ELECTRONIC & RADIO ENGINEER

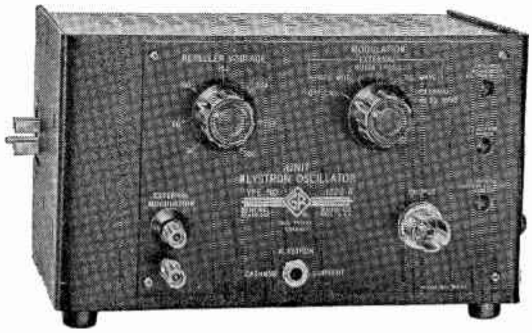
Incorporating **WIRELESS ENGINEER**

In this issue

Television Camera Channel Design
Measurement of Height-Gain
Coherent and Incoherent Detectors
Notes on the Multi-Reflection Klystron

Three shillings
and sixpence

MARCH 1957 Vol 34 *new series* No 3



"GENERAL RADIO" TYPE 1220-A KLYSTRON OSCILLATOR

The new "G.R." type 1220–A Unit Klystron Oscillator generates frequencies between 2700 and 7400 megacycles/sec. It can generate fixed frequencies or swept frequencies and can be amplitude modulated with either square waves or pulses, with very low incidental fm.

This Oscillator, because of its relatively high output, low cost, small size and rugged construction, is equally useful in the laboratory, on the production line, and for classroom demonstrations. It is an excellent source for measurements of impedance and VSWR, measurements of bandwidth, and attenuation measurements on cables, lines and pads.

Briefly, the instrument includes an adjustable, regulated source of repeller voltage, a Schmitt squaring circuit, a 1000-cycle RC Oscillator, and a socket for a reflex klystron tube. Klystron cathode current is furnished by an external Unit Power Supply, the "G.R." type 1201–AQ18 (230v. 50–60 c/s) being ideal for this purpose.

A series of eight plug-in Klystrons cover the frequency range. The following Table gives the type number complete with the related single Klystron: additional tubes can be ordered by the pattern and price quoted. Klystron frequency can readily be adjusted by a screw adjustment at the rear. All tubes except the 6043 are designed for relatively infrequent tuning. The Oscillator will also operate with the Type 2K25 Klystron (8550–9660 Mc) and Type 2K26 (6250–7060 Mc).

Type	Range Mc/s.	Nom. Output: milliwatts	PRICE	Spare Klystron	PRICE
1220–A	less tube	—	£123 0 0	—	—
1220–A1	2700–2960	100	£152 15 0	726–C	£29 15 0
1220–A2	2950–3275	90	£163 15 0	6043	£40 15 0
1220–A3	3400–3960	90	£159 10 0	2K29	£36 10 0
1220–A4	3840–4460	75	ø£187 5 0	2K56	£64 5 0
1220–A5	4240–4910	100	£156 17 6	2K22	£33 15 0
1220–A6	5100–5900	80	£180 17 6	6115	£57 15 0
1220–A7	5925–6450	100	£163 15 0	QK404	§£40 15 0
1220–A8	6200–7425	90	£163 15 0	5976	§£40 15 0
1201–AQ18	Power Supply only	—	£55 0 0	—	—

For complete specifications see the current "GENERAL RADIO" Catalogue "O," Page 118—Oscillators Section. Other sections deal with Amplifiers, Bridges, Coaxial Elements, Frequency and Time Measurement apparatus, Standard-Signal and other Generators, Meters including V.T.V.M.'s, Monitors for Radio and T/V Stations, Capacitors, Inductors, Resistors, Waveform-measuring Equipment, Slotted-Line Equipment, Stroboscopes, "VARIAC" Voltage-Regulating Transformers, Automatic Voltage Regulators, etc., etc.

Catalogue "O" will be sent promptly to suitable applicants against written requests: kindly address our nearest works.

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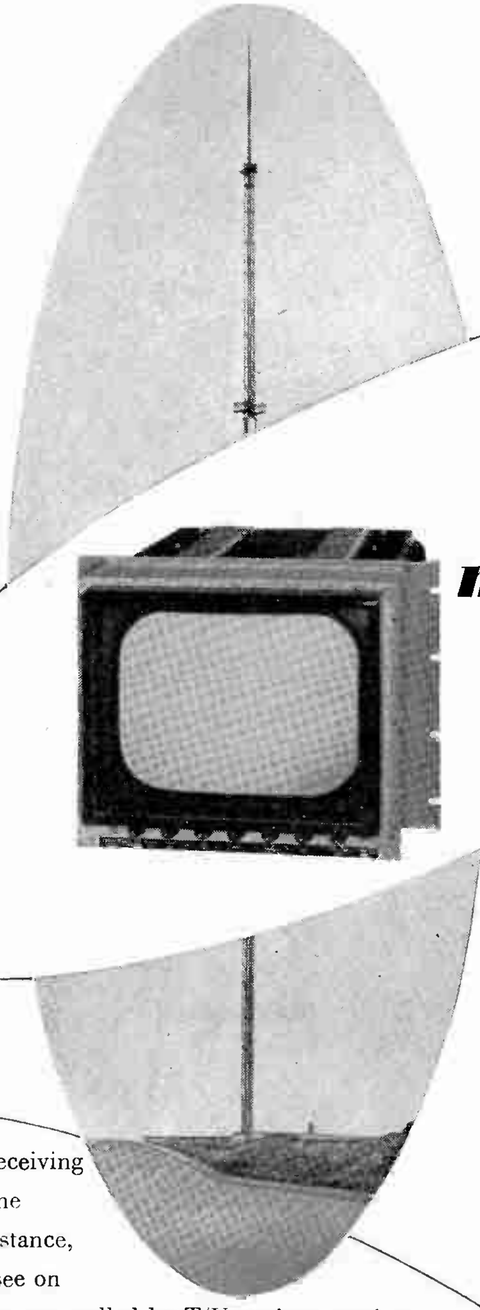
CL 30



T/V engineers monitor with **murphy**

Murphy are on the T/V receiving end with fine sets—and on the transmitting end too. For instance, some of the programmes you see on your screen at home are controlled by T/V engineers using Murphy monitors. And when programmes are being networked, engineers of the G.P.O. use Murphy monitors for checking transmissions throughout the country. Murphy monitors are relatively inexpensive, can be used with any standard equipment. They're just one of the ways in which people keep in touch with Murphy.

keep in touch with **murphy**

Aircraft navigation equipment
Communications receivers
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Electronic test gear
Interference tracing equipment
Mobile radio telephones

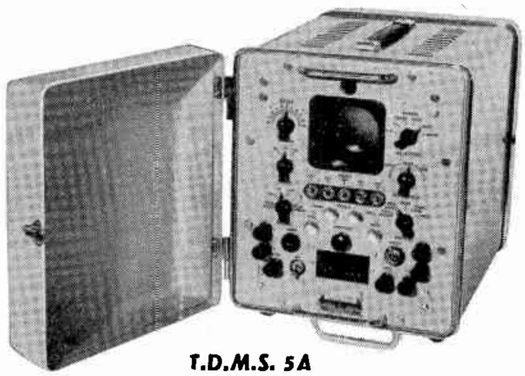
MURPHY RADIO LIMITED (ELECTRONICS DIVISION) · WELWYN GARDEN CITY · HERTFORDSHIRE

CRC31E

Distortion detected - Transmission unaffected

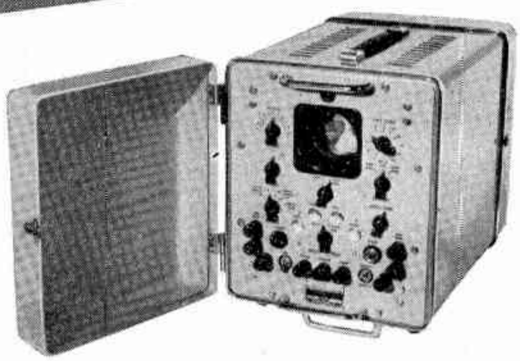
with the T. D. M. S.

The T.D.M.S. 5A and 6A are portable sets designed to measure distortion at any point in a radio teleprinter or line telegraph circuit without interfering with normal transmission. The equipment consists of two units each 18½" x 11½" x 13½" both mains driven and electronically controlled. Either may be used independently for certain tests or both may be used in combination to cover a comprehensive range of testing operations.



T.D.M.S. 5A

Sends an automatic test message, or characters, or reversals at any speed between 20-80 bauds. with or without distortion. The CRO has a circular time base for distortion measurements on synchronous signals only, or relay adjustment. Weight 37 lb.



For distortion measurements on working circuits without interrupting service. Each element of a start-stop signal appears separately on the spiral time base display. Adjustable speeds from 20-80 bauds. Weight 33 lb. Higher speed versions can be supplied to order.

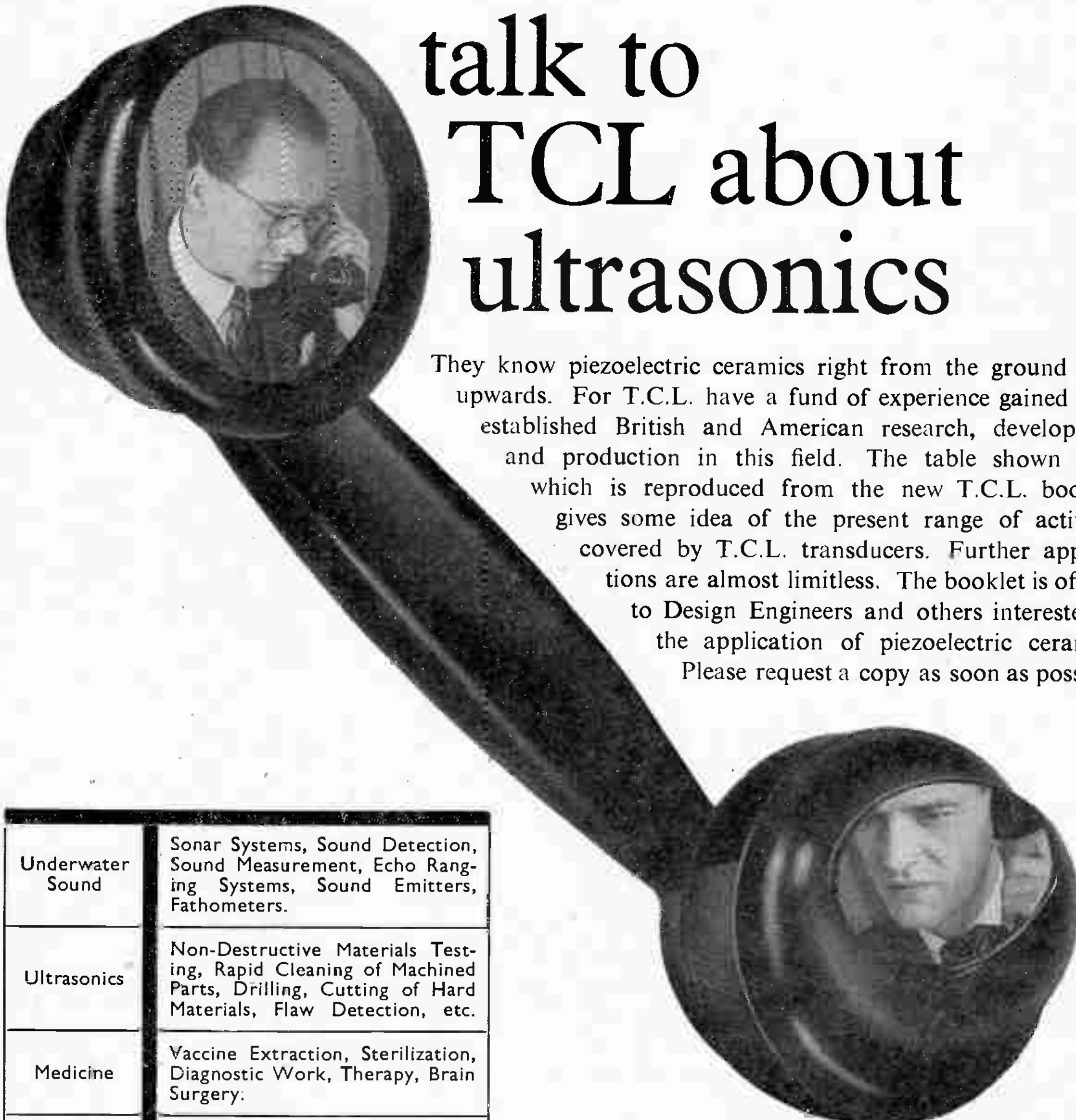
T.D.M.S. 6A

You are invited to apply for a copy of a descriptive leaflet.

AUTOMATIC TELEPHONE & ELECTRIC CO. LTD.,

STROWGER HOUSE, ARUNDEL STREET, LONDON, W.C.2.
TELEPHONE : TEMPLE BAR 9262. CABLEGRAMS : STROWGEREX LONDON.

AT14611-BX107



talk to TCL about ultrasonics

They know piezoelectric ceramics right from the ground floor upwards. For T.C.L. have a fund of experience gained from established British and American research, development and production in this field. The table shown here, which is reproduced from the new T.C.L. booklet, gives some idea of the present range of activities covered by T.C.L. transducers. Further applications are almost limitless. The booklet is offered to Design Engineers and others interested in the application of piezoelectric ceramics. Please request a copy as soon as possible.

Underwater Sound	Sonar Systems, Sound Detection, Sound Measurement, Echo Ranging Systems, Sound Emitters, Fathometers.
Ultrasonics	Non-Destructive Materials Testing, Rapid Cleaning of Machined Parts, Drilling, Cutting of Hard Materials, Flaw Detection, etc.
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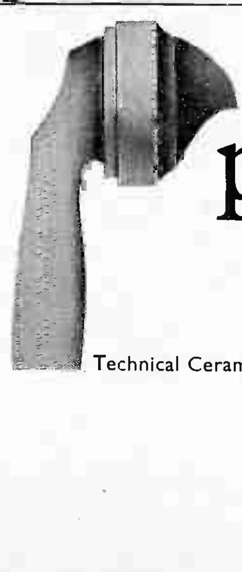
Shock and Vibration	Accelerometers, Pressure and Blast Gauges, Displacement Gauges, Strain Gauges.
General	Gramophone Pick-ups, Filters and Oscillators, Surface Gauges.

TCL

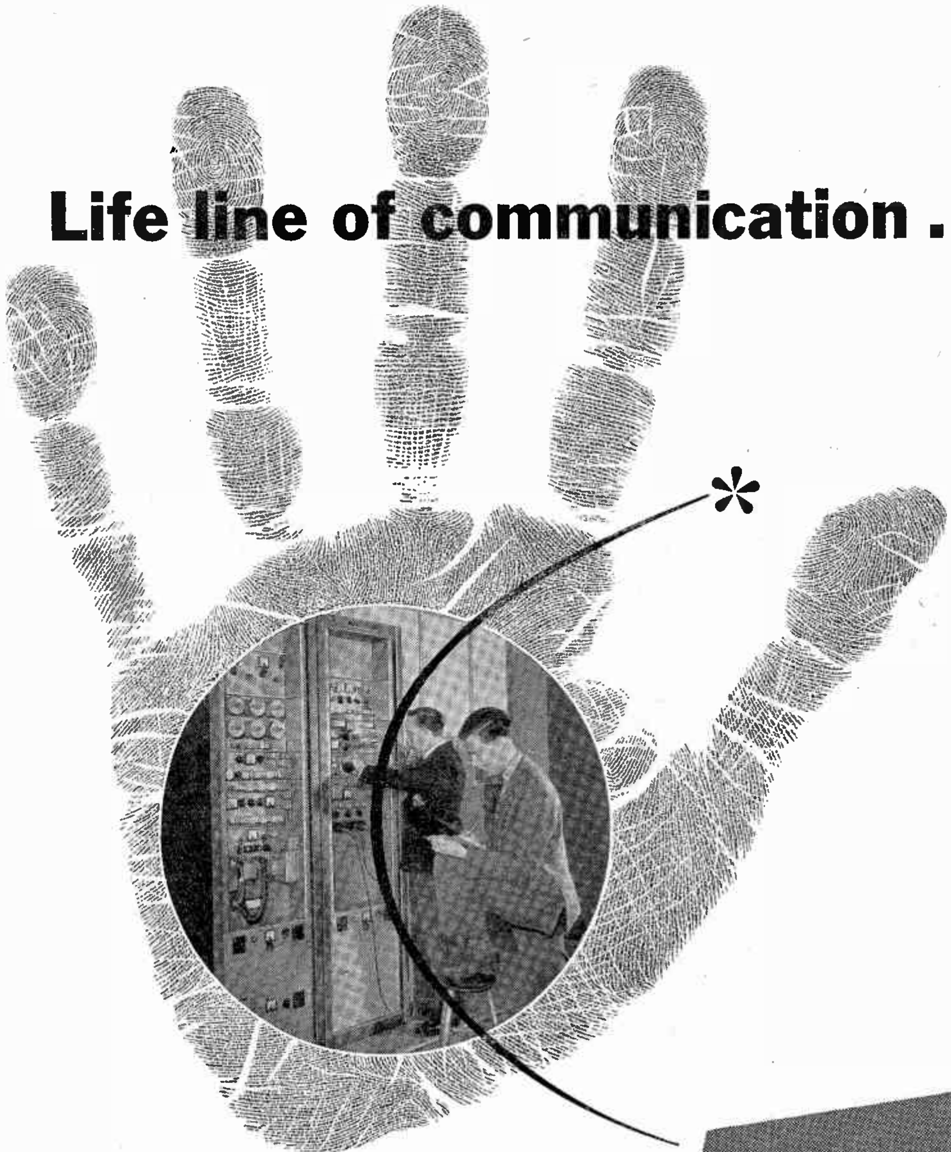


piezoelectric ceramics

Technical Ceramics Limited, Wood Burcote Way, Towcester, Northants Tel: Towcester 312-6

TC5a

Life line of communication . . .



World wide radio-communication began with Marconi's Transatlantic messages in 1901. Since then Marconi research and development have led to every major advance in technique. Marconi equipment today, operating at all frequencies, covers a very wide field of both long and short range radio-telegraph and radio-telephone requirements. Marconi VHF multi-channel equipment can provide for as many as 48 telephone channels and is largely superseding land-line or cable routes on grounds of efficiency, economy and, where terrain is difficult, ease of installation and maintenance.

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LG 1

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It is equally efficient whether it is a question of operating the switch directly by closing a mechanical contact in the energizing circuit (as in the simpler remote control systems), or by the consecutive operation of many relays in complicated electronic switching units (as in the latest radar systems).

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See our exhibits

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RECMF EXHIBITION
and
STAND 201
INSTRUMENTS, ELECTRONICS AND AUTOMATION EXHIBITION

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If your project involves *High-Speed Switching*, details of the Carpenter Relay's performance cannot fail to be of value to you; and you will find much to interest you in our Brochure F.3516, "*Applications of the Carpenter Polarized Relay.*" Write us, or telephone, *now*.

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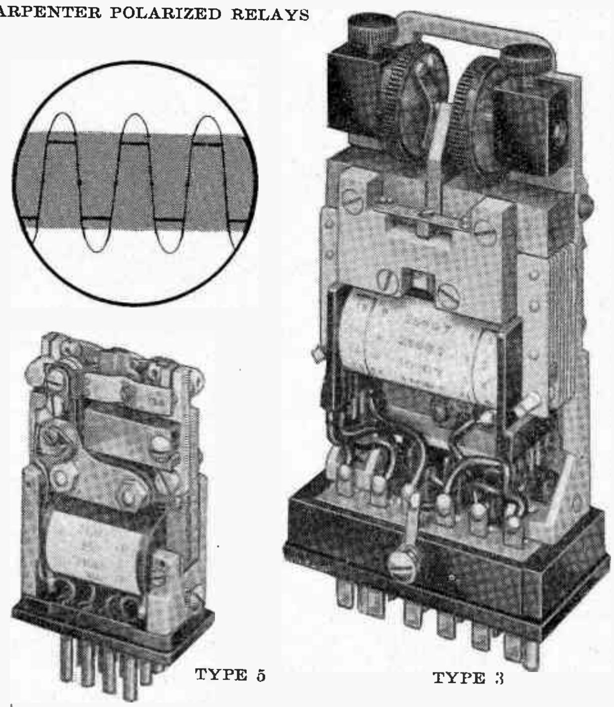
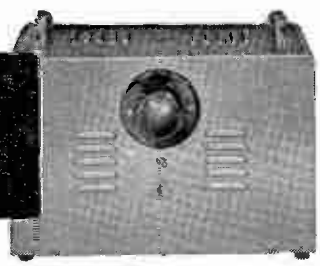
CARPENTER POLARIZED RELAYS



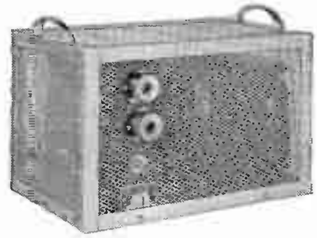
A-C AUTOMATIC VOLTAGE REGULATORS
39 BASIC TYPES IN 6 DESIGN SERIES



BMVR - 1725

WIDEST RANGE IN THE WORLD?

So far as we are aware, our range of A.C. Automatic Voltage Stabilisers is the largest in the World. We have a very wide range of standard models, single-phase patterns ranging from 200 VA to about 30 kVA (3-phase types up to about 90 kVA). There are 39 basic types, in six distinct design series, and all are available in standard form or as tropicalised instruments. We feel that on this account there can be few, if any requirements covering Stabilisers that we are not in a position to meet economically, efficiently and promptly.



BAVR 1000 & BAVR - 1000-E

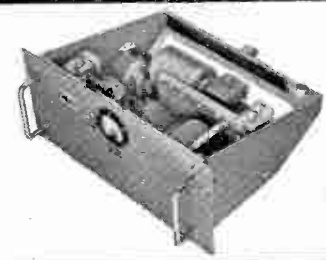
Here are very brief details of the six main series, in handy tabular form: cut this ad. out and use it as a Buying Guide; but please remember that if you do not see *exactly* what you require a written enquiry will probably reveal that we have a "special" to suit, or that the answer is under development. New stabilisers are regularly being added to our range. Several are at the very advanced development stage now—and we do design "specials". One such "special" (AM type 10D/20161) is illustrated (Illustrations not to scale). Nearly 100 have been supplied to Murphy Radio Ltd. for incorporation in equipment supplied by them to the Air Ministry for use on a chain of Radar Marker Beacons. 45 in slightly differing form are currently being made by us for the Air Ministry for another Radar Chain.

For complete data request our 20-Page Supplement Ref. V-549-S and its associated Special Price List, CLL Form VSP-56/16.

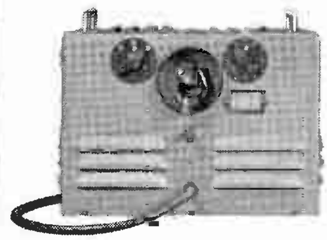
BMVR - 7000 - Series & TCVR - 7000 - Series

DESIGN SERIES	ASR	ATC	BAVR	BAVR-E	BMVR	TCVR
Input Voltage "Swing"	−10% to +5%	−20% to +10%	−10% to +5%	−10% to +5%	Depends on power: typical is from −19% to +8.5%	
Output Voltage Stability	±2½%	±5%	±0.15%	±0.15%	Usually ±0.5%	Usually ±0.5%
Change due to load (0-100%)	NEGLIGIBLE		±2.0%	±0.3%	NIL	NIL
Harmonics Generated	NIL	NIL	YES	YES	NIL	NIL
Response Speed	PRACTICALLY INSTANTANEOUS AVERAGING				1 V/Sec.	40V/Sec.
	2-3 CYCLES		1 CYCLE			
Power Ratings	1150VA 2300VA	575VA 1150VA	200VA 500VA 1000VA	200VA 500VA 1000VA	1600VA to 30kVA (18 models)	1600VA to 12kVA (11 models)
Basic Prices*	£24 to £34	£24 to £34	£50 to £79	£59 to £88	£75 to £237	£91 to £144

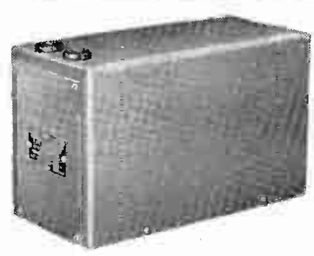
* *From May 1st 1956, subject to 7½% increase.*



BMVR - 2750 - S58 (AM Ref. 10D/20161)



BMVR - 2750/VV & TCVR - 2750/VV



ASR - 1150 & ATC - 575.

Claude Lyons Ltd.

STABILISER DIVISION

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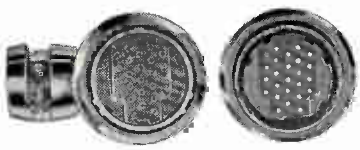
Rapid, Reliable Interconnection for every specialised purpose

Four important ranges of Plessey plugs and sockets

1

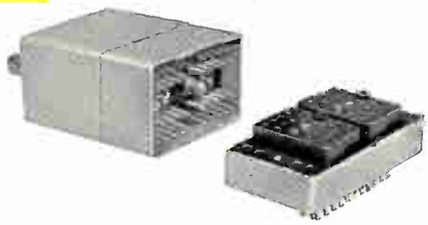
MARK 4 Mark 4 plugs and sockets enable multiple connections of great complexity to be made rapidly and without fear of error. They simplify the prefabrication of complete wiring systems in the factory with a consequent saving in production time.

Rapid disconnection for servicing of units, high electrical and mechanical efficiency and the absolute flexibility of the system are other outstanding advantages. For full details, request Publication No. 863.



2

MULTIWAY This standardised range provides a rapid and foolproof method of interconnection for multi-line circuits up to 80 ways. It permits a unit method of construction which is superior in operation and eminently suited for application within the electronics and light electrical industries. For full details, request Publication No. 741/2.



3

E.H.T. Extra High Tension connectors by Plessey, have high insulation properties and are suitable for high voltages. Two types are available; Demountable (7kV. peak) and Moulded (10kV. peak). Both are interchangeable and units of each are obtainable for free cable, bulkhead or panel installations. For full details, request Publication No. 560/1.

4

S.H.F. This is a range of highly efficient interchangeable connectors for the termination of Uniradio Cable operating equipment in the Super High Frequency bands. These units are standardised so that no confusion can arise when making connections between various S.H.F. devices. For full details, request Publication No. 672/3.

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Design Engineers and equipment manufacturers are invited to request Plessey Publications for the particular ranges which interest them.

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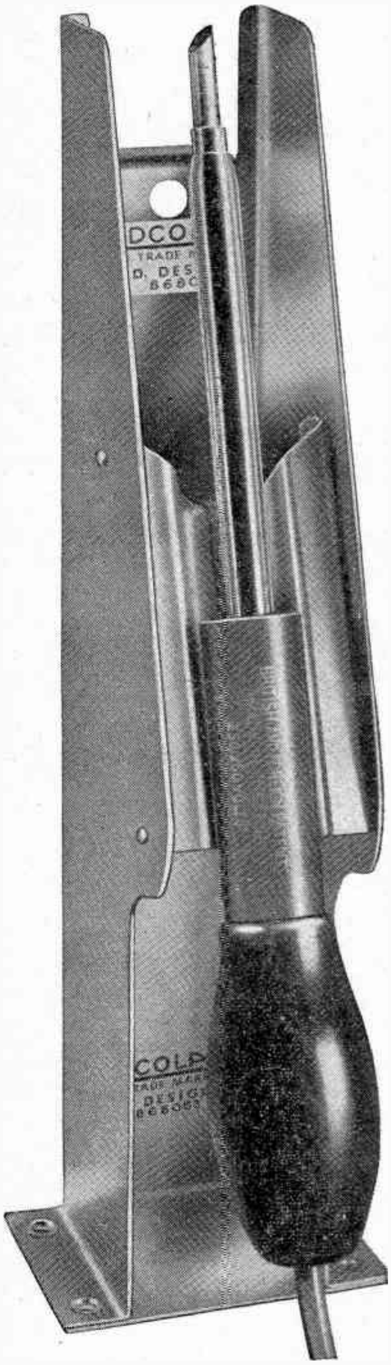

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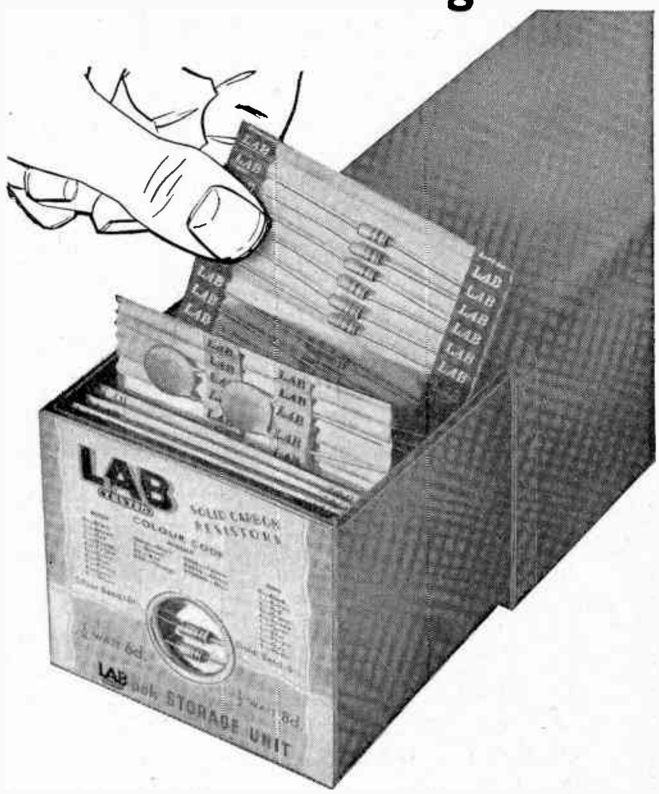

Thousands of LAB Continuous Storage Units are daily solving the problem of control and storage of the great range of resistors. Compact, and capable of storing up to 720 separate resistors, LABpak make selection positive, simple and speedy. Now that Ceramicaps, Histabs and Wirewound resistors have been added to the carded range, the usefulness of LABpak storage units is enhanced.

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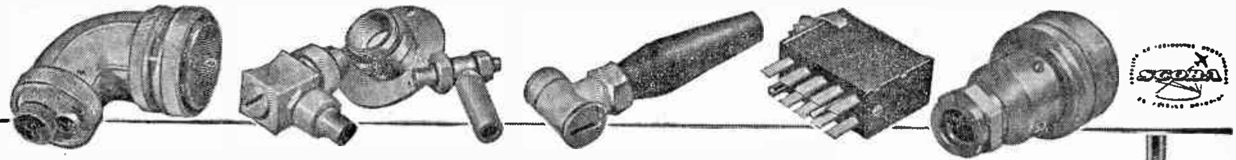

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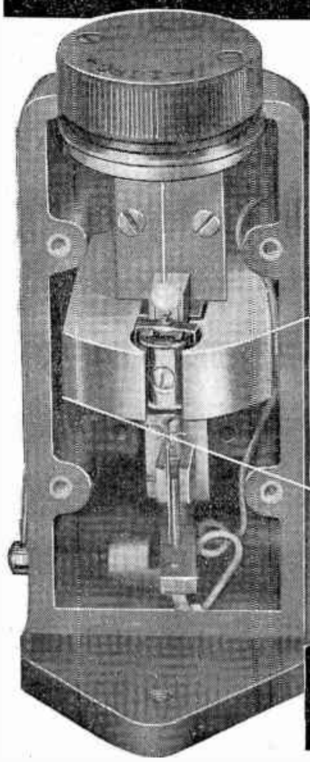
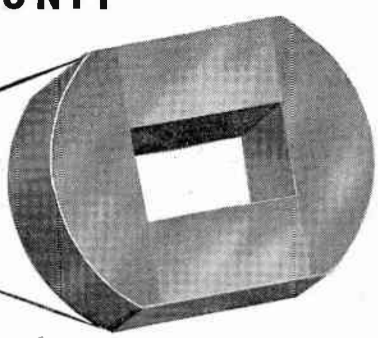
MUREX 'SINCOMAX' MAGNETS

are used in this **E.E.L. GALVANOMETER UNIT**





Actual size of magnet

Photographs of complete unit and Galvanometer Suspension by courtesy of Evans Electroselenium Ltd.

In this new E.E.L. Galvanometer made by Evans Electroselenium Ltd. Murex 'Sincomax' magnets are used to meet the need for low leakage, high flux density and magnetic stability.

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One of the most outstanding technical developments of

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is the Sullivan and Griffiths Precision Inductance Bridge.

Its range 1 μH to 100H; its direct reading accuracy 0·1% or 0·1 μH (quite unaffected by temperature and having good frequency characteristics) and facilities provided for the direct reading measurement of resistance 0·01 ohm to 10 Megohms, capacitance 10 $\mu\mu$F to 1 μF and the inductance and losses of iron-cored inductances with superposed direct current up to 2 amperes . . . . make this bridge invaluable to any factory or laboratory concerned with inductance measurement.

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ELECTRONIC & RADIO ENGINEER

incorporating WIRELESS ENGINEER

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W. T. COCKING M.I.E.E. *Editor*
Professor G. W. O. HOWE D.Sc., LL.D., M.I.E.E., Hon. M. Brit. I.R.E. *Technical Consultant*

CONTENTS

VOLUME 34 NUMBER 3 MARCH 1957

Established 1923
Published on the fifth of each month

ANNUAL SUBSCRIPTION
(*including Annual Index to Abstracts and References*)
Home and Overseas £2 9s od
Canada and U.S.A. $7.50

PUBLISHED BY ILIFFE & SONS LTD. DORSET HOUSE STAMFORD STREET LONDON S.E.1
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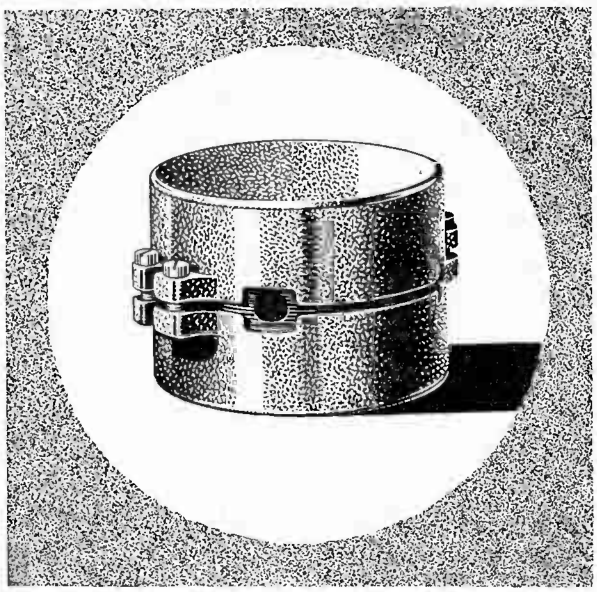
NEW GRADE OF FERROXCUBE RESULTS IN

HIGHER EFFICIENCY POT CORES FOR AUDIO FREQUENCIES



Following the development of audio frequency grades of Ferroxcube, Mullard now introduce a series of 30mm pot cores with exceptionally low losses and high effective permeabilities.

Initial permeability μ_0 of 1,400 with a loss of $\frac{\tan \delta}{\mu}$ of 2.5×10^{-6}.

The added advantages of simple construction and light weight make them specially suitable for use in cable splicing and audio frequency output transformers.

Designers requiring full technical details on this new series of high efficiency pot cores are invited to write to the address below.

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'Ticonal' permanent magnets
Magnadur ceramic magnets
Ferroxcube magnetic cores

MULLARD LTD., COMPONENT DIVISION, MULLARD HOUSE, TORRINGTON PLACE, W.C.1

MC256a

VOLUME 34 NUMBER 3 MARCH 1957

ELECTRONIC & RADIO ENGINEER

incorporating WIRELESS ENGINEER

Colour Television

ON 30th and 31st January, the B.B.C. transmitted a special colour-television programme for the benefit of Members of Parliament, so that they might have an opportunity of assessing the capabilities of one system. The programme, which was partly of live studio shots and partly of film, originated at Alexandra Palace and was radiated from the Crystal Palace. The system used was basically the N.T.S.C., but modified in details, and was, of course, 405-line. This is a compatible system and can produce a normal black-and-white picture on any ordinary television set.

We were privileged to see the programme at about 30 miles distant on a colour receiver fitted with a 21-inch tricolour tube. We can only say that we were very impressed by the results which were greatly superior to any previous colour demonstrations that we have seen. Over 30 minutes of colour transmission proceeded without a hitch; the normal production techniques of cuts, fades and mixes were carried out perfectly and, at all times, the reproduction of flesh tints was natural.

The live shots and one special film resulted in reproduction greatly superior to that given by colour film of normal commercial quality and we feel that it was as much this as anything that made the results so much better than anything we have seen before.

We are in no doubt at all that this British version of the N.T.S.C. system can provide a very acceptable colour picture; one which is quite adequate for a broadcasting service. The addition of colour results in an apparant improvement of definition which is almost startling. Partly because of this, and partly because of the effect of the colour itself, black-and-white seems very uninteresting by comparison.

We do not mean to imply by this that colour television is yet in a state for a regular service. It has been demonstrated that the system can produce a very good picture. There is a big step between this and the quantity reproduction of reliable and simply-operable receivers at a price within the purse of most people.

The fact that the N.T.S.C. system is capable of the required performance does not necessarily mean that it can ever provide this economically. We feel, therefore, that it is still desirable to continue the investigation of alternative systems.

There is one other factor. We have, hitherto, considered that compatibility was an essential. We are not so sure now. We feel strongly that the owner of a colour television set will not be content with anything but colour and that he will be very dissatisfied by any attempt at the gradual introduction of colour. Black-and-white transmissions must continue, of course, but we think that a strong case could be made for colour as a parallel service and, for that, compatibility would not be necessary nor even the 405-line system.

Television Camera Channel Design

LIGHTWEIGHT EQUIPMENT USING PHOTOCONDUCTIVE CAMERA TUBE

By J. E. Attew*

SUMMARY. *The design of a small, lightweight television camera and associated equipment with full programming facilities is described. The specification is capable of meeting full British transmission standards for studio and outside broadcasting use, as laid down by the British Broadcasting Corporation.*

The reduced size of this equipment, electrically and mechanically, is governed by the use of the 1-in. diameter photoconductive camera tube, available in this country and abroad (i.e., Staticon, Vidicon, etc.). A general description of the complete equipment is given, portions of particular interest being treated in greater detail. The overall performance is described.

While many types of camera channels are available employing image orthicons, image iconoscopes, etc., giving excellent results, there is still the basic need for a camera channel using inexpensive, lightweight equipment, particularly for outside broadcasts where considerable mobility is required. An experimental lightweight camera equipment has already shown the increased potentialities for television entertainment (e.g., the B.B.C. transmission from a submarine in June 1956). This type of programme could not be carried out with larger equipment.

For a given performance, the size of the camera equipment is governed by the camera tube used. It had already been shown by its use in telecine equipments that the 1-in. diameter photoconductive camera tube could achieve the exacting performance demanded by the British transmission standards, so work was put in hand to find how this type of tube performed under 'live' conditions. This paper describes the design of a camera channel which is the result of these tests.

No ideal camera tube exists; all have their faults, which are difficult to overcome and have to be accepted. At low light levels, the photoconductive camera tube suffers from 'lag' or image retention, frame to frame, causing smearing of moving objects. This defect must be weighed against its numerous advantages, such as its small size (allowing reduced lens sizes), small scanning powers, complete stability at all light levels, true black level reference, ease of electrical control, absence of warming-up period and image 'stick-on', good gradation, and reduced running costs, among others.

The equipment described here has been designed with size and weight in mind, but not at the sacrifice of electrical performance or the reduction of programming facilities. It is felt that the result has been a well-balanced compromise, where ease and comfort of operation, convenience of maintenance and standard of performance have all been achieved. A precision 14-in. picture monitor is available with the channel and also a lightweight synchronizing generator, but these are not described in this article.

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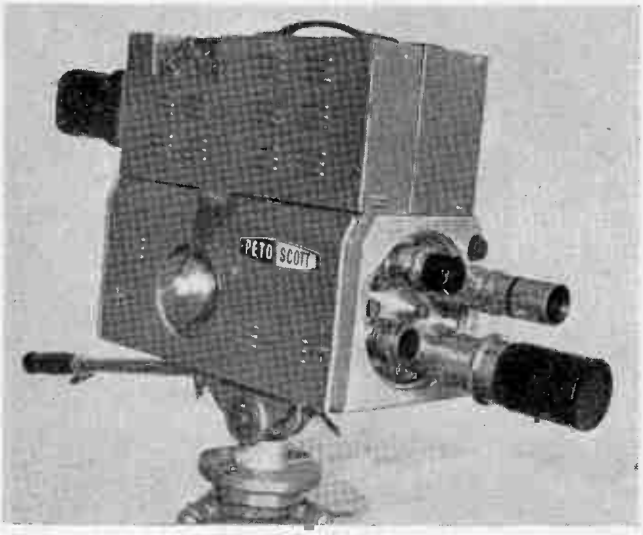


The camera with viewfinder

Factors Influencing the Design

The photoconductive camera tube has been fully described elsewhere, so a brief summary of its principal characteristics is sufficient here.

As shown in Fig. 1 (left), the tube consists basically of an evacuated glass envelope with a photoconductive target at one end, scanned by a low-velocity beam of electrons from an electron gun at the other. The image to be televised is focused optically on the target, which is composed of a thin film of material possessing the property of changing electrical conductivity in relation to the incident illumination. The target material is deposited on a transparent electrically-conducting coating which forms the signal electrode, which initially is deposited on the inside of the optical glass 'window'.

The electron gun consists of a cathode, a beam control electrode (grid 1) and an accelerating electrode (grid 2). The electron beam is focused at the surface of the photoconductive layer by the combined action of the uniform magnetic field of the external focusing coil and the electrostatic field of the focusing electrode (grid 3). A fine mesh screen (grid 4) serves to provide a uniform decelerating field between itself and the target layer, so that the electron beam approaches the layer in a direction perpendicular to it—a condition necessary for driving the target surface to cathode potential. This electron beam arrives at the target at low velocity due to the low operating potential of the signal electrode.

The target acts like a leaky capacitor, having one plate fixed at the positive potential of the signal electrode and the other plate floating [Fig. 1 (right)]. The conductivity at any element is related to the incident light on that element, so that there appears on the electron gun side of the target a positive potential pattern of the image optically focused on the target. When the pattern is scanned by the electron beam, electrons are deposited from the beam in sufficient quantities to reduce the surface potential to that of the cathode. This recharging of the capacitor elements causes current to flow through the load resistor R so constituting the video signal, which is negative-going towards highlights in the image.

Transfer Characteristic and Colour Response

A log-log plot of the transfer characteristic of a photoconductive tube shows a nearly straight line over a wide range of illumination and shows no 'knee' as with the image orthicon, etc. The average slope of the transfer curve is between 0·6 and 0·7. This is higher than the required channel characteristic of approximately 0·5, so that some additional gamma correction is necessary, amounting to about 6 dB increase in gain in the blacks up to a value of 0·2 of peak whites, referred to the output signal. Unfortunately, this correction appears to accentuate lag effects, due to small amounts of image retention being increased by a factor of 2. The gamma correction should, therefore, be removed under conditions of low light levels.

Measurements show that present tubes are essentially panchromatic.

Signal-to-Noise Ratio

The photoconductive camera tube has in itself an excellent signal-to-noise ratio, the noise output being equal to a temperature-limited diode with an anode current equal to the output current of the photoconductive camera tube. The signal-to-noise ratio is, therefore, almost entirely determined by the video amplifier noise characteristics, and can be more than adequate to allow gamma and aperture correction.

Aperture Characteristic

Owing to the finite size of the scanning beam and lens aberrations in the optical system, the aperture characteristic curve of the photoconductive camera tube shows a reduction of output with increasing frequency or line number amounting to a loss of 8–9 dB at 3 Mc/s. The inverse of this frequency response should be applied to the video amplifier as aperture correction.

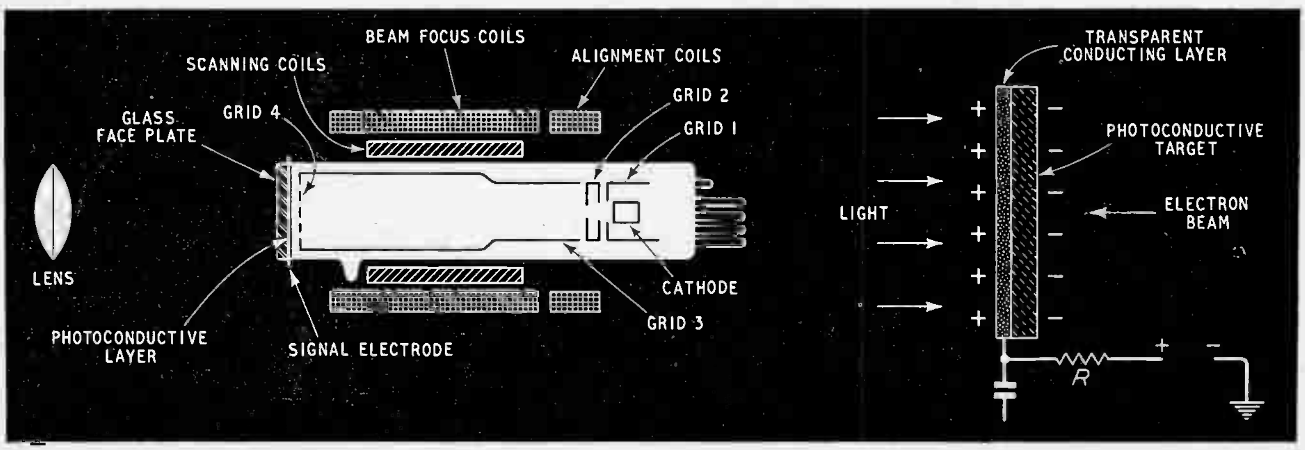
A number of methods are possible to provide aperture correction.[1,2] The method used in the present equipment is to match the aperture characteristic by means of staggered high peaking using L, C and R circuits. The phase distortion produced by these circuits is corrected by a bridged-T phase corrector. The advantage of this method is the relatively sharp cut-off above the maximum usable frequency which limits noise in this region.

Spurious Signals

Persistence of an image following the removal of incident illumination is termed 'picture lag', and can be measured as per cent output from the camera tube at a given time after removal of the illumination. If the illumination is removed during a frame-suppression period, then the third frame amplitude after this removal can be compared with the first frame amplitude giving the percentage lag in one picture period. Measurements by different workers do not agree, but subjective measurements show with present photoconductive camera tubes that approximately 150 ft/L off peak white is required with a lens aperture of f/2 to give no apparent lag effects, but these values are affected to some degree by the picture composition.

The use of the camera-tube manufacturers' curves shows that signal current increases with target bias voltage, as does the dark current. This dark current is a spurious signal originating in the photoconductive camera tube itself and is termed 'flare' or background. To obtain a satisfactory signal current to dark current ratio the target bias voltage must be kept low, which for a peak signal current of 0·2 μA again requires adequate illumination. Tests with normal photoconductive camera tubes show that flare or background is not a problem at lighting levels necessary to overcome lag.

Fig. 1. *Schematic layout of the photoconductive camera tube (left) with a diagram of the target electrode (right)*



Due to lateral current leakage, the photoconductive camera produces a picture framed with a white edge on all four sides. This white edge is only troublesome at the bottom of the picture, which is not normally covered by the system suppression pulses. To overcome this defect, the frame trigger pulses to the camera time-base must be delayed by 2 to 3 lines to ensure that this spurious signal occurs during the frame-suppression period.

The absence of charge redistribution effects in the photoconductive camera tube eliminates shading problems inherent in photo-emissive camera tubes, so allowing the generation of an absolute black level in the output signal. The camera-tube beam-current must be switched off by pulses applied to the control grid of the tube during the system suppression period.

The excellent signal-to-noise ratio obtainable ensures retention of this absolute black level throughout the system.

Deflection

The photoconductive camera tube uses the principles of low-velocity electron-beam scanning[3,4] and, due to the small volume occupied by the scanning field, relatively small line-frequency deflection power is required, a small output pentode working in class A being more than adequate. Consequently, it is quite easy to obtain adequate linearity of deflection but, due to the small size of deflection yoke, great care must be exercised in the construction of the coils to achieve good geometry.

By recourse to a type of construction in which the deflection coils are wound on precision-made jigs which are part of the final assembly, it has been found possible to reduce scanning errors to approximately 0·5% positional error of scan.

As can be seen from Fig. 1, there is no decelerating ring between the mesh and the target as in the CPS Emitron[5] so that there is no correction for spiral distortion of the image. This distortion amounts to about 5–10° of trapezium distortion, which can be corrected by electrical or mechanical skew of the scanning fields.

The present design incorporates mechanical rotation of the frame and line deflector coils relative to one another, but care must be taken to ensure that the resultant coupling between the two circuits does not cause spurious deflections outside the normal system suppression time.

General Mechanical Requirements

For maximum mobility, it was decided that the equipment should be divided into 3 units—camera, viewfinder and camera control unit. The camera plus viewfinder should weigh less than 50 lb. and the camera control unit less than 100 lb. The viewfinder should be capable of being detached from the camera and used on the end of a connecting cable to enable the use of servo-controls to operate the camera.

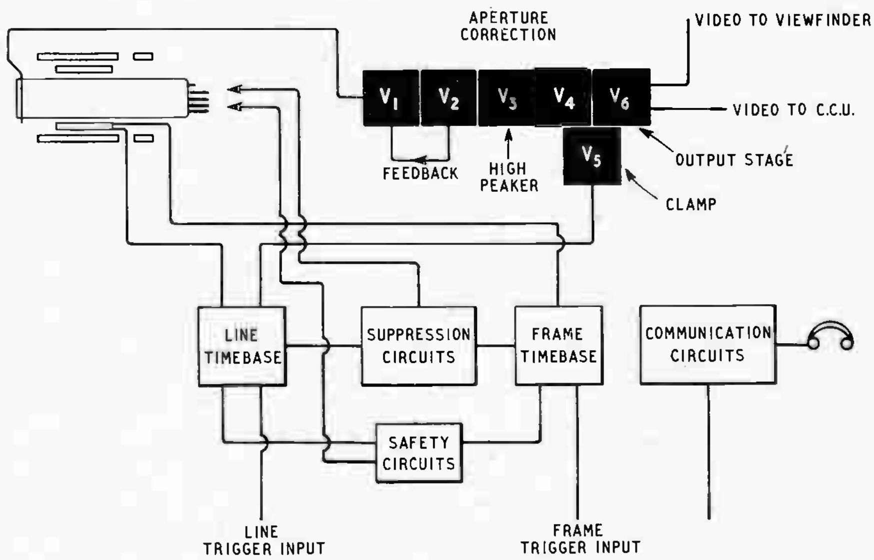


Fig. 2. *Schematic of camera circuits*

The connecting cable should be as small in diameter as possible and a new design of cable by B.I. Callender's Cables was ideal for this purpose.

Distribution of the Circuitry

It is obviously very desirable to keep the size of the camera as small as possible and, to help in this direction, the camera circuitry must be kept to a minimum, but at the same time thought must be given to the total size and weight of the equipment and of the camera cable, both of which will be increased considerably if the camera is simplified to an extreme. Consideration shows that there is an optimum condition here.

The use of an electronic viewfinder influences the circuitry to a great extent. First, the cathode-ray tube will require up to 50V p–p video modulation, so that considerable video amplification is required at the camera end of the camera cable if it is desired to save one coaxial cable. The video amplification may well, therefore, be employed in the camera itself to raise the video level into the camera cable well above interference level.

Secondly, the viewfinder will require drive pulses to operate the frame and line time-bases. These signals require coaxial conductors in the camera cable so that it is obviously desirable to place the very small camera-tube deflection circuits in the camera to save additional coaxial conductors in the camera cable. Scanning currents can be fed down camera cables, but must be generated by circuits, particularly at line frequency, requiring considerably more power than local scanning generators, also the linearity and amplitude of scanning currents are influenced by the camera cable length. The channel power supplies and the complexity of the camera control circuits must, therefore, be greater for the small reduction of the camera size made possible by this method of deflection.

Thirdly, the viewfinder which, for convenience operationally, sits on top of the camera will influence at least the length of the camera, the minimum length being governed by the cathode-ray tube used.

Optical Requirements

To keep the lighting level requirements to a minimum requires fast lenses of aperture f/2 or better. Fortunately, the small picture diagonal (⅝ in.) requires short focal-length lenses for given viewing angles, it being easier to obtain fast lenses with short focal lengths. The depth of field is also greater with the shorter focal lengths.

A few very good lenses are obtainable in the range designed for 16-mm cine work. These are generally fitted with a standard type 'C' mount and have been found to provide good coverage of the picture format size used (½ in. × ⅜ in.), lenses in the range of 0·7 to 4 inch focal length providing most requirements for outside broadcast and studio use. Also readily available are small zoom lenses covering this focal length range with apertures of f/2·4.

The use of a manually-operated four-lens turret is desirable and the optical requirements of this turret tend to govern the minimum frontal size of the camera.

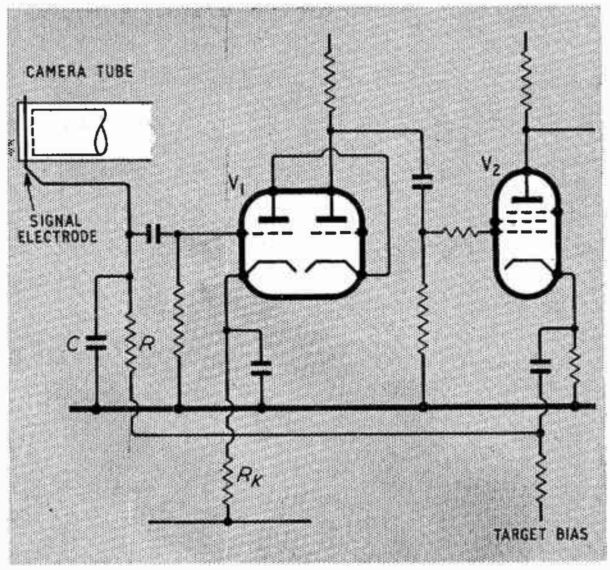


Fig. 3. *Simplified camera input circuit*

Camera

The camera channel consists of a camera, with detachable viewfinder, camera cable, camera control unit, picture monitor and synchronizing generator. A small rack is available to house the camera control unit, picture monitor and sync generator. The camera is intended to mount on a lightweight tripod and can be used with up to 1,200 ft of camera cable. The size and weight of the individual items is shown in Table 1.

TABLE 1

	Height (in.)	Length (in.)	Width (in.)	Weight (lb.)
Camera ...	7	15	7	25
Viewfinder ...	5	15	6	15
C.C.U. ...	6¾	26	16½	85
Monitor ...	12	22	16½	60
Sync Generator	6¾	15	16½	34

The main structure of the camera is formed of light-alloy castings, so providing a rigid foundation for the optical system. The four-lens turret at the front is operated by a turret-rotating handle at the rear. The lens mounts, which are normally Type 'C' mounts but can be made to suit any lens, are quickly releasable by turning two thumbscrews, so that any combination of lenses can be fitted, the normal range being 1-in. to 4-in. focal length with f/1·9 aperture. Focusing is achieved by movement of the camera tube carriage on p.t.f.e. bearings by means of a handle which can be quickly set to any angular position. Cueing indicators are fitted front and rear, while communication sockets and controls are fitted beneath a sliding panel at one side of the camera.

Fig. 2 is a block diagram of the camera circuitry. All the circuitry is built as one unit, which is easily removable from the main camera body. This procedure facilitates easy maintenance.

The photoconductive camera tube is a constant-current or high impedance generator, the peak signal being approximately 0·2 μA. The signal voltage is developed by the flow of current through a load resistor *R*. This is indicated in a simplified diagram of the input stages in Fig. 3. It can be seen that the load resistor *R* is shunted by the input stray capacitance *C*, which is of the order of 15 pF. In order to reduce microphony and hum, the low-frequency input is made relatively large by making *R* large, approximately 0·5 megohm, which, of course, produces a drooping frequency response, approximately 44 dB of high frequency equalization at 3 Mc/s being required to ensure flat amplifier response. This equalization is provided partly by negative feedback applied across the load *R* and partly by a conventional cathode by-passed high peaker stage. The negative feedback applied from V_2 across the load resistor provides approximately 25 dB of the required equalization of the frequency characteristic.

The first stage is a low-noise input circuit using a double-triode cascode amplifier. The triodes used have a working mutual conductance of 12·5 mA/V. To ensure constant gain within the feedback loop, the anode current of this stage is stabilized by heavy current feedback. The large cathode resistor is returned to a stabilized negative supply for this purpose.

The low-frequency response is accurately maintained by conventional compensated couplings between each valve stage. This procedure ensures complete absence of low-frequency streaking.

The aperture correction is achieved by two networks as in Fig. 4 (a) and one network as Fig. 4 (b), the resonant frequency of each network is arranged to be outside the required passband of 0–3 Mc/s. In Fig. 4 (a) the resistor R_D is adjusted to control the rate of increase of amplitude with frequency within the passband. Phase errors are corrected by a bridged-T network [Fig. 4 (c)].

The video output circuit is arranged to drive both viewfinder and camera control unit, the video input to this stage being clamped by a double-diode line-by-line clamp.

Both frame and line time-base circuits employ negative feedback to make linearity and amplitude of scan virtually independent of valve parameters. Fig. 5 is a simplified diagram of the line time-base.

The output stage V_7 drives low-impedance scanning coils via a small line output transformer using a ferrite core and potted in Araldite.

The valve V_8 is used as a switch, being put on by the positive-going input pulse and used to discharge the circuit at the end of each scan. During the scanning period, the time constants of the feedback network ensure a linear change of current through the scanning coils. The input pulse is an amplified version of the line trigger pulse sent down the camera cable from the camera control unit and is of suitable duration to be used as the line suppression pulse for the camera tube. To complete the suppression waveform to the camera tube, an amplified version of the frame trigger pulse is added to the line pulses. This pulse is also used to discharge the frame time-base.

The output stage of the frame time-base drives high impedance scanning coils directly, a large amount of negative feedback being used to ensure linear deflection current.

A camera tube protection circuit is used to prevent damage to the tube in the event of a scanning failure.

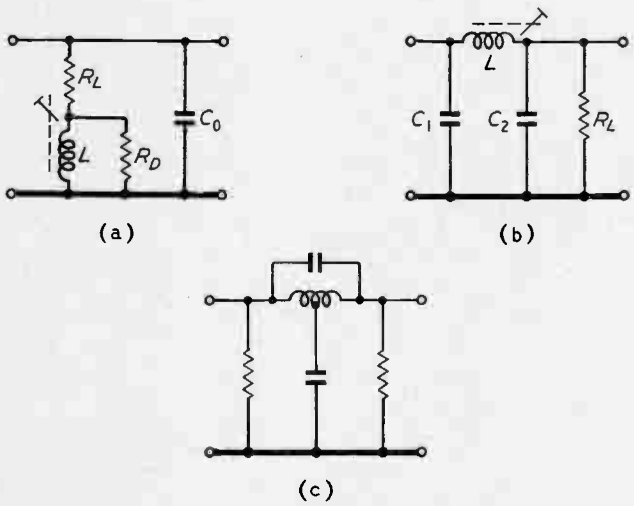
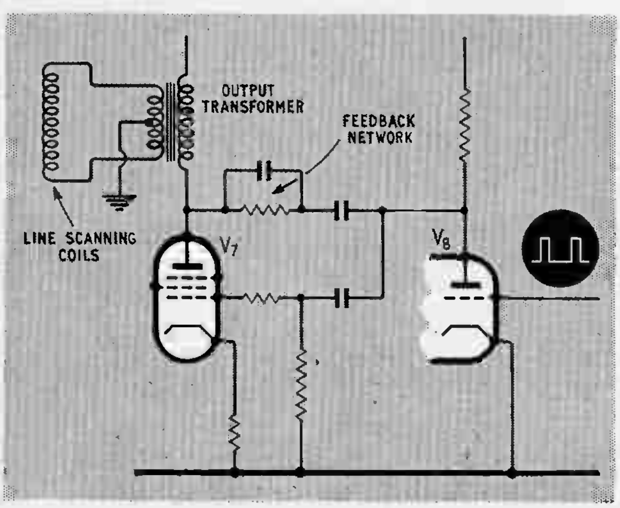


Fig. 4. *Aperture correction filter networks*

Fig. 5. *Simplified circuit diagram of camera line time-base*



Waveforms of the two time-bases are rectified and the resultant steady positive voltages used to control a pentode valve with a relay in the anode circuit. Loss of either of the voltages cuts off the valve, so releasing the relay. This causes the bias on the control grid of the camera tube to be taken below cut-off and also connects the wall anode to earth, preventing damage to the target.

Cueing lamps are fitted front and rear of the camera, operated via a relay which in turn is operated from the camera control unit. The rear cueing light is visible within the viewfinder visor to provide cueing information to the cameraman.

On the side of the camera, a sliding door hides a small control panel housing the camera scanning controls, a communication socket for headset, volume level controls for the headset, microphone switch and a camera control call button. This button operates a small neon lamp on the front panel of the c.c.u. to enable the camera operator to communicate with the c.c.u. operator without the use of the microphone.

The channel was designed to operate with the small Mk.4B camera cable manufactured by B.I.C.C. This cable has moulded end couplers and is only 0·7 in. diameter, but has 3 coaxial cables, 4 screened quads and 18 single wires. Up to 1,200 ft can be used, compensation for cable delay and frequency attenuation being provided by means of a switch in the c.c.u.

Viewfinder

The prototype viewfinder was designed around a 5-in. diameter aluminized magnetically-scanned electrostatically-focused cathode-ray tube, using an aspherical plastic lens to increase the apparent picture size. The production models use a 6-in. diagonal rectangular version of the tube.

Because of the small camera size, the viewfinder must be kept as small as possible or the combination of the two units looks awkward. Considerable thought must be given to the circuitry, to reduce the size and quantity of components. The use of an electrostatic focus c.r.t. helps by eliminating the need for a large and heavy magnetic focusing unit. The final design employs but 8 valves and achieves the high performance required by a camera viewfinder for accurate optical focusing of the scene.

The viewfinder video amplifier employs two triode-pentodes, providing sufficient gain and bandwidth to amplify the input signal of approximately 0·4V p–p to a level sufficient to modulate the cathode-ray tube. Due to the use of a line-by-line clamp in the camera, d.c. restoration of the video signal at the cathode-ray tube has been found adequate.

The line scanning current and e.h.t. are both derived from the line time-base, which is of the high-efficiency direct-drive type. More than adequate linearity has been achieved by the use of a circuit that provides damping proportional to scan velocity within the scanning field. This circuit has been found to be independent of valve samples and other components.

The source impedance of the 11-kV e.h.t. supply has been reduced to a satisfactory value over the working beam-current range of the viewing tube by a feedback circuit that feeds a direct voltage proportional to the flyback pulse height back into the control grid of the line output valve. This is shown in the simplified diagram of Fig. 6. Also shown is the velocity damping circuit coupled to the scan coils. It can be seen that the line amplitude is controlled by a variable resistor, which has no effect on the linearity of the scanning waveform. The frame time-base uses two valve envelopes, the output circuit being a triode-pentode. The scanning current is linearized by a frequency-conscious feedback network, values being selected on test to achieve the required linearity.

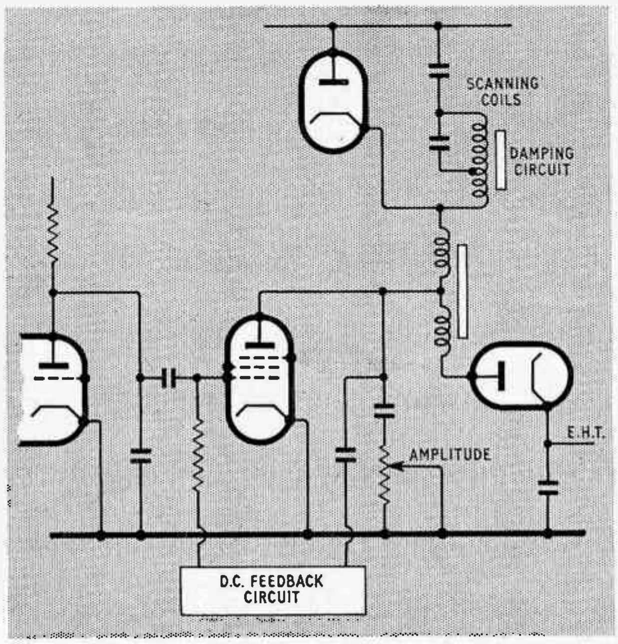


Fig. 6. *Simplified circuit of viewfinder line time-base circuit*

Camera Control Unit

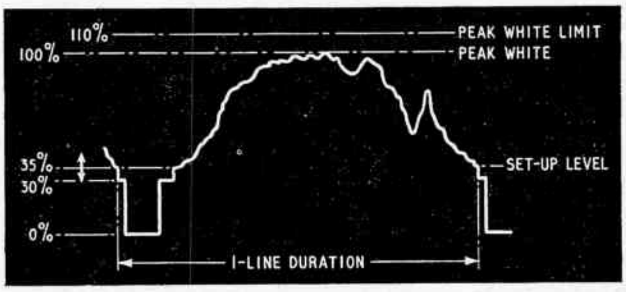
The case of the camera control unit is fabricated from light alloy sections and houses the camera control chassis, waveform monitor chassis and stabilized power supplies for the complete channel. The mechanical design is such that all components are accessible by removing the top and bottom covers of the unit, so allowing easy servicing. The front and rear panels are protected from damage by rails which are also used as carrying handles.

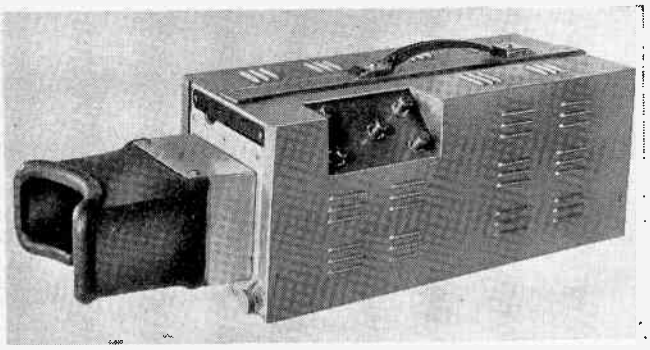
The front panel houses the main operational controls for the camera tube, the waveform monitor and communications. All the controls necessary for setting up the channel prior to operational use are contained under the front portion of the top cover which can be raised for access to these controls.

A cooling fan is fitted to the rear panel, which also houses plugs and sockets such as mains input, camera cable, synchronizing generator connections, test input, communications socket and two composite video outputs.

The circuitry on the camera control chassis performs all the functions necessary to produce from the picture signal, arriving via camera cable, a complete composite video signal as shown in Fig. 7. This circuitry is shown as a block diagram in Fig. 8, and various other functions, such as pulse-timing delays, focus-current stabilization and various potential stabilizers, are incorporated on this chassis.

Fig. 7. *Composite waveform*



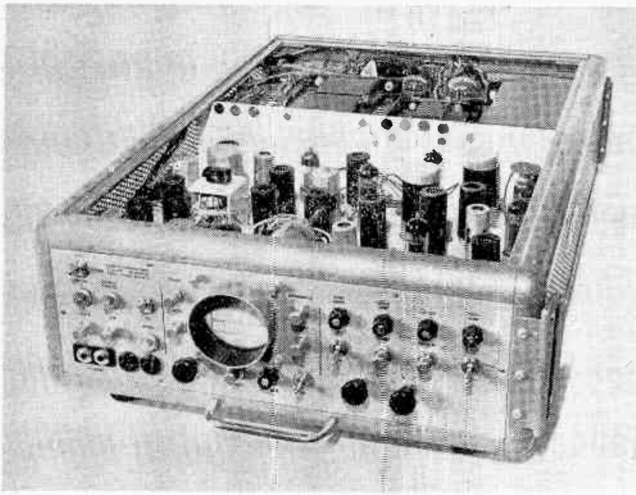


The viewfinder can be detached from the camera for remote use

The picture signal arriving into this chassis is fully aperture corrected, but contains phase errors which need correction. The phase corrector shown in Fig. 4 (c) is of the bridged-T type, with a characteristic impedance of 75 ohms, and is fitted before the video gain control, which is required to adjust the overall channel gain to ensure that the camera tube is working with the desired signal current of 0·2 μA. A test signal can be fed into the camera input circuit to facilitate correct gain setting.

The first valve stage of the picture signal chain has, in the cathode circuit, switched compensation for camera cable high-frequency losses. A further section of this switch is used to adjust the tappings on the delay line used to provide compensation for camera cable delay. When 1,000 ft of camera cable are used, the total time delay in both directions is approximately $3\frac{1}{2}$ μsec. In order that the relative pulse timings at line-scanning frequency remain the same for shorter lengths of cable, artificial delay must be added to keep the total delay constant. It has been found adequate to provide compensation for camera cable length in steps of 200 ft up to a total length of 1,200 ft. The total delay of the delay line is 5 μsec to enable correctly timed clamping pulses to be formed. This is shown at V_{10} and V_{11} in Fig. 8. The camera picture signal is amplified further by V_2 before being clamped by V_9, which is a line-by-line two-diode clamp.

The simple gamma correction required is provided by a diode circuit in the cathode of V_3 and is shown in Fig. 9 (a). This provides an increase of 6 dB gain in the black region of the curve in Fig. 9 (b). The resistor values in the circuit are chosen to ensure that the knee of the curve is not sharply defined but is rounded. Adjustment of the bias controls the position of the knee on the curve. This is normally set so that the knee



Camera control unit with top cover removed

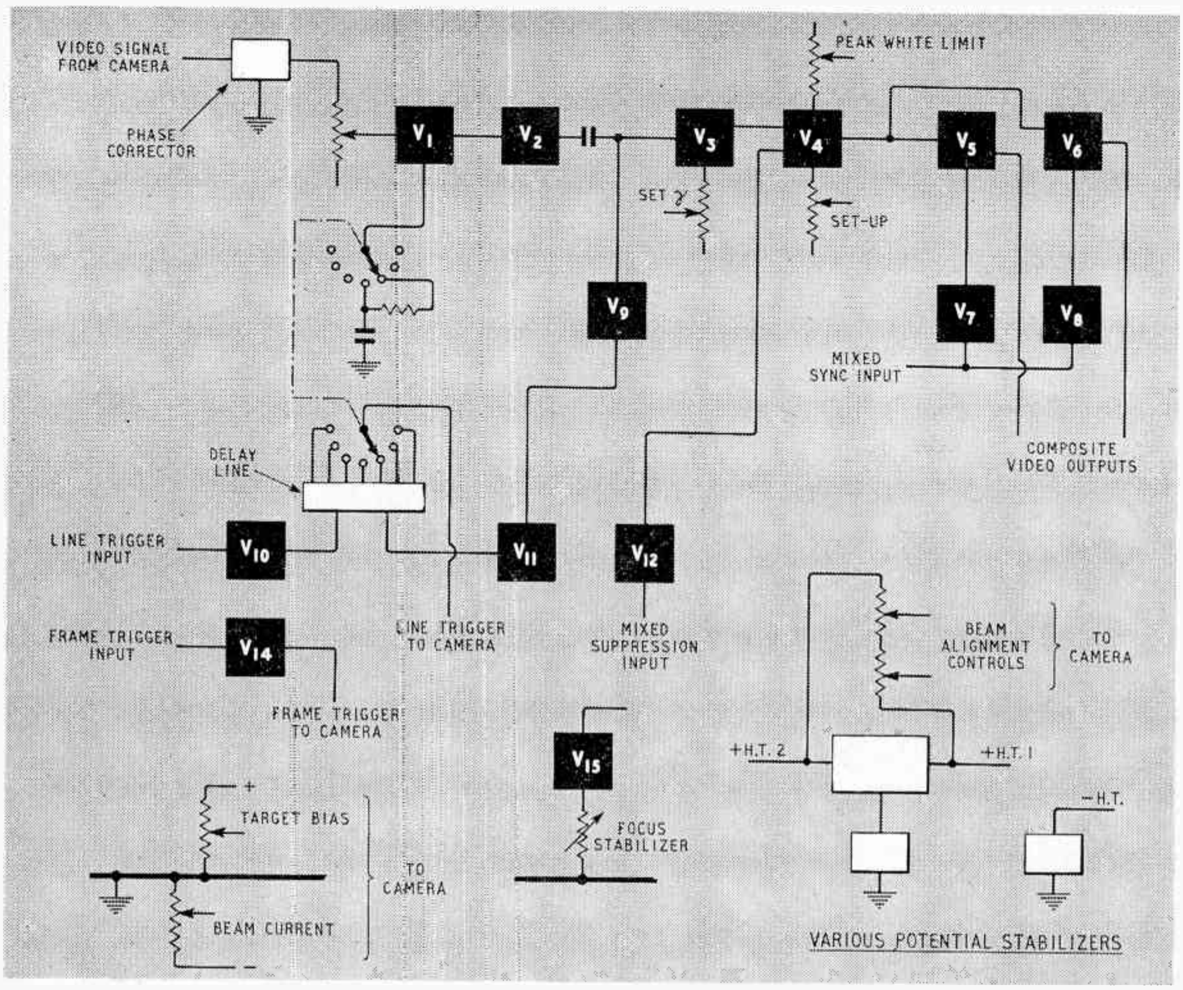
corresponds to 20% of the peak-white output current. Removal of the bias ensures that the diode does not conduct, so that no change of cathode impedance occurs over the working range of the input voltage. Gamma correction is, therefore, inoperative under this condition.

The method used for mixing system-suppression or blanking pulses into the waveform has been described by the author previously, but additional components have been added to provide control of set-up of black level as shown in the waveform of Fig. 7. This circuit is shown in Fig. 10. The black level of the positive-going picture signal fed to the control grid of V_3 is clamped to a bias level which is adjusted by the black-level control. Current over the curved part of the I_a/V_g characteristic of the valve V_3 flows through R_4, so that the black level control is set to the point where the picture signal black level just causes current to flow through D_2 and so adds to the current of V_{4b}. This eliminates black level compression of the picture signal due to the switching process of the mixed suppression pulses fed into the grid of V_{4a}.

It can be seen that, when the diode D_2 is passing no current, some current still flows through R_5, which is switched regularly by V_{4a}. The output signal black level, therefore, contains a 'set-up' which can be controlled by the potential to which R_5 is returned. This potential is adjustable between 0–10% of the output composite waveform.

A conventional series-diode limiter is used in the anode of V_{4b} as a peak white limiter, the output signal being fed into two output stages, providing an output impedance of 75 ohms. At these points are added the synchronizing waveform, which has been clipped and amplitude stabilized by the valve stages V_7 and V_8. The line drive waveform to the camera is derived from the tapped delay line and is 8 μsec in duration.

Fig. 8. *Schematic diagram of camera-control chassis showing the principal controls*



As indicated in the section dealing with the camera tube, it is necessary to delay the frame trigger pulse to the camera by 2 or 3 lines duration. It was shown earlier that this pulse is used as part of the camera tube suppression waveform and must, therefore, be of 9 to 10 lines duration. The frame drive waveform available from a synchronizing generator is of 4 lines duration and coincident with the leading edge of frame suppression pulse, and the above functions to this pulse are performed by a double-triode valve stage V_{14}. This stage is a Schmitt trigger circuit with a large input voltage 'backlash'. The two voltages at which a change of state occurs are widely separated. On the input grid is an integrating network to which is applied the input frame trigger pulse. The constants are arranged so that the first change of state occurs after two lines duration from the beginning of the input pulse and the circuit automatically recovers another 9 lines duration after. The output pulse is fed to the camera at 75 ohms impedance.

The camera-tube beam-focus coil current is adequately stabilized by a pentode valve stage with a large cathode resistor across which is a regulated voltage. The extremely large anode impedance of the valve prevents any change of focus current due to change of focus coil resistance with temperature. The beam focus control adjusts the value of this current.

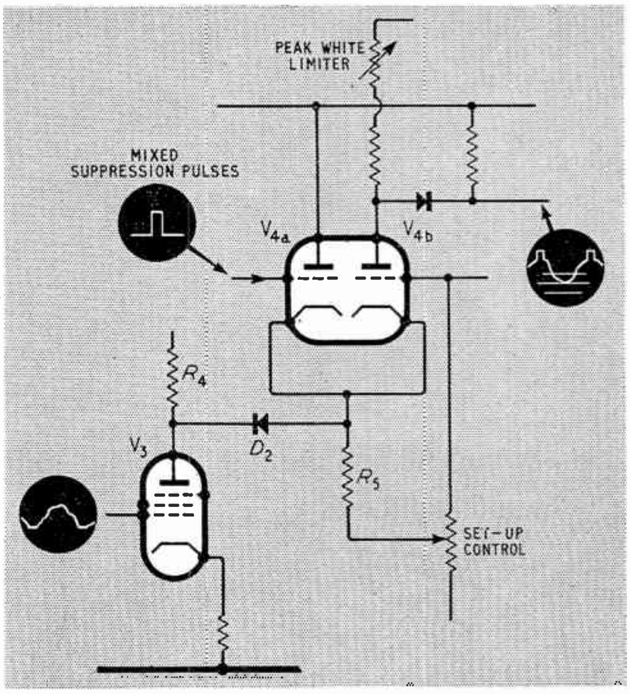
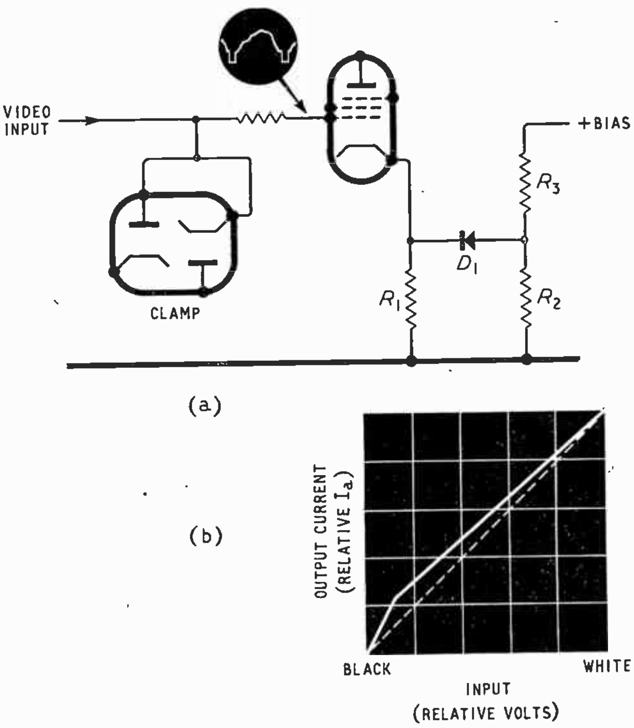


Fig. 10. *Simplified suppression-insertion circuit*

Fig. 9. (*a*) *Simple gamma corrector;* (*b*) *characteristic of* (*a*)



Other circuitry on this chassis consists of conventional voltage stabilizers providing some of the voltages necessary throughout the camera channel.

Waveform Monitor

The waveform monitor has been designed to display the composite video waveform of either output from the camera control chassis on a 2¾-in. diameter cathode-ray tube.

The time-base has been arranged to show (a) one complete frame period, (b) the frame suppression period, (c) one complete line period and (d) the line suppression period. This has been achieved by a triggered time-base using a Miller run-down circuit, with direct coupling between screen grid and suppressor grid. The potentials are arranged so that the circuit has one stable state. Fig. 11 is a simplified circuit of this time-base. It can be seen that V_1 is the Miller run-down stage, directly feeding into the cathode follower V_2, which provides fast recovery of the circuit after the run-down has been completed by virtue of the large charge current it can supply to the capacitor *C*. The potentials at the anode of V_1 and the cathode of V_2, when either valve is cut off, are used to limit the start and finish of the run-down and, therefore, keep the sawtooth amplitude constant. Consequently, once the run-down has been initiated by the appropriate trigger pulse, the time duration is determined by the values of *R* and *C*, the circuit quickly recovering to its initial state. The phase inverter V_3 is used to provide the inverted sawtooth required for push-pull operation of the cathode-ray tube.

The cathode-ray tube used requires approximately 120 volts peak-to-peak of video signal in push-pull to its Y deflecting plates for correct presentation. This level is provided by an amplifier with a large amount of negative feedback to stabilize the gain, as shown in Fig. 12. It can be seen that the output signals are d.c. restored at the Y plates. Calibration of the waveform monitor is achieved by the use of a scaled graticule and a 50-c/s calibration voltage derived from a bridge circuit having non-linear elements in two arms. This bridge reduces the effect of input voltage changes by 20 to 1 referred to the output. The cathode-ray tube has a stabilized e.h.t. supply, the voltage of which is adjusted during the calibration process.

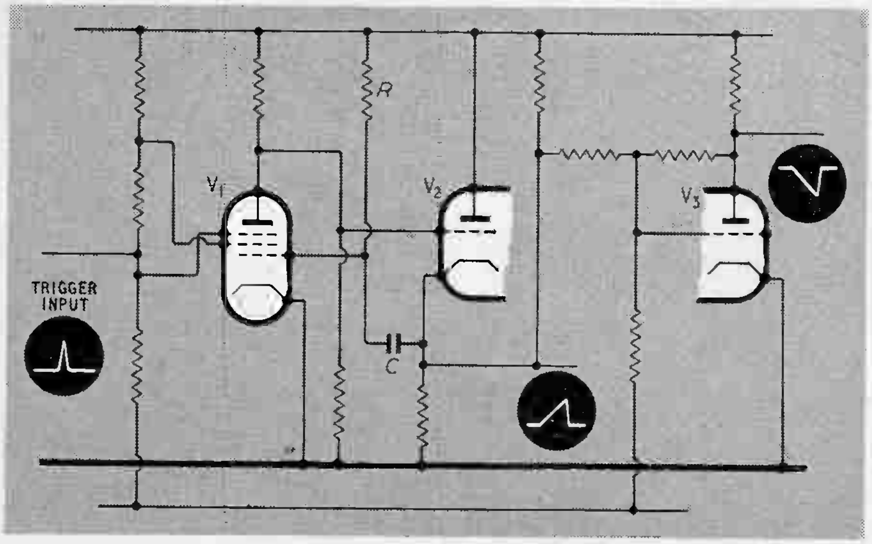


Fig. 11. *Skeleton diagram of waveform monitor time-base*

Normal operational controls, such as brightness, focus, astigmatism, are mounted on the front panel, while other controls, such as X and Y shifts, calibration switch and control, are mounted under the lift-up lid for use during calibration of the camera channel. This procedure reduces the risk of mistakes being made during operational use.

Communication Circuits

These circuits are located on the waveform monitor chassis, and consist of a double triode providing two isolating microphone amplifier stages. One amplifier provides amplification of the camera microphone signal and is distributed to camera control operator and to producer; the other stage amplifies the signal from the camera control microphone and feeds to the camera. Talkback from the producer and the programme sound is also taken in and fed to camera and camera control unit. A headset jack and volume level controls are on the front panel.

A cueing light, normally operated from a vision mixer, is provided on the front panel, the same switching line being fed to the camera cueing lights. Also on the front panel are an internal cueing switch, used when only one camera is in operation, and the camera-to-camera control call-light.

Power Supplies

All the d.c. potentials used throughout the camera channel are carefully stabilized against mains input variations, all the output voltages being referred to the main h.t. supply of 285V. Little need be said about these circuits, as they are more or less conventional. The power supply chassis is cooled by a blower fitted to the rear of the unit. The camera channel load is approximately 600VA.

Performance

The methods used of evaluating the performance of a television channel have been well discussed in literature[7,8] so that only the results are given here.

Definition

Sufficient aperture correction has been used to ensure that the response to 3-Mc/s bars at the centre of the picture is within — 1 dB of a black-to-white transition. The 3-Mc/s response at the corners of the picture will involve losses due to optics and electron-optics used. The corner loss due to the optics can be reduced to a small amount by stopping down the lens. This was done to enable measurements to be made of the losses due to the scanning assembly and the camera tube used.

The average results of a number of tubes show that, if care is taken with beam alignment, then the maximum average amplitude loss of the 3-Mc/s bars at any corner need not be more than 3 dB relative to a black-to-white transition in the corner.

Scan Linearity and Geometry

These measurements were made with a cross pattern test transparency and synchronous electronic grid pattern. With a good camera tube, it has been shown that it is possible to set up both scanning linearities and raster geometry to within a positional error of $\pm \frac{1}{2}\%$ of the picture width, so that the requirement of $\pm 2\%$ positional error is easily satisfied.

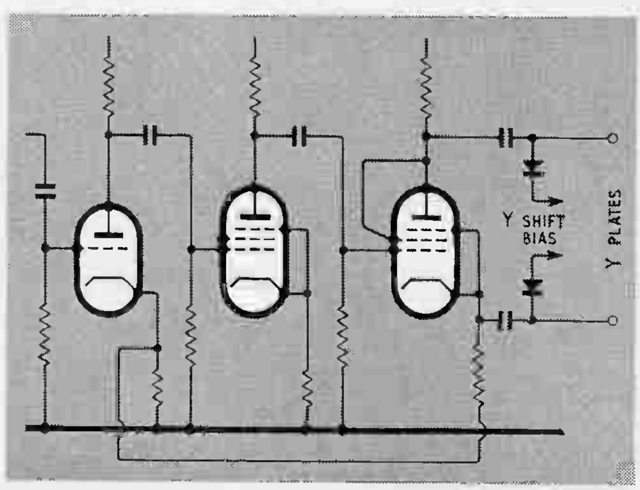
Signal-to-Noise Ratio

This has only been checked by the oscilloscope method but, at a video gain value required to produce a 0·7-V peak white signal at the output of the channel from a camera tube signal current of 0·2 μA, the peak signal to peak-to-peak noise has been measured at approximately 20:1.

Sensitivity

Because of 'lag' and 'flare' this parameter is very difficult to specify, being dependent largely on the type of scene being televised. Very good outside broadcast

Fig. 12. *Basic form of waveform monitor Y-amplifier circuit*



pictures have been produced of a low contrast scene, of motor cars travelling along a main highway at late evening, where the estimated high-light level has been approximately 20–30 ft/L.

Acknowledgments

The development of the project was only possible due to the work of many of the writer's colleagues. Among them must be mentioned Messrs. J. Barrett, S. Coveney, J. Hill-Venning, W. Knight, J. Smith, P. Tregear and G. Vale. The writer is indebted to Mr. R. C. Heath, Chief Engineer, for his encouragement, and to Messrs. A. E. Cartwright and D. Craven, of the British Broadcasting Corporation, for their helpful criticisms. Thanks are due to Peto Scott Electrical Instruments, Ltd., for permission to publish this paper.

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Measurement of Height-Gain at Metre Wavelengths†

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SUMMARY. *A description is given of the development of equipment, incorporating a simple system of telemetry, for the measurement of the variation of the field strength of metre-wave transmissions with height above the ground. A captive balloon is used to raise a v.h.f. receiver and telemetering transmitter together with the necessary aerials and power supplies. Provision is made for the continuous comparison of the field strength measured using the balloon-borne receiver with that observed by means of a second receiver having an aerial at a relatively low fixed height above ground. Some typical examples of the results obtained with the equipment are included.*

One of the characteristics of the radiation field of a given transmitter, the examination of which should help in the understanding of the mode of propagation at metre wavelengths through the troposphere, is the variation of the field strength with height above the ground, particularly at receiving points beyond the horizon. It is known that as weather conditions vary, so leading to the predominance of one or other of the possible modes of tropospheric propagation, the height-gain should conform to different patterns[1]. With this in mind, equipment has been designed to enable field strengths to be measured at heights up to several thousands of feet; and the present paper describes the experimental techniques involved together with a few typical examples of the results obtained.

Apart from its bearing on the fundamental study of very high frequency wave propagation, the investigation of height-gain is of considerable practical interest to the radio engineer. A knowledge of the manner in which the field strength varies with height, as the heights of the transmitting and receiving terminals (which behave in a reciprocal manner) of a given transmission path are varied, is of great assistance in the planning of v.h.f. communication links or broadcasting services; not only from the point of view of defining the service area, but also for the purpose of estimating the magnitude of long-distance fields which may be a source of interference in the common-frequency working of two or more transmitters.

There appear to be only a few published accounts of experimental investigations of height-gain at very high frequencies for heights greater than, say, 200 feet (60 metres), and in most cases the measurements were made by means of equipment carried by aeroplanes[2,3,4,5,6]. In the experimental procedure to be described here, the receiver is raised by means of a captive balloon, and the required information is obtained on the ground by means of a system of telemetry: it is believed that more

† Official communication from D.S.I.R. Radio Research Station, Slough.
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controlled observations can be made in this manner than by the use of aircraft. Tagholm and Ross[6] have also used a captive balloon, but to carry a small transmitter, the field strength measurements being made on the ground.

General Principles of the Measurement Technique

The receiving equipment was designed to operate in the frequency range 40 to 70 Mc/s, since this enabled field-strength measurements to be made on the transmissions (sound channels) from the five high-power television stations of the B.B.C. in the Broadcasting Band I; and the sensitivity of the receiver was such that observations could be performed at distances well beyond the horizons of the various transmitters. The height-gain measurements were carried out at the Radio Research Station, Slough, and at Cardington, Bedfordshire, where facilities were provided by the Royal Air Force and the Meteorological Office.

The balloon used for raising the receiving equipment at Cardington was able to lift a weight of several hundreds of pounds to a height of 5,000 feet (1,500 metres) or more; it was attached to a steel cable and its altitude controlled by a motor-driven winch. The balloon available at Slough was much smaller; it was only capable of lifting a weight of about 50 pounds to a height of 600 feet and, in this case, a rope and hand-operated winch were used. The receiver and its aerial were suspended 50 feet below the balloon in order to reduce any disturbing effect of the balloon on the field in the neighbourhood of the aerial; and in the Cardington experiments a piece of rope 100 feet in length was inserted between the steel cable and the balloon to minimize any similar disturbances due to the cable.

In preliminary investigations at Slough, where it was important to keep the weight carried by the balloon as small as possible, a system was tried in which, apart from the receiving aerial, only the frequency changer and its battery supplies were raised from the ground, and connection was made to the intermediate-frequency amplifier and the rest of the receiver by means of a flexible coaxial transmission line. This procedure proved unsatisfactory, however, largely because of the pick-up on the transmission line of unwanted signals at the intermediate frequency of about 1 Mc/s. If a much higher i.f. had been used in an endeavour to avoid this interference, any light-weight transmission line available would have introduced too much loss when lengths of 1,000 feet or more were involved. It was therefore decided to raise the entire receiver, and to use a form of telemetry, the details of which are given later.

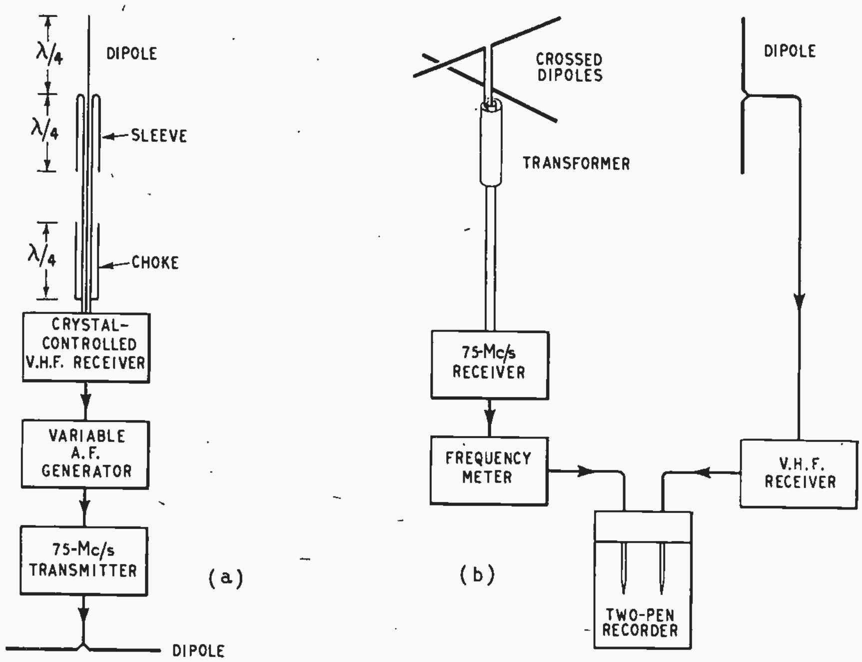


Fig. 1. *Receiving equipment: (a) balloon-borne station; (b) ground station*

At distances well beyond the horizon, changes in the refractive index of the troposphere cause considerable variations with time of the field strength at any given point. It was thus necessary, in order to obtain a reasonably accurate evaluation of the height-gain, to compare on a continuous basis the field strength as determined by the balloon-borne receiver with that measured by means of a second receiver with its aerial on a mast at a fixed height above ground level; and for this purpose the two signals were recorded simultaneously by a double-pen recorder.

The first ascents were made with the balloon rising at a more-or-less uniform rate, but it was found that often the fading of the signal was so rapid that a false impression of its variation with height was being obtained. In subsequent ascents, therefore, the balloon was stopped at various fixed levels for a few minutes so that the total range of variation of the fluctuating signal could be recorded, and also, when possible, a median value obtained for comparison with the median value obtained at the lower fixed aerial. At Slough these stops were made both with the balloon ascending and descending. At Cardington, with the much greater height attainable, this procedure would have taken so long that propagation conditions might on occasion have changed appreciably during the observations, and stops were made generally only on the descent, the ascent being used to get a quick overall impression of the height-gain characteristic.

At all but the lowest wind speeds, a degree of lateral as well as vertical movement of the balloon occurred as the cable was extended; the length of the cable from the ground to the balloon, which could be measured by a meter on the winch was, in general, not the true height of the balloon. Calculation showed, however, that even with wind speeds of 30 to 40 knots the error in assuming the height to be the same as the length of the cable was unlikely to exceed 10 per cent, and this maximum error only occurred when the balloon had reached an altitude of 5,000 feet. Since in practice it proved not possible to fly the balloon at Cardington at wind speeds much in excess of 15 knots, it was decided to tolerate the error of a few per cent which might occur from time to time in equating the height of the balloon to the length of the cable, and not to have recourse to more elaborate methods of height measurement.

Balloon-Borne Equipment

It was desirable, particularly for the experiments with the smaller balloon at Slough, that the receiver carried by the balloon should be as light as possible; and it was found that the receiving section of a commercially-available mobile radio-telephone equipment was suitable for the purpose.* This receiver was of a double-frequency-change design with crystal-controlled local oscillators, and the bandwidth to the 6-dB level was ±15 kc/s: suitable crystals were obtained to enable measurements to be made at the frequencies of the sound channels of the five high-power B.B.C. television transmitters in Band I. Small modifications to the final detector stage of the receiver were necessary in order to obtain direct-current outputs of the magnitude required for the operation of the telemetering unit.

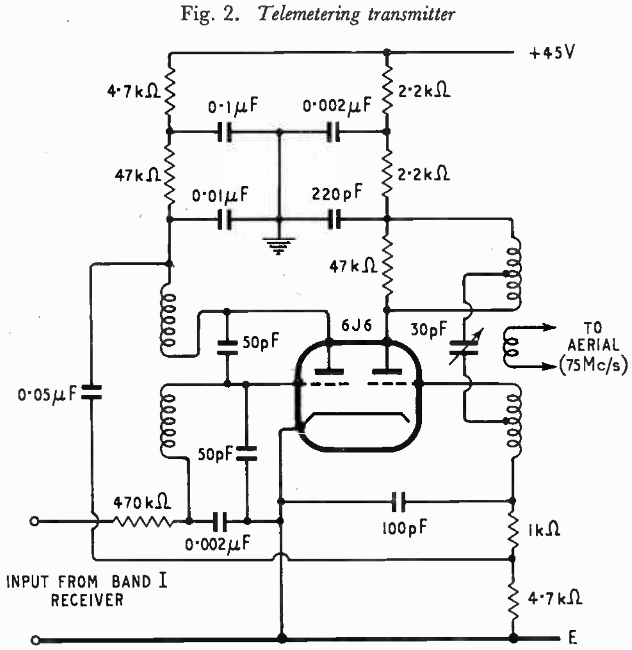
The Band I transmissions are, of course, vertically polarized, so that some simple form of vertical dipole, having a uniform horizontal polar diagram, was all that was required to avoid any undesirable effects due to the rotation of the balloon during measurements. The aerial was fixed to the balloon rope immediately above the receiver, and it was necessary as far as possible to ensure that the presence of the transmission line did not affect the field at the receiving aerial. For the major part of the investigation, a half-wavelength sleeve dipole (one for each frequency) of the kind shown in Fig. 1(a) was used, and to eliminate currents on the outside of the short section of transmission line a quarter-wavelength choke was added. It was subsequently found that a quarter-wavelength unipole over an earth plane formed by four horizontal rods, mutually at right angles and each a quarter of a wavelength long, was equally effective and required no choke.

* The authors are indebted to Pye Telecommunications Ltd. for the loan of this item.

Telemetering Unit

Also carried by the balloon was a telemetering unit. The design of this unit was based on equipment used by the National Bureau of Standards[7] for radio-sonde purposes, and the circuit diagram is shown in Fig. 2. The left-hand half of the double triode acts as a modulating oscillator for the other half which is used to generate a radio frequency for the transmission of the required Band I field-strength information to the ground. The frequency of the modulating oscillator is not critical, being about 1 Mc/s, and well below that of the carrier oscillator, which in the present experiments was 75 Mc/s: the oscillations of the 1-Mc/s modulating oscillator are blocked at an audio frequency determined primarily by the time constant of the $R\,C$ network in its grid circuit. In the original American application, the blocking frequency was varied by changing the value of the resistance: in the present instance, however, the same effect was achieved by varying the positive bias voltage applied to the grid. (A similar arrangement was used earlier by one of the authors for the measurement of atmospheric potential gradients[8,9].) The d.c. output of the v.h.f. receiver was used to produce this variation, and thus to control the audio-frequency modulation of the carrier oscillator. It was found that, for a given change in the positive bias, the range of the audio-frequency variation increased as the anode voltage of the modulating oscillator was reduced: 45 volts was finally chosen as a suitable anode voltage, and a typical calibration curve showing audio frequency as a function of the positive bias is illustrated in Fig. 3.

Fig. 2. *Telemetering transmitter*



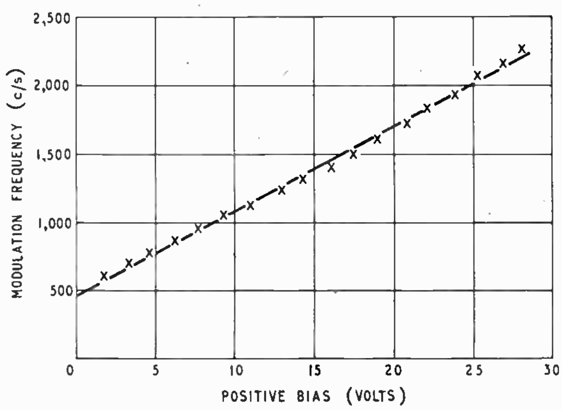


Fig. 3. *Calibration of telemetering unit*

The 75-Mc/s transmitter was connected to a horizontal half-wavelength dipole, and the radiated power of 10 milliwatts was both adequate to provide a good signal at the ground over the range of heights involved, and sufficiently small to keep the current taken from the power source to a reasonably low level. A vibrator power-pack was used to obtain the h.t. supply for the Band I receiver and the telemetering unit: it was operated by a 6-volt accumulator which also supplied the current for the valve heaters. The current taken from the accumulator was 4 to 5 amperes. Special lightweight accumulators, which would give this current for about an hour, were used in the experiments with the small balloon at Slough; but at Cardington it was possible to use an ordinary car accumulator which would give the required current for several hours without any significant change in voltage.

The balloon-borne equipment, together with Band I receiving aerial and the 75-Mc/s ground receiving aerial described below, are shown in the photograph. A waterproof cover enabled ascents to be made in rainy as well as in dry weather.

Ground Equipment

The ground station consisted of two receivers, one for the reception of the telemetered information at 75 Mc/s from the balloon, together with a means of converting the audio modulation frequencies to their corresponding field strengths, and a second for the direct measurement of the Band I transmission under investigation at a fixed height near to the ground during the whole of the ascent and the descent of the balloon. The two sets of field-strength measurements were recorded simultaneously with a two-pen recording milliammeter, and a chart speed of 12 inches per hour was sufficient to enable the detailed fading of the signals to be taken into account in the assessment of the height-gain. The general arrangement of the ground receiving equipment is indicated in Fig. 1(b).

Since the ground station was placed close to the balloon winch it was, except for very low aerial heights, almost vertically below the balloon-borne receiver. As the balloon turned in the wind it was possible for the horizontal dipole radiating the 75-Mc/s telemetering signal to rotate through a very large angle: and it was necessary to allow for this in the design of the receiving aerial on the ground. Two half-wavelength dipoles were set horizontally and at right angles to each other and connected by a quarter-wavelength of transmission line of characteristic impedance 75 ohms. If the two dipoles are in the same plane, this arrangement ideally gives a uniform response whatever the orientation of a horizontally-polarized incident wave. In the present investigation, however, it was also necessary to see that, as far as possible, no null above zero elevation occurred in the radiation pattern of the receiving aerial: the two dipoles were thus separated vertically by about one-eighth of a wavelength, and the centre of the system was arranged to be at about three-eighths of a wavelength above a ground plane. The small vertical spacing of the dipoles slightly, but not significantly, impaired the uniform response to horizontally-polarized waves. The receiving aerial was matched to a 75-ohm coaxial feeder by means of a quarter-wavelength transformer, and connected to a conventional communications receiver tuned to 75 Mc/s, the final output of which was in the form of pulses at the audio modulation frequency of the telemetering transmitter.

The frequency-measuring circuit used to convert the output of the 75-Mc/s receiver into the direct current required to operate a recording milliammeter was based on a design by Hunt[10]. In this circuit, which is illustrated in Fig. 4, the time constants were adjusted to give a good sensitivity over the required frequency range without too much loss in linearity. The lowest frequency generated by the telemetering transmitter, for zero bias, was about 450 c/s (see Fig. 3): and, in order to enable the whole of the scale of the recording milliammeter to be used, the deflection of the milliammeter corresponding to this lowest frequency was reduced to zero by means of a current in opposition, separately applied from a battery. Any changes in the calibration of the frequency meter, which might have been produced by a change of indicating instrument, were avoided by maintaining the total resistance of the chain containing the instrument at 3,500 ohms by means of a series variable resistor.

The crossed-dipole ground receiving aerial is shown here with the Band I aerial and balloon-borne equipment

Calibration of Equipment

To interpret the final chart records in terms of the variation of field strength with height it was necessary to make an overall calibration of the balloon-borne

Band I receiver and telemetering chain. This was normally effected by applying (at ground level) a known voltage directly to the input terminals of the balloon receiver, by means of a standard signal generator, and, with the telemetering system in operation, noting the corresponding reading of the recording milliammeter. It was found that, as the e.m.f. of the accumulator supplying power for the balloon equipment varied slightly, small changes in the overall calibration occurred : and, to keep a check on this, calibrations were performed both before the ascent and after the descent of each set of height-gain observations.

To establish more certainly the absolute values of the field strengths being measured, a further calibration was made using a radiation method[11] in which a known horizontally-polarized field is established at the receiving aerial. The balloon-borne equipment was detached from the cable for the purpose of this calibration, and the sleeve-dipole used for reception disposed horizontally in an appropriate position relative to that of the transmitting aerial of the local transmitter providing the calibrating field. Similar calibrations were performed for the receiver used for the measurement of the field strength near to the ground to serve as a standard of reference. In the case of this receiver, the sensitivities derived from the standard-signal-generator and radiation-field methods of calibration were to all intents and purposes the same, assuming the effective length of the receiving half-wavelength dipole to be λ/π. The agreement between the two methods for the balloon receiver was not so good, and it appeared that the sleeve dipole had an effective length only about 65 per cent of that corresponding to a true half-wavelength dipole. It was therefore necessary to make due allowance for this in the interpretation of the measurements.

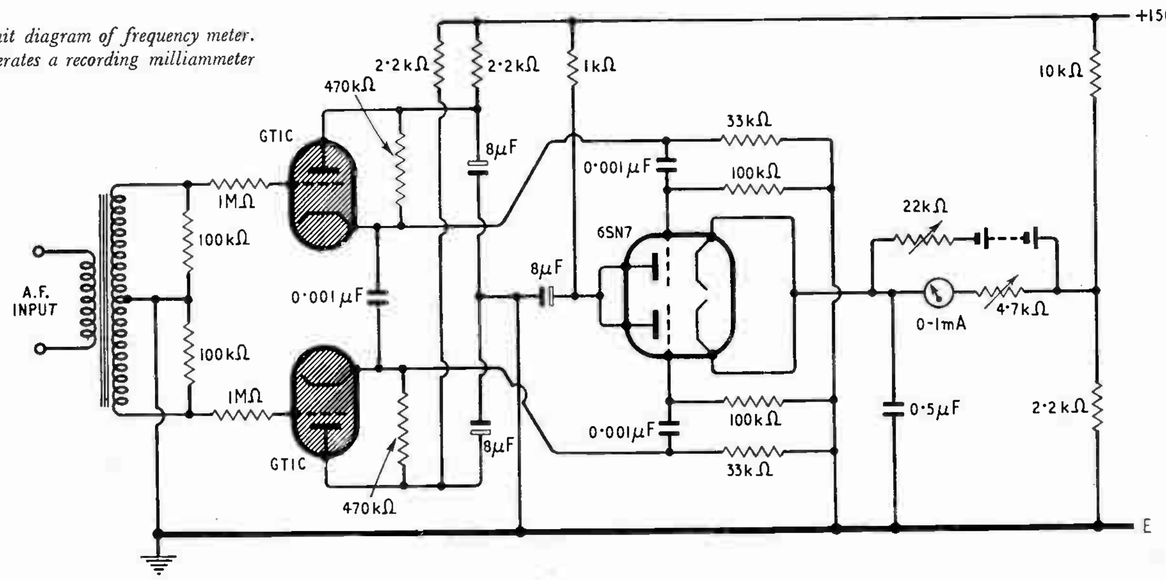
Some Typical Height-Gain Measurements

Although measurements of height-gain have been made on all of the five B.B.C. high-power television transmissions in Band I at intervals over a period of two years, and over paths varying in length from 40 to 300 miles (65 to 480 km); the examples of the results obtained given in this paper are confined to some of the observations made at Slough and Cardington on the transmissions from Sutton Coldfield on a frequency of 58·25 Mc/s. These will suffice to illustrate the use and potentialities of the equipment and methods described above; and it is intended to present in a further paper a more complete account of the whole series of measurements, together with a detailed discussion of the results in relation to the prevailing meteorological conditions.

The distance from Sutton Coldfield to Slough is 95 miles (152 km). The height of the transmitting aerial above sea level is about 1,300 feet (400 metres), and for this path, under conditions of standard atmospheric refraction, a receiving aerial would have to be at a height of at least 2,000 feet (610 metres) to be above the horizon of the transmitter. Since the measurements at Slough were limited to a maximum height of 600 feet, they were all well within the shadow region. From Sutton Coldfield to Cardington the distance is 70 miles (112 km), and the ground profile in this case is such that the receiving aerial would, for standard atmospheric refraction, be above the horizon of the transmitter for heights exceeding about 1,000 feet. At Cardington, therefore, where heights of some 5,000 feet were attainable, it was possible to observe the behaviour of the height-gain as the receiving aerial moved from the region below the horizon to that above it.

Fading of the received signal was generally found to occur over both of these transmission paths for all aerial heights, though the rate and range of the fading varied from time to time : the range of fading also decreased as the height of the receiving aerial was increased. There was fairly close correlation between the fading observed at the reference level near to the ground and that observed with the raised receiver at relatively low heights : the degree of correlation decreased, however, as the balloon ascended and became substantially zero at heights greater than about 200 feet. This fading presented a problem in the analysis of the records for, since the time during which observations were made at each of the stationary levels was only a few minutes, an accurate median value of the field strength with respect

Fig. 4. *Circuit diagram of frequency meter. Its output operates a recording milliammeter*



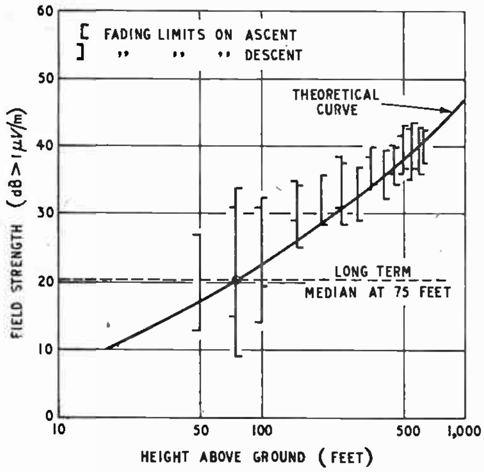


Fig. 5. *Height-gain under conditions of standard atmospheric refraction* (1500 *G.M.T.*, 22*nd June* 1953); *transmissions on* 58·25 *Mc/s from Sutton Coldfield to Slough* (*distance* 95 *miles*)

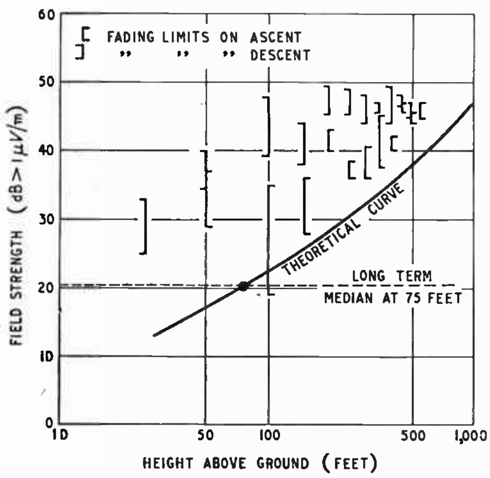
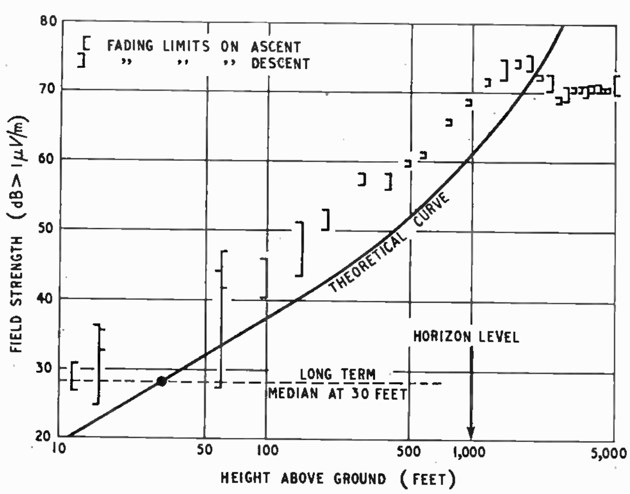


Fig. 6. *Height-gain under anticyclonic conditions* (1530 *G.M.T.*, 8*th June* 1953); *transmissions on* 58·25 *Mc/s from Sutton Coldfield to Slough* (*distance* 95 *miles*)

Fig. 7. *Height-gain measurements below and above the horizon* (1800 *G.M.T.*, 10*th August* 1953); *transmissions on* 58·25 *Mc/s from Sutton Coldfield to Cardington*



to time could not in general be obtained, there usually being present components of the fading pattern having periods greater than a few minutes. Under these circumstances it was decided to determine the maximum and minimum values of the field at each height where observations were made, and to compare these 'fading limits' as the height of the balloon was varied.

Observations at Slough

A typical example of the type of height-gain behaviour observed at Slough under conditions of standard atmospheric refraction is shown in Fig. 5. The meteorological data showed that, at the time of the measurements, a depression situated over the English Channel was giving fresh winds and a well-mixed atmosphere over the transmission path, and there were no significant temperature inversions present. The fading limits observed at each height on the ascent and descent were closely similar, and it will be seen that between the levels of 50 and 600 feet there was a height-gain of about 20 dB. The theoretical curve shown in the figure is based on the theory developed by Eckersley[12], and it is drawn through the value of the median field strength measured over a considerable period of time at a height of 75 feet (23 metres), the height of the standard reference aerial at Slough for this work. There is good agreement between the observations and the theoretical curve, which was calculated for standard atmospheric refraction conditions.

In contrast to the above example, Fig. 6 shows height-gain measurements, also at Slough, when a ridge of high pressure extended across the British Isles, thus producing stable atmospheric conditions over the transmission path. The winds were light, and a temperature inversion of 3·3°C was present between the heights of 3,400 and 4,200 feet (1,040 and 1,280 metres), as opposed to the lapse of about 1·7°C which would have occurred over the same height interval under standard conditions. The fading limits observed at a given height on the ascent and on the descent did not agree very well in this instance: this was no doubt due to the fact that the received field was characterized by deep slow fading, and the samples at each height, of duration only a few minutes, were not long enough to show up the full fading range. It is nevertheless apparent that the height-gain was very much less than that shown in Fig. 5 for standard conditions of refraction: it was in fact only about 10 dB over the height range 50 to 600 feet. The theoretical height-gain curve (for standard refraction) is again included for comparison, and it will be seen that all of the observations lie above this curve, the differences from theory being greatest at the lower heights. This type of behaviour is to be expected under conditions of non-standard tropospheric refraction, particularly when reflection at elevated inversion layers plays an important part in determining the field strength beyond the horizon[1].

Measurements at Cardington

An example, from the measurements at Cardington, of the variation of field strength with height when the ascent is partly below and partly above the horizon is given in Fig. 7. The theoretical height-gain curve shown in this figure has been drawn through the median value with respect to time of the field strength observed at a fixed height of 30 feet (9 metres) above ground during the whole of the investigation at Cardington. The measured field strengths follow a curve approximating to the shape of the theoretical curve, at least for the first 1,000 feet or so, though at a somewhat higher level. Above the horizon, the measurements show a broad maximum of field strength, and at still greater heights this is followed by some suggestion of a minimum, which, however, is not too well defined.

The ascent illustrated in Fig. 7 was made when a ridge of high pressure covered the transmission path; and it was found that, when the path was under the influence of a depression, the results for heights below the horizon tended to be in better agreement with the theoretical curve. The positions and magnitudes of the maximum and possible minimum observed above the horizon varied from one ascent to another. An attempt to explain these features of the height-gain curve in terms of diffraction at a hill near to the centre of the transmission path was not successful; they may, however, be connected with a possible minimum in the vertical radiation pattern of the Sutton Coldfield transmitting aerial (as observed at Cardington) due to a ground-reflection at a point about 10 miles from the transmitter.

Conclusions

A method has been devised, using lightweight, balloon-borne equipment incorporating a system of telemetry, for the measurement of height-gain at metre wavelengths. The equipment has been designed primarily to operate at frequencies in the television Band I. Preliminary measurements made on the sound channel of the Sutton Coldfield transmitter of the B.B.C. (frequency 58·25 Mc/s) have shown that, under conditions of standard atmospheric refraction, the observed height gain is very similar to that predicted by diffraction theory[12]; but divergencies from this theory occur when non-standard modes of propagation occur.

Acknowledgments

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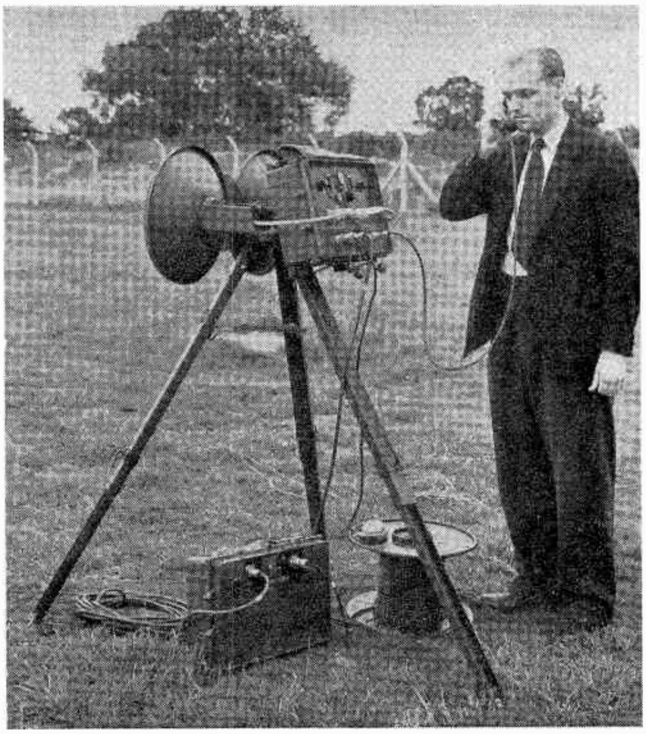
Marconi Portable S.H.F. Multi-Channel Equipment



THIS photograph shows a Marconi portable s.h.f. multi-channel radio-telephone equipment in use in open country. The link operates in the band 4,580–4,860 Mc/s, and employs wideband frequency modulation. The transmitter and receiver both employ Heil tube cavity resonators. Full duplexing is made possible by the use of separate transmitting and receiving aerials.

Up to 12 channels are available. The range using 4 channels is quoted as 20 to 30 miles over a line-of-sight path. The range can be extended by using back-to-back repeaters. It is claimed that unattended operation for up to 7 days is possible.

The equipment is useful where communication facilities of a more or less temporary nature are required quickly, for example, on large construction sites or pipeline projects.

Coherent And Incoherent Detectors

RESPONSE TO SIGNAL AND NOISE

By R. Kitai*

SUMMARY. *The responses of the 'linear' diode detector and the coherent ('phase-sensitive') detector to combined signals and random noise are compared for signal-to-noise ratios less than and greater than unity. It is shown that for amplitude-modulated signals coherent detection gives an output signal-to-noise ratio 3 dB better than that with the linear detector. For unmodulated signals much larger improvements can be effected by restricting the post-detector bandwidth.*

The response of various detectors to combined signal and noise has received considerable attention, more particularly in recent years when the problem of detecting signals well below prevailing noise levels has often arisen. It is interesting to note that an elementary comparison of responses of different types of detector to signal and noise (including the 'homodyne' detector) was begun some thirty years ago by J. R. Carson.[1] However, later investigations have shown that the subject is one of considerable complexity ; in general, noise can only be defined in terms of statistical parameters, while a further resort to statistics arises because of the random phase relations existing between signal and noise oscillations in the receiver. To complicate matters it is invariably the case that the detector is non-linear, and whereas it is usually in order to sum the responses to signal and to noise in receiver circuits up to the detector, this does not hold at the detector output.

A large variety of detectors are in common use in amplitude-modulated systems, but for the purpose of this paper, they may be divided into two categories:

(a) *Incoherent* detectors whose output depends on the amplitude, and not on the phase of the input carrier. The so-called 'linear diode' detector, based on a short time-constant charge and long time-constant discharge of a capacitor is the most commonly used.

(b) *Coherent* or 'phase-sensitive' detectors in which a reference voltage at carrier frequency is mixed with the incoming signal, and provides an output which is dependent on both the amplitude of the signal and the phase angle between the signal carrier and the reference voltage. These detectors have important advantages over incoherent detectors in certain applications.

The response of various detectors to signal and noise has received exhaustive mathematical treatment[2,3,4]. A comparison of the responses of coherent and incoherent detectors with specified pre-detector filters has been carried out by Smith[5] based on relations developed by Rice[6]. Tucker[7] has approached the same problem by considering the noise to be made up of an infinite number of side frequencies of infinitesimal amplitude, and in this way has avoided consideration of noise on a statistical basis.

A striking feature of these analyses is their mathematical complexity, and in most cases the theory extends into realms which are beyond the scope of the practising engineer. The aim of this paper is to present the rudiments of the subject in a more comprehensible manner. It is also hoped that this approach will be useful for teaching purposes. The analysis is restricted to a consideration of the 'linear' diode and the coherent detectors, and does not include comparison of the frequency spectrum of their output. It is also felt that since random factors are intrinsic in the problem, a theory which involves elementary statistics is more appropriate than one which evades it.

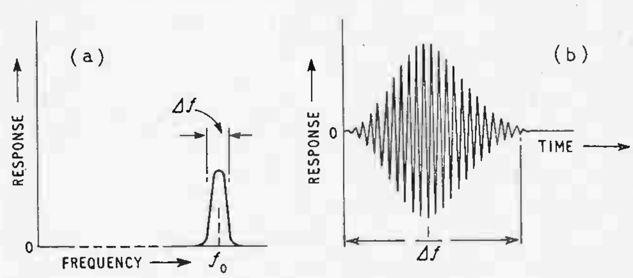


Fig. 1. (a) *The bandwidth of a communication channel* (Δf) *is usually small compared with the carrier frequency* f_0 ; (b) *response of such a channel to a single noise impulse*

1. Pre-Detector Circuit

In communications we are invariably concerned with the reception of frequencies in a bandwidth Δf which is small compared with the carrier frequency f_0. [Fig. 1(a)]. Two important properties of the pre-detector circuit then follow:

(i) If the carrier is amplitude-modulated, the highest modulation frequency passed is determined by the bandwidth. Hence each carrier cycle will exhibit only small variation in amplitude during its period $1/f_0$.

(ii) If a single noise impulse is induced in the aerial,

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the pre-detector output will consist of an oscillation at the frequency f_0 which is appreciable for a time of the order $1/\Delta f$ sec, [e.g., Fig. 1(b)]. In the more complex condition of noise of an arbitrary nature in the aerial, the pre-detector response can be obtained by using the impulse response in conjunction with the superposition integral. In this process the arbitrary noise input waveform is broken up into a series of impulses which follow each other in time. Fig. 1(b) shows, however, that the rise of pre-detector voltage due to each impulse is determined by the bandwidth, so that the variations in the envelope of the pre-detector noise oscillation must also be restricted to frequencies within the bandwidth Δf. It follows that the noise oscillation is such that the frequency fluctuates *slowly* within the band of width Δf centred on f_0. No matter what nature of noise is assumed, any one cycle of the pre-detector noise oscillation must be of nearly constant amplitude and of frequency which differs from f_0 by a small amount.

Assume that the receiver circuits up to the detector are linear. Referring to Fig. 2, let n be the amplitude of noise oscillation and s the amplitude of signal oscillation over any particular cycle. The phase angle ϕ between these oscillations is random so that the detector input voltage is :

$$v = s \cos \omega t + n \cos (\omega t + \phi) \qquad \text{(1)}$$

where $\omega = 2\pi f_0$,

or $$v = [s^2 + 2ns \cos \phi + n^2]^{1/2} \cos (\omega t + \theta) \qquad \text{(2)}$$

where $$\theta = \tan^{-1} \left[\frac{n \sin \phi}{s + n \cos \phi} \right] \qquad \text{(3)}$$

2. Linear Diode Detector

Ideally, this detector produces at its output the envelope of the oscillation at its input, irrespective of phase, so that the detector response is—

$$V_d = [n^2 + s^2 + 2\,ns \cos \phi\,]^{1/2} \qquad \text{(4)}$$

If signal and noise oscillations are in phase, $V_d = n + s$, but when they are antiphase, $V_d = \pm\,(n - s)$ with V_d always positive. These are the extremes of the range of V_d for given n and s.

The dependence of detector output voltage on ϕ is easily demonstrated as follows:

Fig. 2. *Components of detector input*

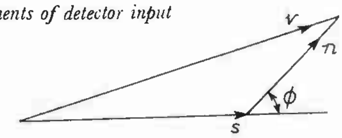
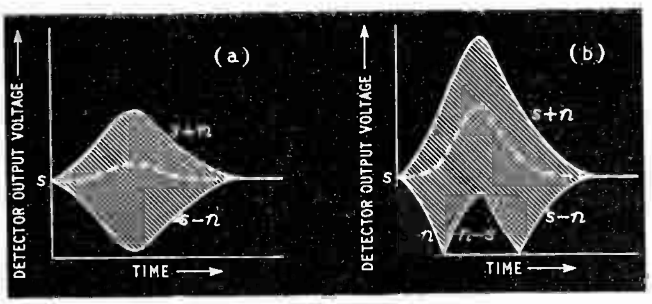


Fig. 3. *Response of 'linear' detector to signal and noise.* (a) *Signal > noise* ; (b) *signal < noise*



A square-wave generator and a sine-wave oscillator (unmodulated) are connected together to the input terminals of an a.m. receiver incorporating a diode detector. If the square-wave generator frequency is low enough, each rise and fall of its voltage will cause non-overlapping responses at the detector input. The signal generator and square-wave generator are deliberately not locked to each other so that a different value of ϕ is obtained for each successive voltage step from the square-wave source. Assuming the receiver impulse response to be that of Fig. 1(b), the patterns observed on an oscilloscope connected to the detector output (with time-base synchronized to the square-wave

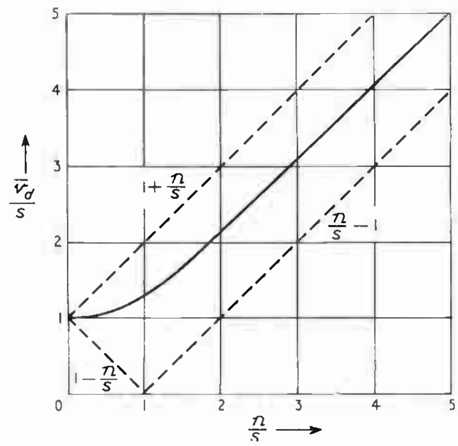


Fig. 4. *Ratio of total output to signal output as a function of input noise-to-signal ratio for a 'linear' detector*

frequency) are as shown in Fig. 3. Fig. 3(a) obtains when the peak noise response is less than the peak signal, while Fig. 3(b) obtains when the peak noise response exceeds the peak signal.

In general, the sources of the signal and noise operate entirely independently so that all values of ϕ in equation 4 are *equally* probable. For given n and s then the statistical average detector output voltage is:

$$\bar{V}_d = \frac{1}{2\pi} \int_0^{2\pi} V_d \, d\phi$$

It is shown in the appendix that this can be expressed in terms of the complete elliptic integral of the second kind, and for given n and s,

$$\bar{v}_d = (n + s) \frac{2}{\pi} E\,(k) \qquad \text{(5)}$$

where $k^2 = 4\,ns/(n + s)^2$

Values of $E\,(k)$ versus k^2 are tabulated.*

Equation (5) has been plotted in Fig. 4, the curve being normalized with respect to the signal s. The extreme values of $\bar{v}_d$ are also shown. Using Fig. 4, the values of $\bar{v}_d$ relevant to Fig. 3 have been inserted (dotted).

The power in the detector load is also of interest, and this is proportional to—

$$V_d^2 = n^2 + s^2 + 2\,ns \cos \phi$$

For given n and s the statistical mean power is therefore proportional to

$$n^2 + s^2 \qquad \text{(6)}$$

* *Jahnke and Emde "Tables of Functions" 4th edition, p. 80*

The theory brings to light the peculiar characteristics of the linear diode detector. It is a linear detector in a very restricted sense. Fig. 4 also shows that when the noise is below the signal level, the non-linearity reduces the effect of the noise ; the converse is true when the noise exceeds the signal. This reducing effect is quite marked, for when $n/s = 2$, $\bar{v}_d/s = 2\cdot 13$ and when $n/s = 5$, $\bar{v}_d/s = 5\cdot 05$.

3. Coherent Detector

A simple coherent detector is shown in Fig. 5(a). Here a push-pull input voltage V is combined with a large polarizing voltage V_p of the same frequency. The combined voltages V_1 and V_2 are shown in Fig. 5(b),

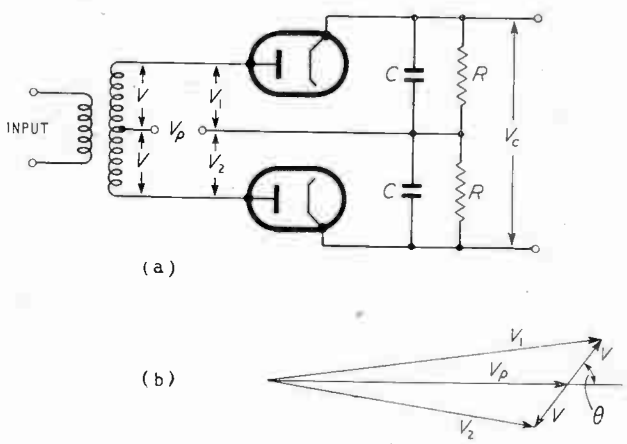


Fig. 5. *Simple form of coherent detector* (a) *and its vector diagram* (b)

and these are applied to two peak-reading linear diode detectors. It is easily shown that if $V_p \gg V$,

$$V_c \approx 2V \cos \theta$$

It is customary to arrange that V_p is in phase with the signal input. Referring to Fig. 2 then, for signal and noise at the detector input, the polarizing voltage vector is horizontal. The detector output voltage will be—

$$V_c = s + n \cos \phi \quad \ldots \quad (7)$$

The extremes of V_c are again $s + n$ and $s - n$, but unlike the linear diode detector the output can reverse in sign when the noise exceeds the signal.

From equation (7) for given n and s, the statistical mean output voltage is

$$\bar{v}_c = \frac{1}{2\pi}\int_0^{2\pi} v_c \, d\phi = s \quad \ldots \quad (8)$$

Fig. 6 shows the curves for the coherent detector corresponding to those of Fig. 4 for the linear diode detector.

The power in the detector load is made up of contributions from the sources of both V_p and of V. Referring to Fig. 5, the power in the upper resistor R is

$$\frac{2V_1^2}{R} = \frac{2}{R}\left[V_p^2 + V^2 + 2V_pV\cos\theta\right]$$

and that in the lower resistor R is

$$\frac{2V_2^2}{R} = \frac{2}{R}\left[V_p^2 + V^2 - 2V_pV\cos\theta\right].$$

The total load power is then

$$(4/R)\,[V_p^2 + V^2]$$

while in the absence of input V, the total load power is $4\,V_p^2/R$. In the case under consideration, $V = s + n\cos\phi$ so that the power in the load from this source is proportional to $s^2 + 2\,ns\cos\phi + \frac{1}{2}\,n^2\,(1 + \cos 2\,\phi)$. The statistical mean power from the input source (for given n and s) is therefore proportional to

$$s^2 + \tfrac{1}{2}\,n^2 \quad \ldots \quad (9)$$

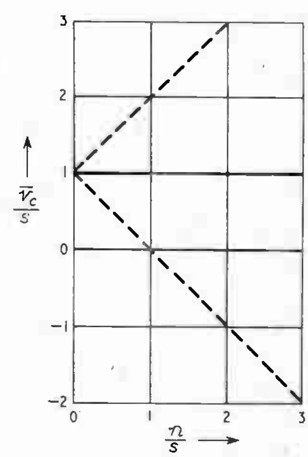
Conclusion

Inspection of the above theory brings to light the following advantages of the coherent detector:

(i) Equation (8) shows that if the output of a coherent detector can be averaged over a sufficient length of time (by some process of integration) the output will be largely independent of n. This averaging is tantamount to reducing drastically the post-detector bandwidth, and is not permissible in the case of amplitude-modulated signals. However, when s is not modulated a considerable immunity from noise can be achieved, and this technique can be used to advantage in any application in which some waiting time for the required information can be tolerated.

(ii) If the input signal is modulated so that no restriction on post-detector bandwidth is permissible, then equations (6) and (9) show that the coherent detector offers a 3-dB improvement in signal/noise power over the linear diode detector. The reason for this is that the coherent detector is concerned only with that component of the noise voltage which is in phase (or in anti-phase) with the signal. Thus on a statistical average only half the available noise power is absorbed. It is seldom that advantage is taken of this, for in most cases the improvement in signal/noise power is more than offset by the complication in having to provide the polarising voltage for the coherent detector.

Fig. 6. *Ratio of total output to signal output as a function of input noise-to-signal ratio for a coherent detector*



A classical example of the technique in (i) above is Dicke's Radiometer[8], used initially for the detection of small microwave noise from the sun, and later also employed in radio spectroscopy. Here the incoming noise from an aerial is required to be measured, but has a level which is only a few per cent of the receiver noise. Immunity from the latter is achieved by switching the input periodically between the aerial and a resistor (at room temperature) of resistance equal to that of the aerial radiation resistance. By so doing, a discrimination is achieved between the incoherent noise of the receiver and the coherent voltage (at the switch frequency) of the receiver input. A coherent detector, supplied with a polarizing voltage from the switching source, is followed by a low-pass filter, the output of which is fed to the d.c. recording meter.

The author is grateful to D. G. Lampard for several helpful suggestions.

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APPENDIX

The integral $\bar{V}_d = \frac{1}{2\pi}\int_0^{2\pi}[n^2 + s^2 + 2\,n\,s\cos\phi]^{1/2}\,d\phi$

can be evaluated as follows:

Let $h = \frac{2ns}{n^2 + s^2}$. Then

$$\bar{V}_d = \frac{[n^2 + s^2]^{1/2}}{2\pi}\int_0^{2\pi}[1 + h\cos\phi]^{1/2}\,d\phi$$

Substituting

$\phi = 2\alpha$ whence

$d\phi = 2\,d\alpha$, $\cos\phi = 1 - 2\sin^2\alpha$,

$$\bar{V}_d = [n^2 + s^2]^{1/2}[1 + h]^{1/2}\frac{1}{\pi}\int_0^{\pi}[1 - k^2\sin^2\alpha]^{1/2}\,d\alpha$$

where $k^2 = \frac{2h}{1 + h} = \frac{4ns}{(n + s)^2}$

Further $(1 + h)^{1/2} = \frac{n + s}{[n^2 + s^2]^{1/2}}$ so that

$$\bar{V}_d = \frac{2}{\pi}(n + s)\,E(k)$$

where $(E\,k) = \int_0^{\pi/2}[1 - k^2\sin^2\alpha]^{1/2}\,d\alpha$

From tables of $E(k)$ the extremes of the range are $k^2 = 0$ when $E(k) = \pi/2$ and $k^2 = 1$ when $E(k) = 1$. It is necessary that $k^2 \leqslant 1$ and this is satisfied since $k^2 = 1 - \left\{\frac{n - s}{n + s}\right\}^2$

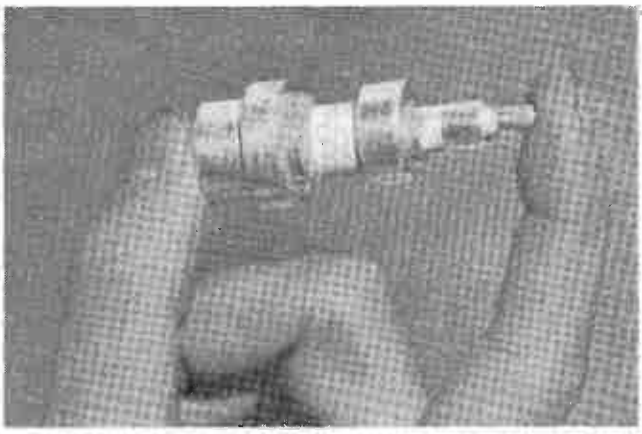
Ceramic Envelope Valves

THE use of ceramic materials instead of glass for valve envelopes confers two immediate advantages; increased mechanical strength, and the ability to withstand high temperatures. One result of the latter is that valves can be 'baked' at a high temperature during the evacuation process. Occluded gases are released more readily as the temperature is raised, and so a harder vacuum is obtainable. Getters can be dispensed with.

Increased mechanical strength is of use in airborne equipment and, possibly, in industrial and military equipment subject to vibration or shock.

Less immediate, but in the long run more useful, advantages may result from the fact that the envelope components of a ceramic valve can be made to fine limits.

Typically, a valve is built up from ceramic rings or discs of ceramic soldered together, the electrode connections being brought through the soldered joints or sandwiched between them. This construction suggests the use of planar electrodes. Now, if a planar grid can be located precisely in relation to a cathode by making use of the ceramic parts as precision spacers, it will clearly be possible to produce good high-frequency valves. Most of the ceramic valves so far produced have been for high-frequency operation. The first American mass-produced ceramic receiving valve, the 6BY4, operates efficiently at 900 Mc/s (gain 15 dB, bandwidth 10 Mc/s, noise figure 8 dB). British ceramic power valves (Ferranti UL11, UL31) are operable at 2,000 Mc/s. This is not as good as the best disc-seal glass triodes, but it is a promising beginning.



Ferranti 15-W ceramic triode for use in c.w. or pulse operation up to 2,000 Mc/s

There is a further potential advantage of precision pre-formed envelope parts. It seems possible that ceramic valves might be capable of much easier assembly than glass valves, in which the electrode assembly is a difficult operation demanding highly-trained operators. It has been suggested that assembly might be so much easier that it could be done by machines but, even without taking the technique this far, any simplification of assembly will be of advantage provided, of course, that it is not obtained at the cost of excessive difficulties in other directions.

The Fringe of the Field — ***By Quantum***

THE COLOUR VECTOR IN TELEVISION

The previous article examined the idea of colour as a vector in general terms, carefully avoiding anything quantitative and only mentioning incidentally the behaviour of the eye towards equal-energy (or equal-power) stimuli in different regions of the spectrum. But since energy, power, or derived voltage is the way in which the information is collected, stored, or transmitted in any reproduction process, and this is all ultimately for the benefit of the eye, the eye's response to energy is the first consideration in practice. A dietician may do marvellous calculations in calories, but the result must ultimately depend on the caprices of the digestive tract, rather than on the law of conservation of energy; and the same sort of thing applies to colour calculations. Fig. 1 shows what is called the relative luminosity (or relative luminance) curve for the equal-energy spectrum when the illumination is reasonably high. Along the horizontal axis the visible spectrum is plotted, from violet to red, wavelengths 4×10^{-5} cm to 7×10^{-5} cm. By equal-energy we mean that for any chosen finite interval between wavelengths λ and $\lambda + \delta\lambda$, the energy (or power) received for a given $\delta\lambda$ is the same wherever λ is taken. The ordinates represent relative luminance; 1·0 appears at $5{\cdot}6 \times 10^{-5}$ cm, where the eye is most sensitive. At $5{\cdot}1 \times 10^{-5}$ cm and $6{\cdot}1 \times 10^{-5}$ cm the relative luminance is 0·5; this means that a monochromatic source at either of these wavelengths would appear half as bright as one of the same absolute power (wattage) at $5{\cdot}6 \times 10^{-5}$ cm, and so on.

The usual spectral primary lights differ greatly in relative luminance; thus, from Fig. 1, we have

Primary	*Wavelength* ($\times 10^{-5}$ cm)	*Relative Luminance*
R	6·5	0·107
G	5·3	0·862
B	4·6	0·060

The result of mixing these primaries to give white or any other colour can then be expressed in two ways; either in terms of the relative quantities of energy involved, or else in terms of the relative luminances. Both forms of statement mean exactly the same.

Thus, the 'equal-energy' or reference white (*W*) obtained from mixing equal absolute quantities of energy of *R*, *G*, *B* can be written in energy terms as

$$\tfrac{1}{3} R + \tfrac{1}{3} B + \tfrac{1}{3} G = W \quad \ldots \quad (1);$$

or, in terms of relative luminances as

$$0{\cdot}107\, R + 0{\cdot}862\, G + 0{\cdot}060\, B = 1{\cdot}029\, W;$$ and by dividing through by 1·029 in order to have the three coefficients adding up to 1,

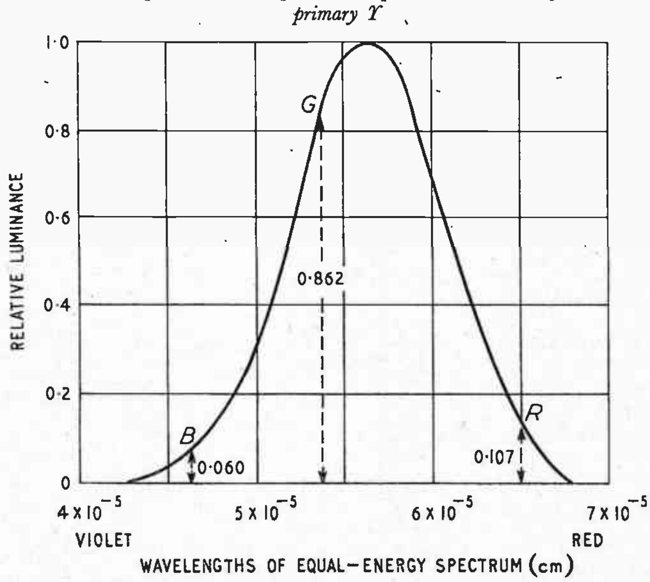
$$0{\cdot}104\, R + 0{\cdot}835\, G + 0{\cdot}058\, B = W \quad \ldots \quad (2)$$

It is at first sight difficult to realize that (1) and (2) are really two forms of the same equation. But we meet the same kind of thing in elementary chemistry. Carbon dioxide contains 27% of carbon and 73% of oxygen by weight; the carbon dioxide molecule contains one atom of carbon and two atoms of oxygen; these two statements are perceived as identical only when we know the relative weights of C and O, or their atomic weights. The relative luminance curve, in fact, is as important in colour work as the atomic weight table is to the chemist, and has much the same function. A poor analogy, you say; bursting to tell me I have forgotten about isotopes? Well, of course, these are lumped together in the observational values used in chemistry, but the point can be taken. For there is another relative luminance curve operative in very weak illumination, with the peak considerably nearer the violet end of the spectrum; but it is of no interest in this discussion.

The coefficients in the luminance equation (2) are those for the particular *R*, *G*, *B* primary wavelengths chosen and, for any other spectral primaries, we should have the same kind of equation but with different numbers. If the primaries are not spectral colours, of course the coefficients cannot then be obtained directly from the curve, but they can be found experimentally. For the *R*, *G*, *B* non-spectral primaries used in colour television reproduction the luminance equation is

$$0{\cdot}3\, R + 0{\cdot}59\, G + 0{\cdot}11\, B = W \quad \ldots \quad (3)$$

Fig. 1. *Bright-light relative luminance curve showing the relative response of the eye to equal energy-stimulus in different regions of the spectrum. A curve of the same shape would also represent the spectral distribution of the C.I.E. primary Y*



Since we are not now dealing with spectral lights each of definite wavelength, the corresponding energy equation cannot be directly related to Fig. 1. But the luminance equation, concerned with the colour-properties alone, does not involve knowledge of the composition of R, G, B at all, and we should never really want to do this in any case.

The equal-energy white is devoid of chrominance, and has the character of luminance alone. This gives the clue to the juggling needed in order to separate luminance and chrominance for transmission purposes. Suppose that light of colour C entering the camera is analyzed by filters into R, G, B components, and that these operate on linear photocells to give voltage signals E_R, E_G, E_B which are proportional to the relative *energies* of the primaries. We can extract the luminance component from C by taking quantities of each of the E signals in such proportions as to satisfy equation (2). That is, $0{\cdot}3\,E_R$, $0{\cdot}59\,E_G$ and $0{\cdot}11\,E_B$ are extracted and added to give a signal E_Y, when

$$E_Y = 0{\cdot}3\,E_R + 0{\cdot}59\,E_G + 0{\cdot}11\,E_B \quad .. \quad (4)$$

Comparing equations (3) and (4), it can be seen that E_Y should reproduce on its own the equal-energy white, at the appropriate luminance.

The signal E_Y is so called because, when the C.I.E. primaries X, Y, Z are being used (and we can at any stage suppose that we have transformed the co-ordinate system from R, G, B to this) the spectral distribution of the Y primary is the same in shape as the relative luminance curve. That is, if we relabelled the ordinates of Fig. 1 to represent the relative quantities of energy present and regarded the abscissae as a mere scale of wavelengths, the whole figure as it stands would represent the spectral composition of Y. It follows that, on the X, Y, Z system, the Y component of any colour is proportional to its luminance; and what equation (4) has really done is to collect together signals representing the Y-components of each of the R, G, B primaries. Since X, Y, and Z are by definition independent, and all the luminance information is present in E_Y, nothing that the X and Z components may do to the chrominance can in any way affect the luminance at the receiving end. But we had no idea that, starting off with R, G, B we were going to be left stranded with X and Z! The best thing to do now seems to accept that luminance independent of chrominance has been secured, and follow out the next stage on a constant-luminance diagram. But, first, a vector diagram may be helpful.

In Fig. 2, the vector OC represents the colour C; OW equal-energy white at the same luminance; OR and OB the primary red and primary blue components of OC. This is an energy diagram, so the lengths of the lines can also represent E_Y, E_R, and E_B, the respective signal voltages. Writing the signs + and — to denote *vector* addition and subtraction respectively, $OC = OW + WC$; so that if we extract E_Y and remove OW from OC we are left with the chrominance vector WC. Now,

$$WC = WR + WB,$$
$$= (OR - OW) + (OB - OW).$$

Or, in terms of signal voltages, WC is represented by the resultant of $(E_R - E_Y)$ and $(E_B - E_Y)$.

We find, to our relief, that X and Z are not there to be handled explicitly at all; instead, chrominance is catered for by the two difference signals $D_1 = (E_B - E_Y)$ and $D_2 = (E_R - E_Y)$.

For transmission purposes, E_Y has an independent carrier, and will operate a monochrome receiver as relentlessly as ever. (The elegant term steam-radio suggests a comparable name, incidentally, for the pre-1956 black-and-white receiver—shall we look back on obsolescent petrol-telly ?) The difference signals,

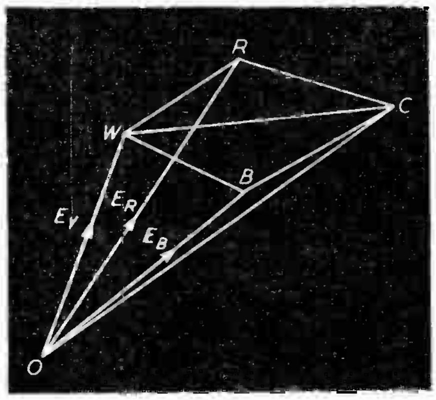


Fig. 2. *Analysis of the colour vector OC: resolved first into OW and WC; then the component WC is resolved into WR and WB; and from the triangles OWR and OWB, WR is OW — OR, and WB is OW — OB. Finally, the components of OC are OW, OR — OW, and OB — OW; and the signal voltages representing the components of OC are E_Y, $E_R - E_Y$, and $E_B - E_Y$.*

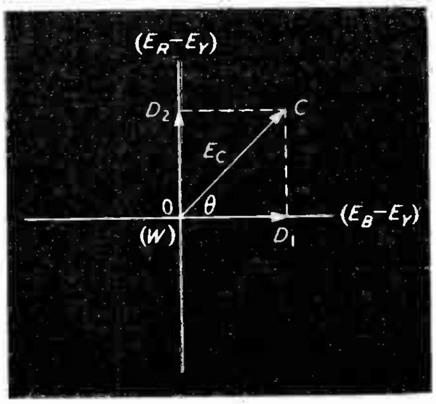


Fig. 3. *OC represents the chrominance only; the signal E_C is the vector resultant of D_1 and D_2*

though they are not sent separately themselves, are compounded to give two chrominance signals E_I and E_Q, which are transmitted together, but out of phase with one another, on a chrominance sub-carrier. They cannot interfere with monochrome reception; this arrangement is called compatibility.

I quoted Gouriet's book last month, and shall follow his argument now. He goes into some detail at this stage with a constant-luminance colour triangle plotted on red and blue axes, and the origin transferred to the point locating equal-energy white. Fig. 3 represents the chrominance C on such a figure with the trimmings removed, expressed in terms of the signal voltages of the difference-signals D_1 and D_2. The origin O represents white (W); the angle θ determines the hue, and the amplitude OC the saturation, just as in Newton's colour circle. The range of hues for this diagram is indicated in Fig. 4. The chrominance signal Ec is then

$$Ec = D_1 \cos\theta + D_2 \sin\theta,$$

or, if we regard OC as a rotating vector with angular velocity ω, then when $\theta = \omega t$,

$$Ec = D_1 \cos\omega t + D_2 \sin\omega t,$$

the modulations of the sub-carrier corresponding to D_1 and D_2 being a quarter of a period out of phase with one another.

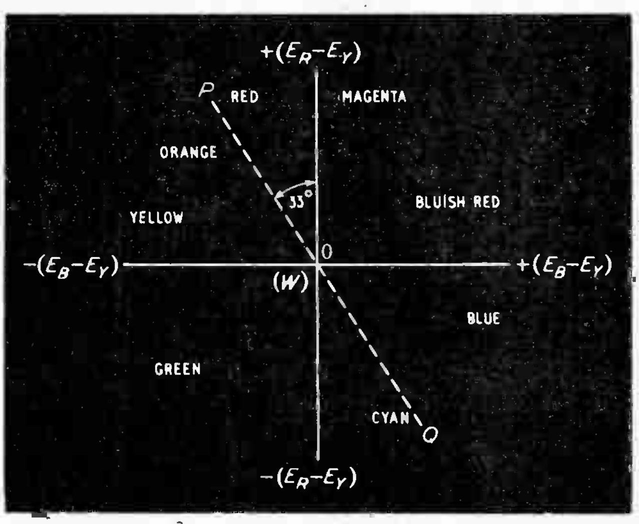


Fig. 4. *Chrominances for different positions of the chrominance vector OC of Fig. 3. The best range of points confined to a single line is on the orange–cyan line PQ. This is analogous to Newton's circle, with added non-spectral chrominances*

Finally, how much of all this information is actually needed, or rather how much can be left out without the customers complaining ? It all depends on the detail of the picture as a whole. The eye is fully sensitive to colour in large patches, is less critical in moderate details, and cannot discriminate chrominance at all in regions of fine detail. So both D_1 and D_2 could be dispensed with in the detailed parts of the picture; and the extensive bandwidth requisite for detailed rendering is not needed at all. In regions of moderate detail, the eye might be satisfied with one of them only; the question is, which one is to be favoured with the greater bandwidth for this purpose ? From Fig. 4, it can be seen that if we are to remove a component and thus clamp the rotating vector down to an excursion along one line, then instead of settling for *either* of the D axes, the best line to choose would be PQ, joining orange and cyan, at about 33° to the (R–Y) axis; for the eye is most tolerant in this region. One more transformation of co-ordinates, then ! Let us rotate the axes through about 33° (Fig. 5), and render the difference-signals "I" and "Q" as

$$E_I = D_2 \cos 33° - D_1 \sin 33°$$

and $E_Q = D_1 \cos 33° + D_2 \sin 33°$.

The I component, taking care of moderate detail, is allotted the wider bandwidth of the two; if Q fails to contribute, nobody will notice anyhow. The symbols and suffixes I and Q denote 'in-phase' and 'quadrature' respectively but, in actual fact, the signals do not bear this relation to the phase-reference colour-burst which is included for synchronizing on account of the 33° staggering; E_I lags the reference-burst by 57°, and E_Q by 147°.

From a technical point of view, this account is all too superficial, I know; but there is only one matter of principle that has been omitted. I used the term 'linear' with reference to photocells, meaning that the voltage made available was proportional to the energy (or power) absorbed and, usually, power is associated with E^2. The photo-emissive photocell does indeed

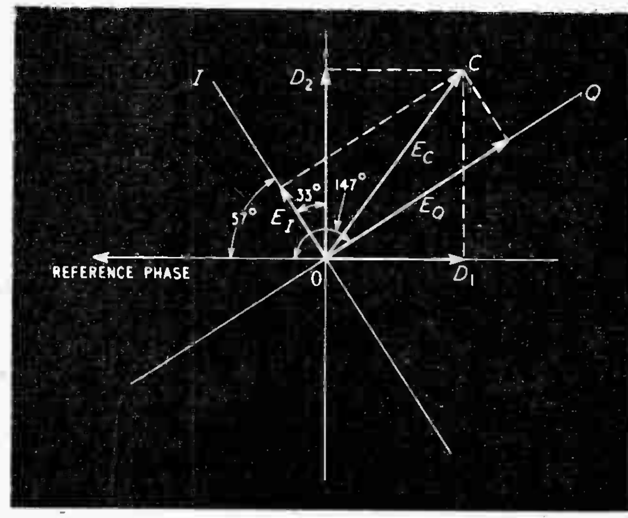


Fig. 5. *Transformation of axes. E_C is represented by the components E_I and E_Q, instead of the equivalent D_1 and D_2. So, if E_Q is suppressed, the range of chrominances given by E_I is the optimum shown in Fig. 4*

furnish a *current* proportional to the rate of reception of energy by the cathode, since each quantum of radiant energy liberates one electron, so the potential difference across a resistor in the anode circuit is proportional to the power absorbed.

But what about the receiving end ? It is easy to say that all we have to do is to reconstitute the original vector, and, if only phosphors were as obliging as photocells, it would be almost as easily done; for E_Y, E_I and E_Q, converted back to E_R, E_G and E_B, would reproduce C for us. In fact, differential amplification is needed to take into account the 'gamma' of the phosphors; for, since their luminances are not proportional to the energy of the impinging electrons, E_R, E_G and E_B must themselves be doctored by factors which ensure that the response is proportional to their original values.

It is interesting, on comparing Fig. 4 with Newton's colour circle, to see how closely his original ideas are incorporated in the process; this is one example only of the many twentieth-century advances that he foretold. The conversion of 'gross matter into light', or mass into energy; the dual wave-and-corpuscle aspects of radiation; and even an artificial earth-satellite, are to be found in the 'Opticks' or the 'Principia'. In some future article I should like to trace the development of another modern technical achievement from the first steps taken by the pioneers of the past.

Microwave Dissipative Material

PLASTIC LOADED WITH POWDER-IRON PARTICLES

By M. Y. El-Ibiary, B.Sc., D.I.C., Ph.D.*

SUMMARY. *A dissipative material for microwave applications may be formed by loading a cold-setting resin with a fine powder of carbonyl iron. The properties of this material were measured at wavelengths in the 3-cm band using a waveguide method and were found to be reproducible and controllable over a wide range.*

The results are compared with Lewin's theoretical solution for a cubical array of spherical particles in a homogeneous medium and the agreement is found to be only qualitative.

The results indicate that carbonyl iron retains a high permeability at microwave frequencies although the value is not determined.

A dissipative material for microwave applications may be formed by loading a cold-setting resin—known commercially as Marco Resin—with particles of carbonyl iron of approximately 5 microns mean particle size. This material was first used by the Telecommunications Research Establishment for making matched terminations for waveguides.

The electromagnetic properties of the material depend on the iron-to-plastic ratio and can be effectively and accurately controlled by varying this ratio. The mixture can be easily prepared and may be left to set at room temperature; the resulting material is mechanically strong and easy to machine. On the other hand, it is not suitable for moulding *in situ* because it shrinks considerably during setting and, if subjected to any excessive temperature, it softens and so should not be allowed to get unduly hot during machining.

The material is suitable for many microwave applications besides matched loads and it has been used by the author for the suppression of unwanted modes in cavity resonators[1]. Measurements for various iron-to-plastic ratios have been made at two wavelengths near the extremities of the 3-cm band and the equality of the constants of the material at these two wavelengths indicates that they can be considered independent of wavelength within the 3-cm band.

Method of Measurement

The material is, by the nature of its formation, ferromagnetic and it may be expected to have a complex permeability. Two methods are available for measuring the electrical properties of such a material, both using sections of waveguide completely filled by the material. In the first, due to Birks[2], the input impedance of the section is measured for short-circuit and open-circuit terminations and in the second, due to Surduts[3], short-circuit and matched terminations are used. The first method was selected as being the simpler.

A sample of the material is placed in a rectangular waveguide as shown in Fig. 1. For the short-circuit measurement the sample is directly backed by a short-

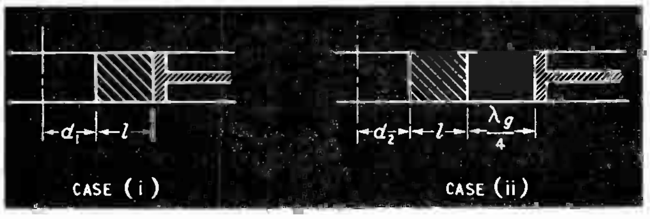


Fig. 1. *Method of measurement*

circuiting plunger while for the open-circuit measurement the plunger is withdrawn backwards a quarter of the guide wavelength in order to give the equivalent of an open circuit at the back of the sample.

Let ρ_1, ρ_2 be the standing-wave ratios E_{max}/E_{min} in front of the sample in the two cases, and

$$\theta_1 = \frac{2\pi d_1}{\lambda_g}, \quad \theta_2 = \frac{2\pi d_2}{\lambda_g}$$

where d is the distance between E_{min} and the face of the sample, and λ_g is the guide wavelength. Suffixes 1 and 2 refer respectively to situations (i) and (ii) in Fig. 1. If β is the propagation constant of the filled waveguide, taken in general as a complex quantity which becomes purely imaginary if there is no attenuation, and l is the length of the sample, then

$$\tanh \beta l = \left(\frac{1 - j\rho_1 \tan \theta_1}{\rho_1 - j \tan \theta_1}\right)^{1/2} \Big/ \left(\frac{1 - j\rho_2 \tan \theta_2}{\rho_2 - j \tan \theta_2}\right)^{1/2}$$
$$= u + jv$$

from which the value of βl can be determined using

* *Joint Establishment for Nuclear Energy Research*

Kennelly's charts or may be calculated using the relation [4] :—

$$\beta l = \tfrac{1}{4} \log \frac{(1+u)^2 + v^2}{(1-u)^2 + v^2} + j\,\frac{\pi - \tan^{-1}[(1+u)/v] + \tan^{-1}[(u-1)/v]}{2} + js\pi \qquad (1)$$

in which s is an arbitrary integer or zero.

Now, using the fundamental waveguide relations for H_{01} mode propagation, the complex permeability of the material can be obtained as:

$$\mu = \frac{\beta\lambda g}{2\pi j}\left[\frac{1 - j\rho_1 \tan\theta_1}{\rho_1 - j\tan\theta_1}\right]^{1/2} \times \left[\frac{1 - j\rho_2 \tan\theta_2}{\rho_2 - j\tan\theta_2}\right]^{1/2}$$

$$= |\mu| \angle\delta\mu \quad \ldots \ldots \ldots \ldots \ldots \quad (2)$$

and the complex permittivity is given by

$$\epsilon = \frac{1}{\mu}\left[1 - \left(\frac{\lambda}{\lambda_g}\right)^2 - \frac{\beta^2\lambda^2}{4\pi^2}\right] = |\epsilon| \angle\delta_\epsilon \quad \ldots \ldots \quad (3)$$

in which λ is the free-space wavelength.

It should be noted that there is always an ambiguity because of the presence of the arbitrary integer s in equation (1) but this can be resolved either

(a) if an appropriate value for ϵ or μ is known when the correct value for β can be recognized, or (b) by measuring two samples of different lengths, the value of s for each case being chosen to make the two values obtained for β equal.

This method of measurement suffers, in common with other transmission-line methods, from a minor weakness which becomes apparent if either δ_μ or δ_ϵ is small compared to the other. In such a case, the accuracy in the value obtained for the small angle is rather poor. In a transmission line, it is only possible to measure the characteristic impedance and the propagation constant. The characteristic impedance has a loss angle which depends on the sum of δ_μ and δ_ϵ while the propagation constant has a loss angle which depends on their difference. It is only possible to measure the sum and the difference of δ_μ and δ_ϵ from which, in principle, each angle can be obtained separately. If it happens that one of them is small compared to the other, the inaccuracy in the value obtained for the small angle may be abnormally high.

This difficulty may be overcome by measuring each angle independently. For example, δ_ϵ may be measured by placing a small sample of the material in a cavity resonator at a position where the magnetic field is very small as in the method described by Horner et al[5] using an E_{010} cavity. The quantity δ_μ may also be measured independently by placing small spheres of the material at the nodal cylindrical surfaces of an E_{020} cavity resonator[3].

Fortunately, the precise separation of losses into electric and magnetic components is not usually required for applications of the material.

Experimental

Apparatus

The waveguide used has a rectangular cross section of 0.9 × 0.4 inch internal dimensions and the arrangement is shown in Fig. 2. Care was taken to avoid flanges between the short-circuiting plunger and the travelling probe by letting the plunger project inside the waveguide section containing the standing-wave indicator.

The sensitivity of detection was increased by using square-wave modulation at 1,500 c/s on the klystron grid and a high-gain tuned amplifier for the detector output. The amplitude of the square wave must be large enough to switch off the klystron completely during the negative half-cycle otherwise a certain amount of microwave power, in general at a different frequency, may still be emitted and will cause faulty measurements. It is advisable to examine the detector output on a d.c. oscilloscope to check that there is no signal during the negative half-cycle.

Standing-wave ratios were measured by adjusting the accurately calibrated attenuator to maintain constant output from the probe detector as it was moved along the standing-wave indicator carriage. For large values of the standing-wave ratio, the Roberts–von Hippel method was used.

Preparation of Samples

The plastic part of the material consists of 100 parts of resin, 5 parts of monomer, 4 parts of catalyst and 4 parts of accelerator. The first three components are added and thoroughly stirred together, then the desired amount of iron powder is added in small quantities and thoroughly mixed. The accelerator is then added and the mixture is poured in the mould, a piece of waveguide 5 inches long, closed at one end

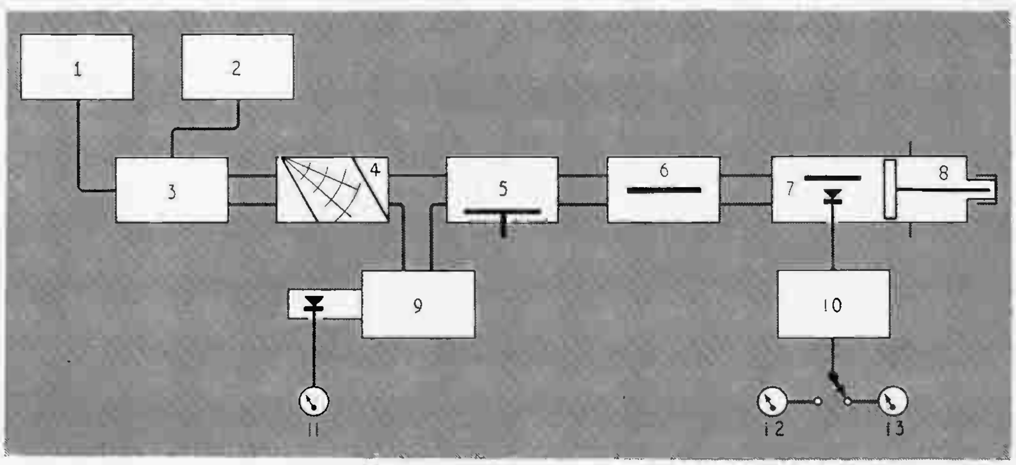


Fig. 2. *Details of equipment:*
1 *Stabilized-power supply*
2 *Square-wave generator*
3 *Klystron CV* 129
4 *Wooden attenuating pad*
5 *Variable attenuator*
6 *Fixed attenuator*
7 *Standing-wave indicator*
8 *Short-circuiting plunger*
9 *Wavemeter*
10 *Tuned amplifier and an output rectifying diode*
11 *Galvanometer*
12 *Microammeter* 0–120 μA
13 *Milliammeter* 0–0·5 mA

by a tightly fitting piece of ebonite. The inside surface of the waveguide was treated with chromic acid to render it about 2 mils oversize in order to compensate for the shrinkage of the material during setting and to permit a thin coating to prevent the material from sticking to the walls. The coating was carnauba wax deposited on the surfaces by wetting them with a dilute solution of the wax in carbon tetrachloride (2 gm wax to 100 c.c. carbon tetrachloride) and then allowing the solvent to evaporate.

The material was allowed to set in an oven at a temperature of about 50°C to reduce the time of setting and hence the chance of the iron particles falling to the bottom of the mould.

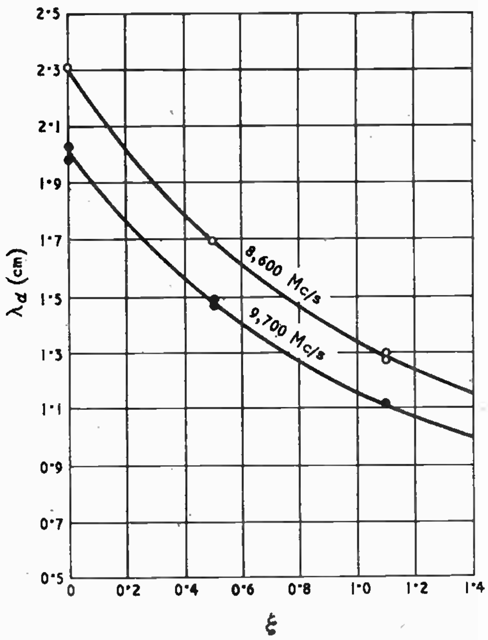


Fig. 3. *Relation between the wavelength in the filled waveguide and the iron content*

The samples were carefully cut, the two faces being always planar and normal to the sides to within 0.5 mil or better. If the face of the sample is not a plane normal to the axis of the waveguide, high-order modes may be set up at the interface and may even propagate in the filled waveguide, because of the high refractive index of the material, and thus cause extra losses in the sample.

In order to check the uniformity of distribution of iron throughout the length of the mould, two samples, one cut from the top of the mould and the other from the bottom, were measured and the results compared. Further, to check that the particles did not form batches or chains inside the material, transparent sections were made and examined under a powerful microscope.

Sources of Error

The principal sources of error in the method are:

(a) Departures of the sample from the desired shape. The tolerances on the dimensions are as tight as practicable but even so they are probably the major factor in determining the accuracy of the results.

(b) The short-circuit being imperfect. In principle this could be allowed for but, as the error involved is small, it is not necessary to do so.

(c) The attenuation in the empty waveguide. This becomes important for low-loss samples if accurate values of the loss angles are required. The measured standing-wave ratio in the guide, ρ_m, is less than the value ρ_c for a loss-free guide[7] and the following formula can be used to deduce ρ_c from ρ_m:

$$\rho_c = \rho_m \, (1 + \alpha_0 \, x \, \rho_m)$$

where α_0, the attenuation constant of the empty guide may be obtained from the standing-wave ratio when the guide is terminated by a short-circuit, and x is the distance from the sample face and the minimum field position which is selected for a determination of ρ_m by the Roberts–von Hippel method.

(d) The difference between the guide wavelengths in ordinary guide and in the slotted section. A correction can be made for this.

Results

Preliminary measurements indicated that the properties of the material are only weakly dependent on frequency within the 3-cm band. Precise measurements were therefore made only at 9,700 Mc/s and at 8,600 Mc/s, near the extremities of the 3-cm band.

The material may be made with ratios of iron to Marco Resin of up to 3 : 1 by weight or more. The present investigation is, however, limited to ratios of up to 1·4 : 1 corresponding to approximately 1 : 6 by volume. Beyond this, the attenuation constant of the material becomes too high for accurate measurements by the present technique.

Approximate values for λ_d, the wavelength in the filled waveguide, were found for three mixtures with

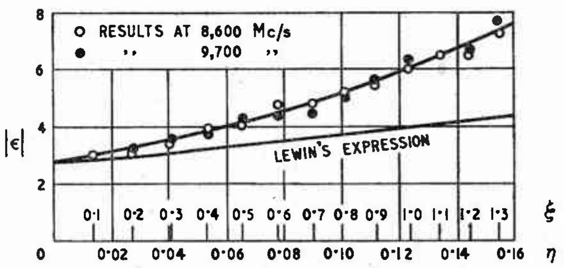
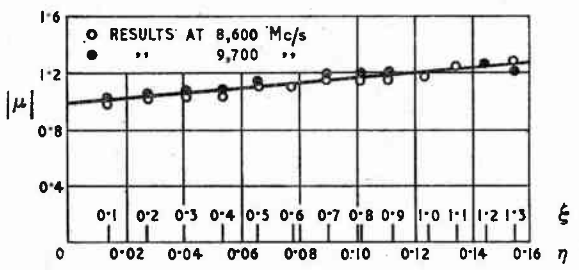


Fig. 4. *The change of permittivity with the iron content*

Fig. 5. *The change of permeability with the iron content*



ratios of iron to plastic to cover the range under investigation, two samples from each being measured. The results were used for plotting an approximate curve of λ_d against ξ, the weight ratio of iron powder to Marco Resin (Fig. 3).

The magnitude of permittivity $|\epsilon|$ is shown in Fig. 4

against η, the volume ratio of iron in the mixture. The values obtained from measurements at the two frequencies are so close that only one curve is drawn.

The electric loss angle δ_ϵ was found to be independent of the iron content while the magnetic loss angle δ_μ

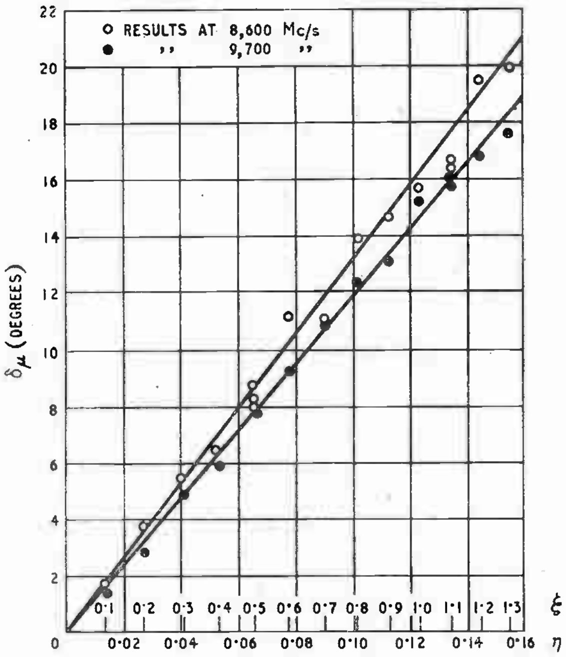


Fig. 6. *Relation between the magnetic loss angle and the iron content*

was found to increase rapidly with the iron content and to show a slight increase with frequency (Fig. 5).

The magnitude of the permeability $|\mu|$ is shown in Fig. 6 against η. One curve is drawn from the results at the two frequencies.

The weight ratio of iron to resin ξ is always marked on the axis because it is more convenient, when preparing a mixture, to have the iron content as a weight ratio rather than a volume ratio.

Finally, Fig. 7 is plotted to give the attenuation per centimetre of a $0{\cdot}9 \times 0{\cdot}4$ inch waveguide filled with the material.

Discussion of Results

An experimental investigation was carried out by Kelly, Stenoien and Isbell[8] into the properties of metal powders suspended in paraffin wax. They obtained results similar to the ones given here except that, in their case, the permeability of the mixture decreased with the increased filling ratio. The particles were non-magnetic and reduced the magnetic storage in the mixture since the interiors of the particles were shielded by skin effect. This shielding effect is also present in the case of magnetic particles but since the particle material possesses a high permeability, the increased magnetic storage in the outside shell of the particle may overcompensate the shielding effect, resulting in an overall increase in permeability.

Lewin[9] has treated the problem of a material loaded with a cubical array of equal spheres and it is interesting to compare his solution with the present case, although the particles are not exactly spherical nor of equal size and are distributed at random throughout the material.

Lewin's expressions for the constants of the material are

$$\epsilon = \epsilon_1\left[1 + \frac{3\eta}{K_\epsilon - \eta}\right] \quad \ldots \quad (7)$$

$$\mu = \mu_1\left[1 + \frac{3\eta}{K\mu - \eta}\right] \quad \ldots \quad (8)$$

where: μ_1, ϵ_1 are the constants of the unloaded material, any or both of which may be complex.

K_μ, K_ϵ are auxiliary constants which depend on the properties and dimensions of the particle.

For particles of medium or high conductivity in an insulating medium, $K_\epsilon \approx 1$ and equation (7) reduces to the Clausius Mossoti relation

$$\epsilon = \epsilon_1 \cdot \frac{1 + 2\eta}{1 - \eta} \quad \ldots \quad (9)$$

from which it can be seen that the loss angle δ_ϵ is independent of η, which is true for the present case.

On the other hand, the measured values for ϵ were always higher than those given by equation (9). This same discrepancy was observed by Kelly et al. and is apparently due to the ideal conditions assumed in Lewin's calculations which do not exist in the mixture. For example, if the particles are not exactly spherical, the average polarizability per unit volume increases and so does the dielectric constant[10]. The effect of the

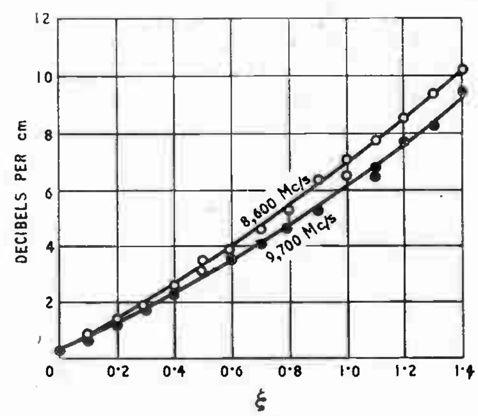


Fig. 7. *The attenuation constant of a* $0{\cdot}9 \times 0{\cdot}4$*-in. waveguide filled with the material*

random distribution of particles and their range of size may also contribute to this discrepancy.

The expression for μ given by equation (8) contains a complex constant K_μ which is given by

$$K_\mu = \frac{\mu_\rho + 2\mu_1}{\mu_\rho - \mu_1} \quad \ldots \quad (10)$$

where μ_ρ is an effective complex permeability for the sphere and is different from the permeability of the material due to the reduction of field strength inside the particle. For low values of η, equations (8) becomes:

$$\mu = \mu_1\,(1 + 3\eta/K_\mu) \quad \ldots \quad (11)$$

which shows that as long as $K_\mu \gg \eta$ both the magnitude and loss angle of μ increase linearly with η. This is also found to be true in the present case.

The results for μ were used in conjunction with equations (11) and (10) in order to obtain values for the effective particle permeability, which are shown in Table 1.

Now, the mean dimension of the particles is comparable to the skin depth so that the interior of the particle is considerably shielded from the main magnetic field. Thus, the values of $|\mu_p|$ given in Table 1 can only be realized if the particle material has a high permeability.

TABLE 1
Effective Particle Permeability

	η	0·05	0·1	0·15
$\lvert\mu_p\rvert$	9,700 Mc/s	2·86	2·73	2·67
	8,600 Mc/s	3·06	2·87	2·73

Conclusions

The material formed by loading Marco Resin with particles of carbonyl iron is quite suitable for most microwave applications in which a dissipative material is required with reproducible properties which can be controlled over a wide range. Further, it can be easily prepared and has good mechanical qualities.

Lewin's theoretical results give a qualitative explanation of the behaviour of the material but are not sufficiently accurate for predictions of the electrical constants, because of the shape of the particles and their random distribution.

Acknowledgments

The author wishes to thank Dr. John Brown of the Imperial College of Science and Technology for assistance in the presentation of this paper, and the Mond Nickel Company for providing samples of carbonyl iron powder.

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MATHEMATICAL TOOLS

By Computer

Solution of Algebraic Equations: Complex Roots

In an earlier article, we showed how to find real roots of an algebraic equation of any degree by a process involving algebraic long-division. A single pair of complex conjugate roots could be found last, when factors corresponding to the real roots had been divided out, so that only a quadratic equation remained. We did not cover, however, the case of an equation having more than one pair of complex conjugate roots, and we now show that the quartic equation

$$F(x) = x^4 + 3x^3 + 12x^2 + 11x + 9 = 0 \quad \ldots \quad (1)$$

which has two pairs of complex-conjugate roots, can be solved in a very similar manner.

As before, it is the root-pair which has least modulus which should be sought first. With complex roots, no graphical procedure is available for finding approximations, but an adequate starting approximation is usually obtained by taking the last three terms of $F(x)$ and dividing through by the coefficient of x^2, unless a better approximation is initially known. Rounding this off to two places, our starting approximation to the factor corresponding to the root-pair having least modulus is

$$x^2 + 0{\cdot}92x + 0{\cdot}75 \quad \ldots \quad (2)$$

$F(x)$ is now divided by $x(x^2 + 0{\cdot}92x + 0{\cdot}75)$ and, as in the real-root case, the same divisor would be used whatever the degree of $F(x)$. The quotient is $(x + 2{\cdot}08)$ and the remainder $9{\cdot}3364x^2 + 9{\cdot}44x + 9$, which we write as

$$9{\cdot}3364(x^2 + 1{\cdot}01110x + 0{\cdot}97468) \quad \ldots \quad (3)$$

We next divide $F(x)$ by $x(x^2 + 1{\cdot}01110x + 0{\cdot}97468)$; the quotient is $x + 1{\cdot}98890$ and the remainder $9{\cdot}01434x^2 + 9{\cdot}06146x + 9$. Again, we divide out by the coefficient of x^2 in this remainder, and obtain

$$x^2 + 1{\cdot}00523\,x + 0{\cdot}99841 \quad \ldots \quad (4)$$

Alternative Steps

There are now two possible ways to proceed. The easier way, which is the more effective in this particular case, is to repeat the same process with (4) instead of (2) and then with the resulting remainder, and so on.

The successive divisors obtained in this way for the particular equation (1) are thus

(a), $x^2 + 1\cdot00133x + 1\cdot00040$;
(b), $x^2 + 1\cdot00065x + 1\cdot00059$;
(c), $x^2 + 1\cdot00008x + 1\cdot00014$;
(d), $x^2 + x + 1\cdot00002$

and the next repetition gives the actual factor $(x^2 + x + 1)$ correct to 5 places. But convergence is not always as rapid as this and there may even be divergence. The following procedure, analogous to what was done when seeking real roots, is safer, though it has the disadvantage of requiring complex numbers to be substituted in a formula we have already used in connection with real roots.

First, find the zeros, by formula, of the quadratic expressions (2), (3) and (4) which have positive imaginary parts. These zeros are

$$p_0 = -0\cdot46+0\cdot73376j\,;\; p_1 = -0\cdot50555 + 0\cdot84800j\,;\; p_2 = -0\cdot50261(5) + 0\cdot86359j \quad \ldots \quad (5)$$

Then, a good approximation to the root we are seeking is

$$P = \frac{p_1{}^2 - p_0 p_2}{2p_1 - p_0 - p_2} = p_0 + \frac{(p_1 - p_0)^2}{2p_1 - p_0 - p_2} \quad \ldots \quad (6)$$

The value of P obtained by substitution from (5) into (6) is $-0\cdot50092 + 0\cdot86513j$; the corresponding real quadratic factor is

$$x^2 + 1\cdot00184x + 0\cdot99937 \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

which is only in error in the third decimal place. A repetition of the whole process with (7) replacing (2) as the starting divisor, two divisions, determination of new values of p_0, p_1 and p_2 as in (5), and substitution in (6) will often give the required complex conjugate root-pair having least modulus with sufficient accuracy. Two repetitions would very seldom fail to do so.

As in the case of real roots, we can find the complex root-pair of largest modulus by using the 'reciprocal' equation ; that is, putting $(1/y)$ for x and multiplying through by y^4 in the case of (1), y^n in the general case of an equation of degree n.

Difficulties

There are two main causes of difficulty which we can now discuss briefly, but adequately for most practical purposes. The first is relatively easy to overcome. We may find that, having selected the trial divisor (2), the division process is violently divergent. This indicates that the given equation has a single real root of smaller modulus than any complex conjugate pair, and we should therefore start again and seek a real root ; having divided out the corresponding linear factor, the divergence will have been removed for the residual equation. If we seek a quadratic factor as above for an equation which has two or more real roots small in modulus compared to any complex roots, we shall succeed in obtaining a quadratic factor but, instead of having complex conjugate zeros, it will have two real zeros.

The other case of difficulty occurs when the equation has a number of repeated or nearly-repeated roots. On the rare occasions when such cases occur in practice, the following procedure will usually remove the difficulty. If it fails to do so, a mathematician should be consulted at an early stage. We can test, by means of the H.C.F. process, whether an equation has repeated or closely clustered roots. Consider as an illustrative example the equation

$$G(x) = (x^2 + 2x + 2)^2 - 0\cdot01 = 0$$

or

$$x^4 + 4x^3 + 8x^2 + 8x + 3\cdot99 = 0 \quad \ldots \quad (8)$$

We have

$$G'(x) = 4(x^3 + 3x^2 + 4x + 2)$$

The factor 4 has no particular significance for our present purpose and may be dropped. Now divide $G(x)$ by $\frac{1}{4}\, G'(x)$, and we find

$$G(x) = \tfrac{1}{4}\, G'(x)\,\{x + 1\} + (x^2 + 2x + 1\cdot99)$$

Next divide $(x^2 + 2x + 1\cdot99)$ into $\frac{1}{4}G'(x)$, and we have

$$\tfrac{1}{4}G'(x) = (x^2 + 2x + 1\cdot99)\,(x + 1) + (0\cdot01x + 0\cdot01)$$

and the remainder $(0\cdot01x + 0\cdot01)$ has remarkably small coefficients. This indicates that the preceding divisor, $(x^2 + 2x + 1\cdot99)$, has factors $x + 1 \pm 0\cdot995j$ which are, or are nearly, repeated factors of $G(x)$. We now put $x = -1 + 0\cdot995j + z$ (which we shall round off to $-1 + j + z$) in (8), and it reduces to

$$z^4 + 4jz^3 - 4z^2 - 0\cdot01 = 0 \quad \ldots \quad \ldots \quad (9)$$

This implies $z = \pm\, 0\cdot05j$ if we neglect powers of z above the second in (9). It follows that (8) has one root $x \approx -1 + 1\cdot05j$ and another $x \approx -1 + 0\cdot95j$. The conjugates of these quantities are also roots so, as (8) is a quartic, we have found all the roots.

To obtain the root near $-1 + 1\cdot05j$ more accurately, transpose the $4z^2$ term to the right-hand side of (9), and substitute $0\cdot05j$ for z on the left-hand side ; only the positive sign is relevant after taking the square root. Then, to obtain the root near $-1 + 0\cdot95j$ more accurately, transpose the $4z^2$ term again, substitute $-0\cdot05j$ for z on the left-hand side, and use only the negative sign after taking the square root.

In the general case, if the original polynomial has a squared factor, the lowest power of z genuinely represented in the equation corresponding to (9) will be z^2 ; if the original polynomial has a cubed factor, the lowest power of z will be z^3, and so on. There may be terms involving lower powers of z but, if so, they will have small coefficients and they can be neglected to a first approximation ; it is the lowest power of z having a coefficient of normal size which alone should be transposed.

It thus appears that the procedure we have discussed is capable of solving almost all the algebraic equations with numerical coefficients likely to occur in practice. In many cases, the solution is obtained surprisingly quickly. At several points in the process, we have to make a choice ; for example, do we try first for a real linear factor or a real quadratic factor, and do we continue the division process after the first two rounds, or not ? We may sometimes make the wrong choice, as we have no advance knowledge of the whereabouts of complex conjugate pairs of roots. But, if we do make a wrong choice, we are soon aware that it is wrong and the number of possible alternatives is reasonably small.

Notes on the Multi-Reflection Klystron

CONDITIONS FOR MAXIMUM EFFICIENCY

By B. Meltzer, B.Sc., Ph.D. *

SUMMARY. *The mode of operation of the multi-reflection klystron oscillator is described, and the conditions for maximum efficiency established by considering the behaviour of electrons in the device. 100% efficiency is possible in principle and, to obtain this, the transit times must be correct. An electrode system capable in theory of producing the required reflection fields is discussed, and the effect of incorrect transit times analysed.*

Since the invention of the multi-reflection klystron (Coeterier[1]), little more information on it appears to have been published. If this means that little effort has been devoted to its development, it is a surprising state of affairs, for this klystron is a microwave generator capable, in principle, of 100% efficiency in energy conversion, like the magnetron or class C valve amplifier.

Coeterier's paper[1] probably contributed to this neglect, for it was misleading on the question of efficiency. The figure of 48% for the maximum efficiency given rested on no real physical basis, the argument deriving it was a non-sequitur, and Coeterier himself reported experimental values as high as 50%. The theoretical figure has become embalmed in the standard British text on klystrons (Beck[2]).

Some notes on the efficiency, reflection fields and a few other features of this device are given below.

Power Efficiency and Modulation Factor

The multi-reflection klystron has a single resonator, which in the original models consisted of unshielded Lecher metal strips, but which might be a cavity of one of the standard types with a gap. Electrons from the cathode are accelerated, cross the gap and are then turned through the gap by an electrostatic reflector. However, unlike the case of the reflex klystron, the electrostatic fields on both sides of the gap are designed to be good reflection fields, so that if there were no interaction with the cavity and no aberrations, the electrons would merely perform to-and-fro motions across the gap.

Suppose the reflecting fields are parabolic; i.e., the potential is given by a law of the form

$$V = V_0\left(1 - \frac{z^2}{d^2}\right) \qquad \ldots \quad (1)$$

where V_0 is the potential at the gap, V is the potential at distance z along the beam from the gap, and d is the distance of the cathode. Then each electron is attracted by a force proportional to its displacement from the gap and therefore performs a simple harmonic motion of fixed period, say $2\tau_1$. The transit time of every electron between successive passages of the gap is equal to τ_1.

Suppose the resonator is excited and oscillating with frequency f and period $T = 1/f$. Consider what happens to the beam arriving at the gap from the cathode, carrying a current I_0, and of V_0 electron volts energy. During one half-cycle of the resonator oscillation the electrons are slowed down; but they return to it carrying the same current I_0—since the transit times are equal—and if τ_1 is chosen to be equal to an odd number of half-periods $T/2$, they will cross the gap against an opposing field and deliver energy to the resonator. They emerge on the cathode side with reduced energy but are reflected back carrying a current I_0 and at the right phase to deliver energy to the resonator again. They will continue to oscillate to and fro, delivering energy at each passage of the gap, until brought to rest in the gap.

However, electrons which arrive from the cathode at the gap during an accelerating half-cycle would also carry a current I_0 at successive transits of the gap but absorb energy from the resonator each time, so there would be little, if any, net power delivered to the resonator by the combined effects of the two electron groups.

Advantage is therefore taken of the fact that the electrons which emerge from the gap during the accelerating half-cycle will all have sufficient energy to take them beyond the zero equipotential on the reflector side. In fact, this surface may be considered as a kind of sorting surface, none of the group of slow electrons getting beyond it while all the fast ones do. Therefore, beyond this surface the field is modified so as to provide a suitable transit time τ_2 for the fast electrons that get into it.

Ideally it would be arranged that the total transit time of these fast electrons is an even number of half-periods $T/2$; i.e., they are held in the reflection space an odd number of half-periods longer than the slow ones. Then they would be returned to the gap synchronously with a half-cycle group of slow electrons,

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which they simply join in their further to-and-fro energy-delivering transits of the gaps. In all their later excursions into the reflector field, they will have insufficient energy to get beyond the sorting surface.

From this description it is clear that provided the transit times in the reflector and cathode fields are correct, and the electrons are removed once they have been brought to rest in the gap, all the energy of the beam will be converted into electromagnetic energy in the resonator.

The efficiency will be 100% and the power output therefore V_0I_0 watts.

There is a variety of reasons why this theoretical efficiency may not be attained in a particular design. It may be very difficult to provide fields which would give the correct transit times for all electrons in the beam ; and it may be difficult to prevent lateral spread which would cause electrons to be taken up by the resonator walls before they had had all their kinetic energy converted into electromagnetic energy. In fact, as is shown below, a field which is parabolic along the axis of the beam is essentially a defocusing field off the axis, and therefore the original Dutch tubes—at any rate—employed a longitudinal magnetic focusing field to keep the electrons going through the gap. It may also be difficult to prevent some electrons which have been brought to rest in the gap from being then accelerated instead of being taken up by the resonator walls, so using up electromagnetic energy. In high-density beams space-charge would probably accentuate all these effects. The initial thermal energies and aberrations lead to back-bombardment of the cathode, to such an extent that some of the Dutch tubes, once oscillating, were able to continue running with heater power switched off.

The effect is that the output power P is less than V_0I_0 and may be expressed as

$$P = V_0I_0 - V_aI_0 \qquad \qquad (2)$$

where V_aI_0 is the power lost as heat due to bombardment of mainly the resonator walls, but also of the cathode. V_a is somewhat analogous to the averaged anode voltage during the current pulse of a class C triode oscillator and just as in that case one aims at keeping it low. The efficiency η may then be expressed as

$$\eta = 1 - \frac{V_a}{V_0} \qquad \qquad (3)$$

The efficiency of power delivery of a single transit is of interest. In the optimum case (all transit times correct), the current returning to the gap after the first velocity modulation is zero during one half-cycle and of magnitude $2I_0$ during the next, since the fast electrons are returned at the same time as the slow. The current is a square-wave of amplitude $2I_0$ and its fundamental frequency component is of amplitude $4I_0/\pi$ therefore.

Let α be the modulation factor at which the resonator is operating, and β the gap factor (cf. Beck[2], for values of different types of gap), so that the ultra-high-frequency electromotive force opposing the current is effectively $\alpha\beta V_0$. The power delivery of a single transit of the gap is then given by

$$P_1 = \frac{2}{\pi}\alpha\,\beta\,V_0I_0 \qquad \qquad (4)$$

and the single-transit efficiency is

$$\eta_1 = \frac{2}{\pi}\alpha\,\beta \qquad \qquad (5)$$

This shows that an upper bound ($\alpha = \beta = 1$) to the single-transit efficiency is $2/\pi$ or about 64%.

The modulation factor α depends on the ratio of the resonator impedance and the beam-impedance. For, if Z is the resonator impedance, the total resonator power is $\frac{1}{2}\alpha^2V_0^2/Z$, and therefore in the optimum case

$$\frac{1}{2}\frac{\alpha^2V_0^2}{Z} = V_0I_0,$$

so that

$$\alpha = \sqrt{\frac{2Z}{(V_0/I_0)}} \qquad \qquad (6)$$

In the same way it follows that in the non-optimum case

$$\alpha = \sqrt{\frac{2Z}{(V_0/I_0)}\cdot\left(1 - \frac{V_a}{V_0}\right)} \qquad \qquad (7)$$

One cannot conclude from these results that a low beam impedance is desirable in a multi-reflection klystron, for a high modulation factor α does not necessarily mean high efficiency. It is true that a higher modulation factor means a smaller number of transits to yield a given output power, and therefore less chance of the cumulative effects of imperfect reflection fields and aberrations producing a high V_a loss. But a high beam current may mean an increase in space-charge and other aberrations, leading to poor transit times. The essential requirement is for 'good' reflections; i.e., correct, or nearly correct, transit times; and it will be seen below, that with reflection fields envisaged this is easier to attain with low modulation factors than with high.

Only total resonator power has been considered above, but if Z_L is the effective shunt impedance of the output load coupled to the resonator, and Z_R the shunt impedance of the resonator without load, then

$$\frac{1}{Z} = \frac{1}{Z_L} + \frac{1}{Z_R}$$

and only the fraction

$$\frac{Z}{Z_L} = \left(1 + \frac{Z_L}{Z_R}\right)^{-1}$$

of the resonator power will be useful. The load efficiency then will be given by

$$\eta_L = \left(1 - \frac{V_a}{V_0}\right)\Big/\left(1 + \frac{Z_L}{Z_R}\right) \qquad \qquad (8)$$

and one would aim at having Z_R/Z_L as large as possible, e.g., by using resonators of very high Q.

The Reflection Fields

It has been seen that keeping the transit times correct is the crucial requirement for high efficiency, and it needs first to be established that it is possible to establish reflection fields which will achieve this, in limiting cases at least.

The field in the first reflector space (and the cathode space) given by (1) can certainly be established: for example, if an electron beam of circular cross-section is to be used, one may design cylindrically symmetrical electrodes from the well-known expression (cf. Coslett[3]) giving the potential at a distance r from the axis in terms of that on the axis:

$$V(r,z) = V(0,z) - \frac{r^2}{4}\frac{\partial^2 V(0,z)}{\partial z^2} + \frac{r^4}{64}\frac{\partial^4 V(0,z)}{\partial z^4} \ldots \quad (9)$$

To obtain the potential (1) on the axis, put

$$V(0,z) = V_0\left(1 - \frac{z^2}{d^2}\right)$$

giving

$$V(r,z) = V_0 + \frac{V_0}{2d^2}(r^2 - 2z^2) \quad (10)$$

Therefore two electrodes, as shown in Fig. 1, one of rectilinear and the other of hyperbolic profile, with potentials of V_0 and zero, respectively, will give the required field.

The transit time of slow electrons on the axis in this field is

$$\tau_1 = \frac{\pi d}{u_0} \quad (11)$$

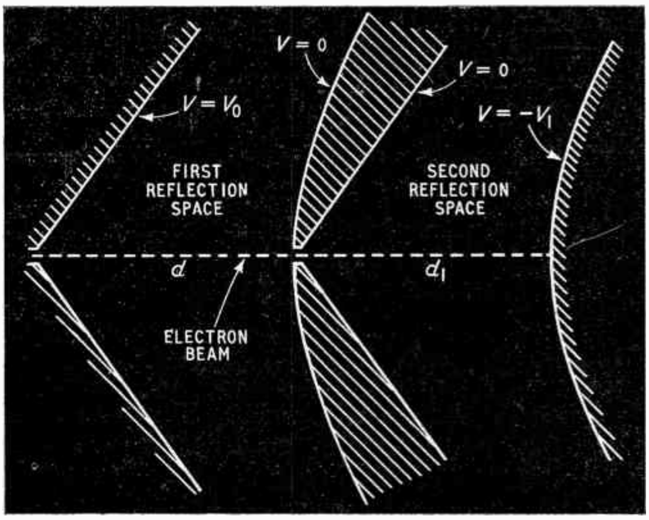

Fig. 1. *Double reflector system for a beam of circular cross-section*

where $u_0 = \sqrt{2eV_0/m}$ is the unmodulated speed at the gap, e/m the charge-to-mass ratio of the electron.

Therefore by choice of V_0 and d, τ_1 can be made equal to the desired number of half-periods $T/2$ of the required ultra-high-frequency oscillation.

The excursion time τ_2 of accelerated electrons on the axis in the auxiliary reflector space can also be made constant by arranging for the field on the axis to be parabolic of the form

$$V = -V_1\left(\frac{z-d}{d_1}\right)^2$$

where d_1 is the axial distance at which a reflecting electrode of negative potential $-V_1$ is placed.

From (9) again, it follows that the field off the axis is

$$V(r,z) = +\frac{V_1}{2d_1^2}\left[r^2 - 2(z-d)^2\right] \quad (12)$$

It can therefore be produced for a circular cross-section by electrodes of the profile shown in Fig. 1, where the rectilinear-profile electrode is kept at zero potential, and the hyperbolic one at $-V_1$ volts.

The excursion time is

$$\tau_2 = \frac{\pi d_1}{u_1} \quad (13)$$

where $u_1 = \sqrt{2eV_1/m}$ and τ_2 may thus be made equal to the desired number of half-periods $T/2$.

It is therefore only necessary to provide the three electrodes shown in Fig. 1, the middle one having a tiny hole on the axis to permit entry of the fast electrons, to ensure that slow electrons have the required transit time τ_1 and fast ones the required additional transit time τ_2.

But this is not sufficient, for the accelerated electrons—in their first transit—will perform only part of a simple-harmonic-motion in the main reflector space, so that their total transit time will be $\tau_1' + \tau_2$, where $\tau_1' < \tau_1$, and therefore the phasing for power-delivery at the gap will be incorrect. But in the next section it will be shown that the effect of this on power delivery tends to zero to second order as the modulation factor is decreased towards zero to first order.

It may be concluded that in the limiting cases of very thin parallel beams, no aberrations, very small modulation factor, 100% efficiency may by this electrode system be approached as closely as desired, provided the electrons when finally brought to rest at the gap are taken up by the resonator walls.

It is of interest to note that for thick beams, the parabolic fields described above would, by themselves, necessarily cause the beam to diverge. For instance, in the case of the field (10), the radial electric field axis is given by

$$E_r = -\frac{\partial V}{\partial r} = -\frac{rV_0}{d^2}$$

which is negative, so that the effect on the electrons will be centrifugal.

The Effect of Incorrect Transit Times

It is of interest to analyse the case of incorrect transit times. Below is considered the single-transit output power for any values of transit time in the reflection spaces. This is of some use in assessing the tunability of the device. For simplicity the case of low modulation is considered.

The transit time of the slow electrons is τ_1. Since the motion is simple-harmonic, the transit-time of the accelerated ones is

$$\frac{2\tau_1}{\pi}\sin^{-1}\frac{\pi d}{u\tau_1} + \tau_2, \quad (14)$$

where u is the initial speed of a fast electron.

Let ω be the radian frequency of the oscillation, so that the speed u is given as a function of time by

$$u^2 = u_0^2(1 + \alpha\beta \sin \omega t).$$

Here, as before u_0 is the unmodulated velocity $\sqrt{2eV_0/m}$.

For small modulations, therefore,

$$u = u_0(1 + \tfrac{1}{2}\alpha\beta \sin \omega t).$$

Consider the energy delivered by the slow electrons. They carry a current I_0 and are opposed by an effective electromotive force $\alpha\beta V_0 \sin \omega t$. Therefore the ultra-high-frequency energy delivered is

$$\alpha\beta V_0 I_0 \int_{t=\frac{\pi}{\omega}+\tau_1}^{t=\frac{2\pi}{\omega}+\tau_1} \sin \omega t \, dt = -2\alpha\beta V_0 I_0 \frac{\cos \omega\tau_1}{\omega} \quad .. (15)$$

The return current of the fast electrons is not constant but is given in terms of I_0 by

$$I_1 = I_0 \frac{dt}{dt_1}$$

where t_1 is the time of return to the gap of the electron which left the gap at time t.

Now

$$t_1 = t + \tau_1 + \tau_2 + \eta(t),$$

where $\eta(t)$ is a function of t given according to (14) above by

$$\eta(t) = -\tau_1 \left[1 - \frac{2}{\pi} \sin^{-1} \frac{\pi d}{u\tau_1} \right]$$

Also

$$\frac{\pi d}{u\tau_1} = \frac{\pi d}{u_0\tau_1} \cdot \frac{u_0}{u} = \frac{u_0}{u} = 1 - \tfrac{1}{2} \alpha\beta \sin \omega t$$

Therefore $\sin^{-1} \frac{\pi d}{u\tau_1}$ differs from $\frac{\pi}{2}$ by a small quantity, and it follows that to first order

$$\eta(t) = \frac{-2\tau_1}{\pi} (\alpha\beta)^{\frac{1}{2}} (\sin \omega t)^{\frac{1}{2}}$$

A group of fast electrons, which left the gap between $t = 0$ and $t = \pi/\omega$, returns against an effective ultra-high-frequency electromotive force of $\alpha\beta V_0 \sin \omega t$ so that the energy delivered is

$$\alpha\beta V_0 \int_{t=0}^{t=\frac{\pi}{\omega}} I_1 \sin \omega (t + \tau_1 + \tau_2 + \eta) \, dt_1$$

$$= \alpha\beta V_0 I_0 \int_{t=0}^{t=\frac{\pi}{\omega}} \sin \omega (t + \tau_1 + \tau_2 + \eta) \, dt$$

Since η is small compared to $(\tau_1 + \tau_2)$, the integrand to first order is

$$\sin \omega \overline{(t + \tau_1 + \tau_2)} + \omega\eta(t) \cos \omega \overline{(t + \tau_1 + \tau_2)}.$$

The first term gives a contribution

$$\frac{2 \alpha\beta V_0 I_0}{\omega} \cos \omega (\tau_1 + \tau_2) \quad .. \quad .. \quad .. (16)$$

to the energy.

The second term's contribution is

$$-(\alpha\beta)^{3/2} V_0 I_0 \frac{2\tau_1\omega}{\pi} \int_{t=0}^{t=\frac{\pi}{\omega}} (\sin \omega t)^{1/2} \cos \omega (t + \tau_1 + \tau_2) \, dt,$$

which can by the substitution $\theta = \omega t$ be transformed into an integral expressible in terms of Gamma functions (cf. Whittaker and Watson[4]) yielding

$$\frac{2\Gamma(5/4)}{\sqrt{\pi}\Gamma(7/4)} \tau_1 (\alpha\beta)^{3/2} V_0 I_0 \sin \omega \overline{\tau_1 + \tau_2} \quad .. \quad .. (17)$$

Collecting the three terms (15), (16), and (17) one obtains for the total power delivery

$$P_1 = \frac{\alpha\beta V_0 I_0}{\pi} \Big[-\cos \omega\tau_1 + \cos \omega (\tau_1 + \tau_2)$$
$$+ 0{\cdot}49 (\alpha\beta)^{1/2} (\omega\tau_1) \sin \omega (\tau_1 + \tau_2) \Big] \quad .. (18)$$

An interesting point follows at once from this general result. Putting

$$\omega\tau_1 = (2m + 1)\pi$$
$$\omega(\tau_1 + \tau_2) = 2n\pi,$$

where m and n are integers, is equivalent to having the required relation between transit times and half-periods $T/2$. For this case

$$P_1 = \frac{2\alpha\beta V_0 I_0}{\pi}$$

which is the same as (4), showing that the varying transit times of the accelerated electrons in the first reflection space can have only a second-order effect on the power.

The expression (18) does not of itself yield the tunability of the device, because alteration of frequency alters not only the values $\omega\tau_1$, $\omega\tau_2$ of the transit angles, but also the modulation factor, α. This is quite apart from the fact that only the first return transit has been considered. A detailed study of all the later transits and the mechanism of electron removal would be necessary to assess the tunability. But the result obtained shows that analytical techniques may be successful for this purpose.

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[4] E. T. Whittaker and G. N. Watson: "Modern Analysis," Cambridge University Press, 1940, p. 256.

PREMIUMS FOR TECHNICAL WRITING

The Radio Industry Council has announced the award of five premiums of 25 guineas each for technical writing. They are to:

P. L. Stride for his article on "Weather Avoidance with Airborne Radar" which appeared in *British Communications and Electronics*, April 1956.

D. R. Chick and C. W. Miller for their article which appeared in *British Communications and Electronics*, October/November 1956.

R. J. D. Reeves for his article on "Klystron Control System" which appeared in *Wireless Engineer*, June, July and August 1956.

F. H. Brittain and D. M. Leakey for their article on "Two-Channel Stereophonic Sound Systems" which appeared in *Wireless World*, May and July 1956.

J. J. Gait and J. C. Nutter for their article on "Tridac—A Research Flight Simulator", which appeared in *Electronic Engineering*, September/October 1956.

The awards will be presented at a luncheon to be held by the Radio Industry Council on 14th March.

OBITUARY

Air Vice-Marshal Oswyn George William Gifford Lywood, C.B., C.B.E., L.M., died on 3rd February 1957 at the age of 62. During the war he was Director of Signals at the Air Ministry and later Air Officer Commanding No. 26 Group. On his retirement from the R.A.F. he joined the Automatic Telephone & Electric Co. Ltd.

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.

Phase-Adjusting Circuits

SIR,—Your correspondent, Mr. Campbell in the February issue, appears to have misunderstood the fact that a restriction was imposed on all the phase-adjusting circuits discussed, in that the output amplitude was designed to be independent of the phase variation. He also seems not to have noticed that a number of alternative practical circuits were described, and has misinterpreted a suggestion for extending the range of these circuits (should this be necessary) as being the only practical circuit shown in the paper which, of course, is manifestly untrue.

His two circuits are of some interest obviously, but neither obeys the requirement of giving phase adjustment without a concomitant change in amplitude.

An analysis of the circuit in his Fig. 1 shows that:

$$\frac{v}{e} = \frac{x(1-x)\,(1+\omega^2LC) + j\,\dfrac{\omega L}{R}\,(1-2x)}{x(1-x)\,(1-\omega^2LC) + j\,\dfrac{\omega L}{R}}$$

where

v = output voltage.

e = voltage across one half of secondary of the transformer.

and x = proportion of the total resistance R above the slider.

By taking the modulus of v/e, it can be shown that this cannot be made independent of x whatever values of ω, L, C and R are used.

Considering, for example, the conditions given by Mr. Campbell, namely $\omega^2LC = 1$, and $\omega L = R/4$, we obtain:

$$\frac{v}{e} = (1-2x) - j\,8x\,(1-x)$$

$$\left|\frac{v}{e}\right|^2 = 1 - 4x + 68x^2 - 128x^3 + 64x^4$$

This expression has the value 1 when $x = 0$ or 1 as would be expected, but varies considerably in between these two values of x and would obviously be quite unsuitable for use in a circuit requiring constant amplitude.

His analysis of his Fig. 2 seems also to be at fault since, using the same nomenclature as before, I obtain

$$\frac{v}{e} = \frac{(1-2x) + x(1-x)\,j\omega CR}{1 + x(1-x)\,j\omega CR}$$

As Mr. Campbell states, this does not have a constant output amplitude as x is varied but, what is more, the condition he gives that when $x = \frac{1}{2}$ the phase shift should be 90° cannot be realized. When $x = \frac{1}{2}$

$$\frac{v}{e} = \frac{j\omega CR}{4 + j\omega CR}$$

and no value of ωCR will give 90° phase change. As $\omega CR \to 0$ this condition can be approached but with a rapidly decreasing amplitude.

Department of Electrical Engineering, University of Birmingham. J. W. GRIFFITHS
11th January 1957.

Gas-Filled Voltage Stabilizers

SIR,—With reference to Dr. Benson's article "Gas-filled Voltage Stabilizers" in the January issue, we have been making spectral noise measurements on the Mullard gas-filled voltage reference tube type 85A2 in the frequency band 20 c/s–10 Mc/s, and attempting to correlate the noise properties with the measured impedance, Z, of the tube.

To this end, the gas tube has been represented by (a) a zero-impedance noise voltage generator, e.m.f. e (μV per $\sqrt{\text{kc/s}}$), in series with Z and (b) an infinite-impedance noise current generator, short-circuit current i (mμA per $\sqrt{\text{kc/s}}$), in shunt with Z. The values of e and i were computed from the r.m.s. noise voltage measured across a known load.

Certain preliminary conclusions have been reached and these may be of interest.

(i) e increases as the d.c. tube current is reduced.

(ii) At frequencies below 1 kc/s, i decreases as the d.c. tube current is increased, but above 1 kc/s i increases with tube current.

(iii) Above about 2 Mc/s i is of the same order as the shot-noise current of a saturated diode with the same space current.

(iv) For the higher tube currents e is approximately constant up to about 500 kc/s.

(v) The impedance of the tube decreases with current at all frequencies, and a marked resonance occurs at about 500 kc/s.

From (i) and (ii) it may be deduced that whether or not the tube shows an increase of terminal noise voltage with decreasing current depends on the associated load circuit (R in Dr. Benson's article) and the frequency band concerned.

These measurements have been spread over a three-year period, and during this time no significant change in tube noise with life has been observed. This is consistent with Dr. Benson's remarks concerning the high-stability reference tube.

*Physics and Telecommunications Dept., The Woolwich Polytechnic, London, S.E.*18. K. B. REED, J. F. DIX
14th January 1957.

Phase-Sensitive Discriminator

SIR,—It appears to me that the "Phase-Sensitive Discriminator" described by Chatterjee in the January issue of your journal, p. 37, is incorrectly named, in that its output approximates not to the instantaneous phase of the input but to the reciprocal of the instantaneous frequency, which is quite different.

I believe that Mr. Chatterjee may have been led astray by use of a sine-wave modulation, which is a particular case giving a sine-wave output. However, a more accurate picture can be obtained by considering phase modulation by a step function. In this case, the frequency will remain constant except for a brief period in the neighbourhood of the epoch of the step. If the step is positive in the sense of an increase in phase, then the waveform will be equivalent to an abrupt and short-lived increase in instantaneous frequency.

Clearly, Mr. Chatterjee's circuit would then produce a negative-going spike approximating, not to the modulation waveform, but to the negative of its derivative.

The general phase-modulated waveform may be represented by:

$$S = A \sin\{\omega_c t + f(t)\}$$

where $f(t)$ is the modulating waveform.

The instantaneous frequency is the derivative of the instantaneous phase and is given by

$$2\pi f_i = \omega_c + f'(t)$$ where the prime denotes $df(t)/dt$.

The system described gives an output proportional to $1/f_i$, and hence to

$$V_0 = \frac{2\pi}{\omega_c + f'(t)} = \frac{2\pi}{\omega_c\{1 + f'(t)/\omega_c\}}$$

If the modulating frequencies are much smaller than the carrier requency, as is generally true, then $f'(t)/\omega_c \ll 1$ for all t and hence

$$V_0 \approx \frac{2\pi}{\omega_c}\left\{1 - \frac{f'(t)}{\omega_c}\right\} = \frac{2\pi}{\omega_c} - \frac{2\pi}{\omega_c}f'(t)$$

Ignoring the d.c. term, the output is therefore proportional to the negative of the derivative of $f(t)$, as in the example above.

For the sine-wave case, putting $f(t)$ equal to $B \sin \omega t$, we obtain

$$2\pi f_i = \omega_c + B\omega \cos \omega t$$

so that the maximum instantaneous frequency occurs when the modulation waveform $B \sin \omega t$ is zero. Reference to Mr. Chatterjee's Fig. 2, however, will show clearly that his output is *maximum* (in a negative sense) at the instant of maximum instantaneous frequency.

It can scarcely then be accurately the same as the modulation waveform, unless this is applied as *frequency* modulation.

N. Baddesley, Hants. L. C. WALTERS
7th January 1957.

MEETINGS

I.E.E.

12th March. "An Analogue Computer for Nuclear Power Studies" and "The Application of Analogue Methods to Compute and Predict Xenon Poisoning in a High-Flux Nuclear Reactor", by G. J. R. MacLusky, B.Sc.

18th March. "What is Limiting the Application of Servo Mechanisms in the Electrical Industry?", discussion to be opened by C. Ryder.

20th March. "Recent Developments in X-ray and Electron Microscopy with some Applications to Radio and Electronics", by V. E. Cosslett, M.A., Ph.D., and C. W. Oatley, O.B.E., M.A., M.Sc.

1st April. "Colour Television", by L. C. Jesty, B.Sc., and E. L. C. White, Ph.D., M.A.

4th April. "Infra-Red Radiation", The Forty-Eighth Kelvin Lecture by G. B. B. M. Sutherland, Sc.D., F.R.S.

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 March. "Disk Recording", by G. F. Dutton, Ph.D. to be held at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, at 6.30.

The Physical Society

25th March. "The International Geophysical Year", by Sir Harold Spencer Jones, K.B.E., F.R.S.

27th March. "Recent Developments in Acoustics", by Professor E. G. Richardson.

These meetings are held in conjunction with the Physical Society's Exhibition at the Horticultural Halls, Westminster, London, S.W.1, and will commence at 6.15.

28th March. Annual General Meeting of the Acoustics Group and a symposium on Sound Recording: "Factors Limiting the Performance of Magnetic Recording Systems", by Dr. P. E. Axon; "Standardization of Recording Characteristics", by H. J. Houlgate; "Application of Magnetic Recording to Computers and Automation", by B. W. Pollard and "Magnetic Strip on Cinematograph Film", by J. Moir, to be held at 4 p.m. in the Henry Jarvis Hall of the Royal Institute of British Architects, 66 Portland Place, London, W.1.

The Television Society

15th March. "The Return of Electrostatic Focusing", by Dr. R. Pearce, B.Sc.

29th March. "Studio Production Techniques", by Ian Atkins.

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

Society of Instrument Technology

26th March. "Process Development and Plant Design—The Role of Instrumentation with Particular Reference to the Application of Computers", by S. T. Lunt, B.A., at 7 o'clock at Manson House, Portland Place, London, W.1.

Radar Association

13th March. "Radar Techniques in Science and Industry", by Sir John Cockcroft, K.C.B., C.B.E., F.R.S., at 7.30 at the Anatomy Theatre, University College, Gower Street, London, W.C.1.

British Sound Recording Association

15th March. "Ultra Linear Amplifiers", by D. M. Leakey, B.Sc., at 7.15 at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.

Women's Engineering Society

5th April. "The Use of Electronic Computers in Engineering", by Miss Jill Robinson, at 7 o'clock at Hope House, 45 Great Peter Street, Westminster, London, S.W.1.

I.E.E. NORTH-WESTERN CENTRE

An exhibition will be held in the College of Science and Technology, Manchester, on 26th and 27th March, 1957, under the auspices of the Radio and Telecommunications Group of the North-Western Centre of the Institution of Electrical Engineers. The exhibition will be open from 10 a.m.–9 p.m.; admission free.

EXHIBITIONS

The following exhibitions are being held during March and early April and a review of the exhibits will appear in the May issue of *Electronic & Radio Engineer*:

March 25-28 Physical Society. Held at Royal Horticultural Society's Halls, London, S.W.1. Hours of opening: 25th March, 10.30 a.m.–7 p.m. (members only 10.30 a.m.–2 p.m.); 26th March, 10 a.m.–9 p.m.; 27th March, 10 a.m.–7 p.m.; 28th March, 10 a.m.–4 p.m. Applications for tickets, enclosing a stamped addressed envelope, should be made to The Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

March 25-29 Third International Instrument Show. Sponsored by B & K Laboratories Ltd. and Allied International Co. Ltd. Held at Caxton Hall, Westminster, London, S.W.1, from 10.30 a.m.–6.30 p.m. daily 26th–28th March. (25th March, 12.15–6.30 p.m.; 29th March, 10.30 a.m.–12.15 p.m.) Tickets are available on request from B & K Laboratories Ltd., 57 Union Street, London, S.E.1.

April 8-11 Radio and Electronic Component Manufacturers' Federation. Held at Grosvenor House and Park Lane House, Park Lane, London, W.1, from 9 a.m.–6 p.m. on 9th April; 10 a.m.–6 p.m. on 10th April; and 11 a.m.–5 p.m. on 11th April, with a preview on 8th April from 10 a.m.–6 p.m. Application for tickets should be made to the Radio and Electronic Component Manufacturers' Federation, 21 Tothill Street, London, S.W.1.

April 9-13 The Electrical Engineers' Exhibition (A.S.E.E.). Held at Earls Court, London, S.W.5, from 10 a.m.–7 p.m. daily (Wednesday, 10th April, 10 a.m.–9 p.m.). Tickets are available on request from the Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, W.C.1.

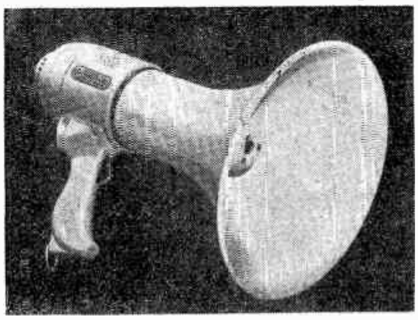
STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)
Values for January 1957

Date 1957 January	MSF 60 kc/s Frequency deviation from nominal:* parts in 10^9
1	0
2	+ 1
3	+ 1
4	+ 1
5	0
6	+ 1
7	0
8	+ 1
9	+ 1
10	+ 1
11	+ 1
12	+ 1
13	+ 1
14	+ 1
15	+ 1
16	+ 1
17	+ 1
18	+ 1
19	+ 1
20	+ 1
21	+ 1
22	+ 2
23	+ 2
24	+ 1
25	+ 1
26	N.T.
27	N.T.
28	+ 1
29	+ 1
30	+ 1
31	+ 1

* *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. NT = No Transmission.*

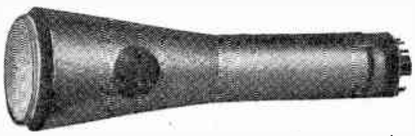
New Products



Transistor Loud Hailer

The Pye Transhailer is a portable electronic megaphone with a range of 440 yards or more. The use of transistors results in a great saving in weight and battery consumption. The weight is 5 lb, and the instrument is powered by small torch batteries. The expected battery life corresponds to speaking 20,000 messages each of 10-seconds duration.

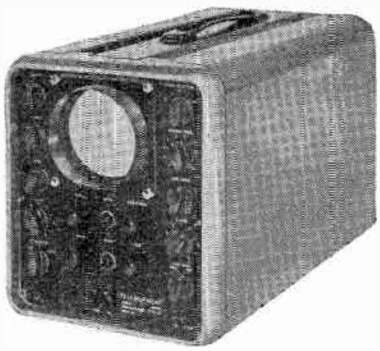
Pye Telecommunications Ltd.,
Newmarket Road, Cambridge.



Magnetic Shields for G.E.C. Cathode-Ray Tubes

The type S.T. 24 magnetic shield has been developed for use with the 4GP instrument tubes described in the January issue. They are made of a high-permeability nickel-iron alloy, specially heat-treated. Fixing is by a metal clamp to the tube base-cap. Shock-absorbing pads are fitted inside the shield.

Magnetic & Electrical Alloys Ltd.,
Ann Street, Burbank, Hamilton.

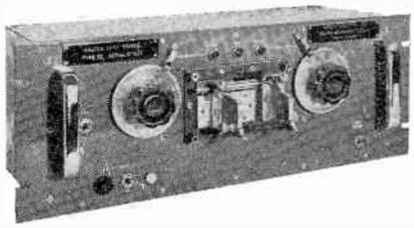


Inexpensive Oscilloscope

The Telequipment 620 is a wide-band (—3 dB at 6 Mc/s) oscilloscope employing a 3½-inch post-deflection accelerator cathode-ray tube. The Y amplifier is a.c. coupled, with a good low-frequency performance (a 50-c/s square wave is stated to have less than 1% tilt), and a rise time of 0·06 μsec. Gain is continuously variable and the bandwidth is constant. A frequency-compensated attenuator (×1, ×10, ×100) is provided. For calibration purposes, a 50-c/s square wave is available, with a peak-to-peak amplitude 1 V ±2%. Overall voltage measurement accuracy is ±5%.

The timebase can be either triggered or repetitive, sweep times being variable between 0·2 sec to 3 μsec for a complete sweep. Sweep expansion of 5 screen diameters is provided. For examining television waveforms, an internal sync separator enables the timebase to be locked either to the line or to the frame pulses.

Telequipment Ltd., 313 *Chase Road,*
*Southgate, London, N.*14.



Limit Bridge

This new bridge is designed for the rapid comparison of resistors, capacitors and inductors with standard components. Comparisons of mixed *R*, *L* and *C* impedances can also be made.

In operation, the unbalance voltage is compared with that obtained from each of two pairs of auxiliary ratio arms, which are used to set the upper and lower tolerance limits. The output of the comparison circuit is amplified and detected and, if sufficiently large, operates relays which switch on "reject high" or "reject low" lamps.

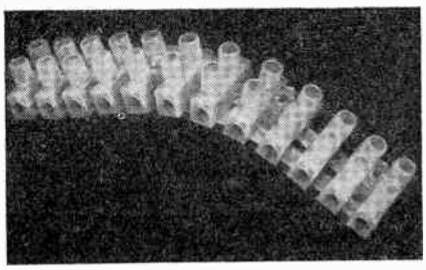
The equipment can also be set up as a conventional bridge. This facility is useful for checking standards.

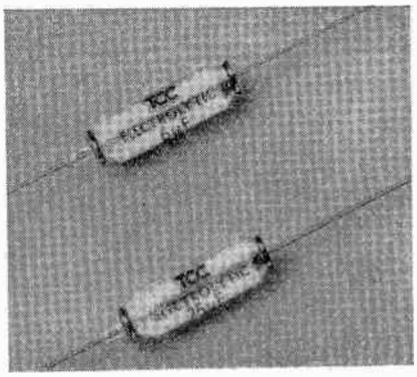
Aveley Electric Ltd.,
Ayron Road, South Ockendon, Essex.

Flexible Terminal Blocks

Nylon is the material used in flexible 12-way terminal blocks manufactured by Metway. The blocks have ratings of 250 V to earth and 400 V between terminals, at temperatures up to 250° F. Current ratings are 5, 15–20, and 25–30 A.

Metway Electrical Industries Ltd.,
Brighton 7.





Miniature Electrolytic Capacitors

All the capacitors in the new T.C.C. range illustrated are the same size ($1\frac{1}{16}$ in. by $\frac{3}{8}$ in.). Capacitance values range from 100 μF (6 V) to 2 μF (200 V). The elements are hermetically sealed in aluminium tubes. Maximum working temperature is 70° C.

The Telegraph Condenser Co. Ltd.,
(*Radio Division*), *North Acton, London, W.*3.

A.C. Millivoltmeter

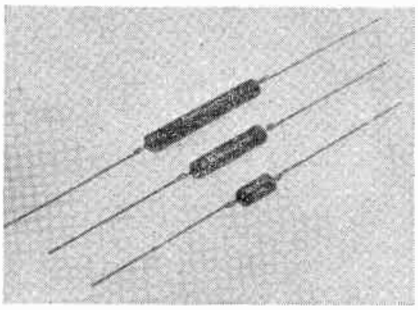
This new instrument is a straightforward a.c. millivoltmeter produced to meet the needs of audio engineers. Five r.m.s. voltage ranges are provided, ranging from 20 mV to 200 V f.s.d. A decibel scale is also incorporated, and is correct for a reference level of 1 mW in 600 ohms when the instrument is switched to the 2-V range. The decibel scale reads − 16 dB to + 8dB. The indicating meter scale has forty divisions.

The instrument incorporates a two-stage RC-coupled valve amplifier with negative feedback. The amplifier output is rectified by a full-wave circuit. An input potentiometer is provided which has a total resistance of over 500,000 ohms. Five tappings provide the voltage ranges, and the input impedance of the meter is the same on all ranges and also when the range-selector switch is in the "off" position, so that the input signal source cannot be short-circuited by operating the switch.

E.I.R. Instruments Ltd.,
329 *Kilburn Lane, London, W.*9.

Vitreous-Enamelled Wire-Wound Resistors

A modified form of vitreous-enamelled wire-wound resistor is announced by Welwyn Electrical Laboratories Ltd., under the designations V1, V2 and V3.



The vitreous enamel is claimed to be completely homogeneous and free from pinholes and porosity. It does not crack readily or show crazing marks. No joints between dissimilar materials are made beneath the surface of the enamel, the leads emerging from the enamel being of the same material as the wire used in winding the element. Terminations are secured to the body of the resistor in such a manner that no mechanical stress can be transmitted to the resistance element. Terminal leads are made from best quality tinned-copper wire.

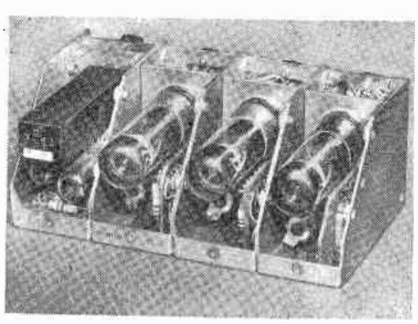
The resistors are manufactured in three sizes which correspond to the Radio Components Standardization Committee's patterns RWV4–J, RWV4–K and RWV4–L. They are stated to perform extremely well when undergoing tests to the standard required by RCSC specification RCS 111, particularly in the case of the test which calls for the application of a light d.c. load in humid conditions.

The modified form of construction allows a considerable increase in maximum available resistance including 100 kΩ on the type corresponding to style RWV4–L. It also moves the brazing pips to the axis of the resistors and enables them to be used in a smaller space without fear of accidental shorting.

Welwyn Electrical Laboratories Ltd.,
Bedlington, Northumberland.

Plug-In Counting Units

By means of a number of power units and a wide range of plug-in counting sub-units, an almost infinite variety of instruments may be quickly assembled by means of a simple block technique.



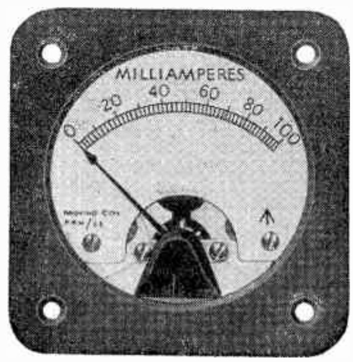
Speeds up to 5 c/s are counted on resettable or non-resettable electro-mechanical registers, while speeds up to 350 c/s are obtained on Ericsson Dekatron units employing cold-cathode-tube coupling stages. For speeds up to 20 kc/s, the Dekatron units utilize a hot-cathode drive stage, while binary units are capable of counting speeds up to 200 kc/s.

Also included in the range are input, output and control units to meet the requirements of many types of instruments and a 1-kc/s valve-maintained tuning-fork oscillator designed for timing and tachometry applications.

Ericsson Telephones Ltd.,
High Church Street, New Basford, Nottingham.

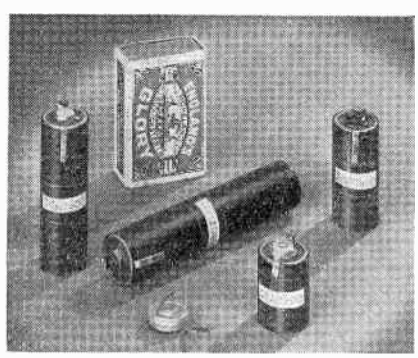
Sealed Two-Inch Instruments

A range of 2-in. sealed moving-coil instruments is now being produced by



Ferranti. The instruments, which comprise voltmeters and millammeters, are type approved to RCS.231/RCL.231.

Ferranti Ltd.,
Hollinwood, Lancs.

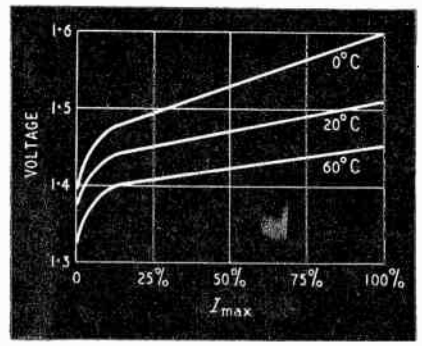


Low-Voltage Stabilizers

Low-voltage stabilizers of the cadmium/nickel cell type are now available in the U.K. The cells are rated at 1·5 V, with a range of maximum currents of 20 mA to 1 A, according to type. Cells with a small storage capacity are also available; these maintain a terminal voltage of 1·1–1·2 V at maximum current for about 1 minute after the supply is cut off.

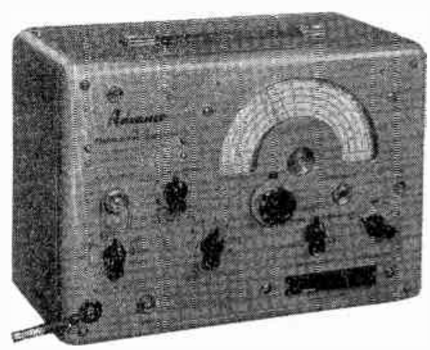
The current–voltage characteristic of the cells is shown in the accompanying diagram.

Mercia Enterprises Ltd.,
Opera House Buildings, 30 Silver Street, Coventry.



F.M./A.M. Signal Generator

A new Advance signal generator has been primarily designed for servicing radio and television receivers for Bands I, II and III. It provides frequency- or amplitude-modulated signals over a continuous frequency range of 7·5 to 230 Mc/s. The r.f. oscillator is a variable capacitance Colpitts circuit with switched inductances for five ranges. The frequency is directly calibrated to an accuracy of ± 1%, and a slow-motion drive, with a reduction ratio of 40:1, is fitted to the frequency control. An internal



5-Mc/s crystal calibrator has been incorporated so that the calibration may be checked at 5-Mc/s intervals to an accuracy of ± 0·01%. For setting between check points, an interpolating scale is provided. The cursor is adjustable for correcting small errors. The output signal may be frequency-modulated by a built-in oscillator at 1,000 c/s with a fixed deviation of ± 60 kc/s or, at the mains supply frequency, with a variable deviation of 0 to ± 150 kc/s. An external modulating source may also be used for deviations up to ± 150 kc/s and modulating frequencies between 20 c/s and 20 kc/s. The signal may also be amplitude-modulated by the 1,000-c/s source. The output level is continuously variable from one microvolt to 100 millivolts and the oscillator circuits are triple-screened to minimize leakage.

Advance Components Ltd.,
Roebuck Road, Hainault, Ilford, Essex.

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 publishers concerned.*

ACOUSTICS AND AUDIO FREQUENCIES

534 (47) 658

Recent Research in Ultrasonics and Physical Acoustics in the U.S.S.R.—R. T. Beyer. (*Nuovo Cim.*, 1956, Vol. 4, Supplement, No. 1, pp. 31–64. In English.) A review with 314 references to Russian literature as well as 43 other references.

534.2-8 659

The Absorption of Ultrasonic Waves in a Number of Pure Liquids over the Frequency Range 100 to 200 Mc/s.—E. L. Heasell & J. Lamb. (*Proc. phys. Soc.*, 1st Sept. 1956, Vol. 69, No. 441 B, pp. 869–877.) Measurement apparatus and results are described. Values of α/f^2 are given for 94 liquids, where α is the absorption coefficient relating to the excess pressure and f is the frequency. The mechanisms responsible for the attenuation are discussed.

534.2-8-14 660

Ultrasonic Relaxation Theory for Liquids.—J. H. Andreae & J. Lamb. (*Proc. phys. Soc.*, 1st Aug. 1956, Vol. 69, No. 440 B, pp. 814–822.) Analysis is presented expressing the relations between the absorption of the sound per wavelength, the velocity of the sound, and the thermodynamic parameters of the liquid.

534.213.4-8 661

Approximate Formulae for some Frequently Occurring Combinations of Sound Conduits.—C. Kleesattel. (*Acustica*, 1956, Vol. 6, No. 3, pp. 288–294. In German.) Combinations of $\lambda/2$ and/or $\lambda/4$ elements for ultrasonic purposes are discussed. Formulae are derived for the forces and velocities at the end faces as functions of impedance, internal friction and tuning. Application of the formulae to electroacoustic transducers is indicated.

534.232 : 621.395.6 : 621.372.5 662

Equivalent Quadripole Networks for Electromechanical Transducers: Part 2.—A. Lenk. (*Acustica*, 1956, Vol. 6, No. 3, pp. 303–316. In German.) For previous work see 2181 of 1955 (Reichardt & Lenk).

534.232 : 621.395.6 : 621.372.5 663

Transducers and their Equivalent Circuits. Applications to Microphones.—N. Rouche. (*Acustica*, 1956, Vol. 6, No. 3, pp. 317–323. In French.) A classification similar to that of Fischer (e.g. 953 of 1954) is established on a more general basis by examining all the possible forms of the transduction equation compatible with the principle of conservation of energy.

534.232-8 : 621.318.134 664

Magnetostrictive Ultrasonic Transducers made of Ferrites.—Y. Kikuchi, H. Shimizu & M. Terajima. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, June 1955, Vol. 7, No. 1, pp. 9–15.) An experimental investigation of underwater transducers for the frequency range of 70–80 kc/s is reported. Three different methods of construction are suggested. Electroacoustic efficiencies of 60–93% are obtained. The investigation of the ferrites for these transducers is described in separate papers by Kikuchi et al. (843 below).

534.24 + 538.566 : 535.43 665

Scattering Theorems for Bounded Periodic Structures.—Twersky. (See 746.)

534.24-14 666

Reflection of Sound by a Thin Rod in Water.—L. M. Lyamshev & S. N. Rudakov. (*C. R. Acad. Sci. U.R.S.S.*, 1st Sept. 1956, Vol. 110, No. 1, pp. 48–51. In Russian.) Experimental results with copper, steel, and aluminium rods, of a thickness small compared with the wavelength in water, indicate that the nonspecular reflections are due to flexural and longitudinal waves in the rod. The critical angle for nonspecular reflection is given by $\sin\theta = c/c_x$, where c is the velocity of sound in the liquid and c_x the velocity of the waves in the rod.

534.4 : 534.7 667

Various Methods of Representing Sound Spectra.—L. Cremer & L. Schreiber. (*Frequenz*, July 1956, Vol. 10, No. 7, pp. 201–213.) The relative advantages of various methods are discussed, particularly with regard to their suitability for representing line or continuous spectra. For objectively derived spectra, graphs based on filter characteristics are proposed. Following consideration of the distribution of nerve impulses along the basilar membrane, it is recommended that subjective measurements be represented by loudness/frequency-group graphs which allow for masking effects. See also 1604 of 1956 (Zwicker & Feldtkeller).

534.75 **668**

The Form of Vibrations of the Impulse- or Noise-Excited Basilar Membrane, as Measured on an Electrical Model of the Inner Ear.—H. Bauch. (*Frequenz*, July 1956, Vol. 10, No. 7, pp. 222–234.) Measurements made using a network consisting of 65 T-sections, based on anatomical data and the calculations of Zwislocki (1052 of 1951), gave results in close agreement with anatomical measurements.

534.836.087.4 **669**

The Measurement of Noise in the Presence of Level Fluctuations.—G. Bobbert & R. Martin. (*Z. Ver. dtsch. Ing.*, 1st July 1956, Vol. 98, No. 19, pp. 997–1002.) The apparatus described determines the average noise level over a given period. A coupled recorder and counter mechanism automatically counts and registers the numerical value of the level at successive short time intervals. Its application in the analysis of traffic noise is detailed.

534.84 : 534.6 **670**

Proposal for the Definition and Measurement of Intelligibility on a Subjective Basis.—H. Niese. (*Hochfrequenztech. u. Elektroakust.*, July 1956, Vol. 65, No. 1, pp. 4–15.) Difficulties involved in the pulse echo technique proposed by Thiele (311 of 1954) are discussed. In the new method proposed, a determination is again made of the ratio between the useful and disturbing components of the sound, the analysis of the echo oscillogram into the two components being made in accordance with two empirically established time functions depending on the integration effected by the ear and on the subjective perception of noise. Details of suitable test apparatus are given.

534.846.6 **671**

Some Experiments in a Room and its Acoustic Model.—A. F. B. Nickson & R. W. Muncey. (*Acustica*, 1956, Vol. 6, No. 3, pp. 295–302.) Experiments made on a room about $14 \times 5 \times 3\ m^3$ over an interval of about an octave around 200 c/s, and on a quarter-scale model over a correspondingly scaled frequency range, confirm that the accuracy of the model measurements is satisfactory for objective acoustic tests.

AERIALS AND TRANSMISSION LINES

621.372.2 **672**

Dispersive Properties of Multifilar Helices.—N. N. Smirnov. (*C. R. Acad. Sci. U.R.S.S.*, 11th Sept. 1956, Vol. 110, No. 2, pp. 212–215. In Russian.) The characteristics of a bifilar helix are analysed by the method of space harmonics used previously (3276 of 1956) and the extension of the analysis to *m*-wire helices is outlined. Dispersion characteristics of a bifilar helix are presented graphically for (*a*) in-phase, and (*b*) antiphase excitation.

621.372.8 **673**

Approximate Method of Calculating a Slightly Irregular Waveguide.—A. G. Sveshnikov. (*C. R. Acad. Sci. U.R.S.S.*, 11th Sept. 1956, Vol. 110, No. 2, pp. 197–199. In Russian.) The solution of Maxwell's equations for propagation in a slightly irregular cylindrical waveguide is obtained in the form $\mathbf{E} = \mathbf{E}^0 + \epsilon_0\mathbf{E}' + \ldots$, with a similar expression for the magnetic vector, where ϵ_0 is a function of the shape of the waveguide. The system of coordinates used is similar to that of Jouguet (3786 of 1947).

621.372.8 **674**

A Clear Representation of Processes in the Propagation of Discontinuous Signals in Waveguides.—A. Rubinowicz. (*Z. angew. Math. Phys.*, 25th July 1956, Vol. 7, No. 4, pp. 316–325.) The field is analysed in terms of the primary radiation and the components contributed by successive reflections from the walls. Relations between the forerunner and the main wave are elucidated.

621.372.8 **675**

Waveguide Hybrid Circuits and their Use in Radar Systems.—J. W. Sutherland. (*Electronic Engng*, Nov. 1956, Vol. 28, No. 345, pp. 464–469.) "The principal types of waveguide hybrid are described and their properties are compared. Balanced duplexers, balanced mixers and waveguide switching, adding and subtracting circuits are discussed."

621.372.8 **676**

Symmetrical Dielectric Junctions in Waveguides with Circular Cross-Section for H_{01} Waves.—B. Z. Katsenelenbaum. (*Radiotekhnika i Elektronika*, March 1956, Vol. 1, No. 3, pp. 339–343.) The method of analysis used previously (3485 of 1955) is applied to the case of an H_{01} wave incident on a long transition between two waveguides having equal cross-sections but filled with different dielectrics. The general formula for the reflection coefficient is derived.

621.372.8.002.2 **677**

Waveguide Surface Finish and Attenuation.—J. Allison & F. A. Benson. (*Electronic Engng*, Nov. & Dec. 1956, Vol. 28, Nos. 345 & 346, pp. 482–487 & 548–550.) The surface properties of drawn, mechanically lined, sprayed, cast, electroplated, electropolished, chemically polished and electroformed waveguides are discussed. Attenuation values and roughness factors are tabulated. 36 references.

621.396.67 : 621.372.54 **678**

On the Wide-Band Matching of a Dipole Antenna and Yagi Antenna.—R. Sato & K. Nagai. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, June 1955, Vol. 7, No. 1, pp. 23–44.) A dipole aerial is shown to be equivalent to a high-pass filter having a certain resistance across its output terminals; it is matched when this terminal resistance coincides with the image impedance of the preceding filter. Application of standard network theory to the problem is illustrated by examples.

621.396.67.029.62 **679**

Radiotelephony Aerials for the 4-Metre Band.—W. Seefried. (*Nachr Tech.*, July 1956, Vol. 6, No. 7, pp. 319–325.) A survey of various dipole types for fixed and mobile stations, including a description of a modified folded dipole for use on locomotives.

621.396.674.3 **680**

The Radiation Field and Impedance of Aerials.—K. Fränz. (*Arch. elekt. Übertragung*, July 1956, Vol. 10, No. 7, pp. 269–273.) A relation between the inductance and the overall frequency characteristic of the radiation resistance of dipole aerials of any shape is obtained, and it is proved that the reactive component of radiated power is concentrated in the vicinity of the aerial. The calculation of a long-wave dipole of maximum damping is given, and the impedance of a free aerial is derived as a limiting case of the reactance of an aerial enclosed in a cavity. Formulae are included for the determination of conductor arrangements to satisfy the boundary conditions of given fields.

621.396.677.3 **681**

Calculating the Efficiency of Antenna Arrays.—G. Mather. (*Tele-Tech & Electronic Ind.*, June 1956, Vol. 15, No. 6, pp. 102–103..208) The efficiency is estimated by comparing the r.m.s. current of the array with the current of an omnidirectional radiator of equivalent height and power input.

621.396.677.7.012.12 **682**

Radiation Patterns of a Dielectric-Coated Axially-Slotted Cylinder.—R. A. Hurd. (*Canad. J. Phys.*, July 1956, Vol. 34, No. 7, pp. 638–642.) Expressions for the field are derived theoretically, and azimuthal radiation characteristics are plotted. The dielectric coating enhances the radiation in the shadow region, but does not render the pattern omnidirectional. Variations of field with angle increase with increasing dielectric constant and coating thickness; the positions of the minima appear to be determined only by the diameter of the metal cylinder. Measurements in good agreement with the theory are reported.

621.396.677.8 **683**

Aerial Reflections—the Reflex Aerial.—F. J. Charman. (*R.S.G.B. Bull.*, Aug. 1956, Vol. 32, No. 2, pp. 59–60.) Short account of the construction and performance of 'reflex' aerials of a type described by von Trentini (1310 of May), based on multiple reflections between a main reflector sheet and a grating. With a model scaled for 3 kMc/s the half-power beam widths in the E and H planes were 26° and 30° respectively.

621.396.677.8 : 621.396.96 **684**

Aerials for Fire-Control Radar.—L. Thourel. (*Ann. Radioélect.*, July 1956, Vol. 11, No. 45, pp. 216–229.) Discussion indicates that the parabolic reflector is frequently preferable to a lens. Methods of calculating the radiation pattern are derived for the defocused paraboloid; the results obtained agree closely with experimental findings.

621.396.677.83 : 621.396.11.029.6 685

The Deflection of Short Electromagnetic Waves.—Megla. (See 921.)

AUTOMATIC COMPUTERS

681.142 686

A New Computing Method using High-Frequency Currents.—H. J. Uffler. (*Ann. Radioélect.*, July 1956, Vol. 11, No. 45, pp. 187–199.) An electromechanical process is described for performing algebraic operations in analogue computers. The system operates at 472 kc/s and comprises only passive components. Considerable accuracy and stability are achieved.

681.142 687

Applications of a Transformer Analogue Computer.—J. R. Barker. (*Brit. J. appl. Phys.*, Aug. 1956, Vol. 7, No. 8, pp. 303–307.) Use of the Blackburn analyser for extracting latent roots of matrices, locating zeros of polynomials, and solving linear and nonlinear simultaneous equations is discussed.

681.142 : 621.383 688

Photoformer Analysis and Design.—E. Elgeskog. (*Chalmers tek. Högsk. Handl.*, 1956, No. 172, 40 pp.) Analysis is presented permitting the design of a photoformer with a bandwidth of several kc/s, suitable for use in a high-speed repetitive electronic differential analyser. Difficulties due to the short response time are discussed in detail. Results obtained with an experimental system using a plane c.r. tube screen and photocathode are in good agreement with the theory.

CIRCUITS AND CIRCUIT ELEMENTS

621.314.2 : 621.372.512.3 689

Design Charts for Tuned Transformers.—M. J. Hellstrom. (*Electronics*, Nov. 1956, Vol. 29, No. 11, pp. 182–186.)

621.316.86 : 621.372 690

Calculation of Circuits with Indirectly Heated Semiconductor Thermoresistors [thermistors].—N. P. Udalov. (*Avtomatika i Telemekhanika*, April 1956, Vol. 17, No. 4, pp. 340–342.) The effect of a variation in the heating current on the resistance characteristics may be replaced, in calculations, by an equivalent temperature change. Examples are given.

621.318.57 : 537.311.33 691

Microwave Semiconductor Switch.—M. A. Armistead, E. G. Spencer & R. D. Hatcher. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, p. 1875.) The performance of switches comprising crystal diodes arranged inside waveguides is discussed. Useful degrees of isolation can be attained with *n*-type Ge more readily than with *p*-type Si, probably on account of the smaller effective mass of the carriers in the former case.

621.318.57 : 621.314.63 692

Fast Switching with Junction Diodes.—Scobey, White & Salzberg. (See 958.)

621.318.57+621.317.769.029.3] :621.314.7 693

Three New Transistor Circuits.—N. Hekimian. (*Electronics*, Nov. 1956, Vol. 29, No. 11, pp. 178–181.) Descriptions are given of a temperature-stabilized flip-flop, a tone keyer and an a.f. frequency meter using junction transistors.

621.318.57 : 621.314.7 694

An Asymmetrical Bistable Circuit using Junction Transistors.—(*Mullard tech. Commun.*, July 1956, Vol. 2, No. 19, pp. 254–278.) Conditions for the stable states of the basic switching circuit are analysed and an empirical method for investigating the dynamic operation is presented. Detailed procedure for the design of a particular modified circuit is indicated. Reliable switching times of the order of 4 μs may be obtained, with repetition rates up to a fifth of the grounded-base cut-off frequency; trigger sensitivity is good.

621.318.57 : 621.387 695

The Design of Cold-Cathode-Valve Circuits.—J. E. Flood & J. B. Warman. (*Electronic Engng*, Oct.–Dec. 1956, Vol. 28, Nos. 344–346, pp. 416–421, 489–493 & 528–532.) Switching circuits using cold-cathode diodes and triodes are discussed. Circuit elements are described for performing logical operations, counting, information storage, etc. The effects of tolerances on circuit operation are examined. Applications of multicathode valves are mentioned. 37 references.

621.372.4 696

Representation of a Type of Lossy Network in Standard Form.—B. Gross. (*Arch. elekt. Übertragung*, July 1956, Vol. 10, No. 7, pp. 299–302.) The method is limited to two-terminal networks consisting of regular arrangements of two groups of identical sub-systems, with either lumped or distributed elements. A lossy uniform transmission line is treated as an example.

621.372.4 697

Partial Equivalence of Two-Terminal Networks.—K. H. R. Weber. (*Hochfrequenztech, u. Elektroakust.*, July 1956, Vol. 65, No. 1, pp. 1–4.) Analysis is given for networks including *R*, *C* and *L*. The term 'partial equivalence' is used to indicate that, while the equivalence extends over a complete frequency range, it applies only for certain combinations of circuit parameters.

621.372.4 : 621.314.7 698

Graphical-Analytic Method of Constructing Voltage/Current Characteristics of a Two-Pole Network containing a Semiconductor Triode.—N. I. Brodovich. (*Avtomatika i Telemekhanika*, April 1956, Vol. 17, No. 4, pp. 335–339.) The construction of the dynamic characteristics of a point-contact transistor in an earthed-base circuit is described.

621.372.413 699

Formula for Calculating the Frequency of a Toroidal [cavity] **Resonator.**—V. A. Teplyakov & B. K. Shembel'. (*Radiotekhnika i Elektronika*, April 1956, Vol. 1, No. 4, pp. 443–446.) An empirical formula accurate to within 5% is given for re-entrant cylindrical resonators.

621.372.5 700

The Derivation of the Parameters of a Loss-Free Quadripole from the Reactive Transformation Diagram.—F. Gemmel. (*Arch. elekt. Übertragung*, July 1956, Vol. 10, No. 7, pp. 273–274.) The quadripole parameters are determined from the position of the perspective axis in the reactive transformation diagram. See also 372 of February.

621.372.5 701

Nonreciprocal Quadripoles and the Gyrator.—E. Cambi. (*Ricerca sci.*, July 1956, Vol. 26, No. 7, pp. 2049–2070.) Theory and application of the gyrator [301 of 1951 (Tellegen & Klauss)] are summarized. Natural systems with gyrator properties normally have considerable insertion losses; an approximation to the ideal gyrator can be achieved by introducing active circuit elements.

621.372.54 702

Minimum Signal Distortion and Noise Power in Linear Filters.—R. Kulikowski. (*Bull. Acad. polon. Sci., Classe* 4, 1956, Vol. 4, No. 2, pp. 123–126. In English.) Analysis is presented facilitating the design of physically realizable filters for transferring, with minimum distortion, signals with random and non-random components. See also 1327 of 1956 (Kulikowski & Plebánski).

621.372.54 703

Bridged-T Filters with One or Two Cut-Off Frequencies.—J. E. Colin. (*Câbles & Transm.*, July 1956, Vol. 10, No. 3, pp. 165–206.) Formulae for the image parameters are derived and the filters are classified according to operational type. Both symmetrical and nonsymmetrical forms are examined and a proof is given of the nonexistence or limitations of special types. Examples are given of symmetrical filters which are more advantageous for high-pass or band-elimination purposes than the very restricted ladder-type and which can be realized as crystal filters. Filter-design tables are appended.

621.372.543.2 : 538.652 : 621.396.41 704

Electromechanical Filters for Single-Sideband Applications.—D. L. Lundgren. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1744–1749.) The design of filters comprising cylindrical resonators with coupling necks or slugs is discussed; both longitudinal and torsional modes of vibration are considered. From the point of view of production, the preferred frequencies are from 200 to 250 kc/s. The frequency characteristics of typical filters with various numbers of sections are described; a typical 9-section torsional-mode filter for 250 kc/s provides a carrier rejection of 27 dB.

621.372.553 **705**
Phase-Adjusting Circuits.—J. W. R. Griffiths & J. H. Mole. (*Electronic Radio Engr*, Jan. 1957, Vol. 34, No. 1, pp. 26–30.) "A well-known phase-adjusting circuit is shown to be a special form of a more general type of circuit. Various other forms of this generic circuit are discussed, and shown to be of practical use under certain conditions of load, where the original circuit would not be suitable. The results are presented in a form useful for reference."

621.372.56.029.6 **706**
Wide-Band Coaxial Magnetic Attenuators.—G. W. Epprecht. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st July 1956, Vol. 34, No. 7, pp. 281–285.) The matching properties of attenuators of the type described e.g. by Reggia & Beatty (964 of 1953) are improved by arranging the magnetic material, particularly ferrite, as axially spaced disks. The marked frequency dependence of the attenuation is eliminated by combining units in such a way that their frequency characteristics compensate one another.

621.373 **707**
Self-Oscillations in a System with Delayed Feedback.—Yu.M Az'yan & V. V. Migulin. (*Radiotekhnika i Elektronika*, April, 1956, Vol. No. 4, pp. 418–427.) A system comprising an amplifier and a time-delay feed-back circuit is considered, taking into account the dispersion of the circuit. The predicted effects on the oscillation characteristics of changes in the circuit parameters were confirmed experimentally.

621.373 : 621.396.822 **708**
Influence of Slow Fluctuations on an Oscillator.—V. I. Tikhonov & I. N. Amiantov. (*Radiotekhnika i Elektronika*, April 1956, Vol. 1, No. 4, pp. 428–432.) Expressions are derived for the statistical characteristics of the amplitude and phase; the phase fluctuations are calculated.

621.373.4.029.6 **709**
The Influence of an External Force on Self-Oscillating U.H.F. Systems.—E. S. Vorobeichikov & F. M. Klement'ev. (*Radiotekhnika i Elektronika*, March 1956, Vol. 1, No. 3, pp. 335–338.) Amplitude and stability characteristics of triode and klystron oscillators are derived, taking into account the effect of the finite transit time of electrons.

621.373.421.11 **710**
A Class of Self-Oscillating Systems.—I. M. Volk. (*C. R. Acad. Sci. U.R.S.S.*, 11th Sept. 1956, Vol. 110, No. 2, pp. 189-192. In Russian.) Analysis is presented covering the case of a triode valve oscillator with two coupled tuned circuits in the grid circuit.

621.373.44 : 621.317.755 **711**
A High-Voltage Pulse Generator and Tests on an Improved Deflecting System of a Cold-Cathode Oscillograph.—Cones. (See 883.)

621.373.5 : 621.314.7 **712**
Transistor Pulse Generator.—F. Rozner. (*Electronic Radio Engr*, Jan. 1957, Vol. 34, No. 1, pp. 8–10.) The use of *p-n-p* and *n-p-n* transistors in combination to generate pulses with short rise time is discussed. Minority-carrier storage is used to broaden the pulse. The rise and fall times obtainable with l.f. medium-power transistors are of the order of 0·7 μs at a repetition frequency of 100 kc/s with a peak power output of 1 W.

621.373.52 : 621.314.7 **713**
Determination of Steady-State Conditions in Transistor Oscillators.—G. Raabe. (*NachrTech.*, July 1956, Vol. 6, No. 7, pp. 295-302.) Mathematical treatment using Poincaré's method to find the conditions for steady-state oscillations from the circuit parameters and the nonlinear characteristics of the driving device (e.g. point-contact transistor). The effect of parameter changes on the form of oscillation is examined and the frequency deviation and harmonic content are determined. The use of harmonics with frequencies above the transistor cut-off is possible in some circuits.

621.375 : 51 **714**
Application of Orthogonal Step Polynominals in the Analysis of Transient Processes in Multistage Amplifiers.—S. V. Samsonenko. (*Radiotekhnika i Elektronika*, March 1956, Vol. 1, No. 3, pp. 269–273.) The application of Hermite and Laguerre polynominals is discussed. The analysis is simpler than by operational-calculus methods, particularly when the number of stages is large.

621.375.2 **715**
Cascode Characteristics.—W. Grant. (*Wireless World*, Jan. 1957, Vol. 63, No. 1, pp. 33–36.) A graphical method of constructing the characteristics is presented.

621.375.2.018.756 **716**
Bandwidth/Rise-Time Chart [for design of pulse amplifiers].—M. D. Prince. (*Electronics*, Nov. 1956, Vol. 29, No. 11, p. 188.)

621.375.2.029.3 **717**
Audio Amplifier Delivers 3 000 W.—A. B. Bereskin. (*Electronics*, Nov. 1956, Vol. 29, No. 11, pp. 162–163.) A push-pull amplifier for driving a loudspeaker mounted in an aircraft, for direct communication with the ground, uses two Type 4–1000A air-cooled tetrodes. The transformer primary is bifilar wound and is divided into two halves with the secondary sandwiched between them.

621.375.221 : 621.396.61 **718**
Linear-Power-Amplifier Design.—W. B. Bruene. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1754–1759.) Methods of minimizing distortion and improving reliability in class-AB r.f. amplifiers for multichannel s.s.b. transmitters are discussed. The significance of the valve characteristics is analysed. A high-gain three-stage amplifier using tetrodes is briefly described.

621.375.232.9 **719**
A Wide-Band Differential Amplifier of Unity Gain.—J. C. S. Richards. (*Electronic Engng*, Nov. 1956, Vol. 28, No. 345, pp. 499–501.) Description of a circuit with a single-ended output, capable of handling signals as large as 100 V r.m.s. over the frequency range 5 c/s–500 kc/s, with a rejection ratio >500.

621.375.3 **720**
Design of Magnetic Amplifiers with Toroidal Cores.—O. A. Sedykh. (*Avtomatika i Telemekhanika*, May 1956, Vol. 17, No. 5, pp. 445–459.) The application of the formulae derived is illustrated by the design of a 50-W amplifier with internal feedback having an amplification factor of 500 and minimum weight.

621.375.3(47) **721**
List of Russian and Foreign Literature on Magnetic Amplifiers for 1951-1954.—G. B. Subbotina. (*Avtomatika i Telemekhanika*, May 1956, Vol. 17, No. 5, pp. 471–487.) A bibliography of over 300 references, including 77 to Russian sources.

621.375.4 : 621.314.7 **722**
Minimizing Gain Variations with Temperature in *RC*-Coupled Transistor Amplifiers.—T. A. Prugh. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, p. 1880.) A method depending on the appropriate choice of external circuit conductance is discussed briefly.

621.372.5 **723**
Vierpoltheorie und Frequenztransformation. [Book Review]—T. Laurent. Publishers: Springer, Berlin, 1956, 299 pp., DM 34.50. (*Brit. J. appl. Phys.*, Aug. 1956, Vol. 7, No. 8, pp. 310–311.) German edition of an authoritative work on network theory originally published in Swedish.

GENERAL PHYSICS

537.21 : 513 **724**
Calculation of Capacitance.—D. Harrison. (*Electronic Radio Engr*, Jan. 1957, Vol. 34, No. 1, pp. 21–25.) "The method of geometrical inversion is applied to the determination of the capacitance between long parallel circular conductors. Formulae are derived for the capacitance between a long cylindrical conductor and an infinite plane conductor parallel to the axis of the cylinder, between parallel cylindrical conductors and between eccentric cylinders. The application of the inversion technique to field plotting and calculation of maximum voltage gradient is described."

537.21 : 621.319.4.011.4 **725**
Properties of a Coaxial-Torus Capacitor.—W. E. Waters, Jr. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp. 1211–1214.) Calculations are made of the potential distribution and capacitance for a system comprising a length of coaxial line bent into a circle. A special coordinate system is used, and an exact solution is obtained for the

Laplace equation. The analysis is applicable to space-charge-limited diodes of similar geometry.

537.226 : 538.566 **726**

Limit-Periodic Dielectric Media.—R. Redheffer. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp. 1136–1140.) A theoretical study is presented of a medium formed by stacking n similar panels, each of thickness d/n arrived at by compression from an initial thickness d, the dielectric constant and permeability varying over the thickness according to a given function. Expressions are derived for the effective dielectric constant and permeability of the stack as $n \rightarrow \infty$, and the wave transmission properties of the medium are discussed.

537.311.1/.2 **727**

The Influence of Interelectronic Collisions and of Surfaces on Electronic Conductivity.—H. Fröhlich, B. V. Paranjape, C. G. Kuper & S. Nakajima. (*Proc. phys. Soc.*, 1st Aug. 1956, Vol. 69, No. 440B, pp. 842–845.) Analysis indicates that Ohm's law needs to be supplemented by terms describing a viscous flow, in order that surface conditions affecting the current density may be satisfied.

537.52 : 621.315.618 **728**

Breakdown of Air at Microwave Frequencies.—L. Gould & L. W. Roberts. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp. 1162–1170.) Theory is presented for breakdown resulting from application of c.w. or pulse voltages. The conditions for breakdown are determined from a solution of the electron continuity equation for an average electron; ionization, attachment and diffusion are the dominant mechanisms involved. Calculated results are confirmed by observations made using a cylindrical cavity resonant at 2·8 kMc/s.

537.523 **729**

Uniform-Field Breakdown in Air.—R. F. Saxe. (*Brit. J. appl. Phys.*, Sept. 1956, Vol. 7, No. 9, pp. 336–340.) Experiments on breakdown in air at atmospheric pressure are described and spectrograms of the stages of the discharge are reproduced. The results are inconsistent with both the Townsend and the 'streamer' theories.

537.523.4 **730**

Theoretical Analysis of Build-up of Current in Transient Townsend Discharge.—Y. Miyoshi. (*Phys. Rev.*, 15th Sept. 1956, Vol. 103, No. 6, pp. 1609–1618.) Rigorous analysis is presented based on the equations of continuity for the electron and positive-ion streams in a parallel plane gap. The results indicate that the current/time characteristic is expressed by different formulae corresponding to three different time ranges relative to the electron transit time.

537.525 **731**

Simple Way to Obtain the Velocity Distribution of the Electrons in Gas-Discharge Plasmas from Probe Curves.—G. Medicus. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp. 1242–1248.)

537.525.537.56 **732**

Electron Temperature and Noise in Hot Cathode Discharges.—Thong Saw Pak & H. Martin. (*J. Electronics*, Sept. 1956, Vol. 2, No. 2, pp. 128–130.) Experimental evidence is reported pointing to a fundamental interrelation between the electron temperature, the sign of the plasma space-potential and the noise output in low-pressure discharges.

537.525 : 538.63 **733**

Plasma Fluctuations in Crossed Electric and Magnetic Fields.—H. W. Batten, H. L. Smith & H. C. Early. (*J. Franklin Inst.*, July 1956, Vol. 262, No. 1, pp. 17–30.) "An experimental study has been made of the high-amplitude electrical fluctuations associated with a gas discharge in a strong magnetic field. Hydrogen, helium, argon, and nitrogen gas were used at pressures from 0·3 to 100 μ. The power spectrum on plasma probes was investigated for various values of magnetic field, gas pressure, and power input to the discharge. For the range of frequencies studied (0·5 to 4 000 Mc/s), the spectrum shows a continuous high level that increases in amplitude with decreasing pressures at all frequencies and increases with increasing magnetic field at low frequencies. A sharp dip in the spectrum was observed near the ion cyclotron frequency for discharges in hydrogen and helium. The velocity and direction of propagation for the low frequency fluctuations were determined by cross-correlating the potential variations on two neighbouring probes. These fluctuations appear to propagate in the direction of the electron drift and at a velocity somewhat less than the Lorentz drift velocity."

537.533/.534 **734**

The Theory of the Buncher.—V. I. German & A. S. Kompaneets. (*Zh. tekh. Fiz.*, March 1956, Vol. 26, No. 3, pp. 678–682.) Analysis for the bunching process is presented in which the effect of the space charge of the bunch is taken into account.

537.533 **735**

Electron Emission from the Surfaces of Solid Bodies after Mechanical Working and Irradiation.—H. Nassenstein. (*Z. Naturf.*, Dec. 1955, Vol. 10a, No. 12, pp. 944–953.) Detailed development of theory outlined previously (87 of 1955) based on the assumption that the emitted electrons originate from high energy levels.

537.533.7/.8 **736**

Reflection of Slow Electrons at Surfaces of Clean Tungsten and [tungsten] Covered with Thin Films.—N. D. Morgulis & D. A. Gorodetski. (*Zh. eksp. teor. Fiz.*, April 1956, Vol. 30, No. 4, pp. 667–674.) An experimental investigation is reported of the reflection of, and secondary emission due to, electrons with energies up to about 10 eV incident on W, Ba-W and O-W surfaces in high vacuum (10^{-10}–10^{-11} mm Hg pressure). The results are presented graphically.

537.533.8 **737**

Electron Density and Velocity Distribution in Secondary-Electron Resonance Multiplication.—K. Krebs & H. Meerbach. (*Ann. Phys. Lpz.*, 15th Aug. 1956, Vol. 18, Nos. 3/4, pp. 146–162.) Continuation of investigations reported previously (2913 of 1955). The quantity of charge oscillating between the electrodes in a secondary-electron resonance system was determined by measuring the associated temperature variation at an electrode. A retarding-field method was used to measure the energy distribution of the electrons. The most probable energy value is about 20% below that predicted by theory, but its variation with field length is as predicted.

537.533.8 **738**

The Mechanism of the Secondary-Emission Effect in Alkaline-Earth-Oxide Layers.—P. Görlich, A. Krohs & H. J. Pohl. (*Z. Naturf.*, Dec. 1955, Vol. 10a, No. 12, pp. 1029–1030.) Experimental evidence indicates that for primary-current densities over about 10^{-6} A/mm^2 the secondary-emission coefficient for constant withdrawing voltage decreases as the primary-current density increases. Possible explanations of this phenomenon are discussed briefly.

537.533.8 **739**

Secondary Electron Emission of Alloys.—B. S. Kul'varskaya. (*Radiotekhnika i Elektronika*, April 1956, Vol. 1, No. 4, pp. 512–524.) An experimental investigation of the properties of CuMg, CuBe, NiBe, NiZr, NiTi, NiBa and NiMg alloys activated by controlled oxidation is reported. The dependence of the secondary-emission coefficient on the primary electron energy, degree of oxidation, and temperature is shown graphically for several of the alloys.

537.533.8 **740**

Secondary Electron Emission from Tungsten Carbide.—L. M. Volkova. (*Radiotekhnika i Elektronika*, April 1956, Vol. 1, No. 4, pp. 535–536.) A brief note. The maximum value of δ, the secondary-emission coefficient, of W_2C + 6% Co is 0·95. The secondary-electron energy distribution is similar to that of metallic cathodes. Graphs are given of the dependence of δ on the velocity of the primary electrons and on the retarding potential applied to a collector electrode.

537.533.8 **741**

Energy Spectra of Secondary Electrons from Mo and W for Low Primary Energies.—G. A. Harrower. (*Phys. Rev.*, 1st Oct. 1956, Vol. 104, No. 1, pp. 52–56.) Measurements were made using primary electrons with energies up to 100 eV. For primary voltages V_p above 20 V the energy spectrum of the secondary electrons exhibited a true secondary-emission peak and a second peak due to reflected primary electrons. As V_p was reduced, the secondary-emission peak became continuously smaller, disappearing entirely for values of V_p below 5 V.

537.56 : 538.56 **742**

On the Theory of Plasma Waves.—F. Berz. (*Proc. phys. Soc.*, 1st Sept. 1956, Vol. 69, No. 441B, pp. 939–952.) Discrepancies between the results of other workers are elucidated.

537.56 : 538.56 **743**

The Dispersion Equation in Plasma Oscillations.—P. C. Clemmow & A. J. Willson. (*Proc. roy. Soc. A.*, 25th Sept. 1956, Vol. 237, No. 1208, pp. 117–131.) "A theory is developed of longitudinal oscillations in an infinite homogeneous neutral electron gas in which the thermal speeds of the electrons are taken into account, but collisions and the motion of positive ions are neglected. A perturbation method is used and the existence of oscillations which are harmonic in space and time is investigated. The treatment is relativistic and yields a dispersion equation relating the angular frequency ω and the propagation constant k of such an oscillation. It is shown that to any real positive value of ω^2 in the range extending from zero to an upper limit just beyond ω_0^2, where ω_0 is the plasma frequency, there corresponds a real value of k^2 which satisfies the dispersion equation; but that no other solution of the dispersion equation exists for which either ω^2 or k^2 is real. For the case of an unperturbed electron distribution function of Maxwellian type the dispersion equation is expressed in terms of the probability integral and is examined in detail."

538.561 : 537.533.9 **744**

Cherenkov Radiation in Anisotropic Ferrites.—V. E. Pafomov. (*Zh. eksp. teor. Fiz.*, April 1956, Vol. 30, No. 4, pp. 761–765.) The magnetic components of the microwave radiation produced by charges moving in a uniaxial crystal of anisotropic ferrite with a constant velocity greater than the phase velocity of light are calculated. The expressions obtained for the ordinary and extraordinary components are compared with the corresponding expressions for the case of a dielectric medium. The intensity maxima in one case correspond to zero intensities in the other.

538.566 : 535.42 **745**

The Airy Pattern in Systems of High Angular Aperture.—B. Richards & E. Wolf. (*Proc. phys. Soc.*, 1st Aug. 1956, Vol. 69, No. 440B, pp. 854–856.) The possibility is discussed that when the angular aperture of the image-forming pencil in an aberration-free optical or microwave system is sufficiently increased, the diffraction image undergoes a more substantial modification than that of a simple diminution predicted by the classical formula of Airy.

538.566 : 535.43]+534.24 **746**

Scattering Theorems for Bounded Periodic Structures.—V. Twersky. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp. 1118–1122.) Analysis is presented for the scattering of a plane wave by periodic arrays of infinite extent in two dimensions and of finite extent in the third. Green's theorem is used.

538.566 : 537.226 **747**

On the Reflection of Electromagnetic Waves from a Dielectric Cylinder.—H. Wilhelmsson. (*Chalmers tek. Högsk. Handl.*, 1955, No. 168, 16 pp.) An exact solution is presented for the general case of incidence of a plane wave at an oblique angle, with either the magnetic or the electric vector perpendicular to the cylinder; the solution for an arbitrarily polarized wave is obtained by superposing the two special solutions. The coupling between the TM and TE modes produced vanishes for normal incidence.

538.569.4.029.6 **748**

Radiospectroscope for Observing Electronic Paramagnetic Resonance at Centimetre Wavelengths.—A. A. Manenkov & A. M. Prokhorov. (*Radiotekhnika i Elektronika*, April 1956, Vol. 1, No. 4, pp. 469–477.) Two types of equipment are described, one using a crystal detector and a.f. amplifier and the other a superheterodyne circuit with an i.f. of 75 Mc/s. Block diagrams are shown.

538.569.4.029.6 : 535.33.08 **749**

High-Resolution Microwave Zeeman Spectrometer.—R. W. R. Hoisington, C. Kellner & M. J. Pentz. (*Nature, Lond.*, 17th Nov. 1956, Vol. 178, No. 4542, pp. 1111–1112.) Brief description of apparatus in which a Q-band klystron, whose reflector is modulated simultaneously by a 25-c/s sawtooth voltage and a 100-kc/s sinusoidal voltage, supplies power at a frequency of 35 kMc/s to a resonant-cavity absorption cell located between the poles of a large electromagnet: the power reflected from the cavity is detected by a Si crystal.

537.56 **750**

Physics of Fully Ionized Gases. [Book Review]—L. Spitzer, Jr. Publishers: Interscience, New York and London, 1956, 105 pp., $1.75 (*Nature, Lond.*, 17th Nov. 1956, Vol. 178, No. 4542, p. 1083.) An accurate and reliable source of theoretical information for researchers in fields combining hydrodynamics and electromagnetism.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523 : 538.69 **751**

Suggestions Concerning the Nature of the Cosmic-Ray Cut-Off at Sunspot Minimum.—F. Hoyle. (*Phys. Rev.*, 1st Oct. 1956, Vol. 104, No. 1, pp. 269–270.) A mechanism based on an interstellar magnetic field is discussed. See also 1699 of 1956 (Davis).

523.16 : 551.510.535 **752**

The Measurement of Cosmic Radio Emission for Ionospheric Studies.—M. Laffineur & J. D. Whitehead. (*J. atmos. terr. Phys.*, Nov. 1956, Vol. 9, Nos. 5/6, pp. 347–349.) Technique developed at Meudon for automatically recording cosmic noise over the frequency band 24–24·1 Mc/s is briefly described.

523.3 : 621.396.9 **753**

Radio Echoes from the Moon.—I. C. Browne, J. V. Evans, J. K. Hargreaves & W. A. S. Murray. (*Proc. phys. Soc.*, 1st Sept. 1956, Vol. 69, No. 441B, pp. 901–920.) Report of observations made at a frequency of 120 Mc/s, with the moon in transit. The mean echo intensity is compared with theoretical estimates, and the nature of the rapid fading of the echoes is investigated in relation to various laws of scattering from the moon's surface. An investigation was made of slow fading of the echoes in relation to the rotation of the plane of polarization of the radio waves during their passage through the ionosphere. The effect is used to estimate the total electron content of unit cross-section between the observer and the moon.

523.5 : 621.396.11.029.62 **754**

Meteoric Echoes Observed Simultaneously by Back-Scatter and Forward Scatter.—McKinley & McNamara. (See 923.)

523.72 : 538.566 : 551.51 **755**

Solar Temperature and Atmospheric Attenuation in the 7-8-mm Wavelength Range.—R. N. Whitehurst & F. H. Mitchell. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1879–1880.) Measurements made using a Dicke-type radiometer (475 of 1947) indicate a solar temperature of 6 000° ± 500°K and values of total vertical attenuation between 0·3 and 0·6 dB depending on the weather.

55 : 621.396 **756**

Perturbations of a Satellite's Orbit due to the Earth's Oblateness.—L. Blitzer, M. Weisfeld & A. D. Wheelon. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp. 1141–1149.) Measurements by conventional radio techniques of the perturbations of a satellite's orbit can be used for a new determination of the earth's oblateness.

550.371+550.386 **757**

Seasonal Distribution of Short-Period Fluctuations of the Earth's Electromagnetic Field.—M. V. Okhotsimskaya. (*Bull. Acad. Sci. U.R.S.S., sér. géophys.*, Aug. 1956, No. 8, pp. 999–1000. In Russian.) The frequency of fluctuations is greatest at the equinoxes. See also 108 of 1955 (Troitskaya).

550.38 **758**

Vertical Extrapolation of Geomagnetic Field Components.—A. Zmuda & L. McClung. (*Trans. Amer. geophys. Union*, Dec. 1955, Vol. 36, No. 6, pp. 939–942.) "In the region external to sources of magnetism, both the divergence and the curl of the magnetic intensity are zero. From the corresponding analytic expressions, the derivatives in the vertical direction of each field component are obtained in terms of the values of the components on a surface surrounding the sources. A Taylor series is formed with these derivatives and then used to continue, either upward or downward, the respective components. The rapidity of the convergence depends on the complexity of the surface field and on the distance of the computed point from the surface."

550.385 **759**

The Average Electric Current System for the Sudden Commencements of Magnetic Storms.—J. A. Jacobs & T. Obayashi. (*Geofis. pura appl.*, 1956, Vol. 34, No. 2, pp. 21–35. In English.) Report of a statistical investigation of world-wide current systems.

550.385 : 523.74 **760**

Relationships between Geomagnetic Micropulsations and Solar *UM* Regions.—Y. Kato & S. Akasofu. (*J. atmos. terr. Phys.*, Nov. 1956, Vol. 9, Nos. 5/6, pp. 352–354.)

551.510.535 **761**

Convective Diffusion in the Equatorial F Region.—J. W. Dungey. (*J. atmos. terr. Phys.*, Nov. 1956, Vol. 9, Nos. 5/6, pp. 304–310.) Phenomena discussed by Johnson & Hulburt (3045 of 1950) are considered further. The usual formula for the conductivity is inappropriate when diffusion is involved. The convective motion is regarded as that of a gravity-driven dynamo and its speed is controlled by the current flowing along the lines of force into lower levels of the ionosphere. The speed is inversely proportional to the east-west scale of the ionization irregularities present, and may be a few m/s for a scale of 100 m.

551.510.535 **762**

On the Deviate from the Mean Value of f_0F_2.—M. Mambo. (*J. Radio Res. Labs, Japan*, July 1956, Vol. 3, No. 13, pp. 181-187.) The relative deviation of the midnight value of f_0F_2 from its 27-day running-mean value is determined for the period 1949–1955 for Washington, Tokyo, Huancayo and Christchurch. Good correlation is found between all these stations; correlation with sunspot numbers is also good.

551.510.535 **763**

A Universal Formula for the Morning F_2 Ionization at European Stations.—O. Burkard. (*Geofis. pura appl.*, 1956, Vol. 34, No. 2, pp. 207–210. In German.) The following formula is derived from analysis of observations at 11 stations:

$$(f_0F_2)^2 = K\,(\cos\chi/\cos^2\phi)^x\cos^2\phi,$$

where x is the sun's zenith angle, ϕ the geographical latitude, x a parameter depending on locality and K a factor independent of locality.

551.510.535 **764**

The Occurrence of High Multiple Reflections from the F_2 Region of the Ionosphere based on a Study of the Ahmedabad Records.—R. G. Rastogi. (*Proc. Indian Acad. Sci.*, Section A, June 1955, Vol. 41, No. 6, pp. 253–260.) Observations are reported indicating that even at night the F_2 layer cannot be considered as a simple plane reflecting surface; dynamic changes are taking place most of the time. Photographs and graphical analyses of the records are presented.

551.510.535 : 523.3 **765**

The Measurement of the Electron Content of the Ionosphere by the Lunar-Radio-Echo Method.—J.V. Evans. (*Proc. phys. Soc.*, 1st Sept. 1956, Vol. 69, No. 441B, pp. 953–955.) Preliminary results are reported of determinations made using the technique indicated by Browne et al. (753 above). They indicate that the total electron content of the ionosphere is about twice that expected on the basis of a simple parabolic height distribution of electrons.

551.510.535 : 621.3.087.4 **766**

Design and Development of a Simple Ionospheric Equipment.—T.V.S. Murty. (*J. sci. industr. Res.*, Feb. 1956, Vol. 15A, No. 2, pp. 70–74.) Medium-power sounding equipment is described. The transmitter oscillator is excited by a separate pulser with variable pulse width. The equipment is manually operated and can be used with simple horizontal receiving dipoles.

551.510.535 : 621.396.11 **767**

Investigation of Winds in the Ionosphere by the Spaced-Receiver Method.—B. R. Rao, M. S. Rao & D. S. Murthy. (*J. sci. industr. Res.*, Feb. 1956, Vol. 15A, No. 2, pp. 75–81.) Results of measurements made during 1954 are presented in the form of polar diagrams showing the seasonal variations of wind movements in the E and F regions, and are compared with results obtained by several other workers.

551.510.535 : 621.396.11 **768**

Comparison of the Values of $(M3000)F_2$ at the Four Observatories in Japan.—I. Kasuya, K. Sawada & I. Yamashita. (*J. Radio Res. Labs, Japan*, July 1956, Vol. 3, No. 13, pp. 161–175.) A statistical analysis for the period 1948–1954 shows that variations of the $(M3000)F_2$ factor and hpF_2 are closely correlated and are considerably influenced by solar activity; seasonal and diurnal variations are regular functions of latitude.

551.510.535 : 621.396.11 **769**

The Focusing of Short Radio Waves Reflected from the Ionosphere.—Whitehead. (See 914.)

551.510.535 : 621.396.11 **770**

The Absorption of Radio Waves in an Ionospheric Layer.—Whitehead. (See 915.)

551.510.535 : 621.396.11 **771**

The Connection between Ionospheric Patterns and Field Strengths Reflected on the Ground.—Drummond. (See 916.)

551.577/.578 : 621.396.96 **772**

Factors Influencing Radar-Echo Intensities in the Melting Layer.—R. Wexler & D. Atlas: B. J. Mason. (*Quart. J. R. met. Soc.*, July 1956, Vol. 82, No. 353, pp. 349–351.) Comments on a previous paper by Mason (*ibid.*, 1955, Vol. 81, p. 262), together with his reply.

551.594.11 **773**

Short-Period Variations in the Atmospheric Electric Potential Gradient.—W. S. Whitlock & J. A. Chalmers. (*Quart. J. R. met. Soc.*, July 1956, Vol. 82, No. 353, pp. 325–336.) Measurements of the vertical gradient close to the earth's surface indicate that variations over periods of the order of minutes are generally caused by the horizontal motion of wind-borne space charge.

551.594.2 **774**

The Vertical Electric Current during Continuous Rain and Snow.—J. A. Chalmers. (*J. atmos. terr. Phys.*, Nov. 1956, Vol. 9, Nos. 5/6, pp. 311–321.) Investigations of the total current below nimbo-stratus clouds are reported.

551.594.2 **775**

Visible Electrical Discharges Inside Thunderclouds.—D. J. Malan. (*Geofis. pura appl.*, 1956, Vol. 34, No. 2, pp. 221–223. In English.) Photographs of lightning flashes in a transparent thundercloud are reproduced. They show that the negatively charged region reaches to an altitude of at least 8 km above ground and has a horizontal width of about 8 km.

551.594.22 **776**

The Relation between the Number of Strokes, Stroke Intervals and the Total Durations of Lightning Discharges.—D. J. Malan. (*Geofis. pura appl.*, 1956, Vol. 34, No. 2, pp. 224–230. In English.)

551.594.221 : 621.396.96 **777**

The Radar Observations of Lightning.—M. G. H. Ligda. (*J. atmos. terr. Phys.*, Nov. 1956, Vol. 9, Nos. 5/6, pp. 329–346.) Report of observations made with a horizontally scanning system. Various types of echo are distinguished, and radar displays are reproduced; one of the displays corresponds to a discharge estimated to be >100 miles long.

551.594.5 **778**

V.H.F. Auroral Noise.—T. R. Hartz, G. C. Reid & E. L. Vogan. (*Canad. J. Phys.*, July 1956, Vol. 34, No. 7, pp. 728–729.) A typical record is reproduced showing enhanced 32-Mc/s radiation observed at a time when the presence of aurora was indicated by other observations. Repeated observations of enhanced radiation on 32, 50 and 53 Mc/s give support to the view that the phenomenon has an auroral origin.

551.594.5 : 550.385 **779**

On the Ring-Current Hypothesis.—N. Wax. (*Chalmers tech. Högsk. Handl.*, 1956, No. 171, 32 pp.) Discussion indicates that experimental proof of the ring-current hypothesis is still lacking and that theories so far advanced are inadequate.

551.594.6 : 621.396.11.029.45 **780**

Investigation of the Propagation of Long and Very Long Radio Waves by the Analysis of Atmospherics Waveforms.—Al'pert & Borodina. (See 920.)

LOCATION AND AIDS TO NAVIGATION

621.396.93 **781**

Contributions to the Theory of Goniometers and Coordinate Transformers.—K. Baur. (*Frequenz*, July 1956, Vol. 10, No. 7, pp. 213-221.) Solutions for the magnetostatic boundary conditions and equations for the rotor-stator coupling factor and rotor voltage are derived and used to analyse the operation of a simple goniometer and of a coordinate transformer. The latter is a goniometer with two rotor coils at right angles to provide the two signals for the c.r.o. display when a multi-element aerial system is used. The reduction of system errors by a method of harmonic compensation is detailed and examples are given. The whole d.f. system is treated as a network to derive error equations. Errors introduced by the calibration equipment are also examined.

621.396.93.029.62/.63 **782**

Design of Height-Diversity U.H.F. Direction Finders.—J. A. Fantoni & R. C. Benoit, Jr. (*Tele-Tech & Electronic Ind.*, June 1956, Vol. 15, No. 6, pp. 90–92 . . 203.) Description of the U.S.A. Type-AN/CRD-6 equipment for the frequency range 225–400 Mc/s.

621.396.96 **783**

Design of ASDE Radar Equipment.—J. E. Woodward & D. R. Kirshner. (*Tele-Tech & Electronic Ind.*, June 1956, Vol. 15, No. 6, pp. 86–87 . . 186.). A description of 'airport surface detection equipment' for operation at a frequency of 24 kMc/s, under development for the U.S. Air Force.

621.396.96 : 551.577/.578 **784**

Factors Influencing Radar-Echo Intensities in the Melting Layer.—Wexler & Atlas: Mason. (See 772.)

621.396.96 : 621.376.23 **785**

A Radar Detection Philosophy.—W. M. Siebert. (*Trans. Inst. Radio Engrs*, Sept. 1956, Vol. IT-2, No. 3, pp. 204–221.) Discussion of possible methods for specifying radar system parameters from the desired performance, in terms of accuracy, freedom from ambiguity, and resolution. Signal energy and waveform are considered separately.

621.396.96 : 681.142 **786**

Radar Simulator trains Missile-Master Crews.—G. W. Oberle. (*Electronics*, Nov. 1956, Vol. 29, No. 11, pp. 155–157.) The 30-target simulator described is used to train personnel working with a special anti-aircraft fire-control computer.

MATERIALS AND SUBSIDIARY TECHNIQUES

533.5 **787**

Elementary Analogies between Vacuum and Electricity.—A. D. Degras. (*Le Vide*, July/Aug. 1956, Vol. 11, No. 64, pp. 155–162.) The use of equivalent circuits for analysing complex problems in rarefaction technique is discussed.

533.5 : 621.3.032.73 **788**

Equilibrium between Glass and Water Vapour at Bake-Out Temperatures.—B. J. Todd. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp. 1209–1210.) "The diffusion of water from glass is shown to be a reversible process. The equilibrium partial pressure of water for a soda-lime glass was 10 mm (Hg) at 500°C and 12 mm (Hg) at 550°C. In a very dry atmosphere the diffusion of water from the glass proceeded as well as in vacuum." For previous work, see 767 of 1956.

533.583 : 621.385 **789**

Absorption of Oxygen and Carbon Monoxide by Barium Alloy Getters.—R. N. Bloomer. (*Nature, Lond.*, 3rd Nov. 1956, Vol. 178, No. 4540, pp. 1000–1001.) Results obtained by Wagener (3012 of 1951 and 2685 of 1954) are discussed, and a brief account is given of experiments made to clear up uncertainty regarding the influence of an ionizing discharge on the pumping speed. Only a slight influence was observed in gettering oxygen, the magnitude of the effect being directly proportional to the electron current. The variation of the pumping speed with time and temperature is shown graphically. A catalytic effect is exercised by an incandescent tungsten filament. Results with CO differed from those obtained by Morrison & Zetterstrom (2632 of 1955).

535.215 : 537.311.33 : 546.482.21 **790**

The Photoelectric Properties of Cadmium Sulphide.—G. Wlérick. (*Ann. Phys., Paris*, July/Aug. 1956, Vol. 1, pp. 623–679.) Report of a comprehensive investigation. The effect of asymmetrical illumination on the photo-conduction in CdS(Cu) was studied using a symmetrical arrangement of Au electrodes; an asymmetrical (rectifying) effect was observed. The properties of the CdS/Au barrier were studied in detail, as were also those of the internal barrier separating the illuminated and non-illuminated regions of the CdS. From these results the relations between the surface and volume properties of the material were established. The observations can be explained satisfactorily in terms of a simple model introducing only donors and traps.

535.215 : [546.482.21+546.482.31 **791**

Photoconductivity Speed of Response for High-Intensity Excitation in Cadmium Sulphide and Selenide.—R. H. Bube. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp. 1237–1242.) Measurements on single crystals, sintered layers and evaporated layers, using a source at a temperature of 1 900°K giving an illumination of 1 740 f.c., indicated minimum rise times of 250 μs and minimum decay times of 300 μs for CdS with 17 μs and 8 μs as the corresponding figures for CdSe. These figures are for relatively insensitive materials; the variations with sensitivity are discussed. The results can be used to determine trap densities in the materials.

535.215 : 546.482.21 : 537.311.33 **792**

Diffusion Length of Charge Carriers in CdS.—J. Auth & E. A. Niekisch. (*Z. Naturf.*, Dec. 1955, Vol. 10a, No. 12, p. 1035.) A simple method is described for measuring the distribution of charge-carrier concentration in an illuminated photoconducting crystal with a pair of ohmic contacts, and formulae are presented from which the diffusion length can be determined.

535.215 : 546.817.221 : 539.232 **793**

Photoconductivity of Lead Sulphide Films.—G. W. Mahlman. (*Phys. Rev.*, 15th Sept. 1956, Vol. 103, No. 6, pp. 1619–1630.) Measurements are reported of the temperature variation of conductivity, the transient response, the dependence on illumination intensity, and the spectral characteristics, for chemically oxidized films.

535.215 : 546.817.221 : 539.232 **794**

Barrier Theory of the Photoconductivity of Lead Sulphide.—J. C. Slater. (*Phys. Rev.*, 15th Sept., 1956, Vol. 103, No. 6, pp. 1631–1644.) A theory is proposed according to which the high resistance of PbS films is associated with *n-p-n* barriers at the surfaces between the elementary crystallites, these barriers being formed in the oxidizing process used to prepare the films. Values of the various constants of the material deduced on this basis are in good agreement with values found experimentally by Mahlman (793 above).

535.35 : 546.472.21 **795**

Effect of Temperature on the Spectral Distribution of Blue Emission Bands of ZnS : I and Zns : Cu : I Phosphors.—R. E. Shrader & S. Larach. (*Phys. Rev.*, 15th Sept. 1956, Vol. 103, No. 6, p. 1899.) Experimental evidence indicates that the wavelength of the 'blue' emission from phosphors including Cu decreases as the temperature increases between 77° and 300°K; for phosphors without Cu the wavelength shift is in the opposite sense.

535.37 **796**

Luminescence of the Sulphide Phosphors.—P. F. Browne. (*J. Electronics*, Sept. 1956, Vol. 2, No. 2, pp. 154–165.) Discussion based on experimental results indicates that the numerous luminescence bands of ZnS, CdS CdSe and HgS arise from the breaking of a double covalent bond at lattice vacancies. The blue and green emissions arise from one centre, a cation vacancy, and are produced by interionic transitions. Interionic transitions adjacent to anion vacancies cause the 6 700-Å ZnS and the 2·2-μ HgS emissions. The infrared bands are due to transitions between S ion levels which have been shifted into the forbidden zone by the absence of a neighbouring cation. The introduction of Cu^+ into the vacancy does not affect the perturbed levels, but Ag^+ appears to act covalently, lowering one level again into the valence band.

535.37 **797**

Nature of Edge Emission in Cadmium Sulphide.—J. J. Lambe, C. C. Klick & D. L. Dexter. (*Phys. Rev.*, 15th Sept. 1956, Vol. 103, No. 6, pp. 1715–1720.) Experimental and theoretical evidence is reviewed to determine the part played by excitons in the edge emission. It is concluded that this emission results from recombination of a free hole with an electron trapped at an imperfection, but the nature of the centres involved is uncertain.

535.37 **798**

Multi-band Luminescence in Boron Nitride.—S. Larach & R. E. Shrader. (*Phys. Rev.*, 1st Oct. 1956, Vol. 104, No. 1, pp. 68–73.) This material can be excited to luminescence by alternating electric fields, u.v. radiation or cathode rays, the emission spectrum extending from about 2 950 Å to 6 500 Å in all cases. Investigations of the spectral distribution, the field dependence and the temperature dependence of the luminescence are reported.

535.37 : 546.472.21 **799**

Luminescence in ZnS : Cu,Cl Phosphors at High Cu Concentration.—

T. B. Tomlinson. (*J. Electronics*, Sept. 1956, Vol. 2, No. 2, pp. 166–178.) A detailed study of the nature of the emission centres in electroluminescent phosphors.

537.226/.227 **800**

Guanidinium Aluminium Sulphate Hexahydrate: Crystallographic Data.—E. A. Wood. (*Acta cryst.*, 10th July 1956, Vol. 9, Part 7, pp. 618–619.)

537.226/.227 **801**

On a Change of Dielectric Property of ($Ba_{0.5}Sr_{0.5}$) TiO_3 Ceramics due to Thermal Treatment.—S. Nomura. (*J. phys. Soc. Japan*, July 1956, Vol. 11, No. 7, pp. 803–804.) Preliminary results show that heat treatment affects the dielectric-constant/temperature characteristics and the Curie temperature. The latter increases with reduction of treatment temperature; below 1 100°C it becomes nearly constant. For $BaTiO_3$ the Curie temperature does not vary noticeably with treatment temperature.

537.226/.227 : 546.431.824-31 **802**

Investigation of the Dependence of the Permittivity and the Tangent of the Dielectric Loss Angle of Barium Titanate on the Strength of a High-Frequency Electric Field.—E.V. Sinyakov & V. V. Gal'pern. (*Zh. eksp. teor. Fiz.*, April 1956, Vol. 30, No. 4, pp. 675–680.) Results of an experimental investigation show that (*a*) the nonlinear properties of the material are less pronounced at a frequency of 1 Mc/s than at 50 c/s, (*b*) the nonlinear effects are most pronounced near the Curie temperature, and (*c*) tan δ depends only weakly on the field strength at 1 Mc/s. Results of measurements at field strengths up to about 16 kV/cm are presented graphically.

537.226/.227 : 546.431.824-31 **803**

Triple Hysteresis Loops and the Free-Energy Function in the Vicinity of the 5°C Transition in $BaTiO_3$.—E. J. Huibregtse & D. R. Young. (*Phys. Rev.*, 15th Sept. 1956, Vol. 103, No. 6, pp. 1705–1711.) The effect of an electric field on the transition between the orthorhombic and tetragonal states has been studied; the temperatures for the transitions in both directions are lowered by application of the field. When the field exceeds a certain value, both transition temperatures lie below 5°C, the lower transition temperature in the absence of the field; the crystal can thus be switched reversibly between the two states at constant temperatures in a small range below 5°C. This phenomenon can be displayed as a triple loop in the polarization/field characteristic.

537.226/.227 : 548.7 **804**

Dynamics of Ionic Lattices of Ferroelectric Crystals in Limiting Cases.—V. Kh. Kozlovski. (*Zh. eksp. teor. Fiz.*, April 1956, Vol. 30, No. 4, pp. 766–779.)

537.226.2/.31 **805**

Dielectric Properties of Castor Oil at High Pressure.—L. F. Vereschagin, L. F. Kuznetsov & T. I. Alaeva. (*Zh. eksp. teor. Fiz.*, April 1956, Vol. 30, No. 4, pp. 661–666.) Results are reported of an experimental determination of ε at pressure up to 9 050 kg/cm² and of tan δ at up to 7 100 kg/cm² at a frequency of 144 kc/s, up to 6 520 kg/cm² at 464 kc/s and up to 6 050 kg/cm² at 1·48 Mc/s. The maxima in the ε and tan δ curves are connected with the change of viscosity under pressure; at a temperature of 32°C ϵ_{max} is 5·25 at 3 600 kg/cm².

537.311.1 : 538.63 **806**

Quantum Theory of Electrical Conductivity of Metals in a Magnetic Field.—I. M. Lifshits. (*Zh. eksp. teor. Fiz.*, April 1956, Vol. 30, No. 4, pp. 814–816.)

537.311.3 **807**

The Electrical Conductivity of Composite Media.—E. H. Kerner. (*Proc. phys. Soc.*, 1st Aug. 1956, Vol. 69, No. 440B, pp. 802–807.) Analysis is presented for a composite medium containing grains distributed at random. The gross conductivity is a weighted superposition of the component conductivities, with weights containing the volume fractions of the components and an intensity factor depending on the average electric field for the whole medium and for each component. A discontinuity in the gross conductivity occurs in the limit when the grains coalesce. The analysis applies also to the thermal conductivity, the dielectric constant and the magnetic permeability of such media.

537.311.33+535.37 **808**

Semiconductors and Phosphors.—P. T. Landsberg. (*Nature, Lond.*, 24th Nov. 1956, Vol. 178, No. 4543, pp. 1156–1158.) Report of an international colloquium held at Garmisch, in Germany, from 28th August to 1st September 1956. Ninety papers were read, covering both the electronic properties and the manipulation of the materials.

537.311.33 **809**

Avalanche Injection in Semiconductors.—J. B. Gunn. (*Proc. phys. Soc.*, 1st Aug. 1956, Vol. 69, No. 440B, pp. 781–790.) Discussion indicates that additional charge carriers may be injected into a semiconductor by a thin region of high electric field in which avalanche multiplication occurs; negative resistance may be exhibited over a range of values of current. Experimental verification of these effects in Ge is described; the response time may be as short as 3×10^{-9} s. It is deduced from the results that any sufficiently small contact must act as a rectifier, independently of the presence of potential barriers.

537.311.33 **810**

Plasma Interaction and Conduction in Semiconductors.—H. Fröhlich & S. Doniach. (*Proc. phys. Soc.*, 1st Sept. 1956, Vol. 69, No. 441B, p. 961.) A brief theoretical note indicating that in many semiconductors a temperature range should exist over which the density of conduction electrons is sufficiently high to establish an appreciable number of plasma degrees of freedom but is lower than that required for degeneracy.

537.311.33 **811**

The Rational Definition of the Mobility of Charge Carriers in Semiconductors.—T. A. Kontorova. (*Zh. tekh. Fiz.*, March 1956, Vol. 26, No. 3, pp. 670–673.) Various definitions are considered; the numerical results obtained may differ between themselves by as much as 50%.

537.311.33 **812**

The Stoichiometry of Intermetallic Semiconductors.—R. J. Hodgkinson. (*J. Electronics*, Sept. 1956, Vol. 2, No. 2, pp. 201–203.) Theory given previously (3412 of 1956) is extended to systems where the vapour pressures are large.

537.311.33 **813**

Anomalous Lorenz Numbers in Mixed Semiconductors.—P. J. Price. (*Proc. phys. Soc.*, 1st Aug. 1956, Vol. 69, No. 440 B, pp. 851–854.) Results obtained by Goldsmid (2449 of 1956) are discussed and modifications to his formulae are proposed.

537.311.33 **814**

Optical Determination of the Temperature Dependence of the Energy Gap in Type-$A^{III}B^{V}$ Semiconductors.—F. Oswald. (*Z. Naturf.*, Dec. 1955, Vol. 10a, No. 12, pp. 927–930.) Energy-gap values derived from determinations of the position of the absorption edge over the frequency range 100°–500°K are reported.

537.311.33 : 538.632 **815**

The Hall Effect in Semiconductors.—R. Mansfield. (*Proc. phys. Soc.*, 1st Aug. 1956, Vol. 69, No. 440 B, pp. 862–865.) Approximations used by various workers in deriving expressions for the Hall constant of nondegenerate semiconductors are examined; corrections are shown to be necessary in certain cases.

537.311.33 : 546.231 **816**

Dependence of the Electrical Conductivity of Polycrystalline Selenium on Pressure up to 30 000 atm.—P. T. Kozyrev & D. N. Nasledov. (*C. R. Acad. Sci. U.R.S.S.*, 11th Sept. 1956, Vol. 110, No. 2, pp. 207–208. In Russian.) Results are presented graphically of measurements of the variation of conductivity with pressure at the temperatures of 22°, 55°, 76°, 97°, and 125° C, and of the variation of activation energy with pressure.

537.311.33 : 546.26-1 : 538.63 **817**

Hall Effect and Magnetoresistivity in Carbons and Polycrystalline Graphites.—S. Mrozowski & A. Chaberski. (*Phys. Rev.*, 1st Oct. 1956, Vol. 104, No. 1, pp. 74–83.)

537.311.33 : 546.28 **818**

The Evaporation of Impurities from Silicon.—S. E. Bradshaw & A. I. Mlavsky. (*J. Electronics*, Sept. 1956, Vol. 2, No. 2, pp. 134–144.) The influence of growth conditions and rate of evaporation on the concentration of impurities in a Si crystal grown in vacuum is discussed. When evaporation of volatile impurities from the melt is substantially complete before growth of the crystal is begun, B and Al are the only residual impurities from groups 3 and 5. An added impurity such as P is distributed uniformly in a crystal when the growth time from the moment of addition has a critical value. Repeated additions of an impurity such as Sb to a melt containing an impurity of opposite type produces a series of identical junctions. Equations describing the combined effects of evaporation and segregation are derived and the rates of evaporation of certain impurities calculated.

537.311.33 : 546.28 **819**

Copper Precipitation on Dislocations in Silicon.—W. C. Dash. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp. 1193–1195.) Preliminary report of studies made using a microscope and infrared-image converter. Photographs of the observed structures are reproduced.

537.311.33 : 546.28 **820**

On the Measurement of Minority-Carrier Lifetimes in Silicon.—C. A. Hogarth. (*Proc. phys. Soc.*, 1st Aug. 1956, Vol. 69, No. 440 B, pp. 791–795.) "It is shown that if high surface recombination rates can be corrected for or eliminated, then the travelling light spot method is very suitable for measurements of lifetimes in silicon since no ambiguities due to trapping effects are involved and since the measurement can readily be made on large sections of ingots instead of on carefully fashioned rods of rectangular section. Experimental results are given and treatments for the reduction of recombination velocities at surfaces of both *n*- and *p*-type silicon are described."

537.311.33 : 546.289 **821**

Surface Conductance and the Field Effect on Germanium.—J. Bardeen, R. E. Coovert, S. R. Morrison, J. R. Schrieffer & R. Sun. (*Phys. Rev.*, 1st Oct. 1956, Vol. 104, No. 1, pp. 47–51.) Measurements have been made of the variation of the surface conductance of Ge as a function of an applied transverse electric field in various atmospheres. The results are consistent with the existence of two surface states, one with high density and long time-constants, dependent on the atmosphere and located probably at the outer surface of an oxide layer, and the other with low density and short time-constants and located probably at the Ge/GeO interface. The interface states include at least one discrete state together with a small continuous distribution. Surface scattering effects apparently become important for large barrier layers.

537.311.33 : 546.289 **822**

Secular Solution of Cyclotron Resonances for Electrons in Germanium.—L. Gold. (*J. Electronics*, Sept. 1956, Vol. 2, No. 2, pp. 131–133.)

537.311.33 : 546.289 **823**

The Temperature Dependence of the Mobility of Electrons in Germanium.—D. M. Evans. (*Proc. phys. Soc.*, 1st Aug. 1956, Vol. 69, No. 440 B, pp. 845–846.) An investigation was made of *p*-type Ge by measurements on an *n-p-n* transistor; the method used was that described previously (2903 of 1956). The results indicate that the lattice-scattering mobility of electrons in the material varies as $T^{-1\cdot 66}$, in agreement with the results of Morin (1806 of 1954).

537.311.33 : 546.289 : 534.2-8 **824**

Frequency Dependence of Ultrasonic Attenuation in Germanium.—A. Granato & R. Truell. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp. 1219–1226.) Measurements were made of the attenuation of ultrasonic waves of frequencies 5–300 Mc/s, propagated in the [100] direction in Ge specimens with various resistivities. Damped forced oscillations of dislocation segments are considered responsible for the major component of the attenuation at frequencies > 20 Mc/s.

537.311.33 : 546.289 : 537.226 **825**

Effect of Neutral Impurity on the Microwave Conductivity and Dielectric Constant of Germanium at Low Temperatures.—F. A. D'Altroy & H. Y. Fan. (*Phys. Rev.*, 15th Sept. 1956, Vol. 103, No. 6, pp. 1671–1674.) Measurements were made at a temperature of 4°K and a frequency of 9·2 kMc/s. The dielectric constant found for pure Ge was $16 \cdot 0 \pm 0 \cdot 3$. Higher values, up to 80, were found for specimens doped with Sb or Ga. Polarization of neutral impurity atoms increases the dielectric constant; this effect is used to estimate the impurity ionization energy. The relaxation time and effective carrier mass are estimated from the ratio between the d.c. and microwave conductivities.

537.311.33 : 546.289 : 537.32 **826**

An Investigation of the Peltier Effect and Thermoelectric Forces in Germanium.—M. Shtenbek & P. I. Baranski. (*Zh. tekh. Fiz.*, March 1956, Vol. 26, No. 3, pp. 683–685.) The fundamental equations (1) and (2) relating the Peltier heat, Thomson coefficient and differential thermo-e.m.f. to one another do not necessarily follow from the first two laws of thermodynamics and therefore the first two of these quantities cannot be determined uniquely from measured values of the thermo-e.m.f. A method has been developed for direct measurement of the Peltier heat at a Ge-Cu contact. Some experimental curves are shown, and theoretical implications are discussed.

537.311.33 : 546.289 : 538.569.4 **827**

The Effect of High Electric Fields on the Absorption of Germanium at Microwave Frequencies.—J. B. Arthur, A. F. Gibson & J. W. Granville. (*J. Electronics*, Sept. 1956, Vol. 2, No. 2, pp. 145–153.) A decrease of microwave absorption has been observed in *n*-type Ge on application of an electric field. The effect is a consequence of the electron drift velocity tending to a limiting value at high field strengths. The variation of drift velocity with field strength shows significant departures from Ohm's law at field strengths as low as 10 V/cm.

537.311.33 : 546.289 : 539.23 **828**

Electron-Diffraction Study of the Crystallization and Oxidation of Thin Films of Germanium.—J. J. Trillat, L. Tertian & A. Fourdeux. (*Le Vide*, July/Aug. 1956, Vol. 11, No. 64, pp. 190–193.)

537.311.33 : 546.289-31 **829**

Energy Gap and Electrical Conductance of Hexagonal Germanium Dioxide.—H. A. Papazian. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp. 1253–1254.) Measurements are briefly reported.

537.311.33 : 546.817.221 **830**

Electrical Measurements on Natural Galena at Low Temperatures.—D. M. Finlayson & D. Greig. (*Proc. phys. Soc.*, 1st Aug. 1956, Vol. 69, No. 440 B, pp. 796–801.) Measurements of the Hall effect and resistivity of *n*-type crystals are reported; no appreciable change in the number of extrinsic electrons is indicated at temperatures down to 4°K. Mobility is proportional to $T^{-5/2}$ down to about 70°K; at low temperatures mobility varies with the density of extrinsic electrons in a manner which is not explained by present theories of scattering. It is estimated that in a purely intrinsic crystal of PbS the electron density would be 2×10^{15}.

537.311.33 : 548.0 **831**

Energy Levels of a Disordered Alloy.—R. H. Parmenter. (*Phys. Rev.*, 1st Oct. 1956, Vol. 104, No. 1, pp. 22–32.) Continuation of work reported previously (2331 of 1955). The perturbation treatment has extended application to the case when all minority constituents of the alloy have mole fractions $\ll 1$. The theory is applied to a study of the Ge-Si-alloy system.

537.311.33 : 621.315.61 **832**

Simplified Theory of Space-Charge-Limited Currents in an Insulator with Traps.—M. A. Lampert. (*Phys. Rev.*, 15th Sept. 1956, Vol. 103, No. 6, pp. 1648–1656.) Report of a study complementary to that of Rose (2647 of 1955). Limiting conditions of current flow are discussed, corresponding respectively to Ohm's law, Child's law for solids, and the case where the traps have all been filled prior to the application of voltage. Rigorous analysis is given for a material with a single discrete trap level, assuming an ideal ohmic electron-injecting contact and neglecting the contribution due to diffusion. The nonlinearity of the characteristic is of the same type as that previously attributed to the presence of distributed traps.

538.22 : 548.0 **833**

Crystallographic Studies of Perovskite-Like Compounds: Part 1—Rare-Earth Orthoferrites and $YFeO_3$, $YCrO_3$, $YAlO_3$.—S. Geller & E. A. Wood. (*Acta cryst.*, 10th July 1956, Vol. 9, Part 7, pp. 563–568.)

538.221 **834**

Magnetic After-Effects.—W. Holzmüller. (*NachrTech.*, July 1956, Vol. 6, No. 7, pp. 306–312.) The difference between relaxation and resonance-absorption effects in ferromagnetic materials is outlined, with a summary of the observations made by various authors. Spin and Bloch-wall resonances and resulting oscillations of included foreign particles and cavities are examined as causes of the resonance effects. Hysteresis loss may be due to Bloch-wall displacement and the emission of phonons by the inclusions; this may also give rise to noise voltages.

538.221 **835**

Analysis of the Magnetizing Current from the Magnetization Curve.—E. Festl. (*Arch. Elektrotech.*, 9th July 1956, Vol. 42, No. 6, pp. 351–366.) A direct method of harmonic analysis is derived which makes the plotting of the current unnecessary. Conversely, it also permits the display of the hysteresis loop from a plot of the magnetizing current. Within wide limits the magnetization curve can be approximated by a rectangular hyperbola, thus facilitating comparison of the characteristics of commercial-grade laminations.

538.221 **836**

Demagnetization of Magnets due to Contact with Ferromagnetic Bodies.—M. McCaig. (*J. sci. Instrum.*, Aug. 1956, Vol. 33, No. 8, pp. 311–312.) "If a bar magnet is placed a few times on a block of mild steel and removed by a sliding motion parallel to its length, a loss of magnetization of the order of 40% may occur. Over 3 mm thickness of protective material is necessary to keep losses below 1%."

538.221 **837**

Magnetically Soft Materials Embedded in Plastics.—R. Boll. (*Elektrotech. Z., Edn A*, 11th July 1956, Vol. 77, No. 14, pp. 483–487.) The resulting mechanical stresses affect differently the magnetic properties of various materials thus strengthened or impregnated; some measurements are reported. The use of special resins and methods can eliminate these effects; on the other hand, magnetic characteristics may be improved by the deliberate application of stresses [see also 2586 of 1954 (Williams et al.)].

538.221 **838**

Dynamax—a New Crystal and Domain-Oriented Magnetic Core Material.—G. H. Howe. (*Elect. Engng, N.Y.*, Aug. 1956, Vol. 75, No. 8, pp. 702–704.) Details are given of the properties of a high-μ Ni-Fe alloy produced in the form of a thin tape.

538.221 **839**

Magnetic Properties of Electrolytically Precipitated Thin Layers of Nickel.—L. Reimer. (*Z. Naturf.*, Dec. 1955, Vol. 10a, No. 12, pp. 1030–1031.) Brief report of experimental results. The variation of the coercive force with layer thickness is shown graphically for the freshly prepared layer at 20° C and for the layers after treatment at 200° C for two hours.

538.221 : 538.569.4 **840**

Multiple Ferromagnetic Resonance in Ferrite Spheres.—R. L. White & I. H. Solt, Jr. (*Phys. Rev.*, 1st Oct. 1956, Vol. 104, No. 1, pp. 56–62.) Measurements of microwave absorption in Mn- and Mn-Zn-ferrite spheres are reported; five major and seven minor resonance lines were observed over a 700-oersted range of variation of magnetic field. The results are interpreted in terms of complicated modes of precession of the bulk magnetization.

538.221 : 539.234 : 538.61 **841**

Magnification of the Magneto-optical Kerr Rotation by means of Evaporated Films.—J. Kranz. (*Naturwissenschaften*, Aug. 1956, Vol. 43, No. 16, pp. 370–371.) Technique for observing domain structure at the surface of ferromagnetic bodies is described.

538.221 : 621.318.13 **842**

Hysteresis in Magnetically Soft Materials.—R. Feldtkeller & H. Wilde. (*Elektrotech. Z., Edn A*, 1st July 1956, Vol. 77, No. 13, pp. 449–453.) Extension of the method of calculation indicated by Preisach (*Z. Phys.*, 1935, Vol. 94, Nos. 5/6, pp. 277–302), based on the statistical distribution of the elementary loops. By taking account of the elastic nature of the wall movements and assuming a Gaussian law of distribution the reversible permeability can be calculated [see also 1469 of 1956 (Wilde)] and an explanation found for special or anomalous forms of the hysteresis loop.

538.221 : 621.318.134 **843**

Study on Ferrites for Use in Magnetostriction Vibrators: Part 1—Ni-Zn Ferrite. Part 2—Ni-Cu Ferrite.—Y. Kikuchi, N. Tsuya, H. Shimizu, M. Terajima, A. Sugiyama, T. Hirone, S. Maeda & J. Shimoiizaka. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, June & Dec. 1955, Vol. 7, Nos. 1 & 3, pp. 1–7 & 171–178.)

538.221 : 621.318.134 **844**

The Temperature-Dependent Resistivity of Certain Iron-Deficient Magnesium Manganese Ferrites.—L. C. F. Blackman. (*J. Electronics*, Sept. 1956, Vol. 2, No. 2, pp. 199–200.) Critical comment on a paper by Osmond (3456 of 1956).

539.23 **845**

Preparation and Electron-Diffraction Study of Thin Films of Metal Alloys.—P. Michel. (*Ann. Phys., Paris*, July/Aug. 1956, Vol. 1, pp. 719–744.)

539.23 : 537.311.31 **846**

Resistivity of Very Thin Metal Films.—G. Darmois. (*C. R. Acad. Sci., Paris*, 8th Oct. 1956, Vol. 243, No. 15, pp. 1024–1026.) An approximate calculation indicates that the resistivity variations observed by Mostovetch (3031 of 1953) can be explained on the basis of very small differences in the size of the metal grains.

539.32 : [546.72 + 546.621 + 549.514.51 **847**

Dynamic Elastic Moduli of Iron, Aluminium and Fused Quartz.—D. S. Hughes & C. Maurette. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp. 1184–1186.) Measurements at pressures between 1 and 9 000 b and temperatures between 25° and 300° C (200° for quartz) were made using an ultrasonic pulse technique; linear variation of the elastic moduli with both pressure and temperature was observed.

621.315.61 **848**

X-Ray-Induced Conductivity in Insulating Materials.—J. F. Fowler. (*Proc. roy. Soc. A*, 11th Sept. 1956, Vol. 236, No. 1207, pp. 464–480.) "A model based on conduction by free electrons and including the presence of electron traps is proposed, and the theoretical predictions based thereon are shown to be in good agreement with the experimental results. The dependence of induced conductivity and of the subsequent decay upon temperature and dose rate have been investigated. Physical parameters are given for each material: recombination cross-section, number of traps and their distribution in energy, mean distance diffused by free electrons and probability factors of release from traps. The results suggest that when crystalline regions are present in a material (e.g. polyethylene), the boundaries of these regions provide trapping sites in addition to traps of unspecified nature which are present in completely amorphous materials."

621.315.61 **849**

The Effect of Air Inclusions on the Dielectric Strength and Losses of Insulating Materials.—Yu. M. Volokobinski. (*Zh. tekh. Fiz.*, March 1956, Vol. 26, No. 3, pp. 568–575.) The energy dissipation in an agglomeration of pores is investigated.

621.315.61 : 621.317.3 **850**

Investigations on Dielectric Materials for Component Development.—P. Henninger, G. Kremmling & H. Eisenlohr. (*Frequenz*, Aug. & Sept. 1956, Vol. 10, Nos. 8 & 9, pp. 241–252 & 286–291.) A survey of methods for detecting the effects of moisture, temperature and mechanical stresses on the performance and aging of solid and liquid dielectrics. To obtain an accurate assessment of material behaviour, tests should extend beyond the rating limits of temperature and frequency. The use of optical methods in conjunction with dielectric and magnetic measurements is increasing in importance.

621.315.612 : 546.28-31 **851**

Filaments of Silica.—B. E. Vassiliou. (*Nature, Lond.*, 17th Nov. 1956, Vol. 178, No. 4542, pp. 1131–1132.) Brief notes reporting observations of silica filaments of various diameters down to molecular dimensions, formed incidentally in the course of experiments with oxide compounds containing silica. The filaments exhibited strong e.s. charges which decayed slowly.

621.315.612.6 : 666 **852**

Dielectric Losses in Boro-alkaline Glasses at Low Temperatures.—V. A. Ioffe. (*Zh. tekh. Fiz.*, March 1956, Vol. 26, No. 3, pp. 516–525.) Report of measurements over the temperature range 12°–300°K at frequencies of $2{\cdot}4 \times 10^5$ and 10^6 c/s.

621.315.615 : 537.226 : 621.317.33 **853**

Dielectric Properties of Polar Solutes in Non-polar Solvents at Microwave Frequencies.—D. E. Clark & S. N. Kumar. (*Brit. J. appl. Phys.*, Aug. 1956, Vol. 7, No. 8, pp. 282–284.) Report of measurements on solutions of benzophenone over the temperature range 10°–30° C at a frequency of $9{\cdot}2 \times 10^9$ c/s, and of nitromethane over the range 10°–40° C at $3{\cdot}5 \times 10^{10}$ c/s.

621.315.616 **854**

Transient Electric Currents from Plastic Insulators.—R. J. Munick. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10, pp.

1114–1118.) Measurements were made on a number of plastics, at times ranging from 10 to 10^4 sec after a step voltage variation. The results are discussed in relation to possible mechanisms.

MATHEMATICS

512.831 : 621.372 **855**

The *N*th Power of a 2 × 2 Transfer Matrix.—D. T. Swift-Hook. (*Electronic Engng*, Nov. 1956, Vol. 28, No. 345, p. 505.) Relations useful in the analysis of iterated networks are discussed.

513 : 537.21 **856**

Calculation of Capacitance.—Harrison. (See 724.)

517 : 519.2 **857**

Some Discontinuous Stochastic Processes.—A. Dalcher. (*Z. angew. Math. Phys.*, 25th July 1956, Vol. 7, No. 4, pp. 273–304.) Methods are discussed for determining the distribution of a function x at time t, where x is subjected to random discontinuous variations and $x(t)$ is a solution to the differential equation $dx/dt = x(x,t)$ between the discontinuities.

517 : 535.42 **858**

Some Definite Integrals involving Conical Functions.—L. B. Felsen. (*J. Math. Phys.*, July 1956, Vol. 35, No. 2, pp. 177–178.) A method is presented for evaluating integrals occurring in the solution of diffraction problems.

MEASUREMENTS AND TEST GEAR

529.786 **859**

Stark-Modulation Atomic Clock.—I. Takahashi, T. Ogawa, M. Yamano, A. Hirai & M. Takeyama. (*Rev. sci. Instrum.*, Sept. 1956, Vol. 27, No. 9, pp. 739–745.) Details are given of an instrument in which particular attention has been paid to long-term stability.

621.3.018.41(083.74) : 621.314.7 **860**

A Transistor-Driven Tuning-Fork Frequency Standard.—F. Haas. (*Toute la Radio*, Sept. 1956, Vol. 23, No. 208, pp. 282–283.) The economical circuit described includes a junction transistor and is suitable for a 1·5-V battery supply.

621.314.7.001.4 **861**

A Transistor Tester.—(*Mullard tech. Commun.*, July 1956, Vol. 2, No. 19, pp. 248–253.) The instrument described permits the d.c. determination of current gain, collector leakage current and collector turnover voltage for grounded-emitter *p-n-p* junction transistors, to an accuracy within about 5%.

621.317.3 : 621.315.61 **862**

Investigations on Dielectric Materials for Component Development.—Henninger, Kremmling & Eisenlohr. (See 850.)

621.317.3 : 621.372.41 **863**

A New Method of Precise Measurement of Quadrantal Frequency-Difference [of resonators] **by applying Carrier-Suppressed Modulation.**—Y. Kikuchi, H. Shimizu & M. Terajima. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, June 1955, Vol. 7, No. 1, pp. 17–21.) The carrier frequency is made equal to the natural frequency of the resonator under test; the frequency of the modulating signal is adjusted so that the voltage across the resonator is $1/\sqrt{2}$ of that produced by the same current in a resistance equal to that of the resonator at resonance. The modulating frequency is then 1/2 of the required frequency difference.

621.317.3 : 621.372.5.012 **864**

The Measurement of the Efficiency of a Quadripole.—R. Harmegnies. (*Câbles & Transm.*, July 1956, Vol. 10, No. 3, pp. 207–214.) Three methods based entirely on impedance measurements are outlined; two are known [see 196 of 1955 (Mathis)], and the third uses simpler calculations, in particular, to evaluate the attenuation in nepers.

621.317.3 : 621.374.3 **865**

Measurement of Extremely Small Periodic Pulsed Voltages and Currents.—B. A. Mamyrin. (*Zh. tekh. Fiz.*, March 1956, Vol. 26, No. 3, pp. 652–658.) A method is proposed in which a large number of original pulses are stored and transformed into a single pulse of longer duration. The pulses so obtained are amplified and observed on the screen of an oscillograph. Such a transformation of the frequency composition of the periodic signal sharply reduces the frequency band to be amplified and results in an increase by one or two orders of the output signal/noise ratio in comparison with direct amplification of the original pulses by a wide-band amplifier.

621.317 : 311 : 538.632 **866**

The Measurement of High-Intensity D.C. with Hall-Effect Devices.—F. Kuhrt & K. Maaz. (*Elektrotech. Z., Edn A*, 11th July 1956, Vol. 77, No. 14, pp. 487–490.) Description of a simple system in which a busbar or apparatus carrying the current is embraced by an iron yoke having two gaps accommodating the Hall-effect devices.

621.317.328.084 : 621.372.413 **867**

Investigation of the Electromagnetic Field in Cavities using a Probe with High-Resistance Leads.—V. S. Lukoshkov, A. S. Bondarev & B. N. Shevtsov. (*Radiotekhnika i Elektronika*, April 1956, Vol. 1, No. 4, pp. 497–511.) The construction and use of a small probe are described. The accuracy of field-strength measurements is to within 5%.

621.317.335.2 : 621.318.42 **868**

Measurement of the Self-Capacitance of an Inductor at High Frequencies.—M. G. Scroggie: H. W. Lamson: J. P. Newsome. (*Electronic Engng*, Nov. 1956, Vol. 28, No. 345, pp. 504–505.) Comments on a paper by Newsome (3475 of 1956) and author's replies.

621.317.335.3 **869**

A New Method for computing the Compound Dielectric Constant from Ultra - high - Frequency Impedance Measurements.—K. V. G. Krishna. (*Trans, Faraday Soc.*, Aug. 1956, Vol. 52, No. 404, pp. 1110–1111.)

621.317.335.3 + 621.317.411].029.64 **870**

Measurement of the Complex Permittivity and Permeability of Magnetodielectrics at Centimetre Wavelengths.—V. I. Sarafanov. (*Radiotekhnika i Elektronika*, March 1956, Vol. 1, No. 3, pp. 320–328. Correction, *ibid.*, June 1956, Vol. 1, No. 6, p. 888.) A development of the cylindrical-cavity-resonator method [966 of 1946 (Horner et al.)] is reported. The resonance length and Q of the resonator are determined with the cavity first empty and then containing disk specimens of thickness d and $2d$ respectively. Alternatively, only one disk specimen is used and the resonance length and Q are also determined with the specimen placed so that the load is infinite. The formulae for calculating ϵ, μ, $\tan \delta_\epsilon$ and $\tan \delta_\mu$ are given.

621.317.34 **871**

Pulse Echo Meter for Coaxial-Line Repeater Sections.—G. Comte, M. Bouderlique & A. Ponthus. (*Câbles & Transm.*, July 1956, Vol. 10. No. 3, pp. 245–258.) Details are given of a mobile installation for use during cable laying or subsequently. The equipment produces raised cosine pulses of length 0·17 μs and incorporates circuits to correct phase and amplitude distortion and improve signal/noise ratio [see also 204 of 1955 (Oudin)]; use of a mechanical recorder eliminates observation errors.

621.317.35 : 621.396.41 **872**

Linearity Testing Techniques for Sideband Equipment.—P. J. Icenbice, Jr, & H. E. Fellhauer. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1775–1782.) "The basis for using the two-tone method of measurement is described by showing the types of nonlinear distortion products generated by the different orders of transfer characteristic curvature. Measurements by noise loading are described and it is shown that the results are essentially independent of the delay distortion characteristics of an amplifier. Descriptions of two basic types of distortion-measuring equipments, one using noise and the other using two tones, are given. Brief descriptions, photographs, and block diagrams are shown for audio-video and high-frequency spectrum measuring instruments."

621.317.7 : 538.632 **873**

Some New Types of Instruments using Semiconductors (New Applications of the Hall Effect).—V. N. Bogomolov. (*Zh. tekh. Fiz.*, March 1956, Vol. 26, No. 3, pp. 693–694.) The possibility of using the Hall effect in square-law and linear detectors and in frequency analysers is discussed.

621.317.7 : 621.374.3 **874**

Argonne 256-Channel Pulse-Height Analyser.—R. W. Schumann & J. P. McMahon. (*Rev. sci. Instrum.*, Sept. 1956, Vol. 27, No. 9, pp. 675–685.) An instrument is described of the type in which a number proportional to the amplitude is generated in response to the input pulse, and this is converted into a binary number. Magnetic-core storage is used. A c.r. tube display of the data, in the form of a plot of counts in each channel, is available during and after operation, as well as a permanent record. Pulse rates $>5 \times 10^6$/min can be handled.

621.317.7 : 621.376.23 : 621.396.822 **875**

The Measurement Threshold set by Statistical Fluctuation Effects in an Amplifier System.—T. Ankel & W. Wintermeyer. (*Ann. Phys., Lpz.*, 15th Aug. 1956, Vol. 18, Nos. 3/4, pp. 181–189.) The detection of signals in noise is analysed for systems using (*a*) phase-sensitive and (*b*) square-law rectifiers. If the pass band of the subsequent low-pass filter is small compared with that of the amplifier, the phase-sensitive system gives the lower threshold; if the amplifier has the smaller bandwidth, the two systems give the same results.

621.317.73 **876**

Selective Admittance-Measuring Set for Use at Medium Frequencies.—D. D. Crombie. (*Electronic Radio Engr*, Jan. 1957, Vol. 34, No. 1, pp. 11–15.) A resonance method is used; the selectivity necessary to remove interference, such as may arise when measurements are made on aerials, is obtained by using a homodyne voltmeter.

621.317.733 : 621.3.017.22 **877**

Eddy-Current Bridge for Measuring Skin Losses.—C. A. Kerns. (*Tele-Tech & Electronic Ind.*, June 1956, Vol. 15, No. 6, pp. 106–107..362.) Eddy currents are excited in a sample by induction from an energized loop, and a signal proportional to the loss is coupled out by a coaxial loop lying close to the surface. Flux leakage under the pickup loop produces a quadrature voltage which is balanced off by an adjustable loop close to the driving loop. Good accuracy is obtained even with surface resistance as high as that of graphite.

621.317.733 : 621.316.825 **878**

Improved Thermistor Bridge for R.F. Power Measurements.—(*Tech. News Bull. nat. Bur. Stand.*, Sept. 1956, Vol, 40, No. 9, pp. 134–135.) Using only one thermistor, the bridge has a range of 100 μW–100 mW, the corresponding limits of error being 5% and 0·05% respectively.

621.317.733 : 621.317.332.015.3 **879**

A Simple Bridge Circuit for the Accurate Measurement of Pulse Impedance.—J. B. Gunn. (*J. sci. Instrum.*, Sept. 1956, Vol. 33, No. 9, p. 364.) An arrangement is described using a c.r. tube with the anode connected to one of the deflecting plates. No separate h.v. supply or timebase is required; the screen display consists of a stationary spot.

621.317.74 : 621.397.6.001.4 **880**

Measuring Colour-Television Luminance vs Chroma Delay.—A. Ettlinger. (*Tele-Tech & Electronic Ind.*, June 1956, Vol. 15, No. 6, pp. 88–89..190.) A colour-bar generator is described which gives an encoder output of whose waveform the degree of symmetry provides a qualitative check of the delay.

621.317.75 **881**

A Waveform Recorder employing Sampling Techniques.—A. W. Gooder. (*J. Brit. Instn Radio Engrs*, Nov. 1956, Vol. 16, No. 11, pp. 623–631.) "The instrument provides a permanent record on a pen recorder of oscilloscope traces of recurrent waveforms. The X sweep voltage from the oscilloscope is used in the recorder to determine once per sweep the time at which a 0·5-μs pulse is to be generated. The recorder is 'gated' by the pulse to produce a sample of the amplitude of the waveform, which is peak rectified, and applied to the recorder."

621.317.755 **882**

The Cathode-Ray Oscillograph.—(*Elektronik*, Aug. 1956, Vol. 5, No. 8, pp. 201–226.) A group of articles covering the latest developments in c.r.o. technique with details of special circuitry, c.r. tubes and applications, particularly in television testing.

621.317.755 : 621.373.44 **883**

A High-Voltage Pulse Generator and Tests on an Improved Deflecting System of a Cold-Cathode Oscillograph.—H. N. Cones. (*J. Res. nat. Bur. Stand.*, Sept. 1956, Vol. 57, No. 3, pp. 143–152.) Description of apparatus for high-voltage surge testing, designed to minimize errors due to transit time and to impedance mismatch between the signal coaxial cable and the deflector; the generator produces single pulses with durations of the order of millimicroseconds.

621.317.755 : 621.374.33 **884**

Synchronizing Low-Frequency Pulses with a High-Frequency Free-Running Timebase.—M. V. L. Bennett. (*Electronic Engng*, Nov. 1956, Vol. 28, No. 345, pp. 496–498.) A gating circuit is described which allows a pulsing unit driven by a low-frequency oscillator to be synchronized with a high-frequency free-running timebase. The arrangement was designed particularly for electrophysiological applications where stimuli may be applied only at intervals long compared to response time. The circuit includes a new type of bistable trigger.

621.317.755 + 621.385.8].029.63/.64 **885**

Oscillograph for Investigating U.H.F. Oscillations and some Results of its Application in the Study of Pulsed Magnetrons.—A. M. Chernushenko. (*Radiotekhnika i Elektronika*, March 1956, Vol. 1, No. 3, pp. 381–392.) A special c.r. tube is described for the display and photographic recording of high-speed transients. The first (signal) pair of deflector plates is replaced by a cavity resonator which is practically aperiodic at wavelengths of 8–12 cm. Post-deflection acceleration is not used. The timebase is designed to provide for writing speeds of $10^4 - 5 \times 10^2$ km/s; it can be synchronized with each pulse, or it can be triggered by a single pulse to give a single sweep or 50 sweeps per sec. Complete circuit diagrams are given. The application of the oscilloscope in the study of pulsed magnetron oscillations is described and illustrated by oscillograms.

621.317.769.029.3 + 621.318.57] :621.314.7 **886**

Three New Transistor Circuits.—Hekimian. (See 693.)

621.317.78.029.6 : 621.316.825 **887**

A Microwave Thermistor Calorimeter.—M. J. Smith & J. R. M. Vaughan. (*J. sci. Instrum.*, Sept. 1956, Vol. 33, No. 9, pp. 353–356.) A continuous-flow instrument is described, for measuring powers down to a few mW. The circuit is a direct-reading four-thermistor d.c. bridge indicating degrees of temperature rise and watts at a standard rate of water flow on a specially calibrated microammeter. Mathematical analysis is presented covering compensation for variations of ambient temperature and correction for internal heat losses. The error is probably $< \pm 10\%$ for powers $>$ 1 W at 8–9 mm λ with a reading time of a few seconds.

621.317.794.029.6 **888**

A Semiconducting Antimony Bolometer.—E. J. Gillham. (*J. sci. Instrum.*, Sept. 1956, Vol. 33, No. 9, pp. 338–341.) Description of an instrument using a thin film of 'amorphous' Sb sputtered on to a plastic pellicle; the resulting resistance of the film is suitable for matching into a valve amplifier.

621.389 : 539.155.082.7 **889**

Non-magnetic Mass Spectrometers.—L. W. Kerr. (*J. Electronics*, Sept. 1956, Vol. 2, No. 2, pp. 179–198.) A general theory of r.f. 'energy-gain' mass spectrometers is presented, based on a Fourier analysis of the r.f. analyser field. The performance of instruments in this class is compared with that of magnetic mass spectrometers.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

534.232-8 : 538.652 **890**

Magnetostrictive Transducers with Mechanical Loads.—R. R. Whymark. (*Acustica*, 1956, Vol. 6, No. 3, pp. 277–287.) The influence of loads comprising thin stubs on a window-type transducer is considered theoretically and checked by measurements. Liquid loads are simulated with high-loss structures. An optimum value of 42% is observed for the electromechanical efficiency; this is in good agreement with the value predicted from theory.

550.8 : 621.387.4 **891**

An Airborne Computer-Controlled Detector for Radioactive Ores.—E. J. Frank. (*J. Brit. Instn Radio Engrs*, Nov. 1956, Vol. 16, No. 11, pp. 633–645. Correction, p. 621.)

621-52 : 621.395.625.3 **892**

Delay Unit using Magnetic Recording.—V. A. Ivanov. (*Avtomatika i Telemekhanika*, April 1956, Vol. 17, No. 4, pp. 324–328.) A variable-speed recorder used in conjunction with a set of magnetic-tape loops of various lengths can be used for producing delays between 0·5 s and 20 min in signals of frequencies up to 10 c/s for purposes of automatic control. The signal is recorded using a carrier frequency of 820 c/s with a.m., or, in the case of a d.c. signal, f.m.

621-52 : 621.9 **893**

Machine Tool Control.—C. K. Marklew. (*Elect. Rev., Lond.*, 3rd Aug. 1956, Vol. 159, No. 5, pp. 189–193.) A brief survey of electronic control systems using punched tape, cinematograph film, magnetic tape, photocell devices, etc.

621.317.39 : 531.71 : 538.63 : 537.311.33 **894**

A Magnetoresistance Displacement Gauge.—I. M. Ross & E. W. Saker. (*Nature, Lond.*, 24th Nov. 1956, Vol. 178, No. 4543, p. 1196.) The stylus displacement to be measured causes an InSb crystal to move relative to a permanent magnet whose poles are shaped to provide a strong field gradient; in a practical arrangement, two InSb crystals are used in a bridge. A galvanometer deflection of 5 mm has been obtained for a stylus movement of 1 μ.

621.317.79 : 531.7 **895**

Transducer Characteristics.—H. G. M. Spratt. (*Electronic Radio Engr*, Jan. 1957, Vol. 34, No. 1, pp. 2–8.) "The principles of transducers employed for the measurement of the vibration of and strain in mechanical bodies are explained and some representative types are described."

621.384.6 **896**

Fixed - Field Alternating - Gradient Particle Accelerators.—K. R. Symon, D. W. Kerst, L. W. Jones, L. J. Laslett & K. M. Terwilliger. (*Phys. Rev.*, 15th Sept. 1956, Vol. 103, No. 6, pp. 1837–1859.) Radial-sector and spiral-sector types of fixed-field alternating-gradient accelerators are described. The former are simpler to construct; the latter occupy a smaller volume for a given particle energy. Analysis for the orbits is presented. The principles discussed have applications in the design of fixed-field synchrotrons, betatrons and high-energy cyclotrons.

621.384.6 **897**

On Exceeding the Critical Energy in a Strong-Focusing Accelerator.—A. A. Kolomenski & L. L. Sabsovich. (*Zh. tekh. Fiz.*, March 1956, Vol. 26, No. 3, pp. 576–584.) When the energy of particles in an accelerator reaches a certain critical value the normal operating conditions are disturbed. Under certain conditions, a transition through this value is possible without affecting the operation of the accelerator.

621.384.612 **898**

Radiation Resonance in Synchrotrons.—A. N. Matveev. (*Zh. eksp. teor. Fiz.*, April 1956, Vol. 30, No. 4, p. 804.) The resonance due to radiation results in an increase in the amplitude of betatron oscillations.

621.384.622.1 **899**

Ion-Beam Focusing in a 200-kV [linear] **Accelerator.**—D. Kamke & H. Seguin. (*Z. Naturf.*, Dec. 1955, Vol. 10a, No. 12, pp. 1036–1038.) Results of calculations and measurements are compared.

621.385.833 **900**

Focal Properties and Chromatic and Spherical Aberrations of the Three-Electrode Electron Lens.—G. D. Archard. (*Brit. J. appl. Phys.*, Sept. 1956, Vol. 7, No. 9, pp. 330–332.) "Published theoretical and experimental values of the focal lengths of simple three-electrode electron lenses are compared and found to be in general agreement. These are presented in the form of graphs which show directly the dependence of focal length on lens geometry and voltage ratio. Analogous graphs are derived for spherical and chromatic aberrations in the form of the ratios C_S/S and C_C/S (S being the separation of adjacent electrodes), and the general relation between the various curves is discussed."

621.385.833 **901**

Study of the Leakage Fields of a Four-Pole Magnetic Lens.—A. Septier. (*C. R. Acad. Sci., Paris*, 8th Oct. 1956, Vol. 243, No. 15, pp. 1026–1029.)

621.385.833 **902**

Use of a Four-Pole Magnetic Lens to Reduce Image Distortion in Reflection Electron Microscopy.—C. Fert & R. Saporte. (*C. R. Acad. Sci., Paris*, 15th Oct. 1956, Vol. 243, No. 16, pp. 1107–1110.)

621.385.833 **903**

Study of the Effective Length of a Four-Pole Magnetic Lens and of its Variations over the Gap.—A. Septier. (*C. R. Acad. Sci., Paris*, 29th Oct. 1956, Vol. 243, No. 18, pp. 1297–1300.)

621.385.833 **904**

Improvement of the Resolving Power of the Emission-Type Electron Microscope.—C. Fert & R. Simon. (*C. R. Acad. Sci., Paris*, 29th Oct. 1956, Vol. 243, No. 18, pp. 1300–1303.) Description of an instrument with which a resolving power of 300 Å has been attained. The cathode emission is produced by ion bombardment, and a beam-limiting diaphragm is used.

621.385.833 **905**

Scanning Electrometer for Electron Microscopy.—G. F. Bahr, L. Carlsson & G. Lomakka. (*Rev. sci. Instrum.*, Sept. 1956, Vol. 27, No. 9, pp. 749–750.) An arrangement for direct measurement of electron intensities in the image plane of an electron microscope comprises probe with preamplifier, mechanical drive, amplifier and recording device.

621.395.625.3 **906**

Magnetic Head has Megacycle Range.—O. Kornei. (*Electronics*, Nov. 1956, Vol. 29, No. 11, pp. 172–174.) A range of recording heads for high frequencies have ferrite cores with the gap defined by means of thin pole shoes made of 16-alfenol, with coatings of silicon monoxide. Recording at pulse densities up to 2 500/in. is feasible.

621.398 : 629.13 **907**

'Jindivik' — Radio-Controlled Aircraft.—E. W. Baynton, B. S. Deegan & R. W. Leslie. (*Proc. Instn Radio Engrs, Aust.*, Aug. 1956, Vol. 17, No. 8, pp. 267–277.) "The Jindivik is a jet powered target aircraft, which is controlled by radio either from a ground station or from a shepherd aircraft. The switching method of control is used; the control signals transmitted over the radio link specify the required flight manoeuvres which are carried out under the control of the automatic pilot system. An f.m./a.m. telemetry system based on inductance-type transducers transmits flight data back to the ground controller. Twin-track magnetic tape equipment records the control and telemetry signals throughout each trial for subsequent study."

681.84 : 621.37/.38 **908**

Punched-Card Reader for the Blind.—F. Dado, V. Proscia & M. Raphael. (*Electronics*, Nov. 1956, Vol. 29, No. 11, pp. 148–149.) Brushes attached to a slider move in parallel lines over the punched card, closing circuits through the perforations so as to produce coded tones. A linear braille scale is provided on the card.

621.38 **909**

Static and Dynamic Electron Optics. [Book Review]—P. A. Sturrock. Publishers: University Press, Cambridge, 1955, 30s. (*Proc. phys. Soc.*, 1st Sept. 1956, Vol. 69, No. 441 B, p. 962.) "This book will be indispensable to all those who want to do original work in electron optics or on particle accelerators. . . ."

PROPAGATION OF WAVES

621.396.11 **910**

The Calculation of Radio [wave] **Refraction.**—D. M. Vysokovski. (*Radiotekhnika i Elektronika*, March 1956, Vol. 1, No. 3, pp. 274–276.) Expressions for the angle of refraction in the form of an integral and of a power series are briefly considered. Conditions are formulated for the refraction to be independent of the height distribution of the refractive index.

621.396.11 **911**

Influence of the Height Distribution of the Permittivity of Air on the Refraction of Radio Waves in the Lower Layers of the Atmosphere.—A. V. Shabel'nikov. (*Radiotekhnika i Elektronika*, March 1956, Vol. 1, No. 3, pp. 227–280.) Results of calculations indicate that the angle of refraction is practically independent of the form of the function $\epsilon(h)$ for angles of elevation $\geqslant 10°$ on arrival.

621.396.11 **912**

Comparative Performances of High-Frequency Radio-Telegraph Circuits during Disturbed Conditions.—R. J. Hitchcock. (*Electronic Engng*, Nov. 1956, Vol. 28, No. 345, pp. 476–481.) The performances of the Melbourne-London and Nairobi-London circuits for the sunspot-minimum period September 1952 to

January 1955 were analysed by the superposed-epoch method, the performance of the New York-London circuit being taken as the basis for defining disturbed ionospheric conditions. Curves are also shown for the Montreal-London and Capetown-London circuits for the sunspot maximum period July 1946 to October 1949. Examination of the data indicates that while high-latitude routes deteriorate during disturbed periods, the performance of other routes may be unaffected or may even improve.

621.396.11 : 550.385 : 523.7 **913**

On Radio Propagation Disturbances.—K. S[h]inno. (*J. Radio Res. Labs, Japan*, July 1956, Vol. 3, No. 13, pp. 155–160.) Propagation disturbances associated with solar M regions, having a 27-day recurrence period, are more severe than those associated with non-recurrent magnetic storms. Forecasts of disturbance are more accurate during the decreasing half-cycle of solar activity.

621.396.11 : 551.510.535 **914**

The Focusing of Short Radio Waves Reflected from the Ionosphere.—J. D. Whitehead. (*J. atmos. terr. Phys.*, Nov. 1956, Vol. 9, Nos. 5/6, pp. 269–275.) "It is shown that short-lived increases in the mean amplitude of waves reflected from the F region of the ionosphere are the result of focusing effects caused by large-scale distortions moving horizontally. The velocity of the movement can be determined from simultaneous observations of changes in the amplitude and the phase. It proves to be of the same order as that found at the same time for the small irregularities. There is a marked diurnal variation in the number of amplitude increases caused by focusing."

621.396.11 : 551.510.535 **915**

The Absorption of Radio Waves in an Ionospheric Layer.—J. D. Whitehead. (*J. atmos. terr. Phys.*, Nov. 1956, Vol. 9, Nos. 5/6, pp. 276–281.) "The absorption of radio waves travelling vertically through or reflected in a Chapman layer is investigated by a method which takes into account the presence of the earth's magnetic field. The disturbance of the absorption along the path is considered, and it is shown that when the wave is reflected inside the layer an important contribution to the absorption occurs near the level of reflection."

621.396.11 : 551.510.535 **916**

The Connection between Ionospheric Patterns and Field Strengths Reflected on the Ground.—J. E. Drummond. (*J. atmos. terr. Phys.*, Nov. 1956, Vol. 9, Nos. 5/6, pp. 282–294.) "If the ionosphere is regarded as a plane, patchy reflector, it can be shown by using Doppler shift theory and wave theory that drift and turbulent processes with periods less than $\lambda/2\sin\alpha$ (λ is the radio wavelength and 2α is the angle subtended by the reflecting area on the ground) do not produce patterns on the ground and other short-length processes are attenuated. The correlogram of the reflected signal is also correspondingly modified, and some ionospheric observations are examined in the light of this theory."

621.396.11 : 551.510.535 **917**

The Calculation of Group Velocity in Magneto-ionic Theory.—R. F. Mullaly. (*J. atmos. terr. Phys.*, Nov. 1956, Vol. 9, Nos. 5/6, pp. 322–325.) "It is shown how the magneto-ionic refractive index μ^1 may be calculated as a function of the direction of propagation θ by expressing both these quantities in simple form in terms of a parameter λ, which is given a series of values. A similar method gives μ as a function of the electron density for a fixed value of θ. Whereas most computations of μ' made up to the present have required electronic calculating machines, the simplified formulae given here are suitable for use with a desk calculator. Throughout, the effect of collisions in the medium is neglected."

621.396.11 : 551.510.535 **918**

On the Degree of Suitability of Ionospheric Prediction.—H. Shibata, Y. Arima & T. Oguchi. (*J. Radio Res. Labs, Japan*, July 1956, Vol. 3, No. 13, pp. 177–180.) A statistical method for comparing quantitatively the predicted values of f_0F_2 with observed values is described. An example taken from figures for Tokyo shows satisfactory results.

621.396.11.029.45 **919**

Calculation of the Field Strength of Long and Very Long Radio Waves above the Earth's Surface in Practical Conditions.—Ya. L. Al'pert. (*Radiotekhnika i Elektronika*, March 1956, Vol. 1, No. 3, pp. 281–292.) Results are presented of calculations of propagation at frequencies of 500 c/s–30 kc/s, taking into account the inhomogeneity of the ionosphere and the frequency dependence of the conductivity. Analysis of the wave interference factor $Ae^{i\phi}$ shows that A and ϕ depend on distance and frequency in a complex and irregular way; the various functions involved in the calculations are tabulated and graphs are shown of the modulus of the interference factor and the differential and mean phase velocities, all as functions of distance. Graphs are also shown of the field strength at various distances as a function of frequency. The calculated results are in fair agreement with published experimental results.

621.396.11.029.45 : 551.594.6 **920**

Investigation of the Propagation of Long and Very Long Radio Waves by the Analysis of Atmospherics Waveforms.—Ya. L. Al'pert & S. V. Borodina. (*Radiotekhnika i Elektronika*, March 1956, Vol. 1, No. 3, pp. 293–308.) The method described involves the harmonic analysis of oscillograms of single lightning discharges and the goniometric determination of their origin. The equipment used is briefly described and block diagrams are given. The results obtained for the dependence of the field strength and mean phase velocity on the frequency and distance are, in general, in good agreement with calculated results.

621.396.11.029.6 : 621.396.677.83 **921**

The Deflection of Short Electromagnetic Waves.—G. Megla. (*Hochfrequenztech. u. Elektroakust.*, July 1956, Vol. 65, No. 1, pp. 15–36.) Control of field-strength at points beyond the horizon by using diffraction and refraction effects and deflecting reflecting aerials is discussed. Various shapes and combinations of reflectors are examined. Quantitative assessments are made of the limits within which these effects are usable. Measurements made using wavelengths of 6·2, 3·2 and 1·5 m and 20 and 10 cm are reported.

621.396.11.029.62 **922**

Taking Account of Aerial Height in the Theory of Tropospheric Scattering of Metre-Wavelength Radio Waves.—O. I. Yakovlev. (*Radiotekhnika i Elektronika*, March 1956, Vol. 1, No. 3, pp. 309–312.) A development of the work of Booker & Gordon (1757 of 1950) and Gordon (1136 of 1955) is reported. A formula is derived for the attenuation of the scattered power relative to the free-space power; the diffraction field and the effect of super-refraction are neglected, but the effect of the ground-reflected wave is taken into account. This function is plotted against aerial height in wavelengths, and against the distance between the aerials, with $f(H)$, a function of the dielectric inhomogeneity of the troposphere, as parameter.

621.396.11.029.62 : 523.5 **923**

Meteoric Echoes Observed Simultaneously by Back-Scatter and Forward Scatter.—D. W. R. McKinley & A. G. McNamara. (*Canad. J. Phys.*, July 1956, Vol. 34, No. 7, pp. 625–637.) "Simultaneous observations of back-scatter and forward-scatter meteoric echoes have been made by means of a high-power 33 Mc/s pulse transmitter at Ottawa, with identical receiving systems at Ottawa and at Scarboro, 337·8 km distant. Two-way transmissions, employing a low-power transmitter at Scarboro, were also used to measure absolute time delays. The approximate positions of each meteor was plotted from the observed time delays, which enabled corrections to be applied to the echo durations for variations in antenna patterns and other factors, and which also determined the forward-scatter angle, 2ϕ, for each meteor. In the majority of cases an enhancement was observed in the forward-scatter duration relative to the back-scatter duration. The data were divided into a short-duration or underdense group and a long-duration or overdense group. Assuming a theoretical forward-scatter enhancement proportional to $\sec^m\phi$, it was found that the exponent, m, was 1·73 for the underdense group and 1·13 for the overdense group."

621.396.812.3.029.6 **924**

Fading of Ultra-short Waves and its Relation to the Meteorological Conditions.—K. Hirao. (*J. Radio Res. Labs, Japan*, July 1956, Vol. 3, No. 13, pp. 189–255.) Observations taken in Japan on a frequency of 65·82 Mc/s are discussed in relation to interference fading due to large-scale irregularities of refractive index, and scintillation fading caused by atmospheric turbulence. A specially designed semi-manual record reader and a relay computer used for autocorrelation analysis of data are described and the results are related to meteorological conditions in the lower atmosphere, quantitative conclusions being drawn.

RECEPTION

621.376.23 : 621.3.018.7 **925**

Detection of Pulses with Complex Form.—E. L. Gerenrot. (*Radiotekhnika i Elektronika*, April 1956, Vol. 1, No. 4, pp. 438–442.) Transient processes in an ideal pulse detector are considered, assuming that the source impedance cannot be neglected. A general method of calculating the voltage appearing across the load is given for signal pulses of arbitrary shape.

621.376.233 : 621.3.018.7 **926**

Transient Processes in the Detection of Weak Signals.—L. S. Gutkin. (*Radiotekhnika i Elektronika*, April 1956, Vol. 1, No. 4, pp. 433-437.) Analysis of the transient processes in a crystal-diode detector is presented. A formula is derived for the distortion of a pulse of arbitrary shape.

621.396.3 : 621.376.4 **927**

Elimination of 'Reverse Operation' in an Amplitude-Phase Detector due to Fluctuation Interference.—Yu. S. Lezin. (*Radiotekhnika i Elektronika*, March 1956, Vol. 1, No. 3, pp. 329–334.) The probability is calculated of the occurrence of a change of polarity of the output voltage in an amplitude-phase telegraphy detector due to fluctuation-type interference. Results indicate that if the signal/noise ratio at the input of the detector is greater than unity, then the probability can be made negligibly small by narrowing the pass band of the tuned detector circuit relative to that of the i.f. amplifier. A circuit diagram of the amplitude-phase detector is given and its operation is briefly described.

621.396.62 : 621.396.41 **928**

The Phase-Shift Method of Single-Sideband Signal Reception.—D. E. Norgaard. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1735–1743.) Analysis complementary to that for s.s.b. signal generation (955 below) is presented. Zero-frequency signals derived by demodulators from a transmitted pilot carrier may be used for control of gain and frequency in the receiver.

621.396.621 : 621.396.41 **929**

Factors Influencing Single-Sideband-Receiver Design.—L. W. Couillard. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1750–1753.) The factors considered include frequency stability, cross modulation, gain distribution and diversity combining.

621.396.621.54 : 621.376.3 : 621.314.7 **930**

Transistorized Receiver for Mobile F.M.—A. M. Booth[e]. (*Electronics*. Nov. 1956, Vol. 29, No. 11, pp. 158–161.) A receiver for mass production uses printed circuits and 19 available-type transistors. It operates on a 12·5-Mc/s signal produced as an i.f. by a valve tuner covering the band 20–70 Mc/s. Temperature variations from −67° to +149°F and simultaneous supply-voltage variations from 22 to 30 V are tolerable. A limiter stage and a Foster-Seeley discriminator are included.

621.396.822 : 621.376.23 : 519.2 **931**

On the Distribution of the Product of Diode Detector Waveforms.—E. L. R. Webb. (*Canad. J. Phys.*, July 1956, Vol. 34, No. 7, pp. 679–691.) "The probability distribution of the product of two waveforms such as come from the diode second detectors of radio receivers is examined over the whole range of signal to noise ratios. Computed curves of probability density are given for small and moderate values of signal to noise ratio and the limiting form for large signal to noise indicated. The pure noise case is the only one immediately available in terms of tabulated functions. Compared to the Rayleigh distribution it rises much faster, reaches its maximum sooner and lower, and decays much more slowly. The very large signal to noise ratio case approaches an impulse function. Estimates of mean and variance are given."

STATIONS AND COMMUNICATION SYSTEMS

621.3.018.7 **932**

Signals of Finite Duration, containing Maximum Energy for a Given Bandwidth.—M. S. Gurevich. (*Radiotekhnika i Elektronika*, March 1956, Vol. 1, No. 3, pp. 313–319.) A mathematical paper on a problem similar to that discussed by Chalk (1518 of 1950).

621.39.001.11 **933**

1956 Symposium on Information Theory.—(*Trans. Inst. Radio Engrs*, Sept. 1956, Vol. IT-2, No. 3.) The text is given of papers presented at a symposium held at the Massachusetts Institute of Technology in September 1956, including the following:

The Zero Error Capacity of a Noisy Channel.—C. E. Shannon (pp. 8–19).

A Linear-Circuit Viewpoint on Error-Correcting Codes.—D. A. Huffman (pp. 20–28).

Theory of Information Feedback Systems. —S. S. L. Chang (pp. 29–40).

A Linear Coding for Transmitting a Set of Correlated Signals.—H. P. Kramer & M. V. Mathews (pp. 41–46).

On an Application of Semi-group Methods to some Problems in Coding.—M. P. Schützenberger (pp. 47–60).

An Extension of the Minimum Mean-Square Prediction Error Theory for Sampled Input Signals.—M. Blum (pp. 176–184).

A New Interpretation of Information Rate.—J. L. Kelly, Jr (pp. 185–189).

An Outline of a Purely Phenomenological Theory of Statistical Thermodynamics: Part I—Canonical Ensembles.—B. Mandelbrot (pp. 190–203).

Abstracts of these papers appear in *Proc. Inst. Radio Engrs*, Nov. 1956, Vol. 44, No. 11, pp. 1643–1644.

621.39.001.11 **934**

Theory of Ideal Coding of a Binary Transmission.—V. I. Siforov. (*Radiotekhnika i Elektronika*, April 1956, Vol. 1, No. 4, pp. 407–417.)

621.39.001.11 **935**

The Formation of Code Words.—R. Schauffler. (*Arch. elekt. Übertragung*, July 1956, Vol. 10, No. 7, pp. 303–314.) Formulae and charts are developed to facilitate the detection and correction of common forms of mutilation in code transmission. The formation of more general code systems is discussed.

621.396.41 **936**

Synchronous Communications.—J. P. Costas. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1713–1718.) The performance of a system using synchronous detection with d.s.b. a.m. is compared with that of a s.s.b. system. The d.s.b. system is less susceptible to jamming and is equal to the s.s.b. system as regards the efficient use of power; the d.s.b. system also shows an advantage by virtue of the greater simplicity of the equipment, especially at the transmitter. The number of usable channels is not necessarily doubled, and in some practical situations may not be increased at all by the use of s.s.b. In a synchronous receiver designed for the U.S.A.F., phase information for controlling the local oscillator is derived from the sidebands alone, no pilot carrier or synchronizing tone being required.

621.396.41 **937**

Single-Sideband Technique.—(*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12.) The main part of this issue is devoted to a group of papers constituting a survey of the technique of communication by s.s.b. Abstracts of some of the papers are given individually; titles of the others are as follows:

An Introduction to Single-Sideband Communications.—J. F. Honey & D. K. Weaver, Jr (pp. 1667–1675).

Early History of Single-Sideband Transmission.—A. A. Oswald (pp. 1676–1679).

Synthesizer-Stabilized Single-Sideband Systems.—B. Fisk & C. L. Spencer (pp. 1680–1685).

A Suggestion for Spectrum Conservation. —R. T. Cox & E. W. Pappenfus (pp. 1685–1688).

Power and Economics of Single Sideband. —E. W. Pappenfus (pp. 1689–1691).

Application of Single-Sideband Technique to Frequency-Shift Telegraph.—C. Buff (pp. 1692–1697).

Frequency Control Techniques for Single Sideband.—R. L. Craiglow & E. L. Martin (pp. 1697–1702).

Comparison of Linear Single-Sideband Transmitters with Envelope-Elimination-and-Restoration Single-Sideband Transmitters.—L. R. Kahn (pp. 1706–1712).

Automatic Tuning Techniques for Single-Sideband Equipment.—V. R. DeLong (pp. 1766–1774).

Single-Sideband Operation for International Telegraph.—E. D. Becken (pp. 1782–1788).

S.S.B. Receiving and Transmitting Equipment for Point-to-Point Service on H.F. Radio Circuits.—H. E. Goldstine, G. E. Hansell & R. E. Schock (pp. 1789–1794).

Conversion of Airborne H.F. Receiver-Transmitter from Double Sideband to Single Sideband.—H. A. Robinson (pp. 1794–1799).

Problems of Transition to Single-Sideband Operation.—N. H. Young, Jr (pp. 1800–1803).

The Problems of Transition to Single-Sideband Techniques in Aeronautical Communications.—J. F. Honey (pp. 1803–1809).

Single-Sideband Techniques applied to Coordinated Mobile Communication Systems.—A. Brown (pp. 1824–1828).

Single Sideband in the Amateur Service.—G. Grammer (pp. 1829–1833).

Comparison of S.S.B. and F.M. for V.H.F. Mobile Service.—H. Magnuski & W. Firestone (pp. 1834–1839).

Design of a High-Power Single-Sideband V.H.F. Communication System.—J. W. Smith (pp. 1848–1853).

621.396.41 **938**

S.S.B. Performance as a Function of Carrier Strength.—W. I. Firestone. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1839–1848). "This paper shows the important part that the carrier plays in over-all system performance and in particular compares the various systems using full carrier, reduced carrier, suppressed carrier and controlled carrier. It is concluded that as the carrier is reduced, the factors of modulation splatter, transmitter efficiency, available peak sideband power, desensitization, and intermodulation all tend to improve. It is also pointed out that due to system stability requirements, complete suppression at the higher radio-frequencies is not feasible. Because there are many types of s.s.b. receiving systems, each requiring a different amount of carrier for synchronizing purposes, it is necessary to consider all values of transmitted carrier to compare the resulting systems and to gain a better understanding of the system characteristics considered. The characteristics of the controlled carrier system are discussed for completeness."

621.396.41 : 621.396.11 **939**

Single-Sideband Techniques in U.H.F. Long-Range Communications.—W. E. Morrow, Jr, C. L. Mack, Jr, B. E. Nichols & J. Leonhard. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1854–1873). A comparison of f.m. and s.s.b. a.m. techniques for communication systems based on beyond-horizon propagation indicates that the s.s.b. technique affords advantages in respect of spectrum conservation, performance in the presence of multipath propagation, and power requirements for a given signal/noise ratio. The design of equipment for the frequency band 300–400 Mc/s is described; methods of achieving efficient operation with high-power klystrons are indicated.

621.396.41 : 621.396.931 **940**

The Application of S.S.B. to High-Frequency Military Tactical Vehicular Radio Sets.—R. A. Kulinyi, R. H. Levine & H. F. Meyer. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1810–1823.) Advantages obtainable by the use of s.s.b. rather than d.s.b. communication systems for military purposes include improved signal/noise ratio, leading to increased range and intelligibility, reduced interference, improved spectrum utilization, quasi-duplex operation, reduced heat generation, greater reliability and amelioration of maintenance problems. Compatible s.s.b. and d.s.b. systems are discussed.

621.396.41.029.6 : 621.3.018.78 **941**

R.F. Bandwidth of Frequency-Division Multiplex Systems using Frequency Modulation.—R. Hamer: R. G. Medhurst. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, p. 1878.) Comments on a paper by Medhurst (1547 of 1956) and author's reply.

621.396.41.029.63 : 621.318.57 **942**

Subcarrier Switch for Microwave Party Line.—B. Harris. (*Electronics*, Nov. 1956, Vol. 29, No. 11, pp. 175–177.) Circuit arrangements are described for ensuring that in any channel of a multichannel radio-communication system only one station shall have its carrier operating at any time, the rectified output from the receiver providing a bias which cuts off the carrier at the local transmitter unless the outgoing a.f. signal is greater than the incoming one.

621.396.662 : 621.396.61/.62 **943**

Automatic Tuning Mechanisms using Instantuners Type SZT 201 and/or 202.—W. L. Vervest & L. van Gorkom. (*Philips Telecommun. Rev.*, Aug. 1956, Vol. 17, No. 1, pp. 2–16.) Detailed description of equipment incorporating improvements over that described previously [2941 of 1949 (Vervest)].

621.396.712.029.62 : 621.376.3 **944**

High-Quality Sound Broadcasting.—G. H. Russell. (*Wireless World*, Jan. 1957, Vol. 63, No. 1, pp. 31–32.) Discussion of a report published by the European Broadcasting Union on *The Present Position and Prospectives of V.H.F. Sound Broadcasting in Europe*. Both technical and economic aspects of the development of v.h.f. f.m. transmitting networks are examined, and the stage reached in various countries is indicated.

SUBSIDIARY APPARATUS

621.311.6 : 621.316.722 : 621.314.7 **945**

Regulated Transistor Power-Supply Design.—J. W. Keller, Jr. (*Electronics*, Nov. 1956, Vol. 29, No. 11, pp. 168–171.) Simple analysis is presented for series and shunt-regulated circuits for low-voltage power supplies.

621.352 **946**

Recent Patents on Electric Cells.—L. Jumau. (*Rev. gén. Elect.*, July 1956, Vol. 65, No. 7, pp. 401–418.) Continuation of previous review (264 of 1954).

TELEVISION AND PHOTOTELEGRAPHY

621.397.26 : 621.397.6 **947**

A British Microwave Television Link in Canada.—A. D. Hodgson & G. M. B. Wills. (*G.E.C. J.*, July 1956, Vol. 23, No. 3, pp. 123–129.) A description is given of the London–Windsor radio link, in the province of Ontario. The route length is 120 miles; there are four repeater stations. Operation is in the frequency band 1·7–2·3 kMc/s; frequency modulation is used, with a transmitter deviation of 6 Mc/s peak-to-peak and a receiver bandwidth of 16 Mc/s. Disk-seal valve are used in the transmitter u.h.f. circuits.

621.397.5/.6 : 535.623 **948**

Colour Television.—G. N. Patchett. (*J. Brit. Instn Radio Engrs*, Nov. 1956, Vol. 16, No. 11, pp. 591–620.) "The theory of colour mixing and of colorimetry is discussed briefly. Various systems for colour television are outlined and studio and receiver equipment described. The N.T.S.C. system and its modification to British standards are discussed." Over 150 references.

621.397.5 : 535.623 : 778.5 **949**

Recent Improvements in Black-and-White Film Recording for Colour-Television Use.—W. L. Hughes. (*J. Soc. Mot. Pict. Telev. Engrs*, July 1956, Vol. 65, No. 7, pp. 359–364. Discussion, p. 364.) Account of the development of a system suitable both for producing films by mechanical camera for flying-spot scanning, and for making kinescope recordings. Similar material is presented in *Convention Record Inst. Radio Engrs*, 1955, Vol, 3, Part 7, pp. 69–80.

621.397.5 : 535.623 : 778.5 **950**

Colour Kinescope Recording on Embossed Film.—C. H. Evans & R. B. Smith. (*J. Soc. Mot. Pict. Telev. Engrs*, July 1956, Vol. 65, No. 7, pp. 365–371. Discussion, p. 371–372.)

621.397.5 : 621.39.001.11 **951**

Television Systems with Statistical Encoding.—B. B. Gurfinkel'. (*Radiotekhnika i Elektronika*, April 1956, Vol. 1, No. 4, pp. 478–496.) Theory of encoding systems using a nonlinear transformation of the signal-function time-scale is presented, and several practical systems reported in the literature are briefly discussed.

621.397.6.001.4 : 621.317.74 **952**

Measuring Colour-Television Luminance vs Chroma Delay.—Ettlinger. (See 880.)

621.397.61 : 771.35 **953**

Optics Before the Camera.—C. Burns. (*J. Telev. Soc.*, July–Sept. 1956, Vol. 8, No. 3, pp. 117–120, 122.) Practical details are given regarding the nature and adjustment of optical systems used with television cameras.

621.397.621.2 : 621.385.832 **954**

Frequency Characteristics of Kinescopes.—L. M. Selyakov. (*Radiotekhnika i Elektronika*, April 1956, Vol. 1, No. 4, pp. 525-534.) The dependence of M, the ratio of the modulation coefficient of the visual brightness of the sinusoidal signal on the screen to the modulation coefficient of the signal at the modulation valve, is calculated as a function of the video frequency, taking into account the effect of the halo. Calculated and experimentally determined characteristics of typical Russian picture tubes are tabulated and presented graphically.

TRANSMISSION

621.396.61 : 621.396.41 **955**

The Phase-Shift Method of Single-Sideband Signal Generation.—D. E. Norgaard. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1718–1735.) A general expression is derived for sideband suppression obtained by the phase-shift method. The suppression ratio is expressed in terms of four system parameters, three of which depend on the wide-band phase-shift networks used. A simple dual-channel s.s.b. generator is described. Use of the phase-shift method in conjunction with band-pass filters is discussed. The effects of intermodulation distortion and the performance stability are examined.

621.396.61 : 621.396.41 : 621.375.221 **956**

Distortion-Reducing Means for Single-Sideband Transmitters.—W. B. Bruene. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1760–1765.) Methods of reducing intermodulation distortion products from r.f. power amplifiers used in multichannel s.s.b. transmitters are discussed. Direct r.f. feedback is adjudged preferable to the method of envelope-distortion cancelling modulation. A circuit combining the two techniques is described.

VALVES AND THERMIONICS

537.533 **957**

Single-Component Stationary Electron Flow under Space-Charge Conditions.—B. Meltzer. (*J. Electronics*, Sept. 1956, Vol. 2, No. 2, pp. 118–127.) It is shown analytically that for all electron beams issuing from a cathode with zero or negligible velocity the flow can be treated as one with a single velocity component. The differential equation describing the flow is relatively simple, particularly when the coordinates are chosen to be orthogonal. Explicit expressions are obtained for the current, charge densities and potentials in a flow from a space-charge-limited cathode constrained to a circular path.

621.314.63 : 621.318.57 **958**

Fast Switching with Junction Diodes.—J. E. Scobey, W. A. White & B. Salzberg. (*Proc. Inst. Radio Engrs*, Dec. 1956, Vol. 44, No. 12, pp. 1880–1881.) By taking as operating point the reverse breakdown voltage rather than zero voltage, switching speed and upper frequency limit can be increased. Special selection of diodes is necessary for this class of operation.

621.314.632 **959**

On the Anomalous Rectification of Cuprous Sulphide Detectors.—M. Anastassiades & D. Ilias. (*Proc. phys. Soc.*, 1st Sept. 1956, Vol. 69, No. 441B, pp. 958–960.) Reversal of the direction of rectification is observed in CuS rectifiers as the applied voltage passes through the value 0·3 V r.m.s. The effect is attributed to rectification at the contact with the holder, acting in opposition to that of the unit proper.

621.314.7 **960**

Developmental Study on Point-Contact Transistors.—M. Aida. (*Rep. elect. Commun. Lab., Japan*, May 1956, Vol. 4, No. 5, pp. 18–28.) Aspects of the assembly relevant to reliability of subsequent operation are discussed, and a cartridge designed to ensure correct contact pressure is described. Measured temperature variations and noise characteristics are presented, as well as results of life and humidity tests.

621.314.7 **961**

Measurement of the Parameters Determining the High-Frequency Performance of Transistors. Elements of the 'Natural' Equivalent Circuit.—J. Riethmüller. (*Ann. Radioélect.*, July 1956, Vol. 11, No. 45, pp. 239–248.) Test methods are described. A comparison between measured values and those derived from the 'natural' equivalent circuit [607 of 1956 (Zawels)] confirms the validity of this network.

621.314.7 : 621.396.822 **962**

Temperature Dependence of Flicker Noise of *p-n-p* Junction Transistors.—K. Amakasu & M. Asano. (*J. appl. Phys.*, Oct. 1956, Vol. 27, No. 10. p. 1249.) Measurements over the temperature range −150° to +43°C are presented graphically and discussed briefly.

621.314.7.001.4 **963**

A Transistor Tester.—(See 861.)

621.383.27 **964**

An Improved Photomultiplier Construction.—A. E. Jennings & C. E. F. Misso. (*J. sci. Instrum.*, Aug. 1956, Vol. 33, No. 8, pp. 323–324.) A slatted design described by Sommer & Turk (2085 of 1950) is discussed and a modified construction giving improved focusing is proposed.

621.383.4 **965**

Alternating-Current Measurements on Cadmium Sulphide Photocells.—E. Klier. (*Ann. Phys., Lpz.*, 15th Aug. 1956, Vol. 18, Nos. 3/4, pp. 163–170.) Cells with ohmic and with non-ohmic contacts were investigated. The results indicate that cells treated in a glow discharge exhibit the same behaviour with alternating current as with direct current.

621.385.029.6 **966**

The Focusing of Electron Beams by an Alternating Longitudinal Magnetic Field.—O. Cahen. (*Ann. Télécommun.*, July/Aug. 1956, Vol. 11, Nos. 7/8, pp. 142–150.) Analysis is developed based on the equations of motion of the electrons. Formulae are derived relating ripple length and beam diameter. A focusing arrangement is discussed comprising two interleaved sets of magnetizable members associated with coils and surrounded by an iron tube to complete the magnetic circuit. The arrangement was tested in a travelling-wave valve.

621.385.029.6 **967**

Study of the Oscillation Modes of the M-Type Carcinotron : Part 2.—M. de Bennetot. (*Ann. Radioélect.*, July 1956, Vol. 11, No. 45, pp. 230–238.) Extension of the analysis given in Part 1 (3255 of 1956) to beams of arbitrary thickness. Expressions are derived for the energy exchange between beam and delay line and the boundary conditions in the interaction space.

621.385.029.6-712 **968**

Air Cooling a Finned Magnetron.—M. Mark. (*Tele-Tech & Electronic Ind.*, June 1956, Vol. 15, No. 6, pp. 100–101 . . 178.) A light-weight forced-air cooling system is described, suitable for use in airborne equipment.

621.385.032.73.001.4 **969**

The Control of Thermionic Valve Envelope Quality by Thermal-Shock Testing.—G. D. Redston. (*Electronic Engng*, Nov. 1956, Vol. 28, No. 345, pp. 470–475.) Failures of all-glass valves in thermal shock tests are discussed; different defects are brought out by different tests. Results of the 'downward' thermal-shock test are more nearly correlated with service life than those of the 'upward' thermal-shock test. Tempering the valve base improves resistance to 'downward' thermal shock but produces no significant change in the number of failures on life test.

621.385.3/.5 : 621.396.822 **970**

Uncorrelated Grid Noise.—D. A. Bell. (*Electronic Radio Engr*, Jan. 1957, Vol. 34, No. 1, pp. 36–37.) An explanation is advanced of the absence of correlation observed e.g. by Houlding & Glennie (1261 of 1954) between grid and anode noise.

621.385.8+621.317.755].029.63/.64 **971**

Oscillograph for Investigating U.H.F. Oscillations and some Results of its Application in the Study of Pulsed Magnetrons.—Chernushenko. (See 885.)

621.387 : 621.316.722.1 : 621.396.822 **972**

Gas-Filled Voltages Stabilizers.—F. A. Benson. (*Electronic Radio Engr*, Jan. 1957, Vol. 34, No. 1, pp. 16–20.) Tubes manufactured specially for previous investigations [640 and 1263 of 1956 (Benson & Bental)] were used for measurements of the effects on the noise characteristics of varying the cathode material, the gas filling and the gas pressure. Results are presented and discussed.

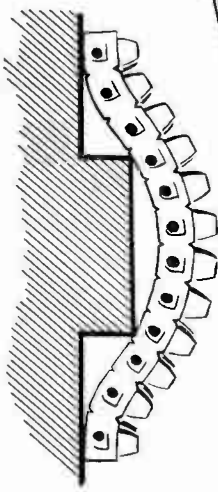
621.387 : 621.318.57 **973**

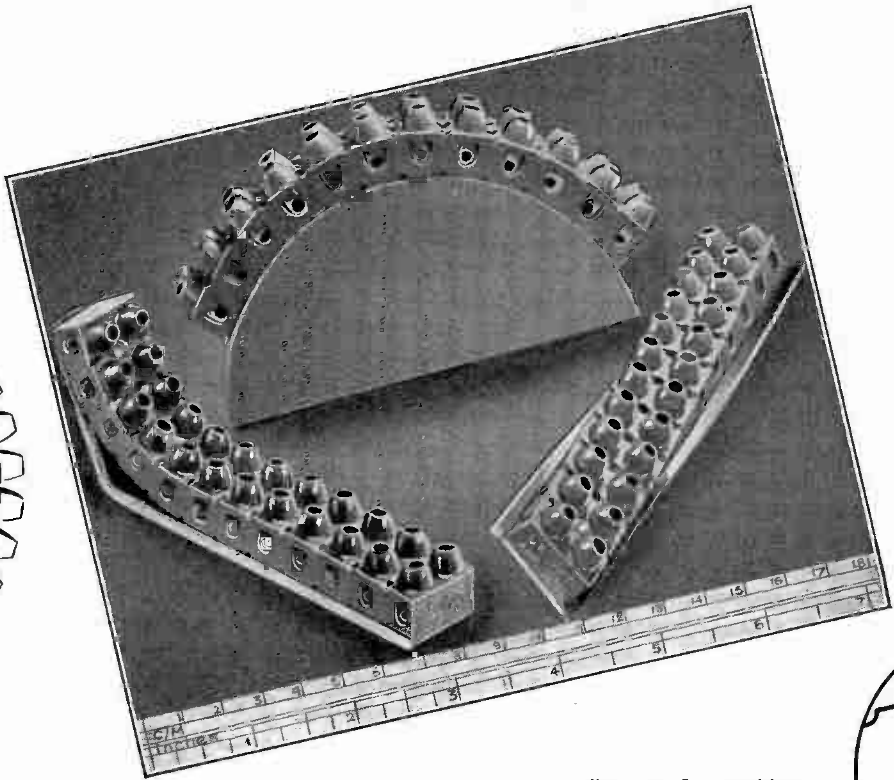
The Design of Cold-Cathode-Valve Circuits.—Flood & Warman. (See 695.)

MISCELLANEOUS

621.3(47) **974**

[Russian] **Books on Radio Engineering and Electronics in 1956.**—P. O. Chechik. (*Radiotekhnika i Elektronika*, April 1956, Vol. 1, No. 4, pp. 537–539.) The list includes over 70 titles of books by Russian authors.





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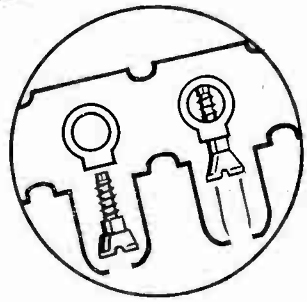

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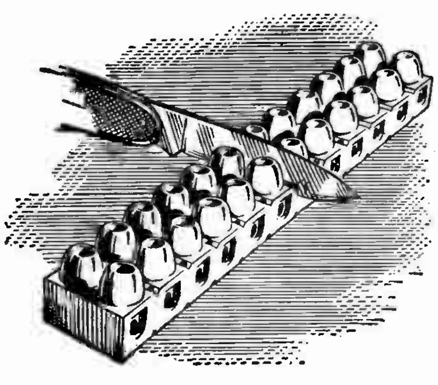

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Maximum peak current (10 seconds max.)	75	mA
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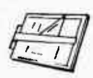
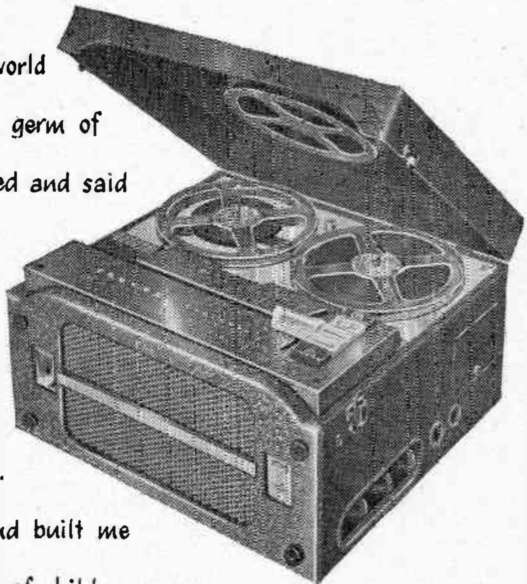
I was conceived in the minds of two enthusiasts  and I grew up on a kitchen table  at the time when my world was young. They built and rebuilt me, as I evolved from the germ of an idea  into reality. Came men who saw and listened and said "This we must build". They drew me  on paper and made me in metals;  they put power in my circuits and as they developed me so I grew over 6 long years, improved constantly, until I was no longer a fractious child but mature  and fit to face the outside world. The enthusiasts who dreamed me and those who finalised and built me now say with pride "This is well done".  The voices of children, the eloquence of oratory, sweetest of music, thunder of orchestra  — all this, and more — I give you.



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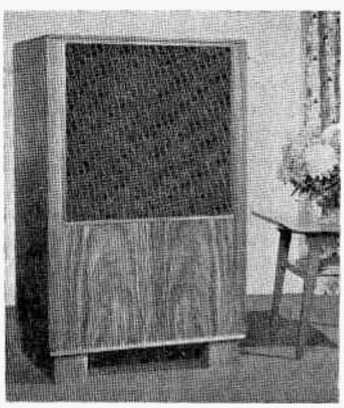
Standard Loudspeaker Cabinet



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* *Wireless World* Nov. and Dec. 1950.

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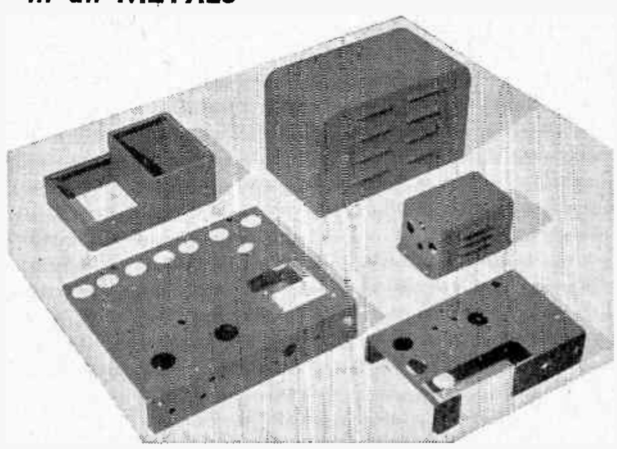

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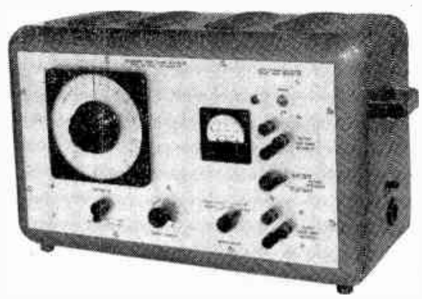

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FREQUENCY 10 c.p.s. to 110 Kc/s
OUTPUT 20 volts into 6 000 ohms
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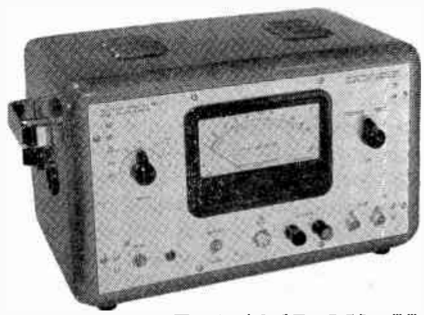

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RANGE 0 to 100 Kc/s
ACCURACY ± 1%
INPUT VOLTAGE Min. 75 mV
Max. 15 volts
Provision for external recorder.

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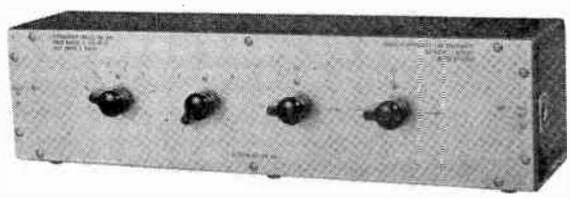

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ATTENUATION 1dB to 99dB in 1dB steps
ACCURACY ± 2% to 100 Mc/s
± 5% to 250 Mc/s
INPUT VOLTAGE 3 volts maximum
CHARACTERISTIC IMPEDANCE 75-ohm
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Attenuation db/100 ft.	ET.5.M	ET.6.M	ET.7.M	ET.8.M	ET.10.M
10 Mc/s.	1.3	1.5	1.0	1.1	0.6
50 ,, ...	3.0	3.4	2.3	2.6	1.5
100 ,, ...	4.3	4.8	3.2	3.6	2.2
200 ,, ...	6.3	7.2	4.9	5.3	3.3
Dimensions (inches)					
Centre Conductor	1/0.022	7/0.0076	1/0.029	7/0.010	1/0.044
Over Cellular TELCOTHENE .	0.093	0.093	0.128	0.128	0.200
Over Wire Braid	0.117	0.117	0.152	0.152	0.230
Over TELCOVIN Sheath . .	0.157	0.157	0.202	0.202	0.290

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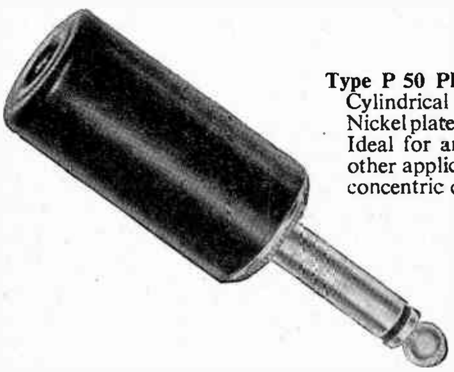

Type P 50 Plug
Cylindrical bakelite case. Nickel plated metal parts. Ideal for amplifiers and other applications where concentric cable is used.

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Moulded bakelite. Suitable for switching-in high frequency circuits. Capacity between springs eliminated. Silver contacts, one hole fixing, perfect contact.

reliability PLUS delivery

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Press date for the April 1957 issue is first post Monday, 25th March 1957

SITUATIONS VACANT

Applications are invited for pensionable posts as

EXAMINERS

in the

PATENT OFFICE

TO undertake the official scientific, technical and legal work in connexion with Patent applications.

AGE at least 21 and under 35 years on 1st January, 1957, with extension for regular Forces' service.

CANDIDATES must have (or obtain in 1957) 1st or 2nd Class Honours in Physics, Organic or Inorganic Chemistry, Mechanical or Electrical Engineering or in Mathematics, or an equivalent qualification, or have achieved a professional qualification, e.g. A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., A.R.I.C. For a limited number of vacancies candidates with 1st or 2nd Class Honours degrees in other subjects—scientific or otherwise—will be considered. Exceptional candidates otherwise qualified by high professional attainments will be considered.

STARTING pay for five-day week of forty-two hours in London between £605 and £1,120 (men) according to post-graduate (or equivalent) experience and National Service. Maximum of scale £1,345. Women's pay above £605 slightly lower but is being raised to reach equality with men's in 1961. Good prospects of promotion to Senior Examiner rising to £2,000 (under review) and reasonable expectation of further promotion to Principal Examiner.

APPLICATION form and further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S128/57 and stating date of birth.

INTERVIEW Boards will sit at intervals, as required. Early application is advised. [1038

TRANSISTORS AND COMPUTERS

THE BRITISH TABULATING MACHINE COMPANY, LTD., is expanding activities in the field of transistor applications to digital computers. We, therefore, are looking for junior and senior engineers to help build up this Section and to create careers for themselves. Whilst experience in pulse and/or transistor circuit technique would, of course, be a great advantage, we are quite prepared to train you at full salary if you are bringing an open mind and enthusiasm to bear on this fascinating new field. Our well-equipped Laboratories are modern and spacious and are situated in pleasant country surroundings. You can live in the modern Stevenage New Town in a house or flat and you are still within striking distance of London. Our holidays run from two weeks to four weeks according to grade, and we have a good contributory Pension Scheme. You are invited to write in, quoting reference ER/509, to the Personnel Superintendent, The British Tabulating Machine Company, Ltd., Icknield Way, Letchworth, Herts, to arrange an interview. [1031

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[1037

ELECTRONIC engineer required to assist in the development of a wide range of Special Measuring Equipment for use in the production of Telephone Line Transmission Components and Equipment. Ample opportunity to broaden experience and develop personal initiative. Reasonable qualifications expected. Write Personnel Manager, Telephone Manufacturing Co., Ltd., Sevenoaks Way, St. Mary Cray, Kent. [1039

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APPLICATIONS are invited from suitably qualified engineers for vacancies on the development staff engaged on Telecommunication Transmission. Activities in this field are being expanded under the control of Dr. J. A. Pim, Ph.D., B.Sc., M.I.E.E., with special emphasis on work connected with:

(A) **ELECTRONIC** Circuits based on the use of transistors.

(B) **NETWORK** development including the design of filters and transformers.

THESE vacancies offer opportunities for wide experience and advancement in a compact working group, experimenting with and applying important new techniques. Senior and junior positions are available. In both cases qualifications of honours degree standard in electrical engineering, mathematics or physics are required but the actual possession of an honours degree is not insisted upon. For senior grades several years' additional practical experience in appropriate fields will be expected. Starting salaries are offered in accordance with age and experience from £950 upwards for senior engineers and from £600 upwards for assistant engineers. All are pensionable staff posts with good prospects. As the main works are in London the technical staff can participate in the activities of the professional institutions and attend a wide range of lectures and courses. There is a liberal pension scheme in operation and assistance with housing difficulties, if required, may be available in approved cases. Excellent sports club and canteen facilities.

APPLICATIONS giving a preliminary outline of qualifications should be sent to the Staff Officer, Ref. 744/59, Siemens Brothers & Co., Ltd., Woolwich, S.E.18. [1042

ENGINEERS

TELEPHONE MANUFACTURING CO. LTD., Sevenoaks Way, St. Mary Gray, Kent, is extending its Development Laboratories and invites applications from suitably qualified men to fill a number of vacancies.

MINIMUM qualifications would be a Degree or H.N.C. (Telecoms.).

AT this works, the Company is engaged on the Design, Development and Manufacture of Telecommunication Line Transmission Equipment including Multi Channel Carrier and Associated Apparatus.

STARTING salaries according to age, qualifications and experience. Pension and Staff Bonus Scheme after qualifying period.

ENGINEERS interested in these vacancies should write to the Personnel Manager, giving full details of age, training, experience and salary required.

ALL applications will be treated as confidential. [1032

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QUALIFICATIONS: Recognised engineering apprenticeship or equivalent training: H.N.C. or equivalent and good drawing office experience. Experience in transformer design or manufacture an advantage.

SALARY: £795–£1,210.

SEND Post Card for further details and an application form, which must be returned by April 15th, 1957, to Establishment Officer, A.E.R.E., Harwell, Berks, quoting 725/224. [1043

ENGINEER with experience of the mechanical design of electronic equipment, particularly in relation to chassis and case components. Preference will be given to an engineer holding H.N.C. in electrical engineering, or has experience in development of units up to production stage. Age between 30 and 35. Apply in writing, stating qualifications, experience and salary required, to Chief Development Engineer, Waymouth Gauges & Instruments, Ltd., Station Road, Godalming, Surrey. [1040

TECHNICAL Assistants Grade I required by Kumasi College of Technology, Gold Coast.

DEPARTMENT of Electrical Engineering (M2C/41848 INJ) and Radio Research Laboratory (Ionosphere Research) (M2C/42178 INJ). Appointment for two tours normally of ten months each in first instance either (*a*) on agreement with prospect of pensionable employment salary scale (including 5 per cent non-pensionable addition) £871 rising to £1,060 a year or (*b*) on contract with above salary scale plus 10 per cent contract addition and gratuity at rate of £150 a year. Commencing salary according to experience. Outfit allowance up to £60. Furnished quarters available for officer and family. Free passages. Leave on full salary normally granted annually. Preservation of superannuation rights under F.S.S.U. Scheme might be arranged. Candidates must possess H.N.C. or equivalent and have experience in research laboratories of manufacturer of telecommunications equipment or of an operating organisation. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote the reference number shown against the post applied for. [1035

SENIOR Scientific Officers or Scientific Officers required by Mechanical Engineering Research Laboratory (D.S.I.R.), East Kilbride, Glasgow, to develop electronic techniques of measurement in researches on: (*a*) *Plasticity* (Ref. A. 38/7A)—ranging from metal physics to formation and cutting processes. Measurement of force, strain, torque, pressure, temperature, and short time intervals; (*b*) *Fluids* (Ref. D.317/6A)—Turbines, pumps, valves and bends for water, air and oil. Application of modern transistor, magnetic amplifier and thermionic circuits to measurement and control problems. Qualifications: 1st or 2nd class hons. degree in Electrical Engineering or Physics or equivalent. Salary: (S.S.O.) £1,075–£1,265, (S.O.) £565–£995. Five-day week. Women's pay slightly less but subject to improvement under Equal Pay Scheme. East Kilbride offers good housing prospects. Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate reference. [1033

SENIOR Electronic Engineer required by The de Havilland Aircraft Co., Ltd., for their new computing department at Hatfield, to be responsible for maintaining a large modern analogue computer and its associated equipment. The work will also include computer programming and operation, and the design of additional apparatus. This is an interesting post in a new and expanding department solving varied problems of aerodynamic and mechanical design. Applicants should have H.N.C. in electronics or its equivalent and several years' experience in the design and testing of electronic equipment, preferably including D.C. Amplifiers. Some knowledge of Servo-Mechanisms would be an advantage. Applications should be addressed to the Personnel Manager, de Havilland Propellers, Ltd., Hatfield, Herts. [1041

DE HAVILLAND PROPELLERS LIMITED need New Technicians to work on the electronic, servo or instrumentation aspects of Guided Weapons. Men with the ambition to secure a good position in this type of work are invited to write to the Personnel Manager (Ref. 75), de Havilland Propellers Limited, Hatfield, Herts. Alternatively, for the benefit of those who would prefer to discuss this matter immediately, the Company is holding a series of Informal Interviews at Norman House, 12 Stratford Place, Oxford Street, London, W.1 (opposite Bond Street Underground Station). Applicants are invited to telephone Hyde Park 9811 and make an appointment to see the Company's Chief Electronics Engineer at this address on any Tuesday evening between 6 p.m. and 8.30 p.m. [1027

ELECTRONIC Engineer required for development of Railway Traffic Control and Signalling Equipment. Age 25–30. Essential qualifications—a Communications Degree or H.N.C. Electronics or C. and G. Certificates. The post is permanent and there are good prospects of progress for a successful applicant showing the necessary interest and ability. Applicants should preferably have had two or three years' experience in some electronic field, such as the design of communication equipment, or of amplifiers and/or filters for similar purposes. Experience with transistor circuitry an advantage but not essential. Pension scheme and five-day week. Write giving full particulars of age, qualifications and experience to The Personnel Superintendent, Westinghouse Brake & Signal Co., Ltd., Chippenham, Wilts. [1034

SCHOLARSHIPS

THE Council invite applications for the following scholarships which are offered for award this year:

RESEARCH Scholarships—I.M.E.A., value £420 for one year, may be extended; Oliver Lodge, value £420 for one year, may be extended; Swan Memorial, value £120 for one year, which may be increased in exceptional circumstances; C. P. Sparks War Thanksgiving Fund, maximum grant £100.

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STUDENT Scholarships—for study at undergraduate level at a university or a technical college. Duddell, value £200 p.a. for three years; Silvanus Thompson, value £200 p.a. for three years; Sir Arthur Fleming, value £120 p.a. for four years; Paul, value £75 p.a. for four years, but may be increased to £150 for a meritorious applicant; Salomons, value £60 for one year; David Hughes, value £60 for one year; Sir Charles A. Parsons, value £60 p.a. for three years; Thorrowgood, value £25 for one year.

THE closing date for the receipt of applications is 1st May, 1957, for Student Scholarships and 1st June, 1957, for Graduate and Research Scholarships. Further particulars and nomination forms may be obtained on application to the Secretary, The Institution of Electrical Engineers, Savoy Place, London, W.C.2. [1036

BOOKS, ETC.

"ADVANCED Theory of Waveguides." By L. Lewin. Sets out various methods of treating problems arising in work on this complex subject. The author has selected for discussion a number of topics as representative of the field in which the centimetre-wave engineer is engaged, many of the examples being concerned with the rectangular waveguide. 30s. net from all booksellers, 30s. 10d. by post from Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1.

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for various attractive positions with this new British Company which will manufacture Transistors on a large scale. The Company's factory will be at Bedford.

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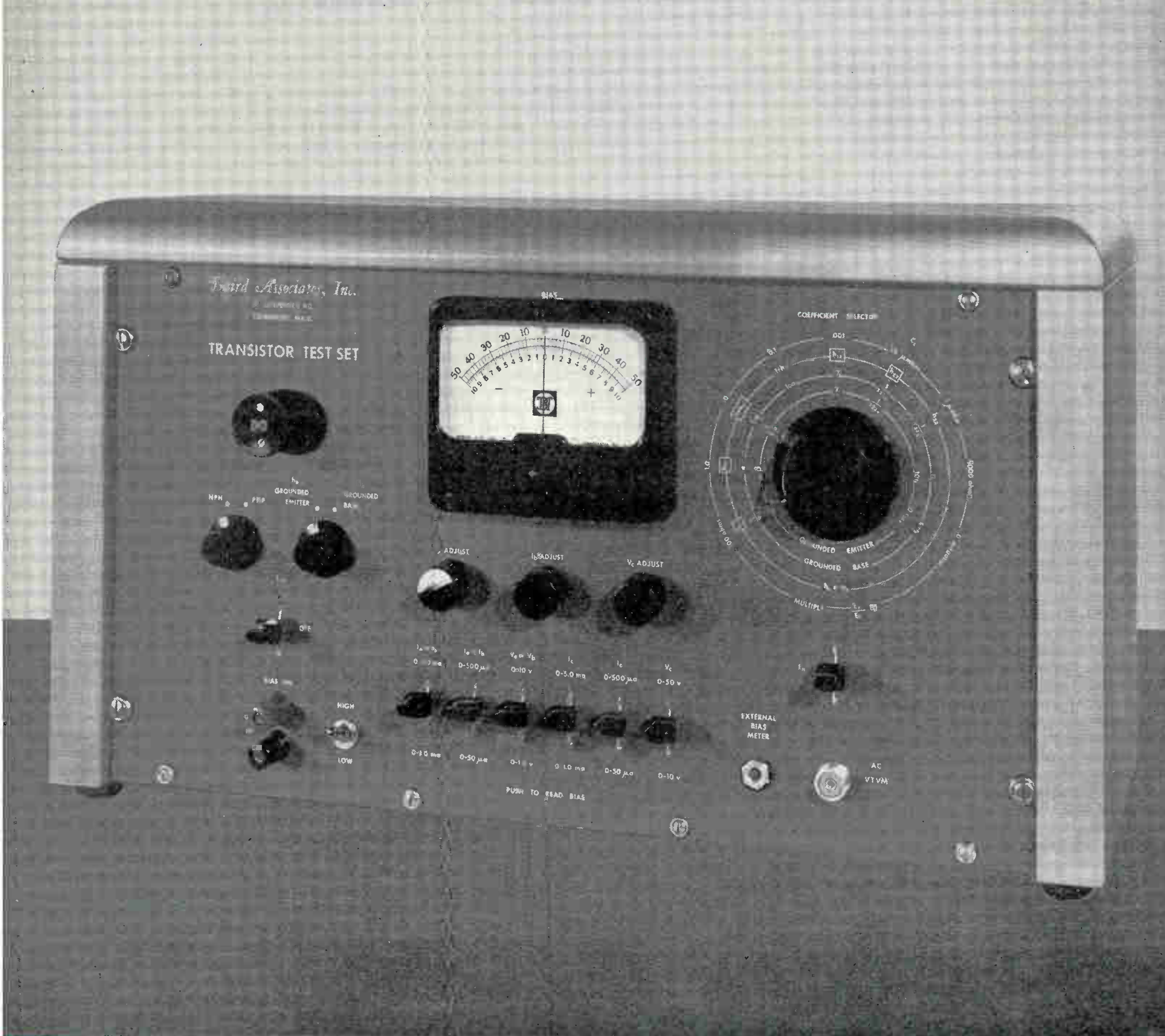

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Here is a versatile precision instrument designed to analyse transistors at any frequency from 100 c.p.s. to 1 mc. in terms of well-known standard parameters. The transistor coefficients thus obtained enable the circuit designer to predict the performance of amplifiers in the AUDIO, INTERMEDIATE and LOW RADIO FREQUENCY ranges. The Test Set is used in conjunction with an external oscillator and vacuum tube voltmeter. An oscilloscope, although not necessary, may be used to observe the noise and wave-shape of the output signals.

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