in precision equipment where rapid selection of close tolerance attenuation with absolute reliability is essential.

Any combination of six pads is available from 0 to 50 db. in 10 db. steps.

For use at all frequencies up to 3000 Mc/s.

RANGE:	0 to 50 db in 10 db steps.
ACCURACY:	± 1 db up to 1000 Mc/s.
V.S.W.R.:	Less than 1·2 d.c. to 3000 Mc/s for 20-50 db range. Less than 1·2 d.c. to 1000 Mc/s for 0-20 db range. At 3000 Mc/s increases below 20 db. to not more than 1·7 d.c. at zero attenuation.

★ CONTINUOUS ROTARY MOVEMENT
selects any pad simultaneously giving visual indication of pad selected.

Export enquiries invited.

Advance TURRET ATTENUATOR

TYPE A63

Full technical details available in Leaflet R49

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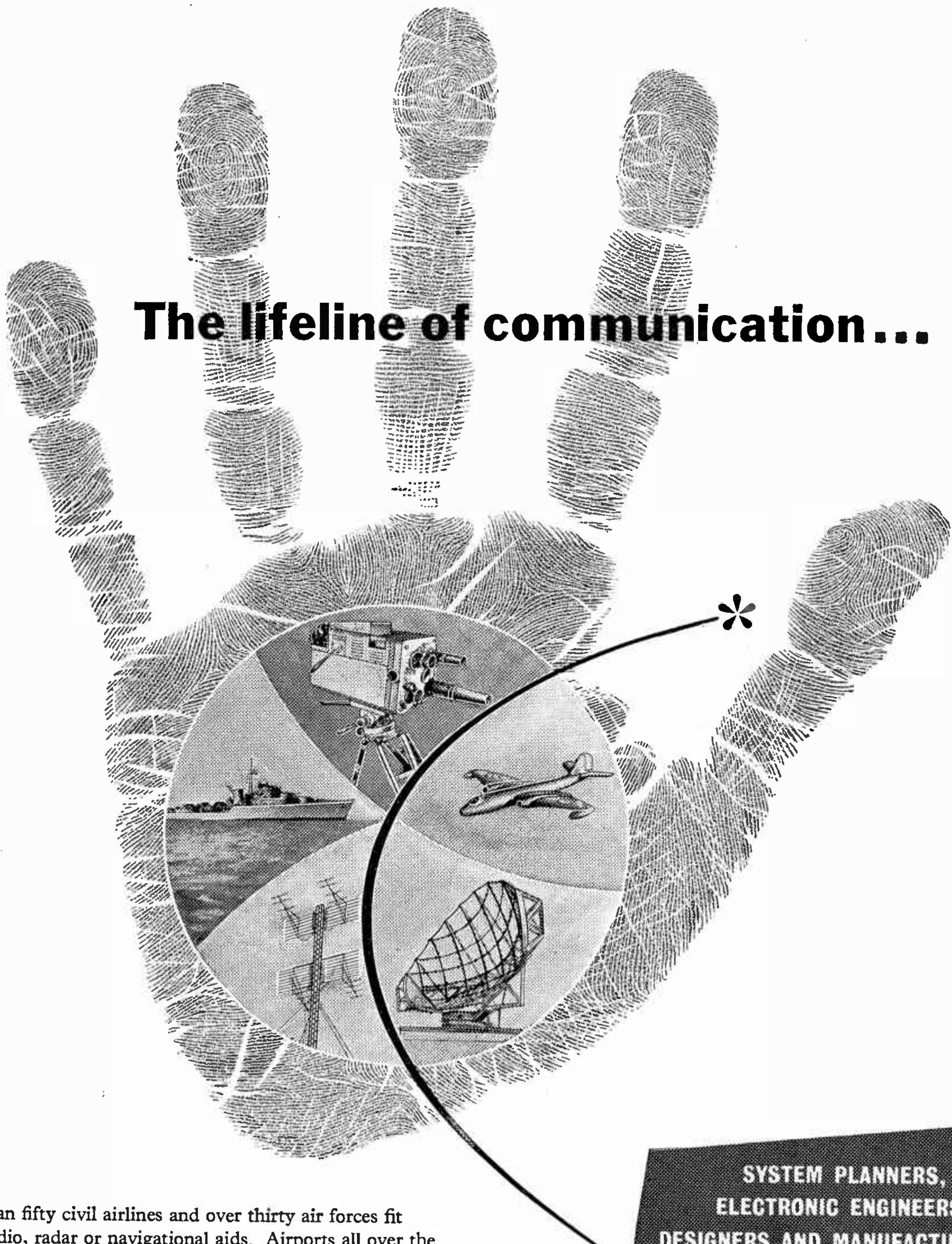
The lifeline of communication...



• More than fifty civil airlines and over thirty air forces fit Marconi radio, radar or navigational aids. Airports all over the world rely on Marconi ground installations • The armed services have entrusted radar defence networks, both at home and overseas, to Marconi's • The broadcasting authorities of 75% of the countries of the world operate Marconi broadcasting or television equipment • 80 countries have Marconi equipped radio telegraph and communications systems • All the radio approach and marker beacons round the coasts of Britain have been supplied by Marconi's.

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From 200 cycles/sec. to 90 Mc/sec.

G.E.C.

For long term stability and unfailing activity, G.E.C. Quartz Crystal Units provide the basis for reliable communications systems.

A complete range of units to meet D.E.F. 5271 and R.C.L.271 Inter-Services styles can be supplied.

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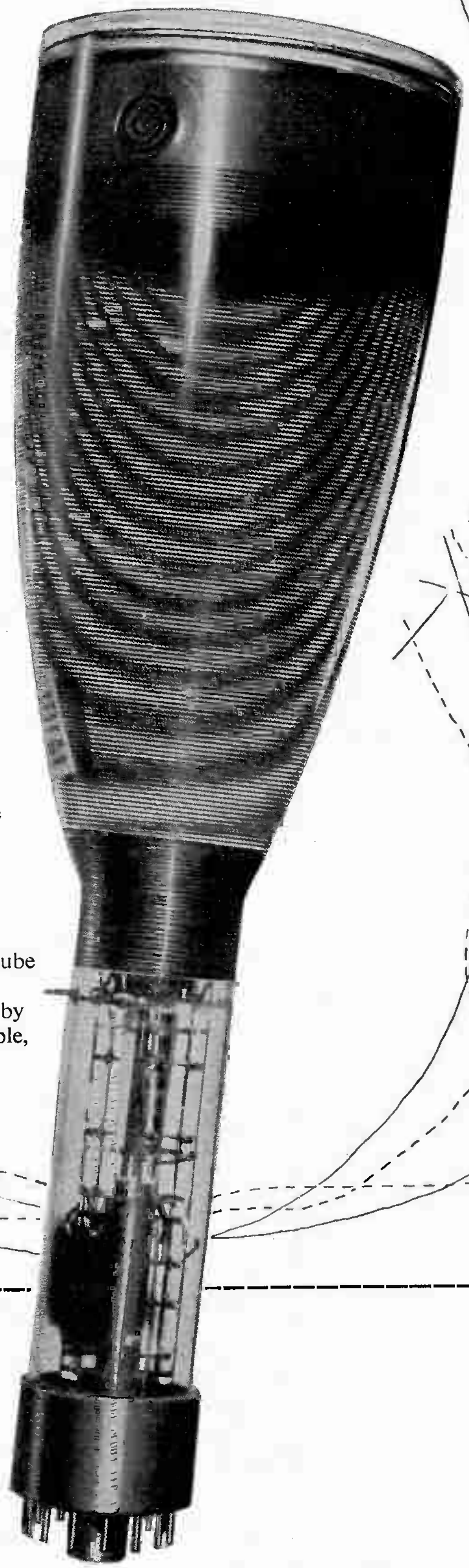
high sensitivity 5 inch cathode ray tube with SPIRAL P.D.A.



THE 5BHP SERIES BY

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Electrostatically focused and deflected cathode ray tubes, the 5BHP series has been produced for high performance oscillographic applications. The tubes have a high deflection sensitivity and a helical post-deflection acceleration system to permit the use of high p.d.a. ratios. The screens are aluminised and the tube is available with any of the standard screen phosphors—the phosphor type being denoted by the last number in the tube title. For example, 5BHP1 has a P1 phosphor screen.

PLATE SENSITIVITIES*

S_x .... 30.5mean ..... V/cm

S_y .... 6.5mean ..... V/cm

*With a helix potential of 10kV

Useful x scan .... 10 cm

Useful y scan .... 4 cm

Pattern distortion .... 1.5 max. %
(at 100% of useful scan)

Spot position .... within 0.5 cm radius circle
(undeflected)

Orthogonality of deflection axes ± 1°

For further details, write to the G.E.C. Valve and Electronics Department

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1 000 000 CYCLES PER SECOND

S.T.C. are able to offer a range of high-performance close-tolerance 1 Mc/s crystal units. The range comprises:—

S.T.C. TYPE	DESCRIPTION	EQUIVALENT
4044	2 pin metal containers	D.E.F. 5271 Style B
4046	2 pin metal containers	D.E.F. 5271 Style D
4013	B7G glass envelopes	D.E.F. 5271 Style E

The above units all meet the extreme climatic conditions laid down in RCS11

1 Mc/s CRYSTAL UNITS

As a direct replacement for the 1 Mc/s crystal unit in the popular BC221 wavemeter S.T.C. offer a unit mounted in a glass envelope with a special international octal base (service equivalent 10XAR5).

ALL UNITS

- meet the vigorous bump and vibration requirements of interservices specifications.
- can be supplied to a minimum frequency tolerance of ± 0.005% over temperature range − 55°C to + 90°C.
- can be manufactured for operation at either series resonant or at 30pF or 50pF input conditions.
- have excellent short and long term stability.

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, W.C.2.

QUARTZ CRYSTAL FACTORY: HARLOW · ESSEX

IMPROVEMENT IN THE ACCURACY OF DECADE RESISTANCES

SULLIVAN and GRIFFITHS

INEXPENSIVE SERIES OF

NON-REACTIVE DECADE RESISTANCE BOXES

FOR ALL FREQUENCIES

have now been improved in accuracy to

0·05 PER CENT

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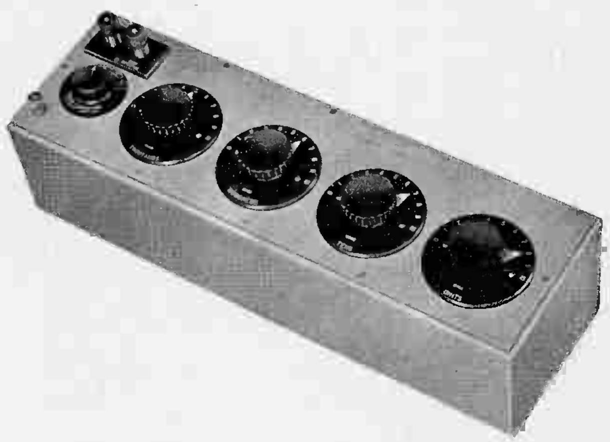

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CONTENTS

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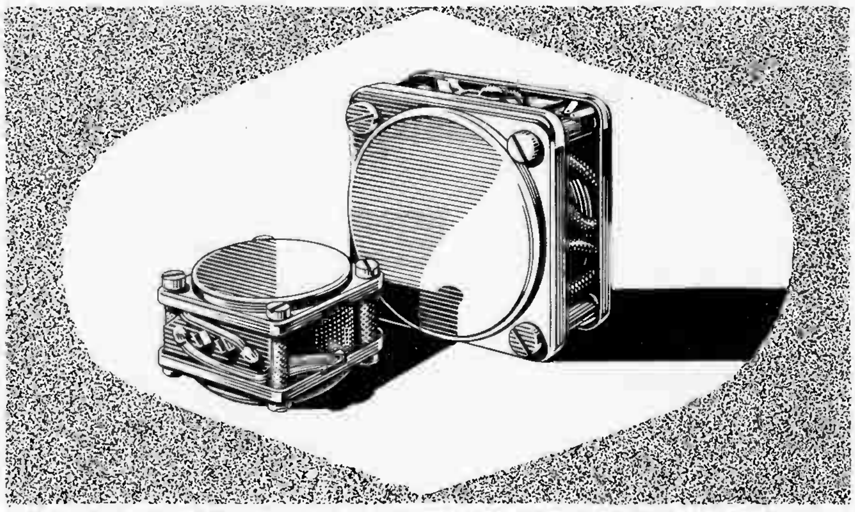

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The Satellite

THE launching of the first earth satellite has caused a flurry of activity among astronomers and radio engineers. Since the best way of detecting such an object is by making use of its own radio emissions, listening stations have been busy. By a stroke of good luck, the Cambridge radio astronomers had available an interferometer aerial which could be quickly modified so as to track the new 'moon' when it approached the British Isles.

The Royal Aircraft Establishment, in collaboration with the Royal Radar and the Signals Research and Development Establishments, has also been making observations with crossed radio interferometers and Doppler velocity-measuring equipment. The Jodrell Bank radio telescope has been coupled to radar equipment to enable radar tracking and range measurement to be effected.

Most of the observations depend on the signals emitted by the satellite, and these have persisted for a surprisingly long time. So far, few details of the results of the observations have been made public. Little more definite information than the transmission frequencies of 20 Mc/s and 40 Mc/s and an estimate of the power as 1 W has yet become available.

Information from Russian sources confirms these figures for frequency and power. In addition, however, the frequencies are said to be employed in a manner analogous to the two frequencies of frequency-shift keying. The two frequencies are used alternately with pulse lengths of 0·05 sec to 0·7 sec.

There is an additional Doppler modulation brought about by the movement and rotation of the satellite itself and the polarization can be expected to vary from linear to circular as the aspect of the satellite's aerials varies from the observer's point of view.

World Radio History

Rhombic Aerials

DESIGN CHARTS FOR HIGH FREQUENCIES

By F. J. Norman, B.E.E. (Hons), D.I.C., Grad. I.E.E.* and J. F. Ward, Ph.D., D.I.C., A.M.I.E.E.*

SUMMARY. *The design of aperiodic rhombic aerials is examined and a method derived whereby a set of charts of open scale yields all the aerial parameters of practical significance for high-frequency operation. The angle of fire and the gain with respect to a dipole in free space are displayed for an adequate range of aerial side lengths and included angles. Corrections are given for the height above ground and a simple method to find the shape of the main lobe suggested.*

An extensive literature exists on the performance of aperiodic aerials of the class in which the horizontal rhombic is a special case. To analyse aerial performance in relation to the overall engineering design of long distance h.f. radio circuits, it appears desirable to differentiate between the requirements for transmission and reception. The properties desired to be known about the rhombic aerial for transmission are primarily its gain in the given direction of fire throughout the frequency range, and to a lesser extent the azimuthal and vertical distribution, with the relative amplitudes, of the unwanted minor lobes. Usually, for reception, a design is sought which yields the greatest suppression of unwanted lobes, notwithstanding a decrease thereby in the gain of the main lobe in the anticipated direction of the incident signal. At the same time a sufficient beam width in the vertical plane must be attained to accommodate a reasonable range of fluctuation in the angle of the downcoming incident signal—perhaps of the order of $\pm$ 3°. In the past, the different requirements for transmitting and receiving rhombic aerials have not been clearly distinguished, with the result that the findings of various authors have not been easy to correlate.

This paper indicates a straightforward method from which rhombic aerial parameters may be derived to meet specific engineering needs, particularly those of transmission.

Review of Literature

The earliest systematic treatment of the horizontal rhombic aerial in both the free space condition and when above a conducting earth was given by Foster[3], who introduced the elegant stereographic representation later to be elucidated by Laport[9] and given such engineering significance that wide use has been made of this particular graphical approach. The spatial distribution and relative amplitudes of all significant lobes are given readily but information on the shape and the directivity gain of the main lobe with respect to a dipole is lacking. The method is most suited to the analysis and examination of a known design rather than the determination of the best aerial from given parameters. It will be found in fact to lead to designs appropriate to reception.

Both Harper[4] and Christiansen[6,7] give sufficient data to enable a comprehensive design to be attempted but, in each case, and particularly in that of Harper's work, the practical application of the detailed curves to design is rather lengthy.

Barker[8] has shown how the pattern of the main lobe might be investigated in some detail but in his method ranges of gain are presented well beyond those normally expected. The design procedure is not easily adapted to field work since the height, which in practice is frequently restricted, is intimately connected with the geometrical configuration of the rhombic where adequate degrees of freedom normally exist.

Design Procedure

The charts and procedures described here yield most of the information usually sought in the design of a rhombic aerial for use in h.f. communication. They are valid as far as certain practical approximations allow and the effect of these on the accuracy of the results is discussed.

The steps in the design procedures are as follows:—

Given both Δ = the vertical angle of fire or reception; derived either from field measurements or geometrical estimation.

and λ = wavelength; specified over a range to meet the propagation requirements.

Select both L = the side length; maximum value normally restricted by site limitations and structural requirements.

and H = the average wire height above ground; maximum value normally restricted by structural requirements.

Then the charts of Figs. 1 and 2 give the values of gain G relative to a dipole in free space correct to about one decibel, and of angle of fire correct to about one degree, over the frequency range (see below). Fig. 3 may be used in conjunction with methods explained by Foster

* *Engineer-in-Chief's Staff, Australian Post Office.*

World Radio History

and Laport to give information on the shape of the main lobe and the distributions and relative amplitudes of the minor lobes.

Variation of Gain and Angle of Fire

The theoretical analysis of the free-space rhombic aerial, from which the chart of Fig. 1 is derived, is that of Foster[3], whose treatment is outlined in the Appendix. Methods of extending the theory of the horizontal rhombic aerial to yield expressions for the gain of its main lobe with respect to a dipole at the same height are given by Harper[4], Christiansen[7] and Barker[8], among others, but the most useful form for the present purpose is that given by Christiansen; i.e.,

$$G = 20 \log_{10}\left[\frac{4 \sin A}{1 - \cos \Delta \cos A} \cdot \sin^2\left(\frac{\pi L}{\lambda}(1 - \cos \Delta \cos A)\right) \cdot \frac{I_a}{I_0} \cdot \left\{\frac{R}{Z}\right\}^{\frac{1}{2}}\right] \quad (1)$$

where G = the gain in decibels of the main lobe with respect to a dipole at the same height.

A = half apex angle (see Fig. 4).

I_0 = input current.

I_a = average current along the rhombic aerial wires assuming exponential attenuation.

Z = input impedance of the rhombic aerial.

R = radiation resistance of the reference dipole.

The degree of accuracy sought in the present instance allowed the approximations $I_a/I_0 = 0{\cdot}80$ and $R/Z = 65/700$, based upon experimental observations of Christiansen[6].

Equation (1) is capable of more direct application than is the form given by Harper and is not complicated by the height factor appearing implicity as for Barker. It may be noted that the height factor, which is treated separately in Fig. 2, is not a correction unique to rhombic aerials, but is an expression applying to any aerial above a reflecting medium.

The computation of G as a function of Δ, L/λ and A is complicated, since Equ. (1) is transcendental and the solution depends on graphical procedures as well as upon numerical substitution. The results, for practical values of Δ, L/λ and A, are given in Fig. 1 which consists of a family of gain curves for variation in A—always with Δ at a value required to give G at the peak of the main lobe—together with a family of gain curves for variation of Δ.

Fig. 1 enables the given Δ to be

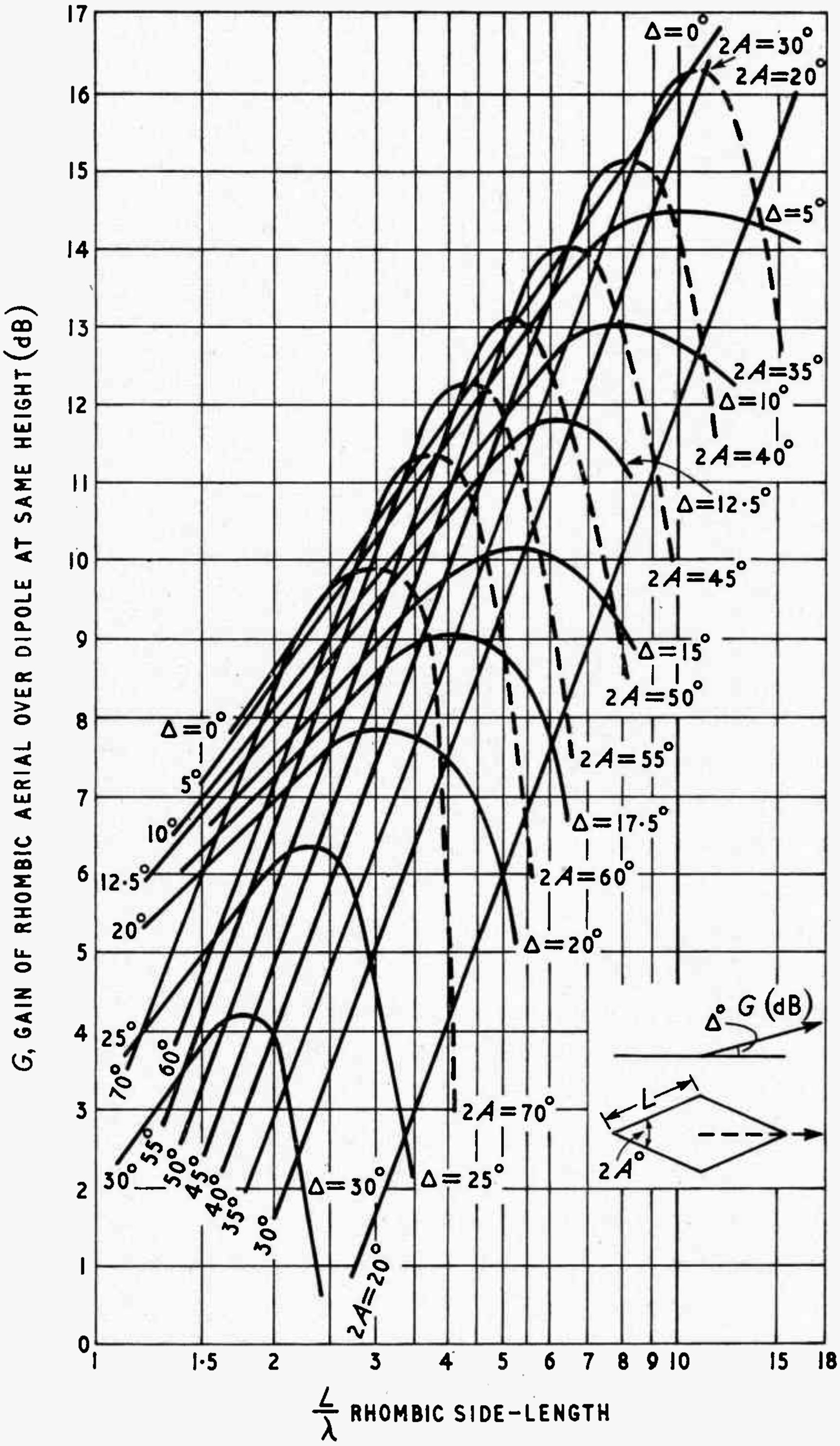


Fig. 1. *Variation of gain and angle of fire with side length and included angle (free-space condition). Curve regions in the A family shown dotted (negative slope) represent conditions when the main lobe is only partially formed. The corresponding value of Δ will always be zero regardless of the magnitude designated by the Δ curve at the point of intersection with the A curve. G is measured in the direction of the principal axis of the rhombic aerial but at Δ° to the plane of the rhombic. The gain is computed from equation* (1)

World Radio History

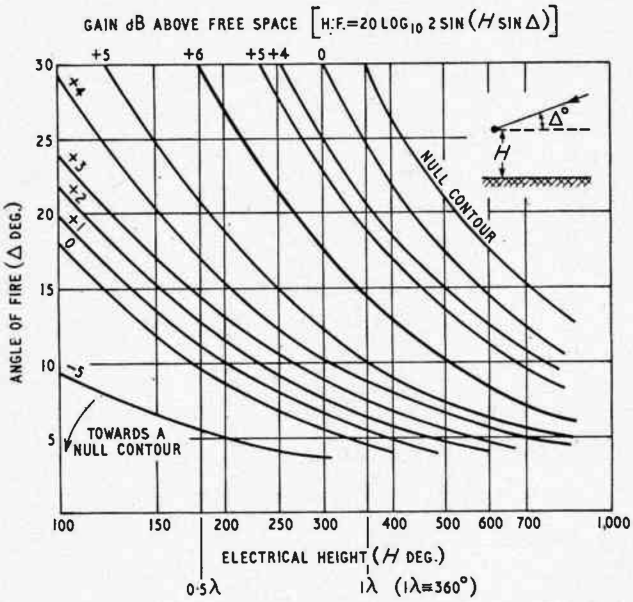


Fig. 2. *Height-factor gain with respect to free-space condition*

used to design a rhombic aerial of maximum gain with its lobe perfectly aligned in the desired direction of fire. The turning point of the curve of Δ yields a value of L/λ and of $2A$ which gives this design of maximum gain. As a starting point, the value of L/λ is related to a design frequency which is taken as the arithmetic mean of the limits of the frequency range. The variation of gain over this range is then shown directly from the chart and, if necessary, a new design frequency can be adopted to yield a closer fit to the gain versus frequency response specified by operational needs.

It may be observed that having selected a design value of A, additional gain can be achieved by choosing a value of L/λ slightly greater than the chart specifies for the desired Δ. Under these circumstances, although the required direction of fire for the circuit is now above the lobe peak, the loss of gain which would result thereby is outweighed by the overall increase in gain due to the greater side length. For practical rhombic aerials of side length above 5 wavelengths an increase in gain of about 1 dB may be expected, corresponding to a lowering of the vertical angle of the lobe maximum by about 3 degrees. This means that, for transmission, to achieve the best aerial performance over the frequency range specified, the design frequency of the aerial should be located towards the lower limit of that frequency range.

When interpreting Fig. 1 it must be noted that the dotted portions of the curves of the $2A$ family (which correspond to regions in which the main lobe is degenerate), are perfectly valid to give values of gain but that, regardless of the classification of the intersecting Δ curves within this domain, the angle for maximum radiation in the vertical plane through the principal axis remains zero. The propagation represented here is that of a free-space aerial and within the dotted regions the single main lobe has been replaced by a pair of lobes, both at zero vertical angle, but spreading apart in azimuth as the angle A increases while L/λ remains constant.

It will be found that although the values of G derived from the Fig. 1 are slightly lower than those of Harper[4] and the C.C.I.R.[10] for the free-space case, it is probable that the lower values are nearer to the practical figures, since they employ several numerical quantities derived from the actual experimental measurements of Christiansen[6].

Height Factor Correction

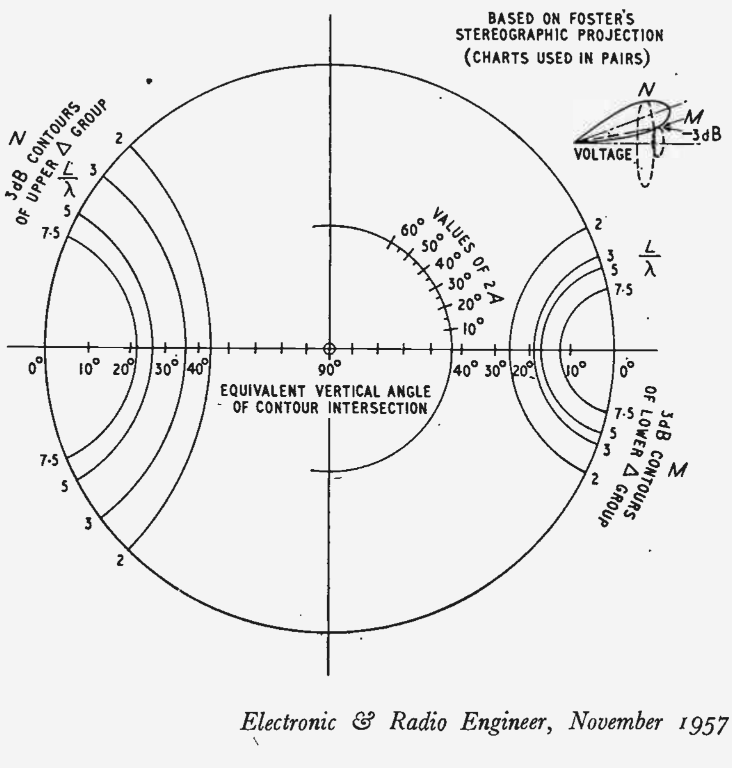
The height factor correction must now be applied by the use of Fig. 2, which is a plot of the function $20 \log_{10} [2 \sin (H \sin \Delta)]$ where H is the electrical height in degrees of the rhombic aerial above a perfectly conducting earth ($\lambda \equiv 360°$), and Δ is the vertical angle of elevation of the particular lobe under consideration.

Usually the minor lobes have values of Δ differing from that of the main lobe so that a judicious choice of H can enable a resulting height factor which discriminates against the unwanted minor lobes while contributing, in the direction of the main lobe, the maximum enhancement of up to 6 dB relative to free-space conditions. Fig. 2 is concerned only with the height factor for vertical angles up to 30° as this covers all normal design but, if detailed information is desired at very large values of Δ, as for the case of a high-angle minor lobe, a separate evaluation must be made by substitution in the equation quoted above.

Shape of Main Lobe (3-dB Points)

The requirement of next importance in the specification of the rhombic aerial is some information on the rate of decrease of field strength within the main lobe,

Fig. 3. *3-dB contours for various L/λ values (free-space condition)*



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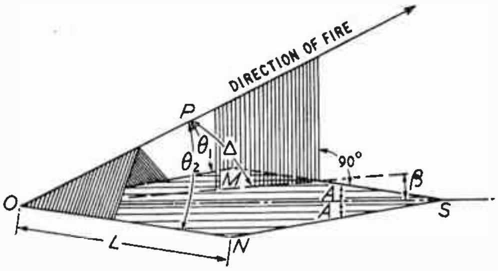

Fig. 4. *Quantities used to specify K^2; OMSN is a free-space, horizontal rhombic aerial in which L = length of side, θ_1 = angle in the plane POM, θ_2 = angle in the plane PON, Δ = angle in the vertical plane included by OP and the plane of the rhombic aerial. Point P is specified in space by the length OP and the angles θ_1 and θ_2. For radiation in the vertical plane through the principal axis OS, $\theta_1 = \theta_2 = \theta$ say, and by geometry, angle Δ is seen to be a function of angles A and θ; β = azimuthal angle*

but at directions differing slightly from the known azimuthal and vertical angles of the peak of that lobe. This data is a function of the spatial lobe shape for which the polar patterns in the azimuthal and vertical planes for free space will be dissimilar, while ground-reflection effects for practical aerials tend to distort these patterns even further.

The stereographic charts which map maxima and nulls of lobe patterns of single wires have been extended to give intermediate contours representing levels 3 dB below the maximum of the main lobe. Using these charts in the fashion described in the literature[9] four points on the main lobe of the aerial, 3 dB below the peak amplitude, may be derived for the free-space condition.

Fig. 3 illustrates 3-dB contours for which $L/\lambda = 2, 3, 5$ and 7·5. Contours for other values of side lengths may be interpolated approximately.

In the interests of clarity the upper 3-dB contours are plotted on the opposite sides of the stereographic projection to those of the lower 3-dB contours. A pair of transparencies of Fig. 3 is required to yield the 3-dB points for various values of the angle $2A$. The intersection of two sets of these contours for a given angle $2A$ will determine, for each L/λ value, the upper and lower angles in the vertical plane of the 3-dB points of the resultant rhombic aerial pattern. The contours have been prepared by deducing the two values of the angle θ (33° and 105°)—for which each of the factors $\frac{\sin^2 u}{u}$ and $\frac{\sin^2 v}{v}$ of the Appendix has a value $0{\cdot}707 \times 0{\cdot}7246 = 0{\cdot}512$ and plotting the corresponding pairs of contours on the stereographic map for various values of L/λ.

It will be found also that by using the chart in Fig. 3 for a given L/λ and $2A$ and noting the angles in azimuth at which the upper 3-dB contour intersects the lower 3-dB contour, the two angular values of the 3-dB points in azimuth are obtained. This use of the chart assumes that the form of the first half cycle of the expression $\frac{\sin^2 u}{u}$ or $\frac{\sin^2 v}{v}$ is symmetrical about its maximum value—this is a second-order approximation.

When the aerial is placed above earth, allowance must be made for the height factor which varies throughout the vertical angular range and can modify the pattern as determined above or cause complete cancellation in particular directions.

Refinements to Computation by Chart

It has been shown that by the use of the charts in Figs. 1, 2 and 3, the main properties of a horizontal rhombic aerial above a perfect earth can be determined quickly and to an acceptable engineering accuracy. Refinements for precise computations may be applied when required.

Variation of Gain

The directivity gain computed from Equ. (1) has assumed both I_a/I_0 and R/Z to be constant. The current ratio will vary with the frequency, the terminating impedance, and the physical configuration of the rhombic aerial; while both R and Z vary with physical conditions, terminating impedance and also the height above ground. If experimental values are available in a particular instance, the appropriate corrections can be made to G by substitution back into Equ. (1) after the initial parameters of the aerial have been obtained from Fig. 1 in the manner already described. Calculations from available values of I_a/I_0 and R/Z for a typical rhombic aerial suggest that the error arising from their variation over a 2·5 to 1 frequency range is less than 10% in the case of the current term and less than 5% for the impedance ratio.

Variation of Angle of Fire

The angle of maximum radiation in the vertical plane of a free-space rhombic aerial will be altered if this aerial is placed at a non-optimum height above earth. Under these conditions the vertical voltage pattern of the main lobe for the free-space rhombic aerial must be plotted, the height-factor curve in the region of this lobe then superimposed, and the vector resultant of the two voltage polar diagrams deduced to determine the angle at which the overall maximum of radiation occurs. A similar procedure must be adopted to determine accurately the angles of the 3-dB points in the vertical plane since the two values of Δ given by Fig. 3 for the free-space condition are different and thus subject to different values for the height-factor correction. Fig. 2 shows that the greatest rate of variation of the height factor term with vertical angle is of the order of 1 dB per degree and this occurs when the angle is small and the electrical height is one wavelength or greater. If a rhombic with $L/\lambda = 5$ and $2A = 30°$ for which the 3-dB points in the vertical plane would be about $\pm 7°$ (see Fig. 3), is so elevated that the height-factor maximum occurs considerably above 17°, it is possible for the height factor correction—in this case an improvement—to be about 2 dB higher for the upper 3-dB free-space contour than at the angle of the lobe peak in free space. The effective gain, therefore, at this contour for the practical aerial will be $(+2-3) = -1$ dB relative to the lobe peak, and this indicates that some elevation in the lobe propagation has taken place.

Height Factor Correction

Harper[4] has shown how the height-factor term can

World Radio History

be adjusted for the case of an imperfect earth by an appropriate substitution of known values of ϵ (soil dielectric constant) and σ (soil conductivity). Harper's curves for these parameters should cover all practical requirements. Barker has pointed out that, for ground conditions normally experienced, a perfect earth reflection may be assumed; this is supported further by evidence indicating that a difference of about 3% in radiated power exists between an aerial above a good earth ($\epsilon = 10$, $\sigma = 10^{-13}$ e.m.u.) and a similar aerial over a poor earth ($\epsilon = 4$, $\sigma = 10^{-14}$ e.m.u.), where $L/\lambda = 5$, $2A = 40°$, $f = 12$ Mc/s, $\Delta \approx 15°$, $H \approx 260°$.

Shape of Main Lobe

The following equations enable the shape of the main lobe to be examined fully.

The relative field strength in the azimuthal plane is given by :—

$$E_H = K_H (\cos \beta - \cos A) \sin A \cdot \frac{\sin X_1}{X_1} \cdot \frac{\sin X_2}{X_2} \cdot \quad (2)$$

where $X_1 = \frac{\pi L}{\lambda} \left(1 - \sin (90 - A + \beta)\right)$

$X_2 = \frac{\pi L}{\lambda} \left(1 - \sin (90 - A - \beta)\right)$

K_H = constant

β = azimuthal angle referred to the principal axis (see Fig. 4).

The relative field strength in the vertical plane is given by :—

$$E_V = K_V \frac{\sin A}{1 - \cos \Delta \cos A} \sin^2\left(\frac{\pi L}{\lambda} (1 - \cos \Delta \cos A)\right) \quad \ldots \quad (3)$$

where K_V = constant; see Equ. (1).

Equation (3) for E_V is that from which Fig. 1 was computed whereas the expression for E_H is less familiar since it introduces the generality involving angle β which becomes lost when radiation only in the direction of the principal axis is considered.

The procedure to be adopted for a complete analysis of the pattern is to use the known rhombic aerial parameters found from the charts to derive from Equations (2) and (3) sufficient points for a plot to be made of the respective voltage polar diagrams.

Distribution and Amplitudes of Minor Lobes

When the rhombic aerial is to be used for receiving high-frequency signals, the complete azimuthal directivity pattern, as a guide to the signal-to-noise ratio to be expected, must be examined. Frequently, received signal strengths are such as to permit the gain for the main beam to be reduced—by reducing angle A—in order to give greater control and suppression of the minor lobes. Likewise, the value of H may be so chosen as to reduce these undesired lobes rather than to maximize the signal from the main lobe—a procedure which differs from the requirements appropriate to the need of transmission.

Additional information on the distribution and relative amplitudes of minor lobes may readily be obtained by use of the stereographic projection of Laport together with the argument of the Appendix.

Normally the lobes (1-2), (2-2) and (1-3)—(see Appendix)—must be investigated with respect to the main lobe (1-1) and since their relative amplitudes are already fixed mathematically, the known value of G for the main lobe can be used to derive the gains of the minor lobes with respect to a dipole at the same height as the rhombic aerial. The differential height-factor corrections can then be added. For convenience, the relations of minor lobes to the main lobe as derived for the free-space rhombic aerial in the manner of the Appendix are listed below :—

Lobe (1-2) relative to main lobe (1-1)	− 5·3 dB
Lobe (1-3) relative to (1-1)	− 7·7 dB
Lobe (2-2) relative to (1-1)	−10·7 dB

Conclusion

A direct-reading method of design has been described in which the variation of gain of a rhombic aerial over a frequency range is given for a specified angle of fire.

Fig. 1 brings out two interesting features: first, the relative gain will remain more nearly constant if the design frequency is selected to be towards the lower limit of the frequency range. Secondly, if physical conditions permit, there is a strong case for the design of narrow rhombic aerials—angle $2A$ small (less than 30°), combined with large L/λ (greater than 5) to improve the value of G—if it is desired to work over bandwidths greater than 2/1. With such a configuration the value of Δ will tend to become low but some increase in this parameter, and so of the enhancement of signal due to the height factor increase, might be attained by judicious tilting of the whole plane of the rhombic aerial above the horizontal. The range of values of L/λ in Fig. 1 is sufficient to allow its use for rhombic aerials intended to operate in the v.h.f. range where side-lengths of ten or more wavelengths, and direction of fire in the plane of the rhombic aerial, are to be expected.

Fig. 2 shows the amplitude changes due to the height-factor correction as a function of the angle of fire and the electrical height above ground. The form of presentation of this factor is believed to be that which is most readily applied in normal aerial design.

Fig. 3 gives the planar maps, for various L/λ, of contours to be used in the preparation of transparencies which enable four points, 3 dB below the values of the peak amplitude of the main lobe, to be determined by inspection.

Acknowledgement

The above investigations were undertaken in connection with the extension of high-frequency communication and broadcasting services in Australia and are published with the permission of the Engineer-in-Chief, Australian Post Office.

APPENDIX

Theoretical Basis for the Design Charts

Foster[3] used the mathematical expression for the radiation intensity (power per unit solid angle) of an elemental radiator as a basis for the vector summation of the respective radiations from the four sides of a free space rhombic aerial. This gives a radiation

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power function K^2 which is dependent upon the direction, and not upon the distance, from the source of radiation.

$$K^2 = 16.I_0^2.L^2.\sin^2 A.\frac{\sin^2 u}{u}\cdot\frac{\sin^2 v}{v} \quad \ldots \quad (4)$$

where:— A, L, θ_1 and θ_2 are designated in Fig. 4.

$I_0^2 . L^2 . \sin^2 A$ is constant for a particular input current and rhombic configuration.

$u = \pi . L/\lambda . (1 - \cos\theta_1)$

$v = \pi . L/\lambda . (1 - \cos\theta_2)$

It will be clear from the geometry of the configuration that θ_1 and θ_2 may be specified as a function of A and Δ, where Δ is the angle in the vertical plane made by the direction of fire with the plane of the rhombic. For the radiation in the direction of the vertical plane containing the principal axis, $\theta_1 = \theta_2 = \theta$ say, and the solution of K^2 for turning points gives:—

Minima or nulls: $\sin u = 0$ or $\sin v = 0$ .. .. .. (5)

Maxima: $2u - \tan u = 0$ and $2v - \tan v = 0$ .. .. (6)

The roots of Equ. (5) are $u = 0, \pi, 2\pi, \ldots$; $v = 0, \pi, 2\pi \ldots$; and correspond to the nulls of radiation which, within the principal plane, give successive values of:—

$$\cos\theta = 1, \left(1 - \frac{\lambda}{L}\right), \left(1 - 2\frac{\lambda}{L}\right), \ldots \left(1 - \frac{N\lambda}{L}\right) \quad \ldots \quad (7)$$

The roots of (6) give:—

$u = 0, 0{\cdot}3710\pi, 1{\cdot}466\pi, 2{\cdot}480\pi, 3{\cdot}486\pi$, etc.) .. .. (8)

$v = 0, 0{\cdot}3710\pi, 1{\cdot}466\pi, 2{\cdot}480\pi, 3{\cdot}486\pi$, etc.)

which when taken in pairs yield the maxima of the function K^2 and correspond to the points of intersection of the cones of radiation with respect to the individual rhombic wires for which, in the case of the principal plane, θ is given by:—

$$\cos\theta = \left(1 - \frac{\lambda}{L}0{\cdot}3710\right); \left(1 - \frac{\lambda}{L}1{\cdot}466\right); \ldots \text{etc.}; \quad \ldots \quad (9)$$

It can be verified that the successive angles θ given by (9) are in fact those of the main and minor lobes exhibited by the radiation pattern of a single wire carrying a travelling wave and of length equal to the rhombic side length L/λ.

The charts prepared by Foster and Laport are the stereographic projections, on the plane containing the rhombic, of the contours of maximum and minimum radiation from the various lobes of the individual wires of the rhombic aerial. The points of intersection of the contours for a given L/λ, and any chosen value of $2A$, yield the value of Δ for the main lobe which results, and provide a complete specification of the directions with respect to the rhombic aerial of all other maxima and minima. The value of the relative magnitudes of the successive maxima of K^2 are fixed purely by the nature of the product of two functions of the form $\sin^2 x/x$ [see Equation (4)]. For such an expression the series of maxima have magnitudes:— $0{\cdot}7246, 0{\cdot}2147, 0{\cdot}1278, 0{\cdot}0911, \ldots$ etc., or expressed in a form to give relative field-strengths; $(0{\cdot}7246)^{\frac{1}{2}}$, $(0{\cdot}2147)^{\frac{1}{2}}$, $(0{\cdot}1278)^{\frac{1}{2}}$, $(0{\cdot}0911)^{\frac{1}{2}}$, etc. The main lobe of the rhombic aerial, for example, will have a maximum voltage whose amplitude is proportional to the product of $(0{\cdot}7246)^{\frac{1}{2}}$ and $(0{\cdot}7246)^{\frac{1}{2}}$. Call this lobe (1-1) and allot it a reference amplitude taken to be unity. The next largest lobe pair of the rhombic aerial, termed (1-2), will have an amplitude proportional to $(0{\cdot}7246)^{\frac{1}{2}} \times (0{\cdot}2147)^{\frac{1}{2}}$; i.e., of magnitude $0{\cdot}54$ ($-5{\cdot}3$ dB) compared to the unity of the (1-1) lobe. Similarly lobe (2-2) will have an amplitude proportional to $(0{\cdot}2147)^{\frac{1}{2}} \times (0{\cdot}2147)^{\frac{1}{2}}$; i.e., of magnitude $0{\cdot}29$ ($-10{\cdot}7$ dB) compared to (1-1); lobe (1-3) of $0{\cdot}41$ ($-7{\cdot}7$ dB); and so on for the lesser lobes.

The stereographic method therefore specifies the directions in space of the maxima and nulls in the radiation pattern, while the nature of the expression for K^2 determines the amplitudes of the minor lobes relative to the maximum of the main lobe. In practice, the lobes which symmetry indicates must appear below the plane of the free-space rhombic are taken into account by means of the height factor correction of Fig. 2.

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Radar System for New Zealand

THE topographical conditions in the Rongotai area of New Zealand make the siting of a surveillance radar particularly difficult. It is necessary to erect the radar head on top of one of the hills (elevation 1,650 ft).

In the past, the usual practice has been to build the operations centre near the site of the radar head, the signals picked up by the aerial being passed to the display units via coaxial cable. At Rongotai, the radar head lies some four miles away from the airways control centre in Wellington City, and in an area subject to earthquakes, so that a coaxial-cable connection is undesirable.

Under these conditions, a microwave link system provides an ideal solution on grounds of lower cost, reliability and overall convenience. One terminal station will be erected alongside the radar head (A on the photograph), with the signals beamed toward an aerial array mounted on a hilltop (B) immediately overlooking Wellington (C) and the airport (D). This array will split the incoming radar-signal information, one portion being deflected to the airport itself, the remainder being beamed to the airways control centre in Wellington City. Full remote control of the radar head will also be effected over the radio link.

The equipment is being supplied by Marconi's Wireless Telegraph Co. Ltd.

World Radio History

Stacked Valve Circuits

SIMPLIFIED ANALYSIS

By J. B. Earnshaw, B.Sc. (Hons), A.Inst.P.*

SUMMARY. *Stacked valve circuits are defined as arrangements where the valves are connected in series across a common d.c. supply. A circuit common to all stacked valve arrangements is analysed and the results for specific circuits appear as simplifications of the general equations. The analysis, which contains no initial simplifying assumptions, combines the results of some well-known feedback theorems and uses modified equivalent circuits.*

Analysis of stacked valve circuits from first principles is tedious. The task can be greatly simplified if the results of some well-known feedback theorems are applied to the problem.

Fig. 1 shows a simple valve circuit with anode load R_L and cathode load R_K. Negative-current feedback applied by R_K modifies the circuit performance from that obtained when R_K is zero or satisfactorily bypassed.

Knowledge of the impedance 'down' from A, the effective impedance to voltage changes at B, and the impedance 'up' from C constitutes all that is necessary for complete analysis of stacked valve circuits.

If the potential of A is raised by e volts, the potentials of both B and C remaining unchanged, the current through the valve will increase by i amps., where

$$i = -g_m\,(iR_K) + [e - i(R_L + R_K)]/r_a$$

$$\therefore \frac{e}{i} = R_L + r_a + (\mu + 1)\,R_K$$

Hence, the dynamic impedance looking 'down' from A is given by

$$Z_A = R_L + r_a + (\mu + 1)\,R_K \quad \ldots \quad \ldots \quad (1)$$

When a change takes place in the potential of B relative to A and C the current increase is

$$i = g_m\,(e - iR_K) - i\,(R_L + R_K)/r_a$$

so that $\frac{e}{i} = [R_L + r_a + (\mu + 1)\,R_K]/\mu$

In this case the effective impedance of the circuit to a voltage change at B is

$$Z_B = [R_L + r_a + (\mu + 1)\,R_K]/\mu \quad \ldots \quad (2)$$

To obtain the corresponding current increase by varying the potential of C, this potential is lowered relative to A and B. The current increase is

$$i = g_m(e - iR_K) + [e - i(R_L + R_K)]/r_a$$

and so $e/i = Z_c = (R_L + r_a)/(\mu + 1) + R_K$ (3)

The various impedances as seen from the points A, B, and C are illustrated by the equivalent circuits of Fig. 2(a), (b) and (c).

Summarizing these well-known results it can be loosely stated that, when viewed from above the cathode, impedances below the cathode appear to be increased by a factor $(\mu+1)$, and vice versa.

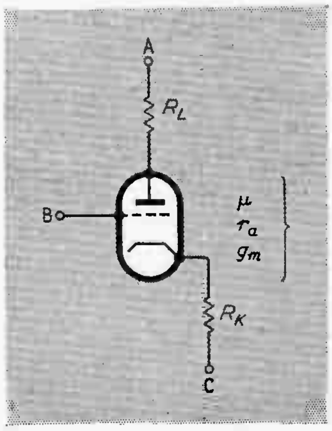

Fig. 1. *Simple valve circuit*

Although primarily designed to illustrate the current changes taking place, the equivalent circuits also indicate the output and parallel output impedances. For example, the parallel output impedance[1] at the anode is, from Fig. 2(a), equal to R_L in parallel with $r_a + (\mu+1)R_K$, and from Fig. 2(c) the parallel output impedance at the cathode is $(R_L+r_a)/(\mu+1)$ in parallel with R_K. These agree with the values calculated by more conventional methods.

General Case with Two Stacked Valves

For analysis of the general case of stacked valves, two valves V_1, and V_2, with parameters $(\mu_1 r_{a1} g_{m1})$, $(\mu_2 r_{a2} g_{m2})$ are shown connected in series in Fig. 3(a). Signals e_1 and e_2 are applied at the respective control grids and the equivalent circuits of Figs. 3 (b) and 3(c) enable the current changes due to each signal to be calculated immediately. Hence the total current change i is given by the expression

$$i = \frac{\mu_1 e_1}{(R_2+r_{a2})/(\mu_2+1)+R_1+r_{a1}+R(\mu_1+1)} + \frac{\mu_2 e_2}{R_2+r_{a2}+(R_1+r_{a1})(\mu_2+1)+R(\mu_1+1)(\mu_2+1)}$$

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World Radio History

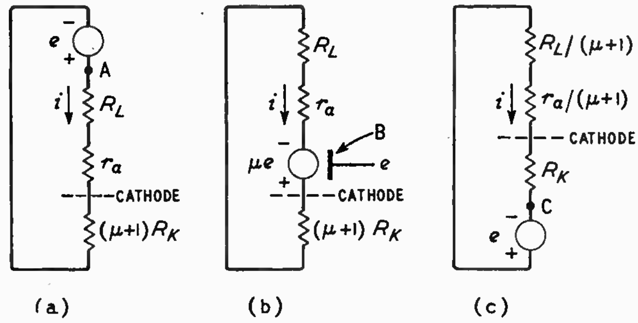


Fig. 2. *Valve circuits showing effective impedances*

$$\therefore\ i = \frac{\mu_1 e_1 + \mu_3 e_2}{(R_2+r_{a2})/(\mu_2+1)+R_1+r_{a1}+R(\mu_1+1)} \qquad (4)$$

where $\mu_3 = \mu_2/(\mu_2+1)$

Circuits Employing Stacked Valves

Fig. 4 shows examples of six types of stacked valve circuit. The d.c. conditions of operation have been excluded from the diagrams for the sake of clarity.

To illustrate the application of the general analysis to special circuits the cascode amplifier and White cathode follower are discussed below.

(*a*) *Cascode Amplifier*[2]

The initial conditions $R=R_1=0$, $e_2=0$ specify the cascode amplifier as a special case of the general solution. Equ. (4) becomes

$$i = \frac{\mu_1 e_1}{(R_2+r_{a2})/(\mu_2+1)+r_{a1}} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

The output signal $e_0 = -iR_2$

$$\therefore \text{ the gain } \frac{e_0}{e_1} = \frac{-\mu_1 R_2}{(R_2+r_{a2})/(\mu_2+1)+r_{a1}}$$

and as $(R_2+r_{a2})/(\mu_2+1) \ll r_{a1}$

so the gain $= -g_{m1}R_2 \quad \ldots \quad \ldots \quad \ldots \quad (6)$

The view from the anode is illustrated in Fig. 5(a) and the parallel output impedance is clearly equal to R_2 in parallel with $r_{a2}+(\mu_2+1)\ r_{a1}$.

[In connection with this arrangement a resistance R_0 connected from h.t. to the anode of V_1 will not alter the analysis if $R_0 \ll (R_2+r_{a2})/(\mu_2+1)$. It will, however, increase g_{m1} due to the increased current conducted by V_1 and consequently the final gain can be greatly improved by this method[3].]

(*d*) *White Cathode Follower*[4]

In this case the initial conditions are

$$R = R_1 = 0,\ e_1 = -iR_2.$$

Equ. (4) thus becomes

$$i = \frac{-\mu_1 i R_2 + \mu_3 e_2}{(R_2+r_{a2})/(\mu_2+1)+r_{a1}}$$

and simplifying

$$i = \frac{\mu_3 e_2}{(R_2+r_{a2})/(\mu_2+1)+r_{a1}+\mu_1 R_2} \qquad (7)$$

The output signal $e_0 = -\mu_1 e_1 + i r_{a1}$ and substituting for e_1 we have

$$e_0 = (\mu_1 R_2 + r_{a1})i \quad \ldots \quad \ldots \quad (8)$$

Combining Equs. (7) and (8)

$$e_0 = \frac{\mu_3 e_2}{1+\dfrac{(R_2+r_{a2})}{(\mu_2+1)}\cdot\dfrac{1}{(\mu_1 R_2+r_{a1})}}$$

As $\dfrac{R_2+r_{a2}}{\mu_2+1}\cdot\dfrac{1}{\mu_1 R_2+r_{a1}} \ll 1$ the gain

$$\frac{e_0}{e_2} = \mu_3 = \frac{\mu_2}{\mu_2+1} \doteqdot 1 \quad \ldots \quad \ldots \quad (9)$$

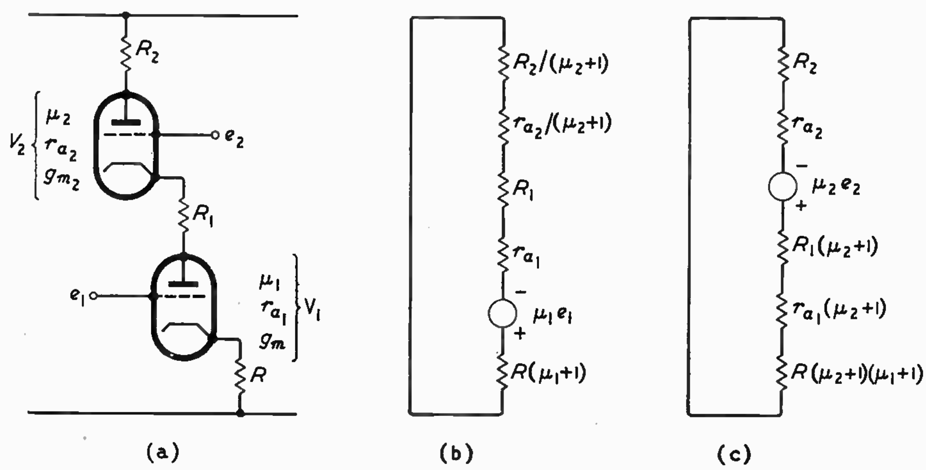
The parallel output impedance of the White cathode follower is not obvious due to the double coupling between V_1 and V_2, and Fig. 5(b) illustrates the 'view' from the output terminal K.

[The term parallel output impedance arises as a result of the inadequacy of the standard definition of output impedance to cope with arrangements where the disconnection of the load destroys the physical significance of the circuit.]

With reference to the notation of Fig. 5(b), when the potential of K is raised 1 volt a current of i_1+i_2 must be supplied by the source of potential. The parallel output impedance $Z_0 = 1/(i_1+i_2)$

Signal current through V_2, $i_2 = (\mu_2+1)/(R_2+r_{a2})$

Fig. 3. *General stacked valve circuit; (a) actual circuit, (b) equivalent circuit for current changes due to e_1, and (c) equivalent circuit for current changes due to e_2.*



World Radio History

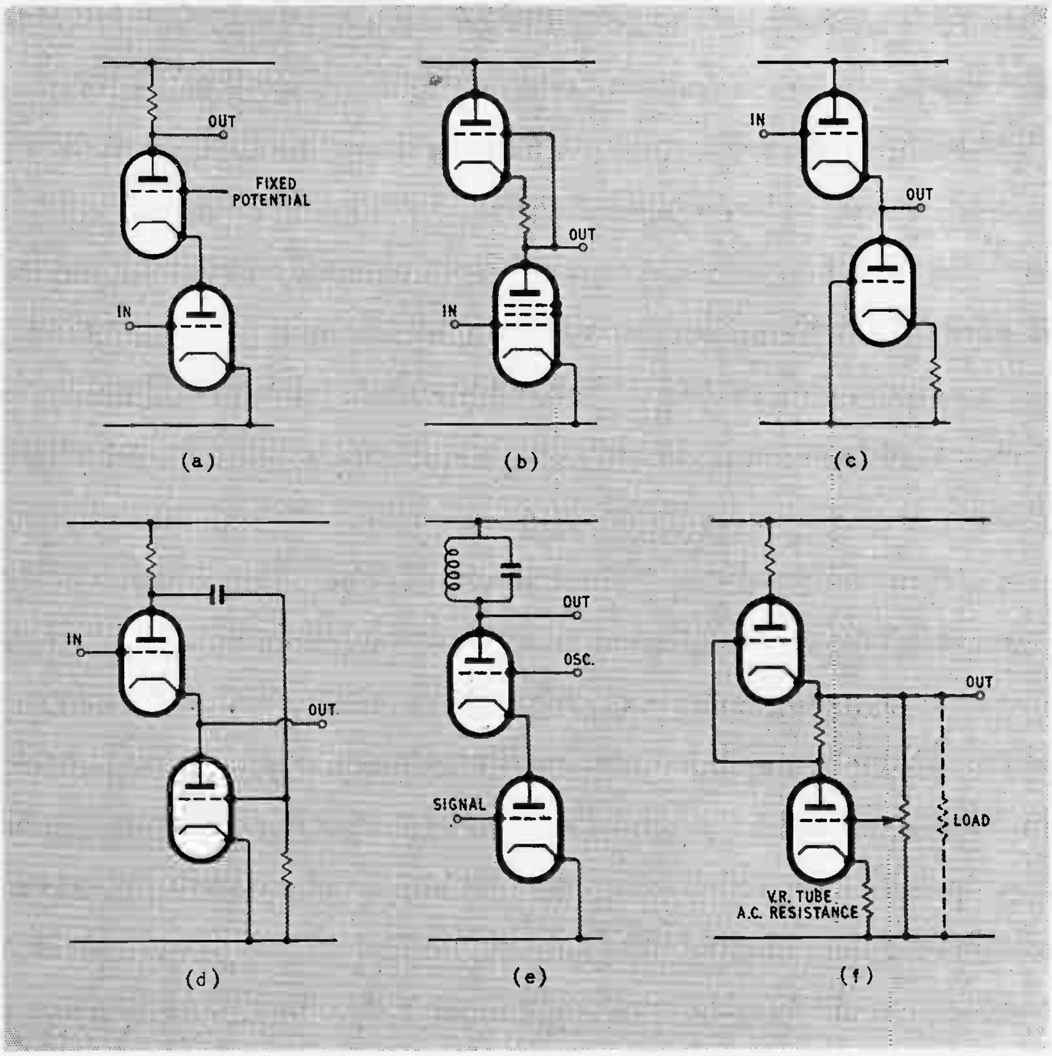


Fig. 4. *Types of stacked valve circuit; (a) cascode amplifier, (b) constant-current anode load, (c) constant-current cathode follower, (d) White cathode follower, (e) modulator and (f) voltage-regulated power supply.*

Signal current through V_1, $i_1 = (1+\mu_1 R_2 i_2)/r_{a1}$

so that $i_1+i_2 = \dfrac{\mu_2+1}{R_2+r_{a2}}[1+g_{m1}R_2]$ ignoring $\dfrac{1}{r_{a1}}$

$$\therefore Z_0 = \left(\frac{R_2}{\mu_2}+\frac{1}{g_{m2}}\right)\left(\frac{1}{1+g_{m1}R_2}\right) \quad \ldots \quad \ldots \quad (10)$$

The parallel output impedance of this circuit rarely appears in the complete form of Equ. (10) and is usually quoted as

$$Z_0 = \frac{1}{g_{m2}(1+g_{m1}R_2)} \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

thus giving a false impression that when $R_2 \gg 1/g_{m1}$ then

$Z_0 = 1/g_{m1}g_{m2}R_2$ and that $Z_0 \propto 1/R_2$.

From the complete form of Equ. (10) it can be seen that as R_2 increases above a value which is much greater than r_{a2}, the value of Z_0 approaches an asymptotic limit of $1/\mu_2 g_{m1}$ (i.e., $1/g_{m1}g_{m2}r_{a2}$).

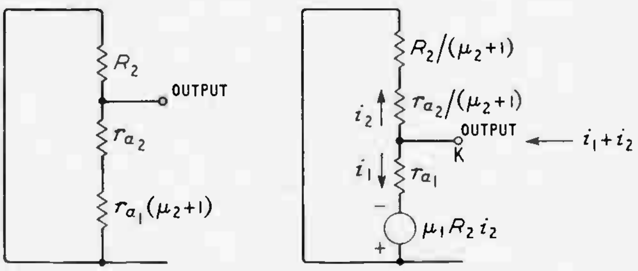


Fig. 5. *(a) Cascode amplifier equivalent output circuit and (b) White cathode follower equivalent output circuit*

Conclusions

The use of equivalent circuits modified to accommodate the results of feedback theorems enables analysis to be accomplished simply and with a better understanding of the physical behaviour of the actual circuit. In some cases the output impedances are readily deduced by mere inspection of the diagram so that the effect of stray capacitances, ignored in the analysis presented, can be readily appreciated.

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World Radio History

Farnborough Air Show

THE SOCIETY OF BRITISH AIRCRAFT CONSTRUCTORS' EXHIBITION

This year's air show was marked by a static display of guided weapons. Although very little information about these was available, the effects of this branch of military aeronautics on the electronics industry were visible throughout the exhibition in the shape of an increased emphasis on compactness, reliability, and good performance under severe physical conditions. The general aspect of the show was not, however, a warlike one, many of the electronics exhibits being concerned with improved civil air communications and navigational aids. Here again, reliability was emphasized, a great deal of space being given to such mundane components as cable connectors and switches. Another aspect of airborne equipment which is receiving much attention is simplicity of operation. A pilot has so many knobs and dials to attend to these days that simplification at the control panel is desirable even if it is achieved at the expense of extra complexity elsewhere.

The same tendency was visible also in ground equipment. For instance, Decca demonstrated the possibilities of easing the work of a ground controller at a busy airport by sifting the information obtained by radar and other means and presenting it in a single readily-assimilable form. Two special techniques are employed. The first is the use of 'interscan' displays on the airport p.p.i. tube. These are symbols written on the tube during flyback by locally-generated high-speed scanning signals. The symbols are derived from a monoscope and can therefore be of any form ; squares, circles and numbers were used for the purpose of demonstrating the system. Symbols can be associated with a radar echo for identification purposes. If the speed and direction of approach of the aircraft producing the echo are known, the symbols can be made to move with it on the p.p.i. In addition, the position of an aircraft outside radar range can be added to the p.p.i. display.

The other technique, known as 'Deccafax', is a simple adaptation of the video part of a television receiver. A transparency of, say, a map, is placed over a television tube face on which an unmodulated raster is written. The tube is used as a flying-spot scanner in conjunction with a photomultiplier. Additional information can be written by an operator on the transparency with a chinagraph pencil. Video signals from the multiplier are transmitted, together with sync pulses, by coaxial cable to a remote receiver, which reproduces the original picture. (The device can readily be made into a two-way simplex system if necessary.)

The way in which 'interscan' and Deccafax can be combined is illustrated in Fig. 1. The interscan is under the control of the p.p.i. operator, who sees that the 'tracks' are correctly tagged. Each 'track' of interest is

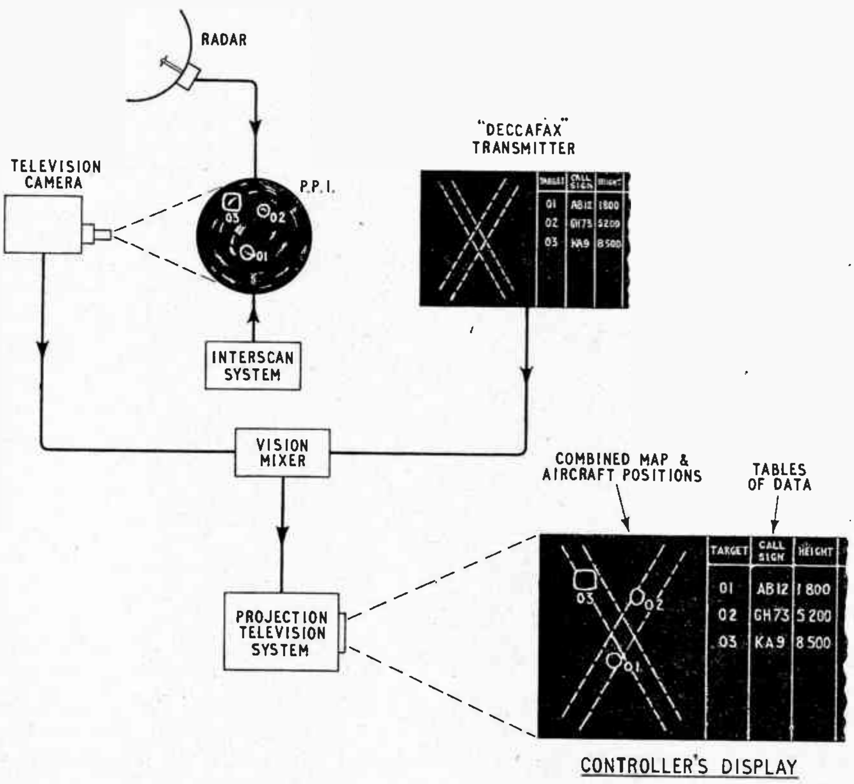
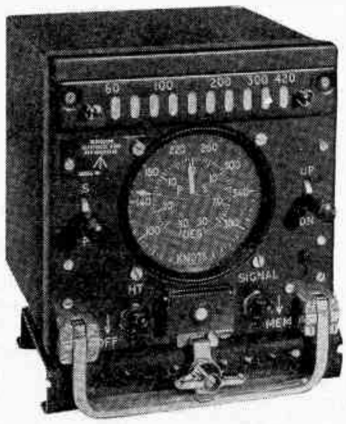


Fig. 1. (*Right*) *Diagram of Decca airport control system*



Indicator unit of the Marconi Doppler navigator Type AD2100. Direct indication of ground speed and drift angle is read off from the central dial given a number and enclosed by, say, a circle if it is a radar echo or a square if it marks the reported position of an aircraft outside radar range. The Deccafax operator fills up a table by the side of a map of the airways and environs of the airfield, giving against the number allocated to an echo such information as call sign and height. All the relevant information is combined in the controller's display as indicated on the diagram. The television camera is, of course, synchronized with the Deccafax. The camera responds only to the interscan signals because these are much brighter than the rest of the p.p.i. display. The controller is thus presented with just the information he requires in a convenient form and the display can readily be duplicated if there is more than one controller. There are, of course, some obvious possibilities for improvement of the system, such as the automatic locking of symbols to tracks and the use of opaque originals on the Deccafax, but the proposers have demonstrated how, at the expense of increased technical complexity, considerable simplification can be achieved in other directions.

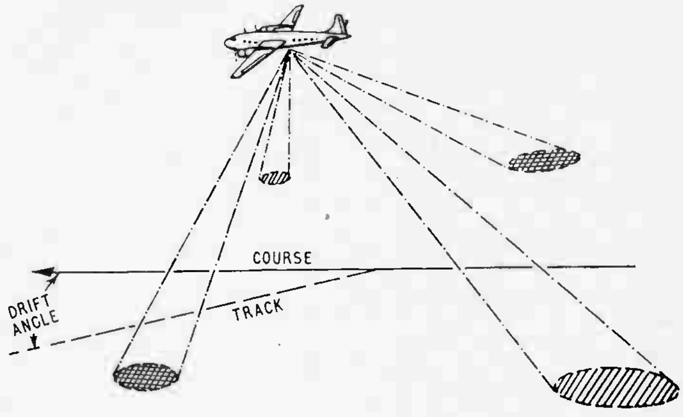
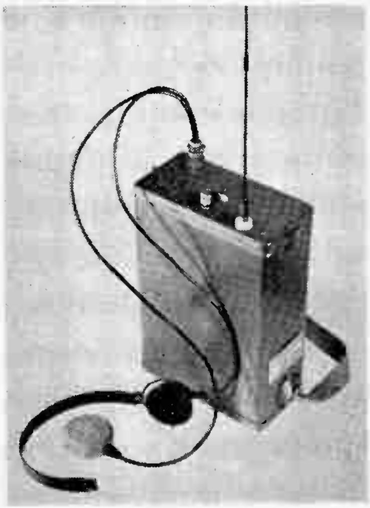


Fig. 2. *Principle of Doppler navigation system*

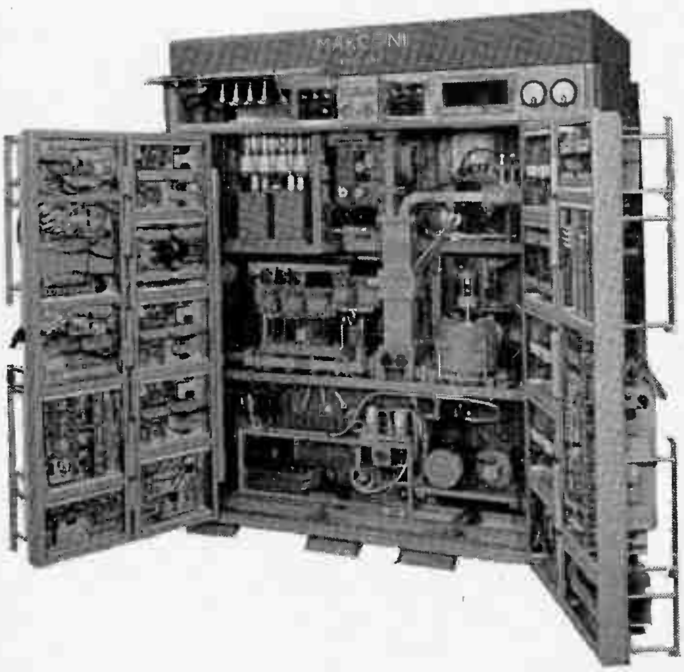
Radar and Navigational Aids

Among the more conventional radar sets was a completely self-contained Marconi equipment with an output power of about 3 MW at 10 cm. The transmitter, receiver, cooling plants, and all necessary test and monitoring gear are housed in a single cabinet. The radar is designed to run unattended. Should a fault develop, the equipment switches itself off, then on again up to a maximum of three times so that, if the fault is of a transitory nature, there is a good chance that normal operation will start again without human intervention. Among the test gear is an automatic noise-factor measuring set which operates continuously. It is claimed that this equipment is the only high-power radar in the world which requires no external supplies other than a.c. mains.



Cossor lightweight V.H.F. transmitter/receiver for motor cycles

*Marconi Type SR*1000 *high-power radar transmitter/receiver, a* 10-*cm equipment with an actual output of* 3 *megawatts*



An airborne search radar shown by Ekco Electronics employs a servo-stabilized platform for the scanner. The characteristics of the aerial can be changed in use to give best performance for map-painting or cloud turbulence detection.

A new Doppler navigation system was demonstrated diagrammatically by the Ministry of Supply, and commercial equipment by Marconi embodied the basic principle. Beams of radiation on a wavelength of 3 cm. are transmitted in two pairs (Fig. 2). The beams are oriented so that the Doppler shifts are the same for each pair when the aerial system is aligned with the direction of motion of the aircraft with respect to the ground. This enables drift to be measured, and by comparison of a compass reading with the drift angle, the true course of the aircraft is obtained.

This system of navigation has the advantage that an aircraft can compute its position without the aid of ground stations, a fact which makes it attractive for military purposes. On the other hand, its accuracy can

World Radio History

be no better than that of the aircraft's compass. For this latter reason, Decca have produced a navigation system in which Doppler navigation is combined with ground-aided devices.

Several airborne automatic direction-finding receivers were shown. A Marconi equipment used the aircraft's 28-V d.c. supply for h.t. as well as l.t. The saving of weight from the absence of the usual rotary converter, combined with the use of sub-miniature valves and components, make this a compact, lightweight equipment. A new direction finder for ground stations, shown by Standard Telephones & Cables, employs a commutated aerial system claimed to be much less subject to site errors than Adcock systems. A counterpoise system is employed which reduces sensitivity to signals of lower elevation than the horizontal, such as are caused by unwanted reflections from the ground.

The increased range for a given transmitter power of secondary radar, together with the possibility of coding signals from transponders, so that individual aircraft may be identified, seems to have renewed interest in the system. Several firms showed transponders. These, however, employ superheterodyne receivers in place of the super-regenerative detectors of the old i.f.f. system.

As might be expected, there were no outstanding developments in ordinary h.f. and v.h.f. communication equipment. Crystal control is now universal, and elaborate systems of frequency-selection incorporating as many as 40 crystals are in vogue though, in some cases, the number of crystals is reduced (at the cost of extra circuitry) by harmonic selection. A single-sideband airborne h.f. transmitter-receiver was shown by Mullard. The carrier is transmitted when there is no modulation input, but is suppressed during modulation. This system lends itself to the incorporation of a.g.c. and a.f.c. circuits, which are actuated by the carrier during the intervals of speech.

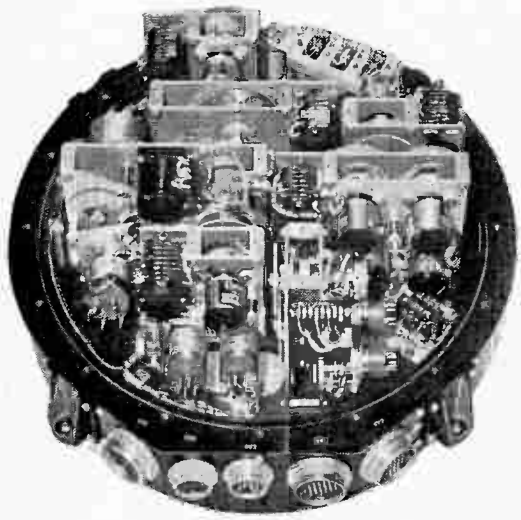
Automatic transmitter tuning is incorporated in most aircraft radio sets nowadays. The critical element is generally the aerial circuit, since this cannot always be pre-set. Tuning is sometimes effected by a simple servomechanism.

Transistors

Transistors are just beginning to make their appearance in airborne equipment. The Canadian Marconi Company showed a transistor d.c. converter type of power-supply unit for producing a 250-V, 60-mA h.t. supply from a 28-V aircraft battery supply. This unit is rated to operate over the temperature range of –55° to 71° C, and is a plug-in replacement for a rotary transformer. A transistor h.t. supply is also incorporated in a Cossor v.h.f. motor-cycle radio telephone. This is a frequency-modulation system, capable of working with channel separations down to 20 kc/s, and is very compact and light, weighing about 10 lb. Transistors were also seen used in aircraft audio systems (Marconi) and in a complex airborne electromechanical computer (Elliott Bros.). The latter processes data obtained from pressure and temperature transducers so as to provide meter readings of various quantities which depend on these. The transistors are used to amplify the transducer outputs and themselves drive magnetic amplifiers. This is, perhaps, a significant innovation, for there seems to be no reason why power transistors should not ultimately be used to replace high-power magnetic amplifiers, with a saving of weight and cost.

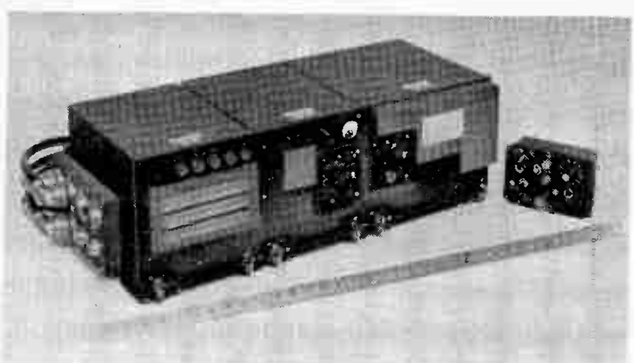
Loud-hailers, incorporating transistor amplifiers, were

The de Havilland Firestreak guided weapon uses an infra-red photoconductive cell to detect enemy aircraft



Elliott air-data computer showing electromechanical components

Airborne single-sideband transmitter/receiver Type X7743. This equipment has been developed to meet requirements for a long-range pilot-operated radio-telephone set (Mullard)



World Radio History

shown by Pye and Canadian Marconi, the latter's equipment having a peak output of 100 W. It is intended for air-to-ground communication from slow-flying aircraft, such as helicopters. We were interested to see a portable loud-hailer (of considerably lower power) in operation outside the airfield, where a police officer was using it to good effect for traffic control.

Other semiconductor devices seen at the exhibition included photoconductive cells, silicon power rectifiers, and silicon Zener voltage-reference diodes. Infra-red-sensitive photoconductive cells using lead sulphide, selenide and telluride were shown by Mullard. Such a cell forms the sensing element of the "Firestreak" guided missile, which homes on an aircraft by detecting heat radiated from the latter's engine. Such a system has the obvious advantage of being difficult to jam, and one may hazard the guess that, since the wavelengths involved are microscopic, the aerial system may well be compact. Also, no radar transmitter is needed. On the other hand, an infra-red system may perhaps be useless in heavy cloud or rain.

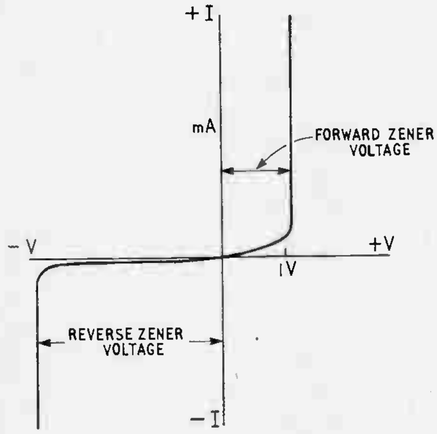
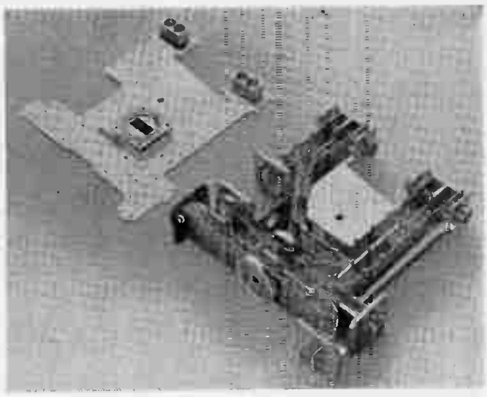


Fig. 3. *Characteristics of silicon rectifier*

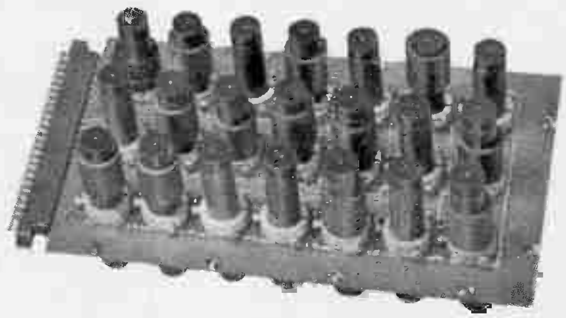
Zener diodes are likely to be of great use in voltage stabilizers and other circuits in which a steady reference voltage is required. The current–voltage characteristic of a silicon rectifier is as shown roughly in Fig. 3. There are two Zener breakdown voltages, one in the forward-biased region at about 1 volt, and one in the reverse-biased region. The latter is the voltage of greater interest and may be varied in manufacture. Diodes shown by Standard Telephones & Cables had reverse voltage drops of 3·3, 4·7, 6·8, 10 and 15 volts at —20 mA, the incremental resistance being 15 to 45 ohms. Zener voltages are generally believed to be very stable with time, though they are generally affected by temperature.

Components

Waveguide components made by a simple new technique were shown by G.E.C. This makes use of a lug and slot construction to hold components during brazing. Assembly and brazing jigs are dispensed with, and tolerances on X-band waveguides can be held to 0·002 in. Quite thin sheet aluminium can be used, giving a saving of weight up to about eight times. It is further claimed that the technique lends itself well to the incorporation of modifications during production runs.



Tongue-and-slot method of assembly of waveguide components (G.E.C.)



Bank of electromechanical filters. The ferrite resonators are housed in the plastic tubes. Fine tuning is obtained by external dust-iron slugs, some of which are shown in the photograph. (Cossor Radar & Electronics Ltd.)

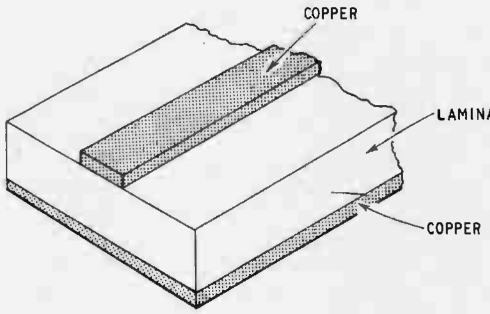


Fig. 4. *An unbalanced line made by etching a copper strip on one side of a copper-clad laminate, the copper sheet on the other side forming the ground plane*

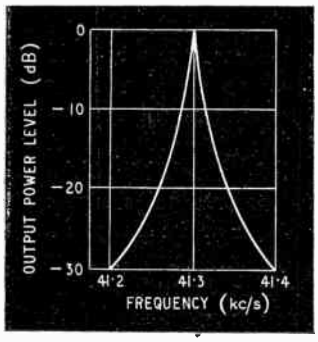
Microwave strip lines and allied types of transmission lines were shown by Cossor. These are made by printed-circuit techniques and have three forms: sandwich line, which has a centre conductor located between two earth planes; strip-line proper, which has two centre conductors, and microstrip, an unbalanced line with one conductor above an earth plane (Fig. 4).

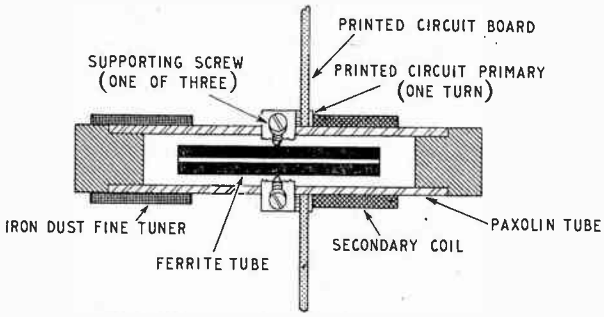
Conventional coaxial cable of very small dimensions

World Radio History

Fig. 5 (*left*). *Typical response of single ferrite filter*

Fig. 6 (*right*). *Construction of ferrite electromechanicol filter element*





(outside diameter 0·064 in.) was shown by S.T.C. This is given extra strength by making the centre conductor of high-tensile steel wire, copper clad and silver plated to improve the surface conductivity. The attenuation at 200 Mc/s is 18 dB/100 ft., and the voltage rating is 0·9 kV peak. S.T.C. also showed thermistors with improved sensitivity (3 mW dissipation produces a resistance change of 20 : 1) for use in transistor circuits at low power levels.

Electromechanical filters in which the resonant elements were vibrating wires or pieces of ferrite were shown by Cossor. Banks of 20 filters, each with a bandwidth of 7 c/s at centre frequencies of about 5 kc/s or 40 kc/s have been developed, the response of a single ferrite filter being shown in Fig. 5 and the construction in Fig. 6.

Telemetry is important in guided missile research. In general, the technique employed seems to be to transmit data from each of a number of channels in succession. The necessary switching required to connect a channel to a telemetry transmitter can be performed by a motor drive switch. A suitable component was shown by Vactric. It consists of a servomotor, reduction gear and an ordinary bank of wafer switches. The information rate obtained is quoted as about 2,300 samples of data per minute.

The presentation of such data on a c.r.t. was demonstrated by the Ministry of Supply. One channel is used for synchronization and two to transmit reference levels. The display obtained has typically the form of Fig. 7.

High-voltage batteries activated by fresh or salt water were shown by Burndept. Hitherto, it has been impracticable to connect more than a few cells in series because of short-circuiting by the electrolyte, but up to about 200 can now be so connected. The cell voltage is 1·2-1·3 V, and the material used is cuprous or silver chloride.

A very different power pack was shown by Plessey in the form of a turbine driven by isopropyl nitrate fuel and developing up to 7·5 kW.

Test and Measurement Equipment

A visitor to the show was heard to remark that a new industry has now grown up; namely, the maintenance-of-test-gear industry. There was certainly a good deal of test equipment on show, much of it electronic. On the whole, however, it was of a fairly

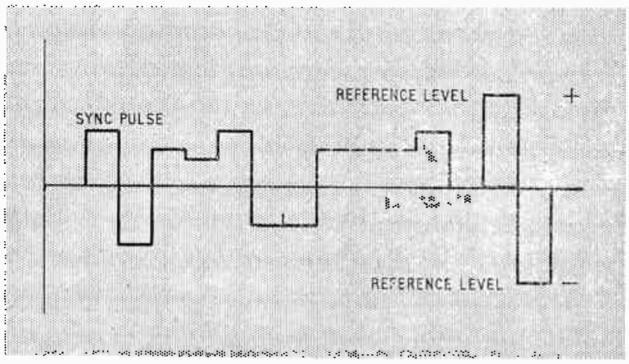
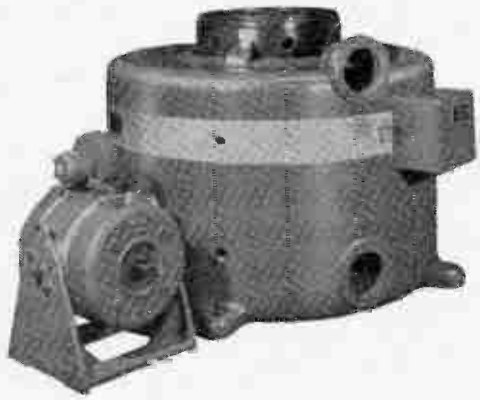


Fig. 7. *Presentation of telemetered information on c.r. tube*

Model of an early experimental homing head for a guided-weapon test vehicle (General Electric Co. Ltd.)

Low-frequency decade oscillator (Short Brothers & Harland Ltd.)

World Radio History



*Goodmans VG*109 *vibration generator. Peak force generated is* 9,900 lb *at* 20 *c/s*

standard nature—strain gauges, oscilloscopes, measuring transducers and the like. Something more specific to the aircraft industry was to be seen in the shape of enormous vibration generators giving thrusts of over 9,000 lb. (Goodmans). It is difficult to recognize in these monsters the descendents of the homely loudspeaker.

The application of standard test instruments to specific problems was ably demonstrated by Wayne Kerr, who showed what can be done with transformer ratio-arm bridges. In one demonstration, the dielectric constants of samples of aircraft fuel containing no water and a trace of water were compared, the moisture content being displayed on a meter calibrated in parts per million. Too much water can give rise to dangerous ice crystals in fuel tanks during high-altitude flights. In the other, the stretching of turbine blades as a result of centrifugal force was simulated, the capacitance of rotor to stator being measured. Accuracies of 1% are claimed and the instrument is calibrated in micro-inches.

A low-frequency (0·01 to 100 c/s) oscillator, incorporating a drift-corrected d.c. amplifier as described in our October issue, was shown by Short Brothers & Harland. Both the d.c. component and distortion component in the output are very small.

The Fringe of the Field **by Quantum**

INFRA-RED RADIATION AND ITS DETECTION

Infra-red radiation is that part of the electromagnetic spectrum of wavelengths ranging from $0 \cdot 75\mu$ to perhaps 1000μ or longer, where it overlaps with the microwave region and the method of generation decides which of the two it is called. Writing in 1947, Dr. G. B. B. M. Sutherland said, "the developments which have taken place in the infra-red region of the spectrum during the past seven years will probably have a very great effect on the general development of science in the next decade". Which brings us to the present time, and suggests a good look round. Well, I may as well be frank ! Information that is less than a couple of generations out of date is rather hard to come by; indeed, two outstanding university textbooks published in 1957 (one on Heat, and one on Physical Optics) say very little more about the infra-red than you would find in an early edition of Thomas Preston on either subject, and rather less than John Tyndall.

The reason is, I suppose, that infra-red radiation is so versatile a tool that in order to find out how people have been using it you would have to embark on a very wide abstracting campaign; most of us prefer to leave undertakings on such a scale to the specialists who can do them really properly. Thus, infra-red spectroscopy is used by the organic chemist as a rapid method of analysis and identification, and by the physical chemist to determine molecular structures—that of penicillin was a notable early triumph. In these fields it is at least as important as the earlier X-ray analysis techniques. Non-radioactive isotopes can be identified by their infra-red spectra; indeed, the absorption spectrum of the atmosphere has been obtained with sufficient resolution to show the heavy-water vapour present. Rapidly varying surface temperatures can be measured, valuable in the study of engineering problems. The solar spectrum has been mapped in detail far into the infra-red; and the reflecting microscope extends possible applications to the biological sciences.

In all these applications, everything hinges on the detector. Given suitable transmitting and dispersing optical elements, infra-red spectroscopy merely follows the same general pattern as for the visible and ultra-violet, with the substitution of rock-salt or one of the newer materials for quartz or glass, and the use of echelette or blazed Merton-ruled gratings for the more conventional types. There are, fortunately, several valuable sources to consult on infra-red detectors. First, a review article by G. B. B. M. Sutherland and E. Lee in Vol. XI (1946-7) of the Physical Society's Reports on Progress in Physics; then, an article by A. Elliott in the Pilot Press book "Electronics" of about the same date, which describes the war-time developments on both sides of infra-red photocells; and finally "The Detection and Measurement of Infra-Red Radiation",

World Radio History

by R. A. Smith, F. E. Jones, and R. P. Chasmar, published this year by the Oxford University Press. There is also an article in last year's Physical Society Report by H. Y. Fan, on "Infra-Red Absorption in Semiconductors", which goes deeply into the mechanism underlying the action of the photoconductive process.

From a fundamental point of view, the work has been cumulative; information obtained from infra-red observations about the structure of semi-conductors has all been fed back to the design of more sensitive detectors, and so on. Again, much of the exhaustive work on the detection of weak signals against a noise background has been aimed at improving the sensitivity of detecting systems.

Detectors of Infra-Red Radiation

Most of the thermal detectors, operated by the temperature rise caused by the absorption of radiant energy, are well known in their cruder forms, and all have an unlimited wavelength range. Quantum detectors, which include the photoemissive and photoconductive cells, stimulated phosphors, and Hall-effect cells, respond in the first instance by the absorption of quanta with sufficient energy to eject electrons from an energy level, or band of levels, to some other state in which they are acceptable; and as there is a more or less definite minimum energy required, each of these has its own long-wave limit in the near infra-red; this in some cases is as long as 7–8μ.

In each detector, the initial response is passed on to an amplifier system. As it is much simpler to amplify a.c. than d.c., the radiation beam is interrupted by a 'chopper', operating at a frequency of between 5 c/s and 800 c/s, and the response, as a modulation of the chopper frequency, passes on to a narrow-band amplifier tuned to that frequency. Detector noise is a rather complicated matter, and the various factors seem to have different orders of precedence in different types of detector. In some, the Johnson noise (proportional to $\sqrt{kT}$) is the main factor; in others, a kind of thermal shot effect, due to internal statistical temperature fluctuations (proportional to $\sqrt{kT^2}$), is equally important; current noise affects bolometers and photoconductive cells; and if none of these was present at all, statistical fluctuations in the incident radiation itself would still give a 'natural' noise in thermal detectors proportional to $\sqrt{kT^5}$. A high signal-to-noise ratio is, in general, favoured by making T small, and by using as high a chopper frequency as possible. The time-constant τ of the detector, however, prescribes the highest usable frequency; sensitivity is lost if it is not allowed to take its own time, and a frequency considerably lower than $1/\tau$ is preferred

The figure for the least detectable power, W_m, used throughout this article, is that given by Smith, Jones, and Chasmar. It refers to the whole system, amplifiers and all, and is the value of the incident power-flux which would give a signal-to-noise ratio of unity for a bandwidth of 1 c/s. It is also called the equivalent noise input (e.n.i.), and by the sticklers for dimensional precision the minimum detectable *energy* (m.d.e.). The statement that the Johnson noise is "proportional to $\sqrt{kT}$", and so on, really means here that the value of W_m, calculated if there were only this one noise contribution, would vary in that way.

Thermal Detectors

The thermocouple is probably the most widely favoured of all detectors, and while the antimony-bismuth pair is still used, various semiconducting pairs of higher thermoelectric power have appeared recently. The time-constant, even when attention has been paid to reducing the thermal capacity, is rather long as compared with other kinds of detector and, even at 5 c/s, the full sensitivity is not obtained. In the modern Schwartz type, the two components are united by a thin blackened gold foil, and the whole is mounted in vacuo. Compared with the radio-micrometer, which has been extolled in all the books for the past 60 years, and was indeed a good detecting system when coupled to the output of a 16-inch reflecting telescope, W_m appears to be about a thousand times less than the best they could do with thermocouples in the nineties.

The bolometer, depending on the change of resistance with temperature, gives little less sensitivity than the best thermocouples, but time-constants are usually shorter. Much depends on the thermal contact with the surroundings, and the operating temperature. Besides the conventional platinum and nickel strips, carborundum 'thermistors' and superconducting materials such as columbium nitride have been used. The superconductor has to be used in the transition region (at about 14° K in this case) where the temperature coefficient of resistance is very large.

The Golay pneumatic detector, which can be regarded as a development of the differential air thermometer, uses the expansion of air or helium which is heated by the radiation absorbed by the blackened face of the containing cell. This distorts a flexible reflecting diaphragm which is part of an optical system that forms an image of a grid on a series of slits, in such a way that the dark parts of the grid cover the slits. When the reflector bulges, the image is defocused, and light passes through the slits on to a photocell—an ingenious arrangement not unlike the double-grating trick used in automation control.

The figures given in Table 1 for actual instrument assemblies, and also for calculated conditions for a theoretical bolometer, should be compared with those for an ideal thermal detector at 300° K subject only to incident radiation fluctuations ($W_m = 5{\cdot}5 \times 10^{-12}$ watt for comparable area) and with a radio detector at 300° K ($W_m = 4 \times 10^{-21}$ watt). Actual detectors fall far short of the ideal, because of the numerous sources of noise. But the factor of 10^9 by which the thermal receiver loses to the radio receiver can be explained in two ways. First, there are no appreciable radiation fluctuations in the narrow waveband of a radio receiver; the thermal receiver takes the whole black-body spectrum, fluctuations and all. Secondly, the thermal detector is a heat engine, and you cannot cheat the second law of thermodynamics; only about 10^{-9} of the heat absorbed can be available as electrical energy with the small temperature difference that it causes. Both these explanations are, in fact, the same principle expressed in different forms. It has indeed been

World Radio History

suggested that simpler methods, such as evaporation or convection detectors which employ all the absorbed heat might, in view of this enormous inefficiency, promise something better !

TABLE 1

Comparison of Thermal Detectors

	Incident power W_m giving signal/noise ratio unity for 1-c/s bandwidth (watt)	Time constant τ in milliseconds
Actual detectors :		
Thermopile	1×10^{-10}	10–50
Bolometer	3×10^{-9}	4
Golay cell	$1 \cdot 4 \times 10^{-9}$	3
Calculations of theoretical performance :		
Bolometer, radiation cooled :		
at 290°K.	$2 \cdot 3 \times 10^{-11}$	50
at 20°K.	$2 \cdot 9 \times 10^{-14}$	10
Bolometer, conduction cooled :		
at 290°K.	$5 \cdot 1 \times 10^{-11}$	6
at 20°K.	$3 \cdot 5 \times 10^{-12}$	0·25

Photo-Detectors

The relation between the wavelength λ of a radiation (measured in microns) and its quantum energy $E = h\nu$ (measured in electron-volts) is, approximately, $E = 1 \cdot 2/\lambda$, so that for the nearest infra-red $\lambda = 0 \cdot 8\mu$ and $E = 1 \cdot 5$ eV, while for the longest photo-detectable wavelength at present $\lambda =$ about 8μ and $E = 0 \cdot 15$ eV. While we are on these preliminary figures and feeding a few numbers into the store for future reference, it might be added that the peak of the black-body curve for a radiator at 300° K occurs at 10μ (0·12 eV); it can be seen that radiation from the surroundings, if they are at ordinary temperatures, may make an appreciable contribution to the photo-effect observed.

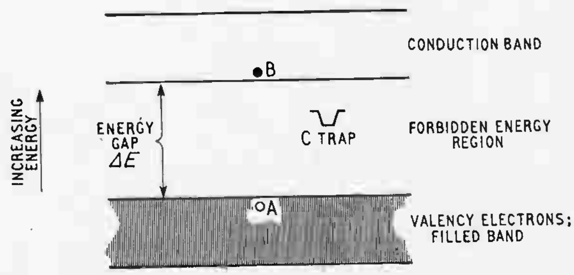
For surface photo-emission from the cathode of a photocell, the value of E for the incident quanta must exceed the work-function for the surface and, for most metals, this is of the order 2–3 eV or more. The only widely used cathode surface for infra-red purposes is the silver-oxygen-caesium surface, which has its maximum response at $0 \cdot 8\mu$, and its long-wave threshold at $1 \cdot 2\mu$ corresponding to a work-function of 1 eV.

The cell may be evacuated or gas-filled. The cathode could be incorporated in a photomultiplier, but the reason why this has not been exploited fully is presumably the very considerable dark current at ordinary temperatures. This, like other kinds of thermal noise, is reduced by cooling the surface; and at liquid air temperature W_m of the order 10^{-14} watt has been obtained, though with a rather long time-constant. Among the applications of the caesium cathode is the infra-red image converter in which the electron pattern from the cathode is accelerated under about 3 kV on to a fluorescent screen. The image is inverted with respect to the original object, but tubes with a wider separation of cathode and screen have been made, interposed focusing anodes reinverting the electron pattern in flight.

With all semiconducting detectors, the prime effect is the translation of an electron from one of the higher valency-electron levels, across the forbidden energy gap, and into the conduction band of energy levels. At least, this is the simplest possible picture, which does more or less apply to intrinsic semiconductors such as silicon and germanium. This is called the internal photoelectric effect; electrons are not set free from the surface of the solid, but are enabled to move about within it, and take part in the flow of current through it (photoconductivity), the generation of an e.m.f. at a barrier (photovoltaic effect), and transverse motion across a magnetic field (Hall, or if you prefer it in this connection, photoelectromagnetic effect). Fig. 1 represents the energy-band arrangement; and an electron is promoted when it absorbs a radiation quantum of energy greater than the gap ΔE. Now, the promoted electrons do not escape from the surface, nor do they accumulate indefinitely in the conduction band; after a short time they return to the original level. So, under steady illumination an equilibrium concentration of conduction electrons is reached when the number returning per second equals the number arriving. At the start, the concentration builds up according to the usual exponential formula and, when the illumination is cut off, it decays similarly. A solid behaving in this simple way would have a single time-constant τ; but recombination centres and electron traps complicate matters, for decay may be via a series of halts in traps—and of course there are carriers of both signs to consider in practice—so there may in fact be several time-constants. Also, Fig. 1 oversimplifies the matter of the valency band, which has been sorted out into levels by infra-red absorption experiments.

The most important devices at present are the photoconductive cells, which operate rather like bolometers in that the signal they give is derived from a resistance change, in this case the reduction of resistance as carriers pour into the conduction band. The value of ΔE for a given material sets a long-wave limit λ to its use, since $\lambda = 1 \cdot 2/\Delta E$. Thus, for the intrinsic semiconductors at ordinary temperatures, the figures are, Si, 1·21 eV, $1 \cdot 0\mu$; Ge, 0·79 eV, $1 \cdot 7\mu$; Te, 0·33 eV, $4 \cdot 0\mu$. At lower temperatures ΔE is reduced for most materials, so that to the ordinary noise advantage of low temperature operation is added an extension

Fig. 1. *Simplified picture of the internal photoelectric effect; absorption of a quantum of energy ΔE raises an electron from A in the valency band, across the energy gap, to B in the conduction band. It may return direct, or lodge temporarily in an electron trap*



World Radio History

of the range. Lead sulphide PbS, lead telluride PbTe, and lead selenide PbSe are the chief materials used for photoconductive cells; and Smith, Jones, and Chasmar, who are particularly authoritative in this field, give a very full account of cells of this type. It is difficult to quote from their figures, which refer to cells of different parameters under different radiation conditions—some for peak-sensitivity wavelength, some for a 500° K black-body which seems to be the standard for com-

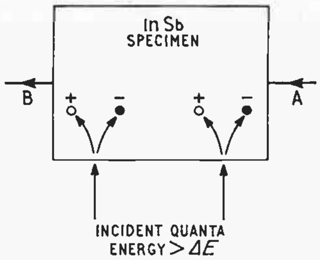


Fig. 2. *The photoelectromagnetic effect in indium antimonide. The carrier-pairs (electron and positive hole) liberated by the incident quanta are deflected as shown by the magnetic field which is directed downwards into the diagram, giving an e.m.f. observed at the leads A and B. This is simply the Hall effect with the carriers being supplied (or increased) photoelectrically*

parison, and so on. But they mention a lead-sulphide cell which at 290° K has $\lambda = 3{\cdot}4\mu$, $W_m = 7{\cdot}5 \times 10^{-11}$, and $\tau = 0{\cdot}1$ msec, while at 90° K the values are $\lambda = 4{\cdot}3\mu$, $W_m = 2 \times 10^{-14}$ watt, and $\tau = 15$ msec; a lead telluride cell (showing two time-constants, of which the effective one was $0{\cdot}10$ msec) for which λ was $4{\cdot}4\mu$ at 195° K, and $5{\cdot}9\mu$ at 20° K; and give curves for a lead selenide cell showing $\lambda = 6\mu$ at 290° K, 8μ at 90° K, and well beyond this at 20° K. The short time-constant is a valuable feature of all these cells; another important point is that they all cover the first of the two atmospheric 'windows', that between 3μ and 4μ, at which the atmosphere is very transparent.

The intermetallic semiconductors, Group III–Group V compounds with a Group IV or germanium-like structure, open up the Hall-effect field because of the extremely high electron mobility and the very small ΔE that some of them possess. Thus, indium arsenide InAs has $\Delta E = 0{\cdot}48$ eV, mobility 14,000; indium antimonide InSb has $\Delta E = 0{\cdot}18$ eV, mobility 50,000, and is the material used in the cell developed by the Plessey Company (Fig. 2). Electron-hole pairs are produced near the front surface by the absorption of quanta of energy greater than ΔE; these diffuse towards the back surface under the influence of the concentration gradient, and are separated by the magnetic field (about 10–15,000 oersted) directed into the plane of the diagram, giving a signal voltage across the end contacts. The value of W_m is given as 7×10^{-9} watt, which is high by comparison with the photoconductive type; but the time-constant is too short to be observed, is certainly less than 1μsec, and has been estimated as about 7×10^{-8} sec. Details of such a cell are also given by C. Hilsum and I. M. Ross, of S.E.R.L. Baldock, in *Nature* for 19th January 1957; the remarkable feature, apart from the short τ, is the range of sensitivity to well beyond 7μ at *air temperature*.

While this article was in the press, a paper by D. G. Avery, D. W. Goodwin, and Miss A. E. Rennie, of R.R.E. Malvern, entitled "New Infra-red Detectors using Indium Antimonide", appeared in the October 1957 issue of the *Journal of Scientific Instruments*. These authors describe a *photoconductive* InSb detector which operates to beyond 7μ at air temperature, and seems to offer all the advantages of the Hall-effect detector without the need of a cumbersome permanent magnet. They also discuss cooled p-n junction photovoltaic detectors, for use at 90° K, which compare favourably with lead telluride cells. Lead sulphide and its congeners have had a long and distinguished innings; it looks as if the materials of the future are going to be the intermetallic compounds, which are so much quicker off the mark.

MEETINGS

I.E.E.

13th November. "Broad-Band Slot-Coupled Microstrip Directional Couplers"; "The Application of Printed-Circuit Techniques to the Design of Microwave Components" and "Re-Entrant Transmission Line Filter using Printed Conductors", by J. M. C. Dukes, M.A.

25th November. "Problems of Sound and Television Broadcasting Coverage", by G. Millington, M.A., B.Sc.

3rd December. "Some Aspects of Half-Wave Magnetic Amplifiers", by G. M. Ettinger, B.Sc.(Eng.), M.Sc.(Eng.); "Some Transistor Input Stages for High-Gain D.C. Amplifiers" and "A Transistor High-Gain Chopper Type D.C. Amplifier", by G. B. B. Chaplin, M.Sc., Ph.D., and A. R. Owens, M.Sc.; and "Dekatrons and Electro-Mechanical Registers operated by Transistors", by G. B. B. Chaplin, M.Sc., Ph.D., and R. Williamson.

These meetings will commence at 5.30 at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2.

Brit. I.R.E.

27th November. Annual General Meeting at 6 o'clock. At 7.15, "Transmission Standards and Signal Distortion in Television and Other Communication Systems", by A. van Weel, Dr. Techn. Sc., to be held at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.

The Television Society

15th November. "Industrial Television", by I. M. Waters.

29th November. "Some Aspects of Waveguide Technique", by J. C. Parr, B.Sc.

These meetings will be held at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2, at 7 o'clock.

Institute of Physics

12th November. "Crossed Field Interaction in Microwave Valves", by W. E. Willshaw, to commence at 5.30 at The Institute of Physics, 47 Belgrave Square, London, S.W.1.

Institute of Navigation

15th November. "Doppler Navigation"; an account of Doppler technique by manufacturers and users of the equipment, to commence at 5.15 at The Royal Geographical Society, 1 Kensington Gore, London, S.W.7.

The Institution of Electronics

28th November. "The High Fidelity Reproduction of Sound", lecture-demonstration by C. Brown in the Assembly Hall, University of London Institute of Education, Malet Street, London, W.C.1, commencing at 6.30.

B.S.R.A.

15th November. "Some Recent Developments in Loudspeaker Enclosure Design," A. R. Neve, to be held at 7 o'clock at the Royal Society of Arts, John Adam Street, Adelphi, W.C.2.

R.S.G.B.

"Some Aspects of Atmospheric Radio Noise," F. Horner, M.Sc., to be held at the Institution of Electrical Engineers, Savoy Place. Victoria Embankment, London, W.C.2, at 6.30.

World Radio History

Comparison of Four Television Standards

BRITISH, AMERICAN, FRENCH, EUROPEAN

By R. D. A. Maurice, Ing.-Dr., Ing. E.S.E., A.M.I.E.E.*

SUMMARY. *The resolutions of four C.C.I.R. standard television systems are compared, some account being taken of the effects of the asymmetric sideband reception. The extent to which some of the distortions may be due to non-linearity of the phase–frequency characteristic is briefly mentioned.*

Discussion occurs on many occasions as to the relative merits of the various television standards that have been adopted in different parts of the world. Some aspects of these television systems will be summarized below. It is not proposed here to make any suggestions as to possible improvements but merely to make technical comparisons. The systems considered are the U.K. 405-line, the French 819-line, the U.S. 525-line and the European 625-line standards as set out in "C.C.I.R. Documents of the VIIth Plenary Assembly, London 1953", Volume 1, Report No. 35, pp. 240–259.

The results and conclusions reached are obtained from a theoretical study of the unit-step, unit-impulse and rectangular-pulse responses, or responses to an abrupt transition from black to white, to a single white dot and to a vertical white bar of each television system having the characteristics shown in the above C.C.I.R. document, subject to the additional assumption that the video circuits prior to the transmitter consist of an ideal (uniform amplitude, uniform group delay) low-pass filter of cut-off frequency $\omega_c/2\pi$. The receiver characteristic is also assumed to have uniform group delay. It can be shown that the departure from uniformity of group delay caused by a sufficient approximation to the standard shape of vestigial sideband receiver characteristic can be negligible.† Envelope demodulation has been assumed.

The parameters of the system which have been taken into account in the calculations from which the material in this paper has been obtained comprise (Fig. 1) the bandwidth on either side of the vision carrier for which the ideal receiver characteristic is non-uniform, the highest video-frequency component transmitted without attenuation relative to components at low video frequencies, the polarity of the modulation, the magnitudes of the carrier wave for the two extreme positions of an abrupt transition from black to white transmitted without aperture distortion, the number of active lines, the active line duration and the channel allocation in megacycles per second. Table 1 summarizes the values of these parameters.

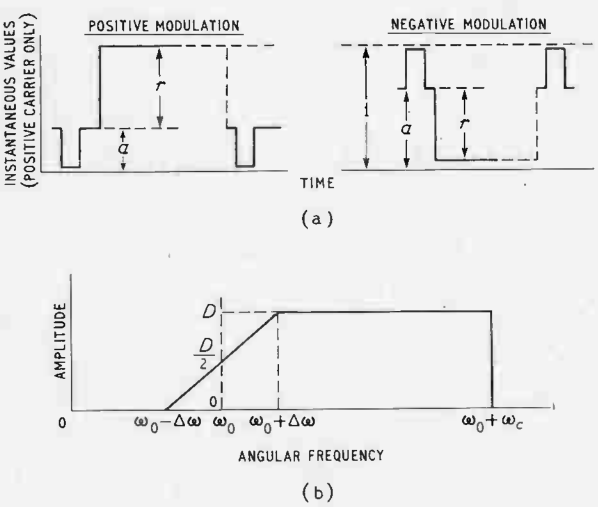


Fig. 1. (*See Table* 1.) (*a*) *The transmitted waveform and* (*b*) *the ideal receiver characteristic, usually formed by the intermediate-frequency circuits;* $\omega_0/2\pi$ = *vision carrier intermediate frequency*

Interpretation of the Calculations

Unit-Step and Unit-Impulse Excitations

Although the various systems have different magnitudes for the value of r (Table 1 and Fig. 1), the demodulated transitions have been normalized to a transition from zero voltage (current) to unit voltage. Figs. 2 and 3 show these normalized transitions and two ideal cases assuming double-sideband transmission and reception.

Fig. 2 shows the demodulated video signal which would be applied to the modulation electrode of a receiver picture tube once during each scanning line when a vertical black-to-white transition in the image of the scene to be televised is being scanned during each horizontal trace of the electron beam in the pick-up tube or flying-spot scanner at the television studio. The

* *British Broadcasting Corporation.*
† See Appendix.

World Radio History

TABLE 1

(See Fig. 1)

System	a	r	ω_c Mrad./s	$\|\Delta\omega\|$ Mrad./s	Number of active lines	Active line duration μs	Channel allocation Mc/s
U.K.	0·3	0·7	$2\pi \times 3/4$	$2\pi \times 3/4$	377	81	5
French	0·25	0·75	$2\pi \times 10{\cdot}4$	$2\pi \times 2$	737	41	14
U.S.	0·75	−0·6	$2\pi \times 4$	$2\pi \times 3/4$	497	53	6
European (625-line)	0·75	−0·65	$2\pi \times 5$	$2\pi \times 3/4$	597	53	7

a = carrier amplitude during transmission of electrical black level.
r = difference between carrier amplitudes corresponding to transmission of peak-white and electrical black level.
ω_c = highest video angular frequency to which transmitter modulator will respond.
$2\Delta\omega$ = width in angular frequency of non-uniform portion of receiver amplitude response characteristic.

effects produced by 'gamma' correction are not considered here. The dashed curve represents the result obtained when double-sideband transmission and reception are used, whereas the solid curves represent the results obtained when asymmetric- or vestigial-sideband reception (it is immaterial in so far as reception is concerned in this case, whether the transmission is asymmetric or double sideband) is used. The scale of abscissae is normalized in the sense that the quantity $\omega_c t$ has been used instead of the more direct time variable t. In order to obtain actual black-to-white transition times for the various television systems it is thus necessary to re-draw each curve with the time t as abscissa: that this has not been shown here is because it is easier to see the changes in the effects of asymmetric-sideband reception on systems using positive modulation on the one hand and negative on the other when the normalized abscissa $\omega_c t$ is used. Nevertheless it was, of course, necessary to determine actual transition times by dividing the normalized abscissae $\omega_c t$ by the value of ω_c applying to each television system before the tables could be drawn up. For example, if we take $\omega_c t = \pi$ as the normalized duration of the response of an ideal linear double-sideband transmission system (Fig. 2), excluding the receiver picture tube, to an abrupt black-to-white boundary in the scene to be televised, we find that the transition time for the U.K. system has the conventional value of $t = \pi/\omega_c = \pi/(2\pi \times 3) = 0{\cdot}17\mu s$.

Fig. 3 differs from Fig. 2 only in so far as the excitation is concerned. In Fig. 3 are shown the responses of the various television systems to a single white dot of infinite brightness and zero width occurring once per scanning line in the image of the scene to be televised.

All the figures are based upon the actual transition times taken to climb from 0·1 to 0·9 in the unit-step case and from 0 through the maximum to 0 again for the unit-impulse case except in the European and U.S. examples, for which column 2 of Table 3 shows figures less than unity. For these two cases, the ideal double-sideband figures have been used, since the number of picture elements per line cannot exceed the ideal figure allowed by the video bandwidth.

Figures for transition time, resolution or number of effective elements per complete picture and picture element asymmetry are open to argument, as various interpretations are possible. Therefore, all such figures have been normalized relatively to the U.K. system, although, of course, they could as easily be normalized to any of the other systems. To clarify the meaning of the figures for relative picture element asymmetry, however, the absolute figures for the U.K. system are shown in notes below Tables 2 and 3.

Rectangular Pulse Excitation

While Figs. 2 and 3 show the unit-step and unit-impulse responses, it was considered that the response of each system to a rectangular pulse of ten picture-element duration would bring out more clearly the effect of modulation polarity coupled with asymmetric-sideband reception.

Fig. 4* shows the responses to such an excitation. The ideal double-sideband case is shown dotted with each response. It should be remembered that the curves shown in Figs. 2, 3 and 4 have all been calculated with the assumption that there is no phase distortion (uniform group delay) whatever in the entire transmission and reception.

* The author is indebted to his colleague, Mr. J. W. Head, for the calculations required for these graphs.

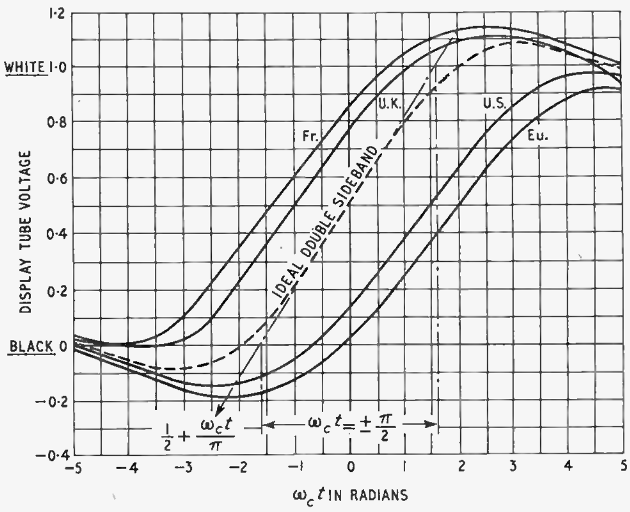


Fig. 2. *Normalized unit-step responses (demodulated outputs). The demodulated normalized display tube video voltage is given by* $E(t)$ =

$$\sqrt{\left(a/r + 1/2 + \frac{1}{\pi}\,\mathrm{Si}\,\omega_c t\right)^2 + \frac{1}{\pi^2}\left(\frac{\sin t\Delta\omega}{t\Delta\omega} + \mathrm{Ci}\,\omega_c t - \mathrm{Ci}\,t\Delta\omega\right)^2} - a/r$$

(*See Table* 1 *and Fig.* 1)

World Radio History

TABLE 2

Unit-Step Transition

Column 1	2	3	4		5		6	7	8
System	Transition time normalized to ideal system and to video cut-off frequencies	Transition time normalized to U.K. system and to video cut-off frequencies	Overshoot %		Greatest overshoot % as excess over :		Excess resolution** provided as % of that of U.K. system	Picture element asymmetry relative to that of U.K. system	Resolution per Mc/s of channel allocation relative to that of U.K. system
			in blacks	in whites	ideal system	U.K. system			
Ideal double sideband	1	0·92	9	9	0	−2½	—	—	—
U.K.	1·09	1	½	11½	2½	0	0	1*	1
French	1·16	1·06	—	15	6	3½	227	1·2	1·17
U.S.	1·18	1·08	15½	—	6½	4	6	1·7	0·88
European (625-line)	1·40	1·28	19½	—	10½	8	34	1·9	0·96

* The actual value (normalized to 1 in the table) of the ratio of the length of a picture element to its height is 0·75 in this case.

** Resolution is based not on the number of picture elements per line but on the number per picture.

Results and Conclusions

Tables 2 and 3, which are more or less self-explanatory, are obtained from the curves shown in Figs. 2 and 3 in conjunction with the parameters given in Table 1.

It has been stated elesewhere* that the human-eye characteristic showing sensation units as a function of brightness approximates to a power law whose exponent does not differ greatly from the reciprocal of that of the gamma law of normal picture tubes. For this reason, the overshoot figures shown in columns 4 and 5 of the tables may be taken as representative of the actual sensations of brightness which the viewer would suffer. Columns 6 show the excess of the ratio of the total number of picture elements per picture reproducible by each system to the figure for the U.K. system expressed as a percentage of the latter. Columns 7 show the ratio of the picture element asymmetry of each system to that of the U.K. system ; thus, if n is the ratio of the horizontal width of a picture element to its vertical height, then columns 7 show $n_{system}/n_{U.K.}$ Columns 8 show which systems use their allotted radio-frequency bands more or less efficiently than the U.K. Columns 2 show that an asymmetric-sideband system has a longer unit-step transition time (Table 2) than the ideal double-sideband system, but that this is no longer true for unit-impulse transitions in systems using negative modulation (Table 3).

* B.B.C. Engineering Division Monograph No. 3, page 5.

It would be tempting to take an average of the resolution figures shown in columns 6 and also of channel efficiencies as shown in column 8, thereby combining the unit-step and unit-impulse results into overall averages ; but the very fact that different results are obtained for different types of modulation function (unit step or unit impulse) shows that the non-linearity introduced by envelope detection of asymmetric sideband signals precludes such methods.

A further point of interest is the question of how much

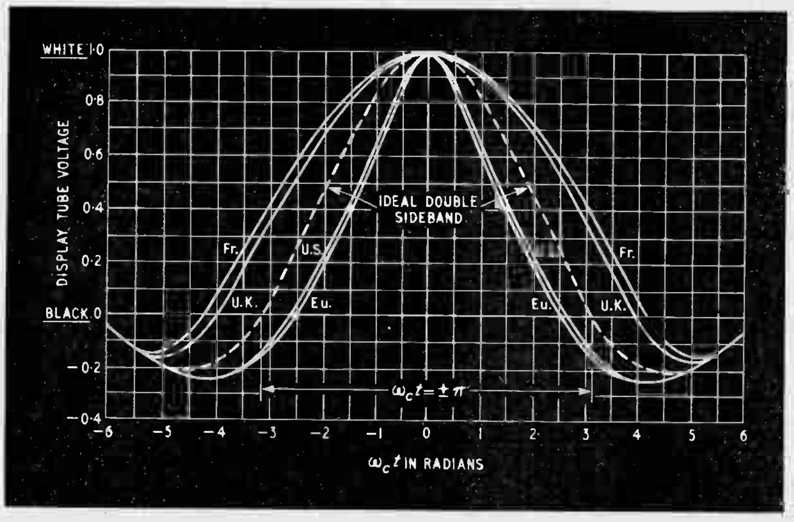


Fig. 3. *Normalized unit-impulse responses (demodulated outputs). The demodulated normalized display tube video voltage is given by* $E^*(t) =$

$$\sqrt{\left(a/r + \frac{\sin \omega_c t}{\omega_c 1}\right)^2 + \left(\frac{\sin t\Delta\omega}{\Delta\omega \cdot \omega_c t^2} - \frac{\cos \omega_c t}{\omega_c t}\right)^2} - a/r$$

(See Table 1 *and Fig.* 1)

World Radio History

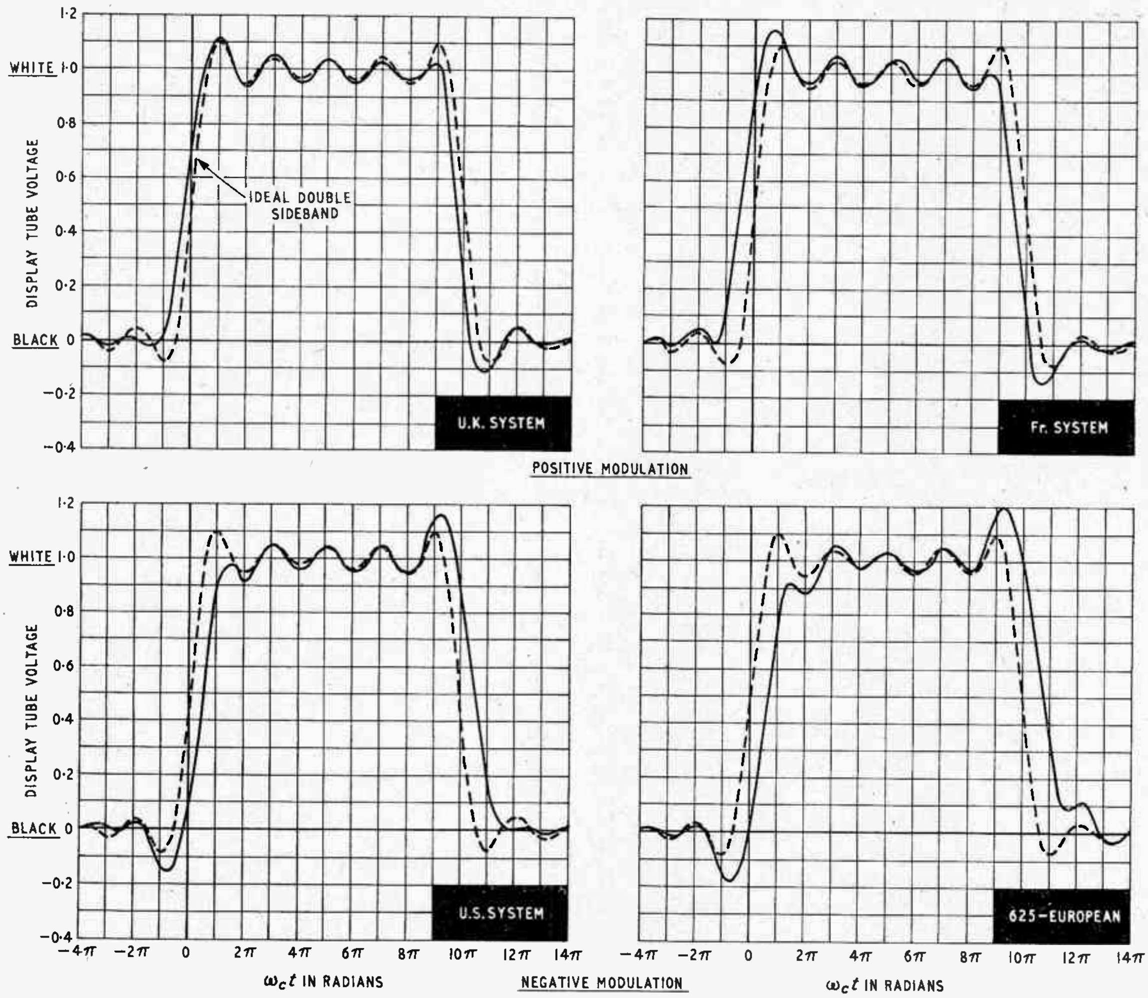


Fig. 4. *Normalized rectangular pulse responses (demodulated outputs). The demodulated normalized display tube video voltage is given by* $E(t) - E(t - 10\pi/\omega_c)$ *where* $E(t)$ *is given on Fig. 2*

TABLE 3

Unit-Impulse Transition

Column 1	2	3	4		5		6	7	8
System	Transition time normalized to ideal system and to video cut-off frequencies	Transition time normalized to U.K. system and to video cut-off frequencies	Overshoot %		Greatest overshoot % as excess over :		Excess resolution** provided as % of that of U.K. system	Picture element asymmetry relative to that of U.K. system	Resolution per Mc/s of channel allocation relative to that of U.K. system
			in blacks	in whites	ideal system	U.K. system			
Ideal double sideband	1	0·78	21	—	0	4	—	—	—
U.K.	1·29	1	17	—	−4	0	0	1*	1
French	1·35	1·05	15	—	−6	−2	228	1·17	1·17
U.S.	0·83	0·64	24	—	3	7	49	1·17	1·24
European (625-line)	0·79	0·61	24	—	3	7	119	1·13	1·55

* The actual value (normalized to 1 in the table) of the ratio of the length of a picture element to its height is 1·0 in this case.

** Resolution is based not on the number of picture elements per line but on the number per picture.

World Radio History

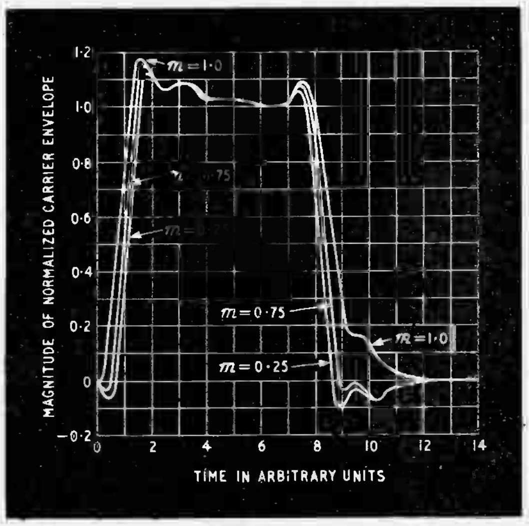


Fig. 5. *Response of a maximally-flat staggered-triple tuned-bandpass coupled circuit to a broad rectangular pulse of carrier at the frequency of* 1/2 *response*

distortion is contributed by the non-uniformity of group delay over the frequency band encompassing the non-uniform portion of the modulus of the receiver transfer function situated close to the vision carrier. It is shown in the Appendix that there exist circuits having satisfactory amplitude/frequency characteristics which do not give rise to serious phase distortion, and opinions differ as to whether or not practical receiver circuits come into the above category. Some light can be thrown on to this question by comparing Fig. 2 with Fig. 5 which is taken from Fig. 6 of the interesting article by Murakami and Sonnenfeldt in *R.C.A. Review* for December 1955 (Vol. XVI, No. 4). In this figure, m is the modulation depth ; that is, $1 - m$ is the magnitude of the vision carrier envelope during maximum inward excursions. The left-hand portion of the pulse corresponds with outward excursions of the carrier, while the right-hand portion is due to inward excursions. Now a black-to-white transition, Fig. 2, gives rise to an outward excursion for the U.K. and French systems, whereas the same transition in the U.S. and European systems produces an inward excursion ; thus we shall first compare the left-hand side of Fig. 5 with the 'Fr' and 'UK' transitions in Fig. 2. The appropriate values of m are $m(\text{Fr}) = 0{\cdot}75$ and $m(\text{UK}) = 0{\cdot}7$. Now Fig. 5 refers to a bandpass coupled circuit possessing that amount of phase non-linearity which might be expected to be typical of television receiver circuits, whereas Fig. 2 results from a characteristic which is free from this. From Fig. 5 we see that the greater m becomes, the longer the transition time, and this trend is also discernible in Fig. 2. Furthermore, that the greater overshoot takes place at the end of the transition rather than at the beginning is shown by both figures. Secondly, we compare the right-hand side of Fig. 5 with the 'US' and 'Eu' transitions in Fig. 2, only in this case we must remember that the bottom of Fig. 2 corresponds with the top of Fig. 5 and that $m(\text{US}) = 0{\cdot}8$ and $m(\text{Eu}) = 0{\cdot}87$. These higher modulation depths assist the comparison between the two figures. Note that the pre-shoot is now greater than the overshoot and, significantly, for high m $(0{\cdot}75 < m \rightarrow 1)$ the transition is not actually accomplished for a relatively considerable time: the well-known 'smear' effect occurs.

The above comparisons are not made easier by the presence of ideal filter 'cut-off rings' in Fig. 2 and practical filter 'cut-off rings' in Fig. 5 ; nevertheless it is thought that there exists some evidence here for exonerating a well-designed receiver from transient distortions caused by phase non-linearity over the non-uniform portion of the amplitude/frequency characteristic situated around the vision carrier frequency.

The only conclusion which can be made from the results obtained is that theoretical comparisons of television systems must be thoroughly supported by very complete field trials before any one system can be said to be superior to any other.

APPENDIX

It might be argued, in spite of the comparisons made above between Figs. 2 and 5, that the comparisons made between the four television systems dealt with in the foregoing text could be

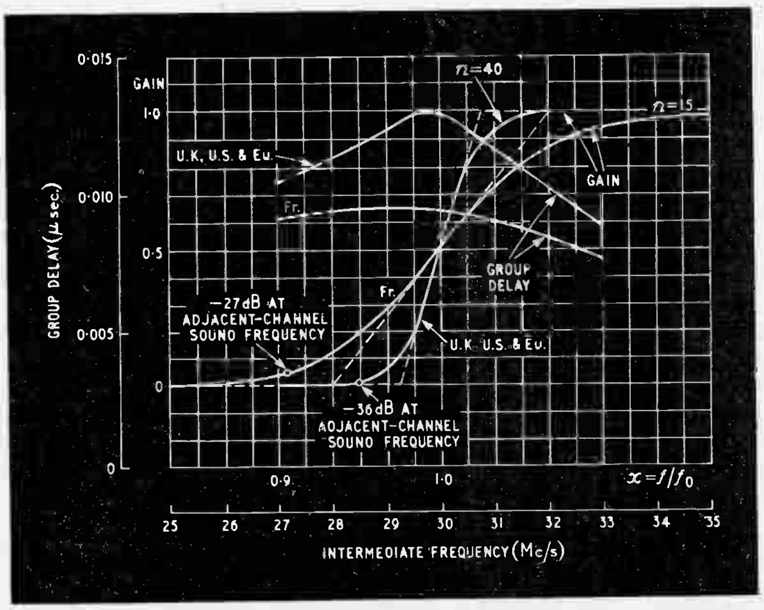


Fig. 6. *Amplitude and group delay responses of an idealized network. The gains are given by* $|G(x)| = x^{2n}/(1 + x^{2n})$ *where* $x = f/f_0$ *and* $n = 40$ (*U.K., U.S., Eu.*), $n = 15$ (*Fr.*). *The group delays are given by* $\tau(x) \approx$

$$\frac{2}{\pi\omega_0(1 - 1/n)x} \text{ arc tanh } \frac{2/x}{1 + (1 + \pi^2/4n^2)/x^2} \; ; \; 1 \ll n$$

World Radio History

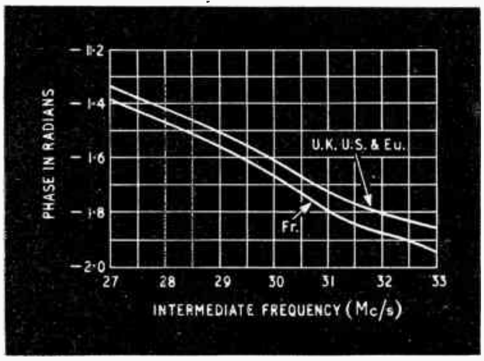


Fig. 7. *Phase shift in an idealized network. (The integrals with respect to ω of the group delay curves in Fig.* 6)

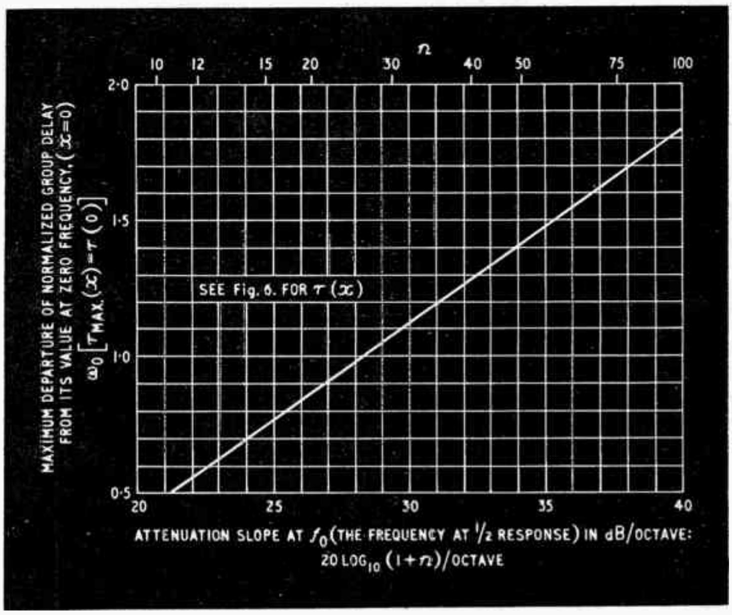


Fig. 8. *The effect of rate of change of attenuation at vision carrier frequency* $x = f/f_0 = 1$ *upon the departure from uniformity of group delay*

falsified by the presence of non-uniformity of group delay over the region of receiver amplitude/frequency characteristic including the linear portion close to the vision carrier—it being well known that a change of gain or modulus of a transfer function is accompanied by a change of group delay.

This question has been examined for one example of transfer function (the Butterworth type) which may perhaps be regarded as a very convenient theoretical 'building block' for the examination of the asymptotic characteristics of low-pass, high-pass and band-pass filters.

The problem was to find a modulus or amplitude–frequency response-function which would adequately simulate the ideal asymmetric-sideband reception characteristic shown in Fig. 1 and then to calculate what the group delay of such a network would be if it were of the minimum-phase type. If the resulting group delay had departed seriously from uniform shape it would then have been necessary to calculate again the unit-step and unit-impulse responses taking account of the phase shifts resulting from the variations of group delay. Such a calculation would have been laborious, but it was found that the group delay non-uniformities resulting from amplitude/frequency characteristics of satisfactory shape were quite negligible, provided that receiver demodulators were of the non-coherent or envelope variety. Synchronous demodulation is never used for obtaining the luminance component of black-and-white or colour television signals, so that we may now rest assured that the comparisons made between the four television systems in the main text are valid within the restrictions and assumptions given therein. Fig. 6 shows two receiver amplitude–frequency characteristics: one suitable for receiving a French transmission and the other suitable for receiving U.S., U.K. and European transmissions. The corresponding group delay curves are shown on the same figure. Phenomena relating to attenuation of sidebands corresponding to high video-frequency components are not considered here. The two phase–frequency curves which represent the integrals of the group delay functions are shown in Fig. 7*. In this the phase is given by:

$$\phi(x) \approx -\frac{2}{\pi(1-1/n)}\left\{\pi B(x) - \frac{2(K^2-1)}{\sqrt{K^4+6K^2+25}}\left[\frac{1}{\sqrt{\alpha}}\arctan\frac{x}{\sqrt{\alpha}} - \frac{1}{\sqrt{\beta}}\arctan\frac{x}{\sqrt{\beta}}\right]\right\}$$

where $K^2 = \dfrac{1}{1-\pi^2/4n^2}$

$$\alpha = \tfrac{1}{2}[K^2 + 5 - \sqrt{K^4 + 6K^2 + 25}]$$

$$\beta = \tfrac{1}{2}[K^2 + 5 + \sqrt{K^4 + 6K^2 + 25}]$$

$$x = f/f_0 \approx 1,\ B(x) = \frac{2}{\pi}\int_0^x \frac{1}{t}\ \mathrm{arc\ tanh}\ t\ dt$$

(See M. S. Corrington, "Table of the integral $\dfrac{2}{\pi}\displaystyle\int \frac{\tan^{-1}t}{t}\,dt$" *R.C.A. Rev.*, Vol. VII, No. 3, Sept. 1946.)

Figs. 6 and 7 refer to a high-pass Butterworth characteristic of modulus $x^{2n}/(1 + x^{2n})$ where $x = f/f_0$, in which the appropriate attenuation slope is obtained by using a suitable integer value of n. The relative smallness of group delay may be appreciated for many practical values of attenuation slope by examination of Fig. 8** which shows the change of normalized group delay, $\omega_0\,[\tau_{max}(x) - \tau(0)]$, as a function of attenuation slope in decibels per octave.

* The author is indebted to his colleague, Mr. J. W. Head, for his co-operation in effecting the integrations.

** The author is indebted to his colleague, Mr. S. J. Lent, for this figure.

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NEW I.E.E. PRESIDENT

T. E. Goldup, C.B.E., M.I.E.E., has been elected President of the Institution of Electrical Engineers for the coming year. Mr. Goldup, who is a director of Mullard Ltd., has been particularly concerned with technical education, and is Chairman of the Ministry of Supply School of Electronics at Malvern.

BRITISH COMPUTER SOCIETY PRESIDENT

The newly-formed British Computer Society announce that their first President will be Dr. M. V. Wilkes, F.R.S. Dr. Wilkes, who is well known as a writer on computers, is a Fellow of St. John's College, Cambridge.

Membership of the British Computer Society is open to anyone with an interest in electronic computers and computing techniques. Applications should be made to the Secretary at 29 Bury Street, St. James's, London, S.W.1.

World Radio History

Operational Calculus—3: Initial Conditions

Hitherto we have applied operational calculus only in cases where the circuit is initially 'dead'; that is to say, at zero time all capacitors have been uncharged and inductors have been carrying no current.

In practice, it often happens that we wish to calculate the performance when capacitors initially have a known charge and inductors initially carry a known current. Such initial conditions can be allowed for by the addition of suitable equivalent circuit elements, and then proceeding as if the circuit were initially 'dead'. We shall show how to determine these additional equivalent circuit elements in a few simple specific cases; and that the same results would be obtained by a purely mathematical approach in the cases discussed.

A capacitor charged to a voltage v_0 is electrically equivalent to an uncharged capacitor of the same capacitance in series with a battery of voltage v_0. In drawing a circuit diagram, therefore, one can indicate an initial charge by including such a battery in series with a capacitor. The circuit equations can then be written down in the manner discussed in earlier articles, for we have replaced the given circuit by a new circuit equivalent to it but having uncharged capacitors.

Fig. 1 (a) shows a simple *RC* circuit. If *C* has no initial charge, we obtain, according to the rules discussed in earlier articles

$$i = E/\{R + 1/pC\} \quad \ldots \quad (1)$$
$$v = i/pC \quad \ldots \quad (2)$$

which lead to the time-expressions

$$i(t) = (E/R)\, e^{-t/CR} \quad \ldots \quad (3)$$
$$v(t) = E\,(1 - e^{-t/CR}) \quad \ldots \quad (4)$$

Suppose now we know that before closing the switch, the capacitor has been charged by some unspecified means to a voltage v_0, the upper plate in Fig. 1 (a) having a higher potential than the lower if v_0 is positive. We redraw the circuit in the form of Fig. 1 (b) with a battery of voltage v_0 in series with *C*, which we now regard as initially uncharged.

From the electrical point of view it is immediately clear that v_0 (if positive) is the voltage of a battery in opposition to *E* when the switch is closed, and that (1) must be replaced by

$$i = (E - v_0)/\{R + 1/pC\} \quad \ldots \quad (5)$$

In computing v we have to take v_0 into account, but we must not forget that the junction of *C* and the battery of voltage v_0 is fictitious: it is not an accessible terminal. We can easily see that (2) must be replaced by

$$v - v_0 = i/pC \quad \ldots \quad (6)$$

so that

$$i(t) = [(E - v_0)\, e^{-t/CR}]/R \quad \ldots \quad (7)$$
$$v(t) = v_0 + (E - v_0)\,(1 - e^{-t/CR}) \quad \ldots \quad (8)$$

Dealing with initial charges on capacitors thus involves no new mathematical method, since the circuit can be reduced to an equivalent one with uncharged capacitors. For the remainder of this article, we shall not be greatly concerned with time-equations like (3), (4), (7) and (8), but rather with the correct adjustment of the *p*-world counterpart equations like (1), (2), (5) and (6) to allow for the initial conditions.

Equations (6) and (7) can be derived by a purely mathematical argument as follows. If v is the *p*-world counterpart of the voltage $v(t)$ across *C* at time t, then the current $i(t)$ through *C* is $Cdv(t)/dt$, so its *p*-world counterpart is $C(pv - pv_0)$, by the rule for finding the *p*-world counterpart of a derivative given in the earlier article. This is equivalent to equation (6) above.

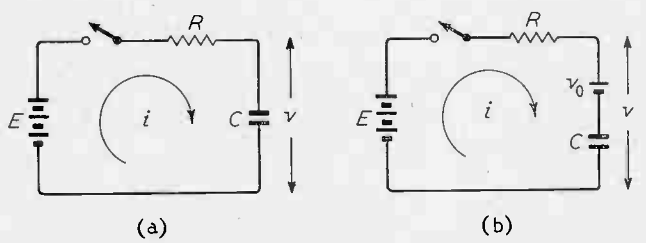
Hence, by applying Kirchkoff's law to the circuit of Fig. 1 (a),

$$E = R\,\{pC(v - v_0)\} + v \quad \ldots \quad (9)$$

Substituting for v in terms of i from (6), (9) becomes an equation for i which easily reduces to (5).

An initial current in an inductor can be similarly treated. The fact that the impedance of an inductance L is pL suggests that a voltage pLi_0 is required across that inductance to produce the initial current i_0. We therefore start by assuming that there is an additional voltage pLi_0 in series with the inductance, and then proceed to solve the circuit as if the inductance were inert. This rule appears to be somewhat puzzling, for we have already seen that the time-function whose *p*-world counterpart is a multiple of a positive power of p is not an ordinary kind of time-function, but one which behaves violently at time zero. But such violent behaviour would indeed be required in order to produce instantaneously a current i_0 in a pure inductance initially inert. In our

Fig. 1. *An initial charge on the capacitor C in (a) can be represented by a battery v_0 in series with an uncharged capacitor as in (b)*



World Radio History

problem the current i_0 is already there before the switch was closed, and we shall see that, in fact, if we follow our somewhat puzzling rule no positive powers of p will remain in association with quantities we can reasonably seek to determine. We shall also see that the answer obtained by the rule can be obtained in a mathematically straightforward manner, as in the RC circuit of Fig. 1 (a) already considered. Hence, the important point is to have confidence that this rule will, in fact, lead to the correct solution, and that any strange terms which would be difficult to interpret will cancel in much the same way as in handling a real algebraic expression by means of complex algebra, we know that any imaginary terms which occur in the working must cancel unless we have made an error of manipulation.

We now apply this to the simple LR circuit of Fig. 2 (a) when the inductor carries a current i_0 in the direction shown at the instant of closing the switch. Fig. 2 (b) shows the equivalent circuit. The equations are

$$i = \frac{E + pLi_0}{R + pL} \quad \ldots \quad (10)$$

$$v = pL\,(i - i_0) \quad \ldots \quad (11)$$

From (10) we deduce

$$i(t) = (E/R)\,(1 - e^{-tR/L}) + i_0 e^{-tR/L} \quad \ldots \quad (12)$$

and substituting for i from (10) into (11) we find

$$v = \frac{pL\,(E - i_0 R)}{R + pL} \quad \ldots \quad (13)$$

so that

$$v(t) = (E - i_0 R)\, e^{-tR/L} \quad \ldots \quad (14)$$

Now when $t = 0$, (12) gives $i(0) = i_0$. In (13) the numerator and denominator are both of the same degree in p. Thus, in spite of the term $-pLi_0$ in (11), (14) gives $v(t)$ in a form which can be found directly from the list of corresponding pairs of expressions given in an earlier article.

It remains to determine i and v by purely mathematical methods, without using the equivalent circuit of Fig. 2(b), to justify the rule we have given.

Suppose then that the p-world counterpart of the current in Fig. 2 (a) is i in the direction indicated. Then the voltage v across L is $L\,di/dt$, and the p-world counterpart of this, by the rule given in the table of an earlier article, is given by

$$v = L\{pi - p[i(t)]_{t=0}\} = pL\{i - i_0\} \quad \ldots \quad (15)$$

since in Fig. 2 (a) the direction of i_0 is the same as the direction of the current due to E. It follows by Kirchhoff's law that

$$E = Ri + pL\{i - i_0\} \quad \ldots \quad (16)$$

(15) is equivalent to (11) and (16) to (10), so that our initially puzzling rule is justified in this case.

With these two simple rules for allowing for initial charges on capacitors or initial currents in inductors, we can deal with any initial conditions in an ordinary electrical circuit, for these initial conditions can only be currents in coils and charges in capacitors.

As a more complicated example, consider a parallel resonant circuit, shown in Fig. 3 (a), of a type which might be used for line scanning. We consider conditions during flyback when the valve is cut off and inoperative. For initial conditions we are given that the valve produces a linearly rising current in L which has reached a peak value of i_0 when the valve is cut off,

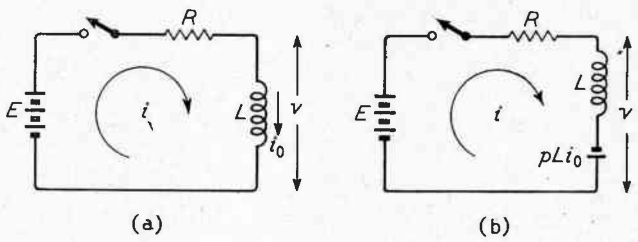


Fig. 2. *An initial current i_0 in an inductor L in (a) is equivalent to a battery pLi_0 in series with the inductor as at (b)*

and that the linear rise of current has been going on for a time τ. Since the inductor back e.m.f. is $L\,di/dt$, it is clear that a linear change of current i_0 in a time τ results in a voltage Li_0/τ across L, and it follows that the capacitor C must be charged to this voltage. Thus, our initial conditions for flyback may be represented as in Fig. 3 (b) by a current i_0 downwards in L and a voltage $v_0 = Li_0/\tau$ across C. According to the rules already given, we have therefore to solve the equivalent circuit of Fig. 3 (c) as if C and L were initially dead.

If i_C, i_R and i_L are the p-world counterparts of the currents in C, R and L respectively in the downward direction indicated in Fig. 3 (c), then by applying Kirchhoff's Laws we have

$$v = v_0 + \frac{i_C}{pC} = Ri_R = pL\,(i_L - i_0) \quad \ldots \quad (17)$$

and

$$i_C + i_L + i_R = 0 \quad \ldots \quad (18)$$

Substituting for i_R and i_C in terms of i_L from (17) into (18), we obtain

$$i_L = \frac{(p^2 + p/CR)\, i_0 + pv_0/L}{p^2 + p/CR + 1/LC} \quad \ldots \quad (19)$$

and hence

$$v = pL\,(i_L - i_0) = \frac{p^2 v_0 - pi_0/C}{p^2 + p/CR + 1/LC} \quad \ldots \quad (20)$$

It follows from (20) that

$$v(t) = \left[v_0 \cos \omega_1 t - \left(\frac{i_0}{\omega_1 C} + v_0 \frac{\alpha}{\omega_1}\right) \sin \omega_1 t\right] e^{-\alpha t} \quad (21)$$

where

$$\alpha = 1/2CR;\ \omega_1{}^2 = 1/LC - 1/4C^2R^2 \quad \ldots \quad (22)$$

Again, (19) and (20) can be derived mathematically from Fig. 3 (b) without introducing the 'fictitious' elements in Fig. 3 (c) if desired. Let q be the p-world counterpart of the charge $q(t)$ on C at time t. Then the current in C is $dq(t)/dt$, and therefore its p-world equivalent is $pq - pCv_0$ since the initial charge on C is Cv_0. If we now let the p-world counterparts of the currents in R and L be i_R and i_L as before, we then have

$$(pq - pCv_0) + i_R + i_L = 0 \quad \ldots \quad (23)$$

Also, the voltage across L is $L\frac{d}{dt}i_L(t)$; the p-world equivalent of this is $L[pi_L - pi_0]$. It follows that

$$v = \frac{q}{C} = Ri_R = pL\,(i_L - i_0) \quad \ldots \quad (24)$$

(23) and (24) are the same as (17) and (18) except insofar as i_C is replaced by $pq - pCv_0$, so that in this case also we can derive the equations without using the 'fictitious' elements provided that we choose with care

World Radio History

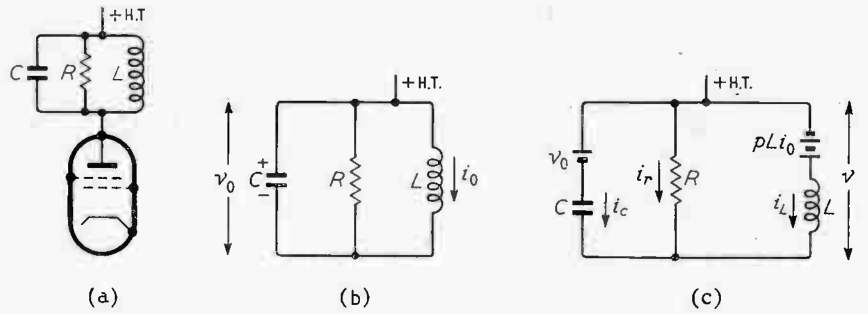


Fig. 3. *In (a) the valve drives current through L. When it is cut off the circuit is left with a current i_0 in L and C is charged to v_0 as in (b). These initial conditions can be represented by the batteries v_0 and pLi_0 in (c)*

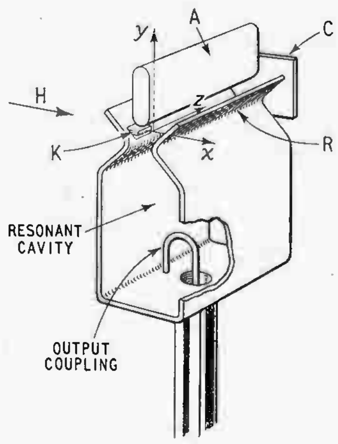
our unknown quantity as the p-world counterpart of the charge on the capacitance C instead of the current in it. It seems clear, however, that in practice it is easiest to use the rule given, that a capacitor charged to a voltage v_0 should be replaced by an equal uncharged capacitor in series with a battery of voltage v_0, while an inductance L carrying an initial current i_0 should be replaced by an inert inductance L in series with a voltage pLi_0 opposing the current. Normally, any terms apparently leading to impulsive time-functions will cancel. It should be noted that the allowance to be made for initial charges on capacitors and coils in inductors is completely independent of the nature of the applied voltage, so that the term due to the voltage v_0 in Fig. 1 (a), for example, would be unaltered if the applied voltage E had been a sine-wave.

The 'Strophotron' A NEW MICROWAVE OSCILLATOR

A MULTI-REFLECTION electron tube, the strophotron, is for medium-power microwave application where some degree of electronic tuning is required. A recent description* quotes as typical performance figures an output of 10 W, an efficiency of 20–30%, and an electronic tuning range of 3–4%.

Although quite different in form, the strophotron operates in a manner somewhat similar to the Barkhausen-Kurz tube, electrons making a number of to-and-fro oscillations near an electrode which extracts energy from them.

A possible structure for the strophotron is shown in Fig. 1. The component parts are a cathode K, a reflector R, which forms a resonant cavity, an anode A, and a collector C. The shape of A is such that, when a suitable p.d. is applied across A and R, a field of the required parabolic configuration is created between the two. This field has components in the directions marked x and y. A magnetic field is also applied in the x-direction. When the device is oscillating, a radio-frequency field exists between A and R. During one half-cycle, the electrons from the cathode are accelerated towards R and collected by it. On the next half-cycle, however, electrons are retarded and, therefore, give up energy to the resonating system. The condition for the energy gained by the system to exceed the energy lost in accelerating the 'wasted' electrons is met if the useful electrons spend a long time in the space between A and R. This is possible if they make a number of to-and-fro oscillations. The effect of the magnetic field is to produce, in conjunction with the y-component of the electric field, a motion of the electrons in the z-direction. Useful electrons, therefore, move in a zig-zag path from the cathode to the collector. In practice, they move along spiral tracks rather than straight lines.

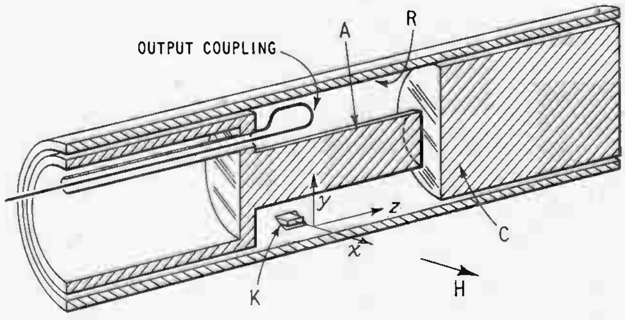


Above: Fig. 1. *Diagram of a strophotron structure*

If the field between A and R is not parabolic, then the time taken for an electron to execute a to-and-fro oscillation depends on the velocity of the electron. Under these conditions, the motion of an initially 'useless' electron can drift out-of-phase with the radio-frequency field, so that it gives up energy; i.e., becomes a 'useful' electron. There can be a net increase of r.f. energy under some conditions.

The principal advantage of the device would appear to be simplicity of construction. Experimental tubes had a coaxial form as in Fig. 2. Field-strengths up to 3,000 gauss were used.

* B. Agdur: 'On the Interaction Between Microwave Fields and Electrons, with Special Reference to the Strophotron' *Ericsson Technics*, Vol. 13, No. 1



Right: Fig. 2. *Diagram of a coaxial strophotron structure*

World Radio History

Measuring Earth Conductivity

AN EXPERIMENTAL COMPARISON OF RADIO AND ELECTRODE METHODS

By M. Strohfeldt, M.Sc.*

The prediction of broadcasting coverage involves many factors, one of the more important of which is the average ground conductivity of the service area. When the conductivity is not known it is generally desirable to measure it using the well established method of measuring the field-strength variation of existing or improvised signals in the required area. This data is analysed graphically to derive a figure for the effective average conductivity, which is, in reality, a measure of overall attenuation rather than a specific indication of soil properties.

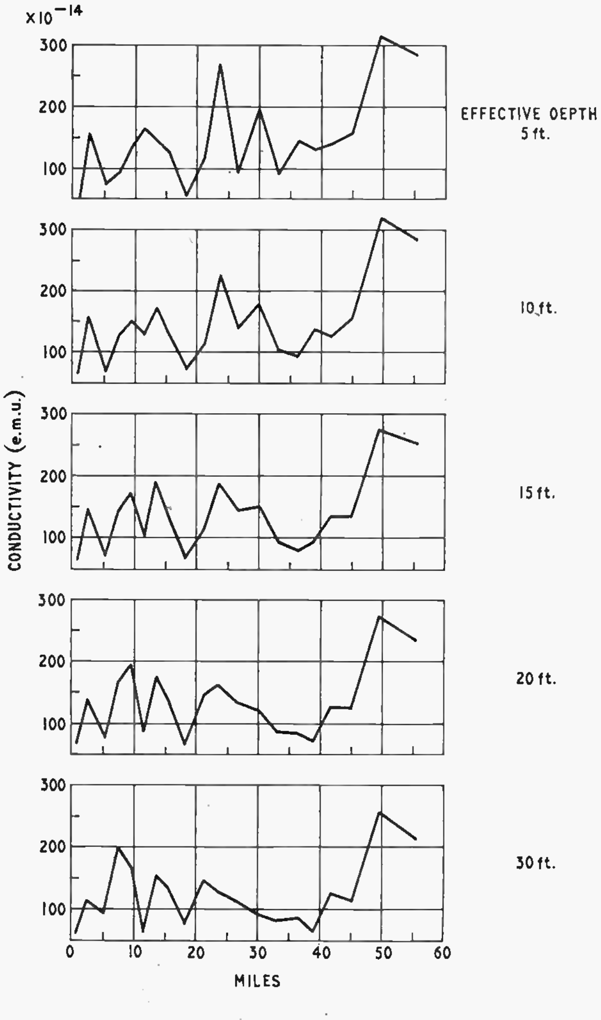


Fig. 1. *Observed conductivities (electrode)*

On the other hand, soil maps[1] may be available which supply data on a large number of soil types and classify them into several conductivity ranges. Such maps have considerable utility in radio engineering, not only for broadcasting but also in connection with such problems as ground reflections of radio waves, earthing of telegraph and telephone equipment, etc. Admittedly, the soil map gives no direct information on frequency effects, soil-composition variations with depth, and seasonal changes in moisture content, but it must be conceded that the effective conductivity or radial type of map is also far from satisfactory in this respect.

The author recently carried out restricted experimental work designed to discover a possible link between the two types of information. In effect, the test amounted to an examination of the possible correlation of ground conductivity as measured by the radio method, with that measured directly from electrodes driven into the ground. It was considered possible that if a correlation were found, the electrode method could be applied in an expeditious accumulation of suitable data for a ground conductivity map, its chief virtues being the simplicity of the calculations and its adaptability for unskilled labour.

In order to obtain maximum chance of correlation a number of co-operative factors were sought. First, the site for the work was a flat plain where it was hoped to avoid unknown attenuations as would occur in rugged terrains, populated areas and dense vegetation. Secondly, as the only apparent radio loss was to be in the ground, it was desirable that the 'radio skin' for the broadcasting signal to be measured be of such a depth that a similar effective depth could be sampled by electrode measurements. Lastly, both sets of measurements were made conjointly, thereby involving the same physical conditions and providing a common basis for comparison.

Test Procedure

Location. The Shepparton-Kyabram plain in Central Victoria was chosen as the site for the work. The plain is very flat with an overall variation of about 30 feet in 55 miles. The plain is an agriculturally rich area of red-brown soil with a generally high moisture

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World Radio History

content from rainfall and irrigation. A broad estimate of the conductivity based on visual evidence was 10^{-13} to 10^{-12} e.m.u. The radial accurately traced a true bearing of 270° from the transmitting aerial of 3SR (Shepparton) on the eastern edge of the plain, the frequency of the signal being 1 260 kc/s. Except for the outskirts of the small town of Kyabram, the radial is substantially clear of any major obstruction which could cause losses or disturbances in the radio field of sufficient magnitude to vitiate the idealized picture of ground absorption. Vegetation on the plain consists mainly of grass and scattered clumps of trees.

Electrode Measurements. The Wenner configuration[2] of four collinear equally-spaced electrodes was adopted for the direct conductivity tests. Each electrode was driven to a depth equal to 0·05 of the electrode spacing, the latter being varied between 5 and 30 feet. The inner electrodes were used for potential measurements, and the outer pair or current electrodes were connected to a 50-c/s current source via a suitable milliammeter. By simple application of Ohm's Law one obtained a value of 'ground resistance' R and the conductivity was calculated from the equation:

$$\text{Conductivity (e.m.u.)} = \frac{522 \times 10^{-14}}{aR}$$

where a = electrode spacing (feet).

The empirical rule of the Wenner method states that

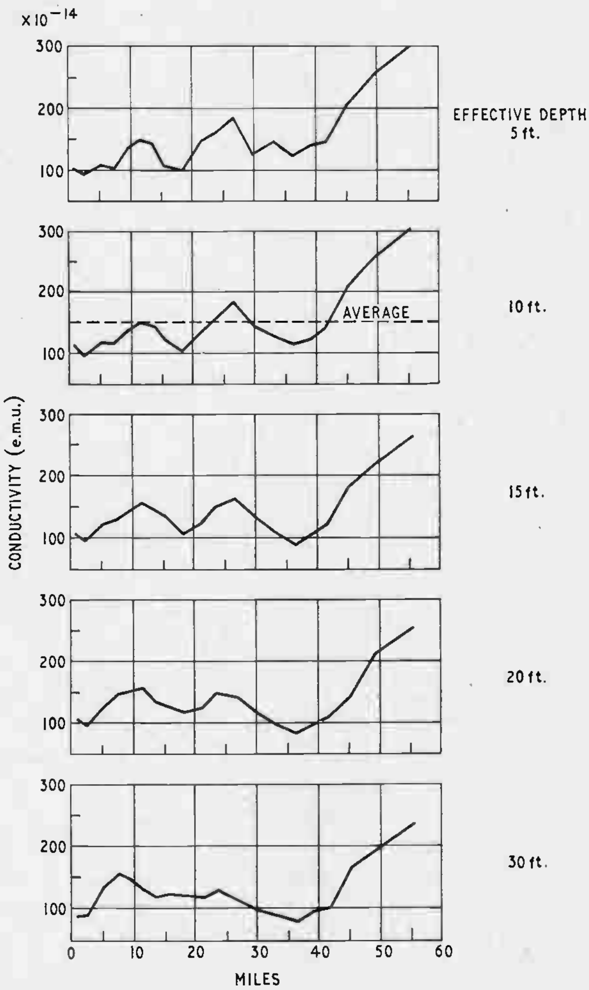

Fig. 2. *Smoothed conductivities (electrode)*

the calculated conductivity is an effective value for a depth and lateral extent equal to the electrode spacing. Thus, when stating conductivity figures for a particular area or point, the electrode spacing should always be quoted.

Radio Measurements. A commercial field-intensity receiver was used to obtain the results of Table 1 below. Care was taken to avoid erroneous readings which may have been influenced by nearby power lines, wire fences, trees, and vehicles. A subsequent calibration of the receiver showed an instrumental accuracy of ±4%.

Table 1

Site	*Distance* (Miles)	*Field-Strength* (m/Vm)
1	0·9	152
2	2·6	46·3
3	5·2	16·9
4	7·5	12·1
5	9·5	11·5
6	11·6	9·56
7	13·6	7·80
8	15·5	7·20
9	18·2	5·70
10	21·3	5·15
11	23·8	4·53
12	26·8	3·91
13	30·0	3·52
14	33·1	2·90
15	36·4	2·32
16	39·0	2·20
17	41·9	1·78
18	45·1	1·58
19	49·7	1·39
20	55·6	1·29

Presentation of Data

Electrode. The electrode results are plotted in Fig. 1 showing the measured conductivities for various electrode spacings at 20 points along the radial. These graphs were partly smoothed, as shown in Fig. 2, by plotting running means for successive groups of three sites, each mean being referred to the middle site in each group. This procedure appears to be justified by the close and fairly regular spacing of the sites.

Radio. In the Sommerfeld region for m.f. vertically-polarized waves the field is predominantly a surface wave, in contrast with h.f. fields where the space wave is more significant. The field-strength obeys a modified law of inverse-distance attenuation, the modification being a complex function of the earth constants, frequency, and distance. Most calculations overcome this complexity by employing graphical methods, several of which are available[3]. In this case, the Eckersley method was applied.

The basic assumption of the Eckersley method is that the rate of attenuation of the ground-wave over any homogeneous part of a composite path is that which would occur if the whole path were of that conductivity but for a transmitter of different power. In applying this principle the F.C.C. Ground Wave Propagation curves[4] were first used to construct a table of theoretical field-strengths (for various average conductivities) at

World Radio History

each of the 20 measuring sites. The attenuation corresponding to each value of conductivity was calculated for successive site intervals, and an attenuation versus conductivity characteristic was drawn for each interval.

By calculating the actual attentuation for each interval and referring to the corresponding attenuation–conductivity characteristic an effective conductivity figure was obtained for each interval. The values of effective conductivity so obtained are referred to the midpoint of each interval and are plotted in Fig. 3.

Because of extraneous factors such as distortion to wavefronts, re-radiation from power lines, fences, trees, etc., instrumental errors, and so on, the method is undoubtedly a crude one. Further, theoretical curves for conductivities greater than 40×10^{-14} are not available (except for sea water) and, as the conductivity in the Shepparton area is high and often apparently greater than 40×10^{-14}, there are frequent occasions when the attenuation cannot be deduced accurately from these curves. In such anomalous situations the conductivity has been taken as 40×10^{-14} e.m.u. A single anomalous case arose where the attenuation was impossibly high—but this is preceded by another where it was impossibly low. (On Fig. 3, these two points are marked X and Y.) Obviously, the intermediate field-strength reading was too high. In fact, the site was not a good one, being on the leeward side of a railway embankment (100 yards away); and the effect of the bank and rails apparently caused the anomaly. Removal of this discrepancy would partly (or entirely) eliminate the peak X, and reduce the depth of the minimum at Y.

Comparison of the Data

The excessive electrode conductivity figures make it clear that an absolute correlation with radio data is impossible. The Wenner equation is derived on the assumption of homogeneous ground and neglects also the highly variable resistances in the electrode-to-earth contacts. It is therefore probable that no simple adjustment to the electrode figures could be made which would be valid for all variations of the experimental conditions.

Although the ground conductivity deduced from radio measurements is an effective figure making due allowances for the integrated effects of longitudinal variations of ground constants, variations with depth of ground composition, rugosity, and obstructions, the experimental conditions support the assumption that the radio field losses in this case are due predominantly to absorption in the ground. The radio skin under the prevailing conditions is about 10 feet deep, and as the longitudinal variations in electrode conductivity for various effective depths appear to be similar for depths down to 20 feet, there would appear to be reasonably similar ground conditions pertaining to both types of measurement.

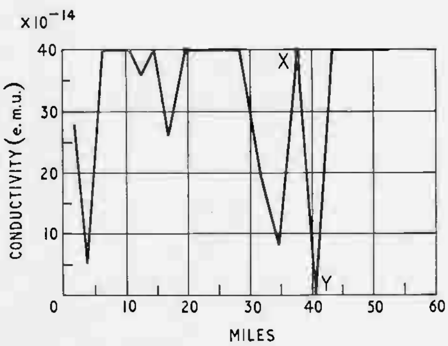

Fig. 3. *Radio picture of conductivity*

On comparing Figs. 2 and 3 it is clear that an excellent qualitative correlation of the longitudinal variations of conductivity exists. The average electrode conductivity for an effective depth of 10 feet is 150×10^{-14}, and there are three 'below-average' intervals. The situations of these are compared with the radio picture in Table 2.

Table 2

Radio (Conductivity less than 40×10^{-14} e.m.u.)	*Electrode* (Below Average)
0 to 7 miles	0 to 12 miles
11 to 20 miles	12 to 23 miles
28 to 43 miles	29 to 43 miles

An interesting point about the first and third low-conductivity areas is that they correspond closely to relatively dry areas, whereas much of the remainder of the radial traverses irrigated areas. The Goulburn River flows through the first section (normal to the radial) and it might be expected that the conductivity of the areas on either side of the river would vary markedly with the season, especially as the river is prone to flooding.

Conclusions

The Shepparton test involved ideal natural conditions which are seldom obtained in practical propagation problems. Although some correlation was found between the electrode and radio measurements, there was no quantitative agreement. This failure is probably due, firstly, to the inherent inaccuracy of the electrode method, and secondly, to the incompatible natures of the two methods. Apart from the inaccuracy of the Wenner method when applied to non-homogeneous ground, it is not possible to allow for variations in the ground-to-electrode contacts. Furthermore, the electrode measurements should be considered as supplying a conductivity estimate for an area no larger than the immediate vicinity of the experimental site. On the other hand, a radio method only achieves reasonable accuracy when it is observed on a wide scale involving integrated losses in space and in the ground as determined by lumped and distributed physical properties which, by the very nature of the method, may not be taken into account with any great accuracy.

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[2] F. Wenner, "A Method of Measuring Earth Resistivity", Bulletin of Bureau of Standards XII, 1915–16, pp. 469–478.
[3] H. L. Kirke, "Calculation of Ground Wave Field Strength Over Composite Land and Sea Path", *Proc. Inst. Radio Engrs*, May 1949, Vol. 37, No. 5, pp. 489–496.
[4] F.C.C. "Standards of Good Engineering Practice Concerning Standard Broadcast Stations", 1944, Appendix I, Graph 16.

World Radio History

International Components Symposium

Twenty-seven papers were given at the Components Symposium held at the Royal Radar Establishment, Malvern, in September, under the chairmanship of Brigadier J. D. Haigh. The subjects included practically every common type of component except the radio valve, and there were a number of papers on general matters. An exhibition of components and relevant work at the Establishment was given at the same time.

The subject of components is hardly calculated to excite the electronic engineer. Nevertheless, as G. W. A. Dummer pointed out in an introductory lecture, the size of the U.K. components industry is impressive. About 6 million components are manufactured daily and the annual turnover of the industry is £75 million. A rapidly increasing proportion of the total output consists of high-grade components for military and industrial purposes.

It would be very pleasant if engineers could specify components with the assurance that they would operate satisfactorily for the whole life of an equipment from manufacture to obsolescence. To a large extent, this state of affairs obtains in the field of domestic equipment. The more exacting conditions encountered elsewhere, however, require that components should be carefully designed for reliable operation. This is much more easily said than done. A circuit designer has at his command some powerful techniques, such as the use of negative feedback, for ensuring that an equipment continues to operate despite wide variations in particular elements. It is easy to be impatient with the component designer for failing to achieve comparable immunity from trouble, but a little reflection shows how unfair this is. No such tricks are available. The causes and remedies of failures must be sought painstakingly, often with recourse to fundamental physics and chemistry quite outside the range of an ordinary factory laboratory.

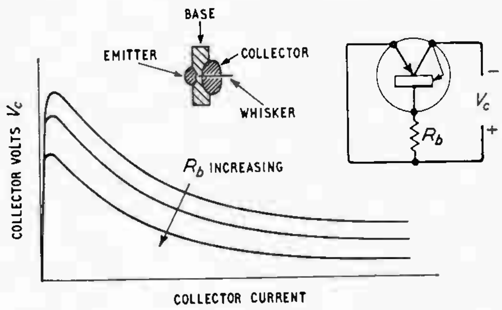
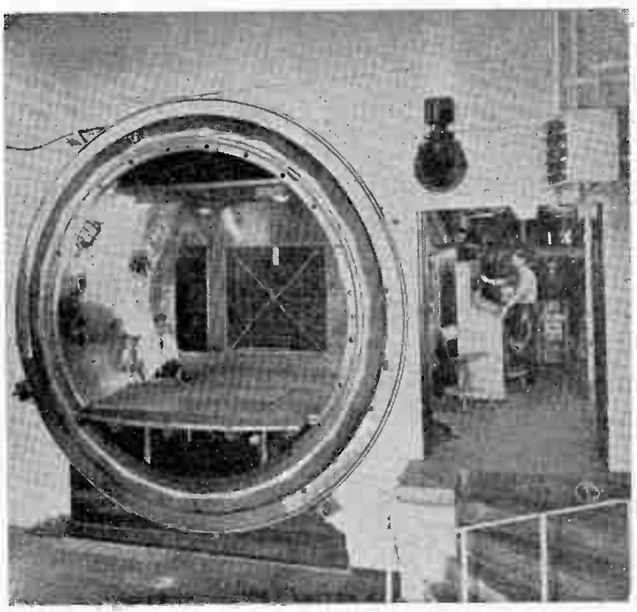


Fig. 1. *Characteristic of junction-transistor trigger device in the circuit shown*

Large test chamber in which equipment can be subjected to any known climatic condition encountered in an aircraft



For example, normal ceramic components have been found to be electrically unstable. One result of this is premature failure of some types of resistor in which the ceramic is used as an insulating base. The cause was eventually traced to the presence of sodium and potassium ions in the material, the result of the use of felspar as a flux during manufacture. One could hardly blame a resistor manufacturer for not knowing this.

On the other hand, a circuit designer cannot really be expected to take an interest in such matters, which are equally outside his field. All he wants is to be given a reliable component and told the operating limits within which it will continue to be reliable. We say this because we were rather conscious that papers were really addressed to two distinct audiences—the component maker and the component user—with different areas of interest. We would not suggest that if the Malvern experiment is repeated there should be two symposiums—there are more than enough already—but some advantage might be gained by holding parallel simultaneous sessions, one for each type of audience. Papers, and especially discussions, which were often cut short, could then be more complete. Some of the more interesting points from papers in both categories are given below.

In the paper by Dummer, already referred to, a comparison was made of the reliability of different kinds of component in military equipment. Reliability is, to a large extent, a matter of definition. If actual failures of components in equipment are used then, in order of increasing reliability, we have valves, resistors, capacitors, transformers. If actual percentage failures are taken as a basis of comparison, we have valves, meters, relays, and cables and connectors as

World Radio History

the four worst offenders, resistors and capacitors actually giving the best performance. Fault rates are ten to twenty times as great as those of components in domestic radio and television sets. An experimental airborne radar equipment is being made at R.R.E., using the best-known components and constructional techniques, to discover the maximum obtainable operational reliability.

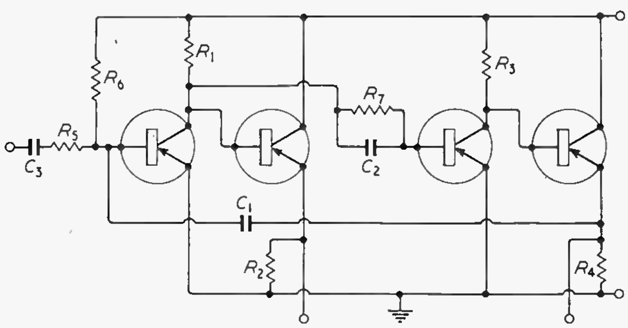
A considerable amount of testing under severe environmental conditions is carried out at R.R.E., a notable piece of equipment for doing this being a 'stratosphere test chamber' of imposing dimensions. The development of new components by industry is sponsored. An interesting concept is the 'solid circuit'; in the example referred to by the speaker a tiny block of silicon was treated so as to create four junction transistors and associated resistors and capacitors to form a flip-flop.

Saving Space

This technique represents the ultimate in what another speaker, A. W. Rogers, of the U.S. Signal Corps Engineering Laboratories, called 'volumetric efficiency'. The number of components which are in practice packed into a given space in an equipment is deplorably small compared to the number which could be got into the same space with perfect packing and Mr. Rogers described what is being done to remedy this state of affairs. By using machine-assembled modules, an efficiency of 27% is obtained, but the overall equipment efficiency is still only 15%. The aim is to achieve 50% ultimately.

At the same time, very small components are being developed, especially for transistor circuits where the working voltage is low. The reliability of such 'micro-miniature' components is as good as that of full-sized components. In addition, space economy is being achieved by adopting new techniques such as the use of piezo-electric resonators in the form of small discs of titanate dielectric as i.f. filters in place of the usual *LC* circuits. The saving of space is about six times, and the components are less affected by stray capacitance than i.f. transformers. Ferrite wideband high-frequency transformers (1 kW at 4–30 Mc/s) yield a similar space saving over conventional balun units, have improved standing-wave ratios, and can be made at about a twenty-fourth of the cost.

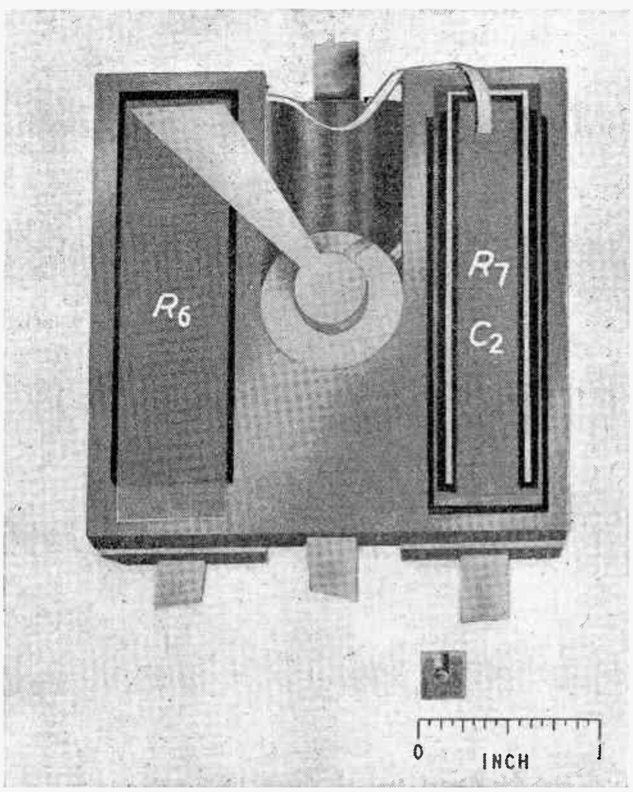
Enlarged model of 'solid circuit', shown with the component itself for comparison, and a diagram of the equivalent circuit. The base material is silicon



The target failure-rate for components has been set at 0·1% per 1,000 hours of operation. In the case of carbon composition resistors 0·3% has been achieved. At the target rate, typical communication receivers (1,200 components) would average 8,000 hours' operation before failure.

New Switching Transistor

A new transistor for trigger circuits was described by Dr. W. von Münch. This consists of a junction transistor with a tungsten whisker projecting through the collector region into the base. The high fields set up in the base region by the whisker give the device the characteristics of Fig. 1. These are somewhat similar to those of a point-contact transistor, but some important advantages of the junction transistor, such as a low 'bottoming' voltage and a small incremental resistance (10 Ω) in the bottomed condition are retained. In circuit applications, a switching-on pulse is applied to the base. This causes the transistor to bottom and it stays in this condition indefinitely. An important advantage claimed is that, owing to the fact that the whisker sets up a field in the base region, transit-time is small, and the device gives faster switching than point-contact transistors, double-base diodes, or combinations of junction transistors in simple circuits. This fast switching (0·2 μsec rise and fall times) is obtained even if the basic junction transistor has a base thickness of 50–100 μ. (No doubt this tolerance of thick base layers is helpful during manufacture, since the whisker must be arranged to penetrate the base without going right through to the emitter.) Another advantage is that the 'on' current is not very sensitive to temperature. Dr. von Münch described how the new transistor can be employed in flip-flops, shift registers, speech-path



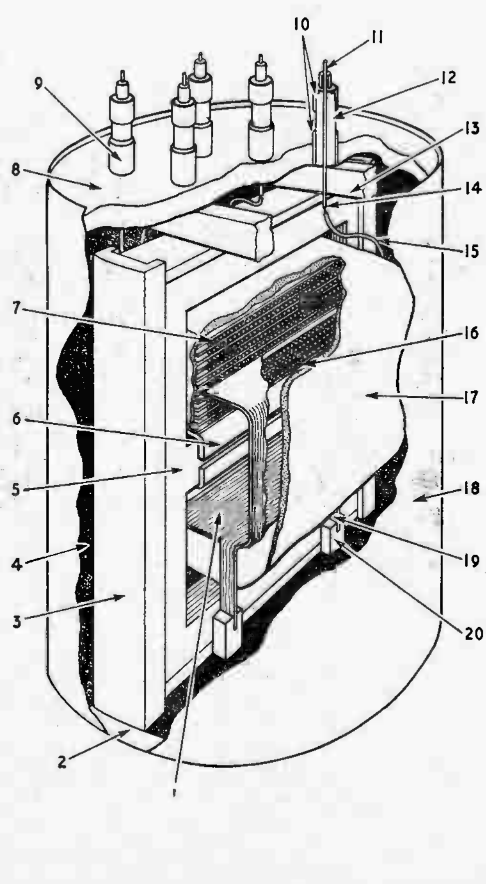
World Radio History

switches, etc. A particularly interesting circuit was that of a two-way speech amplifier for use as a telephony repeater. Symmetrical junction transistors were employed, and these were switched by square waves derived from oscillators using the new transistors so that amplification was obtained first in one direction and then in the other, the switching frequency being above the audio band.

In a paper in which the dielectric properties of a number of insulating materials were compared, G. C. Garton mentioned the possibilities of new compounds formed from pairs of the elements boron, aluminium, carbon, silicon, nitrogen and phosphorus. These should have intrinsically good insulating properties, unlike the glasses, which are merely electrolytes operated at low temperatures and which, consequently, have a poor high-temperature performance. Boron nitride is the only compound in the group to have been tried so far. It is ceramic-like, but can be machined.

An interesting point about plastic dielectric materials is the recent proof that the apparent loss of dielectric strength at high electrical stresses is due to thinning of the sheet of material being tested as a result of the mechanical pressure which occurs when the test voltage is applied.

500°*C Transformer.* 1, *Internal nickel-plated-copper heat sink for winding;* 2, *Machined base for maximum heat conduction;* 3, *Core heat sink;* 4, *Granulated refractory filler*; 5, *Grain-oriented silicon-iron laminated core (phosphate insulation on laminations)*; 6, *Split anodized-aluminium coil former;* 7, *Nickel-plated-copper conductors with glass-fibre insulation;* 8, *Stainless-steel top plate E.C.H.-brazed in position under vacuum;* 9, *Ceramic metal terminal seals E.C.H.-brazed into top plate;* 10, 42/58 *nickel-iron ferrules eutectic-brazed and bonded to ceramic;* 11, *Nickel-iron terminal pin eutectic-brazed into position;* 12, *High alumina ceramic insulation;* 13, *Top-plate support;* 14, *Silver-alloy brazed connection;* 15, *Flexible glass-fibre sleeving;* 16, *Woven glass-fibre interlayer insulation;* 17, *External coating of refractory cement;* 18, *Stainless-steel container;* 19, *Brazed-in lugs;* 20, *External heat sink for winding*



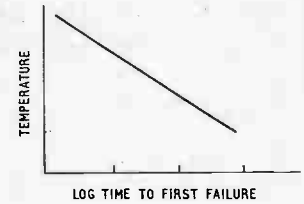


Fig. 2. *Graphs of capacitor life against temperature usually have this form*

Plastic dielectric capacitors were discussed by J. H. Cozens, and electrolytics by G. C. Gaut. At normal temperatures, polystyrene film, if stabilized by heat-treatment to reduce drift in capacitance, is an excellent material. Some capacitors charged to 500 V six years ago still have over 400-V charge ; their time constant is about 50 years. The chief reason for the defects of aluminium electrolytic capacitors is contamination by other substances. Tantalum is much better. A porous tantalum electrode can give a surface-area gain of 200. The material is not attacked by strong electrolytes, sulphuric acid being commonly used. An interesting new capacitor is the Bell Telephone solid electrolytic, in which the electrolyte is replaced by a semiconductor. The low-temperature performance is good, and the h.f. series resistance is low.

New developments in titanate high-κ capacitors were described by a French delegate, M. J. Peyssou. Low-voltage capacitors are now manufactured in sizes of about 4 c.c. per microfarad. A major difficulty is the elimination of ions in the dielectric. When a steady voltage is applied, these migrate towards the plates of the capacitor, causing a non-uniform field pattern with breakdown at points of high dielectric stress, which may amount to 10^6 V/mm. A useful feature of titanates is that the leakage currents generally decrease with increase of temperature.

All the speakers on capacitors and dielectrics paid attention to high-temperature effects, since these are important in military and aircraft applications. The effect of temperature on component failures is as indicated in Fig. 2.

Resistors

New resistor materials discussed by R. W. Burkett included metallic films and tin oxide. The former are linear, but very susceptible to attack by moisture. Tin oxide, being a semiconductor, is not linear with applied voltage, but is strong and stable. These materials will work at high temperatures, and tin oxide can withstand heavy loading (e.g., 4 W/sq. in.) with little change in resistance.

Ordinary carbon composition and pyrolitic carbon resistors have been improved, the latter by the use of alkali-free porcelain formers to reduce oxidization by anodic ions. New nickel-chromium alloys are being investigated for wire-wound resistors. An increase in resistivity of 30% has been obtained over normal nichrome, with a temperature coefficient of 20 parts per million per degree centigrade.

The design of high-performance variable capacitors was discussed by L. W. D. Sharp. An important constructional feature of those described was that all

World Radio History

the mechanical members which determine plate spacing were of ceramic material. In addition, the bold step has been taken in the manufacture of a seven-gang capacitor of dispensing with the usual winged end-vanes. Careful manufacture and automatic checking of dimensions ensure that capacitance tolerance is maintained. At the same time, discontinuities in the capacitance law, which cause trouble in the calibration of modern communications equipment, are eliminated. In studying manufacturing problems it became clear that two kinds of tolerance should be specified. The effects of proportionate errors such as are caused by an angular error in alignment of rotor vanes with respect to stator vanes are largely eliminated in an equipment by adjustment of associated inductors and trimmers. Random errors cannot be taken up in the adjustments and closer tolerance is called for.

An unusual method of cooling power transformers was described by an American speaker, L. F. Kilham. Boiling liquids (inert fluorine dielectric compounds) are employed, together with air cooling. The hermetically-sealed transformer can is partly filled with a suitable liquid, which is carried to the transformer laminations by means of a wick (Fig. 3). The liquid boils and condenses on the metal can, which is cooled by an air stream. The system is claimed to be about 100 times as effective as an ordinary oil-cooling system. The vapours employed are heavy, with high dielectric strengths and are non-toxic. Temperatures up to 200° C are possible. The vapour is soluble; this reduces build-up of pressure when operating. The technique is clearly extensible to components other than transformers.

Another method of cooling components shown in the R.R.E. laboratories uses a hollow chassis through which water is circulated. After passage through the chassis the heated water is cooled by means of a fan and radiator, then re-circulated. This system is very efficient, only a trickle of water being required to keep the temperature of the air in the demonstration model (which had a chassis power loading of 1 watt/sq. in. and a total power dissipation of about 300 W in 700 cu. in.) below 70° C. The chassis obviously forms an excellent heat sink for components which can be thermally bonded to it. This is expected to make possible spectacular savings in weight by way of permitting the use of miniature components which would ordinarily run too hot. The overall weight saving may be as much as four times.

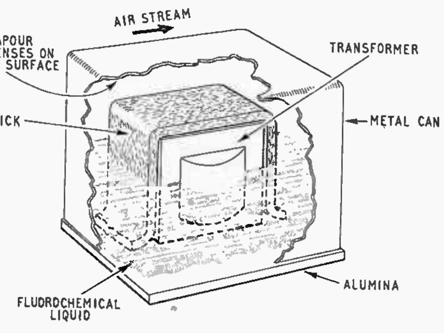
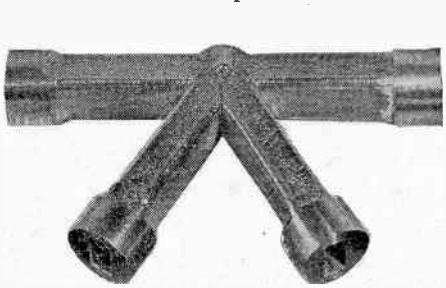


Fig. 3. *Method of cooling sealed transformer by boiling liquid*



Electroformed waveguide components. Accuracies of 0·001 *inch are possible. The illustration is about full size*

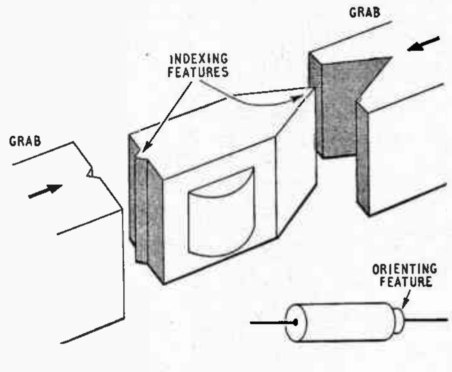


Fig. 4. *Components for automatic assembly*

One speaker dealt, not with the performance of components, but with their physical form. This was another American, J. W. Buffington, in a thoughtful paper on components suitable for automatic assembly. The latter should cost only about a third as much as hand assembly, but the capital equipment cost is very high, and the components must therefore be just the right shape so that the best results can be obtained. Components handled by the leads require an 'orienting feature' where polarity is important, while body-held components must be provided with 'indexing features' so that the automatic handling devices pick them up correctly (Fig. 4).

Automatic testing of components was dealt with by J. A. Sargrove, who described the design of the R.R.E. Automatic Component Testing Equipment (A.C.T.E.). This subjects batches of 1,000 resistors to climatic tests lasting up to four months, and records the resistance of each component at intervals. The machine is programmed by punched tape.

Some interesting features of the laboratory exhibition were a demonstration of a transformer operating at 500° C ; a radar synchronizer made in eight different forms to show progressive miniaturization; magnetic modulators for radar in which the usual thermionic discharge devices are replaced by saturable reactors (a paper on this subject was given by D. W. R. Sewell); and component assemblies using Bell Telephone solderless wrapped connections. A meter protection circuit using silicon Zener diodes was demonstrated. The diodes were connected in a normal full-wave bridge circuit. When the applied voltage was raised appreciably above the safe limit, the diodes broke down in the reverse direction and effectively short-circuited the meter.

World Radio History

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.

Uncorrelated Grid Noise

SIR,—The statements set out by Dr. Bell in paragraphs (3) and (5) of his letter[1] are agreed but, if they are applied directly to the problem of low-noise amplifiers, the conclusions can be misleading because the problem is not represented completely. These statements, as well as those following Fig. 2 of the first letter[2], refer to the transit of one electron. While they are undoubtedly correct statements about the resulting pulses of current in the grid and anode leads, the Fourier analyses of these two pulses can give neither all the information required to ascertain the correlation between fluctuations in the grid and anode currents nor the complete picture of events when the input circuit advances the phase of sinusoidal currents. To study these problems, one must consider a large number of electrons in transit.

The following is a descriptive account of the method which I believe to be adequate in dealing with noise problems and which forms the basis of the derivation of the formulae given in my first letter[3].

The method makes use of the Fourier analysis of the fluctuating quantity itself taken over a long period of time. This is not subject to the limitations of the Fourier analysis of the pulse arising from a single electron transit, which has to be supplemented by information on the randomness of the sequence of transients. Furthermore, it enables the theory of transit-time electronics to be applied directly to fluctuation problems in valves. The nature of such a Fourier analysis can be seen from the following. (For an analytical account, see ref. 7.)

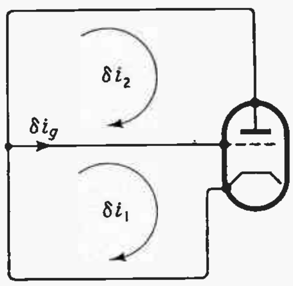
Consider the convection current at a given cross-section in a particular valve space during a long period of time. (To avoid any difficulty with infinities, let it be assumed that the electron is of finite extent so that the impulse of convection current of an electron passing through a surface is of finite amplitude and duration.) The graph of convection-current versus time will be similar in principle to the histogram produced by Dr. Bell (ref. 4, p. 239, Fig. 88) and it has a definite Fourier representation. Graphs of the convection current at the same cross-section taken on different occasions over similar periods will all differ but, on comparing the Fourier representations of a large number, certain regularities will be observed. Thus, although the amplitude of each harmonic differs on different occasions, it is closely distributed about a mean value.

The phases of the harmonics are uniformly distributed, no particular values being favoured. The most probable value of the amplitude of a given harmonic is the root-mean-square of the fluctuation in an ideal device responding only to the harmonic. If the period over which the Fourier analysis is made is increased without limit, the Fourier series clearly becomes a Fourier integral, defining a continuous spectrum with the above properties.

If we now consider the fluctuations of convection current at a subsequent cross-section in the valve space and we are sure that nothing has happened in transit to change the state of randomness, it is evident that the current–time graph will be similar at both cross-sections, but with the pattern of the second one delayed by the time of transit. If, as is customary, complete correlation means a linear relationship between the two current–time graphs, obtained on any occasion, then we may say that the convection currents at different cross-sections in a valve space have completely correlated fluctuations. Again, it is not difficult to see that their Fourier components are also completely correlated; i.e., the amplitudes of any component are linearly related and different in phase according to the transit angle between the two cross-sections in question. The passage of an electron stream through an ideal grid (i.e., of very fine wire and small pitch) will not materially change the randomness of the time intervals between the passage of individual electrons, so that the fluctuations in convection current at a cross-section in space 1 (the potential-minimum to grid space) will be completely correlated with the fluctuations in convection current in space 2 (the grid to anode space) in the same sense as that stated above.

To determine the correlation between the Fourier components of the fluctuations of current in the grid and anode leads, we need to know the induced-current fluctuations in the two spaces of the triode. It is a result of transit-time electronics that the induced current between any adjacent pair of electrodes at a given instant is the average of all the convection current between the electrode-pair at the instant. Since all the convection-current fluctuations in space 2 are correlated with those in space 1, with the appropriate time lags, the Fourier coefficients of the fluctuations in the two induced currents will be linearly related with definite phase differences. Application of the analysis shows that in a triode with an ideal grid the Fourier coefficients of the induced-current fluctuations in spaces 1 and 2 are approximately equal in amplitude, and have the phase difference angle $\frac{1}{3}\omega T_1 + \frac{2}{3}\omega T_2$ for the angular frequency ω.

The source of the fluctuating grid current may best be seen by referring to the figure. The complex amplitudes of the Fourier coefficients of the correlated induced-current fluctuations in the two



spaces are denoted by δi_1 and δi_2 for the frequency range f to $f + df$. These are the currents which appear in the corresponding external circuit loops. The current in the circuit branch to the grid is the difference $\delta i_1 - \delta i_2$; the combination of δi_1 and δi_2 occurs in the conductor and not in the valve spaces. (Even if the currents are regarded as the rate of change of the charges induced on the grid, the charges associated with δi_1 and δi_2 are induced on opposite sides of the grid wires and the combination is in the grid wire and the remainder of the grid-circuit branch.) In view of the correlation of δi_1 and δi_2 with the phase angle between them, the induced grid fluctuations have a mean-square value for the narrow band centred around ω given by the following expression:

$$\overline{\delta i_g^2} = \overline{\delta i_1^2}.\ \tfrac{1}{9}(\omega T_1)^2 (1 + 2T_2/T_1)^2$$

which is the expression given by van der Ziel[5] for an ideal triode. If, on the other hand, δi_1 and δi_2 were largely uncorrelated, the value of the grid noise would be given by:

$$\overline{\delta i_g^2} \approx \overline{\delta i_1^2} + \overline{\delta i_2^2} \approx 2\,\overline{\delta i_1^2}$$

and, contrary to experimental evidence, would have a very large value at both low and high frequencies.

It is evident that if different parts of the valve have different transit-times, the correlation between δi_1 and δi_2 as defined above will be adversely affected. The problem may be dealt with by dividing the triode into a number of differing parts, in each of which the transit time is sensibly uniform, and combining the results by summing mean-square values. This is because the fluctuations in any part of a cross-section are uncorrelated with those in any other part. This process results in the factor S in my formula[3].

The noise factor is calculated independently of the grid noise, using the correlated induced currents δi_1 and δi_2 directly in conjunction with the electronic equations which express the currents resulting from voltage fluctuations that may build up across any

World Radio History

impedances in the circuit branches. Finally, it should be noted that in most v.h.f. applications of low-noise amplifiers, the bandwidth is small compared with the mid-band frequency. In such cases, the Fourier representation of the fluctuations may always be represented by the expression:

$$\delta i(t) = |\delta i| \cos(\omega t + \phi)$$

where $|\delta i|$ and ϕ fluctuate slowly about mean values; the narrower the pass-band, the more slowly do they flucuate (*cf.* ref. 4, p. 38, Fig. 16). It is seen that, in this case, a moderate phase advance of a continuous sinusoid by the input-circuit has a meaning relative to the fluctuations, as indeed Dr. Bell infers[1] at the end of his paragraph (5). With wider bandwidths, the correct results can be obtained by integrating the weighted modulus squared of the Fourier spectrum over the frequency band.

Referring now to paragraph (3) of Dr. Bell's letter[1], it is agreed that the pulse of current of an elastically-reflected electron must be correlated with the pulse of the same incident electron, but here again one must consider many incident and reflected electrons. Suppose the incident electrons arrive at the anode at slightly irregular intervals (i.e., with space-charge reduced shot-effect). Because the reflection of a given incident electron is a random event, the elastically-reflected electrons occur at completely random intervals, the long time mean of which is determined by the mean fraction r elastically reflected. Except in so far as each reflected electron is related to some primary electron, the random event of reflection is not connected with the slight irregularities in the intervals between the electrons in the incident stream, so that the completely random intervals in the reflected stream constitute fluctuations that are uncorrelated with the fluctuations in the incident stream. The fact that each elastically-reflected electron is inescapably related to one of the incident electrons merely results in a fraction r^2 of the mean-square space-charge reduced noise in the incident stream appearing in the elastically-reflected stream, which is correlated with the fluctuations in the incident stream. In symbols, the mean-square fluctuation in the convection current leaving the anode is:

$$\overline{\delta i_r^2} = 2eI_a\Gamma^2 r^2 . df + 2eI_a r (1 - r) . df$$

where the first term is correlated with the incident fluctuations and the second term, due to the randomness of the reflection process, is uncorrelated with the incident fluctuations. It is clear that when $r = 1$ (i.e., every electron is reflected) there is no uncorrelated part, as would be expected. Electrons not elastically reflected are, of course, not all absorbed by the anode. Some are inelastically reflected and others give rise to true secondary emission with low initial velocities, but only the elastically-reflected electrons are of major importance in the theory of fluctuations at v.h.f.

The reason for requiring the terms in $(\omega T)^3$, questioned in Dr. Bell's letter, is to obtain the *variation with frequency* of the capacitance change between the conditions of resonance and minimum noise factor, which was observed by Houlding and Glennie[6].

Princes Risborough, Bucks. I. A. Harris
4th September 1957.

REFERENCES

1 D. A. Bell, "Uncorrelated Grid Noise", *Electronic & Radio Engr*, August 1957, Vol. 34, p. 315.
2 *Ibid.*, January 1957, Vol. 34, p. 36.
3 I. A. Harris, *Electronic & Radio Engr*, May 1957, Vol. 34, p. 193.
4 E. B. Moullin, "Spontaneous Fluctuations of Voltage", Oxford University Press, 1938.
5 A. van der Ziel, "Induced Grid Noise in Triodes", *Wireless Engr*, 1951, Vol. 28, p. 226.
6 N. Houlding and A. E. Glennie, "Experimental Investigation of Grid Noise", *Wireless Engr*, 1954, Vol. 31, p. 35.
7 A. van der Ziel, "Noise", Chapman & Hall, 1955. Chapter 12.

Low-Noise Stabilized D.C. Supplies

Sir,—We would like to bring to your notice a small oversight in the otherwise excellent article by Mr. Rogers in your September issue. Stabilization of the supply to the reference voltage source was shown to improve its performance enabling a drift of 0·04% or better to be obtained. To obtain the full benefit from this high degree of stability the sampling attenuator must be of the same order of stability. Drifts of 0·5% are not uncommon in the cracked-carbon-film high-stability resistors and their temperature coefficient of 0·01% per degree C can easily lead to warming up changes of 0·2%. Wire-wound resistors, on the other hand, have long-term stabilities of better than 0·05% and temperature coefficients less than 0·002% per degree C. In general the changes brought about by 'warming up' can be minimized by mounting the temperature-sensitive components together so that they experience the same change in ambient temperature and arranging that the temperature rise in each resistor due to power dissipation is similar. The temperature effects may then be less than the long-term drifts.

G. F. C. Selby-Lowndes

Rivlin Instruments Ltd.,
Camberley, Surrey.
2nd October 1957.

Sir,—I would like to make the following comments regarding Mr. G. F. C. Selby-Lowndes' valued remarks.

(1) It is, of course, essential that the sampling attenuator must have the same order of stability as the voltage-reference source.

(2) In Fig. 7 of my article the resistors R_{37}, R_{38}, and RV_3 were wire-wound, rated at 6 W, 6 W and 1 W respectively and mounted side by side on the same tag strip. It will be noted that they are operated well within their ratings in order to maintain their temperatures close to the ambient temperature.

(3) A small controlled jet of air was employed to cool each resistor of the sampling attenuator in turn and the corresponding drifts noted.

(4) All long-term drifts were continuously recorded using the voltage of a Weston standard cell for comparison. The figures and results quoted by Mr. G. F. C. Selby-Lowndes agree remarkably well.

D. W. W. Rogers

H.M. Underwater Detection Establishment,
Portland, Dorset.
6th October 1957.

Coherent and Incoherent Detectors

Sir,—In point (a) of Mr. Crombie's letter in the October issue objections are raised primarily because of insufficient attention to detail. Dr. Smith is concerned with two forms of output signal/noise ratio, both of which are carefully defined in section 2 of his paper: one has to do with the decision as to whether a signal is observable in noise and the other with fluctuations about a mean level of signal due to the presence of noise. Further, in dealing with the linear diode detector, Dr. Smith considers an approximation to a practical detector and not an ideal envelope detector. Dr. Tucker is also concerned with two output signal/noise ratios; one has to do with modulation in the input signal, and the other with d.c. output from the detector. Both differ by definition from those of Dr. Smith. The linear diode detector considered by Dr. Tucker is also not of the envelope type.

The theories involved in both the above are very different from the elementary comparison of signal and noise powers at the detector output as dealt with in my paper, and I do not believe that my analysis is suspect. [There is a correction to the paper in the June issue, but this does not affect the results.]

Concerning point (b), the conclusions drawn in the paper concern the general case of modulating frequencies which are randomly distributed within the pre-detector pass-band. I agree that there is some possibility of being misled because I have not stated this specifically; however, there can be little likelihood of confusion here because the response of the coherent detector to the restricted condition of steady sine-wave modulations is given directly by my equations (7) and (8). Equation (7) shows that the signal output consists of lines at zero frequency and at the modulating frequencies, and equation (8) gives the response after filtering out any of these.

Distinguishing between 'demodulators' and 'detectors' is an issue about which one may feel strongly or otherwise. Is it really useful to be so 'discriminating'?

University of the Witwatersrand, R. Kitai
Johannesburg.
5th September 1957.

Some Matrix Theorems

Sir,—In his interesting letter published in your September issue, Armstrong deals with alternative ways of expressing the nth power of a 2×2 matrix (of determinant equal to unity). In particular, he derives matrices applicable to low-pass four-poles, in which the elements fall naturally into combinations of Tchebychev functions of a normalized frequency ω/ω_0.

As stated by Armstrong, his Tchebychev matrices (6) and (7), although neat expressions, are of little value in practice. The writer

World Radio History

and two of his colleagues have regretfully come to share Armstrong's opinion in this regard. It is just for this reason that the writer has kept to matrix elements in terms of hyperbolic functions. The preferred form of matrix, in the writer's view, is not that quoted at (1) in Armstrong's letter, but the one first mentioned in "Some Matrix Theorems" (4). This is

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^n = \begin{bmatrix} \dfrac{\cosh(u+v)}{\cosh v} & \mu \dfrac{\sinh u}{\cosh v} \\ \dfrac{1}{\mu}\dfrac{\sinh u}{\cosh v} & \dfrac{\cosh(u-v)}{\cosh v} \end{bmatrix}^n = \begin{bmatrix} \dfrac{\cosh(nu+v)}{\cosh v} & \mu \dfrac{\sinh nu}{\cosh v} \\ \dfrac{1}{\mu}\dfrac{\sinh nu}{\cosh v} & \dfrac{\cosh(nu-v)}{\cosh v} \end{bmatrix}$$

where, in terms of the a_{ij}

$$\cosh u = \tfrac{1}{2}(a_{11} + a_{12})$$
$$\cosh^2 v = \sinh^2 u / a_{12}a_{21}$$
$$\mu^2 = a_{12}/a_{21}$$

The form of the above matrix makes it particularly easy to evaluate the elements, with the assistance of charts and tables of hyperbolic functions which are readily available.

In conclusion, the writer may perhaps be allowed to point out, in regard to the introductory paragraph of Armstrong's letter, that his methods of raising a 2 × 2 matrix to the nth power are not restricted to matrices of determinant equal to unity.

W. PROCTOR WILSON

The British Broadcasting Corporation,
Kingswood Warren, Tadworth, Surrey.
18th September 1957.

New Books

Electronics Tubes, Book XIII—Industrial Rectifying Tubes
By members of Philips' Electron Tube Division. Pp. 116. Philips Technical Library U.K. distributors: Cleaver Hume Press Ltd., 31 Wrights Lane, Kensington, London, W.8. Price 15s.

Proceedings of the RETMA Symposium on Applied Reliability
Pp. 105 + 46. Published by Engineering Publishers, G.P.O. Box 1151, New York 1, N.Y., U.S.A. Price $5.00.

Fourteen papers and a 46-page "Guide for technical reporting of electronic systems reliability measurements".

Proceedings of the Second RETMA Symposium on Applied Reliability
Pp. 93. As above. Price $5.00.

Radio Research 1956
Published by H.M.S.O. for D.S.I.R. Pp. 47. Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2. Price 3s. (By post 3s. 2d.)

Annual report of the Radio Research Board. Subjects covered include investigations of very low frequency transmissions for navigational aids, the ionosphere, including back-scatter and v.h.f. ionospheric scatter, the troposphere, r.f. power measurement, semi-conductor research and research on ferrites.

Guide to the Specification and Use of Quartz Oscillator Crystals
Published by R.C.E.E.A., 11 Green Street, Mayfair, London, W.1. Pp. 40. Price 5s.

"This guide was compiled in response to a generally expressed desire on the part of user and manufacturer to remove the erroneous idea that a crystal unit is an absolute frequency-determining device". This booklet contains information on the correct application of crystals, including sections on crystal holders, frequency-temperature characteristics, and the effects of conditions of use, and a specimen of the technical data which should accompany an order for a crystal.

Propagation des Ondes Electromagnetiques de Haute Fréquence
By J. ORTUSI. Pp. 320. Société Française de Documentation Electronique, 12 Rue Carducci, Paris 19e. Price Fr. 3240.

Includes chapters on waveguides and non-reciprocal devices.

Elektromagnetische Wellenleiter und Hohlräume
By GEORG GOUBAU. Pp. 460. Wissenschaftliche Verlagsgesellschaft M.B.H., Stuttgart 1. Price D.M. 89.

Theorie und Technik der Pulsmodulation
By E. HÖLZLER and H. HOLZWARTH. Pp. 505. Springer-Verlag, Reichpietschufer 20, Berlin W.35. Price D.M. 57.

Receiving Tube Substitution Guidebook. Third Supplement
By H. A. MIDDLETON. Pp. 68. Price $1.35. Includes some British and Continental valve types.

Electronic Technology Series
By ALEXANDER SCHURE, Ph.D., Ed.D. No. 166—11, **Wave Propagation.** Pp. 64. Price $1.25. No. 166—14, **Antennas.** Pp. 88. Price $1.50. No. 166—16, **Resonant Circuits.** Pp. 72. Price $1.25.

Repairing Television Receivers
By CYRUS GLICKSTEIN. Pp. 212. Price $4.40.

How to Install and Service Intercommunication Systems
By JACK DARR. Pp. 152. Price $3.00.

Getting Started in Amateur Radio
By JULIUS BERENS. Pp. 144. Price $2.40.

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STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Deviations from nominal frequency for September* 1957

Date 1957 September	MSF 60 kc/s 2030 G.M.T. Parts in 10^9	Droitwich 200 kc/s 1030 G.M.T. Parts in 10^8
1	− 1	N.M.
2	− 1	+ 1
3	− 1	+ 1
4	− 1	+ 1
5	N.M.	+ 2
6	− 1	+ 2
7	0	+ 2
8	0	+ 2
9	0	+ 2
10	0	+ 3
11	0	+ 3
12	0	+ 3
13	0	+ 3
14	0	N.M.
15	0	N.M.
16	0	+ 1
17	0	+ 4
18	N.M.	− 1
19	+ 1	N.M.
20	+ 1	0
21	+ 1	N.M.
22	+ 1	N.M.
23	+ 1	− 1
24	+ 1	0
25	+ 1	0
26	+ 1	+ 1
27	+ 1	+ 2
28	+ 1	+ 1
29	+ 1	+ 1
30	+ 1	+ 2

* *Nominal frequency is defined to be that frequency corresponding to a value of* 9 192 631 830 *c/s for the N.P.L. caesium resonator. N.M. = Not Measured.*

World Radio History

New Products

Crystal Impedance Meter Type UE.24

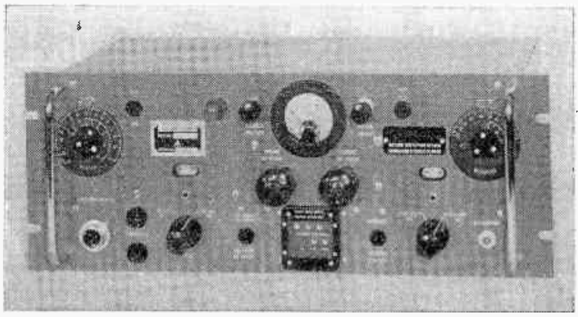
This instrument is designed to measure the effective series-resonant and anti-resonant resistances of quartz-crystal units in the frequency range of 10 to 140 Mc/s.

The instrument will accept directly, crystal units type D of specification DEF-5271, or U.S.A. style HC-6/U. It will also accept, by means of an adaptor supplied with the equipment, crystal units style J of DEF-5271 or U.S.A. style HC-18/U. Other styles can be accommodated by the provision of adaptors specially designed for the particular crystal unit.

Impedance measurement is effected by a substitution method, using calibrating resistors of known value to simulate the impedance of the crystal unit under test. A variable calibrating resistor supplied with the equipment may be used at frequencies below 50 Mc/s and its resistance measured on a suitable bridge to obtain the impedance value.

An adaptor containing a small pre-set capacitor is supplied for anti-resonant impedance measurement.

G. & E. Bradley Ltd.,
Beresford House, Mount Pleasant, Alperton, Middx.

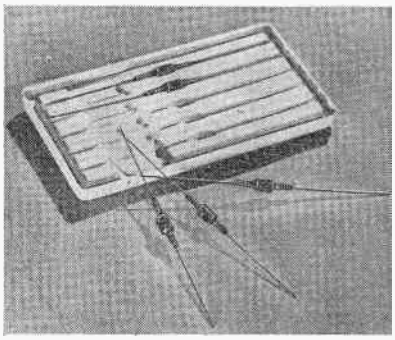


Silicon Junction Rectifiers and Zener Diodes

Ranges of low-power silicon junction rectifiers and Zener diodes have been announced by S.T.C. The rectifiers are stated to be suitable for use up to 100°C, at which the maximum reverse current at the peak inverse voltage is 200 μA. Three types of rectifier are available, differing only in peak inverse voltage ratings, and designated RS20A (p.i.v. 50 V), RS21A (p.i.v. 100 V), and RS22A (p.i.v. 150 V). The maximum rectified output from a single unit in a half-wave capacitor-input circuit is given as 0·4 A at 35°C, falling to 0·2 A at 100°C.

The Zener diodes (illustrated) are intended for use as voltage references or stabilizers, and are available in five voltage grades with $\pm$20% tolerance on voltage. It is pointed out by the makers that a diode biased in the forward direction may be connected in series with a reverse-biased diode to increase the reference voltage slightly.

Standard Telephones & Cables Ltd.,
Connaught House, Aldwych, London, W.C.2.



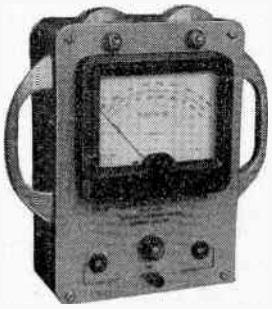
Portable Wire-Temperature Indicator

This instrument has been designed for the rapid measurement, during production, of the temperature of pre-heated copper conductors before these enter an extrusion machine.

The makers state that the need for accurate maintenance of pre-heating temperatures of the conductor in the extrusion of p.v.c., polythene, and foamed insulants, is now widely recognized. If cracks on bending, uneven shrinkage, and excessive or insufficient adhesion of the insulation to the conductor are to be avoided the conductor temperature has to be kept within relatively low limits.

One of the difficulties in this connection has been the accurate measurement of the temperature of the conductor, owing to its motion and low thermal capacity. Contact thermometers and thermocouples cannot normally be relied upon, because of the considerable errors produced by frictional heat at the point of contact. Wax pencils have the disadvantage of tending to cause failure of the cable at places where molten wax has adhered to the conductor. It is claimed that these difficulties have been overcome in the present instrument, which is small, light and self-contained, operating from a torch battery. It comprises a direct-reading indicating meter covering temperatures up to 400°F (225°C). In operation, it is merely necessary to hold the two vee-grooved rollers at the front of the case against the conductor.

The Addison Electric Co. Ltd.,
10–12 Bosworth Road, London, W.10.

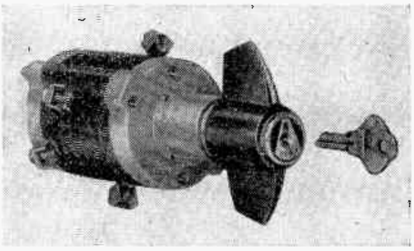


Lockable Switches

New switches operated by means of a Yale key, or with lockable handles, have been introduced by Tok Electrical & Industrial Mechanisms Ltd. That illustrated is of the lockable-handle type and is available in ratings up to 250 V, 60 A. Complex contact arrangements are possible.

The firm also supply a switch with a pilot lamp incorporated.

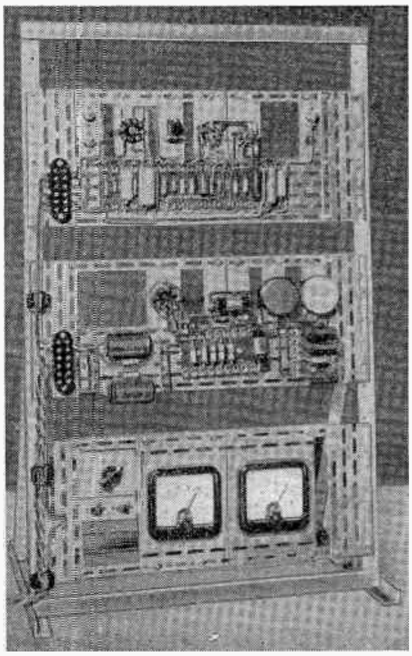
Tok Electrical & Industrial Mechanisms Ltd.,
17 Bury Street, London, E.C.3.



Chassis System

A chassis system for rapid construction, the Rapikon, has been produced by Shandon Electronics Ltd. The component parts, which are firmly held on a rack, require only to be screwed together. Holder plates are available for components such as valves.

It is claimed that, because of the vertica



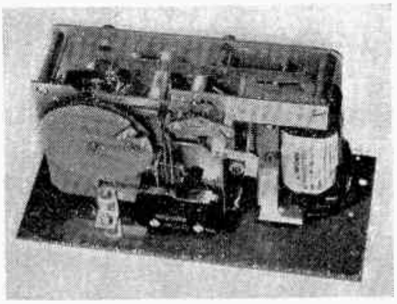
World Radio History

layout, components are always accessible, that layouts can easily and rapidly be modified, and that several chassis or circuits can be simply connected to one another without taking up bench space and with no flying leads.
Shandon Electronics Ltd.,
6 *Cromwell Place, London, S.W.7.*

Valve Protecting Timer

Venner Ltd. have introduced a delayed reset timer, type TDR/S/P635, designed for the protection of thermionic valves in transmitting, receiving and control equipment. A typical application is valve protection in radar equipment.

After the initial switch-on, the timer operates as a standard delay relay. This ensures that the h.t. voltage is not connected until the filaments are warmed up. Upon switching off, the timer resets to zero at a delayed rate controlled by an escapement.



This prevents the full initial delay period having to be completed after a supply interruption of a shorter duration than the normal warm-up time.

The reset time can be either the same as the initial delay period or set for some proportion of this period; e.g., a 5-minute delay time, 2½-minute reset time. The unit can, therefore, be adjusted to suit the cooling characteristic of the equipment under control. A further feature is that the time contacts can be arranged to stay closed during brief supply interruptions of less than, say, 10-seconds duration, opening only when the relay is de-energized for longer than this period.

The timer is fitted in a steel container measuring 8 in. × 4¾ in. × 3½ in. with connections brought out to sealed terminals. Its operating temperature range is −40°C − +70°C.
Venner Ltd.,
Kingston By-Pass, New Malden, Surrey.

Universal Bridge

Marconi Instruments Ltd. have introduced a new version of their universal bridge TF868/1. The new instrument—Type TF868S—incorporates a bridge-volts monitoring system.

For inductance or capacitance measurements, the bridge is energized by a.c. derived from a valve oscillator. If desired, this voltage can be set to a definite required value. For this purpose, there is a continuously-variable *L* and *C* bridge-volts control, a 0–10-volt auxiliary scale on the panel meter and a 'read *L* and *C*' bridge-volts switch. The inclusion of this facility is said

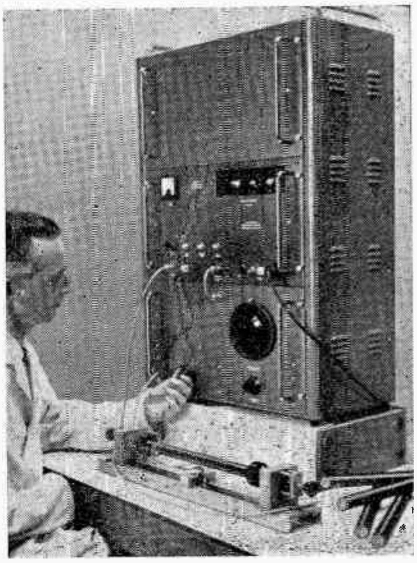
to be especially useful when measurements are being made on components such as iron-cored coils whose inductance is a function of exciting current.

The Marconi bridge measures inductance from 1 μH to 100 H, capacitance from 1 pF to 100 μF and resistance from 0·1 ohm to 10 MΩ. Inductance or capacitance measurements can be made at either 1 or 10 kc/s; resistance measurements are made at d.c.
Marconi Instruments Ltd.,
St. Albans, Herts.

Mechanical 'Q' Meter

The damping constants of a material provide an indication of the condition of its internal structure, including the presence of flaws. An instrument for indicating the '*Q*' of a mechanical part, or comparing it with that of a standard part is therefore likely to be of use for development work or production testing.

A. E. Cawkell have produced such an instrument. Logarithmic decrement is



measured. The test piece is first excited to resonance by a variable-frequency oscillator and transducers, the actual method of supplying mechanical energy being arranged to suit the specimen. The oscillator output is then cut off abruptly, but the specimen continues to vibrate, the vibrations being detected and amplified and applied to an amplitude-sensitive 'gate' which closes when they have decayed to a predetermined level.

The output of the gate circuit supplies cold-cathode counting tubes, and the number of cycles thus counted is simply related to the mechanical *Q*, being in practice approximately *Q*/4. Values of *Q* up to about 45,000 can be measured, and the accuracy claimed is better than 2%.
A. E. Cawkell,
6-8 *Victory Arcade, The Broadway, Southall, Middlesex.*

Inexpensive Oscilloscope

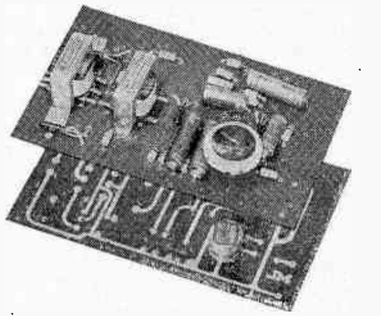
The Telequipment 'Serviscope' is a measuring oscilloscope for general laboratory use and for the service engineer. Points from the maker's specification are as follows:

- 'Y' amplifier response: d.c. to 6 Mc/s (−3dB).
- Sensitivity 100 mV/cm.
- Rise time 0·06 μsec (less than 2% overshoot).
- Voltage measuring accuracy ± 5%.
- Time-base: 18 calibrated sweep speeds from 500 msec/cm to 1 microsec/cm. (triggered).
- X expansion to 10 screen diameters (50 cm).
- Time measurement accuracy ±10%.

The oscilloscope embodies a new stable triggering circuit which is locked automatically to signals up to 1 Mc/s, a television sync separator, and a 50-c/s square-wave voltage calibrator.
Telequipment Ltd.,
313 *Chase Road, Southgate, London, N.*14.

Transistor Audio Amplifier

The printed-circuit amplifier illustrated is claimed to have an audio output of 215 mW at 10% total harmonic distortion, a sensitivity of 3 mV (low impedance) or 400 mV (high impedance), and a frequency response to −3-dB points of 50 c/s to 8 kc/s, The output stage employs two OC72 transistors in class B operation.
Printed Circuits Ltd.,
Stirling Corner, Barnet By-Pass, Borehamwood, Herts.



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. Copies of articles or journals referred to are not available from Electronic & Radio Engineer. *Application must be made to the individual publisher concerned.*

ACOUSTICS AND AUDIO FREQUENCIES

534.133-8 **3369**

Excitation of Ultrasonic Oscillations in Quartz.—K. N. Baranski. (*C. R. Acad. Sci. U.R.S.S.*, 21st May 1957, Vol. 114, No. 3, pp. 517–519. In Russian.) A variable-frequency oscillator of 5–10-W output was used to drive a 240-kc/s X-cut quartz plate to oscillate at frequencies up to 2 kMc/s. Diffraction measurements on the velocity of longitudinal waves in quartz have shown that, in the range of frequencies examined, this remains constant at 5 750 m/s.

534.143 : 621.317.39 **3370**

Measurement of Longitudinal Vibrations in the Mc/s Frequency Range by means of Electrostatic Excitation and a F.M. System of Detection.—P. G. Bordoni & M. Nuovo. (*Ricerca sci.*, March 1957, Vol. 27, No. 3, pp. 695–706.) Description of apparatus with results of measurements on Al disks resonating at frequencies ranging from 0·5 to 5·5 Mc/s.

534.2-14 **3371**

On the Propagation of Ultrasonic Waves of Finite Amplitude in Liquids.—V. A. Krassilnikov, V. V. Shklovskaya-kordy & L. K. Zarembo. (*J. acoust. Soc. Amer.*, May 1957, Vol. 29, No. 5, pp. 642–647.) The dependence of the ultrasonic absorption coefficient on intensity was measured at 1·5 Mc/s for water, ethyl and methyl ethers, toluene, transformer oil and glycerine by means of thermocouples.

534.2-8 **3372**

Action of Infrared Radiation on an Ultrasonic Stationary-Wave Field.—C. Rossetti. (*C. R. Acad. Sci., Paris*, 17th June 1957, Vol. 244, No. 25, pp. 3038–3040.) Measurements made with an interferometer (1223 of 1953) show that infrared radiation is absorbed by a gas in which stationary ultrasonic waves are generated. Two different mechanisms are indicated, one purely thermal, the other of molecular origin.

534.232 : 534.641 **3373**

The Electrical and Mechanical Impedance of Electroacoustic Transducers.—R. Bierl. (*Nachrichtentech. Z.*, April 1957, Vol. 10, No. 4, pp. 160–167.) Equivalent electromechanical circuits are considered which take account of impedance changes during oscillations. The mechanical impedance of resonators with distributed mass and elasticity can be approximately represented by a combination of single-frequency resonators. Theory is confirmed by measurements on an electrodynamic system coupled to (*a*) a cylindrical tube, (*b*) an exponential horn.

534.232-8 **3374**

Research on the Acoustic Air-Jet Generator: a New Development.—E. Brun & R. M. G. Boucher. (*J. acoust. Soc. Amer.*, May 1957, Vol. 29, No. 5, pp. 573–583.) Modifications which substantially increase the efficiency and available power output of the Hartmann air-jet ultrasonic generator are described.

534.232-8 : 538.652 **3375**

Performance of Magnetostrictive Transducers Made of Aluminium-Iron Alloy or Nickel-Copper Ferrite.—Y. Kikuchi. (*J. acoust. Soc. Amer.*, May 1957, Vol. 29, No. 5, pp. 569–573.) Both Ni and the alloy Alfer (13·5% Al) have as high a coupling factor as is necessary for transducers operating at resonance. Improvements in efficiency can be obtained by elimination of eddy currents, e.g. by the use of ferrites such as $(NiO)_{0.85}$ $(CuO)_{0.15}$ Fe_2O_3. Details are given of ferrite transducers with electroacoustic efficiency 90% suitable for high-intensity ultrasonic radiation in water at powers up to 3 W/cm². See also 904 of 1955 (Thiede).

534.232.001.4 **3376**

A Method for Measuring Solvent Resistance of Crystal-to-Crystal Adhesive Bonds.—B. J. Faraday & D. J. G. Gregan. (*ASTM Bull.*, May 1957, No. 222, pp. 42–45.) The apparatus described is suitable for testing bonds in butt-jointed crystals used for l.f. transducers.

534.75 **3377**

Effect of Time on Pitch Discrimination Thresholds under Several Psychophysical Procedures; Comparison with Intensity Discrimination Thresholds.—E. König. (*J. acoust. Soc. Amer.*, May 1957, Vol. 29, No. 5, pp. 606–612.) See also 1237 of 1955 (Pollack).

534.75 : 621.3.018.7 **3378**

How Little Distortion Can We Hear?—M. Lazenby. (*Wireless World*, Sept. 1957, Vol. 63, No. 9, pp. 435–440.) The smallest amount of nonlinear distortion that can be detected by the ear is calculated from known nonlinear hearing effects and compared with existing measurements.

World Radio History

534.78 **3379**

Word Intelligibility as a Function of Time Compression.—G. Fairbanks & F. Kodman, Jr. (*J. acoust. Soc. Amer.*, May 1957, Vol. 29, No. 5, pp. 636–641.) "An experiment is described in which words were automatically compressed in duration and presented to observers for identification. The effects of time compression and of time sampling are assessed, and compared with those of periodic interruption. The results of an analogous non-auditory study of the effects of phonemic sampling are presented."

534.79 **3380**

Concerning the Form of the Loudness Function.—S. S. Stevens. (*J. acoust. Soc. Amer.*, May 1957, Vol. 29, No. 5, pp. 603–606.) Results of experiments based on halving and doubling the loudness of 1-kc/s tone at different levels tend to confirm irregularities in the loudness function.

534.79 **3381**

Critical Bandwidth in Loudness Summation.—E. Zwicker, G. Flottorp & S. S. Stevens. (*J. acoust. Soc. Amer.*, May 1957, Vol. 29, No. 5, pp. 548–557.) The critical bandwidth at which loudness summation begins to depend on the spread of energy is approximately the critical bandwidth determined previously by methods involving thresholds, masking and phase. See also 2944 of 1956 (Bauch).

534.84 : 621.395.623.8 **3382**

System of Sound Amplification in the Congress Hall of the Palace of Culture and Science in Warsaw.—W. W. Furdujew (Furduev). (*Nachr Tech.*, March 1957, Vol. 7, No. 3, pp. 112–117.)

534.845 **3383**

On Standard Methods of Measurement in Architectural Acoustics.—R. V. Waterhouse. (*J. acoust. Soc. Amer.*, May 1957, Vol. 29, No. 5, pp. 544–547.) The sound absorption of acoustical materials and the sound transmission loss of partitions are discussed.

621.395.623.7 **3384**

On the Low-Frequency Radiation Load of a Bass-Reflex Speaker.—R. H. Lyon. (*J. acoust. Soc. Amer.*, May 1957, Vol. 29, No. 5, p. 654.) The radiation load on the port-cone combination of a bass-reflex system near the fundamental resonance involves a coupling between the radiators which is calculated.

621.395.625.3 : 681.84.083.84 **3385**

Noise in a Magnetic Recording Tape.—P. A. Mann. (*Arch. elekt. Übertragung*, March 1957, Vol. 11, No. 3, pp. 97–100.) Magnetic domains arranged at random along the tape give rise to noise voltages when passing the reproducing head. Assuming a statistical distribution of domain position and orientation the relation of noise voltage and frequency is expressed in an equation and plotted. After erasure a tape is noisier than an unused tape because the size of the domains cannot be reduced sufficiently.

AERIALS AND TRANSMISSION LINES

621.372.8 **3386**

The Scattering Effect of a Junction between Two Circular Waveguides.—V. Papadopoulos. (*Quart. J. Mech. appl. Math.*, May 1957, Vol. 10, Part 2, pp. 191–209.) "The exact solution is found for the electromagnetic problem of the scattering effect of a junction between two semi-infinite circular pipes of radius a and b respectively ($a > b$) and having the same axis. The solution involves constants which satisfy an infinite set of equations."

621.372.8 **3387**

Reflection at the Transition from Rectangular Waveguide to Sectoral Horn.—G. Piefke. (*Arch. elekt. Übertragung*, March 1957, Vol. 11, No. 3, pp. 123–135.) The reflection coefficient is calculated for a junction of waveguide and horn flared in the E plane or H plane. Curves of the coefficient are plotted for flare angles up to 90° for the range $1 \leqslant 2a/\lambda_0 \leqslant 2$, where a is the width of the waveguide and λ_0 the free-space wavelength. For horns flared in the H plane the reflection coefficient is independent of waveguide height. An approximate formula for very small flare angles is derived.

621.372.8 : 621.3.017.71 **3388**

Heat Loss in Grooved Metallic Surface.—E. A. Marcatili. (*Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1134–1139.) A theoretical method of evaluating the conduction-current losses in certain parallel periodic grooves in waveguide walls.

621.396.67 : 621.397.62 **3389**

Antenna-Multiplex System Design.—H. K. Schlegelmilch, O. K. Nilssen & W. Y. Pan. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 148–151.) A description of a distribution network giving an average isolation of 25 dB between 256 television receivers connected to a single common aerial.

621.396.67.011 **3390**

A Reactance Theorem for Antennas.—C. A. Levis. (*Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1128–1134.) A rigorous expression for the frequency derivative of the input reactance of an arbitrary aerial, used to predict bandwidth properties.

621.396.673 **3391**

The Measurement of the Efficiency of Short Unbalanced Metre-Wave Aerials.—M. Lohr. (*Nachrichtentech. Z.*, March 1957, Vol. 10, No. 3, pp. 120–124.) The method described involves only simple impedance measurements and accuracy within 2% is obtainable; examples are given.

621.396.674.1 **3392**

Terminated Circular Loop Aerial.—S. B. Rao. (*Electronic Radio Engr*, Sept. 1957, Vol. 34, No. 9, pp. 347–350.) An expression is derived for the radiation field of a circular loop with a terminating resistance diametrically opposite the feeding point. Experimental results using a small loop at 110 Mc/s are given.

621.396.674.1 **3393**

Insulated Loop Antenna Immersed in a Conducting Medium.—J. R. Wait. (*J. Res. nat. Bur. Stand.*, Aug. 1957, Vol. 59, No. 2, pp. 133–137.) "A solution is given for the fields of a circular loop in a conducting medium. The loop is assumed to have a uniform current, and it is enclosed by a spherical insulating cavity. The impedance of the loop is also considered. It is shown that the power radiated from the loop varies approximately as the reciprocal of the radius of the cavity for a specified loop current. Furthermore, if the cavity is electrically small, relative to the external medium, the radiation field is not significantly affected by the presence of the cavity." See also 39 of 1953.

621.396.677.43 **3394**

The Development of Rhombic Short-Wave Aerials for Wide-Band Radiation.—M. Jacob. (*Bull. schweiz. elektrotech. Ver.*, 27th April 1957, Vol. 48, No. 9, pp. 422–428, 445.) Design curves and a nomogram are given and their use explained by examples.

621.396.677.71 **3395**

Slotted-Cylinder Antenna with a Dielectric Coating.—J. R. Wait & W. Mientka. (*J. Res. nat. Bur. Stand.*, June 1957, Vol. 58, No. 6, pp. 287–296.) "Analysis is presented for the fields produced by an arbitrary slot on a circular cylinder which has a concentric dielectric coating. Expressions for the far-zone fields are developed by evaluating the appropriate integrals using a saddle-point method. Numerical results are presented for the case of a narrow axial slot for a range of values of cylinder diameters and electrical constants of the dielectric coating. There is some evidence that the coating provides a trap or a duct for surface waves, resulting in an increase of over-all amplitude of the field in the backward direction."

621.396.677.71 : 621.398 : 621.396.934 **3396**

Beacon Antennas for Guided Missiles.—W. E. Barrick & D. L. Brannon. (*Electronics*, 1st March 1957, Vol. 30, No. 3, pp. 166–168.) S-band and X-band aerial arrays consisting of three elements, equally spaced and circumferentially mounted on the missile, are fed in phase with polarization parallel to the missile axis. Three elements appear to be more satisfactory than a higher number.

621.396.677.8 **3397**

Directional Aerials with Apertures of Special Shape.—G. F. Koch. (*Nachrichtentech. Z.*, April 1957, Vol. 10, No. 4, pp. 175–186.) Side lobes of radiation can be reduced by using apertures of special shape (see also 936 of 1955). Rhombic reflectors are discussed as an example of uniformly illuminated radiator, and radiation patterns for perpendicular and oblique incidence are calculated. Nonuniformly illuminated

World Radio History

apertures of paraboloidal reflectors bounded by cosine curves are also considered. Special reflectors of German manufacture are illustrated.

621.396.677.83 **3398**

Influence of a Dielectric Layer on the Reflecting Properties of a Nonsolid Reflector.—V. G. Yampol'ski. (*Radiotekhnika, Moscow*, Feb. 1957, Vol. 12, No. 2, pp. 59–64.) A theoretical investigation is made of the field distribution at a mesh-type perforated reflector showing that the reflecting properties are reduced by a covering dielectric layer, such as ice.

AUTOMATIC COMPUTERS

681.142 **3399**

The Development of a Business Computer System.—A. St. Johnston & S. L. H. Clarke. (*J. Brit. Instn Radio Engrs*, July 1957, Vol. 17, No. 7, pp. 351–364.) Describes the Elliott 405 system, incorporating a 1·6-ms nickel delay line and a new type of store using 35-mm film coated with magnetic oxide.

681.142 **3400**

LACE (The Luton Automatic Computing Engine).—(*Electronic Engng*, July & Aug. 1957, Vol. 29, Nos. 353 & 354, pp. 306–312 & 380–385.)

Part 1.—R. J. Gomperts & D. W. Righton. The general-purpose analogue computer in operation at the Guided Weapons Division of the English Electric Company was designed to have a high utilization and growth factor. Four separate units called 'bricks' are available which may be operated in combination or separately.

Part 2.—J. C. Jones & D. Readshaw. A description of (*a*) an electronic multiplier and (*b*) an electronic general-purpose function generator developed for use with LACE.

681.142 **3401**

The 'Metrovick 950' Digital Computer.—R. M. Foulkes. (*Metrop. Vick. Gaz.*, May 1957, Vol. 28, No. 454, pp. 111–117.) The computer is a medium-speed general-purpose binary machine designed for application to mathematical and scientific problems. The first model was completed in July 1956. Transistors are used in the computing circuits and thermionic valves in the circuits for writing on the magnetic storage drum. The method of operation of the transistors is that described by Chaplin (see 36 of 1955).

681.142 **3402**

Electronic Computer Study of English Syntax Patterns.—(*Tech. News Bull. nat. Bur. Stand.*, June 1957, Vol. 41, No. 6, pp. 84–86.) Report of an exploratory study for data processing purposes.

681.142 **3403**

Typed Figures Translated into Computer Code: High-Speed Reading by Electric Automaton.—(*Engineering, Lond.*, 15th March 1957, Vol. 183, No. 4749, pp. 348–349.) Description of a pilot model of the electronic reading automaton (ERA). A flying-spot scanning system provides 100 bits for the recognition of each typed figure. The use of many redundant bits ensures that minor defects in typescript do not affect the accuracy of the information supplied to the computer.

681.142 : 537.226/.227 : 546.431.824-31 **3404**

Barium Titanate and its Use as a Memory Store.—Campbell. (See 3501.)

681.142 : 621.039 **3405**

The Place of Analogue Computers in Reactor Control.—J. Walker. (*J. Electronics Control*, July 1957, Vol. 3, No. 1, pp. 125–136.)

681.142 : 621.314.7 **3406**

Computer Delay Unit uses Semiconductors.—W. A. Scism. (*Electronics*, 1st July 1957, Vol. 30, No. 7, p. 173.) Three point - contact - transistor multivibrators are cascaded to provide a delay of 40 μs per stage.

681.142 : 621.374.32 : 621.314.7 **3407**

Basic Logic Circuits for Computer Applications.—G. W. Booth & T. P. Bothwell. (*Electronics*, 1st March 1957, Vol. 30, No. 3, pp. 196–200.) "Digital computer circuits, including flip-flop, gated pulse amplifier, d.c. amplifier, power amplifier and indicator, use high-frequency junction transistors to obtain high reliability and performance characteristics. Circuits operate over temperature range of −30° to +60°C; their low dissipation imposes minimum requirements on power supplies and cooling."

681.142 : 621.394.3 **3408**

Morse-to-Teleprinter Code Converter.—W. R. Smith-Vaniz & E. T. Barrett. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 154–158.) An analogue-digital computer converting international Morse-code signals into standard five-digit teleprinter code.

681.142 : 681.176 **3409**

Computer Selects Premium Bond Winners.—R. K. Hayward, E. L. Bubb & H. W. Fensom. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 138–143.) A description of the electronic random number indicating equipment (ERNIE) used to print a list of purely random bond numbers. See also *P.O. elect. Engrs' J.*, April 1957, Vol. 50, No. 1, pp. 1–6 (Hayward & Bubb).

681.142 **3410**

Electronic Computers. [Book Review]—T. E. Ivall (Ed.). Publishers: Iliffe & Sons, London, and Philosophical Library, New York, 1956, 167 pp., 25s. (*Nature, Lond.*, 1st June 1957, Vol. 179, No. 4570, p. 1095.) A nonmathematical introduction to the principles and applications of digital and analogue computers.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.012 : [621.3.015.3 + 621.3.018.4 **3411**

Approximate Method for Determining the Relation between Frequency- and Transient-Response Characteristics in Radio Circuits.—S. N. Krize. (*Elektrosvyaz*, Jan. 1957, No. 1, pp. 11–16.) The analysis is based on an approximate evaluation of the Fourier integral. Experimental results are given.

621.318.5 : [681.142 + 621.316.7 **3412**

A Method of Synthesis of Computing and Control Switching Circuits.—G. N. Povarov. (*Avtomatika i Telemekhanika*, Feb. 1957, Vol. 18, No. 2, pp. 145–162.) The method described is applicable to bridge-type multiple switching circuits, and particularly to symmetrical circuits. Illustrative examples are given. See also 1351 of May.

621.318.57 : 621.3.042 **3413**

Multihole Ferrite Core Configurations and Applications.—H. W. Abbott & J. J. Suran. (*Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1081–1093.) Describes applications to gating, memory storage, and miscellaneous switching. With suitable equipment, operation over a temperature range of −50°C to +200°C is possible.

621.318.57 : 621.314.63 **3414**

Fast Switching by Use of Avalanche Phenomena in Junction Diodes.—Salzburg & Sard. (See 3682.)

621.318.57 : 621.314.7 **3415**

Boosting Transistor Switching Speed.—R. H. Baker. (*Electronics*, 1st March 1957, Vol. 30, No. 3, pp. 190–193.) The advantages of combining *p-n-p* and *n-p-n* transistors and other switching circuit improvements are briefly outlined.

621.318.57 : 621.387 **3416**

Counters and Control Circuits with Coincidence Thyratrons.—L. Hartmuth. (*Nachrichtentech. Z.*, March 1957, Vol. 10, No. 3, pp. 141–144.) The application of the thyratron Type ST80T is briefly discussed.

621.372.44 : 621.314.26 **3417**

Frequency Conversion with Nonlinear Reactance.—C. H. Page. (*J. Res. nat. Bur. Stand.*, May 1957, Vol. 58, No. 5, pp. 227–236.) "A lossless nonlinear impedance subject to an almost periodic voltage (sum of sinusoids) will absorb power at some frequencies and supply power at other frequencies. Necessary and sufficient relations among these powers are found. It is shown that simple cubic capacitors ($Q \propto V^3$) are sufficient for producing any possible conservative modulation or distortion process." See also 2978 of 1956.

621.372.5 **3418**

The Ideal Power Transformer—a New Element in Electric Circuits.—E. V. Zelyakh. (*Elektrosvyaz*, Jan. 1957, No.

World Radio History

1, pp. 35–47.) The quadripole discussed maintains the voltage ratio equal to the current ratio irrespective of the load. Its application to transistor amplifiers is described.

621.372.5 **3419**

Exact Electronic Integration.—H. Wittke. (*Elektronische Rundschau*, March 1957, Vol. 11, No. 3, pp. 73–74.) The improvement of integrating *RC* quadripoles by the addition of a feedback amplifier is discussed. See also 3060 of October.

621.372.5.012 **3420**

***RC* Network Analogue.**—A. K. Choudhury & B. R. Nag. (*Indian J. Phys.*, March 1957, Vol. 31, No. 3, pp. 121–134.) "An *RC* analogue for obtaining the steady state and transient response of networks is described. The zeros and poles of the network function are realised by a system of cascade feedback amplifiers, the input and feedback networks of the amplifiers being so arranged that the zeros and poles of the transfer function of the system are identical with those of the network function. The root loci of a few basic networks for the feedback amplifiers have been studied. A method of solving polynomial equations using the analogue is also described."

621.372.5.012 **3421**

Application of Linear Systems to the Filtering of Complex Oscillations.—F. M. Gol'tsman. (*Bull. Acad. Sci. U.R.S.S., sér. géophys.*, May 1957, No. 5, pp. 584–594. In Russian). A method is developed for deriving expressions for the frequency characteristics of physically realizable linear systems, and examples are given of improving the selectivity of the analytical characteristics of low-pass and high-pass filters. The theory of filters for transforming signals in a specified way is considered. Practical details are not discussed.

621.372.54 **3422**

Tables of Frequency Transformation and Band-Pass Filters.—H. Weber & J. Martony. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st April 1957, Vol. 35, No. 4, p. 163.) Correction to 2366 of August: Tables III and V have been reprinted and are enclosed with this issue.

621.372.54 : 621.317.3 **3423**

Filter Circuits for Measurement Purposes.—C. Moerder. (*Arch. tech. Messen*, April, May & July 1957, Nos. 255, 256 & 258, pp. 95–96, 115–118 & 161–164.) Survey of methods used for filter calculations. 18 references.

621.372.54 : 621.317.34 **3424**

Wide-Range Analyser Traces Precise Curves.—Feldman. (See 3590.)

621.372.54 : 621.375.13 **3425**

Feedback Filter with Continuously Variable Cut-Off Frequency.—K. Posel. (*Trans. S. Afr. Inst. elect. Engrs*, Dec. 1956, Vol. 47, Part 12, pp. 373–382.) "A feedback filter employing a parallel-T network in the forward loop of a feedback amplifier is described with a cut-off frequency continuously variable over a range of 2·3 to 1. Theory of operation and design equations are presented." See also 1329 of 1956 (Thiele).

621.372.57 : 621.314.7 **3426**

The Iterative Characteristics of Active Quadripoles and their Equivalent Circuit as Applied to Transistors.—C. Kurth. (*Frequenz*, April 1957, Vol. 11, No. 4, pp. 107–114.) The representation of the general type of active quadripole in the form of two series-connected ideal active quadripoles, one reciprocal and the other nonreciprocal, is derived by the use of matrix methods. The solution is applied to transistor circuits where account must be taken of the internal coupling between output and input.

621.373.012.3 **3427**

Universal Curves for Electrical Oscillatory Circuits in Dimensionless Form.—A. Frei & M. J. O. Strutt. (*Bull. schweiz. elektrotech. Ver.*, 16th March 1957, Vol. 48, No. 6, pp. 233–235.) The derivation and application of such curves are briefly outlined.

621.373.4 : 621.385.029.63 **3428**

On Multimode Oscillators with Constant Time Delay.—V. Met. (*Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1119–1128.) A discussion and analysis of high-speed switchable bistable oscillators, analogous to multivibrators. Graphical methods are used to demonstrate switching and threshold phenomena. In an experimental S-band system incorporating a travelling-wave valve, two modes at 2 790 and 2 985 Mc/s could be established, with a switching time of 7 mμs.

621.373.42.029.42 **3429**

A Very-Low-Frequency Three-Phase Oscillator.—M. D. Armitage. (*Electronic Engng*, July 1957, Vol. 29, No. 353, pp. 318–323.) A cathode feedback circuit to increase the time constant of the *RC* networks in a phase-shift oscillator is discussed. A complete oscillator for the frequency range 0·01–40 c/s is described. Nonlinear resistors are incorporated in the anode loads for amplitude limiting. A three-phase output of 150 V peak-to-peak per phase is obtainable with total distortion about 1%.

621.373.421 : 517.43 **3430**

The Periodic Solutions of the Differential Equation of a Resistance-Capacitance Oscillator.—A. W. Gillies. (*Quart. J. Mech. appl. Math.*, Feb. 1957, Vol. 10, Part 1, pp. 101–121.) "The equation is normalized to the form

$$\left\{(D^2+1)\left(D+\frac{\sqrt{6}}{5}\right)\epsilon D^3\right\}x + g(D)\sum_{n=2} c_n\mu^{n-1}x^n = g(D)2B\cos\omega t,$$

where ϵ and μ are small parameters which in the main part of the discussion are related by $\epsilon = \mu^2$, and $g(D)$ is a particular polynominal operator of the third degree. The procedure previously applied to a second-order equation with unsymmetrical nonlinear damping, is used to obtain the periodic solutions having the period of the forcing term when ω is near to 1, i.e. for the case of fundamental resonance."

621.373.421.11.076.12 : 621.316.86 **3431**

New Method of Temperature Compensation for Oscillator Circuits.—F. Müller. (*Elektronische Rundschau*, March 1957, Vol. 11, No. 3, pp. 68–73.) The experimental circuit described uses a thermistor as temperature-dependent device in conjunction with a reactance valve which converts resistance changes into compensating changes of *L* or *C*. Some recorded measurements, possible applications and modifications are discussed.

621.373.52 : 621.314.7 **3432**

Transistor Oscillator Performance.—M. R. E. Bichara. (*Nuovo Cim.*, 1st March 1957, Vol. 5, No. 3, pp. 702–706.) The frequency stability of two crystal-bridge-controlled transistor oscillators was examined. One, operating at 350 kc/s (see also 3203 of 1955) had its stability improved ten-fold to within 0·000 57% by stabilizing its input voltage; the other, using different types of transistor and crystal, had a stability within ±0·001 07% at 100 kc/s.

621.373.52 : 621.314.7 **3433**

Transistor Oscillator Stability.—M. G. Scroggie. (*Wireless World*, Sept. 1957, Vol. 63, No. 9, pp. 443–444.) Describes simple drift tests against the London Light Programme (1 214 kc/s). The superiority of the Gouriet circuit is demonstrated, a temperature coefficient of −50 in 10^6/°C being obtained.

621.374.32 : 53.087 **3434**

Automatic Counting Techniques applied to Comparison Measurement.—C. C. H. Washtell. (*J. Brit. Instn Radio Engrs*, July 1957, Vol. 17, No. 7, pp. 397–402.) A gated dekatron chain and associated equipment print the ratio counts of two independent pulse sources.

621.374.32 : 621.387.4 **3435**

A Fast Kicksorter Channel.—R. D. Amado & R. Wilson. (*J. sci. Instrum.*, May 1957, Vol. 34, No. 5, pp. 205–206.) A single-channel instrument which responds to pulses of 10^{-8} sec duration.

621.374.32 : 621.387.4 **3436**

A Multichannel Analyser using a Rectifier Matrix for Channel Selection.—P. K. Patwardhan. (*J. sci. industr. Res.*, Oct. 1956, Vol. 15A, No. 10, pp. 439–443.) Description of a pulse-height analyser using Type-5687 high-current-capacity valves as buffer amplifiers, which gives a 1 : 3 voltage discrimination between the selected and the nonselected signal.

621.374.32 : 621.387.4 **3437**

Improvements on a Multichannel Pulse Analyser.—S. Colombo, C. Cottini & E. Gatti. (*Nuovo Cim.*, 1st March 1957, Vol. 5, No. 3, pp. 748–750. In English.) For the description of the original analyser, see 2016 of 1954 (Gatti).

World Radio History

621.375.4 : 621.314.7 : 546.28 **3438**

Compensating Silicon Transistor Amplifiers.—S. H. Gordon. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 184–185.) Methods of temperature compensation in i.f. amplifiers using impedance mismatch, feedback, and thermistors.

621.375.9 : 538.569.4.029.6 **3439**

Inherent Noise of Quantum-Mechanical Amplifiers.—Strandberg. (See 3460.)

GENERAL PHYSICS

535.13 : 531.51 **3440**

Influence of the Force of Gravity on the Propagation of Light.—G. V. Skrotski. (*C. R. Acad. Sci. U.R.S.S.*, 1st May 1957, Vol. 114, No. 1, pp. 73–76. In Russian.)

537/538 **3441**

A New Formulation on the Electromagnetic Field.—T. Ohmura. (*Progr. theor. Phys.*, Dec. 1956, Vol. 16, No. 6, pp. 684–685.) By introducing new scalar and pseudo-scalar fields and a pseudo-vector magnetic current, a set of equations for an e.m. field is combined into a single equation of form similar to the Dirac equation for the electron.

537/538 **3442**

Stability of the Electron.—T. Ohmura. (*Progr. theor. Phys.*, Dec. 1956, Vol. 16, No. 6, pp. 685–686.)

537.212 : 621.38.032.24 **3443**

Electrostatic Field of a Conducting Grid with Square Mesh.—B. Ya. Moizhes. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 147–155.) An approximate solution for the electrostatic problem of a mesh of thin cylindrical wires is given. The cylinders are replaced by charged wires and an integral equation for the charge density is derived. The equipotential surface of the approximate solution coincides nearly everywhere with the cylinder surface.

537.228 : 538.63 **3444**

Behaviour of an Electron in a Periodic Electric and Uniform Magnetic Field: Part 1.—G. E. Zil'berman. (*Zh. eksp. teor. Fiz.*, Feb. 1957, Vol. 32, No. 2, pp. 296–304.) The equation of motion of an electron in a weak magnetic field is determined. The broadening of the discrete electron energy levels in a crystal in a magnetic field is considered.

537.523 **3445**

Glow-Arc Transition in Current-Stabilized Electrical Discharges.—J. Jenkins & T. B. Jones. (*J. appl. Phys.*, June 1957, Vol. 28, No. 6, pp. 663–668.) Accurate measurements in the unstable transition region were made possible by the use of a current-stabilized power supply and instrumentation for making voltage measurements in 0·02 μsec. Transitions can occur in argon at atmospheric pressure for currents between 0·002 A and at least 1 A. At low currents an oxide film must be present on the cathode.

537.525 : 535.61-15 **3446**

Infrared Emission from High-Frequency Discharges in CO_2.—D. Cohen, R. Lowe & J. Hampson. (*J. appl. Phys.*, June 1957, Vol. 28, No. 6, pp. 737–741.) The radiation was measured near 2·7 μ and 4·3 μ in a discharge driven by external electrodes at 10 Mc/s at a pulse recurrence frequency of 5–30 c/s. The dependence of the emission on pressure and power were studied together with other characteristics of the discharges.

537.525.08 : 538.566.029.6 **3447**

Microwave Measurements of the Properties of a D.C. Hydrogen Discharge.—B. J. Udelson, J. E. Creedon & J. C. French. (*J. appl. Phys.*, June 1957, Vol. 28, No. 6, pp. 717–723.) The measurements were made by exposing thin cross-sectional elements of the discharge in the gap between the cones of an S-band re-entrant cavity magnetron operating in the TM_{010} mode. The variation of electron density with tube current and gas pressure is discussed and also electron collision frequencies.

537.533 : 061.3 **3448**

Exo-electrons.—(*Acta phys. austriaca*, March 1957, Vol. 10, No. 4, pp. 313–480.) Texts of 17 papers presented at the conference of the Austrian Physical Society held in Innsbruck on 10th-11th September 1956.

537.533.8 **3449**

On the Theory of Secondary Emission of Metals.—J. L. H. Jonker. (*Philips Res. Rep.*, June 1957, Vol. 12, No. 3, pp. 249–258.) The angular distribution of secondary emission of Ni has been measured for small energy intervals. An explanation is given for this distribution following a cosine law.

537.56 : 538.56 **3450**

Plasma Acceleration by a Magnetic Field.—A. I. Morozov. (*Zh. eksp. teor. Fiz.*, Feb. 1957, Vol. 32, No. 2, pp. 305–310.) The motion of ions and electrons is investigated assuming collisions, magnetic interaction of the particles and wave excitation to be negligible. A critical charge density appears to exist in this case.

537.56 : 538.56 **3451**

Pulsations of String-Like Plasma.—A. G. Kulikovski. (*C. R. Acad. Sci. U.R.S.S.*, 11th June 1957, Vol. 114, No. 5, pp. 984–987. In Russian.) The uniform axially symmetric movements of an unbounded gas with infinite conductivity are examined and equations are derived. A cylinder of finite length and radius is considered with ends in conducting material and with a pressure on its side equal to its internal pressure.

537.56 : 538.6 **3452**

Experimental Study of Plasmoids.—W. H. Bostick. (*Phys. Rev.*, 1st May 1957, Vol. 106, No. 3, pp. 404–412.) By firing several plasmoids simultaneously across a magnetic field, it is possible to simulate in geometrical form the production of spiral galaxies and barred spirals.

537.56 : 538.63 **3453**

Conditions of Discharge in an Electromagnetic Cavity and Progressive Waves in Lorentz-Type Plasmas.—R. Jancel & T. Kahan. (*C. R. Acad. Sci., Paris*, 24th June, 1957, Vol. 244, No. 24, pp. 2894–2896.) Application of theory developed previously (3104 of October and back references).

538.24 **3454**

Calculation of the Magnetization of a Prism at Constant Susceptibility.—E. N. Mokhova. (*Bull. Acad. Sci. U.R.S.S. sér. géophys.*, May 1957, No. 5, pp. 680–682. In Russian.) The demagnetization coefficient for an inductively magnetized prism is calculated making simplifying assumptions for the measurement of the intensity of magnetization by the ballistic method.

538.3 **3455**

Nonlinear Electromagnetism and Photons. — F. Destouches-Aeschlimann. (*C. R. Acad. Sci., Paris*, 17th June 1957, Vol. 244, No. 25, pp. 3034–3036.)

538.566 : 535.42 **3456**

The Diffraction of a Dipole Field by a Half-Plane.—B. D. Woods. (*Quart. J. Mech. appl. Math.*, Feb. 1957, Vol. 10, Part 1, pp. 90–100.) A perfectly conducting half-plane is assumed. Solutions for arbitrary orientations of the dipole are determined by extending a method due to Bromwich, which was based on the solution of a scalar problem and valid only when the axis of the dipole is parallel to the edge of a screen. Results are given for an electric dipole with its axis normal to the screen and for an electric dipole with its axis normal to the edge of the screen and lying in a plane parallel to the screen.

538.566 : 535.42 **3457**

A Note on the Diffraction of a Dipole Field by a Half-Plane.—W. E. Williams. (*Quart. J. Mech. appl. Math.*, May 1957, Vol. 10, Part 2, pp. 210–213.) "A simple compact solution is given for the diffraction of the field of a dipole by a perfectly conducting half-plane." See also 3456 above.

538.569.4 **3458**

High-Stability Nuclear Magnetic Resonance Spectrograph.—E. B. Baker & L. W. Burd. (*Rev. sci. Instrum.*, May 1957, Vol. 28, No. 5, pp. 313–321.) Feedback of the error signal from a secondary nuclear resonance probe controls the oscillator driving frequency.

538.569.4.029.6 : 535.33 **3459**

Submillimetre-Wave Spectroscopy: Rotation-Inversion Transitions in ND_3.—G. Erlandsson & W. Gordy. (*Phys. Rev.*, 1st May 1957, Vol. 106, No. 3, pp. 513–515.) Measurement of the $J = 0 \rightarrow 1$ rotational transition of $^{14}ND_3$ at a wavelength of 0·97 mm.

538.569.4.029.6 : 621.375.9 **3460**

Inherent Noise of Quantum-Mechanical Amplifiers.—M. W. P.

World Radio History

Strandberg. (*Phys. Rev.*, 15th May 1957, Vol. 106, No. 4, pp. 617–620.) The noise figure or limiting sensitivity is derived. See also 1036 of April.

538.6 **3461**

Radiation in Anisotropic Media.—F. V. Bunkin. (*Zh. eksp. teor. Fiz.*, Feb. 1957, Vol. 32, No. 2, pp. 338–346.) A general solution is derived for the problem of a field produced by a given current distribution in an infinite homogeneous medium of arbitrary anisotropy. The radiation field is expanded into multipoles and the radiation of a dipole in a magneto-active medium is also examined.

538.65 **3462**

Oscillations of an Infinite Self-Gravitating Cylinder of Gas in a Magnetic Field.—I. M. Yavorskaya. (*C. R. Acad. Sci. U.R.S.S.*, 11th June 1957, Vol. 114, No. 5, pp. 988–990. In Russian.) The problem of radial movements of a gas of cylindrical shape under a strong gravitational force and an internal magnetic field is considered.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.16 **3463**

New Observation of Cosmic Radiation at a Wavelength of 33 cm.—J. F. Denisse, J. Lequeux & É. Le Roux. (*C. R. Acad. Sci., Paris*, 17th June 1957, Vol. 244, No. 25, pp. 3030–3033.) Continuation of previous work (1635 of 1955). Some further localized sources are mentioned. One of these is thought to correspond with the supernova of 1572. Outside the galactic-plane regions no detectable variation in radiation was observed.

523.165 : 550.385 **3464**

27-Day Recurrence Tendency in the Daily Variation of Cosmic Ray Meson Intensity.—R. P. Kane. (*Proc. nat. Inst. Sci. India, A*, 26th Nov. 1956, Vol. 22, No. 6, pp. 398–407.) Analysis of data for Huancayo for the period 1937–1945.

523.745 : 550.385 **3465**

On the Origin of the Long-Lived Solar Corpuscular Streams which Appeared Last Solar Cycle, 1950 to 1953.—K. Sinno. (*J. Radio Res. Labs, Japan*, Jan. 1957, Vol. 4, No. 15, pp. 25–35.) A statistical study of the recurrence tendency of geomagnetic activity and coronal intensity.

523.75 : 621.396.822 : 523.16 **3466**

Solar-Flare Detection for I.G.Y.—R. H. Lee. (*Electronics*, 1st March 1957, Vol. 30, No. 3, pp. 162–165.) A 27-kc/s receiver records the sudden enhancements of atmospheric radio noise which accompany flares, while an 18-Mc/s receiver records the simultaneous decrease in cosmic noise due to D-layer absorption. Both receivers have special circuits designed to reject unwanted signals of different kinds. Time-sharing between the two receivers is used and the outputs appear on a pen recorder.

550.3 **3467**

A Transient Magnetic Dipole Source above a Two-Layer Earth.—J. S. Lowndes. (*Quart. J. Mech. appl. Math.*, Feb. 1957, Vol. 10, Part 1, pp. 79–89.) "The problem of a magnetic dipole acting as a transient current source when situated over a two-layer earth is considered by using the methods of integral transforms. The general expressions have been applied to deduce the induced field at the surface of the earth when the dipole is located on the surface, in the cases when the earth has homogeneous conductivity, and when the conductivities of the two layers are nearly equal." See also 413 of 1956 (Bhattacharyya).

550.38 **3468**

Electromagnetic Induction in Rotating Conductors.—A. Herzenberg & F. J. Lowes. (*Phil. Trans. A.*, 16th May 1957, Vol. 249, No. 970, pp. 507–584.) An experimental and theoretical investigation of induction in a rotating conductor surrounded by a rigid conductor of finite or infinite extent. The results are applied to a discussion of induction in rotating eddies in the fluid core of the earth as a possible origin of the geomagnetic non-dipole field.

551.510.52 : [621.396.11 + 535.325 **3469**

Relation of Radio Measurements to the Spectrum of Tropospheric Dielectric Fluctuations.—A. D. Wheelon. (*J. appl. Phys.*, June 1957, Vol. 28, No. 6, pp. 684–693.) The size spectrum of isotropic fluctuations is related to quantities which can be directly measured by radio techniques. Two types of experiment are analysed: (*a*) line-of-sight phase and amplitude instability, (*b*) refractometer measurements of dielectric fluctuations.

551.510.535 **3470**

A Statistical Distribution arising in the Study of the Ionosphere.—M. S. Longuet-Higgins. (*Proc. phys. Soc.*, 1st June 1957, Vol. 70, No. 450 B, pp. 559–565.) "An approximate distribution is deduced for the directions of the 'lines of maxima' on a random surface. The theoretical distribution is found to be in good agreement with some experimental results obtained previously by Briggs and Page [755 of 1956]."

551.510.535 **3471**

Sporadic Ionization in the E Region of the Ionosphere at Medium Latitudes.—W. Becker. (*Arch. elekt. Übertragung*, March 1957, Vol. 11, No. 3, pp. 101–104.) With reference to the recommendations made by the Special Committee of U.R.S.I. on World-Wide Ionospheric Soundings the more detailed classification of E_s layers by type and height is proposed. An analysis of records taken at Lindau shows at least five different causes for sporadic ionization.

551.510.535 **3472**

Effect of the *Sq* Current System on the Ionospheric E and F_1 Regions.—T. Shimazaki. (*J. Radio Res. Labs, Japan*, Jan. 1957, Vol. 4, No. 15, pp. 37–48.) Departures from the diurnal variation in electron density predicted from Chapman's theory are discussed. They are due to vertical motion caused by a combination of the *Sq* current and the geomagnetic field. Gradients in scale-height and recombination coefficient are considered.

551.510.535 **3473**

A New Theory of Formation of the F_2 Layer: Part 2–The Effect of the Vertical Movement of Electrons and Ions on the Electron Density Distribution.—T. Yonezawa. (*J. Radio Res. Labs, Japan*, Jan. 1957, Vol. 4, No. 15, pp. 1–14.) The vertical velocity is assumed to increase with height in inverse proportion to the molecular density. Solutions of the resulting equation are considered and typical data given for the height and electron density of the F_2 layer. Part 1: 3049 of 1956.

551.510.535 **3474**

On Differences of f_0F_2 between June and December viewed from a World-wide Standpoint.—M. Mambo. (*J. Radio Res. Labs, Japan*, Jan. 1957, Vol. 4, No. 15, pp. 59–71.)

551.510.535 : 523.745 **3475**

Relationship between the Semi-thickness of F_2 Layer at Tokyo and Solar Activity.—I. Kasuya. (*J. Radio Res. Labs, Japan*, Jan. 1957, Vol. 4, No. 15, pp. 49–57.)

551.510.535 : 621.396.11 **3476**

The Proceedings of the International Convention on Radio Propagation in the Ionosphere.—(See 3628.)

551.571 **3477**

Heterogeneity in the Measurements of Humidity Made by the Radiosonde Network of Europe.—A. H. Hooper. (*Met. Mag., Lond.*, Jan. 1957, Vol. 86, No. 1015, pp. 13–21.) Discrepancies in the observations made by stations of the network are examined in respect of magnitude and speed of response to low-level moisture discontinuities of large magnitude. The likely causes are differences in the instruments and techniques used.

551.594 : 621.375.13 **3478**

Measuring Corona from Radioactive Point.—R. W. Hendrick, Jr, F. C. Martin & S. Chapman. (*Electronics*, 1st March 1957, Vol. 30, No. 3, pp. 172–173.) The amplifier described has logarithmic response and is used in conjunction with a radioactive corona point for atmospheric measurements in fair or disturbed weather.

551.594.21 **3479**

Leader Stroke Current in a Lightning Discharge According to the Streamer Theory.—S. R. Khastgir. (*Phys. Rev.*, 15th May 1957, Vol. 106, No. 4, pp. 616–617.) A value is derived for the pilot leader current which is consistent with the observed electrostatic field change.

551.594.6 : 621.317.3 **3480**

Amplitude Probability Distribution of Atmospheric Noise on 10 Mc/s.—T. Ishida & M. Higashimura. (*J. Radio Res. Labs, Japan*, Jan. 1957, Vol. 4, No. 15, pp. 73–75.) See also 3135 of 1956 (Yuhara et al.).

World Radio History

LOCATION AND AIDS TO NAVIGATION

621.396.932 **3481**

One Year's Trials of a Surveillance Radar Installation for Marine Traffic Control at Bremerhaven.—G. Wiedemann, H. Schellhoss & H. Bruckmann. (*Nachrichtentech. Z.*, March 1957, Vol. 10, No. 3, pp. 125–134.)

621.396.933.2 **3482**

Correlation and Phase Methods of Direction Finding.—N. F. Barber. (*N.Z. J. Sci. Tech. B*, March 1957, Vol. 38, No. 5, pp. 416–424.) A comparison of the two methods shows that their resolving powers are equal and their relative merits depend on the conditions of their application.

621.396.96 : 621.318.57 **3483**

Problems in Protection of Radar Receivers.—G. D. Speake. (*Electronic Engng*, July 1957, Vol. 29, No. 353, pp. 313–317.) "The protection of a radio receiver from damage caused either by the associated system transmitter or from external sources is discussed. The main emphasis is placed on t.r. devices based on a gas discharge, and the advantages and limitations of these components are outlined. The use of other forms of protection, based for example on ferrites, and of travelling wave tubes as receiver components capable of withstanding relatively high pulse powers is briefly described."

621.396.963.3 : 621.318.57 **3484**

A Precision Electronic Switch for Fixed Coil Radar Displays.—A. P. Young & D. H. Chandler. (*Marconi Rev.*, 3rd Quarter 1957, Vol. 20, No. 126, pp. 94–103.) In designing a switching circuit to maintain an accurate correlation between operator-controlled marker positions and radar timebase, residual current in the valves causes imperfections in switching action and limits the performance of a capacitor store used to counteract d.c. drift. These effects are overcome (*a*) by modifying the basic switching circuit so that an alternative source supplies the residual current, and (*b*) by using a nonlinear SiC resistor in an improved type of storage circuit.

621.396.969.3 **3485**

Helical Scan Nomograph.—C. W. Wood. (*Electronics*, 1st July 1957, Vol. 30, No. 7, p. 186.)

MATERIALS AND SUBSIDIARY TECHNIQUES

535.215+535.376] : 537.311.33 **3486**

Theory of Dynamic Quenching of Photoconductivity and Luminescence.—F. Matossi. (*J. electrochem. Soc.*, Dec. 1956, Vol. 103, No. 12, pp. 662–667.) A mathematical description of the dependence of quenching effects on time in terms of a simplified model of the energy levels and transitions in a semiconductor. Good agreement with experimental results for conductivity quenching in CdS is shown.

535.215 : 546.321.51 **3487**

Photoelectric Emission from Single-Crystal KI.—H. R. Philipp & E. A. Taft. (*Phys. Rev.*, 15th May 1957, Vol. 106, No. 4, pp. 671–673.)

535.215 : 546.47-31 **3488**

Influence of Impurities on the Photoconductance of Zinc Oxide.—H. A. Papazian, P. A. Flinn & D. Trivich. (*J. electrochem. Soc.*, Feb. 1957, Vol. 104, No. 2, pp. 84–92.) "The photoconductance of pure ZnO and ZnO with known impurities, both in powder form, has been measured using a condenser method. When irradiated by light, ZnO undergoes a 'memory mechanism' which depends on the past irradiation history. It is suggested that the memory is caused by formation of traps independent of charge-carrier formation. The concentration of traps is a function of impurity concentration and temperature."

535.215 : 546.482.21 **3489**

Hydrothermal Syntheses of Photoconductive Cadmium Sulphide.—A. Kremheller & A. K. Levine. (*J. appl. Phys.*, June 1957, Vol. 28, No. 6, pp. 746–747.)

535.215 : 546.482.21 **3490**

Primary Photocurrent in Cadmium Sulphide.—P. J. van Heerden. (*Phys. Rev.*, 1st May 1957, Vol. 106, No. 3, pp. 468–473.) Excitation by light flashes and by α particles produced primary photocurrent of both electrons and holes.

535.215 : 546.482.21 **3491**

Absorption of Light by CdS Crystals.—V. L. Broude, V. V. Ermenko & E. I. Rashba. (*C. R. Acad. Sci. U.R.S.S.*, 21st May 1957, Vol. 114, No. 3, pp. 520–523. In Russian.) The luminescence of CdS at 20·4° K was investigated on samples 1–100 μ thick and with differing surface finishes; 10 absorption lines were found in the range 4 875–4 920 Å.

535.215 : 546.482.21 : 539.166 **3492**

Preparation of High-Sensitivity Cadmium Sulphide Cells for Gamma-Ray Detection.—L. E. Hollander, Jr. (*Rev. sci. Instrum.*, May 1957, Vol. 28, No. 5, pp. 322–323.)

535.243 : 546.482.21 **3493**

Line Spectrum of the Absorption Edge and Structure of Cadmium Sulphide Crystals.—E. F. Gross, B. S. Razbyrin & M. A. Yakobson. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 207–209.) Measurements were made at 4°K and lines of λ=4 817, 4 816 and 4 815 Å were found. See also 3270 of 1955 (Gross & Yakobson).

535.37 : 539.234 **3494**

Formation of Luminescent Films by Evaporation.—C. Feldman & M. O'Hara. (*J. opt. Soc. Amer.*, April 1957, Vol. 47, No. 4, pp. 300–305.) Luminescent films of ZnS-Mn, Zn_2SiO_4-Mn, $Zn_2(PO_4)_3$-Mn, CaF_2-Mn, and $CaWO_4$-W have been formed by evaporation in vacuum and subsequent heat treatment. The luminescence brightness of fogged films, under cathode-ray excitation, approaches that of the powdered phosphors. Zn_2SiO_4-Mn films show most promise in respect of brightness and transparency. See also 444 of 1956 (Studer & Cusano).

535.37 : 546.791 **3495**

The Luminescence of Trivalent Uranium.—L. N. Galkin & P. P. Feofilov. (*C. R. Acad. Sci. U.R.S.S.*, 1st June 1957, Vol. 114, No. 4, pp. 745–747. In Russian.) An investigation of CaF_2-U, SrF_2-U, and BaF_2-U with a uranium content of 0·1–0·3% showed that these substances exhibit strong luminescence in the infrared region.

535.376 **3496**

Contact Electroluminescence.—W. Lehmann. (*J. electrochem. Soc.*, Jan. 1957, Vol. 104, No. 1, pp. 45–50.) "Many powdered crystal phosphors which are normally non-electroluminescent become electroluminescent if they are simply mechanically mixed with suitable powdered metals, or with some nonmetals of good electrical conductivity. The conclusion is drawn, and supported by many facts, that ordinary electroluminescence in powdered phosphors excited by an alternating electric field (Destriau effect) is also due to substances of relatively high conductivity incorporated as small segregations within the essentially insulating phosphor particles."

535.376 **3497**

The Light Output of some Phosphors Excited with Electrons of High Current Density.—P. A. Einstein. (*Brit. J. appl. Phys.*, May 1957, Vol. 8, No. 5, pp. 190–194.) Equipment is described for observing the light output with pulse lengths from 30 to 6 000 μs and current densities from 10^{-5} to 2·7 A/cm². The rise and decay time constants generally increase with current density and empirical laws relating these parameters are given.

535.376 : 546.47.273 **3498**

Zinc Borate Phosphors and their Luminescent Properties.—Yu. S. Leonov. (*C. R. Acad. Sci. U.R.S.S.*, 11th June 1957, Vol. 114, No. 5, pp. 976–979. In Russian.) Results of tests on the luminescence of $ZnO.B_2O_3$-Mn, $3ZnO.B_2O_3$-Mn and $ZnO.B_2O_3$ with light of λ=2 537 Å and at temperatures ranging from about 170° to 500°K are summarized in graphical form.

535.376 : 546.472.21 **3499**

Voltage Dependence of Electroluminescence of Powdered Phosphors.—W. Lehmann. (*J. electrochem. Soc.*, Dec. 1956, Vol. 103, No. 12, pp. 667–672.) Report of measurements made on ZnS phosphors (*a*) with applied sinusoidal voltage V up to 600 V at frequencies between about 20 c/s and 50 kc/s, and (*b*) with voltages up to 3 000 V at 60 c/s. The time-average electroluminescent intensity L is found to be in accordance with the equation $L = A \exp[-B/(V+V_0)]$, where A, B and V_0 are constants.

World Radio History

535.376 : 546.472.21 **3500**

Effect of Crystal Disorder on the Electroluminescence of Zinc Sulphide Phosphors.—A. H. McKeag & E. G. Steward. (*J. electrochem. Soc.*, Jan. 1957, Vol. 104, No. 1, pp. 41–45.) "A blue electroluminescent ZnS phosphor was prepared by prefiring precipitated ZnS at a high temperature, activating with Cu, and refiring at about 700°C. The material was characterized by strong pale blue electroluminescence throughout the body of the crystal. The Cu entered most effectively at that temperature of refiring where the transformation from hexagonal to cubic structure occurred most readily." See also 1736 of 1956 (Short et al.).

537.226/.227 : 546.431.824-31 : 681.142 **3501**

Barium Titanate and its Use as a Memory Store.—D. S. Campbell. (*J. Brit. Instn Radio Engrs*, July 1957, Vol. 17, No. 7, pp. 385–395.) A practical 10 × 10 unit can be constructed in a square inch. Properties of the material limit the minimum access time to 10 μs, but transistor drive circuits can be used since large currents are not required.

537.226/.227 : 546.48.882.5 **3502**

Dielectric Studies in the System $CdO-Nb_2O_5$.—A. DeBretteville, Jr, F. A. Halden, T. Vasilos & L. Reed. (*J. Amer. ceram. Soc.*, March 1957, Vol. 40, No. 3, pp. 86–89.) Room-temperature measurements in the paraelectric phase at 21 kMc/s indicate a dielectric constant of 150 with a dissipation factor of less than 0·002 as compared with the high losses of $BaTiO_3$ in this frequency range.

537.226 **3503**

Electrical Conductivity of Ceramic Materials in Strong Electric Fields.—I. E. Balygin & N. T. Plashchinski. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 138–146.) The conductivities of spinel and other ceramic materials for use at radio frequencies were measured and are plotted against temperature.

537.226 : 537.534.9 **3504**

Etching of Dielectrics by Ionic Bombardment.—G. V. Spivak, A. I. Krokhina, T. V. Yavorskaya & Yu. A. Durasova. (*C. R. Acad. Sci. U.R.S.S.*, 11th June 1957, Vol. 114, No. 5, pp. 1001–1003. In Russian.) The ionic bombardment of the surface of quartz, NaCl, $CaCO_3$ and Rochelle salt is described and photographs of the resultant etching are shown.

537.226.8 **3505**

Dependence of the Dielectric Strength of Ionic Crystals on Temperature.—V. D. Kuchin. (*C. R. Acad. Sci. U.R.S.S.*, 11th May 1957, Vol. 114, No. 2, pp. 301–303. In Russian.) The dielectric strength of NaCl, KBr, KCl and KI was measured by an oscillographic method over the range −130° to +150°C for constant applied voltage and for pulses of 10^{-4}–10^{-8} sec.

537.227 : 546.431.811.824-31 **3506**

Research on the Electrostriction of Ferroelectric Ceramics.—T. N. Verbitskaya. (*C. R. Acad. Sci. U.R.S.S.*, 21st May 1957, Vol. 114, No. 3, pp. 533–536. In Russian.) Four solid solutions of Ba (Ti, Sn)O_3 with differing Sn content were investigated. For the samples examined it was found that an increase in Sn content lowered the Curie point from +80° to +25°C. Graphs show the effect of temperature, with and without a d.c. field, on the coefficient of linear expansion and on capacitance.

537.227 : 621.318.57 **3507**

Polarization Reversal and Switching in Guanidinium Aluminium Sulphate Hexahydrate Single Crystals.—H. H. Wieder. (*Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1094–1099.) The substance has lower hysteresis losses and electromechanical activity than barium titanate, and is easier to grow, but at present its use must be limited to low-speed (< 1-kc/s) switching circuits.

537.228.1 : 548.0 **3508**

Piezoelectric Crystal Techniques.—H. O. Koch. (*Frequenz*, Dec. 1956, Vol. 10, No. 12, pp. 373–383, Feb. & March 1957, Vol. 11, Nos. 2 & 3, pp. 53–57 & 72–82.) After a general discussion of piezoelectric properties, methods of measuring piezoelectric constants and of determining flaws in natural crystals and their relation to the aging characteristics of a crystal resonator are surveyed. Details and results of the method of etching in an electric field are given and its application in artificially reducing flaws in quartz crystals is indicated.

537.311.1 + 538.63 + 537.32 + 536.2 **3509**

Electrical Conductivity, Thermal Conductivity, Thermo-e.m.f., Hall Constant and Nernst Constant in Amorphous Bodies with *n*-Type Conductivity.—A. I. Gubanov. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 3–11.) The temperature dependence of kinetic coefficients is calculated for amorphous conductors, taking into account the spherical scattering of electrons.

537.311.31 : 537.311.8 **3510**

Explosion of a Metal due to an Electric Current.—S. V. Lebedev. (*Zh. eksp. teor. Fiz.*, Feb. 1957, Vol. 32, No. 2, pp. 199–207.) The behaviour of metal wires at currents of 5×10^5–5×10^6 A/cm² was investigated.

537.311.33 **3511**

Some Contributions to the Theory of Electrical Conductivity, Thermal Conductivity and Thermoelectric Power in Semiconductors.—J. E. Parrott. (*Proc. phys. Soc.*, 1st June 1957, Vol. 70, No. 450B, pp. 590–607.) It is shown theoretically that the effects of phonon disequilibrium on electron transport phenomena, and of electron disequilibrium on phonon transport phenomena, are most noticeable in thermoelectric effects, but they may also be important in electrical and thermal conduction. The theoretical results show general agreement with experimental data.

537.311.33 **3512**

Radiative Transitions in Semiconductors.—H. J. Bowlden. (*Phys. Rev.*, 1st May 1957, Vol. 106, No. 3, pp. 427–431.) Matrix elements are obtained for radiative intraband, and for allowed and forbidden interband transitions.

537.311.33 **3513**

Field Dependence of Mobility in Semiconductors.—B. V. Paranjape. (*Proc. phys. Soc.*, 1st June 1957, Vol. 70, No. 450B, pp. 628–629.)

537.311.33 **3514**

Electrical Properties of Some Complex Oxide Semiconductors.—B. T. Kolomiets, I. T. Sheftel' & E. V. Kurlina. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 51–72.) Two main types of semiconductors, $CuO-MnO-O_2$ and $CoO-MnO-O_2$, are considered. The influence of composition, microstructure or crystal lattice structure on the conductivity of the material are investigated. The conductivity in vacuum, air or oxygen is also examined.

537.311.33 **3515**

Preparation and Investigation of Intermetallic Compounds in Thin Layers.—V. A. Presnov & V. F. Synorov. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 123–126.) The electrical properties of Al-Sb, In-Sb, Ga-Sb compounds in the form of strips about 10^{-5} cm thick were investigated at pressures down to 10^{-6} mm Hg and the Hall constant was measured in an electromagnetic field of up to 7 000 oersteds. Results are given in graphical form.

537.311.33 : 537.226.2/.3 **3516**

Investigation of Permittivity of Semiconductors.—Z. I. Kir'yashkina, F. M. Popov, D. I. Bilenko & V. I. Kir'yashkin. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 85–89.) The permittivity at cm λ was measured by two different methods. The free-wave method was used for materials such as WO_3, PbO, CuO, SnO_2, Ni_2O_3, ZnO, V_2O_5, Cu_2O, Na_2WO_4 of resistivity above $10^3\,\Omega$.cm, and semiconductors of lower resistivity, such as ZnS, CdS, ZnSe, ZnTe, CdSe, CdTe, HgS, HgSe, HgTe were tested in powder form in a paraffin dielectric. The results obtained are tabulated.

537.311.33 : 537.32 : 621.362 **3517**

Conversion [efficiency] **of Semiconductor Thermocouples.**—L. S. Stil'bans. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 212–213.) A simple expression is derived for the efficiency of semiconductor devices used for heat generation or refrigeration.

537.311.33 : 538.63 **3518**

Nernst-Ettingshausen Effect in Strong Magnetic Fields.—I. M. Tsidil'kovski. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 12–22.) An experimental investigation on *n*-type HgSe specimens in fields up to about 10^4 oersted at temperatures between about 120 and 440°K is reported. The carrier mobility, u, in the various specimens could be calculated from the relation $(uH/c) = 1$, where c is the velocity of light and H is the magnetic field at which the maximum of the $E_y\,(H)$ curve occurs at the given temperature. These values, calculated from measurements of the

World Radio History

transverse Nernst-Ettingshausen effect, were found to be in good agreement with those obtained from Hall-effect measurements. The longitudinal-transverse thermomagnetic effect, predicted by theory, and the longitudinal Nernst-Ettingshausen effect, were also investigated.

537.311.33 : 538.63 **3519**

Investigation of the Influence of Recombination Processes on Galvanomagnetic Effects.—S. A. Poltinnikov & L. S. Stil'bans. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 30–34.) Two effects were investigated experimentally in a single crystal of Ge with a resistivity of 27 Ω.cm: (*a*) the change in charge carrier concentration at two opposite surfaces of the specimen, and (*b*) change of resistance in a magnetic field in a specimen with different recombination velocities on opposite surfaces. Results are presented graphically.

537.311.33 : 538.639 **3520**

Influence of the Transfer of Electrons by Phonons on the Thermomagnetic Effect in Semiconductors.—V. L. Gurevich & Yu. N. Obraztsov. (*Zh. eksp. teor. Fiz.*, Feb. 1957, Vol. 32, No. 2, pp. 390–392.) The influence of electron transfer by phonons on the Nernst-Ettingshausen effect in semiconductors is discussed.

537.311.33 : 546.23 **3521**

Equilibrium and Non-equilibrium Electrical Properties of Polycrystalline Selenium.—P. T. Kozyrev. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 35–44.) The temperature dependence of the electrical conductivity, thermo-e.m.f., hole concentration and mobility in the temperature range 40–200°C, the effect of pressure, and the relation between the equilibrium hole concentration and the mobility at high temperatures, were investigated in Se specimens containing 0·001% Te, 0·000 8% S and 0·006% other impurities. Results are presented graphically.

537.311.33 : 546.23 **3522**

The Influence of Iodine on the Thermal Conductivity of Selenium.—G. B. Abdullaev & M. I. Aliev. (*C. R. Acad. Sci. U.R.S.S.*, 11th June 1957, Vol. 114, No. 5, pp. 995–996. In Russian.) Experiments show that the specific heat is independent of I content and is higher in amorphous than in crystalline Se samples: 0·118 cal/g.deg and 0·070 1 cal/g.deg respectively. The thermal conductivity decreases with increasing I and passes through a minimum for about 0·2% I.

537.311.33 : 546.24 : 538.63 **3523**

Galvanomagnetic Properties of Tellurium at Low Temperatures: Part 1.—S. S. Shalyt. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 189–204.) The conductivity and Hall constant of pure single-crystal Te were measured on specimens of differing purity in the temperature range 100°C–1·3°K. At 4·2°K an increase in the field strength produced a decrease of resistance much higher than that predicted by theory. This is explained by assuming that two groups of holes exist with mobilities of about 535 cm^2/V.sec and 9 500 cm^2/V.sec respectively.

537.311.33 : 546.26-1 **3524**

Magnetoresistance of a *p*-Type Semiconducting Diamond.—E. W. J. Mitchell & P. T. Wedepohl. (*Proc. phys. Soc.*, 1st May 1957, Vol. 70, No. 449B, pp. 527–530.) The measured constants of the specimen are related to an equation derived from Seitz' theory. The results are similar to those obtained using *p*-type Ge and *p*-type Si.

537.311.33 : [546.28 + 546.289 **3525**

Surface States on Silicon and Germanium Surfaces.—H. Statz, G. deMars, L. Davis, Jr, & A. Adams, Jr. (*Phys. Rev.*, 1st May 1957, Vol. 106, No. 3, pp. 455–464.) On weakly oxidized surfaces these lie 0·42 and 0·13 eV above the Fermi level for intrinsic material, with approximate densities of 10^{11}–10^{12} cm^{-3} and 10^{10}–10^{11} cm^{-3} for Si and Ge respectively. Corresponding figures for well oxidized surfaces are 0·44–0·48 and 0·18 eV, and 10^{12} and 10^{11}–10^{12} cm^{-3}. See also 2434 of 1956.

537.311.33 : 546.28 **3526**

The Drift Mobility of Carriers in High-Purity Silicon.—M. Zerbst & W. Heywang. (*Z. Naturf.*, July 1956, Vol. 11a, No. 7, pp. 608–609.) Brief report of tests on *p*- and *n*-type specimens derived from *p*-type Si of 200–2 000-Ω.cm resistivity. Results are compared with those of Prince (2421 of 1954). The temperature dependence of drift mobility for *p* and *n* type was found to be proportional to $T^{2\cdot 3}$, electron mobility being about 1 400–1 450 cm^2/V.sec and hole mobility about 500 cm^2/V.sec.

537.311.33 : 546.28 **3527**

Internal Field Emission in Silicon *p-n* Junctions.—A. G. Chynoweth & K. G. McKay. (*Phys. Rev.*, 1st May 1957, Vol. 106, No. 3, pp. 418–426.) The forward and reverse d.c. characteristics of narrow *p-n* junctions, formed by solid-phase diffusion, have been studied. The interpretation of these involves internal field emission (Zener effect) rather than local avalanche breakdown.

537.311.33 : 546.28 **3528**

Thermal and Thermoelectric Properties of Alloys of Silicon with Transition Metals.—P. V. Gel'd. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 113–118.) The results of investigations on Fe-Si, Cr-Si and Mn-Si alloys are given in the form of graphs and tables.

537.311.33 : 546.28 : 621.314.63 **3529**

Silicon Diffused-Junction 'Avalanche' Diodes.—Veloric & Smith. (See 3680.)

537.311.33 : 546.28 : 621.314.64 **3530**

Anodic Formation of Oxide Films on Silicon.—P. F. Schmidt & W. Michel. (*J. electrochem. Soc.*, April 1957, Vol. 104, No. 4, pp. 230–236.) Dense oxide films can be formed anodically on *p*- and *n*-type single-crystal Si using a solution of KNO_3 in *N*-methylacetamide and voltages up to 560 V.

537.311.33 : 546.28 : 621.793 **3531**

Electroless Nickel Plating for Making Ohmic Contacts to Silicon.—M. V. Sullivan & J. H. Eigler. (*J. electrochem. Soc.*, April 1957, Vol. 104, No. 4, pp. 226–230.) The contact may be used on either *n*- or *p*-type Si.

537.311.33 : 546.289 **3532**

Field Effect in Germanium at High Frequencies.—H. C. Montgomery. (*Phys. Rev.*, 1st May 1957, Vol. 106, No. 3, pp. 441–445.) Changes in conductivity near the surface have been investigated at frequencies up to 50 Mc/s for both *n*- and *p*-type material, and in wet air, dry oxygen and ozone ambients.

537.311.33 : 546.289 **3533**

Excess Noise in *n*-type Germanium.—J. J. Brophy. (*Phys. Rev.*, 15th May 1957, Vol. 106, No. 4, pp. 675–678.) Experimental examination for single-crystal Ge shows that the phenomenon appears as a conductivity modulation caused by fluctuations in carrier density.

537.311.33 : 546.289 **3534**

Junctions Induced in Germanium Surfaces by Transverse Electric Fields.—J. D. Nixon & P. C. Banbury. (*Proc. phys. Soc.*, 1st May 1957, Vol. 70, No. 449B, pp. 481–485.) The surface conductance of Ge may be modulated by an external field produced by electrodes. A boundary effect appears between the field-free and field-applied surfaces near the edge of the electrodes. The transition region acts as a junction and the properties of such junctions are discussed.

537.311.33 : 546.289 **3535**

Influence of External Electrostatic Field on the Surface Recombination Velocity in Germanium.—V. P. Zhuze, G. E. Pikus & O. V. Sorokin. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 23–29.) Experimental results on single crystals of *n*-type Ge with a resistivity of 30 Ω.cm and on *p*-type Ge with 50 Ω.cm resistivity indicate that the influence is negligible. This result is discussed.

537.311.33 : 546.289 **3536**

Influence of Heating Germanium by an Electric Current on the Thermal Acceptor Concentration.—V. G. Alekseeva, B. N. Zobnina & I. V. Karpova. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 215–217.) Specimens heated for 25–30 h by d.c. showed no noticeable diminution in the concentration of thermal acceptors below 700°C but above this temperature a change in concentration occurs. The samples changed from *n*-type into *p*-type with increase in resistance. Graphs show that with a.c. heating the concentration of acceptors is higher.

537.311.33 : 546.289 **3537**

Diffusion and Solubility of Iron in Germanium.—A. A. Bugaĭ, V. E. Kosenko & E. G. Miselyuk. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 210–211.) The radioactive isotope ^{59}Fe was used for investigations in the temperature range 750–950°C. The maximum diffusion of $1\cdot 5 \times 10^{15}$ atoms/cm^3 occurred near 850°C.

537.311.33 : 546.289 **3538**

The Oxidation of Germanium.—O. Rösner. (*Z. Metallkde*, March 1957, Vol. 48, No. 3, pp. 137–141.) The oxidation of single-crystal and polycrystalline Ge of various degrees of purity subjected to six

World Radio History

different oxidising agents, including air, water and CO_2 was investigated. Single crystals are less oxidized than polycrystalline Ge of equal purity; oxidation decreases with increasing purity. See also 3001 of 1955.

537.311.33 : 546.289 **3539**

Rates of Oxidation of Germanium.—J. T. Law & P. S. Meigs. (*J. electrochem. Soc.*, March 1957, Vol. 104, No. 3, pp. 154–159.) "Oxidation rates of the (110), (111), and (100) faces of a Ge crystal have been measured between 450° and 700°C and at various oxygen pressures."

537.311.33 : 546.289 : 539.433 **3540**

Internal Friction and Defect Interaction in Germanium: Experimental.—J. O. Kessler. (*Phys. Rev.*, 15th May 1957, Vol. 106, No. 4, pp. 646–653.) The logarithmic decrement of germanium crystals undergoing small-amplitude longitudinal forced vibrations was measured as a function of temperature, frequency and concentration of impurities and edge dislocations. Results are tentatively interpreted in terms of the stress-induced migration of lattice vacancies.

537.311.33 : 546.289 : 539.433 **3541**

Internal Friction and Defect Interaction in Germanium: Theoretical.—J. O. Kessler. (*Phys. Rev.*, 15th May 1957, Vol. 106, No. 4, pp. 654–658.) A model is proposed for the energy dissipation caused by the stress-induced change in the equilibrium distribution of relatively mobile impurities around dislocations and used to derive numerical results corresponding to those derived from experiment. For details of the experimental work, see 3540 above.

537.311.33 : [546.3-1.92 + 546.3-1.59 **3542**

Intermetallic Compounds of Platinum and Gold with Alkali and Alkaline-Earth Metals.—I. L. Sokol'skaya. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 127–129.) The electrical properties of Na-Au, Na-Pt and Ba-Pt were investigated in vacuum.

537.311.33 : 546.48.86 **3543**

Electrical Properties of the Intermetallic Compound CdSb.—I. M. Pilat. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 119–122.) Experimental results based on the investigations of Justi & Lautz (1099 of 1954) show the influence of impurities and temperature changes from −180° to +250°C on the electrical properties of CdSb. Rectifying properties of CdSb produced by the addition of Al, Te, Pb or Sn impurities are also considered; additions of Al gave the best results.

537.311.33 : [546.682.19 + 546.681.19 + 546.682.18 **3544**

The *P-T-x* Phase Diagrams of the Systems In-As, Ga-As and In-P.—J. van den Boomgaard & K. Schol. (*Philips Res. Rep.*, April 1957, Vol. 12, No. 2, pp. 127–140.) The maximum melting point for InAs is 943 ± 3°C at an arsenic vapour pressure of 0·33 atm, and for GaAs 1 237 ± 3°C at 0·9 atm; that estimated for InP is 1 062 ± 7°C at phosphorous vapour pressure of 60 atm.

537.311.33 : 546.682.86 **3545**

Diffusion of Indium, Antimony and Tellurium in Indium Antimonide.—B. I. Boltaks & G. S. Kulikov. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 82–84.) The influence of temperature on the diffusion coefficient in InSb was investigated by means of radioactive isotopes ^{114}In, ^{124}Sb and ^{127}Te. The coefficients were found to vary exponentially with temperature, the coefficient for In being highest and that for Sb lowest at any given temperature.

537.311.33 : 546.682.86 **3546**

The Kinetics and Mechanism of Formation of Anode Films on Single-Crystal InSb.—J. F. Dewald. (*J. electrochem. Soc.*, April 1957, Vol. 104, No. 4, pp. 244–251.)

537.311.33 : 546.78-3 **3547**

Electrical Properties of Some Complex Tungsten Oxides.—Z. I. Ornatskaya. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 130–137.) The coefficient of specific conductivity and the thermo-e.m.f. of specimens of Na_2WO_4 and Li_2WO_4 heated in air and in vacuo, were investigated. Their dissociation energies were found to be about 0·94 and 1·43 eV respectively. The conductivity and mechanical properties of samples stored in air did not alter. Na-W and Li-W bronzes were also examined.

537.311.33 : 546.817.221 **3548**

Lifetime of Carriers in Lead Sulphide Crystals.—W. W. Scanlon. (*Phys. Rev.*, 15th May 1957, Vol. 106, No. 4, pp. 718–720.) Experiments show that the lifetime is determined mainly by the density of dislocations in the crystals and is independent of crystal resistivity for a high dislocation density.

537.311.33 : [546.817.23 + 546.817.241] : 537.32 **3549**

Investigation of Thermoelectric Properties of Lead Telluride and Selenide.—N. V. Kolomoets, T. S. Stavitskaya & L. S. Stil'bans. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 73–81.) The properties of PbTe and PbSe were investigated between 0 and 450°C, and between 100 and 700°K. The effect of temperature and carrier concentration on the thermo-e.m.f. was observed. At temperatures below 200°K the thermo-e.m.f. deviated from the theoretical characteristics. The influence of different compositions and temperatures on the carrier mobility were also examined.

537.311.33 : 666.2 : 546.881.5-31 **3550**

Semiconducting Properties of some Vanadate Glasses.—P. L. Baynton, H. Rawson & J. E. Stanworth. (*J. electrochem. Soc.*, April 1957, Vol. 104, No. 4, pp. 237–240.) "Glasses have been made in the systems BaO-V_2O_5-P_2O_5 and Na_2O-BaO-V_2O_5-P_2O_5 with V_2O_5 contents ranging between 50 and 87 mole %. The glasses were found to be semiconductors, those with the highest V_2O_5 contents having a specific conductivity of the order of 10^{-5} Ω^{-1}. cm^{-1} at room temperature."

537.311.33.002.2 : 338.45 **3551**

Semiconductor Manufacture.—(*Elect. Rev., Lond.*, 24th May 1957, Vol. 160, No. 21, pp. 969–970.) A new Mullard plant at Southampton is to employ between 1 500 and 2 000 people. About a third is completed. Details of the production of Ge transistors are given.

537.311.33.07 **3552**

A Miniature Dry-Box for Semiconductor Work.—P. R. Rowland & G. W. Whiting. (*J. sci. Instrum.*, May 1957, Vol. 34, No. 5, p. 207.) Brief descriptive note of arrangement in which the micromanipulator is mounted outside the dry-box.

538.22 **3553**

On a Higher Approximation of the Critical Field Strength for an Antiferromagnetic.—K. F. Niessen. (*Philips Res. Rep.*, June 1957, Vol. 12, No. 3, pp. 259–269.) "The critical magnetic field strength is derived for an antiferromagnetic with different anisotropy constants for the two sublattices, account being taken of the field-strength dependence of the parallel and perpendicular susceptibilities and a higher approximation of the anisotropy energy." See also 3015 of 1955.

538.22 : 546.65 **3554**

The Magnetic Susceptibilities of Lanthanum, Cerium, Praseodymium, Neodymium and Samarium, from 1·5°K to 300°K.—J. M. Lock. (*Proc. phys. Soc.*, 1st June 1957, Vol. 70, No. 450B, pp. 566–576.) At the lowest temperatures cerium, neodymium and samarium appear to become antiferromagnetic.

538.22 : 546.657 **3555**

Magnetic Properties of Neodymium Single Crystals.—D. R. Behrendt, S. Legvold & F. H. Spedding. (*Phys. Rev.*, 15th May 1957, Vol. 106, No. 4, pp. 723–725.)

538.22 : 546.668 **3556**

The Magnetic Susceptibility of Ytterbium from 1·3°K to 300°K.—J. M. Lock. (*Proc. phys. Soc.*, 1st May 1957, Vol. 70, No. 449B, pp. 476–480.) Conclusions regarding the distribution of electrons are given.

538.22 : 621.385.833 **3557**

A New Method of Observing Magnetic Transformations.—M. Blackman, G. Haigh & N. D. Lisgarten. (*Nature, Lond.*, 22nd June 1957, Vol. 179, No. 4573, pp. 1288–1290.) The focus of an electron diffraction camera was deflected by the use of coils carrying a.c. near which a specimen of a magnetic material was placed. Solid haematite, magnetite, and pyrrhotite, and powdered maghaemite (γFe_2O_3), magnetite and haematite and a reversing spinel were examined.

538.221 **3558**

Critical Size and Nucleation Field of Ideal Ferromagnetic Particles.—E. H. Frei, S. Shtrikman & D. Treves. (*Phys. Rev.*, 1st May 1957, Vol. 106, No. 3, pp. 446–455.) The nucleation field is calculated for an infinite cylinder and a sphere, while the critical size for single-domain behaviour is calculated for a prolate ellipsoid.

World Radio History

538.221 3559

Minimum Saturating Fields for Ferromagnetic Crystals.—J. S. Kouvel. (*J. appl. Phys.*, June 1957, Vol. 28, No. 6, pp. 704–706.) The conditions for magnetic saturation are investigated analytically for a very thin single-crystal disk or spheroid. The applicability of the calculated minimum saturating fields to torque measurements is discussed.

538.221 3560

On the Width and Energy of Domain Walls in Small Multi-domain Particles.—H. Amar. (*J. appl. Phys.*, June 1957, Vol. 28, No. 6, pp. 732–733.) It is shown that the inclusion of the magnetostatic energy in the derivation of the wall characteristics in two-domain ferromagnetic particles yields values of these characteristics which differ considerably from those in bulk material.

538.221 3561

On the Mechanism of Magnetite Oxidation.—W. I. Arkharov & B. S. Borisov. (*C. R. Acad. Sci. U.R.S.S.*, 11th May 1957, Vol. 114, No. 2, pp. 293–296. In Russian.)

538.221 : 621.318.134 3562

The Dependence of Coercive Force on Particle Size in Ferrites.—W. Holzmüller & G. Rüger. (*NachrTech.*, March 1957, Vol. 7, No. 3, pp. 118–121.) The coercivity of sintered Ni-Zn and Mn-Zn ferrites was measured before and after grinding. In the resulting powders increases in coercive force by factors up to 60 were noted; after subsequent reheating the coercive force decreased. An interpretation of these results is given.

538.221 : 621.318.134 3563

The Magnetoresistance of the Nickel-Zinc Ferrite System.—R. Parker. (*Proc. phys. Soc.*, 1st May 1957, Vol. 70, No. 449B, pp. 531–533.) Smit's model (*Physica*, June 1951, Vol. 17, No. 6, pp. 612–627) is inadequate to account for the observed effects.

538.221 : 621.318.134 3564

Microwave Properties of some Chromite-Ferrites of Nickel-Zinc.—C. Guillaud, R. Vautier & W. Kagan. (*C. R. Acad. Sci., Paris*, 3rd June 1957, Vol. 244, No. 23, pp. 2781–2784.) X-band measurements made at constant static field of Faraday rotation θ and attenuation α on cylindrical specimens of chromite-substituted Ni-Zn ferrites show the ratio θ/α to increase with Cr_2O_3 content for percentages up to 15 or 20%.

538.221 : 621.318.134 3565

Variation of the Resonance Field in Chromite-Ferrites of Nickel-Zinc.—R. Vautier & W. Kagan. (*C. R. Acad. Sci.*, Paris, 17th June 1957, Vol. 244, No. 25, pp. 3040–3043.) See 3564 above. Further measurements show that the resonance field strength decreases with increasing percentage Cr_2O_3 contrary to theory.

538.221 : 621.318.134 3566

Controlled Crystal Anisotropy and Controlled Temperature Dependence of the Permeability and Elasticity of Various Cobalt-Substituted Ferrites.—C. M. van der Burgt. (*Philips Res. Rep.*, April 1957, Vol. 12, No. 2, pp. 97–122.) "Dynamic elasticity at remanence, piezomagnetic coupling at remanence, and initial permeability of polycrystalline toroids of various cobalt-substituted ferrites are determined in the temperature range from −196°C to +120°C at least. The compositions are represented approximately by $(M_{1-y}Zn_y)_{1-x}Co_xFe_2O_4$, where M stands for one of the divalent metal ions $Li^{1+}_{\frac{1}{2}}Fe^{3+}_{\frac{1}{2}}$, Ni^{2+}, and Mn^{2+}." 48 references.

538.221 : 621.318.134 3567

Oxidation of Manganese Ferrite.—R. S. Weisz. (*J. Amer. ceram. Soc.*, 1st April 1957, Vol. 40, No. 4, pp. 139–142.)

538.221 : 621.318.134 : 538.569.4 3568

Temperature Dependence of the *g*-Factor and Relaxation Time in Ferromagnetic Resonance of Some Ferrites.—A. P. Komar & N. I. Krivko. (*C. R. Acad. Sci. U.R.S.S.*, 1st May 1957, Vol. 114, No. 1, pp. 64–66. In Russian.) The magnitude of the observed decrease of the *g*-factor, in some ferrites, with a decrease in temperature cannot be explained on the basis of existing microscopic theories. The experimental results are tabulated.

538.221 : 621.318.134 : 538.66 3569

The Effect of Grain Size on the Magnetothermal Properties of Ferrites.—D. A. Christoffel. (*Proc. phys. Soc.*, 1st June 1957, Vol. 70, No. 450B, pp. 623–625.) Measurements on two samples of Ni ferrite show differences which are attributed to different particle sizes in the two cases.

538.652 3570

Magnetostriction of Aluminium-Iron Single Crystals in the Region of 6 to 30 Atomic Percent Aluminium.—R. C. Hall. (*J. appl. Phys.*, June 1957, Vol. 28, No. 6, pp. 707–713.) The spontaneous saturation magnetostriction and the forced magnetostriction were measured on slowly cooled single crystals. The results are shown in graphical and tabular form.

539.16/.18 : [537.311.3 + 549.514.51 3571

The Effect of Radiation Damage on the Electronic Properties of Solids.—E. W. J. Mitchell. (*Brit. J. appl. Phys.*, May 1957, Vol. 8, No. 5, pp. 179–189.) A discussion of the effects of atomic displacements produced by elastic collisions between the nuclei and the incident high-energy radiation, with special reference to electron mobility in metals, carrier concentration in Ge, and optical absorption in quartz and diamond. 50 references.

539.23 : 537.311.33 : 546.492.31.46 3572

Some Peculiarities of the Electrical Properties of HgSe-HgTe Films.—O. D. Elpat'evskaya & A. R. Regel'. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 45–50.) Investigations on transparent and opaque film show that carrier mobility increases with the thickness of the film. Tables showing the variation of specific conductivity, Hall constant, carrier mobility and concentration with film thickness are given.

539.23 : 546.571 3573

Oxide Films on Silver at High Temperatures.—D. E. Davies. (*Nature, Lond.*, 22nd June 1957, Vol. 179, No. 4573, pp. 1293–1294.) It is shown that Ag_2O may exist at temperatures up to 800°C.

548.0 : 537 3574

Relation between the Electrical Properties of Crystals and the Crystal Lattice Parameters.—V. A. Presnov & V. I. Gaman. (*C. R. Acad. Sci. U.R.S.S.*, 1st May 1957, Vol. 114, No. 1, pp. 67–69. In Russian.) A preliminary calculation of the relation for alkali halide crystals is reported.

621.357.8 3575

Electrolytic Surface Phenomenon and its Application in Precision Engineering.—M. Naruse & A. Nannichi. (*Technol. Rep. Tohoku Univ.*, 1957, Vol. 21, No. 2, pp. 63–69.) The surface of an anode partially immersed in an electrolyte is more deeply corroded near the liquid/air boundary. Electrolytic polishing, in which this phenomenon is used, can be applied to the production of thin wires and of fine pivots.

666.1.037.5 3576

Fundamentals of Glass-to-Metal Bonding: Part 2—Reactions of Tantalum and Sodium Silicate Glass.—S. P. Mitoff. (*J. Amer. ceram. Soc.*, 1st April 1957, Vol. 40, No. 4, pp. 118–120.) Part 1: 2712 of 1953 (Zackay et al.).

MATHEMATICS

517.43 : 621.373.421 3577

The Periodic Solutions of the Differential Equation of a Resistance-Capacitance Oscillator.—Gillies. (See 3430.)

517.63 3578

A New Method of Inversion of the Laplace Transform.—A. Papoulis. (*Quart. appl. Math.*, Jan. 1957, Vol. 14, No. 4, pp. 405–414.)

517.9 : 621-52 3579

On the Solution of a Differential Equation with Nonlinearity Appearing in the Second Derivative of Combined Linear and Cubic Terms.—Chi-Neng Shen. (*Quart. appl. Math.*, April 1957, Vol. 15, No. 1, pp. 11–30.) Physical applications include a feedback control system for a two-capacity process with nonlinear elements.

517.942.82 3580

Connection between Time Function $A(t)$ and Spectral Function $\phi(p)$.—U. Kirschner. (*Elektronische Rundschau*, March 1957, Vol. 11, No. 3, pp. 87–92.) Amplification of earlier theoretical investigations of transient phenomena (see 3360 of 1952 and 764 of 1953).

World Radio History

517.946.9 : [536+537 **3581**

The General Solution of Boundary-Value Problems of the Transmission of Heat or Electrical Energy.—L. von Szalay & K. H. Löcherer. (*Frequenz*, April 1957, Vol. 11, No. 4, pp. 97–106.) Solutions are tabulated for the case of a parallelepiped, a cylinder and a sphere.

519 **3582**

Diakoptics—the Piecewise Solution of Large-Scale Systems.—G. Kron. (*Elect. J.*, 7th June 1957, Vol. 158, No. 23, pp. 1673–1677.) One of a series of articles dealing with a systematic method of analysing and solving complicated network problems by the method of 'tearing'. See also 2164 of 1954.

519.2 **3583**

Stochastic Processes associated with Integrals of a Class of Random Functions.—P. M. Mathews & S. K. Srinivasan. (*Proc. nat. Inst. Sci. India, A*, 26th Nov. 1956, Vol. 22, No. 6, pp. 369–376). Laplace-transform treatment of a random process involving a Poisson distribution, with application to shot-effect fluctuations.

MEASUREMENTS AND TEST GEAR

53.087 : 621.374.32 **3584**

Automatic Counting Techniques applied to Comparison Measurement.—Washtell. (See 3434.)

536.5 : 621.316.825 **3585**

Thermistor Thermometer Bridge: Linearity and Sensitivity for a Range of Temperature.—K. S. Cole. (*Rev. sci. Instrum.*, May 1957, Vol. 28, No. 5, pp. 326–328.) Analysis and construction of a measuring circuit incorporating a slide-wire Wheatstone bridge. Linearity of scale and constant sensitivity over a wide temperature range are achieved.

621.3.018.41(083.74) : 621.396.712 **3586**

Experimental Standard-Frequency Broadcast on 60 Kilocycles.—(*Tech. News Bull. nat. Bur. Stand.*, July 1957, Vol. 41, No. 7, pp. 99–100.) A note on the transmission from Boulder under the call sign KK2XEI, which started 1st July 1956 on low power. Comparisons have been made with other standard frequencies including GBR and WWV transmissions, and figures are quoted for most days of January 1957.

621.317.087.6 : 681.62 **3587**

A Printing Method for Measuring Instruments with Digital Indication.—J. Hacks & M. Klose. (*Elektronische Rundschau*, April 1957, Vol. 11, No. 4, pp. 97–99.) Electronic equipment is described which in conjunction with a conventional electric calculating machine prints the results of measurements in digital form. The generation of the requisite step voltages is discussed.

621.317.32 : 621.396.61.029.62 **3588**

Intercomparison of the Various Methods of Measuring Spurious Emissions.—S. Kurokawa, T. Takashashi & M. Arai. (*J. Radio Res. Labs, Japan*, Jan. 1957, Vol. 4, No. 15, pp. 89–93.) Experimental data are quoted for half, twice and three times the fundamental transmitted frequency in the v.h.f. band.

621.317.328 : 621.373.421.14 **3589**

Electrical Field Strength Measurements in Endovibrators [cavity resonators] **by the Method of Changing the Resonance Frequency with a Dielectric Probe.**—G. N. Rapoport. (*Radiotekhnika, Moscow*, Feb. 1957, Vol. 12, No. 2, pp. 51–58.) The field distribution within the cavity is perturbed by the insertion of a small spherical, spheroidal or needle-shaped dielectric probe. Field measurements are simplified as the dielectric probe only reacts to the electric field. See also 2265 of 1952 (Maier & Slater).

621.317.34 : 621.372.54 **3590**

Wide-Range Analyser traces Precise Curves.—E. F. Feldman. (*Electronics*, 1st March 1957, Vol. 30, No. 3, pp. 184–187.) The attenuation characteristics of frequency-selective networks may be measured by means of equipment consisting of a swept heterodyne spectrum analyser used as an indicator for a sweep generator. Stop-band attenuations of 100 dB within the range 20 c/s–20 kc/s may be measured.

621.317.422 **3591**

The Rapid and Accurate Measurement of Coercive Force.—F. Förster. (*Arch. tech. Messen*, March & April 1957, Nos. 254 & 255, pp. 65–66 & 87–90.) The astatic instrument described is insensitive to the effects of the earth's field and other disturbing fields; rapid and accurate coercivity measurements can be carried out in the range 10^{-2}–10^{3} oersted.

621.317.44 : 538.614 : 539.23 **3592**

A New Method of Measuring the Magnetic Properties of Thin Films by means of the Faraday Effect.—L. Reimer. (*Z. Naturf.*, July 1956, Vol. 11a, No. 7, p. 611.) The method briefly described uses a magnetizing field parallel to the film and a beam of polarized light incident at 45° to the film. Thus low field strengths suffice to achieve saturation. The magnetization curve obtained for a Ni film 450 Å thick is shown.

621.317.6 : 621.314.7 **3593**

A Simple Transistor Beta Tester for Rapid Determination of Transistor Gain.—(*Tech. News Bull. nat. Bur. Stand.*, June 1957, Vol. 41, No. 6, p. 93.) The circuit diagram is shown of a device designed by G. F. Montgomery for measuring the common-emitter short-circuit current gain of *p-n-p* or *n-p-n* transistors at low a.f.

621.317.6 : 621.314.7 **3594**

Sweeper determines Power-Gain Parameter.—W. N. Coffey. (*Electronics*, 1st March 1957, Vol. 30, No. 3, pp. 201–203.) A comparison circuit using a sweep frequency generator, c.r.o. and reference network for determining the gain of junction transistors is described.

621.317.7.029.64 : 621.396.822 : 537.54 **3595**

A Thermal Noise Standard for Microwaves.—K. S. Knol. (*Philips Res. Rep.*, April 1957, Vol. 12, No. 2, pp. 123–126.) A thermal noise source for the 3-cm waveband, consisting of a heated platinum waveguide terminated with a ceramic wedge, is described. The temperature of the wedge is fixed at the melting point of gold. Using this as a standard, a figure of 21 700°K was obtained for the noise temperature of a noise diode Type K50A.

621.317.725.029.62 : 621.385 **3596**

A Selective Valve Voltmeter for the V.H.F. Range.—H. Mack. (*Elektronische Rundschau*, April 1957, Vol. 11, No. 4, pp. 102–105.) Description of commercial instrument covering 30–300 Mc/s with a range of 80 dB (3 μV–30 mV) and a bandwidth of 45 kc/s.

621.317.729.1 : 621.317.755 **3597**

A High-Speed Electronic Analogue Field Mapper.—R. B. Burtt & J. Willis. (*J. sci. Instrum.*, May 1957, Vol. 34, No. 5, pp. 177–182.) A c.r. tube, the screen of which forms the base of an analogue tank, is scanned in 40 msec by using a 100-line raster. The variations in the secondary emission from the screen operate trigger circuits, corresponding to a series of field potentials, which modulate the brilliance of a second c.r. tube scanned simultaneously.

621.317.73.011.3 : 621.3.029.65 **3598**

Measuring Instrument for Very Low Inductances.—H. Brand & E. Schuon. (*Elektronische Rundschau*, March 1957, Vol. 11, No. 3, pp. 65–67.) The instrument described uses a method of impedance transformation. It covers the range 1–500 mμH at λ = 80 cm.

621.317.733 **3599**

Bridge sorts Capacitors to Tolerance.—S. D. Breskend, J. I. Cooperman & P. J. Franklin. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 177–179.) A description of production test equipment using a Schering bridge to measure loss factor and capacitance deviation from a standard value.

621.317.75 **3600**

Undistorted Reproduction of Waveforms of Very Large Bandwidth by means of Display Units with Narrow Bandwidth: Bandwidth Compression.—H. Riedle. (*Nachrichtentech. Z.*, March 1957, Vol. 10, No. 3, pp. 135–140.) An adaptor circuit is described which by means of a pulse scanning method compresses a frequency spectrum of up to 200 Mc/s of a periodic waveform so that it can be displayed on a c.r.o. of about 25 kc/s bandwidth. Some illustrative oscillograms are shown.

621.317.755 **3601**

Magnetically Deflected 21-Inch Oscilloscope.—H. E. O'Kelley & W. H. Todd. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 159–161.) The deflection-coil waveform is proportional to the input signal voltage. A deflection of 10 in. is achieved at 18·5 kc/s, falling to 4 in. at 50 kc/s.

World Radio History

621.317.755 : 621.385.832 **3602**
A Precision Electron-Beam Oscillograph with a Spot Diameter of a few Microns.—M. von Ardenne. (*J. sci. Instrum.*, May 1957, Vol. 34, No. 5, pp. 206–207.) Brief description of instrument detailed in 1495 of 1956.

621.317.76 **3603**
A Modified Periodmeter.—V. N. Rao & K. Achyuthan. (*Electronic Engng*, July 1957, Vol. 29, No. 353, pp. 338–339.) Modified version of an instrument described by Barker & Cannon (221 of 1954) for observing small changes in the frequency of an a.f. signal of short duration.

621.317.784.029.64 : 621.316.825 **3604**
A New Thermistor Power-Measuring Head for λ = 9–20 cm.—H. Rieck & F. Panniger. (*NachrTech.*, March 1957, Vol. 7, No. 3, pp. 101–104.) The device described uses a single thermistor mounted close to an adjustable $\lambda/4$ stub line. By selection two thermistors were found to cover the ranges 9–17 cm or 12–20 cm respectively with a v.s.w.r. $\leqslant 1\cdot1$.

621.317.794 : 537.311.33 : 546.289 **3605**
Low-Inertia Germanium Bolometers.—V. N. Bogomolov, Yu. V. Ilisavski, M. Kornfel'd, L. S. Sochava & R. I. Strunin. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 213–215.) The bolometer described consists of a vacuum-deposited Ge film, about 1 μ thick, protected by a layer of polystyrene. The sensitivity of this instrument for a modulation frequency of 30 c/s was 60–70 V/W. The temperature coefficient of resistance of the sensitive layer was estimated to be 25×10^{-2} deg^{-1}. A section drawing of the bolometer is shown.

621.317.794.029.64 : 621.317.733 **3606**
A Self-Balancing Direct-Current Bridge for Accurate Bolometric Power Measurements.—G. F. Engen. (*J. Res. nat. Bur. Stand.*, August 1957, Vol. 59, No. 2, pp. 101–105.) "A self-balancing d.c. bridge has been developed that preserves the inherent accuracy of the manual bridge, extends the dynamic range of operation, and greatly simplifies the operating procedure. A general description of the equipment and operating techniques is given, followed by a comprehensive survey of the sources of error accompanying the method and the accuracy achieved."

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

534.1-8 : 61 **3607**
Ultrasonics in Medicine and Dentistry.—W. Welkowitz. (*Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1059–1069.)

534.1-8 : 663.4 **3608**
Ultrasonics bubbles Beer in Brewery.—A. S. Davis. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 162–164.) Unwanted air is expelled from bottles through foam formation resulting from vibration caused by a magnetostrictive transducer.

535.24 : 621.397.6 **3609**
Television-Optical Method of Obtaining Equal - Density Contours. — A. Lohmann. (*Optik, Stuttgart*, April 1957, Vol. 14, No. 4, pp. 178–182.) The easily variable nonlinear characteristics of a television system, such as that used for microscopy by Köhler (3837 of 1956) can be used for photometric applications in place of photographic methods.

621-52 : 621.397.611.2 **3610**
Television Technique Applied to Observation and Control.—McGee. (See 3668.)

621.3.083.7 : 621.314.7 : 616 **3611**
Endoradiosonde.—R. S. Mackay & B. Jacobson. (*Nature, Lond.*, 15th June 1957, Vol. 179, No. 4572, pp. 1239–1240.) A capsule 2·8 cm long and 0·9 cm in diameter contains a junction transistor and battery for transmitting data such as temperature, pressure and pH value from within the gastro-intestinal tract of a human body. The frequency used is about 100 kc/s.

621.316.7.078 : 616 **3612**
Muscles control Iron-Lung Operation.—L. H. Montgomery. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 180–181.) Potentials picked up from the patient's muscles trigger a control circuit for an artificial respirator.

621.317.39 : 531.77 : 621.396.822 **3613**
Tachometer Noise Reduction.—J. C. West. (*Electronic Radio Engr*, Sept. 1957, Vol. 34, No. 9, pp. 342–344.) A discussion of the improvements obtainable using a brushless low-noise accelerometer.

621.365.521 : 621.387 **3614**
Thyratrons Stabilize Induction Heaters.—H. J. Fraser & E. G. Hopkins. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 152–153.) A closed-loop regulator which stabilizes high-power oscillators used for heating receiving-valve electrodes during an automatic exhaust process.

621.365.54 **3615**
Radio-Frequency Energy Transfer Switch.—L. E. Bollinger. (*Rev. sci. Instrum.*, May 1957, Vol. 28, No. 5, pp. 383–384.) The switch can be used at frequencies of 500 kc/s and higher and has been tested at r.f. currents of 140 A.

621.374.3 : 795 **3616**
Electronic Fruit Machine.—G. L. Swaffield. (*Wireless World*, Sept. 1957, Vol. 63, No. 9, pp. 447–451.) Description of a slot machine in which coincidence in the flashing of neon lamps is controlled by pulse circuits.

621.383.27 : 621.3.083.722 **3617**
A Photoelectric Particle Counter for Use in the Sieve Range.—T. Beirne & J. M. Hutcheon. (*J. sci. Instrum.*, May 1957, Vol. 34, No. 5, pp. 196–200.) A suspension of the particles is passed through a capillary tube and the image projected on to a photomultiplier and analysed by a rate-meter. The size distribution is obtained by plotting count rates against discriminator threshold voltage.

621.383.4 : 531.787.4 **3618**
Precise Automatic Manometer Reader.—J. Farquharson & H. A. Kermicle. (*Rev. sci. Instrum.*, May 1957, Vol. 28, No. 5, pp. 324–325.) Electronic and mechanical device registering mercury surface level with a maximum error of ± 0·05 mm.

621.384.612 **3619**
Nonlinear Theory of Betatron Oscillations in a Strong-Focusing Synchrotron.—Yu. F. Orlov. (*Zh. eksp. teor. Fiz.*, Feb. 1957, Vol. 32, No. 2, pp. 316–322.)

621.385.3 : 531.787 : 616 **3620**
Movable-Anode Tube.—(*Electronics*, 1st March 1957, Vol. 30, No. 3, pp. 232–238.) The RCA Type-5734 transducer consists of a miniature triode having a movable anode with a small extension shaft protruding through the centre of a thin air-tight metal diaphragm. Abstract from 'Research on Mechano-electronic Transducer Blood Pressure Manometers' read at the 1956 I.S.A. conference.

621.385.833 **3621**
Magnetic Electron Lenses.—P. Durandeau & C. Fert. (*Rev. d'Optique*, May 1957, Vol. 36, No. 5, pp. 205–234.) A description of design principles with constructional data based on experimental results from the Laboratoire d'Optique électronique, Toulouse. 21 references.

621.385.833 **3622**
Combination of Emission-Type [electron] **Microscope and Reflection-Type Diffractograph.**—R. Arnal & C. Gonçalves. (*C. R. Acad. Sci., Paris*, 24th June 1957, Vol. 244, No. 26, pp. 3139–3141.) The diffraction microscope is vertical, the emission-type microscope horizontal. A single sample can be viewed simultaneously by the two instruments.

621.385.833 **3623**
Condensation of Iron and Platinum on Tungsten Single-Crystal Surfaces in the Field-Emission Electron Microscope at Elevated Temperatures.—K. Neubeck. (*Z. Naturf.*, July 1956, Vol. 11a, No. 7, pp. 587–589.)

621.385.833 : 621.385.032.213.2 **3624**
The Bolt Cathode as Object in the Electron-Emission Microscope.—E. B. Baş. (*Z. angew. Math. Phys.*, 25th May 1957, Vol. 8, No. 3, pp. 203–213.) The use of this type of cathode (see also 3793 of 1955) in electron microscopes, and the method of its preparation are described.

621.396.969 : 533.6.011.7 **3625**
A Radio Method of Determining the Velocity of a Shock Wave.—J. S. Hey, J. T. Pinson & P. G. Smith. (*Nature, Lond.*, 8th June 1957, Vol. 179, No. 4571, pp. 1184–1185.) The change of frequency caused by the Doppler effect on continuous radio waves reflected from the shock discontinuity in a shock tube is measured.

World Radio History

PROPAGATION OF WAVES

621.396.11 **3626**

On the Relationship between the Scattering of Radio Waves and the Statistical Theory of Turbulence.—K. Tao. (*J. Radio Res. Labs, Japan*, Jan. 1957, Vol. 4, No. 15, pp. 15–24.) The scattering cross-section derived by Villars and Weisskopf (see 244 of 1956) is discussed in terms of a mathematical model of a turbulent element. The cross-section can be expressed in terms of the energy spectrum of the turbulence.

621.396.11 : 551.510.52 **3627**

The Concept of the Equivalent Radius of the Earth in Tropospheric Propagation.—G. Millington. (*Marconi Rev.*, 3rd Quarter 1957, Vol. 20, No. 126, pp. 79–93.) "The concept of the equivalent radius of the earth to take account of a linear variation of refractive index with height in tropospheric refraction is re-examined. It is shown that the transformation is not limited to nearly horizontal rays, but that essentially it reduces the curvature of the earth by that of a ray travelling horizontally and the curvature of the rays by the amount required to straighten them at whatever angle to the horizontal they may be going. The results obtained geometrically in a previous paper [1637 of 1946] for the angle of elevation at the reflection point, the optical path difference between the direct and indirect rays and the divergence factor are derived by simple analysis, affording a useful check on the method."

621.396.11 : 551.510.535 **3628**

The Proceedings of the International Convention on Radio Propagation in the Ionosphere.—(*Nuovo Cim.*, 1956, Vol. 4, Supplement No. 4, pp. 1343–1608.) The text is given of the introductory speeches and the following papers presented at the convention held in Venice 18th–21st August 1955 :—

Ionospheric Turbulence and Electromagnetic Wave Propagation.—T. Kahan (pp. 1352–1383, in French. Discussion, p. 1384).

The Electrical Conductivity of the Ionosphere : a Review.—S. Chapman (pp. 1385–1412, in English).

Some Properties of the Meteoric E Layer Used in Radio Wave Propagation.—R. Naismith (pp. 1413–1420, in English. Discussion, pp. 1420–1421).

Some Remarks on the Theory of Self-Demodulation.—M. Carlevaro (pp. 1422–1429, in English).

On the Interaction of Radio Waves.—V. A. Bailey (pp. 1430–1448, in English. Discussion, pp. 1448–1449).

Ionospheric Self-Demodulation of Radio Waves.—M. Cutolo, G. C. Bonghi, F. Immirzi & P. Cachon (pp. 1450–1458, in English. Discussion, pp. 1458–1459).

The Blanketing of Paths : an Important Phenomenon of Ionospheric Propagation.—K. Rawer (pp. 1460–1476, in French, Discussion, pp. 1476–1477).

The Absorption of Short Waves in an Isotropically Ionized Medium.—E. Argence (pp. 1478–1510, in French. Discussion, p. 1510).

The Determination of the Number of Collisions Relative to the F_2 Region of the Ionosphere.—E. Argence & K. Rawer (pp. 1511–1531, in French).

Echo Sounding Experiments with Variable Frequency at Oblique Incidence.—W. Dieminger & H. G. Möller (pp. 1532–1544, in English. Discussion, pp. 1544–1545).

On a Correlation between the Electronic Density of the E Layer and the 500-mb Surface Position.—A. Napoletano (pp. 1546–1551, in English).

Remarks on the Connection between Mode Theory and Ray Theory.—H. Bremmer (pp. 1552–1558, in English).

On Some Characteristics of the F_2 Region in South America.—I. Ranzi (pp. 1559–1560, in English. Discussion, p. 1561).

The Ionized Aurora.—N. C. Gerson (pp. 1562–1571, in English).

Some Observations on the Influence of a Solar Eclipse upon the Ionosphere.—P. Dominici (pp. 1572–1578, in English).

Some Considerations on Temperature Effects in the Upper Atmosphere.—F. Mariani (pp. 1579–1585, in English).

Diffusion in a Not Isothermal Ionosphere.—F. Mariani (pp. 1586–1588, in English).

Some Critical Considerations on the Parameters h' and f_0 of the Ionospheric Layers.—P. Dominici & F. Mariani (pp. 1589–1592, in English. Discussion, p. 1592).

Molecular Spectroscopy of Oxygen by means of Microwaves. The Form of the Absorption Lines.—N. Carrara (pp. 1593–1608, in Italian).

621.396.11 : 551.510.535 **3629**

Propagation of a Plane Electromagnetic Wave Across an Ionospheric Layer.—P. Poincelot. (*C. R. Acad. Sci., Paris*, 17th June 1957, Vol. 244, No. 25, pp. 3045–3047.) Short mathematical treatment of propagation of a plane wave incident vertically on a parabolic layer, considering electrons subject to two forces only, due to (*a*) the e.m. field and (*b*) viscous resistance. See also 3275 of October.

621.396.11 : 621.396.933 **3630**

The Application of Radio Frequency Predictions to Aeronautical Communications.—Foxcroft. (See 3654.)

621.396.11.029.45/.51 **3631**

Mixed-Path Ground-Wave Propagation: Part 2—Larger Distances.—J. R. Wait & J. Householder. (*J. Res. nat. Bur. Stand.*, July 1957, Vol. 59, No. 1, pp. 19–26.) "The theoretical results given in Part 1 [*ibid.*, July 1956, Vol. 57, No. 1, pp. 1–15 (Wait)] for ground-wave propagation over a mixed path on a flat earth are generalized to a spherical earth. The problem is formulated in terms of the mutual impedance between two vertical dipoles which are located on either side of the boundary of separation. Extensive numerical results are given in graphical form for a mixed land-sea path at frequencies of 10, 20, 50, 100, and 200 kc/s." See also 3516 of 1956 (Wait and Howe).

621.396.11.029.51 **3632**

Amplitude and Phase of the Low-Frequency Ground Wave Near a Coastline.—J. R. Wait. (*J. Res. nat. Bur. Stand.*, May 1957, Vol. 58, No. 5, pp. 237–242.) "A theoretical analysis is given for the amplitude and the phase change of the ground wave, originating from a distant transmitter on land, as it crosses a coastline. The land and sea are assumed to be smooth, and homogeneous with a sharp boundary of separation. Attention is focused on the effects that take place near the coastline when it is not permissible to employ arguments based on the principle of stationary phase. A limited comparison is made with the recent experimental work of Pressey, Ashwell and Fowler [3194 of 1956]."

621.396.11.029.55 **3633**

Characteristics of H.F. Signals.—A. F. Wilkins & F. Kift. (*Electronic Radio Engr*, Sept. 1957, Vol. 34, No. 9, pp. 335–341.) Measurements made between 1952 and 1954 of the angles of elevation of both pulsed and c.w. signals arriving at Slough from India and Ceylon on frequencies between 15 and 19 Mc/s showed that $7° \pm 2°$ was the predominant angular range. Back-scatter data from Ceylon and Slough were used to interpret the propagation modes concerned.

621.396.812 **3634**

Variation of the Polarization of Ultra Short Waves due to the Heterogeneity of the Troposphere.—G. Eckart. (*C. R. Acad. Sci., Paris*, 17th June 1957, Vol. 244, No. 25, pp. 3044–3045.) A mathematical note explaining the fact that the field radiated from a vertical antenna is often no longer vertically polarized at the receiver. See 1218 of April.

RECEPTION

621.376.232 : 621.396.822 **3635**

Influence of Fluctuations on a Phase Detector.—V. I. Tikhonov & I. N. Amiantov. (*Radiotekhnika, Moscow*, Feb. 1957, Vol. 12, No. 2, pp. 39–50.) Imperfections of the phase detector are examined and statistical characteristics of output voltage given. Approximate formulae for the average voltage and also a correlation function of voltage fluctuations and phase-detector load are derived.

621.376.33 **3636**

A New Approach to the Nonlinear Problems of F.M. Circuits.—M. A. Biot. (*Quart. appl. Math.*, April 1957, Vol. 15, No. 1, pp. 1–10.) "Closed form expressions are developed for the output of a frequency modulation receiver for an arbitrary number of superposed input signals. This corresponds to problems of interference or disturbance due to scatter and multiple reflexions. It is also shown how the Fourier components of the output may be evaluated by methods more direct than the usual Fourier analysis."

World Radio History

621.396.62 : 621.314.7 **3637**

Further Notes on the Portable Transistor Receiver.—S. W. Amos. (*Wireless World*, Sept. 1957, Vol. 63, No. 9, pp. 452–453.) Details of practical layout. See 2895 of September.

621.396.621 : 621.396.822 **3638**

Method of Increasing the Interference Stability of an Autocorrelated Reception of Pulse Signals.—M. I. Karnovski & V. I. Chaikovski. (*Radiotekhnika, Moscow*, Feb. 1957, Vol. 12, No. 2, pp. 22–27.) Better interference stability is obtained by the addition of a synchronized switching unit in one of the channels thus increasing the selectivity of the system. See also 562 of February (Chaikovski).

621.396.621.54 **3639**

An All - Electronic Signal - Seeking Broadcast Receiver.—C. W. Hargens, III. (*Trans. Inst. Radio Engrs*, Oct. 1955, Vol. BTR-1, No. 4, pp. 5–9. Abstract, *Proc. Inst. Radio Engrs*, March 1956, Vol. 44, No. 3, p. 434.) See also 555 of 1956 (Chih Chi Hsu).

621.396.81 : 621.396.621 **3640**

Probability of Detection of a Signal by a Receiver having a Finite Recovery Time.—A. M. Vasil'ev. (*Radiotekhnika, Moscow*, Feb. 1957, Vol. 12, No. 2, pp. 28–38.) A general equation is derived for the probability density of signal detection by the receiver. Some illustrative examples and results are given.

621.396.812.3 **3641**

Characteristics of Fading in H.F. and M.F. Waves at Middle Distances.—R. Inoue, M. Ose & N. Wakai. (*J. Radio Res. Labs, Japan*, Jan. 1957, Vol. 4, No. 15, pp. 77–87.) The fading characteristics depend on whether pulsed or continuous-wave signals are used and on time of day. The amplitude distribution is presented by automatic equipment.

621.396.82.029.62/.63 **3642**

V.H.F.-U.H.F. Radiation Measurements.—A. B. Glenn. (*Trans. Inst. Radio Engrs*, Oct. 1955, Vol. BTR-1, No. 4, pp. 15–19; *Proc. Instn Radio Engrs, Aust.*, Jan. 1957, Vol. 18, No. 1, pp. 15–19. Abstract, *Proc. Inst. Radio Engrs*, March 1956, Vol. 44, No. 3, p. 435.)

STATIONS AND COMMUNICATION SYSTEMS

621.39.001.11 **3643**

A System of Signal Reception.—A. A. Kharkevich. (*Elektrosvyaz*, Feb. 1957, No. 2, pp. 5–9.) In the system described the whole of the binary coded signal received is compared, for purposes of error detection, with signals pre-recorded in a magnetic-tape memory store. In the case discussed the result of the comparison is displayed on a c.r. tube screen subdivided into 64 squares for a 32-letter telegraphy code. Half the number of the squares are blank and correspond to an error signal.

621.394/.395 : 621.396.933 **3644**

Line Communication Equipment for Air Traffic Control within the German Federal Republic.—K. Heidelauf. (*Nachrichtentech. Z.*, April 1957, Vol. 10, No. 4 pp. 187–194.)

621.394.3 : 681.142 **3645**

Morse-to-Teleprinter Code Converter.—Smith-Vanis & Barrett. (See 3408.)

621.396.24.029.62(494) **3646**

The Basis, Tasks and Aims of U.S.W. Broadcasting.—E. Metzler. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st April 1957, Vol. 35, No. 4, pp. 138–148.) Particular reference is made to the planned expansion of the Swiss network of v.h.f. stations.

621.396.3 **3647**

The Correction of Synchronization in Start-Stop Radio Teleprinter Systems.—W. Kronjäger, B. Lenhart & K. Vogt. (*Nachrichtentech. Z.*, April 1957, Vol. 10, No. 4, pp. 167–174.) Examples illustrate the improvement in transmission quality achieved by generating the synchronizing pulses locally.

621.396.3 : 621.396.933 **3648**

An Experimental Airborne Teleprinter Service for North Atlantic Airlines.—A. Bickers. (*Marconi Rev.*, 3rd Quarter 1957, Vol. 20, No. 126, pp. 104–112.) A ground-to-air teleprinter service for the transmission of weather information in the l.f. band would relieve the existing congestion in m.f. and h.f. bands. Details are given of an airborne teleprinter receiver Type-X2779 which has been designed to test the feasibility of such a service. It is crystal-controlled and is designed for frequency-shift keying in any one of four channels in the range 90–130 kc/s.

621.396.4 : 621.376.3 : 621.3.018.78 **3649**

Distortion Produced in a Noise-Modulated F.M. Signal by Nonlinear Attenuation and Phase Shift.—S. O. Rice. (*Bell Syst. tech. J.*, July 1957, Vol. 36, No. 4, pp. 879–884.) An expression derived for the power spectrum of the distortion yields useful approximations for the second- and third-order modulation terms.

621.396.41 : 534.78 **3650**

The Use of Speech Clipping in Single-Sideband Communications Systems.—L. R. Kahn. (*Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1148–1149.) An analysis of the output waveform produced by a perfect s.s.b. suppressed-carrier transmitter, when fed by a severely clipped a.f. wave, and a discussion of advantages of the system.

621.396.65 : 621.396.4.029.64 **3651**

Microwave Remotes aid Air Traffic Control.—E. K. Peterson, H. R. Ulander, R. N. Hargis & E. Hajic. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 144–147.) Information obtained from a search radar, height-finding radar and I.F.F. equipment is transmitted by a microwave relay system to the control centre 250 miles away.

621.396.72 : 621.396.61/.62 **3652**

Radiotelephony—Prerequisites and Applications.—F. Kruse. (*Telefunken Ztg*, March 1957, Vol. 30, No. 115, pp. 5–8. English summary, p. 71.) The use of mobile radiotelephony installations, particularly in Germany, is briefly surveyed with 27 references which include the papers on portable sets discussed earlier [see 1550 o 1956 (Muth & Ulbricht)]. Details of the development, design and application of some of these installations are given in the following papers:—

FuG7—from the Single-Channel to the Multichannel U.S.W. Radiotelephone Set.—A. Hagen (pp. 9–20, English summary, p. 71).

Radiotelephony Aerials with Broad-Band Characteristics.—R. Becker (pp. 21–26, English summary, p. 72).

The Development of the 100-Channel Radiotelephone Set FuG7.—H. J. Fründt & F. Sobott (pp. 27–36, English summary, pp. 72–73).

Automatic Operation for U.S.W. F.M. Radiotelephone Services with Mobile Subscribers.—W. Kuehl & J. Schon (pp. 36–43, English summary, p. 73).

Fortuna Mine—an Example of Fully Automatic Through-Dialling in Both Directions in a Radiotelephony System.—(pp. 44–46, English summary, p. 74).

Helicopter with Radiotelephone Communication System for Use by the Police.—(pp. 47–49, English summary, p. 74).

U.S.W. Radiotelephony Installations for the Repair and Maintenance Services of Electric Railway Power Supplies.—A. Schepp. (pp. 50–54, English summary, pp. 74–75).

621.396.91 : 621.3.018.41(083.74) **3653**

Time-Signal Broadcast sets Electric Clock.—R. L. Ives. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 174–176.) A method of setting an electric clock by time signals from WWV.

621,396.933 : 621.396.11 **3654**

The Application of Radio Frequency Predictions to Aeronautical Communications.—A. Foxcroft. (*Proc. Instn Radio Engrs, Aust.*, Jan. 1957, Vol. 18, No. 1, pp. 7–12.) Prediction data available in Australia are reviewed and application of long-term and short-term forecasts to the planning and operation of aviation communication systems is discussed. An example of the use of predictions for a flight from Sydney to Nadi (about 2 000 miles) is given.

SUBSIDIARY APPARATUS

621.311.6 : 621.363 **3655**

The Problem of Efficiency of Thermoelectric Generators.—A. Käch. (*Elektrotech. Z., Edn A*, 1st March 1957, Vol. 78, No. 5, pp. 182–187.) Thermoelectric transducers of considerably greater efficiency than those based on present-day low-output

World Radio History

thermoelements appear feasible on theoretical grounds. For pure metals about 80–90% of the Carnot efficiency could be achieved with thermoelectric forces of 2–5 mV/°K.

621.311.62 : 621.316.722.1 **3656**

Low-Noise Stabilized D.C. Supplies.—D. W. W. Rogers. (*Electronic Radio Engr*, Sept. 1957, Vol. 34, No. 9, pp. 320–326.) Sources of hum and low-level noise in power supply units are described, together with methods for greatly reducing their effects. One of the circuits shown (with component values) gives a hum content less than 20 μV r.m.s., drift within ± 0·15% over eight hours, and stability within ± 0·1% for ± 6% mains variation.

621.314.634 : 537.311.33 **3657**

Structure of the Upper Layer adjacent to the Electrode of a Selenium Rectifier.—V. A. Dorin & D. N. Nasledov. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 90–94.) An X-ray investigation of the diffusion in the contact boundaries Sn-S and Sn-Se is described. The products of reactive diffusion of S and Sn were examined in samples heated to 220°C. When S comes into contact with the electrode containing Cd and Sn hole migration takes place in the Se, which results in rectification.

621.316.722.1 : 621.385.2 **3658**

Some Characteristics of Saturated Diodes with A.C. Heating.—Benson & Seaman. (See 3716.)

621.318.57 : 621.396.662.6 **3659**

A Variable Slow-Speed Uniselector Drive.—R. Selby. (*Electronic Engng*, July 1957, Vol. 29, No. 353, pp. 326–327.) "A circuit is described which employs a small thyratron to drive a uniselector without the use of relays or auxiliary power supplies."

TELEVISION AND PHOTOTELEGRAPHY

621.397.2 **3660**

U.S.S.R. Television Standard G.O.S.T. [Government Standard] **7845–55.**—S.V. Novakovski & D. I. Ermakov. (*Elektrosvyaz*, Jan. 1957, No. 1, pp. 24–34.) Details of the monochrome 625-line system in use since 1944 are given.

621.397.335 : 621.314.7 **3661**

Transistors Synchronize Portable TV Camera.—K. Kinoshita, Yasushi, Fujimura, Y. Kihara & N. Mii. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 168–169.) The sync generator described is of modular design and contains 26 transistors on a chassis 12 × 3¾ × 1⅞ in.

621.397.5 : 535.623 **3662**

Monochrome Slides broadcast Colour.—E. L. Covington. (*Electronics*, 1st March 1957, Vol. 30, No. 3, pp. 169–171.) "Two complementary colours can be broadcast from a television transmitter using monochrome slides having well-defined transitions. In addition, special circuits permit continuous transmission of a yellow-green colour stripe for colour receiver adjustment during monochrome broadcasts."

621.397.5 : 535.623 **3663**

Sequential Colour Again.—(*Wireless World*, Sept. 1957, Vol. 63, No. 9, pp. 426–429.) Description of a new French compatible 819-line sytem demonstrated at the Paris symposium. It incorporates a delay line and has the advantage that receivers can be simpler and less critical in operation.

621.397.61 **3664**

The Optimum Ratio between Sound and Vision Transmitter Powers.—L. Kedzierski & S. Ogulewicz. (*Nachr Tech.*, March 1957, Vol. 7, No. 3, pp. 109–112.) Measurements on several Polish and Russian television receivers show that a vision/sound power ratio of at least 5 is acceptable and that a much higher ratio can be used for some types of receiver. This is in agreement with the 1953 recommendations of the C.C.I.R.

621.397.611 **3665**

High-Fidelity Frame-Scanning Method.—L. L. Santo. (*Radiotekhnika, Moscow*, March 1957, Vol. 12, No. 3, pp. 18–24.) Report of experimental investigations and discussion of the conditions necessary to ensure the exact overlapping of frames.

621.397.611 : 621.385.833 **3666**

Electron-Optical Method of Varying the Scale of a Television Image.—I. I. Tsukkerman. (*Radiotekhnika, Moscow*, March 1957, Vol. 12, No. 3, pp. 4–9.) The electron-optical system described produces variable magnification without image reversal. See also 1598 of 1956.

621.397.611.2 **3667**

Automatic Level Control for TV Slide Chains.—E. W. Lambourne. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 182–183.) A simple three-valve circuit which maintains the peak-to-peak video signal from the iconoscope slide chain at a constant predetermined level.

621.397.611.2 : 621-52 **3668**

Television Technique Applied to Observation and Control.—J. D. McGee. (*Trans. Soc. Instrum. Technol.*, March 1957, Vol. 9, No. 1, pp. 26–40. Discussion, pp. 40–43.) Description of some modern pick-up tubes (see also 3418 of 1955) and outline of suitable equipment for some specialized applications. 25 references.

621.397.62 **3669**

Ultrasonic Gong controls TV Sets.—R. Adler, P. Desmares & J. Spracklen. (*Electronics*, 1st March 1957, Vol. 30, No. 3, pp. 156–161.) A device for remote control of a set by the viewer.

621.397.62 **3670**

Interesting Details of the Circuitry of This Year's Television Receivers.—W. Taeger. (*Frequenz*, April 1957, Vol. 11, No. 4, pp. 114–123.) Some improvements and novel features of receivers, mainly of German manufacture, are described.

621.397.62 : 621.385 : 621.375 **3671**

Operating Point and Modulation Range of Video End Stages.—W. Sparbier. (*Elektronische Rundschau*, April & May 1957, Vol. 11, Nos. 4 & 5, pp. 118–121 & 151–153.) General rules are established regarding the operation of video output stages in receivers. The advantages of black-level clamping are discussed and some typical valve operating data are given.

621.397.621 : 621.318.4 **3672**

Yoke Development for Standardization of 70° and 90° Deflection Angle.—C. E. Torsch. (*Trans. Inst. Radio Engrs*, Oct. 1955, Vol. BTR-1, No. 4, pp. 10–15. Abstract, *Proc. Inst. Radio Engrs*, March 1956, Vol. 44, No. 3, pp. 434–435.)

621.397.621 : 621.318.4 **3673**

Overcoming Line-Scan Ringing.—K. G. Beauchamp. (*Wireless World*, Sept. 1957, Vol. 63, No. 9, pp. 441–443.) The method described consists in ensuring that the line-scan transformer can resonate simultaneously at several frequencies in a definite relation. This is achieved in a specially designed transformer with the leakage inductance tuned. See also *Tele-Tech*, June 1953, Vol. 12, No. 6, pp. 108–110 (Torsch).

621.397.621.2 **3674**

Improvements in Television Receivers.—(*Electronic Applic. Bull.*, 1956/1957, Vol. 17, No. 2, pp. 41–63 & 64–71.)

Part 2—The PL 36 Line Output Pentode.—Three phenomena (the effects of Barkhausen oscillations, 'fraying' effect and envelope cracks) which are frequently experienced in line output valves are treated and methods of elimination given.

Part 3—Stabilization of the Frame Deflection Circuit.—Efficient stabilization is obtained without increasing the conventional valve complement as described earlier (Part 1: 3316 of October).

621.397.8 : 535.61 **3675**

The Distortion of Television Image Gradation by Illumination of the Screen.—R. Suhrmann. (*Elektronische Rundschau*, March 1957, Vol. 11, No. 3, pp. 75–77.) The influence of room lighting is investigated and simple circuits for correcting gradation distortion are outlined. See also 3323 of October.

TRANSMISSION

621.396.61-71 : 621.396.933 **3676**

Fluid Cooling an Airborne Transmitter.—J. B. Humfeld. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 170–172.) A 1-kW power amplifier for the range 4–30 Mc/s is described which employs self-rectification and silicone-oil cooling. The total volume occupied is 500 in³.

World Radio History

621.396.61.029.62 : 621.317.32 **3677**

Intercomparison of the Various Methods of Measuring Spurious Emissions.—Kurokawa, Takahashi & Arai. (See 3588.)

621.396.712 : 621.3.018.41 (083.74) **3678**

Experimental Standard - Frequency Broadcast on 60 Kilocycles.—(See 3586.)

VALVES AND THERMIONICS

621.314.63 : 537.311.33 **3679**

Surface Discharges at *p-n* Junctions.—B. M. Vul & A. P. Shotov. (*Zh. tekh. Fiz.*, Jan. 1957, Vol. 27, No. 1, pp. 211–212.) Experiments show that the performance of high-voltage diodes may be limited by breakdown of the air across the *p-n* junction at reverse voltages greater than 400 V at normal pressure.

621.314.63 : 537.311.33 : 546.28 **3680**

Silicon Diffused-Junction 'Avalanche' Diodes.—H. S. Veloric & K. D. Smith. (*J. electrochem. Soc.*, April 1957, Vol. 104, No. 4, pp. 222–226.) The diffusion technique is described and the characteristics of a series of 'avalanche' or voltage-limiting diodes made by this method are discussed. The range of breakdown voltages is from 6 V to >200 V, with areas 5×10^{-3} cm^2 – 5 cm^2.

621.314.63 : 546.289 **3681**

Design Theory and Experiments for Abrupt Hemispherical *P-N* Junction Diodes.—H. L. Armstrong, E. D. Metz & I. Weiman. (*Trans. Inst. Radio Engrs*, April 1956, Vol. ED-3, No. 2, pp. 86–92. Abstract, *Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, p. 955.)

621.314.63 : 621.318.57 **3682**

Fast Switching by Use of Avalanche Phenomena in Junction Diodes.—B. Salzburg & E. W. Sard. (*Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1149–1150.) Reduced transients are obtained when switching through avalanche breakdown from low to high current.

621.314.632 **3683**

Study of Rectifying Characteristics of FeS_2 and Germanium Point-Contact Rectifiers.—J. N. Das. (*Indian J. Phys.*, March 1957, Vol. 31, No. 3, pp. 172–174.) Results of measurements of contact potential difference, spreading resistance, current amplification factor, and the effect of photo-injection on the reverse current with and without bias are given for commercially available Ge diodes and FeS_2 crystals with tungsten-wire contact, the crystals being embedded in Wood's metal to establish a large-area base contact. Observations can be explained by considering the effect of trapped electrons in the surface states.

621.314.632 : 546.28 **3684**

The Silicon 'Zener' Diode. — P. Dobrinski, H. Knabe & H. Müller. (*Nachrichtentech. Z.*, April 1957, Vol. 10, No. 4, pp. 195–199.) Description of the characteristics of commercial types of Si reference diode with Zener voltages between 6 and 9 V. A number of applications are discussed. See also 923 of 1956 (Wulfsberg).

621.314.632 : 546.289 **3685**

Current/Voltage Characteristic and Hole Injection Factor of Point-Contact Rectifiers in the Forward Direction.—K. Lehovec, A. Marcus & K. Schoeni. (*Trans. Inst. Radio Engrs*, Jan. 1956, Vol. ED-3, No. 1, pp. 1–6. Abstract, *Proc. Inst. Radio Engrs*, May 1956, Vol. 44, No. 5, p. 716.)

621.314.7 **3686**

An Approximation to Alpha of a Junction Transistor.—R. D. Middlebrook & R. M. Scarlett. (*Trans. Inst. Radio Engrs*, Jan. 1956, Vol. ED-3, No. 1, pp. 25–29. Abstract, *Proc. Inst Radio Engrs*, May 1956, Vol. 44, No. 5, p. 716.)

621.314.7 **3687**

A Method of Determining Impurity Diffusion Coefficients and Surface Concentrations of Drift Transistors.—L. S. Greenberg, Z. A. Martowska & W. W. Happ. (*Trans. Inst. Radio Engrs*, April 1956, Vol. ED-3, No. 2, pp. 97–99. Abstract, *Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, p. 955.)

621.314.7 : 546.28 **3688**

High-Frequency Silicon Alloy Transistor.—A. D. Rittmann & T. J. Miles. (*Trans. Inst. Radio Engrs*, April 1956, Vol. ED-3, No. 2, pp. 78–82. Abstract, *Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, p. 955.)

621.314.7 : 621.317.6 **3689**

A Simple Transistor Beta Tester for Rapid Determination of Transistor Gain.—(See 3593.)

621.314.7 : 621.317.6 **3690**

Sweeper determines Power-Gain Parameter.—Coffey. (See 3594.)

621.383.5 : 546.289 **3691**

Photocell measures Light Direction.—J. T. Wallmark. (*Electronics*, 1st July 1957, Vol. 30, No. 7, pp. 165–167.) The lateral voltage produced on a germanium-indium junction varies with the angle between the photocell axis and the direction of the incident light. Several applications are discussed.

621.384.5 : 621.385.5 : 621.387 **3692**

An Improved Circuit for Reliable Operation of Nomotron Counter Tubes.—T. M. Jackson. (*Electronic Engng*, July 1957, Vol. 29, No. 353, pp. 324–326.) New operating conditions are given for the nomotron G10/241E cold-cathode multi-electrode counter tube originally described by Hough and Ridler (2933 of 1952).

621.385 : 621.374.3 **3693**

A Search for a Pulser of High Output Requiring Small Grid Drive.—S. C. Nath & B. M. Banerjee. (*J. sci. industr. Res.*, Oct. 1956, Vol. 15A, No. 10, pp. 444–449.) The pulse characteristics of various receiving-type valves have been investigated to select a suitable pulse amplifier for frequency-sweep ionospheric sounding equipment. Figures for some 20 types are listed. The performance of a line pentode Type EL81 is superior to any other valve tested. Other types with useful characteristics for fast pulse applications are the Type 6AH6 and Type EFP60.

621.385.029.6 **3694**

A Small-Amplitude Theory for Magnetrons.—O. Bunemann. (*J. Electronics Control*, July 1957, Vol. 3, No. 1, pp. 1–50.) First publication of a 1944 classified report on magnetron work at the Manchester University C.V.D. group. The impedance of a magnetron electron cloud, defined as the ratio of r.f. electric and magnetic field components at the surface of the cloud, is calculated. This impedance can exhibit a negative resistance component, or a pure reactance which decreases with frequency. This latter property is shown to be a sufficient condition for the spontaneous start-up of oscillations. Calculated operating conditions as a function of load agree closely with experiment.

621.385.029.6 **3695**

Space Charge in the Relativistic Magnetron.—L. Gold. (*J. Electronics Control*, July 1957, Vol. 3, No. 1, pp. 87–96.) Three relativistic solutions for the space-charge behaviour in a magnetron at high energies are calculated. These correspond to the border of the classical region, the intermediate and the extreme relativistic domain.

621.385.029.6 **3696**

Kinetic Theory of Space Charge: Part 1—Cut-Off Character of the Static Magnetron.—L. Gold. (*J. Electronics Control*, July 1957, Vol. 3, No. 1, pp. 97–102.) The effect of damping in the magnetron space charge by electron-electron collisions is shown to account for departures from Child's law, and also for the previously unexplained lack of a sharp cut-off.

621.385.029.6 **3697**

Straight-Field Permanent Magnets of Minimum Weight for TWT Focusing—Design and Graphic Aids in Design.—M. S. Glass. (*Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1100–1105.) The validity of the method has been confirmed by tests upon a series of travelling-wave-valve magnets varying in weight from 3 to 20 lb.

621.385.029.6 **3698**

Some New Circuits for High-Power Travelling-Wave Tubes.—M. Chodorow & R. A. Craig. (*Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1106–1118.) A discussion and description of a new class of propagating circuits for use in pulsed high-power travelling-wave valves in which the electrons interact with the fundamental space component of the propagating wave, and which are suitable for bandwidths of 10–20%. Operation at 100 kV is envisaged, but greater bandwidths at lower voltages should be possible. The structures consist

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of sets of magnetically coupled cavities leading to negative mutual impedances in the pass band and a fundamental space wave of forward phase velocity; the lower impedance of this wave enables greater energy storage to be obtained than with the more usual space harmonic mode resulting from conventional circuits.

621.385.029.6 **3699**

Large-Signal Behaviour of High-Power Travelling-Wave Amplifiers.—J. J. Caldwell, Jr, & O. L. Hoch. (*Trans. Inst. Radio Engrs*, Jan. 1956, Vol. ED-3, No. 1, pp. 6–17. Abstract, *Proc. Inst. Radio Engrs*, May 1956, Vol. 44, No. 5, p. 716.)

621.385.029.6 **3700**

A Large-Signal Analysis of the Travelling-Wave Amplifier: Theory and General Results.—J. E. Rowe. (*Trans. Inst. Radio Engrs*, Jan. 1956, Vol. ED-3, No. 1, pp. 39–56. Abstract, *Proc. Inst. Radio Engrs*, May 1956, Vol. 44, No. 5, p. 717.) See also 1270 of April (Tien: Rowe).

621.385.029.6 **3701**

Small-Signal Power Theorem for Electron Beams.—H. A. Haus & D. L. Bobroff. (*J. appl. Phys.*, June 1957, Vol. 28, No. 6, pp. 694–704.) The analysis deals with a filament beam in arbitrary d.c. electric and magnetic fields. The electromagnetic power delivered by the beam is balanced by a decrease of the 'generalized a.c. power' in the beam which involves products of the small-signal beam-excitation amplitudes. The theorem can also be extended to thick beams.

621.385.029.6 : 537.533 **3702**

Ion Oscillations in Electron Beam Tubes; Ion Motion and Energy Transfer.—R. L. Jepsen. (*Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1069–1080.) A plausible physical picture of some possible positive-ion motions is obtained, and shows that the electric field inside the gridded drift tube may undergo one or more space reversals, leading to a mechanism for transfer of energy between beam and oscillating ions. The occurrence of fluctuating ion oscillations is not predicted.

621.385.029.6 : 537.533 **3703**

Effects of Space Charge in Crossed-Field Valves.—B. Epsztein. (*C. R. Acad. Sci., Paris*, 24th June 1957, Vol. 244, No. 24, pp. 2902–2905.) Application of previous analysis (2568 of 1956) to the M-type carcinotron and the travelling-wave magnetron, and comparison with experimental results.

621.385.029.6 : 537.533 **3704**

Space-Charge Neutralization by Ions in Linear-Flow Electron Beams.—N. C. Barford. (*J. Electronics Control*, July 1957, Vol. 3, No. 1, pp. 63–86.) A theoretical analysis shows that the influence of ions may be represented by a single parameter which is a function of gas pressure, current and collector potential. The analysis is used to find the effect of gas on the operation of a low-voltage reflection oscillator and a high-voltage klystron amplifier.

621.385.029.6 : 537.533 : 538.691 **3705**

Nonlaminar Flow in Cylindrical Electron Beams.—K. J. Harker. (*J. appl. Phys.*, June 1957, Vol. 28, No. 6, pp. 645–650.) Experiments show that the flow from magnetically shielded cathodes is very nonlaminar. Many electrons pass periodically very near the axis of the beam and, when the focusing field is strong, at well defined angles. This results in the distribution of transverse velocities near the axis being composed of discrete classes.

621.385.029.6 : 537.533 : 621.396.822 **3706**

Noise Spectrum of Electron Beam in Longitudinal Magnetic Field.—W. W. Rigrod. (*Bell Syst. tech. J.*, July 1957, Vol. 36, No. 4, pp. 831–878.) Experimental measurements show that the growing noise pattern results from rippled-beam amplification of noise fluctuations over a wide band of microwave frequencies, due to intermodulation and other nonlinear processes within the gain band. Measurements in the u.h.f. region reveal additional forms of instability.

621.385.029.6 : 621.3.032 **3707**

Wave Propagation on Multifilar Helices.—H. R. Johnson, T. E. Everhart & A. E. Siegman. (*Trans. Inst. Radio Engrs*, Jan. 1956, Vol. ED-3, No. 1, pp. 18–24. Abstract, *Proc. Inst. Radio Engrs*, May 1956, Vol. 44, No. 5, p. 716.)

621.385.029.63 **3708**

A U.H.F. Travelling-Wave Amplifier Tube employing an Electrostatically Focused Hollow Beam.—C. B. Crumly. (*Trans. Inst. Radio Engrs*, Jan. 1956, Vol. ED-3, No. 1, pp. 62–66. Abstract, *Proc. Inst. Radio Engrs*, May 1956, Vol. 44, No. 5, p. 717.)

621.385.029.63 : 621.375 **3709**

Scalloped Beam Amplification.—T. G. Mihran. (*Trans. Inst. Radio Engrs*, Jan. 1956, Vol. ED-3, No. 1, pp. 32–39. Abstract, *Proc. Inst. Radio Engrs*, May 1956, Vol. 44, No. 5, p. 717.) See also 891 of 1955.

621.385.032.213 **3710**

Calculation of the Anode Current from a Hollow Cathode.—T. N. Chin. (*J. appl. Phys.*, June 1957, Vol. 28, No. 6, pp. 744–745.)

621.385.032.213 **3711**

The Dynamic Characteristics of Tungsten Cathodes.—W. Ruppel & H. Seifert. (*Nachrichtentech. Z.*, March 1957, Vol. 10, No. 3, pp. 115–119.) The directly heated diode is treated as a l.f. amplifier of heater current fluctuations. Its characteristics and life expectancy are investigated in relation to filament dimensions and operating temperature. The theoretical curves are verified by means of measurements on experimental valves.

621.385.032.213.2 : 621.385.833 **3712**

The Bolt Cathode as Object in the Electron-Emission Microscope.—Baş. (See 3624.)

621.385.032.216 **3713**

Secondary Electron Emission from Barium Dispenser Cathodes.—I. Brodie & R. O. Jenkins. (*Brit. J. appl. Phys.*, May 1957, Vol. 8, No. 5, pp. 202–204.) A description of measurements of the total secondary electron emission coefficient, under electron bombardment, of various dispenser cathodes. Typical results are given and discussed in detail.

621.385.032.216 **3714**

Computer Valves and Cathode Interface Impedance.—J. Seymour. (*J. Electronics Control*, July 1957, Vol. 3, No. 1, pp. 107–125.) The measurement of cathode interface impedance in standard valves, and its reduction in special high-quality valves by the use of improved sleeve materials is described.

621.385.032.24 **3715**

Studies on Grid Emission.—G. A. Espersen & J. W. Rogers. (*Trans. Inst. Radio Engrs*, April 1956, Vol. ED-3, No. 2, pp. 100–107. Abstract, *Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, p. 955.)

621.385.2 : 621.316.722.1 **3716**

Some Characteristics of Saturated Diodes with A.C. Heating.—F. A. Benson & M. S. Seaman. (*Electronic Engng*, July 1957, Vol. 29, No. 353, pp. 343–347.) "Some characteristics of saturated diodes Types 29C1, AV33 and A2087, when operating with a.c. filament supplies, have been examined. The investigations have been concerned with the shapes of anode-current/anode-voltage curves, the variations of mean emission currents with the filament supply frequency and the way in which ripples superimposed on the emission currents vary with frequency and emission current. Some information is also included about the variation of response time with emission current." See also 3447 of 1955.

621.385.3 : 531.787 : 616 **3717**

Movable-Anode Tube.—(See 3620.)

621.387 : 621.318.57 **3718**

Counters and Control Circuits with Coincidence Thyratrons.—Hartmuth. (See 3416.)

MISCELLANEOUS

621.3 (083.7) **3719**

I.R.E. Standards on Letter Symbols and Mathematical Signs, 1948 (Reprinted 1957).—(*Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1140–1147.) Standard 57 I.R.E. 21.S1.

413.164 : [53+621.3 **3720**

The International Dictionary of Physics and Electronics. [Book Review]—W. C. Michels (Ed.). Publishers: Macmillan & Co., London, 120s. (*Engineering, Lond.*, 22nd March 1957, Vol. 183, No. 4750, p. 371.)

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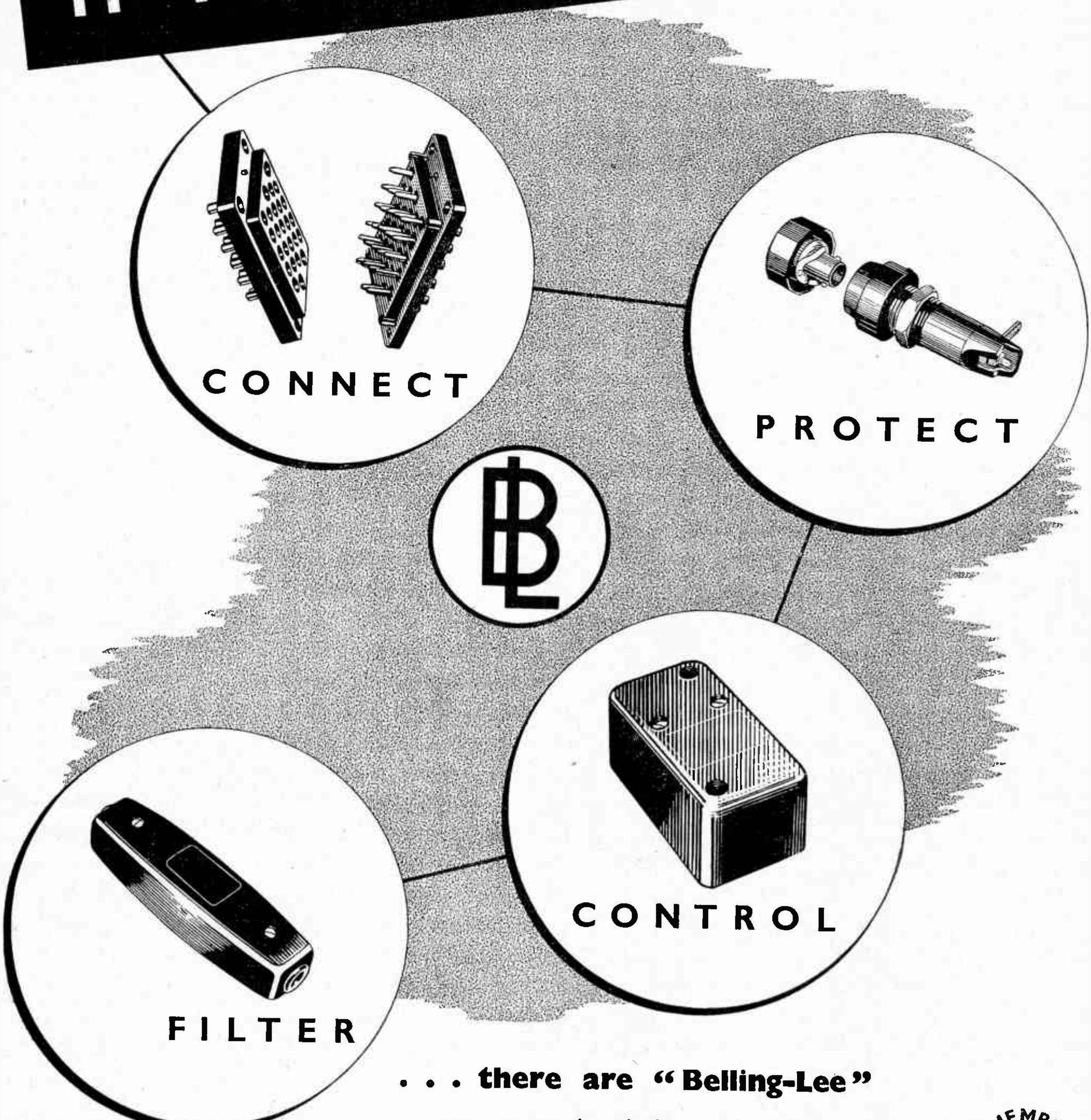

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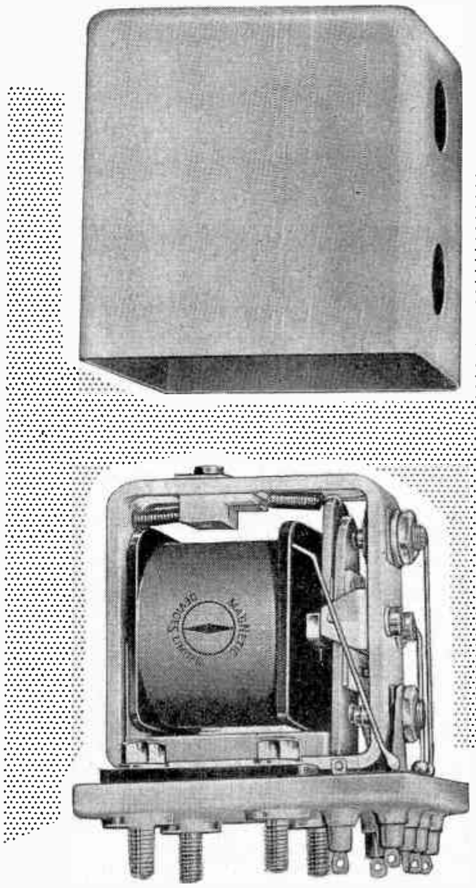

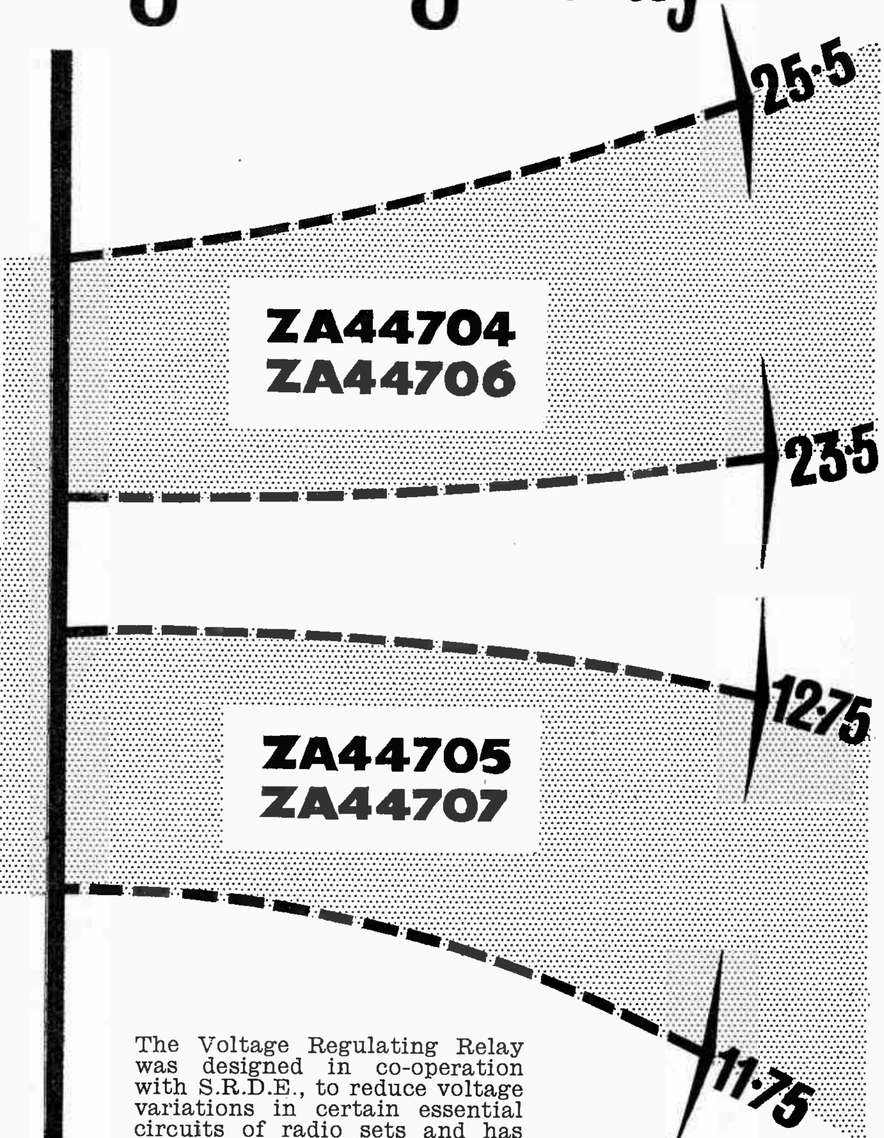

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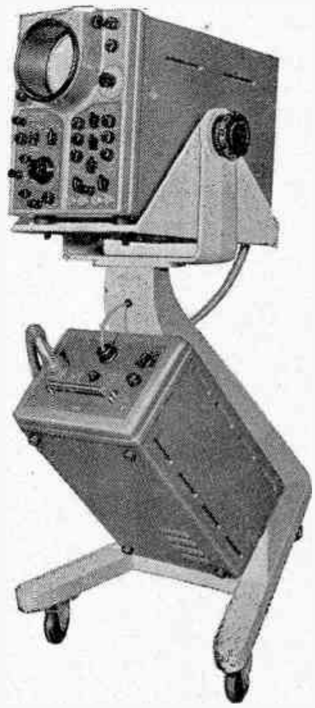

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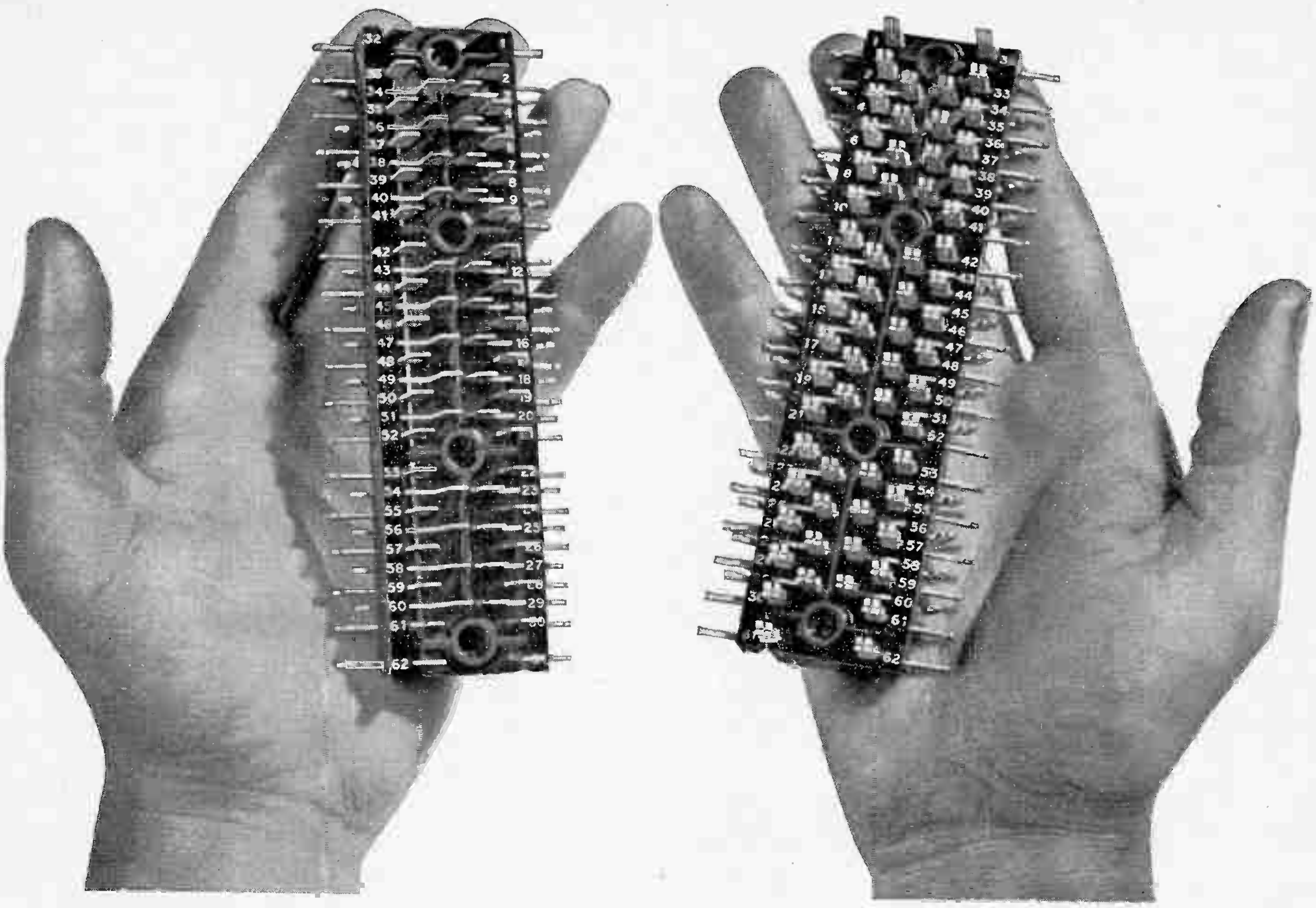

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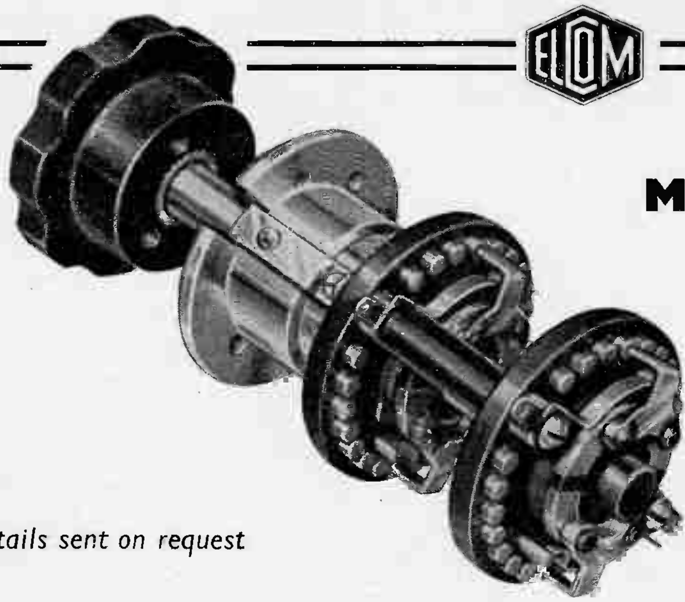

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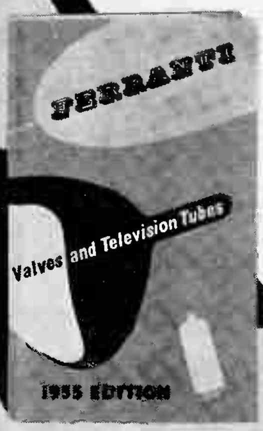

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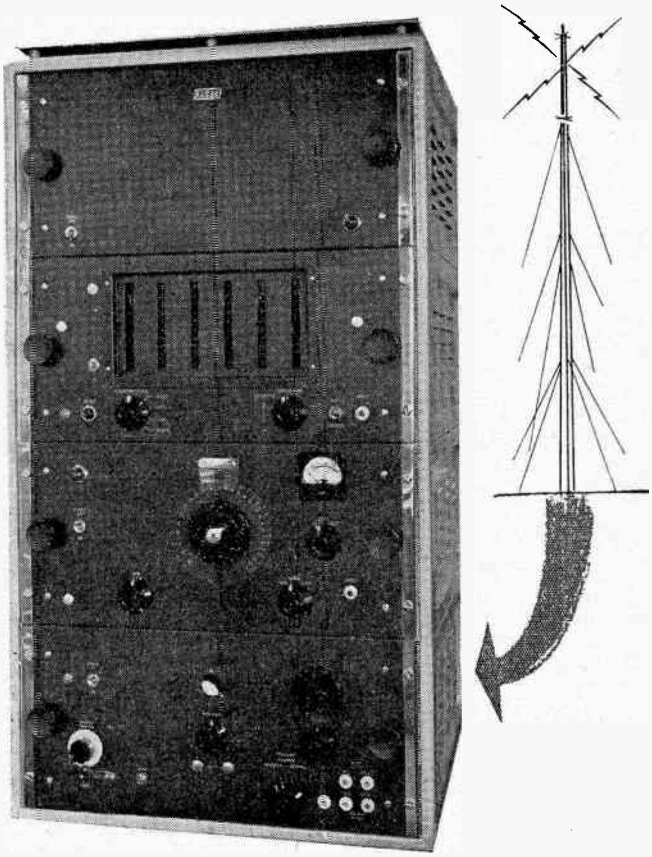

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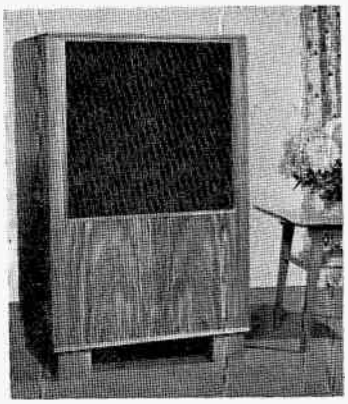

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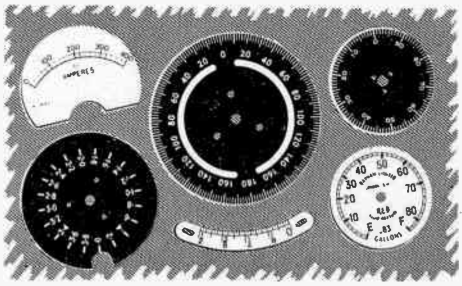

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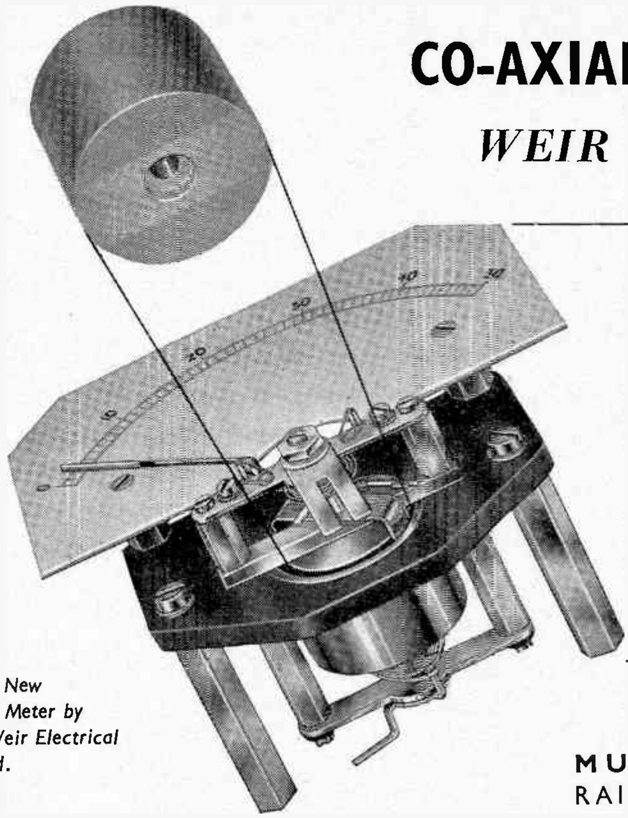

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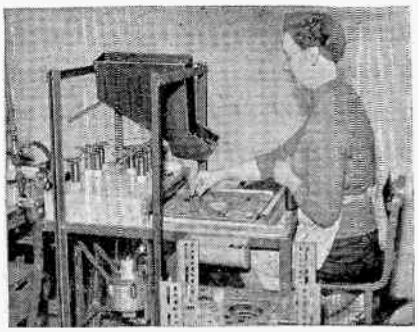

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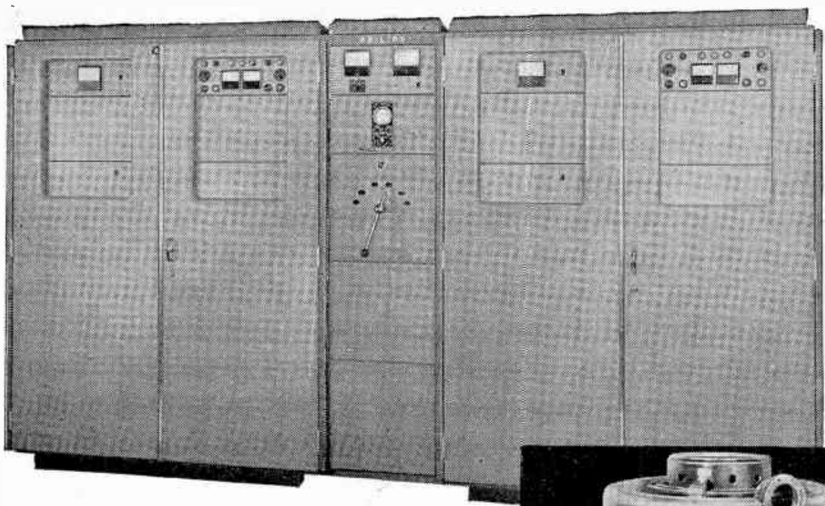

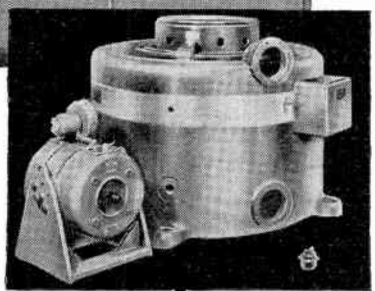

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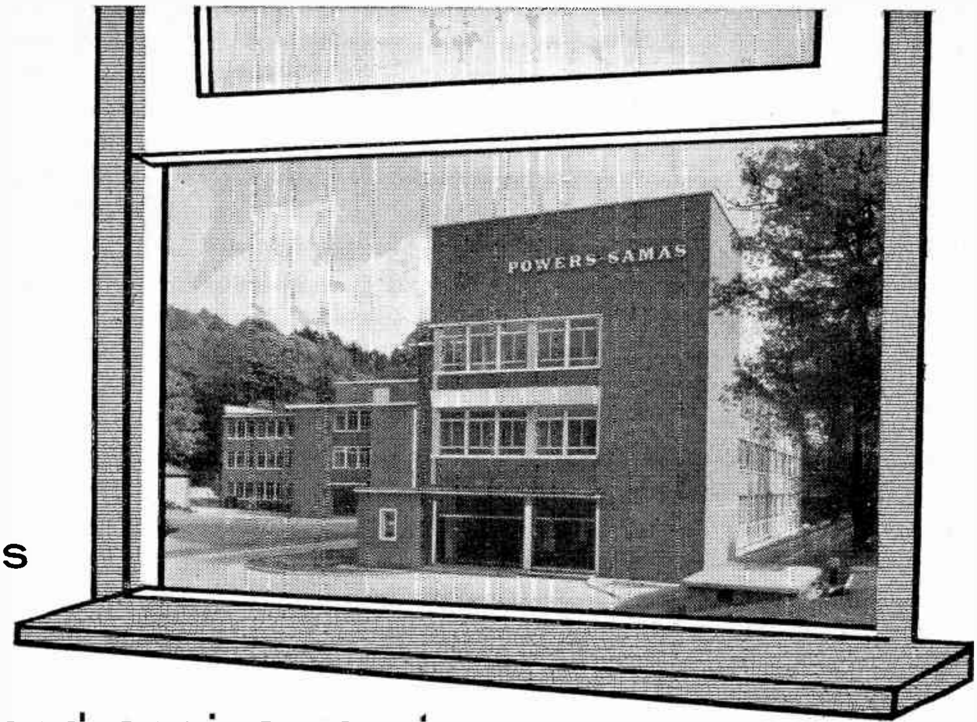

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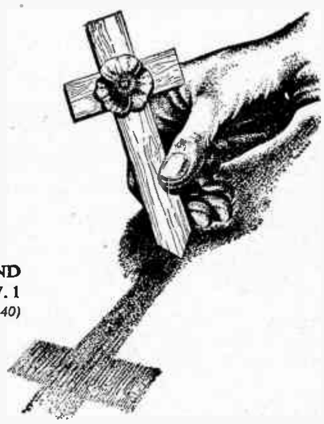

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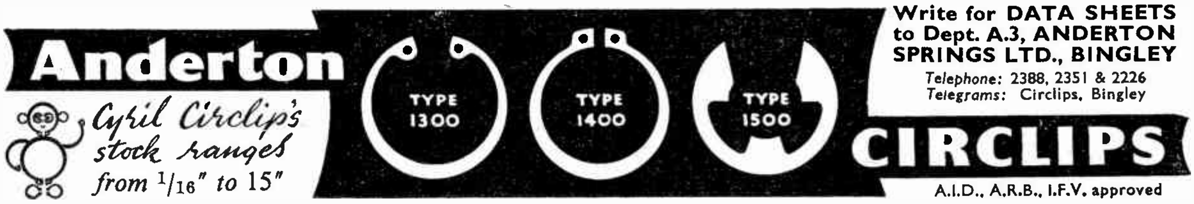

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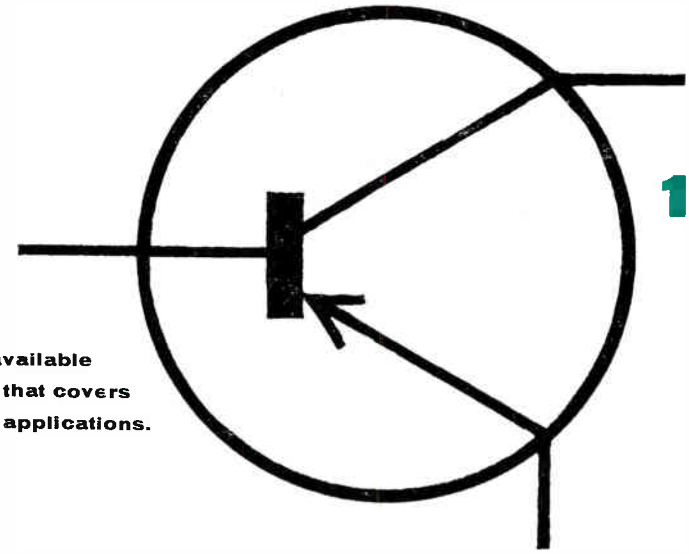

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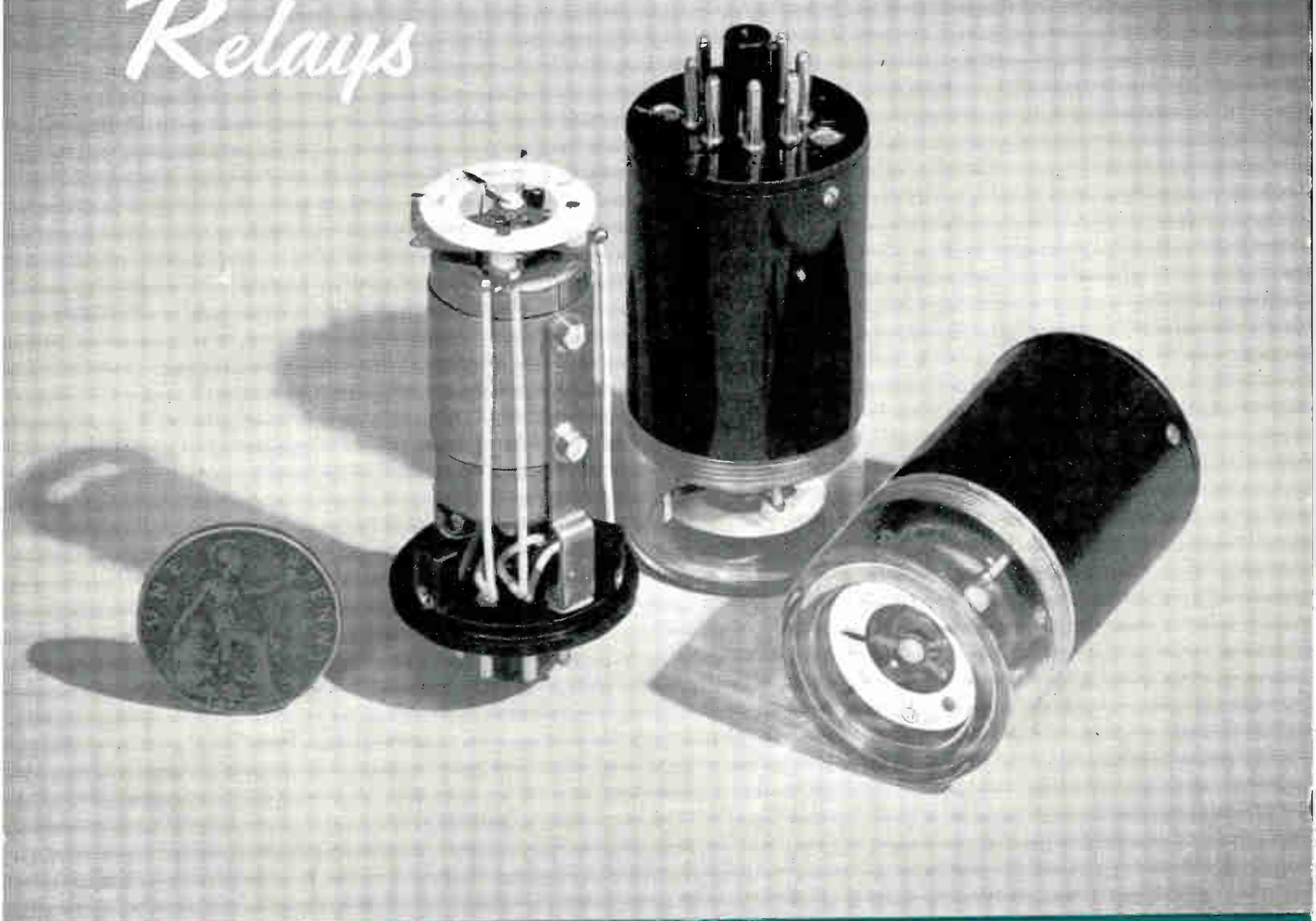

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