ELECTRONIC & RADIO ENGINEER

Incorporating **WIRELESS ENGINEER**

In this issue

Electronic Magnetizing and Demagnetizing

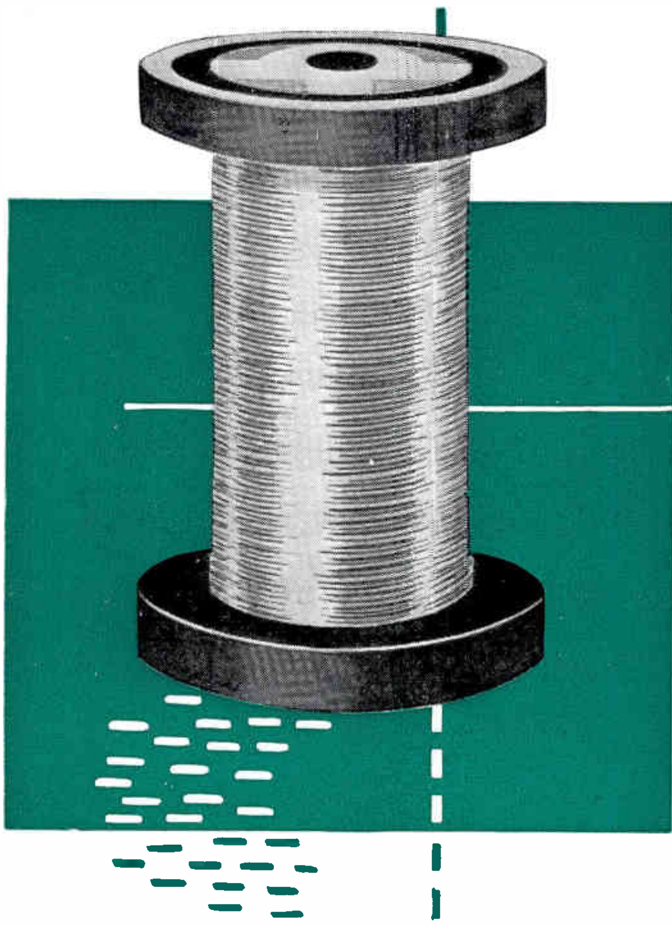
Transistor Current Gain

Echo Distortion in Frequency Modulation

Concertina Phase-Splitter

Three shillings and sixpence

JULY 1959 Vol 36 *new series* No 7



news for coil makers

a TOUGH self-fluxing winding wire

For continuous operation at "hottest-spot" temperatures of up to 120°C.

Adherent and resistant to solvents.

Can generally be used without changes in coil design, winding or impregnation.

Developed in BICC's own laboratories, Bicelflux is an enamel covering for winding wires with toughness approaching that of vinyl acetal or epoxy resin coverings but—*much easier to solder.*

Bicelflux is self-fluxing, with an action comparable to that of organic activated rosin fluxes.

As a result, Bicelflux windings are ideal for applications where large numbers of soldered joints are required, for example in radio and telecommunication equipment.

Further details are given in BICC Publication No. 376—yours for the asking.

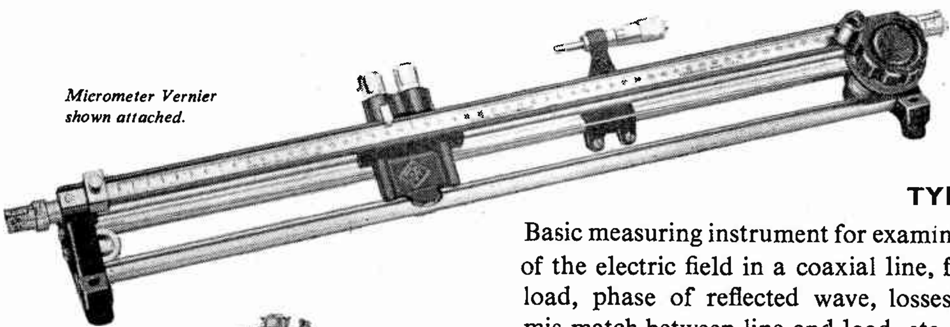
BICC **Bicelflux** **WINDING WIRES**

BRITISH INSULATED CALLENDER'S CABLES LIMITED, 21 Bloomsbury Street, London, W.C.1

U.H.F. MEASURING EQUIPMENT

With basic measuring instruments, such as the Slotted Line or Admittance Meter, generators, detectors, and a wide range of inter-related coaxial elements, all linked through the ingenious Type 874 connector, 'GENERAL RADIO' offer the scientist and engineer a 50-ohm U.H.F. measuring system that is

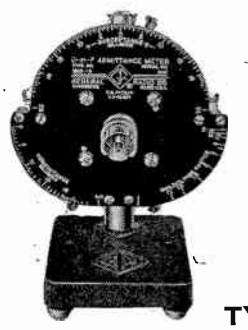
Complete · Integrated · Accurate · Versatile



Micrometer Vernier shown attached.

TYPE 874-LBA SLOTTED LINE:

Basic measuring instrument for examination of the standing-wave-pattern of the electric field in a coaxial line, from which VSWR, impedance of load, phase of reflected wave, losses in attached elements, degree of mis-match between line and load, etc. can be determined. Accurate and straightforward in use. Frequency range 300-5000 Mc/s (with some loss in accuracy: 150-7000 Mc/s). Also available: Type 874-LV Micrometer Vernier (for measurement of high VSWR). Type 874-MD Motor Drive for oscillographic display of standing-wave pattern.



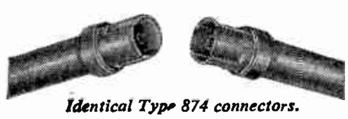
TYPE 1602-B ADMITTANCE METER:

A compact and versatile instrument, accurate and rapid in use, for determining the components of an unknown admittance in the VHF-UHF range. Scales read directly in conductance and susceptance, *independent of frequency.* With unknown connected through quarter-wave-length line, scales read in resistance and reactance. Can be used for measurement of VSWR and reflection coefficient, matching or comparison of impedances, and measurements on balanced line circuits (with the Type 874-UB 'Balun'). Frequency range 41-1500 Mc/s. (Down to 10 Mc/s, with correction). Includes conductance and susceptance standards.

THE GR SYSTEM

Keystone of the entire system is the unique Type 874 coaxial connector, fitted to all elements (see illustration below); this low-loss connector, any two of which, *although identical,* can be plugged together gives the system versatility and ease in setting-up for any measurement, and is characteristic of G-R's clear-sighted engineering philosophy. Low-loss adaptors are obtainable to link up with other systems.

Around this connector G-R have developed a wide range of coaxial elements :— lines, stubs, filters, attenuators, capacitors, inductors, insertion units, ells, tees, terminations, etc., of excellent electrical characteristics. These coaxial elements, together with generators, measuring gear, detectors, 'Balun' (balanced-to-unbalanced transformer) and other instruments form a complete and integrated line of high-frequency measuring equipment, designed for highest accuracy, dependability and convenience in use . . . in keeping with the G-R tradition of supplying only the finest in laboratory eqnipment.



Identical Type 874 connectors.

Claude Lyons Ltd.

Write for complete information

76 OLDHALL STREET, LIVERPOOL 3, LANCS. TELEPHONE: CENtral 4641-2
VALLEY WORKS, HODDESDON, HERTS. TELEPHONE: HODdesdon 4541-4

CL48/1B

Hermetic Sealing

STEATITE & PORCELAIN
NICKEL METALLISING

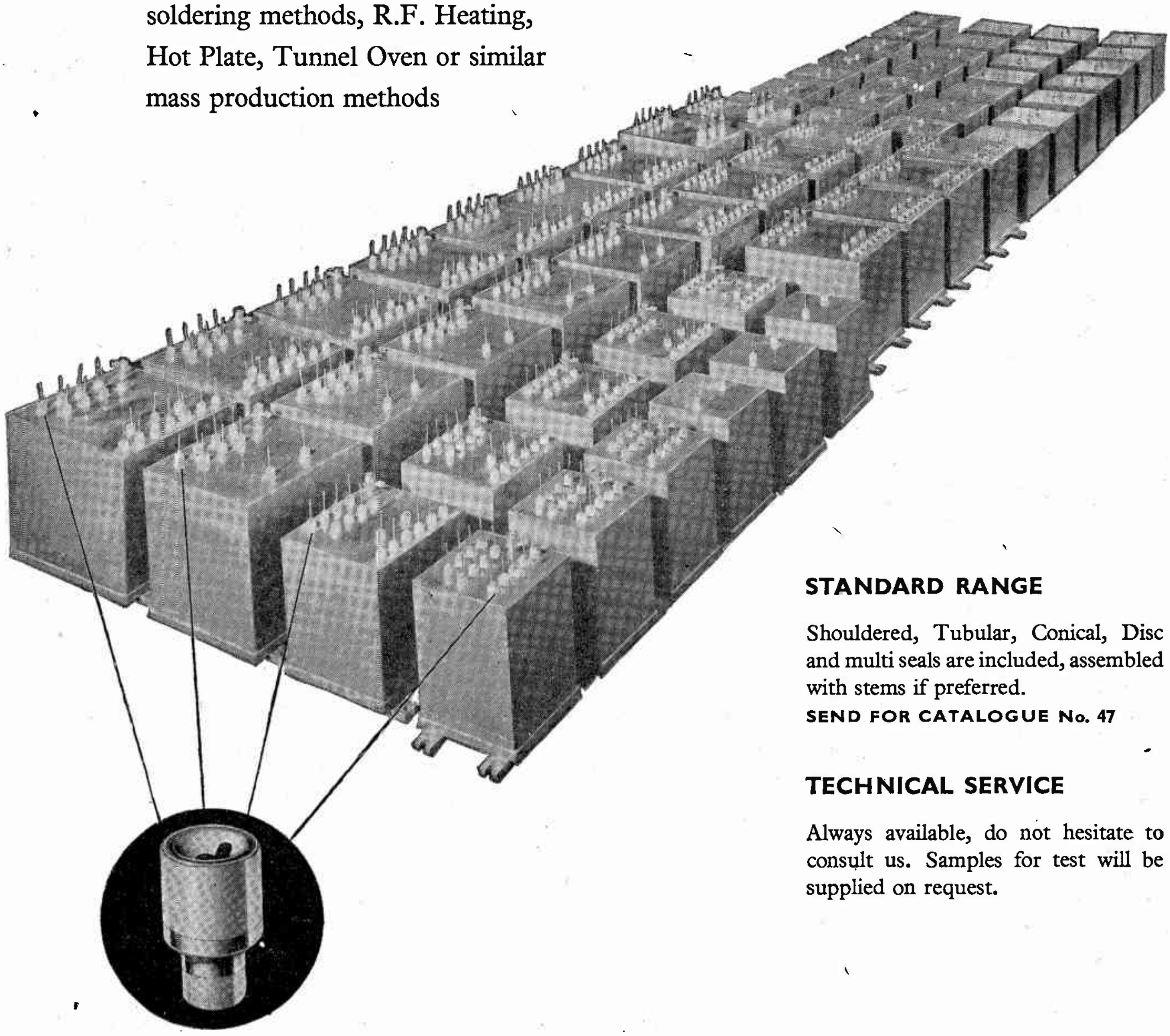
Quality Approved (Joint Service R.C.S.C.)

WILL MEET THE MOST EXACTING REQUIREMENTS

METALLISED BUSHES

Perfect Terminations

—made readily without special precautions by semi-skilled labour, employing simple hand soldering methods, R.F. Heating, Hot Plate, Tunnel Oven or similar mass production methods



STANDARD RANGE

Shouldered, Tubular, Conical, Disc and multi seals are included, assembled with stems if preferred.

SEND FOR CATALOGUE No. 47

TECHNICAL SERVICE

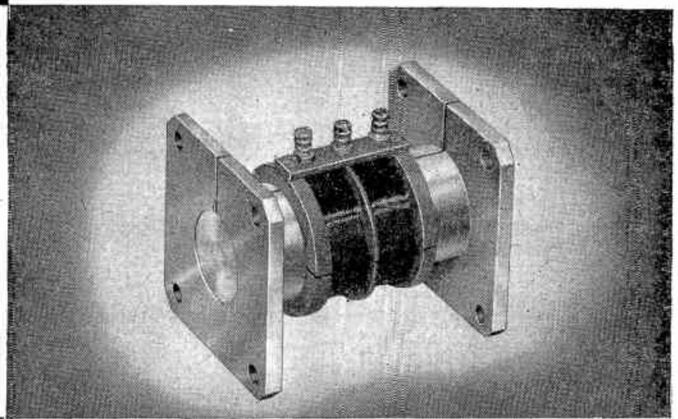
Always available, do not hesitate to consult us. Samples for test will be supplied on request.

STEATITE & PORCELAIN PRODUCTS LTD.

STOURPORT ON SEVERN, WORCS. Telephone: Stourport 2271. Telegrams: Steatain, Stourport

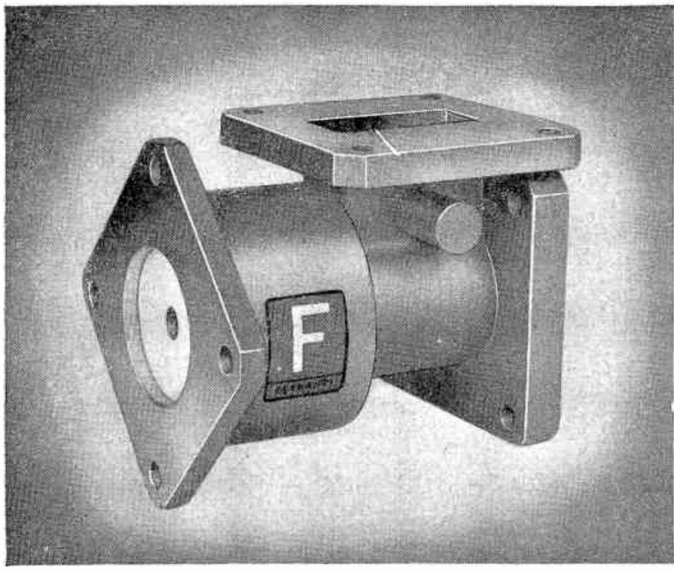
SP 100

FERRANTI X-BAND FERRITE DEVICES



FERRITE SWITCH TYPE 3F

Frequency 9600 to 9800 mc/s. Peak attenuation 30 db min. Insertion loss ·5 db max. Power handling capacity 30 watts. Weight 3 oz.

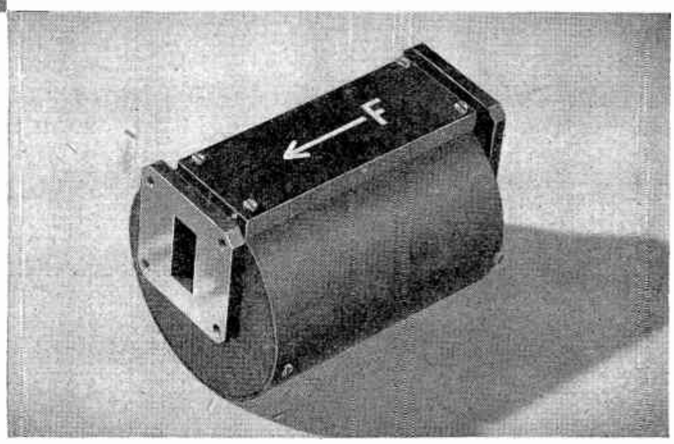


FERRITE CIRCULATOR

A compact three port circulator capable of handling 50 kW peak, 50 watt mean. It can be pre-set to cover a bandwidth of 400 mc/s in the 3 cm. band. The magnetic field is supplied by permanent magnets. The total weight of the component is approximately 4½ oz.

FERRITE ISOLATOR

Type 2F/2. 100 kW peak, 100 watt mean.
Type 2F/3. 200 kW peak, 200 watt mean.
Isolation in both cases greater than 20 db over a bandwidth of 1000 mc/s with an insertion loss of less than 1 db.



FERRANTI LTD · KINGS CROSS ROAD · DUNDEE Telephone: DUNDEE 87141

ES/T 52

From I.C.I. AMMONIA—

Nitrogen and Hydrogen for Industry

I.C.I. Ammonia provides industry with a cheap and reliable source of pure nitrogen and hydrogen. And I.C.I. gas generating plants are available to convert ammonia into a wide range of nitrogen/hydrogen gas mixtures.

Anhydrous Ammonia with a guaranteed minimum purity of 99.98%, to meet more exacting requirements, is offered in bulk and in a wide range of cylinder sizes.

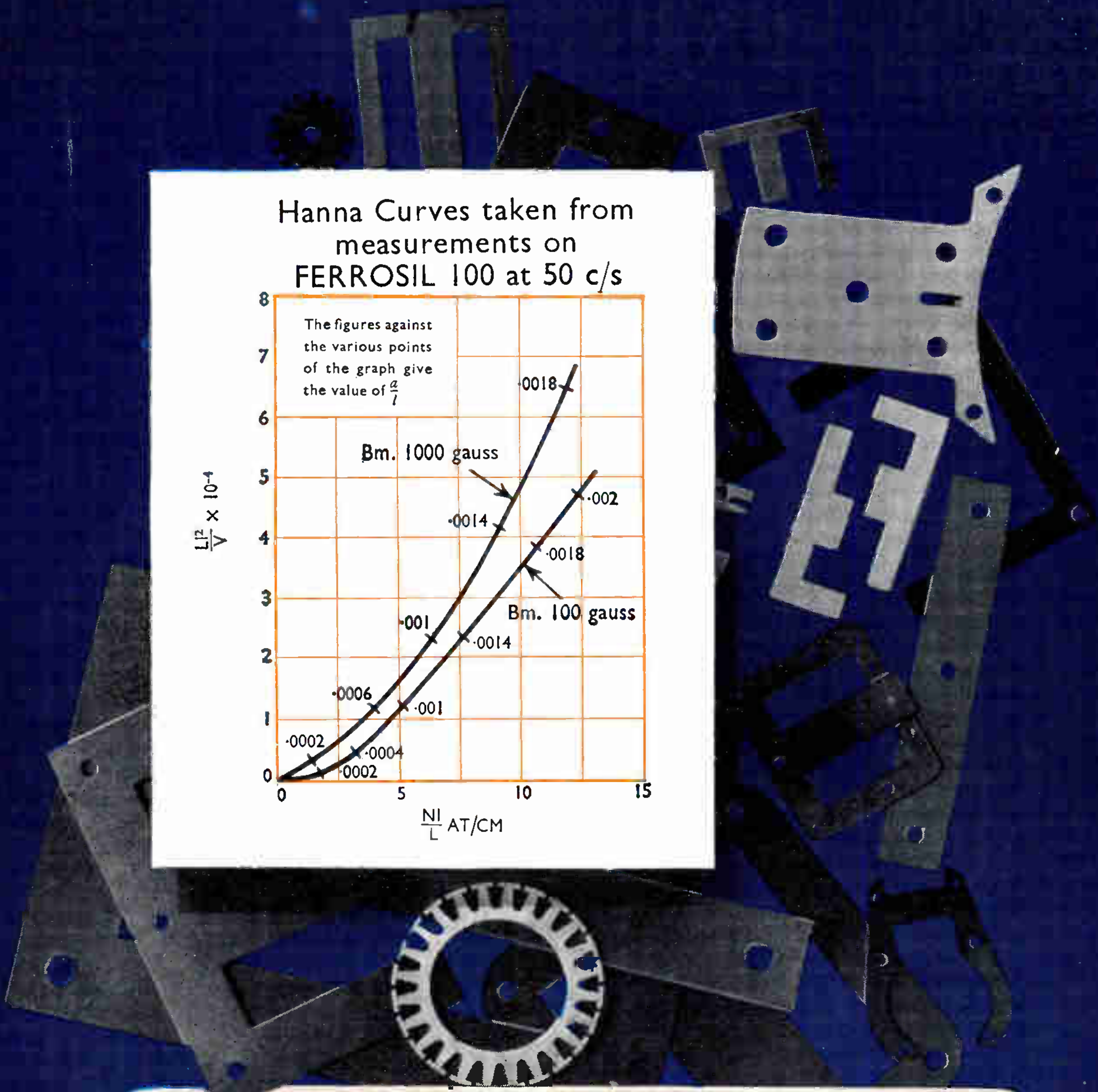
Liquefied Ammonia (*Industrial Quality*), a cheaper grade, is available in bulk and in two-ton containers for the larger consumer, and makes possible substantial economies in gas costs.

A bulk delivery of 10 tons of ammonia provides over $1\frac{3}{4}$ million cu. ft. of nitrogen

Full information on request.

Imperial Chemical Industries Ltd., London, S.W.1.

BI.C



'Hanna' curves for 'FERROSIL 100'

Typical data of 'Ferrosil 100' stampings is shown by Hanna Curves such as are widely used by electronic engineers in the design of iron cored chokes and transformers carrying both A.C. and D.C. currents. Low-loss high-permeability Ferrosil stampings are ideally suited to an infinite number of applications, of which only a few are shown. Not only is there an R.T.B. stamping for every job, but a wealth of technical data is available both in our new catalogue and by request from

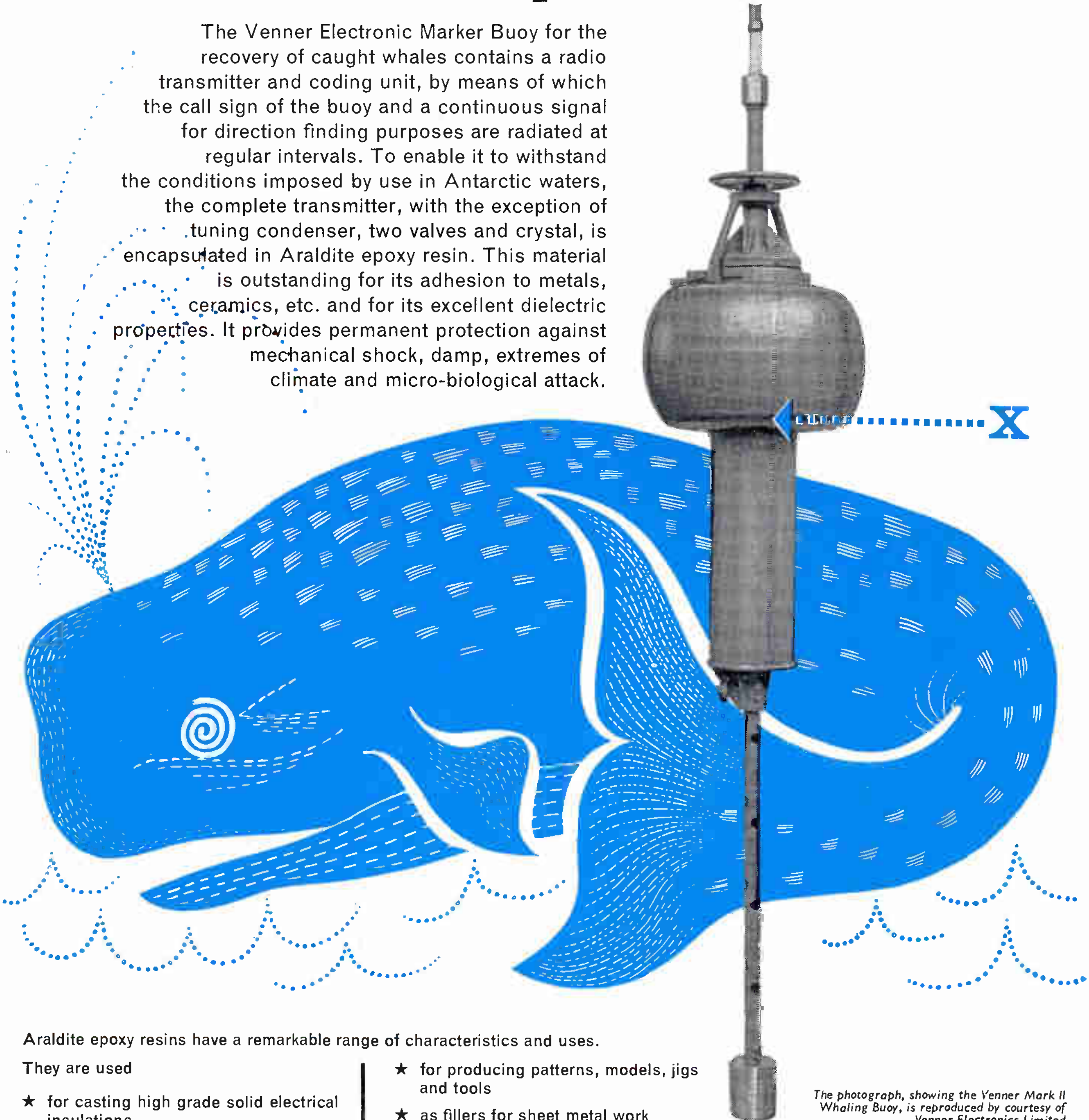
RICHARD THOMAS & BALDWINS LTD.

LAMINATION WORKS: COOKLEY WORKS, BRIERLEY HILL, STAFFS.
MIDLAND SECTION OFFICE: WILDEN, STOURPORT-ON-SEVERN, WORCS.
HEAD OFFICE: 47 PARK STREET, LONDON, W.1

Our Cookley Works is one of the largest in Europe specializing in the manufacture of laminations for the electrical industry.

X marks the spot

The Venner Electronic Marker Buoy for the recovery of caught whales contains a radio transmitter and coding unit, by means of which the call sign of the buoy and a continuous signal for direction finding purposes are radiated at regular intervals. To enable it to withstand the conditions imposed by use in Antarctic waters, the complete transmitter, with the exception of tuning condenser, two valves and crystal, is encapsulated in Araldite epoxy resin. This material is outstanding for its adhesion to metals, ceramics, etc. and for its excellent dielectric properties. It provides permanent protection against mechanical shock, damp, extremes of climate and micro-biological attack.



Araldite epoxy resins have a remarkable range of characteristics and uses.

They are used

- ★ for casting high grade solid electrical insulations
- ★ for impregnating, potting or sealing electrical windings and components
- ★ for producing glass fibre laminates
- ★ for producing patterns, models, jigs and tools
- ★ as fillers for sheet metal work
- ★ as protective coatings for metals, wood and ceramics surfaces
- ★ for bonding metals, porcelain, ceramics, etc.

The photograph, showing the Venner Mark II Whaling Buoy, is reproduced by courtesy of Venner Electronics Limited

may we send you full descriptive literature

Araldite *epoxy resins*

Araldite is a registered trade name

CIBA (A.R.L.) LIMITED Duxford, Cambridge. Telephone: Sawston 2121

AP.372

Example of Novotechnik 10-turn Potentiometer with Dial

Available Now

FIRST IN GREAT BRITAIN

10-TURN DIGITAL DIALS

(3-turn and 15-turn also available)

INFINITE RESOLUTION 10-TURN POTENTIOMETERS

Both Dials and Potentiometers are supplied separately or together as required. Full details from separate leaflet.

DIAL is light-weight 3-digit unit, with last digit sub-divided into 4 divisions. Locking device is provided. Fits all ¼ inch shafts, e.g. potentiometers.

10-TURN POTS have resolution down to **INFINITY, LINEARITY** = 0.15% standard, but down to 0.02% to request. Mounting as size—15 Synchro, or standard bush fit.

Resistances: 5Ω, 10Ω, 25Ω, 100Ω, 500Ω, 1kΩ, 5kΩ, 10kΩ, 30kΩ, 50kΩ and 100kΩ.

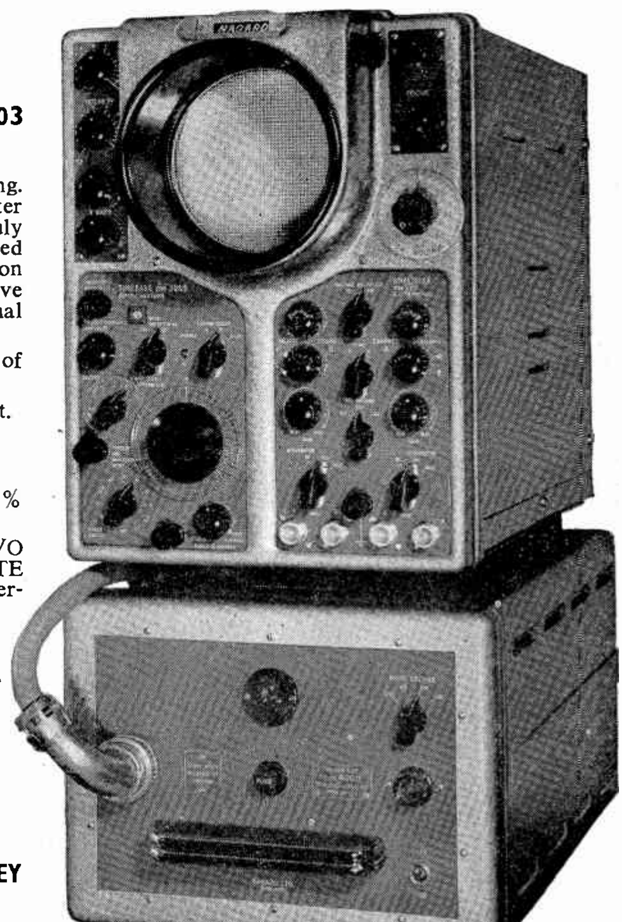
Terminals: Separate terminals connect to winding, case, and to winding mandrel. All-metal case, single-gang or multi-gang, or in one case with size 15 motor, complete with slipping clutch for servo-pot applications. Send for full data.

KYNMORE ENGINEERING CO LTD 19 BUCKINGHAM ST., LONDON, W.C.2

Telegrams and Cables KYNMORE LONDON Telephone: TRAfalgar 2371 (3 lines)

Two channel, cathode ray, high sensitivity

OSCILLOSCOPE MODEL DT 103



This is a truly two channel instrument not dependent on beam switching. Now available with a new type of double gun C.R.T., giving better trace definition and full screen displays free from distortion. The truly linear time base provides continuously variable sweep times calibrated within 2% over a range of 20 seconds to 200 μsec full screen. Expansion × 5 may be applied to either one or both beams for examining wave form details. Reliable and sensitive triggering from 20mV. External beam brightening for photography.

The Y amplifiers are similar in each channel, providing a bandwidth of D.C. to 150 Kc/s (—3dB)—rise time 2·5μsec.

Balanced inputs with high discrimination, low noise and grid current.

Y SENSITIVITY — 1 cm/200μV maximum.

Improved stability against drift.

Voltage measuring facilities by simple direct method within 5% accuracy. Lissajous displays with equal X-Y conditions.

Ideal for ELECTRO-PHYSIOLOGY, VIBRATION STUDY, SERVO MECHANISM DEVELOPMENT, VERSATILE AND ACCURATE FOR THE MODERN LABORATORY. Used by the leading Universities, Aircraft firms and many Government laboratories.

Ask for Data Sheet 4590.

A NEW LOW FREQUENCY DISPLACEMENT TRANSDUCER ideally suited for use with the above CRO is now available. Ask for Data Sheet 1590 *describing the PEP-2- a high sensitive device for vibration recording and analysis in the frequency range zero to* 500 *c/s by direct measurement of static or dynamic displacement.*

NAGARD LTD

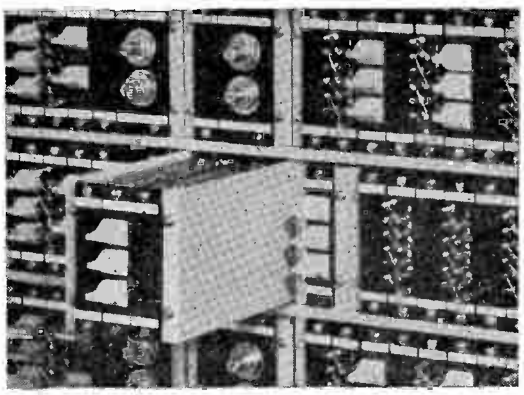
18 AVENUE ROAD · BELMONT · SURREY
Telephone: VIGilant 9161/2

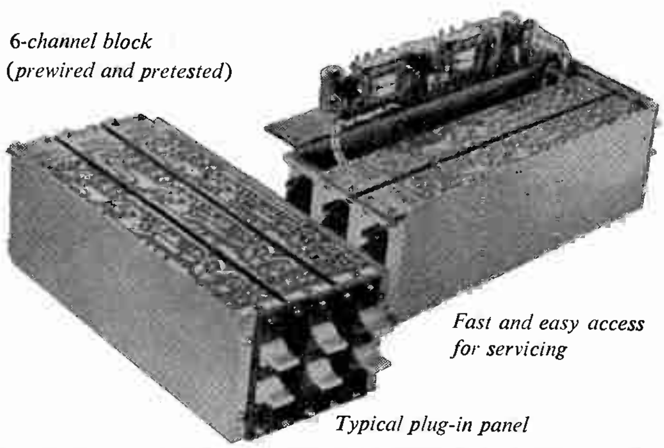
60 channels per bayside . . .

complete with carrier and power supplies

SIEMENS EDISWAN new equipment construction (E.C.3) offers this space saving advantage as well as these other features:

- 120 channel bay from 2 independently mountable baysides bolted back-to-back
- Complete with carrier and power supplies and inbuilt outband signalling
- Plug-in units
- Fully transistorised: designed and built to C.C.I.T.T. standards
- Complete and easy access to all components
- Uses standard 9 ft. by $20\frac{1}{2}$ in. bays, allowing immediate incorporation into existing station arrangements
- Station cabling terminates at each 6-channel block





6-channel block (prewired and pretested)

Fast and easy access for servicing

Typical plug-in panel

extending → the frontiers of telecommunications

SIEMENS EDISWAN

SIEMENS EDISON SWAN LTD *An A.E.I. Company*

Telecommunications Division P.D.8 Woolwich, London, S.E.18 Telephone: Woolwich 2020
Telegrams: Sieswan Souphone London

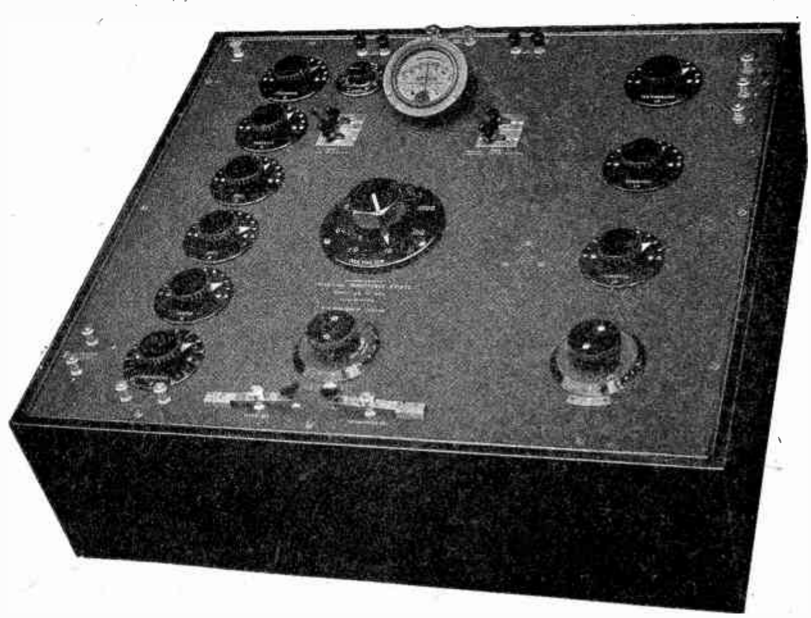
INDUCTANCE MEASUREMENT

One of the most outstanding technical developments of

H. W. Sullivan Limited

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. By using substitution methods, an accuracy of 0·01% is obtained.



Immediate delivery from stock.

ELECTRONIC & RADIO ENGINEER

incorporating WIRELESS ENGINEER

CONTENTS

VOLUME 36 NUMBER 7 JULY 1959

Established 1923

Published on the fifth of each month

ANNUAL SUBSCRIPTION
(*including Annual Index to Abstracts and References*)
Home and Overseas £2 9s 0d *Canada and U.S.A.* $7.50
Second-class mail privileges authorized at New York, N.Y.

Published by

ILIFFE & SONS LTD. DORSET HOUSE STAMFORD STREET LONDON S.E.I
Telephone · Waterloo 3333 Telegrams · Wirenger, Sedist, London

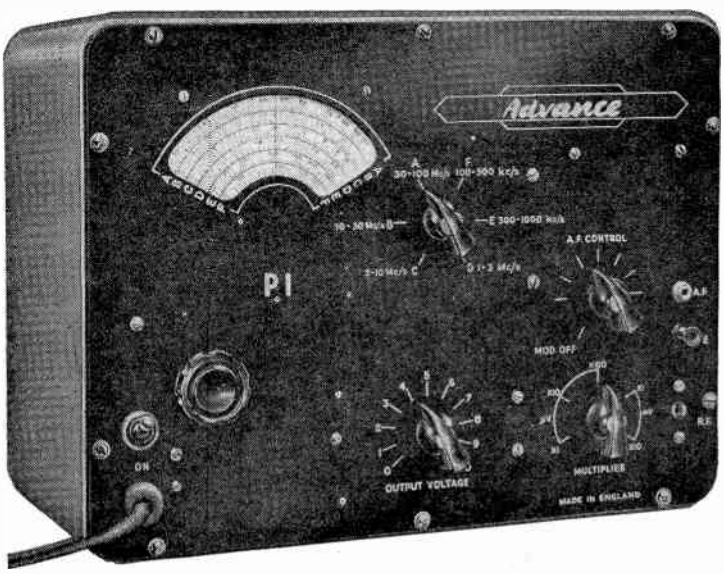
Branch Offices

COVENTRY · *8-10 Corporation Street–Telephone · Coventry 25210:* BIRMINGHAM · *King Edward House, New Street, 2–Telephone · Midland 7191*
MANCHESTER · *260 Deansgate, 3–Telephone · Blackfriars 4412 and Deansgate 3595:* GLASGOW · *26b Renfield Street, C.2–Telephone · Central 1265*

A PRECISION SIGNAL GENERATOR... *for the* SERVICE ENGINEER

Advance

—to be sure!



LIGHTER
Weighs only 10 lb.

SMALLER
12 in. wide by 9 in. high by 6 in. deep

COVERS
100 kc/s to 100 Mc/s on FUNDAMENTALS IN SIX RANGES

COMPLETE
with T.P. Pad and Dummy Aerial, etc.
For 105-125, 210-250 v. 40-100 c/s.

Employing standard signal generator technique, the P.1 incorporates an up-to-the-minute oscillatory circuit with special screening and filtering so that even at 100 Mc/s leakage is less than 3 microvolts.

The accurate attenuator system embodies a non-inductive slide wire followed by a five-position 75-ohm ladder network and the correctly terminated 75-ohm cable obviates mis-match reflections and provides dummy serial output voltages substantially those indicated by the attenuators.

Special Models available: P1/M for 105-125 volts, 210-250 volts, 40-100 c/s. P1/NA for 117 volts, 25-60 c/s.

Full technical details in Leaflet R47.

TYPE **P1**

NET PRICE IN U.K.

£25

Advance COMPONENTS LIMITED
INSTRUMENTS DIVISION
ROEBUCK ROAD · HAINAULT · ILFORD · ESSEX TELEPHONE: HAINAULT 4444

GD74

ELECTRONIC &
VOLUME 36 NUMBER 7 RADIO ENGINEER
JULY 1959 *incorporating WIRELESS ENGINEER*

An Insulating Amplifier

WE have all been brought up to believe that insulators do not conduct electricity. It comes rather as a surprise to learn, therefore, that an insulating material can act as a rectifying diode and that there is a possibility of constructing a triode of performance superior to valve or transistor.

It appears that an insulating crystal will conduct if free electrons can be injected into its allowed bands and if the crystal is sufficiently perfect for electron-trap effects to be small. A metallic cathode contact results in an excessive potential barrier but, if the cathode contact to a cadmium sulphide crystal is made via a diffused layer of indium, it is possible to introduce electrons into the crystal.

Diodes have been made with a cathode area of 1 sq. mm. and exhibit a reverse resistance of over 100 MΩ and pass, for example, a forward current of 4 mA at 10 V, forward conduction starting at 3 V. An amplifying triode is theoretically possible and should have a frequency bandwidth greater than that of a valve with characteristics less temperature-dependent than those of a transistor; and, a high input impedance.

A paper on this device was presented by G. T. Wright of the University of Birmingham at the recent I.E.E. International Convention on Transistors and Associated Semiconductor Devices; and, at the associated International Transistor exhibition, he showed some of the apparatus used in the construction of the diodes. His work has been carried out under the auspices of the National Research Development Corporation.

The theory of the device is developed in his paper which is entitled "Some Properties and Applications of Space-Charge Limited Currents in Insulating Crystals". It appears that the chief difficulties lie in the techniques of growing crystals and constructing diffused contacts. Crystals of considerably greater perfection than are now normal are needed.

Whether or not the device will prove a commercial possibility lies in the future. It is now of great theoretical interest and its appearance serves as a reminder that there is still a great deal to come in our field from solid-state physics.

Electronic Magnetizing and Demagnetizing

By D. Hadfield, M.Sc.(Eng.), Ph.D., M.I.E.E., F.I.M.* and H. Johnson*

Most permanent magnets need to be magnetized, and also possibly demagnetized, at some stage of manufacture.

Some require to be aged artificially from the fully-magnetized state in order to guarantee high stability of flux throughout the useful life of the equipment in which they are incorporated.

For many years, magnetizers have been very large, cumbersome pieces of electrical equipment requiring a high-power d.c. supply from a motor-generator set to operate them. They may be either d.c.-surge transformers producing a high momentary current in a single copper conductor on which magnets are placed, or large electromagnets fitted with specially shaped pole pieces to suit the magnet being magnetized.

Half-cycle magnetizers capable of producing a high d.c. pulse in a copper bar or cable, however, are much more light and compact, and operate direct from the a.c. mains. This type, as described below, can be constructed fairly cheaply, and the field produced used to magnetize a variety of sizes and shapes of magnet economically.

* *Swift Levick & Sons Ltd., Sheffield.*

Artificial stabilization of magnets by alternating fields may be carried out more effectively at a very low frequency, which may be produced by means of an electronic inverter circuit instead of conventional rotating machinery.

Magnetizing

An ignitron, or half-cycle magnetizer, consists of an ignitron tube with a trigger circuit; it is simple to construct and operate and does not require a d.c. source.

There are two ways in which the pulse may be utilized for magnetizing. In the first, the pulse is fed direct to a few turns of heavy-gauge cable and, in the other, a step-up current transformer is used to supply a copper bar.

The ignitron tube consists of a mercury-pool cathode, an anode, and an ignition electrode, called the ignitor, made of boron carbide, the pointed end of which dips into the mercury pool. The envelope of the tube is made of stainless steel and is double-walled to enable water-cooling to be used. However, cooling is not necessary in magnetizing equipment because the current on-off ratio is small, a typical average being 1 : 700. The principle of operation of an ignitron magnetizer when supplying a very high current pulse for magnetizing magnets on a copper bar is described by reference to the circuit diagram shown in Fig. 1. Two lines of a 415 V, 3-phase, a.c. supply are fed direct from a main distribution board through 30-A HRC fuses to a circuit breaker. The cable must be at least 19/0·064 gauge to minimize the voltage drop which is mainly due to resistance when the momentary current is passing. A current pulse of 10 to 40 A is delivered to the ignitor during a period when the anode is positive with respect to the cathode, and its value exceeds the ignition voltage. A hot-spot is formed on the surface of the mercury pool by the intense local field set up between ignitor and

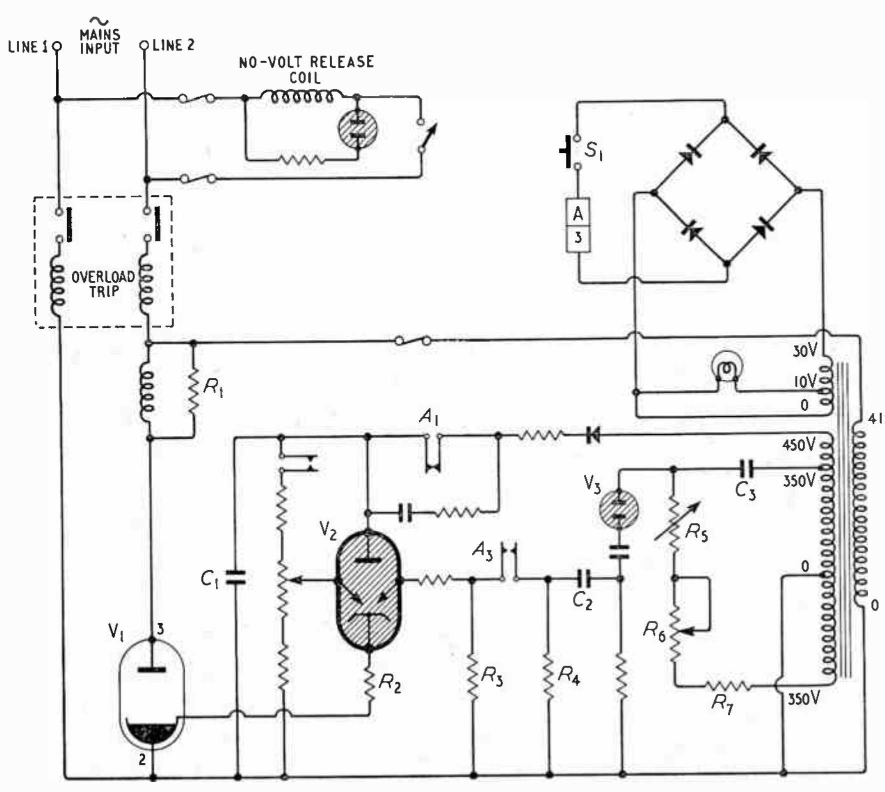


Fig. 1. *Ignitron magnetizer circuit*

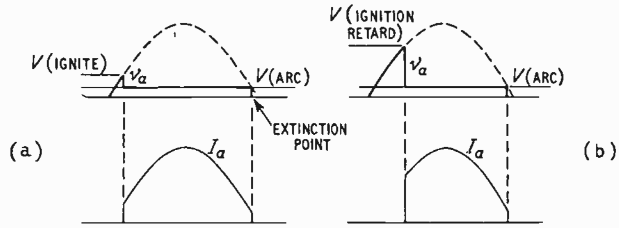


Fig. 2. *Waveforms for ignitron with resistive load*

mercury cathode, and moves at a high speed over the surface, increasing the vapour pressure until complete ionization takes place, and the tube is fully conducting. Approximately 0·75 gramme of liquid mercury is vaporized for an electrical quantity of 100 ampere-seconds[1]. The complete ignition of the tube takes approximately 10^{-5} second, and it continues conducting until at the end of the half-cycle the anode supply voltage falls below the arc voltage (12–18 V) or the tube current falls below 10 A approximately. If the anode load of the ignitron consists of a single or a few turns of heavy-gauge conductor then the load circuit will be mainly resistive, the presence of magnet material around the copper bar or in the coil not greatly affecting the load circuit because the permeability is small. The approximate waveforms of the circuit are shown in Fig. 2(a). The effect of delaying the ignition of the ignitron as a means of controlling the load current is seen in Fig. 2(b). Provided the circuit is resistive and the value of the arc voltage is small compared with the circuit voltage, firing can take place from almost 0–180° of the cycle.

A highly-inductive load (such as a large coil with an iron yoke) would give waveforms as shown in Fig. 3(a), assuming the anode supply voltage to be high enough to enable the current to exceed the critical value for ignition. It can be seen that the duration of the current flow now extends beyond the point at which the anode supply voltage becomes zero. This is because the current wave lags with respect to the voltage curve; the inductive load supplies a back e.m.f. tending to maintain the current flow and the voltage is sufficient to keep the anode of the ignitron positive with respect to the cathode by an amount equal to the arc voltage. Therefore, a full current wave may pass the ignitron even if ignition is retarded by an angle θ. A phase difference of 90° between voltage and current would result in full conductance at 90° firing angle, and a reduction in current between 90–180°, the effective range of firing angles thus being reduced to 90°. A copper bar or coil will contain resistance, hence the phase lag will be less than 90°, and the effective firing range greater than 90°. The phase of the trigger pulse may be varied with respect to the mains voltage by the phase-shift circuit of C_3, R_5 and resistor-chain R_6, the latter giving a coarse control, and R_5 a fine control. The voltage across C_3 lags about 90° behind the voltage across the resistor group (R_5, R_6 and R_7). The sum of both voltages will equal the transformer-secondary voltage (700 V).

Consideration of the vector diagram, Fig. 4, shows that V_g moves on a semicircle, the diameter being the vector of the transformer voltage V_{tr}. The magnitude of the output voltage V_g at point 'A' remains constant and is equal to half the transformer voltage but its phase is shifted by an angle θ which can be varied over a range of approximately 0–180° by altering the value of the resistor group (R_5, R_6 and R_7). V_3, the impulse valve, is a gas-filled discharge tube which fires when the voltage across the tube exceeds the striking voltage, conduction takes place on both negative and positive half-cycles, and the output of V_3 is differentiated by C_2, R_3 and R_4 to sharpen the leading edge of the pulses, and increase the precision of ignitron firing. The pulses are applied to the trigger grid of V_2, C_1 discharges through V_2 via the limiting resistor R_2, and a heavy discharge of some 70-A peak flows from ignitor to cathode of the ignitron, conduction takes place and current (about 5,000-A peak) flows from the 415-V mains to the magnetizing coil or transformer primary for the remainder of the positive half-cycle. During the next half-cycle, the anode of V_1 is negative, and no current flows. Neither V_1 nor V_2 can fire again until pressure on the operating button is removed, permitting relay A_3 to open, thus allowing C_1 to recharge when S_1 is released. This recharging process takes less than a second; the equipment is then ready for a further pulse.

An ignitron tube with a load consisting of a few turns

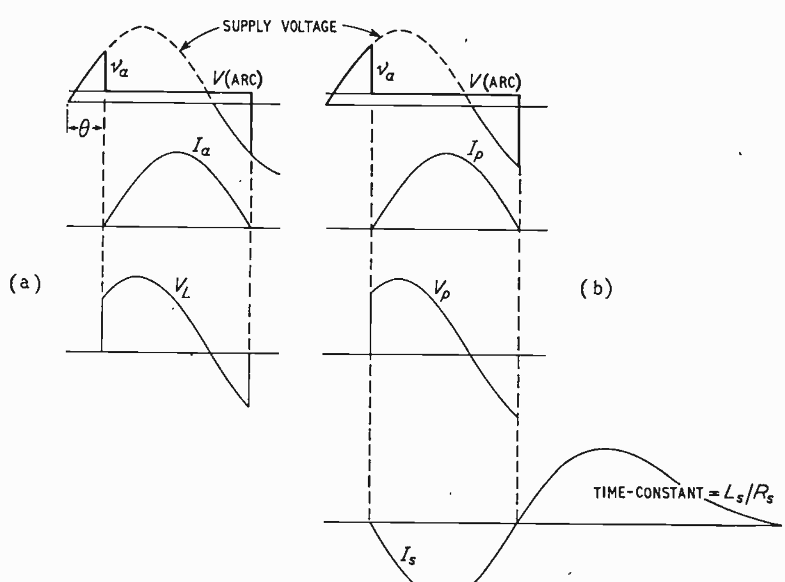


Fig. 3. *Waveforms for inductive load*

of heavy-gauge 19/0·064 can pass a current of a little over 5,000 amperes peak, but modern magnet materials require magnetizing currents many times greater than this; a current step-up transformer is therefore essential. A transformer with a turns-ratio of 40 : 1 is commonly used, its secondary being short-circuited by a large-area copper bar. The secondary current, Fig. 3(b) will reverse when the primary current has fallen to zero; after peak current has been reached in the reverse direction it will die away with a time-constant L_s/R_s, where L_s is the secondary inductance and R_s is the secondary resistance. These are reflected into the primary winding as $L = n^2L_s$ and $R = n^2R_s$; n is the turns-ratio of the transformer. In the first half-cycle, the secondary winding, which is loaded with a short copper bar of at least ½-in. square cross-sectional area, will deliver approximately 75,000 A, and the reverse trailing wave will amount to 45,000 A. The primary may be damped with parallel resistance R_1; this helps to reduce the duration of the primary current and therefore the extent of the secondary reversal. The effect, however, is small, and the main use of R_1 is to damp out the high voltage surge which takes place when the current flowing in the transformer primary circuit ceases abruptly as the ignitron extinguishes at some 10 A current value.

Magnets which can be magnetized with less than 45,000 A are therefore first magnetized in one direction by the forward peak-current, and magnetized in reverse by the trailing wave. Provided the magnets are saturated in the reverse direction, satisfactory results are obtained. Ceramic magnets which have a coercivity almost three

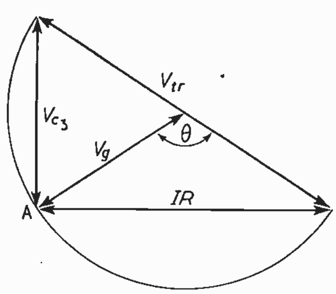


Fig. 4. *Vector diagram showing dependence of $|V_g| \angle\theta$ on the values of C_3, R_5, R_6 and R_7*

times greater than alloy magnets may require currents higher than 45,000 A. To avoid the use of larger transformers, reversal of current in the secondary can also be reduced or almost entirely eliminated by various other devices.

(a) The turns-ratio may be made large enough to give an aperiodically-damped discharge unless the circuit is purely *LR* when this would not be necessary. But the disadvantage is that the pulse decay time is very long, and also the flux density in the transformer core is very high and saturation may occur giving rise to large energy losses in the iron core.

(b) Another method is to bias the transformer to saturation magnetically by means of a d.c. winding. The transformer is then energized in the opposite direction and the whole flux range of the core is now available. Output may be doubled for a given core size, and there is no secondary current reversal. A novel method of biasing the core of the transformer is to fill the usual air gap with ceramic magnet material as this material can function satisfactorily in the form of thin plates magnetized through their thickness[2].

(c) A second ignitron can be used as an inverse shunt tube across the transformer primary, and fired when the primary voltage goes negative; thus the primary voltage is held to a value near zero and current flow in the primary coil is maintained in the same direction. The secondary current therefore also flows in the same direction and dies away exponentially.

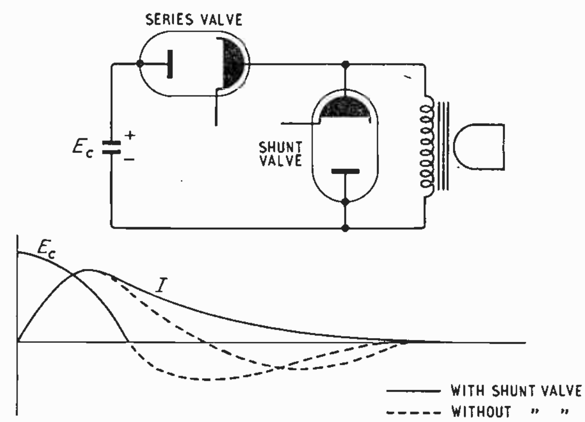


Fig. 5. *Ignitron capacitor discharge magnetizer with shunt ignitron clamp*

This type of magnetizer differs from that previously described, mainly in the source of energy. The heavy-duty magnetizer may be supplied with energy stored in a capacitor bank totalling 1,800 μF and charged by a three-phase rectifier from a high-voltage mains transformer to 3,000 V d.c. One advantage of this system is that the current demand from the mains supply is greatly reduced. This, however, is at the expense of operating speed.

The magnetizing current can now be controlled only by varying the charging voltage, or by adjusting the value of the capacitor bank, thus a simple firing circuit without a phasing network can be used.

The capacitor bank is discharged via a series ignitron into a current step-up transformer; the circuit diagram and waveforms are given in Fig. 5. These are similar to the waveforms of a capacitive discharge welding equipment[3].

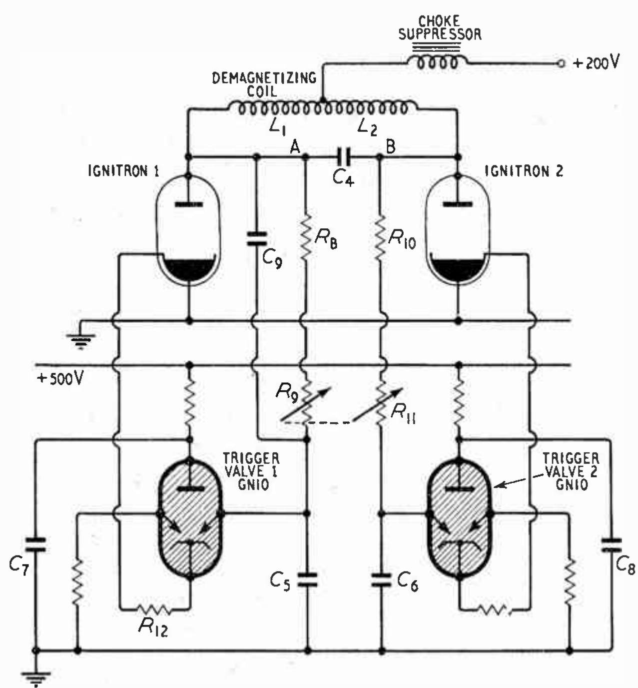
Using a shunt tube, the energy in the secondary is prevented from oscillating back into the primary circuit; the shunt tube is fired at a time when the capacitor bank is fully discharged. The current in the secondary winding decays exponentially and ceases abruptly when the current value will no longer support a cathode hot-spot in the shunt ignitron.

Demagnetizing

An alternating field of frequency 50 c/s for artificial stabilization or complete demagnetization of permanent magnets is often unsuitable, particularly for high coercivity (H_c>700 oersted) materials; e.g., alloys and ceramics, and large magnets (cross-section >50 sq. in.). The alternating field may not always be uniform throughout the cross-section of the magnet due to skin effects, resulting in non-uniform demagnetization. The use of lower frequency fields overcomes this, and a convenient method of obtaining high-power a.c. fields of frequency from 1 to 10 c/s is by means of a self-excited inverter supplying a centre-tapped coil.

A simple circuit is shown in Fig. 6. Two ignitrons are ignited alternately by means of trigger tubes, the frequency of the trigger pulses being governed by a timing circuit. On switching on all supplies, one trigger valve (Ferranti GN10, cold-cathode tetrode) will usually strike first, depending on circuit conditions and also on which trigger tube has the lower striking voltage. Capacitors C_5 and C_6 will commence to charge towards the 200-V supply in a time controlled by $C_5(R_8+R_9)$ and $C_6(R_{10}+R_{11})$. A small capacitor C_9 is connected between the anode of ignitron No. 1 and the trigger electrode of trigger valve No. 1 to enable this valve to strike first when the 200-V d.c. supply is switched on, and thus eliminate the possibility of the two trigger valves firing simultaneously. When trigger valve No. 1 strikes first, C_7 will discharge a heavy current via R_{12} to the ignitor electrode, and ignitron No. 1 will fire. Current from the 200-V d.c. supply then flows through the L_1-half of the demagnetizing coil to earth. The anode potential of ignitron No. 1 drops to approximately 15 V and trigger valve No. 1 is prevented from striking. A negative pulse from ignitron No. 1 anode via C_4 checks any tendency of trigger valve No. 2 to strike immediately by holding point B at a low potential. Capacitor C_4 begins to charge and B goes positive allowing C_6 to charge; when the striking voltage is reached, trigger valve No. 2 discharges C_8 through the ignitor of ignitron No. 2, thus switching the current through the other half (L_2) of the demagnetizing coil.

Fig. 6. *Variable low-frequency demagnetizer circuit*



The negative pulse at ignitron No. 2 anode is fed to ignitron No. 1 anode via C_4. The capacitor is already charged, so the potential drop at point B, which may be approximately −185 V initially, is added to the charge on C_4, and point A may go negative by about 370 V if C_4 is fully charged. Thus, ignitron No. 1 is extinguished and C_5 begins to charge as point A begins to go positive. C_4 first discharges through the demagnetizing coil, then charges positive towards the supply potential, and trigger valve No. 1 strikes, and the sequence begins again.

The circuit will eventually reach a steady state where points A and B are driven alternately below earth potential, thus holding off one trigger valve and allowing the other one to strike. The value of C_4 can be adjusted to resonance, and peak voltages across the demagnetizing coil will increase, thereby increasing the efficiency. R_9 and R_{11} are ganged variable resistances and control the timing period from 1 to 10 c/s. The choke suppressor is merely to prevent switching harmonics being fed back into the d.c. mains.

Greater stability can be achieved by driving the ignitron circuit with a separate oscillator. A circuit of this type is given in Fig. 7. The oscillator circuit is a

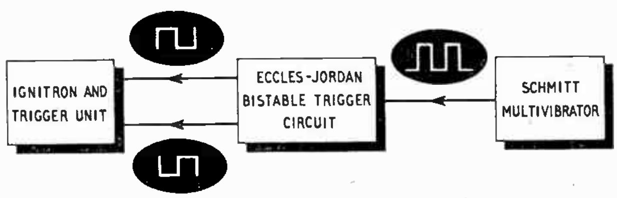


Fig. 7. *Block diagram of stable ignitron circuit*

simple low-frequency saw-tooth pulse generator known as a Schmitt multivibrator[4,5]. The output pulse is used to drive an Eccles-Jordan trigger circuit, and outputs are taken from both anodes to give a push-pull drive to a pair of cathode followers connected to the GN10 discharge valves. The cathode followers are necessary to prevent the triggering surges from the discharge valves interfering with the operation of the Eccles-Jordan trigger circuit. A negative trigger pulse is required by the GN10 discharge valves, which are fired alternately, but the trigger surge-voltage is positive. The Schmitt multivibrator can be made variable over the range 1–10 c/s.

Acknowledgements

The authors wish to thank the Directors of Swift Levick & Sons Ltd., Sheffield, for permission to publish this article.

REFERENCES

1 D. R. Kretzmann, "Industrial Electronics", Philips Technical Library.
2 H. G. Bruijning and A. Rademarkers, "Pre-magnetization of the Core of a Pulse Transformer by Means of Ferroxdure", *Philips Tech. Rev.*, 27th July 1957, Vol. 19, No. 1.
3 H. Klemperer, "Capacitor-Discharge Welding Systems", Markus and Zeluff, McGraw-Hill, 1945, p. 136.
4 R. C. Webb and J. M. Morgan, "Simplified Television for Industry", *Electronics*, June 1950, Vol. 23, p. 70.
5 G. L. Swaffield, "The Schmitt Multivibrator", *Wireless World*, July 1958, Vol. 64, p. 344.

FOUR SOLAIRE

The canasta addicts, and those blithe spirits who never associate Wheatstone with bridge, need not (at least for a moment) turn away with the superior air that the true toxophilite exhales when confronted with a dartboard. This is a pen-of-my-aunt title of the kind that I have got away with once or twice already without overt reproach. And, since the thermonuclear people themselves use cosmic-sounding names for their devices (such as Astron and Stellerator), who am I that I should presume to use plain English? It may seem a little remote as a heading for an article on the Convention on Thermonuclear Processes, held by the Institution of Electrical Engineers in conjunction with the British Nuclear Energy Conference on 29th–30th April of this year. I should prefer to call it far-fetched, and digress a little to tell you how far I went to fetch it.

It was my intention, until the proceedings of this Conference came my way, to write a full article on the solar furnace station at Montlouis in the Pyrenees—my annual touch-of-the-sun holiday contribution. The intention still stands, but I found this much more important matter on my plate when I came back. I got to Montlouis itself, which is an extraordinary-looking place for a village, presenting an almost closed front to the outside world rather like Wadham or Magdalen or the more circumvallated kind of Oxford college. Outside the gate you see the simple legend, "Four Solaire"; and once inside it, a most attractive village (*alt.* 1,600 *m.*; 418 *h.* is all the Guide Michelin tells you about it). Neither pens nor aunts count for very much there, and the only means of communication with the 'habitants' is by a combination of semaphore and telepathy.

They explain that there is no "Four Solaire"; later you find out that local legend has it that the station was set up by a party of sorcerers who are trying to steal all the sunshine, so they probably have another name for it. Eventually you find the Citadel, and begin to feel things starting all over again; for this presents an almost closed front to the outside world, etc., except that it looks much larger than the village itself, and suggests that there must have been a bit of sorcery to get it inside at all. Eventually penetrating to the nucleus of all this (which presents an almost closed front, and appears much more extensive than the Citadel) you come to the Solar Energy Laboratory at last.

Here they have one huge concave mirror, and a battery of smaller ones, producing furnace temperatures of the order of 3,000 °K, and directed mainly, it appears, to ceramics research. This station, however, is only a small one really; something on the Jodrell Bank scale is projected at Font-Romeaux nearby. The details must wait for now; but all this seemed worth mentioning since, if you happen to be one of the many Britons who will be going that way in the summer, it is a visit to be recommended. Don't thank me for the tip; as my aunt would write, that doesn't make nothing.

And now for the relevance of all this to the job in hand. As a means of utilizing thermonuclear energy, the solar furnace is only a stage or so more sophisticated than the efforts of Bullard's fragrant eucalyptus. It shakes one a little to realize that *all* methods of extracting energy usefully are basically simple, even in the fusion field. Hitherto, the engineers have been concerned primarily with trying to attain thermonuclear conditions and with getting the energy conversion at all; the new feature in their programme is that they are thinking seriously about the methods available for extracting the energy with the maximum efficiency. And instead of doing the best they can with what comes out of the source, they are calculating how to manipulate the source itself to the best thermodynamic advantage.

The I.E.E. Convention

The convention itself covered five sets of topics. These were :—

1. *The Development of Thermonuclear Devices in Britain*

Here the major papers were by Dr. T. E. Allibone and Mr. D. S. Chick of Aldermaston on "The Basic Physics of Thermonuclear Processes"; a contribution from the Harwell team on "The Design and Performance of Zeta"; Mr. A. A. Ware on "Sceptre IIIA"; and Dr. R. M. Payne and Dr. S. Kaufman on "Physical Measurements in Heavy-Current Discharges".

2. *Construction Features of Zeta*

The contributions in this session covered the choice of materials and design problems; vacuum system design; switching and control; the Zeta transformer and auxiliary equipment; and the modifications made to Zeta during 1958 in pursuit of the aims noted briefly in an earlier "Fringe" article ("Further Outlook—Warmer", November 1958, p. 416).

3. *Contributions from U.S.A. and U.S.S.R.*

Under the chairmanship of Mr. D. W. Fry, papers were given by Dr. C. M. Van Atta on "Thermonuclear Research in the U.S.A.", and by I. N. Golovin on "The Trapping of Fast Charged Particles by Constant Magnetic Fields". Offprints of these were not, in fact, circulated; but instead I received a copy of a paper by Mr. Fry reviewing work towards nuclear energy from controlled thermonuclear reaction, and summarizing the properties of the devices described at the 1958 Geneva Conference on the Peaceful Uses of

Atomic Energy. There seem already to be about 32 of these, which he classifies broadly into two groups—Closed-Line Containment Systems, such as Zeta and other pinch devices, where the magnetic field operating on the charged particles arises from currents circulating in the plasma itself, or from an equivalent arrangement; and Open-Line Containment Systems of the so-called magnetic-mirror type, which invoke magnetic fields produced by external current-carrying coils. The second of these is that employing elementary mechanics with a new and ingenious twist, and is the one I shall discuss briefly in a moment, assuming that the general idea of the pinch devices is pretty well known by now.

4. *Engineering Design Problems Associated with New Systems*

These included the calculation of the currents in a torus with a continuous conducting liner; the design of switchgear and suitable ignitrons for use in high-voltage heavy-current pulsing circuits; and a paper on transformer design for toroidal discharge systems, one point mentioned in this being that the transformer itself is an agent for the *storage* of energy.

5. *The Constricted Plasma and its Future*

A rather difficult paper by Mr. B. S. Liley on "The Circuit Dynamics of Plasma" is quite beyond me to interpret in simple terms. I find it easy enough to reconcile myself to a state of matter in which an electric current and a mass-movement of material go together, in which magnetic fields and hydrostatic pressure pair off, and in which you use Maxwell's equations and the equations of hydrodynamics in parallel, but I rather think of it as a particularly versatile kind of gas. If, however, you approach the matter from the other side, and derive equivalent circuits, you can think of it as a rather transitory kind of network, and this is what Mr. Liley has done. The two contributions that I shall deal with more fully in a moment, because they involve simple principles that I can better understand, are those by Dr. G. B. F. Niblett on "Rapid Compression of a Plasma by Azimuthal Currents", and by Mr. J. F. Jukes on "Possibilities of Direct Energy Conversion from Fusion Reactors".

Containment

Given a fully-ionized plasma of charged particles, closed-line containment is a straightforward electrodynamic problem, like the establishment of the pinch discharge itself. The magnetic-mirror or open-line method is a good deal more subtle, in that it converts the kinetic energy of translation of a particle that is trying to escape from containment into kinetic energy of rotation, by a sort of cyclotron-resonance effect.

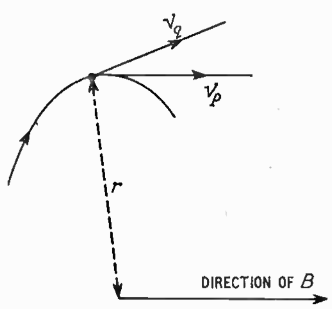


Fig. 1. *Motion of a positively-charged particle describing a helix of radius of curvature r about the direction of the magnetic flux B. The components of its velocity are v_p parallel to B and v_q at right angles to it. Keeping the total energy unchanged, v_p is to be reduced by increasing v_q*

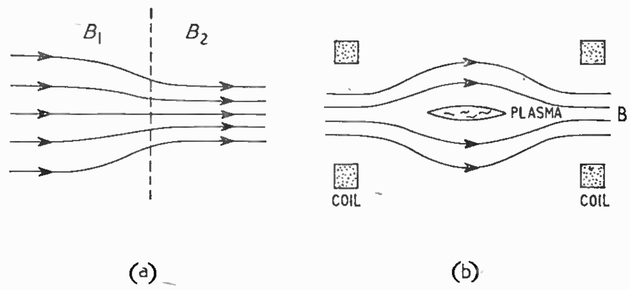


Fig. 2. (*a*) *Principle of the magnetic-mirror effect. Particles drifting from left to right and moving into a region of higher B have their orbital energy increased and their translational energy reduced.* (*b*) *General design of the practical arrangement, in which both ends of a linear tube are "closed" by regions of increased B*

Suppose that (Fig. 1) we have a particle of charge e and mass m, moving in a more or less helical path in a magnetic field of flux-density B, the radius of curvature of the helix being r; the units here are all absolute c.g.s., in which Allibone and Chick's paper is written. The components of its velocity are v_p parallel to B and v_q at right angles to B; the corresponding kinetic energies of translation towards the limit of the field, and of orbital rotation, $\frac{1}{2}mv_p^2$ and $\frac{1}{2}mv_q^2$, will be called W_p and W_q respectively. The sum of W_p and W_q being constant, the object of the exercise is to reduce W_p to zero by transferring its energy to the W_q side.

Then, from the usual equation for a particle moving in a magnetic field, $v_q = Ber/mc$

$$\text{So, } \frac{W_q}{B} = \frac{\frac{1}{2}mv_q^2}{B} = \frac{e}{2mc}(mv_q r) = \mu,$$

where μ is the constant magnetic moment of the 'orbit' round B.

Now suppose, Fig. 2 (a), that the particle goes from place 1, where the values are B_1, W_{p1}, etc., to place 2, where they are B_2, W_{p2}, etc., B_2 being greater than B_1. As μ is constant, then $W_{q2}/W_{q1} = B_2/B_1$. Also, as energy is conserved, $W_{p1} + W_{q1} = W_{p2} + W_{q2}$. The condition for W_{p2} to be zero (that is, for the drift in the direction of the field to be arrested is

$$\frac{W_{p1}}{W_{q1}} + 1 = \frac{B_2}{B_1}.$$

And, although this line of argument does not seem to go on to demonstrate it, if B_2/B_1 exceeds the value needed to reduce v_p to zero, then the direction of v_p is reversed, and the particle moves away from the boundary.

Pushing Plasma About

The thermodynamical properties of plasma, just like those of the magnetic gas we were considering a month or two ago at the other end of the temperature scale, are the same as those of any other sort of working substance. If it is compressed, then external work $dW = pdV$ is done on it by an external agent and, if this is done adiabatically, the temperature rises; if it is allowed to expand adiabatically, external work $dW = pdV$ is done by it on its constraints, and the temperature falls. It is, in principle, just as easy to get to 10^{-6} or 10^{6} °K

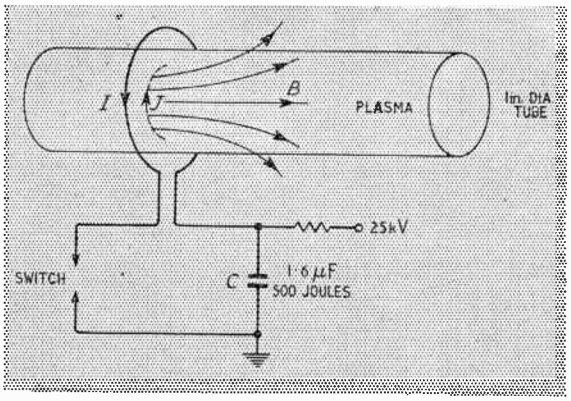


Fig. 3. *Principle of shock-wave generation in plasma (adapted from a figure in Dr. Niblett's paper). The discharge of the capacitor sends a large current-pulse I through the thick copper winding round the plasma tube; this gives an axial magnetic flux B, whose change induces a current J in the plasma. Electromagnetic action between B and J (or, in even simpler terms, repulsion between I and J) causes a rapid implosion which compresses the plasma. The general idea of 'magnetic pumping' is similar*

with the right sort of working substance as it is, say, to start a Diesel engine or to work a cloud-chamber. Before you get cross about this statement, just pause for a moment (or refer back to the article on "Magnetic Refrigeration", March 1959, p. 91) to see what it is that *is* difficult. Not the operation of the laws of thermodynamics, but *arranging for communication of energy between the working substance and the surroundings.*

There is no question of ever being able to make ordinary materials which will be able to push plasma about at million-degree temperatures, so the process will just have to do without them. And the operation of a suitable magnetic-field for containment shows how; for, going only one stage further, a *changing* magnetic field can play the part of a *moving* wall or piston, put energy into the plasma, or take it out again. The general term used for this process is 'magnetic pumping'. Fig. 3 shows the principle of energy-communication to the plasma as a shock-wave. When C is discharged, the changing azimuthal current in the coil produces a changing magnetic field H along the axis, which induces an azimuthal electric field and current in the plasma; the electrodynamic forces between axial field and azimuthal plasma current drive the plasma in towards the axis, with a violent 'implosion' shock. Temperatures of the order of 30 to 200 eV (that is, 3×10^5 to 2×10^6 degrees K) have been obtained in this way, and it is believed that true thermonuclear fusion resulted.

The next step, having got so far, is to try and operate on the hot plasma, after the shock has operated on it, compressing it adiabatically by a rapidly-rising magnetic field produced in a similar way. This is the general principle used in the Scylla device of Elmore, Little, and Quinn, which is a linear tube with "magnetic-mirror" field-shaping, and it has also been adapted to toroidal-pinch devices. By *reducing* the magnetic field, the plasma can be made to expand adiabatically; so all the ingredients for cyclic operation seem to be available.

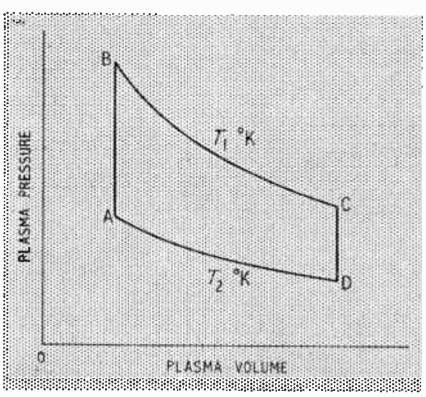


Fig. 4. *Carnot-cycle diagram for plasma. The heat source at T_1°K is the fusion action proceeding strongly at this higher temperature*

The Carnot Cycle

Mr. J. D. Jukes' article takes over at this stage to deal with the possibility of extracting useful work *directly* from a thermonuclear system. In Fig. 4, based on a diagram in his paper, you will recognize none other than the *Stirling* cycle, with two isothermal and two constant-volume stages; the affinity between the thermonuclear fusion reactor and the helium-gas refrigerator is a little closer even in detail than most people would imagine. The constant-volume lines are in fact also adiabatics, so this is really the basic Carnot cycle after all.

Suppose, then, that we can by the magnetic-pumping mechanism described heat the plasma up adiabatically from some temperatures. T_2 °K, at which the abstraction of energy exceeds its rate of production by thermonuclear action, to a higher temperature T_1 °K, at which the fusion reaction proceeds more strongly, generating heat which is taken in by the working substance and causes it to expand, transferring energy to the outside world by electromagnetic induction; then allow the plasma to expand adiabatically until it is down to T_2 °K again; and finally reduce its volume isothermally, following the cycle ABCDA. We then have a direct method of drawing power from the system without the intervention of a 'heat' stage of the usual kind. Mr. Jukes has calculated what might be possible for a toroidal-pinch system, assuming that the changes in the magnetic field are produced by modulating the pinch-current itself. He shows that square-wave modulation is vastly more effective than sine-wave modulation, and gives some figures for the square-wave case. The theoretical thermodynamic efficiency should be of the order of 50 to 75% the contribution made to this by direct electromagnetic extraction being of the order of 30%. In a useful power-producing reactor, the pinch current required would have to be several million amperes for a deuterium-tritium mixture, and between five and ten times as great for pure deuterium. This seems a very great deal, and one can now look back at the more technical papers and see where the importance of heavy-duty switchgear and so on comes in. Naturally, I am not well enough versed in these things to be able to look ahead with the eyes of the people who do understand all the details. But the general plan of campaign seems to be tremendously reassuring now that it has been revealed as an application of the ordinary simple everyday physics that you and I can follow and believe in.

Transistor Current Gain

MEASUREMENT OF COMPLEX α AT FREQUENCIES UP TO 210 Mc/s

By **R. W. Smith, B.Sc.** and **F. J. Hyde, M.Sc., A.M.I.E.E.***

(*Official communication from D.S.I.R. Radio Research Station, Slough*)

SUMMARY. *Apparatus used for a twin-channel comparator method of measuring complex values of current-gain α at frequencies between 1 and 210 Mc/s, and for a single-channel null method at frequencies up to 25 Mc/s are described. Results obtained by both methods in the overlap frequency range are shown, and the effects of stray capacitance on the measurements are illustrated.*

It is of considerable interest to the transistor designer and circuit engineer to know how transistor performance varies with frequency. One of the most rewarding parameters to study in this connection[1,2] is the common-base near-short-circuit current gain $\alpha \equiv i_c/i_e$ when $v_c = 0$, where i_c, i_e and v_c are defined in Fig. 1. In the present article, two pieces of apparatus are described by means of which complex values of α may be measured in the frequency range from 1 to 210 Mc/s. In each case, the principle of the measurement[1,3] is to compare in amplitude and phase the r.f. voltages developed across small resistors R (see Fig. 1) in the emitter and collector circuits. Provided that the resistors are kept small ($\approx$ 50 ohms) and that the stray capacitances C_{eb}, C_{ec} and C_{cb} are also small, then these voltages may be regarded as directly proportional to the transistor r.f. currents i_e and i_c. The two sets of equipment to be described are based on a twin-channel comparator method and a single-channel null method respectively.

Twin-Channel Comparator Apparatus

A schematic circuit of the equipment, which covers the frequency range 1–210 Mc/s is shown in Fig. 2. The twin channels are arranged to have identical phase and amplitude transmission characteristics by a preliminary setting-up operation; this involves replacing the transistor by a short-circuit between the emitter and collector terminals, so that a common signal is injected into the channels. α is subsequently determined with the transistor in circuit, from the shape and orientation of the ellipse displayed on the cathode-ray tube[1]. In fact, the ratio of the magnitudes of the axes of the ellipse and its bearing angle are measured; the complex ratio of the input voltages ($\equiv \alpha$) is then determined from these, using standard graphs.

The receiver used[4] is an Admiralty pattern, type FHB. This has a frequency range from 1 to 24 Mc/s and is a twin-channel superheterodyne model fitted with controls for balancing the transmission characteristics of the channels. The purpose of the converter unit is to extend the range of this receiver and, in this connection, the FHB receiver is used as an i.f. amplifier. To cover the range up to 210 Mc/s, two converter units have been used. The first operates between 21 Mc/s and 105 Mc/s and the second at frequencies of 126, 162 and 210 Mc/s. In each case a symmetrical design has been aimed for in the emitter and collector channels, which are well-screened from each other. Any residual unbalance between the converter channels is taken up by the balance controls of the FHB receiver.

Some details of the transistor circuit associated with

* Now with University College of North Wales, Bangor

Fig. 1. *Basic measuring circuit for α*

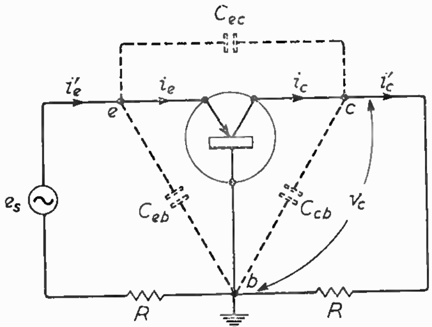
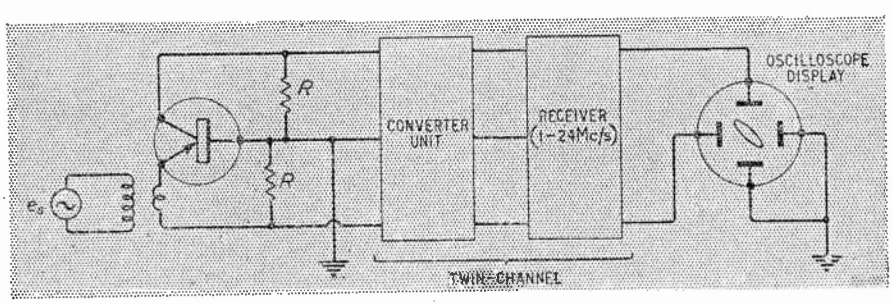


Fig. 2. *Schematic circuit illustrating the twin-channel comparator method of measuring α*



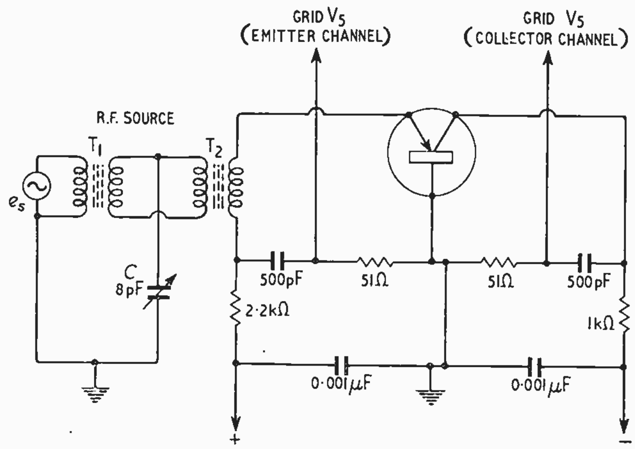


Fig. 3. *Transistor circuit associated with higher-frequency converter*

the lower-frequency converter have already been given[1]. In the following sections the details of the transistor circuit associated with the higher-frequency converter and the design data of each of the converters are described. The latter are both based on the block-schematic diagram of Fig. 4.

Transistor Circuit associated with the Higher-Frequency Converter

The circuit diagram, which includes the bias supplies, is given in Fig. 3. An important desideratum is that there should be no significant capacitive coupling to earth from the transformer feeding the r.f. signal into the emitter circuit. This is because any such coupling will provide an alternative r.f. path to that of the emitter lead and a corresponding potential will be developed across the 51-Ω resistor in the emitter circuit, which is not due to transistor current. It was found necessary to use the double transformer coupling shown, the general principles of design put forward by Maddox and Storer[5] being followed. Transformer T_2 is wound on a Ferroxcube type 1073/A4 core, the former being made of ten turns of 0·003 in. thick polystyrene tape. The primary winding consists of four spaced turns of 20-gauge enamelled wire, primary-to-secondary separation being provided by ten turns of 0·003 in. polystyrene tape. The secondary winding, symmetrically disposed with regard to the primary, consists of six turns of spiral-wound 3/32 in. × 0·001 in. copper foil with 0·003 in. polystyrene tape insulation. The 1 : 1 transformer T_1, whose function is to provide an r.f. output approximately balanced about earth, is constructed in the same way as T_2, with the exception that the primary winding consists of six turns of spiral-wound 3/32 in. × 0·001 in. copper foil with 0·003 in. polystyrene-tape insulation. The 8-pF trimmer capacitor C is included so that capacitive coupling from the transformers to earth can be minimized. The procedure for this, which is carried out at each frequency, is to remove the transistor from the circuit, feed an r.f. signal into the primary of T_1 and then adjust C until the voltage developed across the emitter resistor is a minimum.

By making measurements on the transmission of a CR network replacing the transistor it was found that the capacitance to earth injected into the 'emitter' circuit by the transformer combination was less than 1 pF.

The transistor circuit is wired inside the converter unit (described in the following section); the transistor holder is designed to minimize both collector and base lead inductance and the emitter-base capacitance.

Frequency Converter for 126, 162 *and* 210 *Mc/s*

With reference to the block diagram of Fig. 4, V_1 is a crystal oscillator operating at 48 Mc/s, harmonics at 144 Mc/s or 192 Mc/s being selected and amplified by a tuned-cascode stage V_2. The output from V_2 is fed into two identical channels. V_3 is a tuned-cascode buffer stage, its output being fed to the grid of a triode mixer V_4, which also takes the r.f. signal from the transistor via an untuned-cascode buffer amplifier V_5. The intermediate frequency outputs at 18 Mc/s from V_4 are fed to the FHB receiver.

Frequency Converter for the Frequency Range 21–105 *Mc/s*

The design details are similar to those of the converter described above but pentode amplifiers and a pentode mixer are used. The crystal oscillator operates at 7 Mc/s and harmonics at 42, 63 and 84 Mc/s are selected.

Single-Channel Apparatus

The principle of the method, which has been briefly described elsewhere[3], may be understood by reference to Fig. 5. The voltage developed across a fixed small resistance R_c (about 50 ohms) in the collector circuit is fed to one half of a null detector. A resistance R_e in the emitter circuit is made variable. The voltage developed across it is fed via the potentiometer (comprising R_s and $C + C_{es}$) to the other half of the null detector. Simple circuit analysis shows that the condition for a

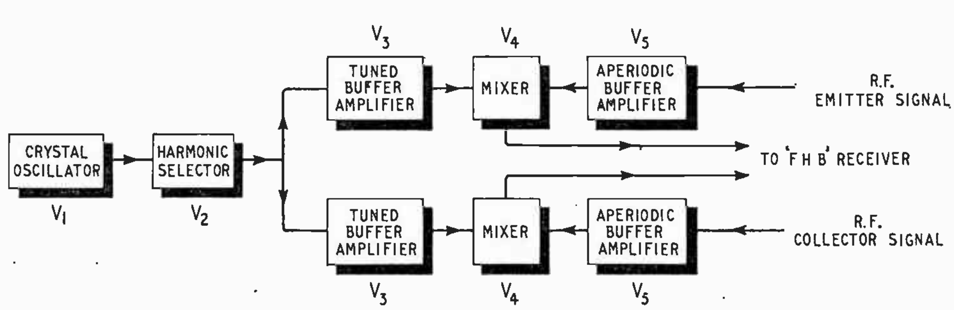


Fig. 4. *Block schematic circuit of converter units used for the twin-channel comparator measurement of* α

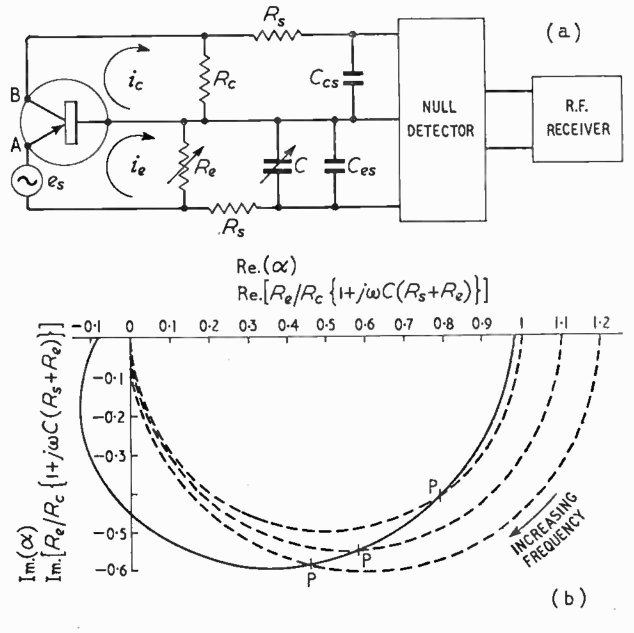


Fig. 5. *(a) Schematic circuit for measurement of α; (b) comparison of α-locus (continuous curve) and semi-circular transmission loci of the CR potentiometer*

null is satisfied when α, the current gain of the transistor, is given by:

$$\alpha\ (\omega) = \frac{R_e}{R_c}\left[\frac{1 + j\omega\, C_{cs}\,(R_s + R_c)}{1 + j\omega\,(C + C_{cs})\ \ (R_s + R_e)}\right] \quad .. \quad (1)$$

provided that the capacitance C_{cs} is adjusted to be equal to C_{es}, which includes the minimum capacitance C_{min} of the variable capacitor C. In addition to C_{min}, C_{es} comprises in practice (see Fig. 6) the stray valve, switch and wiring capacitance on the emitter side, while C_{cs} comprises the stray valve and wiring capacitance plus the equalizing trimmer capacitance on the collector side. In Equ. (1), C represents the difference between the actual capacitance of the capacitor C and C_{min}. If $C \gg C_{cs}$, as will be the case for transistors having low values of cut-off frequency, f_α, then terms involving C_{cs} in Equ. (1) can be ignored so that:

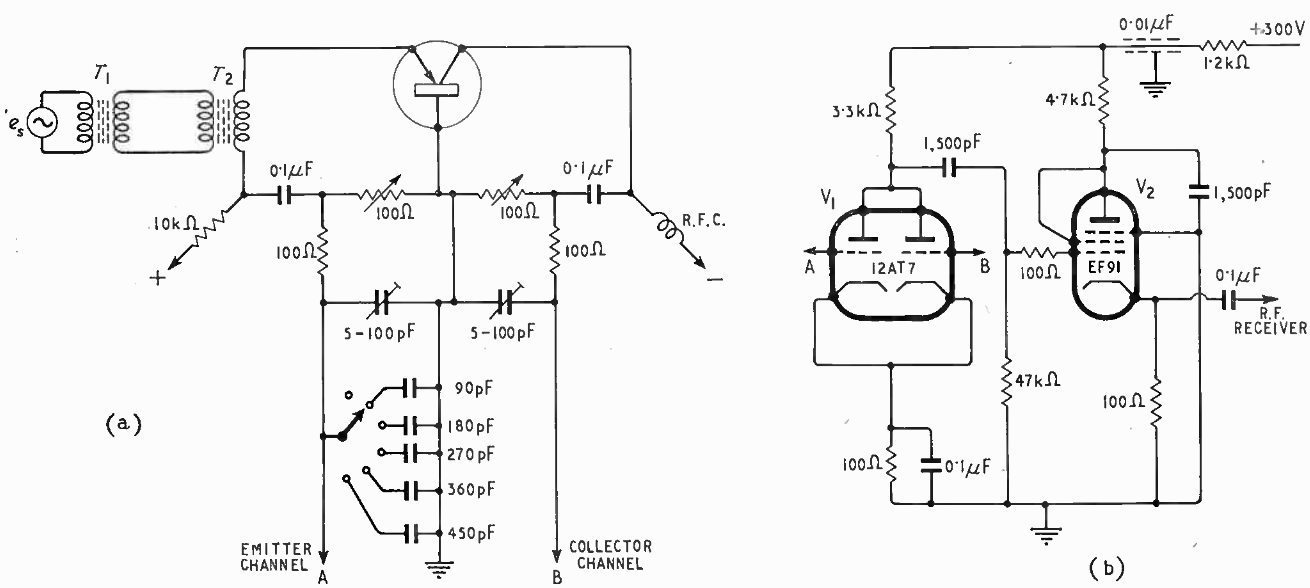
$$\alpha\ (\omega) \approx \frac{R_e}{R_c}\Big/\left[1 + j\omega\, C\,(R_s + R_e)\right] \quad .. \quad (2)$$

For this simple case a graphical interpretation may readily be made. In Fig. 5(b), semi-circular loci of the function $R_e/R_c\ [1 + j\omega\ C\ (R_s + R_e)]$ are shown in the complex plane as broken curves. Provided that suitable values of the variables R_e and C are chosen, a semi-circle will be generated which intersects at P the locus of the current gain $\alpha(\omega)$, at the frequency of measurement. The ratio R_e/R_c determines the diameter of this semi-circle and the value of C, for the particular value of R_e, then determines the frequency-distribution of points on it. The locus of $\alpha(\omega)$ is obtained as a result of choosing the appropriate values of R_e and C to satisfy Equ. (2) at each frequency. It is clear that for practical values of the ratio R_e/R_c measurements will be limited to frequencies such that the phase-angle of α is less than about 80 degrees.

In practice, there is no difficulty in using the accurate expression of Equ. (1) because C_{cs} can be measured and the requirement that $C_{cs} \equiv C_{es} + C_{min}$ can be satisfied by removing the transistor from its socket, connecting A to B in Fig. 5(a) and then adjusting C_{cs} for a null with C set to C_{min}.

The detailed circuit of the apparatus (which has given satisfactory results at frequencies up to 25 Mc/s) is given in Fig. 6(a) and (b). The resistors R_e and R_c are miniature moulded carbon variable types, R_c being set at some convenient value; e.g., 50 ohms. Double-transformer coupling was again found to be desirable. Both T_1 and T_2 are strip spiral-wound 1 : 1 transformers and are similar to the transformer T_1 described in the section dealing with the 'higher-frequency converter'. The gains of the two halves of the detector V_1 are balanced by feeding the grids from the balanced output

Fig. 6. *(a) Transistor circuit for null method of measuring α; (b) valve detector and cathode-follower circuit*



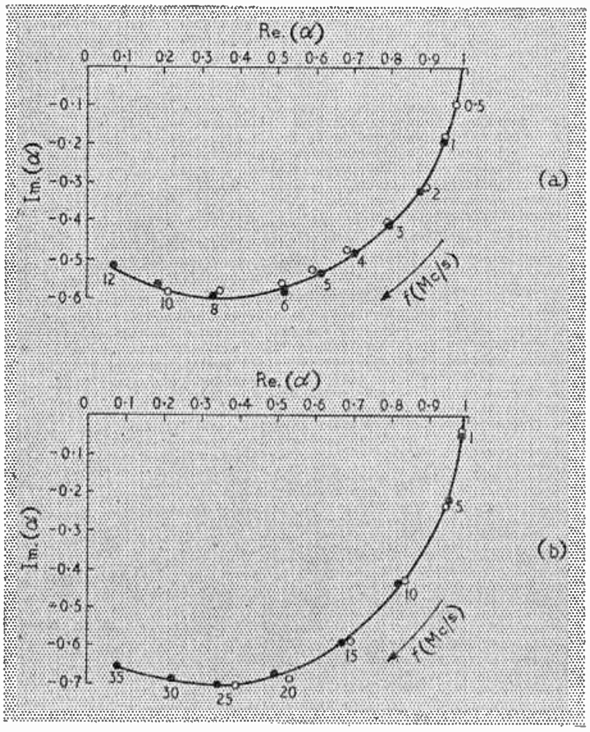


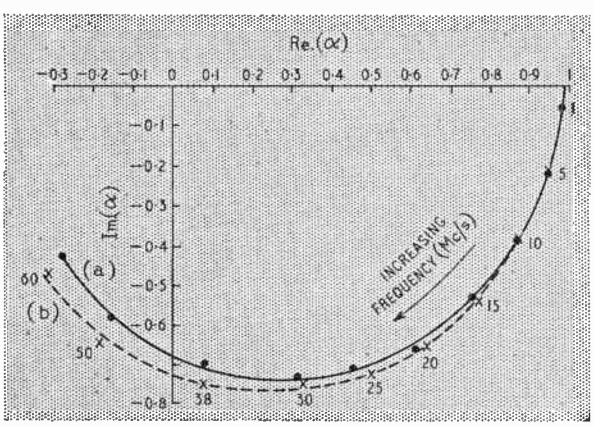
Fig. 7. *Experimental near-short-circuit current-gain loci for (a) V6/R8 diffusion-type transistor ($I_e = 1$ mA, $V_c = -4{\cdot}5$ V); (b) 2N247 drift-type transistor ($I_e = 1$ mA, $V_c = -9$ V). Dots (.) denote twin-channel comparator method; circles (o) denote single-channel null method*

of a signal generator and adjusting the division of a 12·6-V supply between the two heaters.

Typical Results

In Fig. 7 experimental loci of α in the complex plane are presented for a type V6/R8 (diffusion) transistor and a type 2N247 (drift) transistor. Measurements made with the twin-channel apparatus are shown as dots and those by the null method as circles. For the diffusion-type transistor good agreement between the two sets of data is obtained up to 10 Mc/s, which is the practical

Fig. 8. *(a) Normal α locus for a type 2N247 transistor ($I_e = 2$ mA, $V_c = -9$ V (continuous curve); (b) locus modified by the insertion of a 10-pF capacitor to augment c_{eb} (broken curve)*



upper-limiting frequency at which the null method can be used in this particular case. This is because of the large phase-angle of α at this frequency. For the drift-type transistor reasonable agreement was obtained up to 25 Mc/s. Further loci obtained using the twin-channel equipment are reported elsewhere[2].

The effect on the α locus of a type 2N247 transistor caused by augmenting the stray circuit capacitance C_{eb} (see Fig. 1) by a 10-pF capacitor is shown in Fig. 8. The continuous curve is the normal one and the broken curve that obtained when the capacitor is added. The effect shown is typical, in that $|\alpha|$ is apparently increased by the presence of this extra capacitance. Because the actual value[1] of C_{eb} is only of the order of 1 pF it is expected that, for the transistor shown, its effect on α is insignificant. The effect of C_{eb} is greater, however, the larger is the product $r_{bb'}c_c$, where $r_{bb'}$ is the base spreading resistance and c_c the collector depletion-layer capacitance. This point has to be borne in mind when applying the method to a variety of transistor types.

Conclusion

It has been shown that for a limited frequency range, which extends upwards to about 25 Mc/s, it is possible to measure complex values of α using a simple piece of apparatus in a null method. Measurements have been made at frequencies up to 210 Mc/s using apparatus of greater complexity.

Acknowledgement

The work described above was carried out as part of the programme of the Radio Research Board. This article is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

REFERENCES

1. F. J. Hyde and R. W. Smith, "An Investigation of the Current Gain of Transistors at Frequencies up to 105 Mc/s", *Proc. Instn elect. Engrs*, May 1958, Part B, Vol. 105, p. 221.
2. F. J. Hyde, "The Current Gains of Diffusion and Drift Types of Junction Transistor". Paper No. 2937E Institution of Electrical Engineers' International Convention on Transistors and Semiconductor Devices, May 1959.
3. F. J. Hyde, "A Method for Measuring Transistor Current Gain at Radio Frequencies", *J. sci. Instrum.*, 1958, Vol. 35, p. 115.
4. S. de Walden, A. F. L. Rocke, J. O. G. Barrett and W. J. Pitts, "The Development of a High-Frequency Cathode Ray Direction Finder for Naval Use", *J. Instn elect. Engrs*, 1947, Part IIIA, Vol. 94, p. 823.
5. M. M. Maddox and J. D. Storer, "A Design Method for Wide Band Balanced and Screened Transformers in the Range 0.1–200 Mc/s", *Electronic Engng*, November 1957, No. 29, p. 524.

ALEXANDER POPOV GOLD MEDAL

Dr. L. Essen, O.B.E., has been awarded the Alexander Popov Gold Medal by the Academy of Sciences of the U.S.S.R. for the most distinguished scientific work in radio engineering during 1956–58. This work has been on the establishment of an atomic-frequency standard. This standard forms a possible basis for a future standard of time of greater precision and convenience than the astronomical standard for the purposes of radio and physics.

As noted in the May issue, Dr. Essen was recently the recipient of the D.S.I.R. Wolfe Award for this same work.

This is the first occasion on which the Popov Gold Medal has been awarded to a scientist outside the Soviet Union.

Echo-Distortion in Frequency-Modulation

FREQUENCY-DIVISION-MULTIPLEX TRUNK RADIO SYSTEMS

By R. G. Medhurst, B.Sc.*

SUMMARY. *The level of intermodulation distortion generated in an f.m., f.d.m. trunk radio system by a small echo depends on the echo amplitude and delay, on the phase relation between the wanted carrier and the echo carrier, and on the parameters of the modulation; i.e., the maximum and minimum modulating frequencies, the r.m.s. deviation and the base-band spectral distribution. Numerical evaluation for the important case of top channel distortion has been carried out on a Hollerith Hec.2M digital computer, the results being presented as general curves covering a wide range of parameter values. To facilitate use of these results, curves are also given specifically for 240, 600- and 960-channel systems, using C.C.I.R. recommended frequency deviations. In view of current interest in pre-emphasis, distortion levels across the base-band have been calculated for the 600-channel case, and the effect of an idealized pre-emphasis law has been evaluated. It appears that pre-emphasis of the form considered has little effect on distortion due to long feeders.*

Trunk radio systems, consisting of large numbers of telephone channels arranged in frequency-division-multiplex, frequency or phase-modulating an r.f. carrier, are vulnerable to distortion caused by passage through networks, etc., having characteristics non-linear with frequency. One such non-linear process takes the form of the addition of an echo of the modulated wave which may arise, for example, in a mismatched aerial feeder or through multipath transmission. This form of distortion is one of the major factors that have to be considered in system design. Furthermore, besides its direct interest, information on echo distortion is of value since from it can be deduced the distorting effect of transmission networks whose separate amplitude and phase characteristics (as functions of frequency) can be approximated by sinusoidal ripples[1].

Albersheim and Schafer[2] gave formulae for the distortion due to echoes having short delay, when the phase difference between the wanted signal carrier and the echo carrier is such as to produce either maximum or minimum distortion. They also gave a limiting form, independent of echo phase, approached when the delay time is very great. This holds only for large values of the modulation index. Earlier, Lewin[3] had given the formula for the short-delay maximum distortion case, and also a limiting formula for long delay which predicted distortion levels falling off roughly as the inverse square-root of the delay time. This effect (which is additional to effects due to attenuation) is not found either in measurement or in exact analysis, and seems to result from excessive approximation at an early stage of the development of the theory. Medhurst and Small[4] gave an empirical curve covering the long-delay case for any modulation index, and suggested a semi-empirical formula for intermediate-

List of Symbols

ω = carrier frequency (radians/sec).
μ_t = phase modulation (radians).
τ_0 = echo delay time (seconds).
r = relative echo amplitude (voltage ratio).
μ_d = phase error due to the echo (radians).
p = a typical frequency in the modulating base-band (radians/sec).
p_m = maximum modulating frequency (radians/sec).
p_0 = minimum modulating frequency (radians/sec).
Δ = r.m.s. frequency deviation (radians/sec).
ϕ_p = a random phase angle, associated with the base-band tone of frequency p (radians).
D/S = distortion/signal ratio in the same narrow band, at base-band frequency p (power ratio).
$\psi_u(\tau)$ = auto-correlation function of $\mu_t - \mu_{t-\tau_0}$
ψ_0 = $\psi_u(0)$.

$$\mathrm{Si}(x) = \int_0^x \frac{\sin y}{y}\, dy.$$

Some secondary symbols are:

$$a = \Delta\sqrt{\frac{2}{p_m - p_0}}$$

θ = $p\tau$
θ_0 = $p_m\tau_0$
A = Δ/p_m
dBmo = power measured relative to 1mW at a point of zero relative level.

delay times. The problem was first attacked rigorously by Bennett, Curtis and Rice[5], who produced an exact formula in integral form, developed through the Wiener-Khintchine relationship. They computed some numerical values and, on the basis of these and various approximate formulae, gave a set of curves showing distortion levels in the top channel for a range of echo delay times and system parameters. These curves, besides having uncertainties due to the use of approximations, are incomplete in that they show neither maximum nor minimum distortion levels (considered as functions of the echo phase angle), being in fact the

* *Research Laboratories, General Electric Company Ltd., Wembley, England.*

mean (on a power basis) of the possible extremes. In practice, particularly when the echo delay time is small, small changes of echo phase angle will produce very substantial changes in the distortion level.

It thus appeared worthwhile to compute sufficient exact values of small echo distortion of frequency-modulation trunk radio systems to enable reliable sets of curves to be plotted. A total of 192 values have been computed using a Hollerith Hec.2M digital computer. Curves have been plotted for ranges of values of some general system parameters and also, to enable direct reading off, specifically for 240-, 600- and 960-channel systems, using frequency deviations recommended by the C.C.I.R[10].

In references 1 to 5, attention was concentrated on distortion in the speech channel occupying the highest frequency position, since in absence of pre-emphasis the total distortion in a frequency-modulation system will tend to be worst in this channel. Application of pre-emphasis, whereby the power in speech channels occupying high-frequency positions is increased relative to that in the channels at the low-frequency end of the base-band, is expected to cause a more uniform distribution of the total distortion. The effect will, of course, depend on the particular distortion mechanism. In view of recent proposals to standardize a pre-emphasis law[6], distortion levels across the base-band have been calculated for a 600-channel system. The effect of an idealized pre-emphasis law[7], which approximates quite well to the proposal in reference 6, has been evaluated. It appears that this form of pre-emphasis has little effect on the distortion due to long feeders.

Analysis

The sum of the wanted signal and its delayed echo can be written in the form

$$\cos(\omega t + \mu_t) + r\cos(\omega t - \omega\tau_0 + \mu_{t-\tau_0}) \quad .. \quad (1)$$

If (1) is re-written so as to represent a single wave, simultaneously amplitude and phase modulated, the phase modulation becomes (for $r \ll 1$),

$$\mu_t + \mu_d$$

where $\mu_d \approx -r\sin(\omega\tau_0 + \mu_t - \mu_{t-\tau_0})$ (reference 2)

$$= -r\sin\omega\tau_0\cos(\mu_t - \mu_{t-\tau_0}) - r\cos\omega\tau_0\sin(\mu_t - \mu_{t-\tau_0}) \quad .. \quad (2)$$

It has now to be assumed that the frequency-division-multiplex signal can be adequately represented by a band of white noise; e.g., Reference 2. Then, the frequency modulation can be written as

$$a\sum_{p=p_0}^{p_m}\cos(pt + \phi_p)$$

where the frequency p (radians/sec) is supposed to increase by unit steps between the minimum and maximum frequencies p_0 and p_m respectively, and ϕ_p is a random phase angle. 'a' is a constant, related to the r.m.s. frequency deviation Δ (radians/sec) by the equation

$$a = \Delta\sqrt{\frac{2}{p_m - p_0}}$$

Since phase modulation is found by taking the time integral of frequency modulation, μ_t is given by

$$\mu_t = a\sum_{p=p_0}^{p_m}\frac{1}{p}\sin(pt + \phi_p) \quad .. \quad .. \quad .. \quad (3)$$

Then,

$$\mu_t - \mu_{t-\tau_0} = 2a\sum_{p=p_0}^{p_m}\frac{1}{p}\sin(\tfrac{1}{2}p\tau_0)\cos(pt - \tfrac{1}{2}p\tau_0 + \phi_p) \quad .. \quad (4)$$

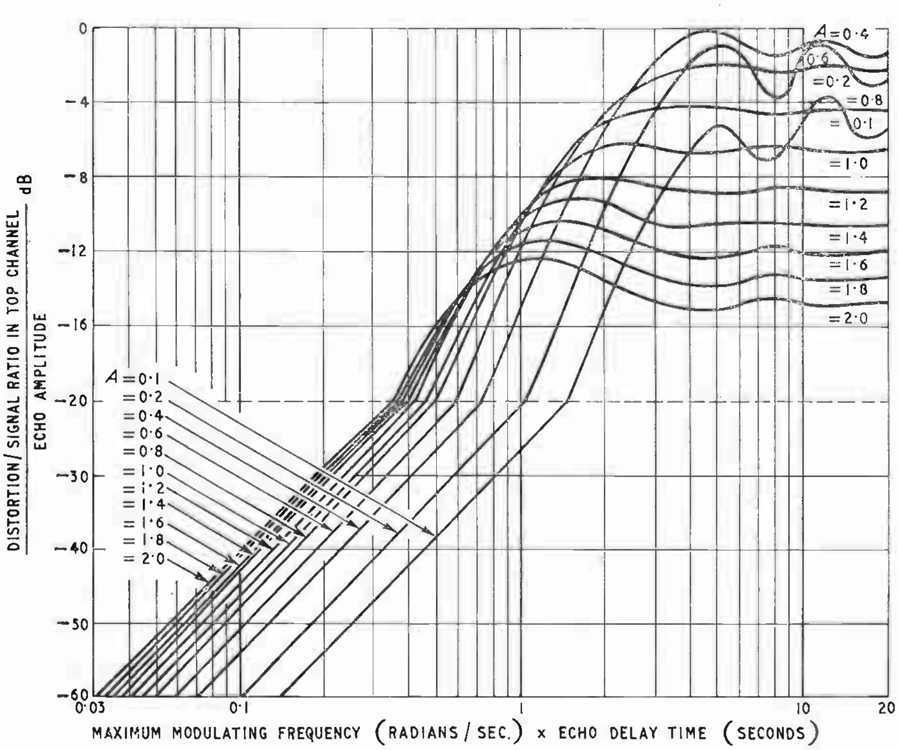


Fig. 1. *Maximum distortion/signal ratio. A = (r.m.s. frequency deviation)/ (maximum modulating frequency)*

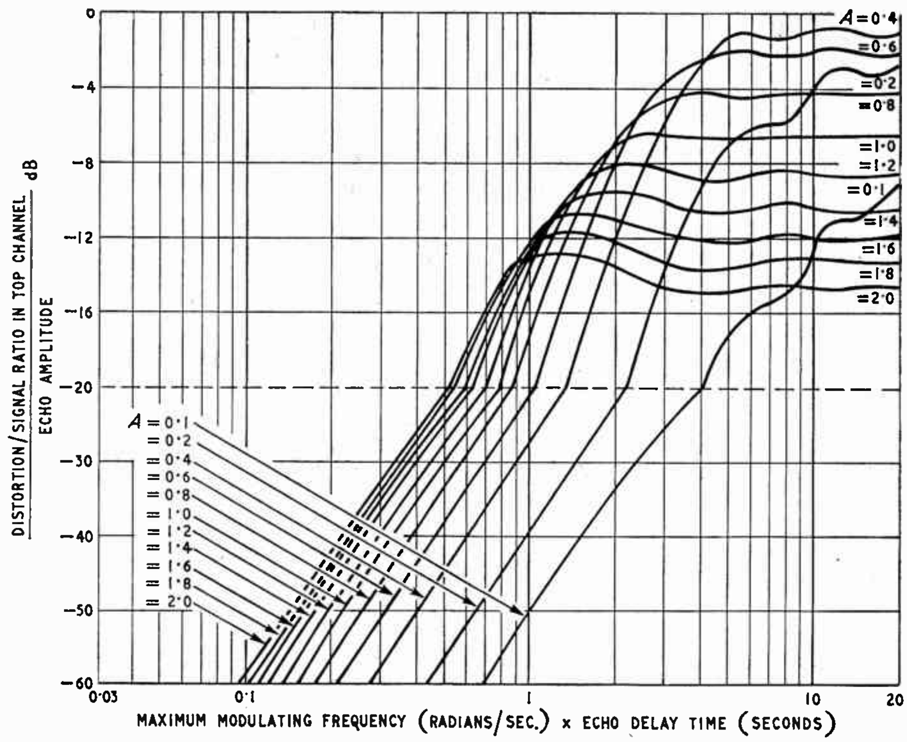


Fig. 2. *Minimum distortion/signal ratio. A = (r.m.s. frequency deviation)/(maximum modulating frequency)*

According to Equ. (2), it is necessary to evaluate the power spectra of the cosine and the sine of the right-hand side of Equ. (4). It will then be possible to compare the amplitude of a distortion tone of base-band frequency p with that of a tone of the same frequency in the undistorted noise band. As $\omega\tau_0$ (i.e., the phase angle between the wanted and unwanted carriers) varies, the distortion arising from μ_d will vary between two values associated with the cosine and the sine of $\mu_t - \mu_{t-\tau_0}$.

It is shown in the Appendix that the distortion/signal ratio in a channel of frequency p is given by the following formulae:

For maximum distortion,

$$\frac{1}{r^2}\frac{D}{S} = \frac{2}{\pi} p^2 \frac{(p_m - p_0)}{\Delta^2} e^{-\psi_0} \int_0^\infty \{\cosh[\psi_u(\tau)] - 1\} \cos(p\tau)\, d\tau \quad .. \quad (5)$$

and for minimum distortion,

$$\frac{1}{r^2}\frac{D}{S} = \frac{2}{\pi} p^2 \frac{(p_m - p_0)}{\Delta^2} e^{-\psi_0} \int_0^\infty \{\sinh[\psi_u(\tau)] - \psi_u(\tau)\} \cos(p\tau)\, d\tau \quad .. \quad (6)$$

where

$$\psi_u(\tau) = \frac{2\Delta^2}{p_m - p_0} \Big\{ \frac{1}{p_0} \cos(p_0\tau)[1 - \cos(p_0\tau_0)] - \frac{1}{p_m} \cos(p_m\tau)[1 - \cos(p_m\tau_0)] + \tau[\mathrm{Si}(p_0\tau) - \mathrm{Si}(p_m\tau)] - \tfrac{1}{2}(\tau - \tau_0)[\mathrm{Si}(p_0\tau - p_0\tau_0) - \mathrm{Si}(p_m\tau - p_m\tau_0)] - \tfrac{1}{2}(\tau + \tau_0)[\mathrm{Si}(p_0\tau + p_0\tau_0) - \mathrm{Si}(p_m\tau + p_m\tau_0)] \Big\}$$

and

$$\psi_0 = \frac{2\Delta^2}{p_m - p_0} \Big\{ \frac{2}{p_0} \sin^2(\tfrac{1}{2}p_0\tau_0) - \frac{2}{p_m} \sin^2(\tfrac{1}{2}p_m\tau_0) - \tau_0[\mathrm{Si}(p_0\tau_0) - \mathrm{Si}(p_m\tau_0)] \Big\}$$

In certain limiting cases, these expressions simplify very considerably. The formulae below apply to the top channel, p_0 being taken as negligible compared with p_m. When θ_0 is small (i.e., for short-delay echoes) Equs. (5) and (6) take the following forms: For maximum distortion,

$$\frac{1}{r^2} \cdot \frac{D}{S} = \frac{1}{4} \theta_0^4 A^2 \text{ (power ratio)} \quad .. \quad .. \quad (7)$$

and for minimum distortion,

$$\frac{1}{r^2} \cdot \frac{D}{S} = \frac{1}{12} \theta_0^6 A^4 \text{ (power ratio)} \quad .. \quad .. \quad (8)$$

When θ_0 is large, Equs. (5) and (6) both approach the limiting form

$$\frac{1}{r^2}\frac{D}{S} = \frac{e^{2A^2}}{\pi A^2} \int_0^\infty \exp\{-A^2[2\theta \mathrm{Si}(\theta) + 2\cos\theta]\} \cos\theta\, d\theta \quad (9)$$

and when A is sufficiently large, this degenerates to

$$\frac{1}{r^2}\frac{D}{S} = \frac{1}{2\sqrt{\pi}A^3} e^{-1/(4A^2)} \text{ (power ratio)} \quad .. \quad (10)$$

Equs. (7) and (8) were first given, essentially, in reference 2.

An expression similar to Equ. (10), but with somewhat different numerical constants, also appears in the same reference.

Numerical Results for Distortion in the Top Channel, Without Pre-Emphasis

It is apparent from Equs. (5) and (6) that for small echoes the intermodulation distortion power in a given channel is proportional to the relative echo power. Further, for most practical situations p_0 can be taken as zero with negligible error. Thus, the distortion in the top channel ($p = p_m$) can be made to depend on three parameters only, p_m, Δ and τ_0, and these can be grouped into two dimensionless quantities, here taken as A and θ_0.

Values of the right-hand sides of Equs. (5) and (6), taking $p = p_m$ and $p_0 = 0$, have been computed for a range of values of A and θ_0 using a Hollerith Hec.2M digital computer. In each case, the upper limit of the integration was taken sufficiently high for further increase to produce no change in the distortion level, to the number of significant figures taken.

Using these values and, for the smaller θ_0 range, Equs. (7) and (8), Figs. 1 and 2 have been drawn. It is seen that while for values of A around unity the curves approach the smooth shape suggested on a semi-empirical basis in reference 4, for the more extreme A values there is considerable fluctuation in the intermediate- and long-delay regions.

Before the information in Figs. 1 and 2 can be applied to particular systems, it is necessary to fix an r.m.s. level for the band of white noise which is to simulate the multiplex telephony signal. In practice, the level will be constantly changing, on a short-term basis following variations in individual speaker volumes and on a long-term basis as the average traffic becomes heavier (during the peak day period) or lighter (during the night). It is conventional to consider levels encountered during the so-called busy hour. For a number of years, it has been the practice to insert the white-noise test signal at a level (determined by measurements with a large number of speakers) not exceeded for more than 1% of the busy hour[8,9]. However, a recent recommendation suggests the use of substantially lower deviations, based on an average over the busy hour[10]. These reduced deviations will generally give a more optimistic picture of the performance of a particular system. Table 1 shows the C.C.I.R. recommended modulation conditions with, for comparison, the earlier values. Figs. 3 and 4 show

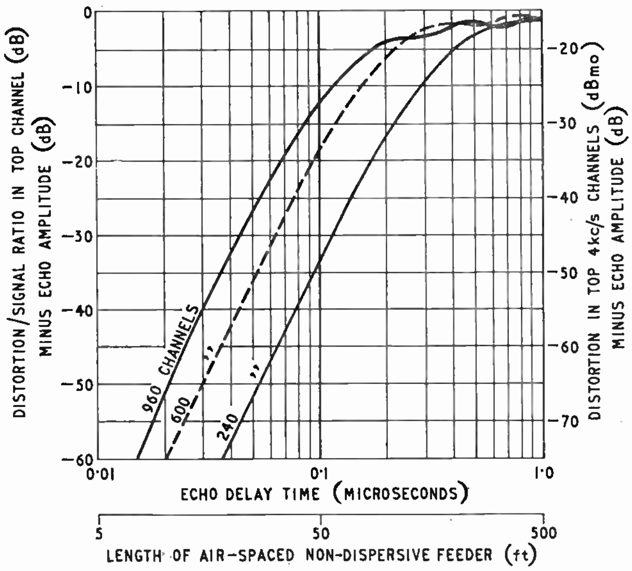


Fig. 4. *Distortion in the top channel due to a small echo.* (*Echo phased for minimum distortion.*) *r.m.s. deviation* = $(-15+10 \log_{10}N)$ *dBmo, where* N = *number of channels*

echo distortion levels in the top channel for 240-, 600- and 960-channel systems, using C.C.I.R. recommended levels. In each case, the actual distortion level is to be obtained by adding, to the values read off, the relative echo amplitude, in decibels.

To facilitate comparison with the results of reference 5, the data of Fig. 1 (maximum distortion) has been replotted in Fig. 5 as a set of contours of constant distortion/signal ratio in the top channel. The vertical and horizontal scales are the same as those of Fig. 5.7 of reference 5. It appears that the two sets of contours are similar in shape, but that there are by no means inconsiderable differences in detail. These can be partly accounted for by the circumstance that, as already

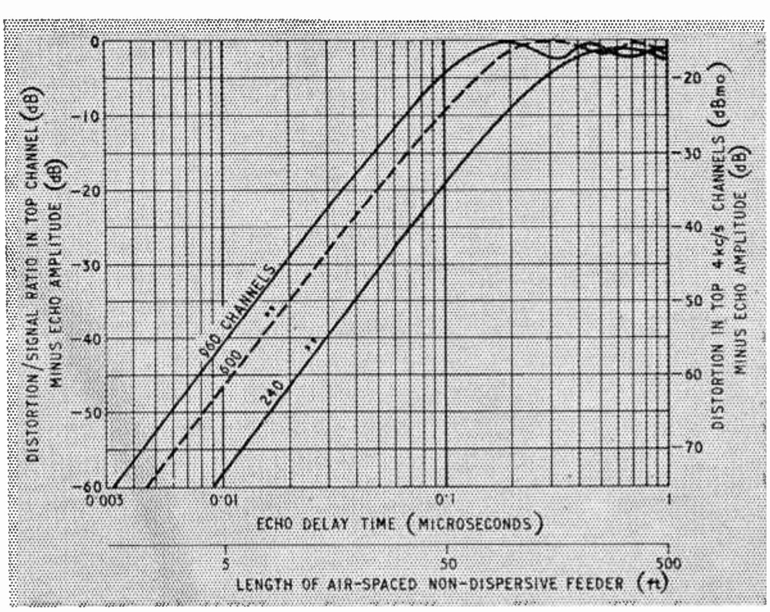


Fig. 3. *Distortion in the top channel due to a small echo.* (*Echo phased for maximum distortion.*) *r.m.s. deviation* = $(-15+10 \log_{10}N)$ *dBmo, where* N = *number of channels*

TABLE 1

Modulation Conditions for Various Numbers of Channels

Number of channels	Base-band frequency range (Mc/s)	C.C.I.R. recommended levels (average loadings over the 'busy hour') (reference 10)			Levels related to system performance during 1% of the 'busy hour' (reference 8)		
		White-noise loading (dBmo)	r.m.s. deviation (Mc/s)	A $(=\Delta/p_m)$	White-noise loading (dBmo)	r.m.s. deviation (Mc/s)	A $(=\Delta/p_m)$
60	0·06–0·300				9·0	0·564	1·88
120	0·06–0·522				10·5	0·671	1·22
240	0·06–1·052	8·8	0·551	0·52	12·3	0·820	0·78
600	0·06–2·540	12·8	0·871	0·34	15·0	1·124	0·44
960	0·06–4·028	14·8	1·100	0·27	17·0	1·415	0·35

mentioned, the results of reference 5 do not give the maximum distortion but the power mean of maximum and minimum. Thus, for small θ_0, where the minimum distortion is very much less than the maximum, a 3-dB difference between the two sets of contours is to be expected.

Variation of Echo Distortion Over the Base-Band

The distribution of echo distortion across the base-band when the echo is phased for maximum distortion has been evaluated from Equ. (5) for the 600-channel system, the results being shown in Fig. 6. The three delay times chosen, 0·125, 0·25 and 0·5 micro seconds correspond to air-spaced, non-dispersive feeder lengths of 62½, 125 and 250 feet. Unlike intermodulation distortion due to low-order group delay transmission characteristics, which has a distribution similar to the familiar 'triangular' distribution generated by uniform radio noise, it is seen that the distortion associated with long feeders tends to be rather uniform over the major portion of the base-band. In fact, in the case of the 250-feet feeder there is a shallow maximum at about 1·5 Mc/s. Thus, it was considered worthwhile to examine the effects of pre-emphasis (which is usually advocated with the aim of reducing the disturbing effect of radio noise and of low-order transmission characteristics) on system performance from the view-point of long feeders.

Effect of Pre-Emphasis on Distribution of Cross-Talk due to Long Feeders

Since, in order to assess the effects of pre-emphasis on long-feeder distortion we are interested in orders of magnitude rather than detailed values, it has been considered adequate to investigate only the limiting case of very long feeders, in which case a useful reduction in

Fig. 5. *Contours of constant distortion/signal ratio in the top channel (maximum distortion). The numbers on the curves denote the ratio (distortion/signal in top channel)/(echo amplitude), expressed in dB*

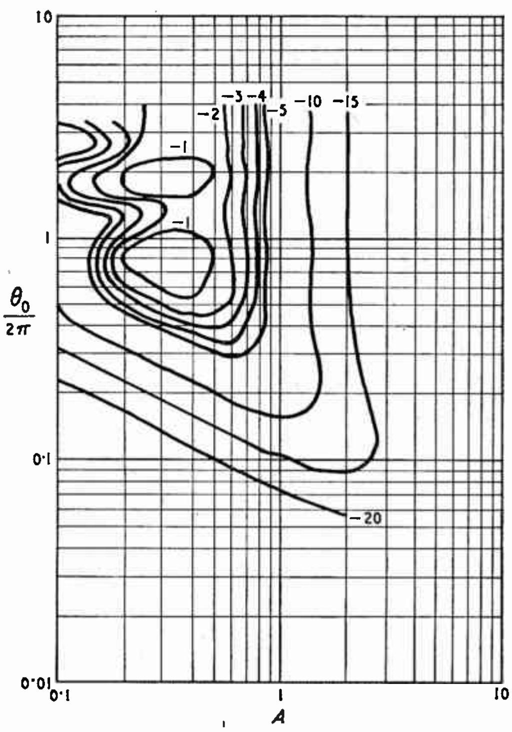
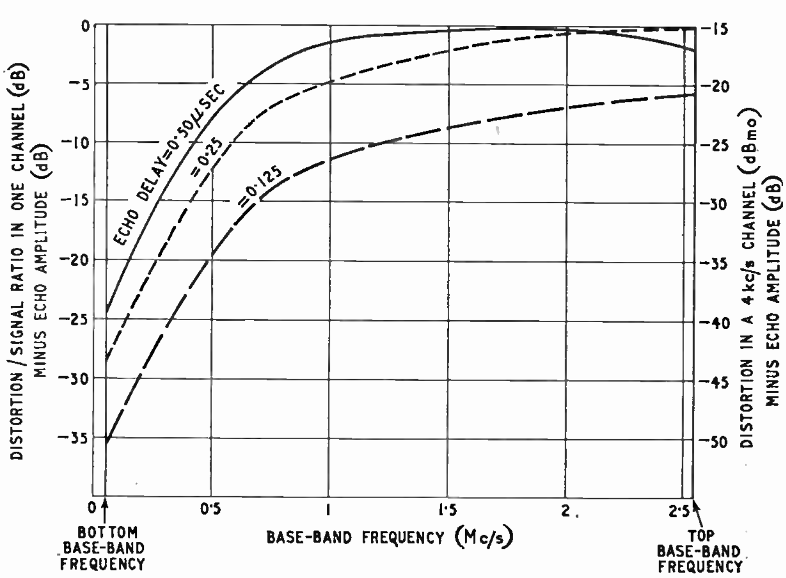


Fig. 6. *Variation of echo distortion over the base-band, for a 600-channel system. (Echo phased for maximum distortion)*



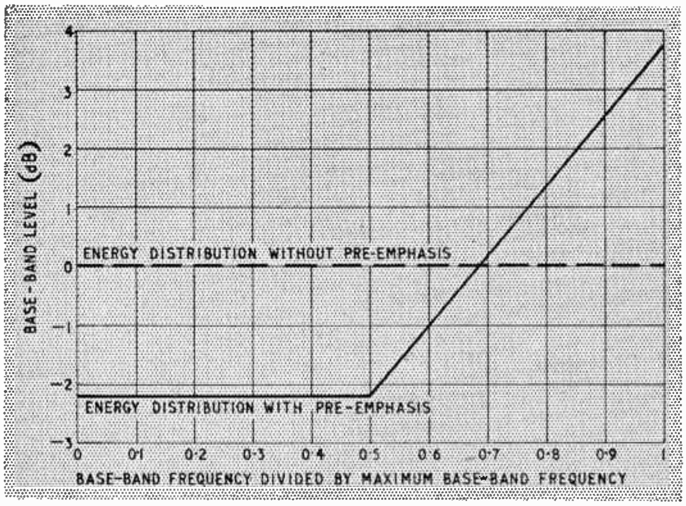


Fig. 7. *Effect on base-band energy distribution of a pre-emphasis which is level over the lower half of the base-band and rises by 6 dB per octave over the upper half*

the arithmetic occurs. For very long feeders ($\tau_0 \to \infty$), Equs. (5) and (6) both approach the form

$$\frac{1}{r^2}\frac{D}{S} = \frac{1}{\pi} p^2 \frac{(p_m - p_0)}{\Delta^2}\int_0^\infty \exp\left[\frac{2\Delta^2}{p_m-p_0}\left\{\frac{1}{p_0}\cos(p_0\tau) - \frac{1}{p_m}\cos(p_m\tau) + \tau[\mathrm{Si}(p_0\tau) - \mathrm{Si}(p_m\tau)]\right\} - \frac{2\Delta^2}{p_m p_0}\right]\cos p\tau \, d\tau \quad (11)$$

For existing systems of large numbers of channels, it will be sufficiently accurate to take $p_0 = 0$. Then, Equ. (11) takes the form

$$\frac{1}{r^2}\frac{D}{S} = \frac{1}{\pi}\frac{p^2 p_m}{\Delta^2}\int_0^\infty \exp\left[\frac{2\Delta^2}{p_m^2}(1-\cos p_m\tau) - \frac{2\Delta^2}{p_m}\tau\mathrm{Si}(p_m\tau)\right]\cos p\tau \, d\tau \quad .. \quad (12)$$

A curve for the 600-channel case, derived from this expression, is shown in Fig. 8.

The forms of pre-emphasis law usually suggested have the aim of reducing the effects of disturbance which increases with the base-band frequency (such as cross-talk due to frequency-modulation distortion introduced by low-order transmission characteristics, or interference associated with evenly-distributed radio noise), without substantially worsening disturbance which is approximately independent of the base-band frequency (such as cross-talk introduced by a modulator characteristic, or due to amplitude modulation introduced by low-order transmission characteristics and surviving the limiter action). These conflicting requirements require some sort of compromise. It has been suggested[6,7] that useful improvement would result from a pre-emphasis network which would leave the lower half of the base-band more or less undisturbed, while applying a tilt of about 6 dB per octave to the upper half. Ideally, such a law takes the form shown in Fig. 7, the levels being chosen so as to produce the same r.m.s. frequency deviation[11] as when pre-emphasis is not applied. If the frequency-modulation spectrum without pre-emphasis is written in the form

$$a\sum_{p=0}^{p_m}\cos(pt+\phi_p)$$

where p increases in unit steps, ϕ_p is a random phase angle, and the minimum modulating frequency has been taken as zero, the application of pre-emphasis results in a frequency-modulation spectrum of the form

$$a\frac{\sqrt{2\cdot4}}{2}\sum_{p=0}^{\frac{1}{2}p_m}\cos(pt+\phi_p) + a\sqrt{2\cdot4}\sum_{p=\frac{1}{2}p_m}^{p_m}\frac{p}{p_m}\cos(pt+\phi_p)$$

In the limiting case of very long feeders, this modification to the base-band spectrum results in an expression for the distortion level of the form

$$\frac{1}{r^2}\frac{D}{S} = \frac{1}{\pi}\frac{p^2p_m}{0\cdot6\Delta^2}\int_0^\infty\exp\left[-\frac{1\cdot2\Delta^2}{p_m^2}\left\{2\cos\frac{p_m\tau}{2} + p_m\tau\mathrm{Si}\left(\frac{p_m\tau}{2}\right) + \frac{4}{p_m\tau}\left(\sin\frac{p_m\tau}{2} - \sin p_m\tau\right)\right\}\right]\cos(p\tau)\,d\tau$$

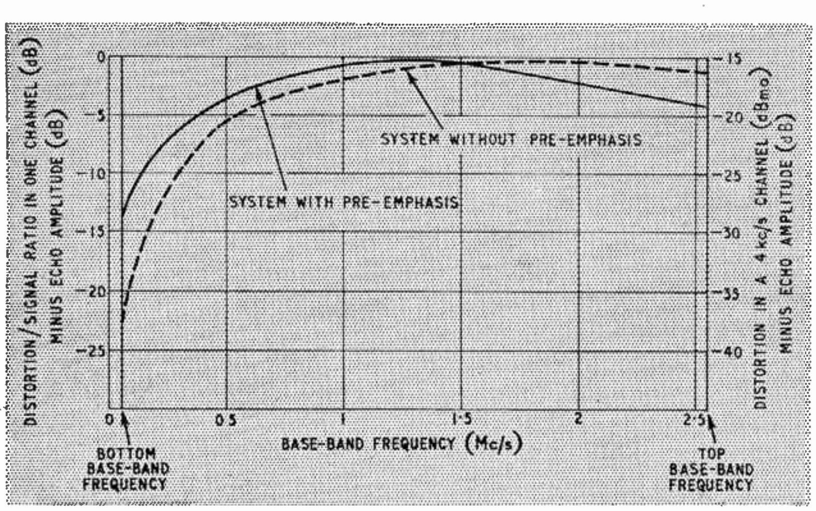


Fig. 8. *Variation over the base-band of echo distortion due to a very long feeder, with and without the use of pre-emphasis* (600-*channel system*)

when $p \leqslant \frac{1}{2} p_m$

$$= \frac{1}{\pi} \frac{p_m{}^3}{2 \cdot 4\Delta^2} \int_0^\infty \exp\left[-\frac{1 \cdot 2\Delta^2}{p_m{}^2} \left\{ 2\cos\frac{p_m\tau}{2} + p_m\tau \mathrm{Si}\left(\frac{p_m\tau}{2}\right) + \frac{4}{p_m\tau}\left(\sin\frac{p_m\tau}{2} - \sin p_m\tau\right) \right\} \right] \cos(p\tau)d\tau$$

when $p \geqslant \frac{1}{2} p_m$ .. .. (13)

In the 600-channel case, values derived from this expression are shown in Fig. 8. It is evident from this figure that the use of pre-emphasis of the form considered will have no important effect, either advantageous or disadvantageous, on system performance as regards long feeder distortion.

APPENDIX

Derivation of Equations (5) *and* (6)

According to the analysis in the article, it is required to derive the power spectra of cos $(\mu_t - \mu_{t-\tau_0})$ and sin $(\mu_t - \mu_{t-\tau_0})$, where

$$\mu_t - \mu_{t-\tau_0} = 2\, a \sum_{p=p_0}^{p_m} \frac{1}{p} \sin(\tfrac{1}{2}p\tau_0) \cos(pt - \tfrac{1}{2}p\tau_0 + \phi_0) \text{ (radians)} \quad .. \quad (4)$$

Since p, in the summation, is supposed to increase in steps of 1 radian/sec, the spectral density of $\mu_t - \mu_{t-\tau_0}$ is

$$\frac{1}{2} \cdot 4a^2 \cdot \frac{\sin^2(\frac{1}{2}p\tau_0)}{p^2}$$
$$= \frac{2\Delta^2}{(p_m - p_0)} \frac{1}{p^2} (1 - \cos p\tau_0)$$

in the frequency range p_0 to p_m, and zero outside it.

The auto-correlation function of $\mu_t - \mu_{t-\tau_0}$, is found by taking the cosine transform of the spectral density. Thus,

$$\psi_u(\tau) = \int_{p_0}^{p_m} \frac{2\Delta^2}{(p_m - p_0)} \frac{1}{p^2} (1 - \cos p\tau_0) \cos(p\tau)\, dp$$

This may be re-arranged to give

$$\psi_u(\tau) = \frac{2\Delta^2}{p_m - p_0} \left\{ \frac{1}{p_0} \cos(p_0\tau) \left[1 - \cos(p_0\tau_0) \right] - \frac{1}{p_m} \cos(p_m\tau) \left[1 - \cos(p_m\tau_0) \right] + \tau \left[\mathrm{Si}(p_0\tau) - \mathrm{Si}(p_m\tau) \right] - \tfrac{1}{2}(\tau - \tau_0) \left[\mathrm{Si}(p_0\overline{\tau - \tau_0}) - \mathrm{Si}(p_m\overline{\tau - \tau_0}) \right] - \tfrac{1}{2}(\tau + \tau_0) \left[\mathrm{Si}(p_0\overline{\tau + \tau_0}) - \mathrm{Si}(p_m\overline{\tau + \tau_0}) \right] \right\} \quad (14)$$

ψ_0 is obtained by putting $\tau = 0$, so that

$$\psi_0 = \frac{2\Delta^2}{p_m - p_0} \left\{ \frac{2}{p_0} \sin^2(\tfrac{1}{2}p_0\tau_0) - \frac{2}{p_m} \sin^2(\tfrac{1}{2}p_m\tau_0) - \tau_0 \left[\mathrm{Si}(p_0\tau_0) - \mathrm{Si}(p_m\tau_0) \right] \right\} \quad .. \quad .. \quad .. \quad .. \quad (15)$$

The power spectra of cos $(\mu_t - \mu_{t-\tau_0})$ and sin $(\mu_t - \mu_{t-\tau_0})$ can be expressed in terms of $\psi_u(\tau)$ and ψ_0 by an analysis exactly similar to that of appendix 7.1. of reference 12. The spectrum of cos $(\mu_t - \mu_{t-\tau_0})$ is given by

$$G(p) = \frac{2}{\pi} e^{-\psi_0} \int_0^\infty \left\{ \cosh\left[\psi_u(\tau) \right] - 1 \right\} \cos(p\tau)\, d\tau \quad .. \quad (16)$$

and of sin $(\mu_t - \mu_{t-\tau_0})$ by

$$G(p) = \frac{2}{\pi} e^{-\psi_0} \int_0^\infty \left\{ \sinh\left[\psi_u(\tau) \right] - \psi_u(\tau) \right\} \cos(p\tau)\, d\tau \quad .. \quad (17)$$

Remembering that the undistorted power per radian per second is given by

$$\frac{1}{2} \frac{a^2}{p^2} = \frac{\Delta^2}{(p_m - p_0)p^2},$$

we arrive at Equs. (5) and (6) for the distortion in a channel of frequency p.

REFERENCES

[1] R. G. Medhurst and G. F. Small, "Distortion in Frequency-Modulation Systems Due to Small Sinusoidal Variations of Transmission Characteristics", *Proc. Inst. Radio Engrs*, November 1956, Vol. 44, pp. 1608–1612.

[2] W. J. Albersheim and J. P. Schafer, "Echo Distortion in the F.M. Transmission of Frequency-Division Multiplex", *Proc. Inst. Radio Engrs*, March 1952, Vol. 40, pp. 316–328.

[3] L. Lewin, "Interference in Multi-Channel Circuits: Dependence on Harmonic Generation", *Wireless Engineer*, December 1950, Vol. 27, pp. 294–304.

[4] R. G. Medhurst and G. F. Small, "An Extended Analysis of Echo Distortion in the F.M. Transmission of Frequency-Division Multiplex", *Proc. Instn elect. Engrs*, March 1956, Vol. 103, Part B, pp. 190–198.

[5] W. R. Bennett, H. E. Curtis and S. O. Rice, "Interchannel Interference in F.M. and P.M. Systems under Noise Loading Conditions", *Bell Syst. tech. J.*, May 1955, Vol. 34, pp. 601–636.

[6] "Standardisation of Multi-Channel Radio Systems Using Frequency-Division Multiplex and Operating at Frequencies above 30 Mc/s. (Question No. 93): Use of Pre-emphasis for F.D.M. Telephony", 12th February 1958, C.C.I.R. IXth Plenary Assembly: United Kingdom, Study Group IX.

[7] R. Hamer and R. A. Acton, "Power Spectrum of a Carrier Modulated in Phase or Frequency by White Noise", *Electronic Radio Engr*, July 1957, Vol. 34, pp. 246–253.

[8] W. J. Bray, "Basic Factors in the Design of Frequency and Phase-Modulation Radio Relay Systems for Multi-Channel Telephony", Post Office Engineering Department, 1952, Radio Report No. 2100.

[9] J. R. W. Smith and J. L. Slow, "Energy Distribution in a Wave Frequency Modulated by a Multichannel Telephone Signal", *A.T.E.J.*, July 1956, Vol. 12, pp. 182–202.

[10] C.C.I.R., "Documents of the VIIIth Plenary Assembly, Warsaw 1956, Vol. 1: Recommendations, Reports, Resolutions, Questions and Study Programmes", International Telecommunication Union, Geneva 1956, (Recommendation No. 197, p. 204).

[11] C.C.I.R., "Documents of the VIIIth Plenary Assembly, Warsaw 1956, Vol. 1: Recommendations, Reports, Resolutions, Questions and Study Programmes", International Telecommunication Union, Geneva 1956, (Recommendation No. 191, p. 199).

[12] R. G. Medhurst, E. M. Jennings and W. Grossett, "Distortion in Frequency-Division-Multiplex F.M. Systems Due to an Interfering Carrier", *Proc. Instn elect. Engrs*, May 1958, Vol. 105, Part B, pp. 282–292.

MANUFACTURERS' LITERATURE

'Airscrew' Laminated Fans and Impellers: Technical Notes 196. Illustrated booklet describing the use of 'Aerodux' 185 (a resorcinol-formaldehyde formulation) for bonding timber fans and impellers.
The Technical Service Department, CIBA (A.R.L.) Ltd., Duxford, Cambridge.

Analogue Computor Techniques. A 13-page booklet dealing with the general techniques, applications and mathematics of analogue computors.

ERA. Illustrated booklet giving details of the Electronic Reading Automaton, a machine for reading printed characters from continuous rolls of paper.

Datatape. Leaflet describing the Solartron precision magnetic tape recorder-reproducer system.

Minispace Analogue Computor. Data sheet of a computer designed to solve up to fifth-order differential equations.

Process Response Analyser. Description of the type JY743 instrument for measuring system transfer functions in the frequency range 1 cycle in 10^4 sec to 100 c/s.

Pressure Transducer. Data sheet giving details of the type NT. 4–317 transducer which is capable of continuous operation at 600 °F.

Precision Electronic Instruments. Catalogue of Solartron instruments.

The above literature is available from
The Solartron Electronic Group Ltd., Solartron Works, Queens Road, Thames Ditton, Surrey.

Beryldur. A folder dealing with a low-priced beryllium copper wrought alloy.
Beryllium Smelting Co. Ltd., 36-38 *Southampton Street, London, W.C.2.*

Atmite Protector. Leaflet describing a lightning protector manufactured by *The Automatic Telephone & Electric Co. Ltd., Strowger House, Arundel Street, London, W.C.2.*

Moving-Coil Instruments. Leaflets giving details of a new range of 240° circular-scale moving-coil ammeters and voltmeters of the panel-mounting type which are available in moulded plastic and sealed metal cases.
Crompton Parkinson Ltd., Crompton House, Aldwych, London, W.C.2.

Integration for Engineers-2

Last month we considered integration as the reverse process to differentiation, the relation between integration and area, and the process of changing the variable. It was pointed out that we are fortunate if any of the processes of integration described are successful. We now have to consider one more general process, known as 'integration by parts', which will sometimes enable us to integrate an expression which cannot otherwise be integrated directly. Thereafter, approximate methods available for dealing with more difficult cases have to be considered. The general idea behind such methods is to replace the given integrand, say $F(x)$, by some other function $G(x)$ which can be integrated and which is a good approximation to $F(x)$ for at any rate some part of the range of integration; it may be necessary to use different approximations for different parts of the range of integration.

The method of 'integration by parts' is really another way of looking at Equ. (17) of the April article on differentiation; this equation was

$$\frac{d}{dx}(uv) = u\frac{dv}{dx} + v\frac{du}{dx} \quad .. \quad .. \quad .. \quad .. \quad (1)$$

where u and v are both functions of x.

Now integrate both sides of Equ. (1) between the limits a and b; after rearrangement, we find

$$\int_a^b u\frac{dv}{dx}\,dx = u(b)v(b) - u(a)v(a) - \int_a^b v\frac{du}{dx}\,dx \qquad (2)$$

Equ. (2) is the formula for 'integration by parts'. It assumes that we have to integrate the product of two functions, one of which is given as u and the other as dv/dx. It is therefore essential that we should be able to integrate the function chosen as dv/dx explicitly; any value we please may be taken for the constant of this integration, because this constant cancels out of the right-hand side of Equ. (2). Equation (2) thus reduces the integral on the left-hand side with which we started to a different integral, specified by the last term on the right-hand side. Unfortunately there is no guarantee that this second integral may not be more intractable than the first, but the process is well worth trying if u is x or an integral power of x. The process may have to be applied more than once to achieve the desired result. Consider for example

$$I_1 = \int_0^1 x^2 \cos(\pi x)\,dx \quad .. \quad .. \quad .. \quad (3)$$

Here the first step is to apply Equ. (2) with u as x^2 and dv/dx as $\cos \pi x$, so that v can be taken as $\{\sin(\pi x)\}/\pi$. We thus find

$$I_1 = -\int_0^1 \left\{\frac{1}{\pi}\sin(\pi x)\right\}.\,2x\,dx \quad .. \quad .. \quad (4)$$

Equ. (4) is better than Equ. (3), but we have to apply Equ. (2) a second time before we can evaluate I explicitly. This time we take the constant factor $(2/\pi)$ outside the integral, and put $u = x$ and $dv/dx = \sin(\pi x)$ so that v can be taken as $-\{\cos(\pi x)\}/\pi$. We thus find

$$I_1 = -\frac{2}{\pi}\left[-\frac{\cos\pi}{\pi} + \int_0^1 \frac{\cos\pi x}{\pi}\,dx\right] \quad .. \quad (5a)$$

$$= -(2/\pi^2)\left[1 + \frac{1}{\pi}\right] \quad .. \quad .. \quad .. \quad (5b)$$

since the term remaining to be integrated in Equ. (5a) is one which can be integrated directly by means of Table 1 of last month's article.

Another case in which 'integration by parts' is successful is

$$I_2 = \int_0^1 e^{-x}\cos\pi x\,dx \quad .. \quad .. \quad .. \quad (6)$$

and the same technique would work for the integrand $\exp(-x)\cos(\beta x + \gamma)$. Putting $u = \exp(-x)$ and $v = \{\sin(\pi x)\}/\pi$ in Eq. (2), we find

$$I_2 = \frac{1}{\pi}\int_0^1 e^{-x}\sin\pi x\,dx \quad .. \quad .. \quad .. \quad (7)$$

Again, at this stage Equ. (7) does not appear to be any improvement on Equ. (6), but, as in the previous example, success depends upon being ready to apply Equ. (2) more than once. Applying Equ. (2) for the second time with $u = \exp(-x)$ as before but $dv/dx = \sin(\pi x)$ so that v can be taken as $-\{\cos(\pi x)\}/\pi$, we find

$$I_2 = \frac{1}{\pi^2}(1 + e^{-1}) - \frac{1}{\pi^2}I_2 \text{ or } I_2 = \frac{1 + e^{-1}}{1 + \pi^2} \qquad (8)$$

and, in this case, success was due to the fact that after two 'integrations by parts', the integration remaining to be performed happened to be not a known integral but a multiple of the original integral I_2 required.

Next consider the integral

$$\int_0^1 \cosh\{(0{\cdot}1x + 0{\cdot}05)^{\frac{1}{2}}\}\,dx \quad .. \quad .. \quad .. \quad (9)$$

Here the fact that the argument is $(0{\cdot}1x + 0{\cdot}05)^{\frac{1}{2}}$ inhibits direct integration, but the fact that this argument never exceeds 0·15 numerically suggests strongly that the correct procedure is to replace the integrand (9) by

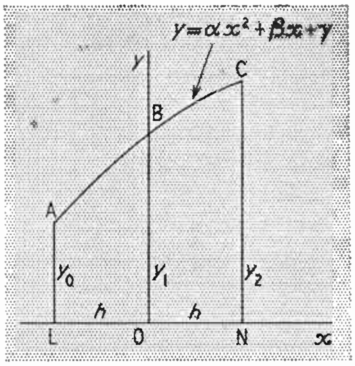


Fig. 1. *Area under a parabola*

a series expansion

$$1 + \frac{0{\cdot}1x + 0{\cdot}05}{2\,!} + \frac{(0{\cdot}1x + 0{\cdot}05)^2}{4\,!} + \quad \ldots \qquad (10)$$

Substituting only the first two terms of the series (10) into the integral (9), it reduces to 1·005. The next term contributes $(0{\cdot}15^3 - 0{\cdot}05^3)/72$, which is about 0·000045, so that it just fails to affect the fourth decimal place.

Now the series (10) happens to be a very 'safe' series, because it is convergent for all values of x. In general, a series of positive powers of y, say

$$S(y) = a_0 + a_1 y + a_2 y^2 + \quad \ldots \quad \ldots \qquad (11)$$

has a 'radius of converence' R. This means that if the modulus of y (which may be complex) is less than R, the series is safely convergent, and the technique used above of substituting the first few terms of the series (which are easy to integrate) for the sum is permissible. This technique must not be used if the modulus of y is equal to R and, if the modulus of y is greater than R, the series is divergent. If the modulus of y is near R but less than R, convergence will be slow. R is usually found from the equation

$$\lim_{n\to\infty} \left| \frac{a_{n+1}R}{a_n} \right| = 1 \quad \ldots \quad \ldots \quad \ldots \qquad (12)$$

which is, in effect, applying the 'ratio test' mentioned in "Mathematical Tools", June 1958, to the series derived from Equ. (11) by replacing y by R and considering only absolute values. In the case of the series (10), R is infinite, so that this series is particularly easy to handle.

Again, a short-range expansion of an otherwise unwieldy expression is often possible. Consider for example

$$I_3 = \int_{\pi/3}^{\pi/2} \cos(3\cos\theta)\,d\theta \quad \ldots \quad \ldots \quad \ldots \qquad (13)$$

and first put $\theta = \phi - (5\pi/12)$, so that the integral I_3 reduces to

$$I_3 = \int_{-\pi/12}^{\pi/12} \cos\left\{3\cos\left[\phi - (5\pi/12)\right]\right\} d\phi \quad \ldots \qquad (14)$$

Now ϕ never numerically exceeds $\pi/12$, and therefore if we can neglect $\frac{1}{2}(\pi/12)^2$, we can write

$$\begin{aligned} &\cos\{\phi - (5\pi/12)\} \\ &\quad = \cos(5\pi/12)\cos\phi + \sin(5\pi/12)\sin\phi \quad \ldots \qquad (15a) \\ &\quad \simeq \cos(5\pi/12) + \phi\sin(5\pi/12) \quad \ldots \quad \ldots \qquad (15b) \end{aligned}$$

and substitution from Equ. (15b) into Equ. (14) reduces the latter to an integration which we can evaluate explicitly, and shall call I_{31}.

When this kind of approximation is made, it is advisable to have a rough idea of the size of the principal error made. In the case of I_3 [Equ. (14)] we replaced $\cos\phi$ by 1 when we should have replaced it by $1 - \frac{1}{2}\phi^2$; replacing $\sin\phi$ by ϕ instead of $\phi - \frac{1}{6}\phi^3$ was also an error, but of higher order.* The principal error is thus neglecting the term $(1 - \frac{1}{2}\phi^2)$ which should have multiplied $\cos(5\pi/12)$ in Eq. (15b). Now when ϕ has the extreme value $\pm(\pi/12)$, $\frac{1}{2}\phi^2$ is about 0·034, and if in Equ. (14) we had replaced $\cos[\phi - (5\pi/12)]$ by

$$(1 - 0{\cdot}034)\cos(5\pi/12) + \phi\sin(5\pi/12) \quad \ldots \qquad (15c)$$

we could have evaluated the integral I_3 explicitly, obtaining a result I_{32} say. I_3 will then lie between I_{31} and I_{32}, and the difference between these two quantities will indicate the error adequately; in such cases we usually only require to know its order of magnitude. It should be noted that this error involves ϕ^2, so that reducing the range over which the approximation (15b) was applied would more than proportionately reduce the error; if the limits of integration in Equ. (14) were $-\pi/24$ to $+\pi/24$, the error would be greatly reduced.

Another kind of approximation which is very useful in dealing with awkward integrals (between finite limits) is known as Simpson's Rule. This is by no means the only such approximation available, but it has a simple idea behind it and is very generally applicable where the integrand does not oscillate too rapidly over the range of integration.

Consider first the area LABCN in Fig. 1, if we are given that the curve ABC is a parabola with a vertical axis so that its equation is of the form

$$y = \alpha x^2 + \beta x + \gamma \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (16)$$

Although we know that the *form* of the equation of the curve ABC is as in Equ. (16), we are not given the values of α, β and γ; we merely know that the parabola passes through the points A $(-h, y_0)$, B$(0, y_1)$ and C(h, y_2). This tells us immediately that $\gamma = y_1$ and we can solve the simultaneous equations

$$\begin{aligned} y_0 &= \alpha h^2 - \beta h + y_1 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (17) \\ y_2 &= \alpha h^2 + \beta h + y_1 \end{aligned}$$

to give

$$\beta = \frac{1}{2h}(y_2 - y_0);\ \alpha = \frac{1}{2h^2}(y_0 - 2y_1 + y_2) \qquad (18)$$

It is also clear that

$$\text{Area LABCN} = \int_{-h}^{h} y\,dx \quad \ldots \quad \ldots \quad \ldots \qquad (19)$$

and by substitution from Equs (18) into Equ. (16) and simplifying, we obtain

$$\text{Area LABCN} = \frac{1}{3}h\,(y_0 + 4y_1 + y_2) \quad \ldots \qquad (20)$$

* We have here assumed the series for $\sin\phi$ and $\cos\phi$ (ϕ in radians) obtained by means of Taylor's Theorem ("Mathematical Tools", December 1958), namely $\sin\phi = \phi - (\phi^3/3!) + (\phi^5/5!) \ldots$; $\cos\phi = 1 - (\phi^2/2!) + (\phi^4/4!) \ldots$

Now Equ. (20), though equivalent to Equ. (19), is much more useful, because it is expressed in terms of the quantities which are given in Fig. 1. Once Equ. (20) has been obtained, we can forget the particular position of the axes used in Fig. 1; the validity of Equ. (20) depends only upon the fact that the curve ABC was a parabola whose axis was the perpendicular bisector of LN.

Now if the points A, B, C are on some other curve, say $y = f(x)$ with the axes used in Fig. 1, and h is sufficiently small, the curve $y = f(x)$ will not in general differ greatly from the parabola unless $f(x)$ oscillates very rapidly. The idea behind Simpson's Rule is to divide up the area $L_1A_1B_1C_1B_2C_2B_3C_3 \ldots QM$ in Fig. 2 into a collection of areas $L_1A_1B_1C_1N_1$, $N_1C_1B_2C_2N_2$ etc., such that each of these areas can be regarded as like Figure 1. We then have

$$\text{Area } LA_1B_1C_1N_1 = \tfrac{1}{3}h(y_0 + 4y_1 + y_2)$$
$$\text{Area } N_1C_1B_2C_2N_2 = \tfrac{1}{3}h(y_2 + 4y_3 + y_4) \quad \ldots \quad (21)$$

and so on. Adding these, and assuming that $L_1M = 2nh$, we find total area $L_1A_1B_1C_1 \ldots QM$

$$= \tfrac{1}{3}h[(y_0 + y_{2n}) + 4(y_1 + y_3 + y_5 + \ldots + y_{2n-1}) + 2(y_2 + y_4 + y_6 + \ldots + y_{2n-2})] \quad \ldots \quad (22)$$

Equ. (22) is what is generally known as Simpson's Rule. In order to use it, we require only to calculate a suitable number of values of the integrand. For a given range of integration, taking a small value of h increases the accuracy but also increases the number of ordinates which have to be calculated.

Perhaps the best way to illustrate the accuracy obtainable with Simpson's Rule is to apply it to the integration of

$$I_4 = \int_0^{\pi} \sin kx \, dx \quad \ldots \quad (23)$$

The exact value is in this case easily obtainable and is

$$I_4 = (1 - \cos k\pi)/k \quad \ldots \quad (24)$$

If we take h to be $\pi/12$, Equ. (22) gives

$$I_4 = \frac{\pi}{36}\left[\sin k\pi + 4\left\{\sin\frac{k\pi}{12} + \sin\frac{k\pi}{4} + \sin\frac{5k\pi}{12} + \sin\frac{7k\pi}{12} + \sin\frac{3k\pi}{4} + \frac{11k\pi}{12}\right\} + 2\left\{\sin\frac{k\pi}{6} + \sin\frac{k\pi}{3} + \sin\frac{k\pi}{2} + \sin\frac{2k\pi}{3} + \sin\frac{5k\pi}{6}\right\}\right] \quad \ldots \quad (25)$$

Now Equ. (25) can be simplified by means of two trigonometrical identities which will be considered more fully in a later "Mathematical Tool", namely

$$\sin\alpha + \sin\beta = 2\sin\tfrac{1}{2}(\alpha + \beta)\cos\tfrac{1}{2}(\alpha - \beta)$$
$$\cos\alpha + \cos\beta = 2\cos\tfrac{1}{2}(\alpha + \beta)\cos\tfrac{1}{2}(\alpha - \beta) \quad (26)$$

It reduces to

$$I_4 = \frac{\pi}{36}\left[\sin k\pi + 2\sin\tfrac{1}{2}k\pi + 8\sin\tfrac{1}{2}k\pi\cos\frac{1}{4}k\pi\left(1 + \cos\frac{k\pi}{12} + 2\cos\frac{k\pi}{6}\right)\right] \quad \ldots \quad (27)$$

If $k\pi$ is so small that $\sin k\pi$ can be taken as $k\pi$ and $\cos k\pi$ as $1 - \frac{1}{2}(k\pi)^2$, Equs (24) and (27) are in complete agreement. Even if k is as large as unity, Equs (24) and (27) give results which only disagree in the fifth significant figure. If k is any even integer, Equs (24) and (27) both necessarily agree, but this is fortuitous: it is due to a cancellation associated with the symmetry of $\sin kx$. We therefore tabulate (Table 1) the values obtained from Equs (24) and (27) when k takes certain odd-integral values:—

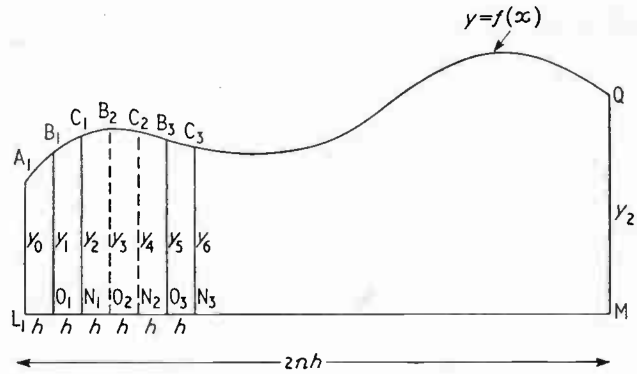


Fig. 2. *Simpson's rule*

TABLE 1

k	1	3	5	7	9
Equ. (24)	2	0·66667	0·4	0·28571	0·22222
Equ. (27)	2·0001	0·66817	0·40816	0·31461	0·31912

Thus it appears that Simpson's Rule is very satisfactory for k up to about 5, but that when k exceeds 5, the replacement of $\sin kx$ by a parabolic arc (as in Fig. 1) over successive intervals of $\pi/6$ for x rapidly deteriorates in accuracy. This suggests as a rough general rule that, in the notation of Figs. 1 and 2, h should be so chosen that the interval $2h$ does not include more than about half a cycle of the highest frequency contained in the integrand.

BIRTHDAY HONOURS

Leslie Carr Gamage (Chairman and Managing Director, The General Electric Co. Ltd.) receives a knighthood.

Professor William John Granville Beynon is appointed a C.B.E.

Cyril John Strother, M.B.E. (Assistant to Chief Engineer, B.B.C.) is appointed an O.B.E.

RADIO INDUSTRY COUNCIL

Edward E. Rosen of Ultra Electric Ltd. has been elected chairman of the Radio Industry Council in succession to G. Darnley-Smith of Bush Radio Ltd. Mr. Rosen was previously vice-chairman and is succeeded by Hector V. Slade of Garrard Engineering & Manufacturing Co. Ltd.

INSTITUTION OF ELECTRICAL ENGINEERS

It is announced that Sir Willis Jackson, D.Sc., D.Phil., Dr.Sc.Tech., M.I.Mech.E., F.Inst.P., F.R.S., has been elected President of the Institution for the year commencing 30th September.

Propagation of Long-Distance H.F. Signals

TRANSMISSION TESTS ABOVE NORMAL M.U.F.*

By Kenichi Miya* and Masashi Kawai*

SUMMARY. *Characteristics of high-frequency signals propagated between the United Kingdom and Japan are described. It has been observed that, in winter and when the frequency in use is above the classical maximum usable frequency, signals of considerable intensity can be received along paths which deviate widely from the great-circle path while, at the same time, pulse signals are too weak to be received. On the other hand (especially in seasons other than winter), both pulse and continuous signals are received at good strength from directions close to the great-circle path during periods when the signal frequency exceeds the classical m.u.f.*

Two propagation modes are postulated to explain these observations: one involves forward ground scattering from regions well off the great-circle path, and the other involves reflection by sporadic E-layer clouds appearing near the great-circle path.

It has been pointed out by radio operators and others that on certain long-distance h.f. circuits, especially the one between the U.K. and Japan, signals at frequencies above the classical m.u.f. can often be propagated with sufficient intensity for practical communications. Investigation of the propagation mechanism involved in this phenomenon is important not only for purely scientific reasons but also for the purpose of improving the reliability of predictions of m.u.f. for the circuits concerned.

It was shown by one of the authors[1] that the discrepancy between predictions of the times of fade-in and fade-out on a circuit and the observed times may be considerably reduced by taking into account the forward scattering which takes place at the ground. Furthermore, by means of a direct-vision type of direction finder developed recently, the authors made many observations of lateral deviation on signals transmitted from Europe and confirmed that a considerable amount of the forward ground scattered energy comes from a direction off the true bearing[2].

Information so far obtained, however, is insufficient to explain various phenomena peculiar to signals propagated over land. In order to elucidate these phenomena, two-way pulse transmissions were conducted between the U.K. and Japan for about two years from the end of 1955, through the close co-operation of the British Post Office and the Radio Research Station of the Department of Scientific and Industrial Research, and Kokusai Denshin Denwa Company of Japan. In the latter part of the test period, continuous wave as well as pulse transmissions were radiated, and a variety of observations, including that of back-scatter, were conducted simultaneously on both types of transmission at receiving stations in Japan.

From the results of these observations, the characteristics of waves propagated between the U.K. and Japan have been clarified. It has been confirmed that not only does a forward ground scatter mode exist in which the signal comes from a direction well off the great-circle path, but also that another mode of propagation exists involving forward ground scatter accompanied by reflections at sporadic E clouds.

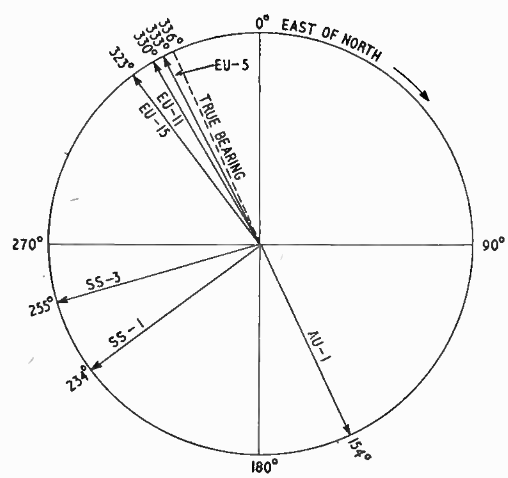


Fig. 1. *Directions of aerials used for comparison test of gain at Fukuoka receiving station*

In this article the results of the observations are described in detail and the evidence given for the existence of these two modes.

Scope of Tests

Tests were mainly made with pulse and dot signals transmitted from two stations near London: pulses of 100-kW peak power, 100-microseconds duration and 25 pulses per second repetition frequency were transmitted from the Radio Research Station at Slough, while dots of 20-kW peak power and speed of 200 bauds were transmitted from Rugby. Corresponding to these transmissions, pulses of 200-microseconds duration and a repetition frequency of 25 per second, and dots with a speed of 100 bauds were radiated from Kawachi

* *Kokusai Denshin Denwa Co., Japan.*

TABLE 1

Test Schedule and Transmissions

Pulse tests 1, 2 and 3: Pulse and dot tests 4 and 5

Test	Date	Period (G.M.T.)	Type of Transmission and Frequency	Remarks
1	24, 26, 28 October 1955 2, 4 November 1955	0800–1600	Pulses: GBW34 (14,975 kc/s) JG4C (14,435 kc/s)	Rhombic aerial and dipole alternately every 30 min.
	9, 11 November 1955			Every 10 min.
2	11, 13, 17 January 1956	0700–1600	Pulses: GBW34 (14,975 kc/s) JG4C (14,435 kc/s)	Rhombic aerial and dipole alternately every 10 min
	24, 25 January 1956		Pulses: GBW34 (14,972 kc/s)	Rhombic aerial only
3	4, 5, 6 April 1956	0500–2100	Pulses: GBW34 JG4C	Rhombic aerial and dipole alternately every 10 min.
	7, 9 May 1956	0800–1600	Pulses (Slough): (19,560 kc/s) Pulses (Osaka): JG4F (19,560 kc/s)	Alternate transmission by rhombic aerial from U.K. and Japan every 10 min.
	15, 17 May 1956	0800–1045 1600–2000		
4	19, 21 November 1956	0900–1630	Pulses (Slough) and Dots (Rugby): GIW39 (19,395 kc/s), Pulses and Dots (Osaka): JG4F (19,395 kc/s)	Alternate transmission from U.K. and Japan every 30 min. 10 min. Pulses 20 min. Dots
	27, 29 November 1956	0800–1630		
	4 December 1956	0900–1400	Pulses: GIW39	Rhombic aerial
	5 December 1956	0800–1630	Pulses: JG4F	
	6 December 1956	0800–1400	Pulses and Dots: GIW39	
	12 December 1956	0800–1630	Dots: JG4F	Broad-side array (direction: 218°)
5	2, 4 April 1957	0000–2400	Dots: GIA39 (19,640 kc/s)	Rhombic aerial
		0830–1600	Pulses: GIA39	
	2, 3, 4 May 1957	0900–0900	Dots: JB4B (19,640 kc/s)	

transmitting station near Osaka, Japan. Pulses were radiated alternately from a rhombic aerial directed to the receiving station and from a half-wave dipole of the same height as the rhombic aerial. Frequencies in the 14-Mc/s and 19-Mc/s bands were used in the tests.

Tests were made during five seasonal periods as shown in Table 1.

Observation of multiple signals, signal intensity and effective gain of aerials were made at Fukuoka receiving station (35°53′N, 139°31′E) near Tokyo. In addition to the two rhombic aerials EU-5 (333°) and EU-11 (330°) directed very nearly along the great-circle bearing of London, other similar rhombic aerials (l = 120 m, β = 70°) were used, namely, EU-15 (323°), SS-3 (255°), SS-1 (234°) and AU-1 (154°) for gain comparison tests as shown in Fig. 1. The mean height above ground of these aerials was 20 metres (except EU-11 which was 50 metres high) to facilitate the reception of rays of low angles of elevation.

The bearings of the signals from London, and of the back-scattered signals from Kawachi, were measured at Komuro receiving station (35°59′N, 139°37′E) near Tokyo.

Results from Pulse Tests 1, 2 and 3

Reception results of GBW34 (14·972 Mc/s) in these tests are summarized in Figs. 2, 3 and 4. In these periods it was frequently difficult to make observations because of severe ionospheric disturbances and of interference on an adjacent frequency. Nevertheless the following notable phenomena were observed.

Received Intensity

Comparison of the period of reception of the pulses with the predicted period shown in the lower part of the figures shows that, except on disturbed days, pulses generally arrive with good intensity for a much longer

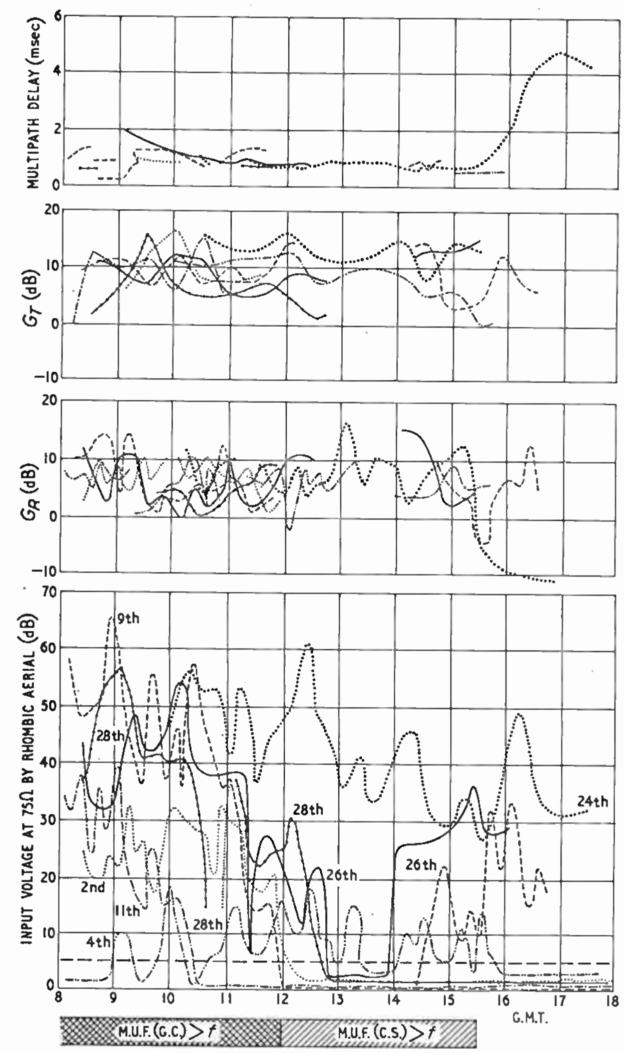
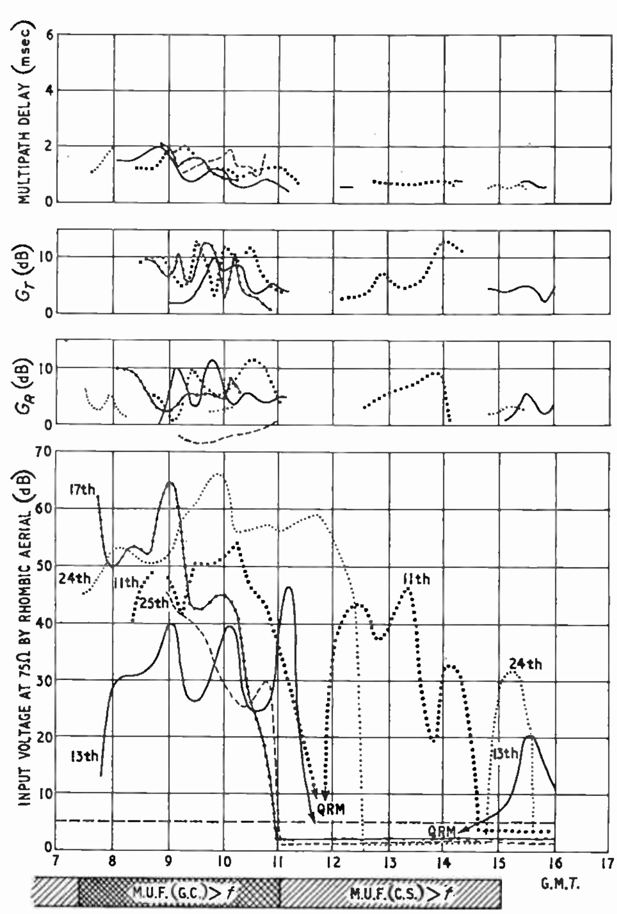


Fig. 2. *Observed results of multipath delay, gain of transmitting and receiving aerials and signal intensity on pulses of GBW*34 (14,975 *kc/s*) *in October and November* 1955

of the transmitting and receiving rhombic aerials, directed along the great-circle bearings, relative to that of half-wave dipoles at the same height. In the test periods both G_T and G_R varied over a wide range due, to some extent, to severe ionospheric disturbances. Cumulative distributions of G_T and G_R for aerial EU-5 were obtained from these results for the period of $f<$m.u.f. (g.c.) and of $f>$m.u.f. (g.c.) respectively. Table 2 shows the 50 % values and distribution ranges expressed as a difference between the 10 % and 90 % values. From the table it can be seen that the measured gains for pulse transmission during the period of $f<$m.u.f. (g.c.) are slightly higher than those for $f>$m.u.f. (g.c.). Earlier measurements by Miya and Kanaya on telegraph signals transmitted from Europe showed that there was a significant difference in the aerial gains during similar conditions of m.u.f. and it must therefore be concluded that there is a discrepancy between the measured gains for pulses and continuous waves. It is also pointed out that G_R generally shows lower values than G_T; such a tendency can be particularly noted around 1800 G.M.T. in Test 3. From this fact it may be deduced that the deviation of bearing at the Tokyo end of the path is greater than at the London end.

The comparison of G_R for aerial EU-5 (directed along the true bearing of London) and of EU-15 (directed 10°

Fig. 3. *Observed results of multipath delay, gain of transmitting and receiving aerials and signal intensity on pulses of GBW*34 (14,972/14,975 *kc/s*) *in January* 1956



period than that indicated by the classical m.u.f. predictions. The double-hatched portion of the prediction in each figure indicates the period when the signal frequency f is lower than the predicted m.u.f., denoted by m.u.f. (g.c.)† in this article. The single-hatched portion of the prediction shows the period during which the signal frequency is lower than the m.u.f., denoted here by m.u.f. (c.s.)‡, predicted by considering forward scattering at the ground propagated by way of the F_2-layer. When the signal frequency is above the m.u.f. (g.c.) the received intensity varies irregularly from very weak to very strong and does not always appear to follow the prediction of m.u.f. (c.s.). The propagation of continuous waves is, however, related closely to the m.u.f. (c.s.) and it will be fully discussed in a later section.

Gains of the Transmitting and Receiving Aerials

Figs. 2, 3 and 4 show the measured gains G_T and G_R

† Great circle.
‡ Continental scatter.

TABLE 2

Measured Gains of Transmitting and Receiving Beam Aerials Pointing to the True Bearing in the Pulse Tests

Pulse test	G_T in dB				G_R in dB			
	Period of $f <$ m.u.f. (g.c.)		Period of $f >$ m.u.f. (g.c.)		Period of $f <$ m.u.f. (g.c.)		Period of $f >$ m.u.f. (g.c.)	
	at 50%	10–90%	at 50%	10–90%	at 50%	10–90%	at 50%	10–90%
1	9·0	9·0	8·7	11·0	5·3	8·8	5·0	13·4
2	6·8	11·2	4·5	11·0	4·4	10·2	(3·6)	(6·8)
3	8·0	10·5	8·0	10·5	4·6	9·2	3·1	14·2

south of the London bearing) showed that, on the average, G_R for aerial EU-15 was somewhat greater than for aerial EU-5. On the other hand, those rhombic aerials directed well off the great-circle bearing of London always showed much lower values of G_R than that for EU-5 and EU-15. It may be deduced from these results that the signal from London generally arrives at Tokyo with slight deviation from the great-circle path. These gain characteristics will be helpful in the discussion of the propagation mechanisms described later.

The gains of two rhombic aerials, EU-5 and EU-11, directed along the same bearing (but of different heights) were compared in Test 1; aerial EU-11, the higher one, showed larger values of G_R by several dB in most cases. From a comparison of the vertical radiation patterns of the two aerials it was deduced that the angle of elevation of the downcoming waves was less than 10°.

Multipath Delay

The multipath delay in terms of the echo spread, measured 20 dB below the peaks of the echoes on an 'A' display, is shown in Figs. 2, 3 and 4 which refer to short-route propagation. Received echo patterns were sometimes complicated and consisted of four or five groups of rays with a delay of up to 3 msec, but they generally contained one main group of less than 2 msec spread.

When the signal frequency was above the m.u.f. (g.c.) the multipath delay was not more than about 1 msec, except in some special cases as seen in Fig. 2.

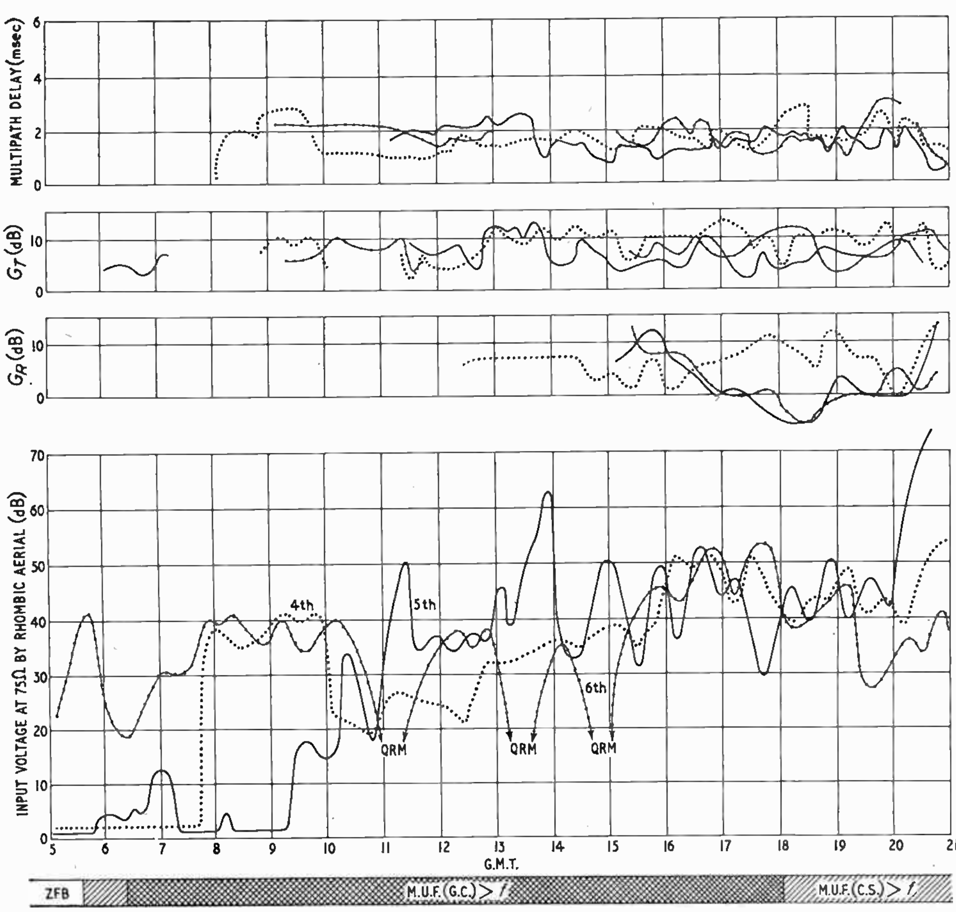


Fig. 4. *Observed results of multi-path delay, gain of transmitting and receiving aerials and signal intensity on pulses of GBW34¦ (14,972 kc/s) in April 1956; ZFB = signals fading badly*

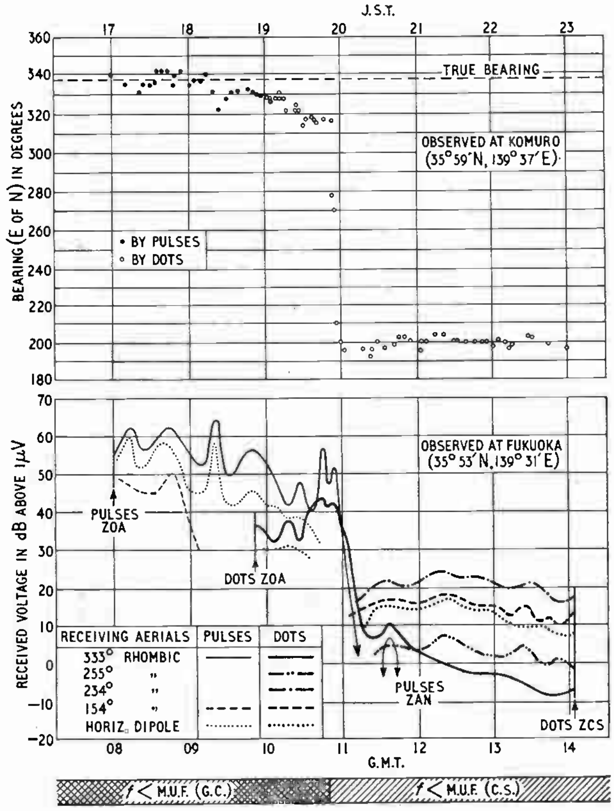


Fig. 5. *Simultaneous observation of bearing and signal intensity of pulses and dots on GIW39 (19,395 kc/s), 6th December 1956; ZOA = transmitter closed down, ZAN = signals inaudible, ZCS = transmitter ceased sending*

Results of Pulse and Dot Observations in Test 4

Observations on European commercial signals made at Ohira Observatory near Tokyo had shown that remarkable lateral deviation of bearing was possible when $f >$ m.u.f. (g.c.) As this result was contrary to that obtained on pulse transmission, it appeared that the propagation mechanism might be different for the two types of signal. To investigate this possibility, simultaneous transmissions of pulse and dot signals were arranged. A typical series of observations of station GIW39 (19·395 Mc/s) made on 6th December 1956, will now be discussed.

Intensity of the Received Signal

The intensity of the signals is shown in the lower graph of Fig. 5. During the period when m.u.f. (g.c.) $> f$, both pulses and dots arrive with considerable intensity and a beam aerial directed along the true bearing shows high gain for both types of signal. After about 1030 G.M.T., when $f >$ m.u.f. (g.c.), pulses become too weak to detect. Thereafter, during the period when m.u.f. (g.c.) $< f <$ m.u.f. (c.s.), only the dots are receivable continuously, if not very strongly. This is one of the most important phenomena brought to light in this test.

Bearing

As is shown in the upper graph of Fig. 5, the bearing of the arriving waves during the period when $f <$ m.u.f. (g.c.) lies close to the true bearing but it begins to deviate southwards within one half-hour of the time at which the signal frequency exceeds the m.u.f. (g.c.), and thereafter the waves arrive on a bearing of about 200° E. of N. In such periods of considerable deviation, the gain of aerials directed along the deviated bearing attains a high value, while that of aerials directed to the true bearing of the transmitter lose their gain. Fig. 6 shows an example of the variation with time of the bearing of dots from GIW39. Each photograph was taken with an exposure of one minute and with a time-constant of the direction indicator of either 0·2 or 10 seconds. From the results of those measurements made in Test 4 during the winter, it was found that the deviation of bearing took place within 30 minutes in all cases.

Received Wave Pattern

The received wave pattern and multipath delay for pulse reception were of similar characteristics to those described in the previous section. In the case of dot reception, however, the wave shape, although little distorted when the signal frequency was below the m.u.f. (g.c.), was so distorted due to the large multipath delay of more than 10 milliseconds when the signal frequency was above the m.u.f. (g.c.) as to be hardly distinguishable. Examples of the observed wave shapes are shown in Fig. 7.

Behaviour of the Back-Scattered Echoes

Experiments involving simultaneous transmission on the same frequency from both the U.K. and Japan were instituted from the latter part of Test 3. Simultaneous observations of back-scattered echoes of the Kawachi transmission were conducted at Fukuoka and Komuro receiving stations about 400 km from Kawachi, and these echoes were compared with the signals received from London. A typical example obtained on 29th November 1956, is shown in Fig. 8. As the electron density of the ionosphere in the direction of the main radiation from the transmitting aerial was not large enough to support propagation on the radiated frequency, the bulk of the back-scattered energy was received from a more southerly direction where deviative absorption was less. The deviation southwards increased with time, accompanied by weakening of the echoes. It is noteworthy that the intensity and bearing of the back-scatter of JG4F agree closely with those of GIW39 after 1100 G.M.T. Comparison of intensities by using various rhombic aerials pointing in different directions gave results supporting these measurements.

Results of the Dot Transmissions of Test 5

As described above, two interesting phenomena were observed in Tests 1 to 4 when the signal frequency was above the classical m.u.f. In the dot transmissions of Test 5 conducted at the beginning of April, both these phenomena were observed; on some occasions dots of good strength arrived nearly at the true bearing as had been observed on pulses in Tests 1, 2 and 3 while, on other occasions, they were weak and arrived with considerable deviation from the true bearing, as had been observed in Test 4.

Discussion of the Propagation Mechanism

From the results of the observations described it is considered that high-frequency propagation between Europe and Japan can take place by the following three mechanisms.

Normal Propagation by the F_2 or Sporadic E layer

This is the normal mode of propagation along the great circle in which reflections take place at the F_2 or

Fig. 6. *Variation of bearing of dots on GIW39 (19,395 kc/s) over the period 1012–1104 G.M.T., 6th December 1956. Time-constant of direction indicator: (a) 10 seconds and (b) 0.2 second*

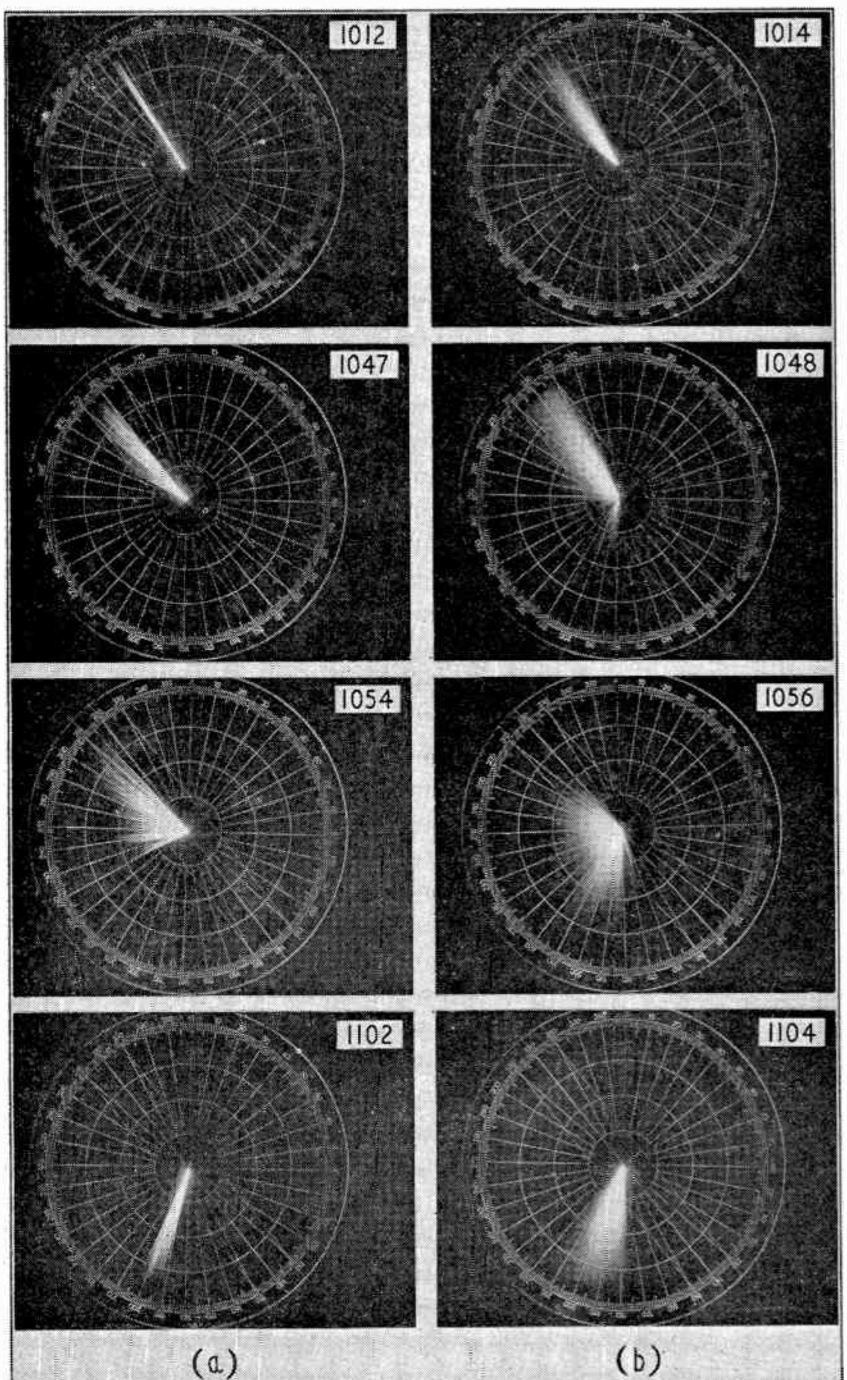
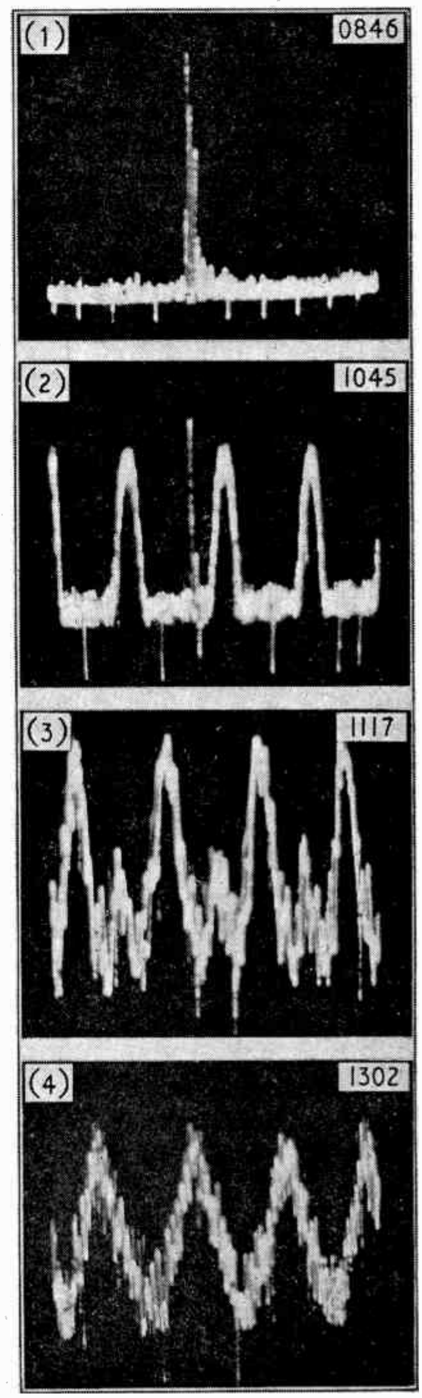


Fig. 7. *Observed patterns of pulses and dots of GIW39 (19,395 kc/s), 6th December 1956. Times shown are G.M.T. (1) Typical pattern of pulses with no dots being sent. Time marks are at intervals of 4 msec. (2) Simultaneous reception of pulses and dots. (3) and (4) Much-distorted dots, while pulses cannot be received.*



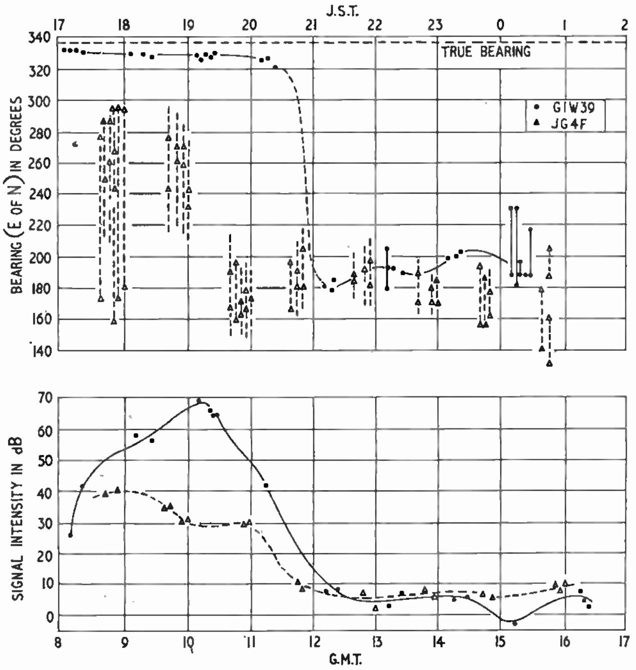


Fig. 8. *Bearings and signal intensities of GIW*39 (19,395 *kc/s*), *London, and back-scattered echo of JG4F* (19,395 *kc/s*), *Osaka, observed at Tokyo on* 29*th November* 1956

sporadic E layers and it is used for obtaining the classical m.u.f. by the 'two control-point method'. As mentioned above, it is insufficient to explain various phenomena peculiar to long-distance propagation over land paths such as that now considered.

Forward Ground Scatter Propagation by Way of the F_2 *layer*

This is a mode of propagation observed when normal propagation is impossible due to electron limitation on the great-circle path. As shown by 2 in Fig. 9, waves arrive at the receiver by many paths through a region of sufficiently high electron density after scattering at irregularities on the earth's surface. The existence of this propagation mechanism was pointed out earlier[4,5], and experimental confirmation was recently given[2]. Further confirmation is provided by the present investigations.

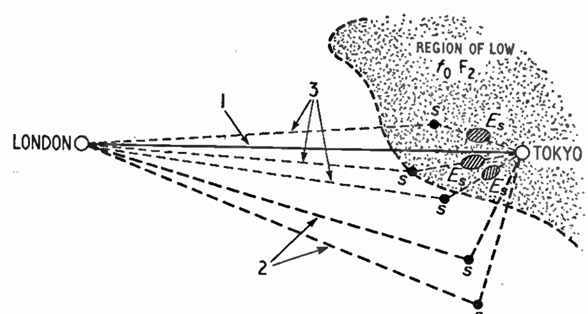
Fig. 10 shows wave paths between London and Tokyo and an ionospheric chart for December 1956, derived from Central Radio Propagation Laboratory predictions and giving contours of (M 4000) F_2 for 19·395 Mc/s (GIW39) at various times. It can be seen that signals from GIW39 cannot be propagated along the great-circle path after about 1100 G.M.T. and will thereafter arrive at the receiver by scattering travelling along paths as shown by the dotted lines. The distribution characteristics of the F_2 layer permit the inference that the scattered signals taking the paths shown should be stronger than those taking paths nearer to the great-circle as the deviative absorption along the latter paths will be greater. This fact is apparent in the back-scatter results described in the previous section. It can also be seen from the contours why the bearings change rapidly in a period of about 30 minutes. The remarkable multipath delays shown in Fig. 7 may also be explained by the lengths of the scattering paths. Although individual rays among the scattered signals are considerably attenuated due to the long paths and scattering losses, interference effects with such multipath rays are such that dots build up to a considerable intensity. On the other hand, pulses cannot be observed because of their short duration compared with the multipath delay and amplitude integration of multiply-scattered waves does not occur. The effect of integration may be demonstrated by the fact that, in ordinary back-scatter sounding, the shorter the pulse duration the weaker becomes the intensity of the scattered echo.

The mode of propagation accompanied by large bearing deviation is peculiar to those radio circuits in which ground scattering can be predominant; it has never been observed on the San Francisco–Tokyo circuit which is entirely over a sea path[1,2].

Forward Ground Scatter Propagation by Way of Sporadic E Clouds

Waves propagated by the mechanism described above are distinguished by the remarkable southerly deviations in bearing which may be observed, by the fact that no pulse signals are receivable, and that they are observed particularly in winter. In contrast to this mechanism it has been noted that both pulses and dots can sometimes be received at high intensity and without noticeable deviation in bearing even when the signal frequency is above the m.u.f. (g.c.). Examples of this were noted in Tests 1, 2, 3 and 5. It is apparent, therefore, that another propagation mechanism must be introduced. From the fact that the phenomenon is noticed very frequently in seasons other than winter, and that it occurs irregularly (and sporadically), it is obvious that the propagation is closely related to the sporadic E layer. Because of the fact that such a phenomenon is never observed on the San Francisco–Tokyo circuit[1], it is deduced that the mode of propagation is not simple such as occurs in normal reflection by the sporadic E layer but that some region of the land along the wave-path plays an important role in the propagation. Considering, moreover, that the bearing of the signals

Fig. 9. *Mechanism of propagation in the London–Tokyo wireless circuit;* 1, *normal propagation along the great circle path.* 2, *forward ground scatter propagation by way of the* F_2 *layer.* 3, *forward ground scatter propagation by way of sporadic E clouds appearing near the great-circle path.* s = *position of scattering on the ground*



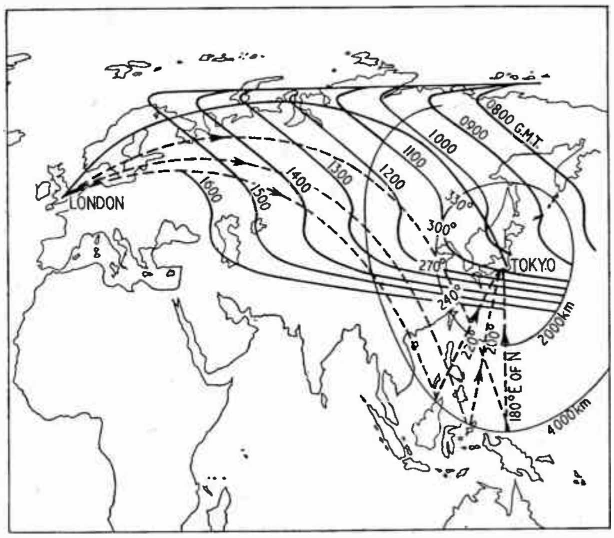


Fig. 10. *Routes of forward ground scatter propagation by way of the F_2 layer and contour lines of* $(M.4000)F_2$ *for GIW*39 (19,395 *kc/s*) *taking G.M.T. as a parameter, on the London–Tokyo wireless circuit in December* 1956

differs little from the true bearing, the mode of propagation is deduced to be that illustrated by 3 in Fig. 9, where the signal arrives at the receiver by forward ground scatter propagated by way of sporadic E clouds existing in areas of low F_2-layer density near the great-circle path. The possibility of propagation by this new mode is thus considerably higher than by normal sporadic-E layer reflection. The reason why it is only observed on transcontinental circuits is due to the fact that, for forward scattering, the scattering coefficient for the earth's surface is greater than that of the sea[6].

It may also be deduced from Figs. 9 and 10 that, when the F_2-layer density is low at the Tokyo end of the path, the bearing deviation as observed at London is smaller than at Tokyo; it is thus possible to interpret the result that the aerial gain at the London end of the path (G_T) is higher than that at the Tokyo end (G_R).

Conclusions

The results of pulse and dot transmissions between Europe and Japan have shown that two modes of propagation can exist when the frequency used is above the classical m.u.f. These are (i) forward ground scatter propagation accompanied by F_2-layer reflection along paths much deviated from the great-circle, and (ii) scatter propagation with reflection from clouds of sporadic-E near the great-circle path. Distinguishing features of these two modes are summarized in Table 3.

A method of predicting propagation conditions taking the first of these modes into account has been given by the authors[1]; it is hoped shortly to devise a satisfactory method of prediction to include the second mode.

Acknowledgement

The authors wish to acknowledge the kind co-operation in these tests of the British Post Office and the Radio

TABLE 3

Comparison of Two Modes of Forward Ground Scatter Propagation

Item	Continental forward scatter propagation by way of F_2 layer	Continental forward scatter propagation by way of sporadic E clouds
Seasons in which observed	Clearly in winter	Sporadically in winter and very frequently in seasons other than winter
Time to be observed	m.u.f. (G.C)* $< f <$ m.u.f. (C.S.)*	m.u.f. (G.C.)* $< f$
Signal intensity	Very low and with little fluctuation	Strong and of the same order as the normally propagated signals
Bearing	Deviates remarkably in the order of 100°	Deviates slightly in the order of 10°
Gain of aerial	Several dB for a suitable aerial oriented for the deviated bearing	Normal gain for the aerial oriented for the true bearing
Multipath delay	Of the order of many milliseconds	Of the order of a few milliseconds
Influence of type of transmission	Observed only on signals of long duration and hardly ever on short pulses	Observed on signals of any type
Quality of signal	With distortion such as echo signals	Available for any practical communication

* m.u.f. (G.C.) means the classical m.u.f., and m.u.f. (C.S.) the m.u.f. considering forward ground scattering on paths deviating widely from the great-circle path

Research Station. They are most grateful to Dr. R. L. Smith-Rose, Director of Radio Research in the Department of Scientific and Industrial Research for arranging the publication of this paper and, for useful assistance and suggestions, to Mr. J. K. S. Jowett of the British Post Office, and Mr. A. F. Wilkins of the Radio Research Station.

Advice and encouragement given throughout the tests by Dr. S. Namba, and Dr. M. Shimbori, Directors of Kokusai Denshin Denwa Co. (K.D.D.), Japan, are also acknowledged. The authors are also grateful to the staff members of the transmitting and receiving stations and of the Electric Wave Section of K.D.D. for their great assistance in making measurements.

REFERENCES

1 K. Miya and S. Kanaya, "Radio Propagation Prediction considering Scattering Wave on the Earth's Surface", *Rep. Ionosphere Res. Japan*, March 1955, Vol. 9, No. 1, pp. 1–15.

2 K. Miya, M. Ishikawa and S. Kanaya, "On the Bearing of Ionospheric Radio Waves", *Rep. Ionosphere Res. Japan*, September 1957, Vol. 11, No. 3, pp. 130–144.

3 K. Miya and S. Kanaya, "On the Lateral Deviation of Radio Waves coming from Europe", *Rep. Ionosphere Res. Japan*, March 1956, Vol. 10, No. 1, pp. 1–8.

4 A. Hoyt Taylor and L. C. Young, "Studies of High-Frequency Radio Wave Propagation", *Proc. Inst. Radio Engrs*, May 1928, Vol. 16, pp. 561–578.

5 R. Keen, "Wireless Direction Finding", Third Edition 1938, p. 377 (Iliffe & Sons, London).

6 K. Miya, T. Kobayashi and N. Wakai, "Field Intensity of Scattered Wave in Radio Wave Propagation," *Rep. Ionosphere Res. Japan*, 1951, Vol. 5, p. 55–73

Concertina Phase-Splitter – 1

The concertina phase-splitter has been widely used for twenty-five years or so for feeding push-pull amplifiers from unbalanced sources. It also has application in phase-shifting circuits.

Its performance is excellent and the only major criticism which is commonly made is about its output impedance. When viewed from the anode, the impedance appears higher than when viewed from the cathode. This worries some people and has even misled some into advocating the use of unequal time constants for the two loads.

In reality, this inequality of output impedance is of no importance at all. It is necessary, however, to demonstrate this.

The basic circuit is shown in Fig. 1 (a) with its equivalent at (b). The fundamental equations are:

$$\left.\begin{aligned} v_{in} &= v_{gk} + i_a Z_k \\ \mu v_g &= i_a(r_a + Z_a + Z_k) \\ v_k &= i_a Z_k \\ v_a &= -i_a Z_a \end{aligned}\right\} \quad \ldots \quad \ldots \quad (1)$$

whence $$i_a = \frac{\mu v_{in}}{r_a + Z_a + Z_k(1+\mu)} \quad \ldots \quad \ldots \quad (2)$$

It is clear from (1) that

$$\frac{-v_a}{v_k} = \frac{Z_a}{Z_k} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

so that the only requirement for the two outputs to be of equal amplitude and in phase opposition is the use of identical anode and cathode load impedances. This is also clear on physical grounds. In Fig. 1(a) the anode current of the valve traverses both Z_a and Z_k and no other current passes through either. The output voltages are developed by this current and their equality thus demands equality of the impedances.

It is also clear from this that output impedance does not enter into the matter of securing equal and opposite outputs at all.

Now it is possible to re-arrange equation (2) in several different ways. We can write

$$i_a = \frac{\dfrac{\mu}{1+\mu} v_{in}}{\dfrac{r_a + Z_a}{1+\mu} + Z_k} \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

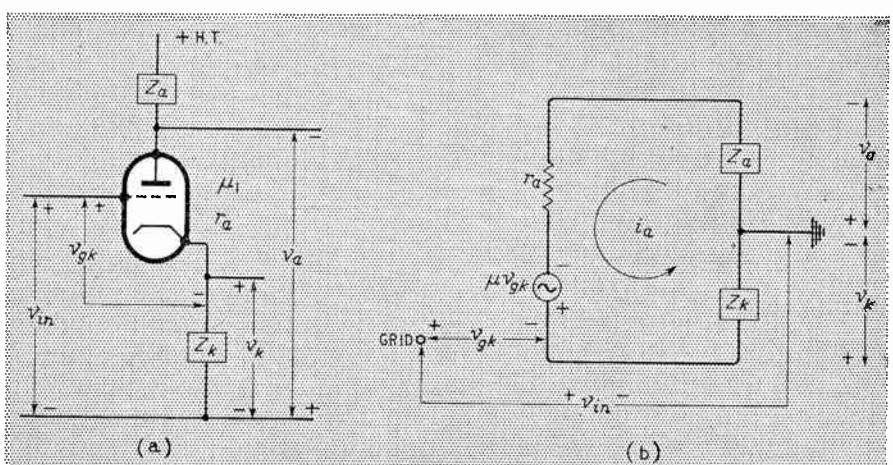


Fig. 1. *The basic circuit of the concertina phase-splitter is shown at (a) with the equivalent circuit at (b)*

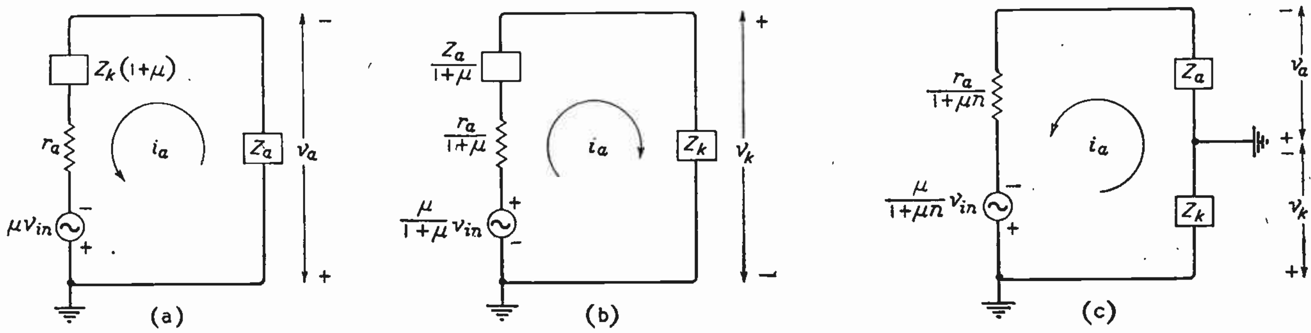


Fig. 2. *Three circuits equivalent for anode current are shown here, but all differ in the matter of generator impedance*

and

$$i_a = \frac{\dfrac{\mu}{1+\mu n}v_{in}}{\dfrac{r_a}{1+\mu n} + Z_a + Z_k} \quad \cdots \quad (5)$$

where $n = Z_k/(Z_a + Z_k)$.

These three equations (2), (4) and (5) have the equivalent circuits shown respectively in (a), (b) and (c) of Fig. 2. The internal impedances of the equivalent generators are those measured from anode to earth (a), cathode to earth (b) and between anode and cathode (c). In (a), for example, Z_a is removed and replaced by a generator e; a current i flows as a result and $e/i = r_a + Z_k(1 + \mu)$. Similarly for (b), Z_k is removed and replaced by a generator e; a current i flows and $e/i = (r_a + Z_a)/(1 + \mu)$. In the case of (c) Z_a and Z_k are left in place and e is connected between anode and cathode; the resulting current i is the anode current of the valve and does not include the current in Z_a and Z_k. The impedance is then $e/i = r_a/(1 + \mu n)$. It is necessary in this case to leave Z_a and Z_k in place in order that the fraction n of e be applied to the grid of the valve.

We shall here discuss only (c) because the other two are well-known results which are easily derived. In Fig. 3, we imagine the generator e placed across Z_a and Z_k. Only the current i_1 flows in Z_a and Z_k and if $n = Z_k/(Z_a + Z_k)$ a fraction ne appears across Z_k making the cathode negative to earth. This voltage appears between grid and cathode so $v_{gk} = ne$ and $e(1 + \mu n) = ir_a$.

All three equivalent circuits in Fig. 2 are identical in so far as they all lead to identical expressions for anode current. On an impedance basis they are all different. The first (a) gives correctly the impedance as seen between anode and earth but gives no clue about how any other impedance may be derived. The second (b) is similarly right for looking at matters between cathode and earth, but its utility is confined to that.

The third (c) appears much more useful. It gives correctly the impedance viewed between anode and cathode and it looks as if it would give the other two also. However, it does not. If one tries to compute from it the impedances viewed between anode and earth or between cathode and earth one obtains the wrong answers.

The circuits of Fig. 2 are thus of restricted utility. They are only equivalents under particular conditions and, because one is apt to forget the restrictions on their use, they can be quite misleading. We shall, however, later point out that the impedance value $r_a/(1 + \mu n)$ is the one which in combination with Z_a and Z_k governs the frequency characteristics.

Now if $Z_a = Z_k = Z$, say, we get, from (1) and (2)

$$\frac{v_k}{v_{in}} = -\frac{v_a}{v_{in}} = \frac{\mu Z}{r_a + Z(2 + \mu)} \quad \cdots \quad (6)$$

Let both Z_a and Z_k comprise resistance R in shunt with capacitance C so that $Z = R/(1 + j\omega T)$ where $T = CR$. Substituting into (6) and re-arranging

$$\frac{v_k}{v_{in}} = -\frac{v_a}{v_{in}} = \frac{A_0}{1 + j\omega T'} \quad \cdots \quad (7)$$

where

$$A_0 = \frac{1}{2}\cdot\frac{\mu}{1+\mu/2}\cdot\frac{2R}{2R + r_a/(1+\mu/2)}$$
$$= \frac{\mu R}{r_a + R(2+\mu)}$$
$$= \text{low-frequency gain}$$
$$T' = \frac{C}{2}\cdot\frac{2Rr_a/(1+\mu/2)}{2R + r_a/(1+\mu/2)}$$
$$= T\cdot\frac{r_a}{r_a + R(2+\mu)} = \frac{TA_0 r_a}{\mu R}$$

It can be seen that equation (7) agrees exactly with Fig. 2(c) if in each case the first forms of A_0 and T' are employed. These are, of course, numerically identical to the others but these others do not lend themselves so well to interpretation. The load of Fig. 2(c) is taken as a whole (i.e., $Z_a + Z_k = 2Z$) and comprises $2R$ in shunt with $C/2$. The time constant T' thus comprises $C/2$ in shunt with $2R$ paralleled by the generator resistance $r_a/(1 + \mu/2)$. Equation (7) could have been written down from Fig. 2(c) by inspection.

The impedance of the generator of Fig. 2(c) is thus the valid one from the point of view of the frequency characteristics of the concertina phase-splitter.

At this point, it is of interest to consider practical values. Typically, we might have $\mu = 20$, $r_a = 15$ kΩ,

$R_a = R_k = 22$ kΩ and $C_a = C_k = 20$ pF minimum. Then $\mu/(1 + \mu/2) = 20/11 = 1{\cdot}82$ and $r_a/(1 + \mu/2) = 15/11 = 1{\cdot}36$ kΩ. The effective resistance from the point of view of the time constant is $44 \times 1{\cdot}36/45{\cdot}36 = 1{\cdot}32$ kΩ and the time constant is $10^{-11} \times 1{\cdot}32 \times 10^3 = 1{\cdot}32 \times 10^{-8}$ sec $= 0{\cdot}0132$ μsec.

The frequency for which the response is -3 dB occurs when $\omega T' = 1$ and is $f = 1/2\pi T' = 1/6{\cdot}28 \times 0{\cdot}0132 = 12$ Mc/s. The basic low-frequency gain is

$$A_0 = \frac{v_k}{v_{in}} = -\frac{v_a}{v_{in}} = \frac{1}{2} \times 1{\cdot}82 \times \frac{44}{45{\cdot}36} = 0{\cdot}885$$

In practice, the capacitance is often higher than 20 pF. The stage may feed subsequent triodes and then the capacitance may be as much as 200 pF. This makes T' ten times as great and so the maximum frequency is one-tenth, or 1·2 Mc/s.

When Z_a and Z_k differ slightly in value, the effect is to unbalance the outputs and, of course, to modify v_k/v_{in} and v_a/v_{in}. The latter is usually negligible in comparison with the unbalance; for this we can write

$$-\frac{v_a}{v_k} = \frac{Z_a}{Z_k} = \frac{R_a}{R_k} \cdot \frac{1 + j\omega C_k R_k}{1 + j\omega C_a R_a} \quad .. \quad .. \quad (8)$$

At low frequencies, obviously $-v_a/v_k = R_a/R_k$ and can be made as near unity as desired by matching R_a and R_k. If this is done, there can exist only a capacitive unbalance. Let $R_a = R_k$ and $C_k = C_a + \Delta C$; then, if $\Delta C \ll C_a$

$$\left|\frac{-v_a}{v_k}\right| \approx \sqrt{\left[1 + \frac{2\omega^2 T_a^2 \Delta C/C}{1 + \omega^2 T_a^2}\right]} \quad .. \quad .. \quad (9)$$

$$\text{and} \quad \theta = \tan^{-1}\frac{\omega T_a \Delta C/C_a}{1 + \omega^2 T_a^2} \quad .. \quad .. \quad .. \quad (10)$$

where $T_a = C_a R_a$.

Maximum difference of phase from the normal 180° between v_a and v_k occurs when $\omega T_a = 1$ and has the value $\tan^{-1}\Delta C/C_a$. At this frequency $|-v_a/v_k| = \sqrt{[1 + 2\Delta C/C_a]} \approx 1 + \Delta C/C_a$.

From the definition of T' in (7) this frequency for $\omega T_a = 1$ is related to the frequency of $-$ 3-dB amplitude response ($\omega T' = 1$) by $A_0 r_a/\mu R$ and, in the example quoted, this had the value 1/33·4. Maximum phase unbalance due to a small inequality in capacitance values thus occurs at a much lower frequency than at which the gain drops by 3 dB. For the two examples given it occurs at 360 kc/s and 36 kc/s.

There is, of course, no practical difficulty whatever in equalizing the resistances and capacitances to any required degree of accuracy. Unfortunately, this is not quite the whole story. The valve has capacitance between grid and anode and capacitance between grid and cathode. The voltage across the first is $v_{in} + v_a$ whereas that across the second is $v_{in} - v_k$. The currents are normally of very different magnitudes and as one flows through Z_a and the other through Z_k they affect the values of v_a and v_k.

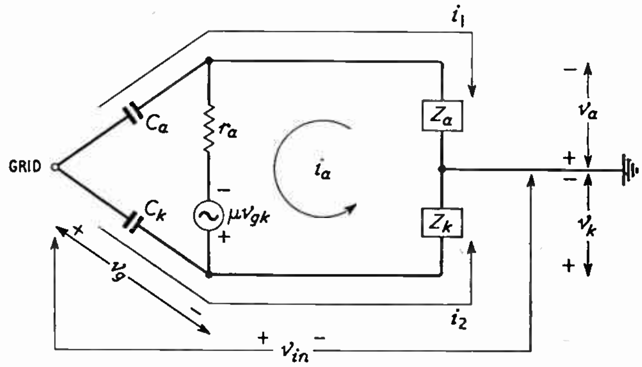


Fig. 4. *Equivalent circuit of concertina phase-splitter taking the valve capacitances into account. The anode–cathode capacitance need not be considered for, as Z_a and Z_k include shunt capacitance, it can always be merged into these*

When these capacitances are taken into account, the equivalent circuit takes the form shown in Fig. 4, which should be compared with Fig. 1(b).

It can be seen that currents i_1 and i_2 flow through the grid–anode and grid–cathode capacitances. They are different in value because the voltages across them are very different. The input and cathode-output voltages are nearly equal in magnitude and are of similar phase; their difference, which appears across C_{gk}, is very small and so i_2 is small. The input and anode-output voltages are similarly nearly equal in magnitude but are almost 180° out of phase so that the voltage across C_a is nearly twice the input voltage and i_1 is relatively large.

Now the cathode-output voltage v_k is due to the sum of the anode and grid–cathode currents in Z_k, whereas the anode-output voltage v_a is due to the difference between the anode and grid–anode currents in Z_a. As a result, $v_k \neq -v_a$ when $Z_k = Z_a$.

Examination of the matter shows that it is not possible to make $v_k = -v_a$ by adjustment of the relative values of Z_k and Z_a. For simplicity, therefore, in all that follows we shall assume $Z_k = Z_a = Z = R/(1 + j\omega T)$ and also $c_a = c_k = c$. this last is approximately true in practice. The cathode and anode loads are assumed to comprise resistance R and capacitance C in parallel so that $CR = T$. From Fig. 4

$$v_{in} = i_1(Z + 1/j\omega c) - i_a Z = i_2(Z + 1/j\omega c) + i_a Z \quad (11)$$

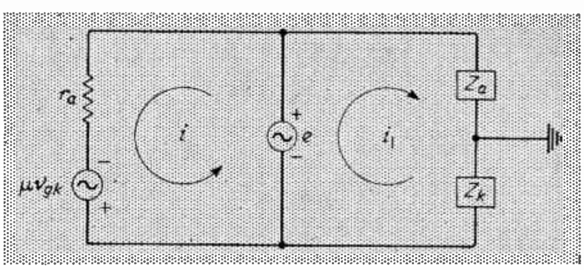
so that the input impedance is

$$Z_{in} = \frac{v_{in}}{i_1 + i_2} = \frac{1}{2}(Z + 1/j\omega c) \quad .. \quad .. \quad (12)$$

It is interesting to notice that the input impedance is independent of the anode current; if Z is small compared with $1/\omega c$, it is approximately the reactance of the sum of the grid–cathode and grid–anode capacitances.

The derivation of the important circuit equations is

Fig. 3. *Circuit for the measurement of internal impedance as in Fig. 2(c)*



straightforward and it is not necessary to give it in detail.

The three important results are

$$i_a = \frac{\mu v_{in}}{r_a(1 + j\omega cZ) + Z(2 + \mu)} \quad \cdots \quad (13)$$

$$\frac{v_k}{v_{in}} = \frac{Z}{1 + j\omega cZ}\left(j\omega c + \frac{i_a}{v_{in}}\right) \quad \cdots \quad (14)$$

$$\frac{v_a}{v_{in}} = \frac{Z}{1 + j\omega cZ}\left(j\omega c - \frac{i_a}{v_{in}}\right) \quad \cdots \quad (15)$$

from which we get

$$-\frac{v_a}{v_k} = \frac{1 - j\omega T\alpha v_{in}/i_a R}{1 + j\omega T\alpha v_{in}/i_a R} \quad \cdots \quad (16)$$

where $\alpha = c/C$.

If v_{in} and i_a were in phase (that is, if v_{in}/i_a represented a resistance) this equation would be that of an all-pass network. The amplitude unbalance would be zero but there would be a phase difference from the desired 180°. Actually, however, from (13) we get

$$\frac{i_a}{v_{in}} = \frac{R}{A_0} \cdot \frac{1 + j\omega T}{1 + j\omega T(1 + \alpha)A_0 r_a/\mu R} \quad \cdots \quad (17)$$

where $A_0 = \mu R/[r_a + (2 + \mu)R]$, the low-frequency gain between input and cathode.

For brevity we shall now write

$$a = \alpha(1 + \alpha)r_a/\mu R$$
$$b = \alpha/A_0$$

and from (16) and (17) we get

$$\frac{-v_a}{v_k} = \frac{1 + \omega^2 T^2 a + j\omega T(1 - b)}{1 - \omega^2 T^2 a + j\omega T(1 + b)} \quad \cdots \quad (18)$$

For a typical stage we may have $\mu = 20$, $R = 22\ \text{k}\Omega$, and $r_a = 15\ \text{k}\Omega$. Taking $C = 50$ pF and $c = 5$ pF as likely values we have $A_0 = 0{\cdot}88$, $a = 0{\cdot}00375$ and $b = 0{\cdot}114$. This indicates the normal order of magnitude of the terms in (18).

At 20 kc/s, for example, $\omega T = 0{\cdot}138$ and at this frequency we find

$$-v_a/v_k = 0{\cdot}995 - j0{\cdot}0327$$

so that the magnitude is 0·9955 while the phase angle is $-1{\cdot}88°$. Amplitude and phase unbalance are thus negligible up to the highest audio frequencies.

In the use of the concertina phase-splitter at audio frequencies, therefore, the effect of the valve capacitances is to cause negligible unbalance.

It was, however, shown earlier that the amplitude–frequency response of the basic circuit is well maintained far above the a.f. range. Depending upon circuit values, the −3-dB response point occurs at some 1·2–12 Mc/s. The example computed from Equ. (18), however, indicates that at frequencies much above 20 kc/s the interelectrode capacitances are likely to cause serious unbalance. This is important, because the frequency response indicates that the circuit would be useful at video frequency but, in fact, the unbalance introduced by interelectrode capacitances precludes its use at such frequencies.

The phase angle between $-v_a$ and v_k can be written

$$\theta = \tan^{-1} - 2\omega T \frac{b + \omega^2 T^2}{2 - b^2 + \omega^4 T^4 a^2} \quad \cdots \quad (19)$$

for typical values this can be approximated to

$$\theta = \tan^{-1} - \frac{2b}{2 - b^2}\,\omega T \quad \cdots \quad (20)$$

and for $b = 0{\cdot}114$ we have $\theta \approx -13\omega T$ in degrees for $\omega T \leqslant 1$. For the values considered here $\omega T = 1$ at 145 kc/s and then the phase error is 13°. These values give an input/output frequency response which is − 3 dB at 4·84 Mc/s; at this frequency the phase angle between v_a and v_k is about 75° different from the proper 180°!

Over the audio-frequency range, the phase and amplitude unbalance brought about by the valve interelectrode capacitances are negligibly small with normal values of components. The phase unbalance becomes serious at much higher frequencies and precludes the use of the circuit as a video phase-splitter. If it were not for the valve capacitances, it could be used at frequencies of at least 5 Mc/s and probably 10 Mc/s with careful design.

A phase-splitter is commonly included within a negative-feedback loop and the performance at frequencies well beyond the audio range then becomes important. If the following push-pull amplifier is perfect, its output is proportional to the total output of the phase-splitter; that is, to the anode–cathode voltage of the valve. From the point of view of overall gain and phase shift, therefore, we require an expression for total output, or $v_a - v_k$. The minus sign arises because we have hitherto considered v_k and v_a each as voltages with respect to earth, with the result that v_a has been itself negative. The required expression can be derived from the earlier equations and is

$$\frac{v_k - v_a}{v_{in}} = 2A_0 \frac{1 - j\omega T}{[1 + j\omega T(1+\alpha)][1 + j\omega T'(1+\alpha)]} \quad (21)$$

whence

$$\left|\frac{v_k - v_a}{v_{in}}\right| = 2A_0 \sqrt{\left[\frac{1 + \omega^2 T^2}{\{1 + \omega^2 T^2(1+\alpha)^2\}\{1 + \omega^2 T'^2(1+\alpha)^2\}}\right]} \quad \cdots \quad (22)$$

and

$$\phi = \tan^{-1} - \omega T' \frac{1 + \alpha(1 + T/T') + \omega^2 T^2(1+\alpha)^2}{1 + \omega^2 T^2(1+\alpha)(1 = \alpha T'/T)} \quad (23)$$

For our example, $A_0 = 0{\cdot}88$, $\alpha = 0{\cdot}1$, $T'/T = 0{\cdot}03$ and $\omega T = 1$ at 145 kc/s. We then get

$$\phi = \tan^{-1} = -0{\cdot}03\omega T \frac{4{\cdot}43 + 1{\cdot}21\omega^2 T^2}{1 + 1{\cdot}097\omega^2 T^2}$$

Then at 0·5 Mc/s, for example, $\omega T = 500/145 = 3{\cdot}45$ and we find $\phi = -7{\cdot}9°$. Without the valve capacitances ($\alpha = 0$) we should have had $\phi = \tan^{-1} - \omega T' = \tan^{-1} - 0{\cdot}03 \times 3{\cdot}45 = \tan^{-1} 0{\cdot}1035 = -5{\cdot}9°$. Thus, the valve capacitances introduce 2° extra overall phase shift at this frequency.

It is apparent, therefore, that although serious phase unbalance occurs at really high frequencies, nothing drastic happens to the overall phase or amplitude responses. In an a.f. negative-feedback amplifier, the inclusion of a concertina phase-splitter within the feedback loop will normally have negligible influence on the overall amplitude and phase responses at high frequencies. Its phase shift will be negligible compared with that of other stages.

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.

Sampling of Signals without D.C. Components

SIR,—In reply to Dr. Bell, I would like to point out that my article was concerned with first-order sampling (i.e., sampling at equally-spaced intervals) and that in this context the sampling frequencies quoted are correct. I am grateful to Dr. Bell for drawing my attention to Kohlenberg's work, which he has correctly interpreted as showing that lower sampling frequencies are permissible if second-order sampling is employed; i.e., if the samples are unequally spaced.

I think arguments about the ease of instrumentation of a sampling technique are irrelevant in the context of my article, but in so far as Dr. Bell has introduced the topic, the argument should be taken to its logical conclusion. It is not sufficient to say that second-order samples can be easily obtained, which they can; it is also necessary to show that the interpolation functions are easily generated, which they are not. If any system, other than direct first-order sampling is contemplated, then by far the simplest technique is that suggested in the first paragraph of my article, namely: frequency shifting of the signal and taking first-order samples of the shifted signal. This also allows lower sampling frequencies to be used than are permitted for first-order sampling of the unshifted signal.

A. R. BILLINGS.

University Engineering Laboratories,
University of Bristol.
19th May 1959.

New Books

Optical Properties of Semiconductors
By T. S. Moss, M.A., Ph.D. Pp. 279 + x. Butterworths Publications Ltd., 4 & 5 Bell Yard, London, W.C.2. Price 50s.

There are few publications which treat fully the optical properties of the more commonly used semiconductors today, such as silicon and germanium, to mention just two.

This book is a very welcome addition to the literature, particularly as the optical method of investigating semiconductors provides a very powerful tool; for example, the determination of the lifetime of carriers or the energy gap of a semiconductor is made usually by the interaction of light with the semiconductor.

The book opens with an account of the theory of reflection, refraction, absorption and dispersion. Photo-electric effects arising from the creation of carriers are described next, and the treatment comprehends such topics as the photo-magneto-electric effect and p-n junction photo-diodes. The last two general subjects discussed are magneto-optical effects (including the interesting new field of cyclotron resonance) and the emission of radiation from semiconductors.

Dr. Moss then discusses a number of elements and compounds in more detail. These include the group four elements; boron, selenium and tellurium; the properties of lead chalcogenides, which have proved so useful in infra-red detection are given, followed by the treatment of the zinc, cadmium and mercury chalcogenides.

The last chapter brings the book right up-to-date with a survey of the III–V compounds, in particular indium antimonide.

The book is well written with a great deal of descriptive matter and numerous references. It can be thoroughly recommended to all those working in the research or development of semiconductors.

M.S.

Electromechanical Energy Conversion
By D. C. WHITE and H. H. WOODSON. Pp. 646 + xv. Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price 100s.

This book is one which has resulted from a revision of the Electrical Engineering course at The Massachusetts Institute of Technology. In their preface, the authors say that "the limits of time set by the conventional four-year college program make it necessary to subordinate the detailed behaviour and design of contemporary devices to scientific concepts and the techniques for their exploitation".

Chapter 1 covers "the dynamic equations of motion of electromechanical systems", and chapter 2 deals with analytical techniques. The generalized, magnetic-field type, rotating, electromechanical energy converter is the title of chapter 3, while two-phase transformations and the generalized machine are treated in chapter 4.

After fundamentals of system dynamics, there are chapters on the dynamics of transducers, commutator machines, induction machines and synchronous machines. The book concludes with generalized analysis of the *n-m* winding machine and space harmonic analysis in machines.

The book is of a highbrow character and is certainly not for the beginner. Although the starting point is Kirchhoff's laws and their mechanical equivalents, their mathematical expression is so generalized as to be quite forbidding. As early as p. 30 an alternative approach is introduced. This is based on Hamilton's principle and involves the Lagrangian and the calculus of variations. Those with limited mathematical ability are likely to get no further.

W.T.C.

Switching Circuits with Computor Applications
By WATTS S. HUMPHREY. Pp. 264 + viii. McGraw-Hill Publishing Co. Ltd., 95 Farringdon Street, London, E.C.4. Price 66s.

The lack of elementary literature on a subject always makes the introduction of an advanced work difficult. Mr. Humphrey has found this difficulty and, in the first two chapters of his book, he is not at his ease, becoming in parts either confusing or ponderous in his attempts to be clear. With few exceptions, the remainder of the book is free of these faults, and can be confidently recommended. One exception to which attention is drawn is the lack of consistency in the diagrams. Thus, while normally-open and normally-closed contacts are shown differently in most parts of the book, in the transistor circuits the same symbol, that of a normally-closed contact, is used regardless of state.

The book is divided into ten chapters each of which is terminated with a summary and a plentiful supply of problems for the reader. A bibliography containing 28 references is included at the end of the book. The first two chapters, to which reference has already been made, are on the binary code and Boolean algebra. The third chapter, on relay contact networks, shows applications of the Boolean algebra to various network forms. This is followed by a

"ELECTRONIC & RADIO ENGINEER"

Because of the recent stoppage in the printing industry, publication of *Electronic & Radio Engineer* has been delayed. It is hoped to publish the August issue early in September and the September issue towards the end of that month, normal publication dates being resumed with the October issue.

chapter on codes which gives a useful introduction to the problems they introduce, although only two codes are treated in any detail—the binary-coded decimal and the excess 3. Error probability is investigated, and both error-detecting and error-correcting versions of the codes are studied.

The chapter on minimizing aids which follows is mainly devoted to the use of the Karnaugh maps and their variants. The logic of unilateral circuits using diodes and transistors is next studied, but it is felt that more space could profitably have been devoted to transistors.

Chapter 7 covers the basic methods of dealing with both series-parallel and non-series-parallel networks by Boolean matrix methods. Under the title of 'bilateral networks', chapter 8 deals specifically with the bilateral use of bridge connections in non-series-parallel networks. Several pages are devoted to the particular case when switch elements of the magnetic-core type are used. These are particularly interesting in that they perform the inverse switching function when the current reverses. The ninth chapter treats cascaded networks, and includes sections on both iterative networks and networks using transistors. The final chapter, on sequential circuits, covers the subject from the two complementary aspects of analysis and synthesis. In all, a very wide field has been covered in the compass of a moderate-sized book and, despite the criticisms, the author is to be congratulated on the amount of material that he has been able to include. R.A.G.

"Wireless & Electrical Trader" Year Book 1959
Pp. 416. Trader Publishing Company Ltd., Dorset House, Stamford Street, London, S.E.1. Price 12s. 6d. (postage 1s.).

Sections included in this thirteenth edition are: Valve Base Connections and Diagrams Specifications (of radio and television receivers and tape recorders), Radio and Electrical Wholesalers, Proprietary Names Directory, Buyers' Guide, Trade Addresses.

Two New B.B.C. Transparencies for Testing Television Camera Channels
By G. Hersee, A.M.Brit.I.R.E., and J. R. T. Royle. B.B.C. Engineering Monograph No. 21. Pp. 19. B.B.C. Publications, 35 Marylebone High Street, London, W.1. Price 5s.

Northern Region Engineering Buyers' Guide 1958–59
Published by the North-East Engineering Bureau, 18 Ridley Place, Newcastle upon Tyne 1. Pp. 100. Price 2s. 6d. (post free).

B.B.C. Handbook 1959
Pp. 270 + xx. Published by the British Broadcasting Corporation, Broadcasting House, London, W.1. Price 5s.

The Bomber's Eye
By Group Captain Dudley Saward, O.B.E. Pp. 265 + vii. Cassell & Co. Ltd., 35 Red Lion Square, London, W.C.1. Price 21s.

This book provides a general account of the war-time use of radar in Bomber Command, dealing in the main with Gee, Oboe and H_2S. Non-technical descriptions of the principles are given.

Video Amplifiers
Edited by Alexander Schure, Ph.D., Ed. D. Pp. 80 + vii. Electronic Technology Series No. 166–28. Price $1.80.

A general discussion and evaluation of video amplifiers, presenting the basic concepts of the subject.

Fundamentals of Nuclear Energy and Power Reactors
By Henry Jacobowitz. Pp. 118. Price $2.95.

Contents include: The Atom and its Nucleus; Nuclear Fision and Chain Reaction; Basic Types of Nuclear Reactors; Power Reactors and Plants.

Fundamentals of Radio Telemetry
By Marvin Tepper. Pp. 116 + ix. Price $2.95.

A non-mathematical book explaining the fundamentals of the various phases of telemetry.

The above three books are published by John F. Rider Publisher Inc., 116 West 14th Street, New York 11, N.Y., U.S.A.

Electronique Générale (2nd Edition)
By A. Blanc-Lapierre, G. Goudet and P. Lapostolle. Pp. 504. Editions Eyrolles, 61 Boulevard Saint-Germain, Paris 6. Price 6,910 francs.

Guide Technique de L'Electronique Professionelle 1959
Pp. 1,100 (in two volumes). Editeur: Les Guides Techniques Industriels, 1 Rue du Dragon, Paris 6e, France. Price Fr. 6,100 (including postage).

The second issue of the buyer's guide to the French electronics industry (in English, French, German and Italian).

Radio Amateur's Handbook. 36th Edn. 1959.
Pp. 746. Published by the American Radio Relay League. West Hartford 7, Connecticut, U.S.A. Price $4.50.

Les Tubes aux Hyperfréquences
By J. Voge. Pp. 260. Editions Eyrolles, 61 Boulevard Saint-Germain, Paris 5e, France. Price Fr. 4,570 (including postage).

Deals with the principles, theory, history, uses and characteristics of u.h.f. triodes and tetrodes, klystrons, magnetrons, travelling-wave tubes, parametric amplifiers, etc.

Practical Robot Circuits
By A. H. Bruinsma. Pp. 125 + viii. Philips Technical Library. Cleaver-Hume Press Ltd., 31 Wright's Lane, Kensington, London, W.8. Price 17s. 6d.

Principles and circuit details of an electronic robot 'dog' and of a 'noughts and crosses' machine.

Multivibrator Circuits
By A. H. Bruinsma. Pp. 65. Philips Technical Library. Cleaver-Hume Press Ltd., 31 Wright's Lane, Kensington, London, W.8. Price 17s. 6d.

An explanation of multivibrator circuits written as an introduction to "Practical Robot Circuits".

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Deviations from nominal frequency for May* 1959

Date 1959 May	MSF 60 kc/s 1500 G.M.T. Parts in 10^{10}	Droitwich 200 kc/s 1030 G.M.T. Parts in 10^9
1	− 178	+ 10
2	− 178	NM
3	− 180	NM
4	− 179	+ 8
5	− 179	+ 5
6	− 181	+ 4
7	− 179	+ 7
8	− 182	+ 11
9	− 182	+ 8
10	− 185	+ 8
11	− 184	+ 8
12	NT	+ 5
13	− 181	+ 6
14	− 179	+ 7
15	− 180	+ 7
16	− 181	+ 6
17	− 182	+ 9
18	− 184	+ 7
19	− 182	+ 11
20	− 178	+ 19
21	− 178	+ 21
22	− 176	+ 20
23	NM	+ 20
24	NM	NM
25	− 177	+ 22
26	− 176	+ 24
27	− 178	+ 27
28	− 176	+ 25
29	− 176	− 16
30	− 178	− 16
†31	− 178	NM

NM = Not Measured. NT = No Transmission.

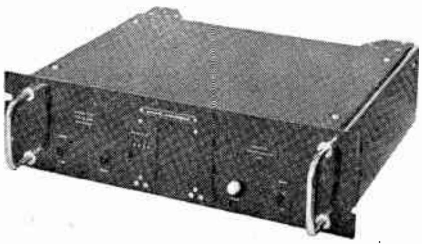
* *Nominal frequency is defined to be that frequency corresponding to a value of* 9 192 631 770 *c/s for the N.P.L. caesium resonator.*

† *At* 2400 *G.M.T. on this day the phase of the seconds pulses was advanced by* 20 *milliseconds.*

New Products

Interval Timer

This timer (type NE.068) which was developed primarily for the makers' control of 'Slow Scalers' (type NE.075) can be used to control any process initiated by either a short exponential impulse or the operation of a change-over contact, and



terminated by a second impulse or the return of the change-over contact to the original position.

Pulses from a hermetically-sealed electro-mechanical timing unit, which starts automatically when the unit is switched on and is compensated over the temperature range −10 °C to +50 °C, are fed at a rate of 4 per second to a 'scale of four' to provide output pulses at 1 per second.

The impulses operate an electro-mechanical counter which subtracts one digit per impulse from the pre-set time indicator. When the pre-determined time interval has elapsed, the change-over contacts are operated and the unit remains in the 'ready' state. An 'adding' counter can be fitted in addition to the 'subtracting' counter to provide an indication of elapsed time.

If the external connection between the 'start' terminals is maintained, counting will recommence as soon as the re-set signal has been applied. If the external connection is not made, it will be necessary to provide a re-set signal and a start signal.

The unit, which is mains-operated, is suitable for rack or bench mounting. It may be operated manually or by remote control.

Details from the makers' provisional specification include:

Timing range	1–9,999 seconds in 1-second steps. Maximum error 40 msec.
Gate-pulse output	50 V (± 10%)
Contact rating	100 V, 300 mA, d.c.
Dimensions	19 in. × 5¼ in. × 15 in. (approx.)

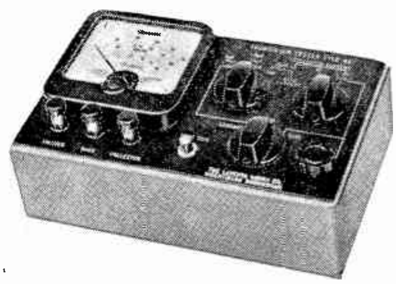
General Radiological Ltd.,
Nuclear Engineering Division,
18 *New Cavendish Street, London, W.*1.

Transistor Testers

Two new portable transistor testers have been produced by the Laventa Sound Company.

Both testers are suitable for measuring the collector leakage current in either the earthed-base or earthed-emitter configuration, the latter connection being used for measuring the current gain at any one of three pre-set base currents.

The battery-operated model 45 (as illustrated) is designed for testing p-n-p junction transistors of up to 900-mW



collector dissipation, all measurements being made at $V_c = -4{\cdot}5$ V.

Model 110, which is mains-operated, is suitable for testing p-n-p and n-p-n germanium and silicon power transistors of up to 50-W collector dissipation, all measurements being made at $V_c = 1$ V and 10 V for p-n-p and n-p-n types respectively.

Both models are almost identical in appearance and measure 7¼ in. × 4¾ in. × 3 in.

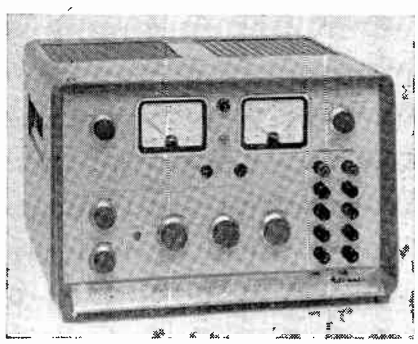
The Laventa Sound Company,
45 *Kilburn High Road, London, N.W.*6.

Stabilized Power-Supply Unit

The Advance power-supply unit Type L.101 is a special-purpose instrument which provides a constant-voltage source of 600 V positive and two stabilized negative 150-V d.c. supplies. Two stabilized 6·3-V a.c. supplies are also provided.

One of the 150-V supplies is variable and has a high source impedance; it is intended for a grid-bias supply or for use in circuits drawing a small current load of not more than 5 mA. A 100 to 800-V unstabilized line is also provided for general use.

The two positive lines have a maximum total load rating of 300 mA. The positive 600-V and negative 150-V d.c. outputs may be used in series to provide a total 750-V



stabilized d.c. output with a maximum rating of 30 mA.

Voltage variation on the positive 600-V and negative 150-V lines is better than 0·03 % of output for a 10 % change of input voltage, and the variation in output from the two 6·3-V a.c. lines is less than 0·02 V for the same condition.

The output impedance is less than 0·1 Ω at d.c. and less than 0·5 Ω at 50 kc/s on all d.c. lines. The variable negative 0–150-V d.c. line has a source impedance of 12,000 Ω. Ripple content is less than 3 mV r.m.s. on all stabilized outputs at 150 V and below. Above 150 V, the ripple content is less than 0·002 % r.m.s. and, on the unstabilized 100–800-V d.c., it is about 3 V r.m.s. at 800 V with 300-mA load.

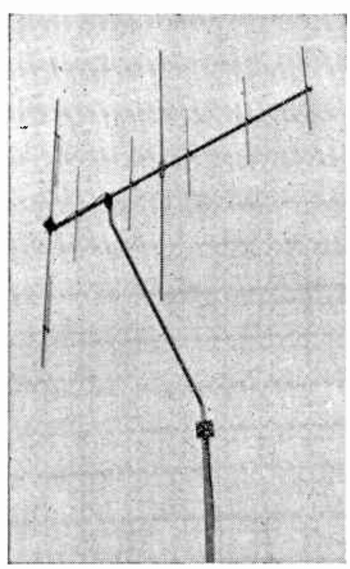
Other facilities include control of the h.t. stabilized d.c. line enabling the output to be set to any desired level from 0-600 V together with a source resistance control over the range 0 to 40 Ω. Hum can be superimposed on the stabilized d.c. h.t. line and may be varied between 0 and 6 V r.m.s. to give a good quality sine wave at the mains input frequency.

All outputs are floating with respect to the chassis, the positive and negative lines being connected through the neutral terminal. A cut-out and fuses are provided for protection and both have a voltmeter and milli-ammeter.

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

Dual-Band Television Aerial

In this aerial for Band I and III, stubs are attached to the Band I dipole in order that it may act on Band III as a co-linear

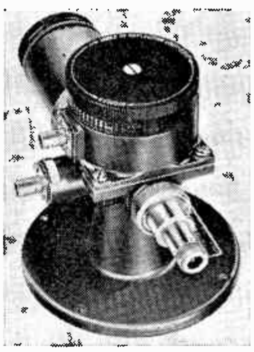


array. This is claimed to result in increased gain on Band III by rendering the full dipole length effective for signal pick-up.
Labgear Ltd.,
Willow Place, Cambridge.

Standing-Wave Detector

This light-weight instrument (type 219) produced by the Polytechnic Research & Development Company, is suitable for measuring the v.s.w.r. and impedance of coaxial components in the frequency range 100–1,000 Mc/s. It may also be used in conjunction with tuning devices to eliminate transmission-line mismatches.

Basically, it consists of a coaxial T-junction of which one arm is fed by the generator and the other two arms are terminated, respectively, by a variable capacitor and by the unknown impedance. A round cut-off tube containing the pick-up assembly is concentrically mounted above the T-junction. At an appreciable distance above the plane of the junction, the fields (induced in the cut-off tube by currents in the three arms) are polarized in the same direction as the respective currents which give rise to these fields. Superposition of the three fields gives rise to a resultant field which is always elliptically polarized. If the capacitor is so adjusted that at any one frequency its normalized susceptance (as



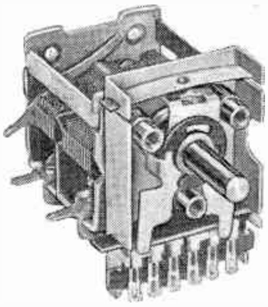
seen at the junction) is equal to unity, then the following simple relationships will result. The ratio of the major and minor axes of the ellipse (which is generated by the field vector during one complete cycle) is equal to the v.s.w.r. of the load. Also, the angle between the minor axis and a 45° reference line is equal to one-half of the phase angle of the load reflection coefficient.

The direct-reading drum dial is used to set the instrument to the desired operating frequency, and the input jack may be connected to any conventional low-harmonic content amplitude-modulated oscillator or signal generator.

An outstanding advantage of this instrument is its small size and weight; it is only 8 in. long and weighs 4½ lb.
Leland Instruments Ltd.,
(U.K. Distributors for P.R. & D. Co. Inc.),
*Abbey House, Victoria Street, London, S.W.*1.

Switched Variable Capacitor

The Plessey Co. Ltd. has introduced a switched variable capacitor which allows



normal wave-change and tuning operations on any two wave-band radio receiver to be carried out with only one control knob.

The component incorporates a conventional moving-vane spindle fitted with a link motion that moves a slide switch in one direction when the vanes are almost fully meshed, and in the other direction when the vanes are almost fully unmeshed. The switching is so arranged that the small loss of usable swing occurs at the high-frequency end of the long wave-band and, at the low-frequency end, of the medium wave-band. Thus, any loss of station coverage is unimportant.

The switch is a two-pole change-over assembly but provision has been made, by the addition of a third pole, for dial-lamp switching or similar operations; provision can also be made for mechanical wave-band indication.
The Plessey Co. Ltd.,
Ilford, Essex.

Trochotron Counting Tube

Mullard Ltd. has introduced a trochotron high-speed counting tube, type ET51, for use as a counter or selector in nucleonic scalers, decimal computing equipment, and electronic switching circuits.

Designed to operate at speeds of up to 1 Mc/s, it provides a constant-current output of 5·5 mA which the makers claim is sufficient to drive a cold-cathode decimal indicator (such as the Mullard Z503M) and compatible with the input requirements of direct read-out digital indicators.

Basically, the trochotron is a vacuum device which makes use of crossed electric and magnetic fields to form a beam of electrons between a thermionic cathode and any of ten groups of three electrodes mounted radially about the cathode. The electric field is provided by the inter-electrode potentials within the tube and the magnetic field by a cylindrical permanent magnet mounted around the glass envelope.

Each group of electrodes consists of a spade, which forms and locks the beams in position; a target, which makes the beam available as a constant-current output; and a grid, for switching the beam from one spade to the next. When power is first applied, all spades will be equally positive with respect to cathode and, due to the action of the magnetic field in preventing electrons reaching the electrode-groups, the tube will be in a cut-off condition, with no beam formed. However, if the potential of any spade is reduced, by means of a high-speed pulse or a d.c. voltage, the beam will form on the electrode group associated with that spade, and an output will appear on the corresponding target.

Once formed, the beam is held in this position by a combination of the spade series resistance and spade current until it is stepped to the next position by lowering the voltage on the associated switching grid.

Since only the grid in its immediate vicinity will affect the beam, the grids are connected internally in two groups; the odd-numbered grids in one, the even-numbered in the other. This makes it possible to use a d.c. input for switching and still obtain single-position stepping, thus avoiding the necessity for a pulse of critical width.

The output characteristic of the trochotron is similar to that of a pentode valve and, with this particular tube, over 80% of the beam current appears in the output, the remainder being used to form and lock the beam.

Mounted on a special 26-pin (B26A) base it has an overall seated height of 3·3 in. (84 mm) and an overall diameter of 1·74 in. (44·2 mm) including the magnet and special protective caps.

Typical operating conditions for the tube, which is a direct replacement for the American Services type 6700, are:

Spade: Voltage, 100 V
Grid voltage, 25 V
Current, 1 mA
Input pulse, −60 V
Load resistor, 100 kΩ
Cathode current, 6·5 mA
Target: Voltage, 100 V
Heater, 6·3 V, 300 mA
(a.c. or d.c.)
Output current, 5·5 mA

Mullard Ltd.,
*Torrington Place, London, W.C.*1.

Wire-Wound Resistor for Printed Circuits

A new sub-miniature precision wire-wound resistor is claimed to be the smallest commercially available in Great Britain. The resistance range is from 10 Ω to 200 kΩ with a tolerance of ±0·1 % down to 100 Ω, below which it is ± 1 %. The resistors are rated at 0·1 W.

The resistor is wound on a special miniature ceramic bobbin in two sections to minimize inductance. The lead spacing is 0·3 inch and is suitable for both the 0·1-inch and 0·15-inch printed-circuit board grids.
Alma Components Ltd.,
551 *Holloway Road, London, N.*19.

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

534.143-8 : 537.228.1 **2078**

The Generation of Very Short Ultrasonic Pulses by means of Piezoelectric Resonators.—J. Koppelmann, R. Frielinghaus & F. J. Meyer. (*Acustica*, 1958, Vol. 8, No. 4, pp. 181–187. In German.) The possibilities are discussed of using thickness vibrations of $BaTiO_3$ resonators for generating very short pulses and single pressure waves, and experimental methods are described.

534.15.087.252 **2079**

A Stroboscopic Method of Making Frequency Response Measurements on Small Electromechanical Devices.—M. Shepherdson & R. Walters. (*Electronic Engng*, April 1959, Vol. 31, No. 374, pp. 220–221.) A simple pulse amplifier and phase shifting network are used with a stroboscopic lamp and travelling microscope. No loading of the test component occurs and amplitudes below 0·001 in. can be measured.

534.2 + 538.566 **2080**

Guided Propagation in a Slowly Varying Medium.—Weston. (See 2204.)

534.21 : 534.6 **2081**

Instrumentation for Study of Propagation of Sound over Ground.—F. M. Wiener, K. W. Goff & D. N. Keast. (*J. acoust. Soc. Amer.*, Sept. 1958, Vol. 30, No. 9, pp. 860–866.)

534.21 : 534.88 **2082**

Sound Absorption at 50 to 500 kc/s from Transmission Measurements in the Sea.—S. R. Murphy, G. R. Garrison & D. S. Potter. (*J. acoust. Soc. Amer.*, Sept. 1958, Vol. 30, No. 9, pp. 871–875.) The absorption coefficient, in decibels per thousand yards for sea water at 10 °C and with a salinity of 30 parts per thousand, is: $14 \cdot 4 \pm 0 \cdot 3$ at 60 kc/s, $35 \cdot 7 \pm 0 \cdot 7$ at 142 kc/s, 57 ± 3 at 272 kc/s and 101 ± 3 at 467 kc/s. The equipment and the method of measurement are described.

534.26 **2083**

An Experimental Study of the Scattering of Sound in a Turbulent Atmosphere.—M. A. Kallistratova. (*Dokl. Ak. Nauk S.S.S.R.*, 1st March 1959, Vol. 125, No. 1, pp. 69–72.) A graph shows the dependence of the scattering of sound on the turbulence of the atmosphere for scattering angle of 25° when the distance between the emitter and receiver is 40 m.

534.6-8 : 621.385.83 : 537.228.1 **2084**

Results Obtained in the Construction of an Electronic Ultrasonic Image Converter.—W. Freitag & H. J. Martin. (*Acustica*, 1958, Vol. 8, No. 4, pp. 197–200. In German.) In the ultrasonic image converter described the sound waves impinge on a piezoelectric plate which is scanned by an electron beam. The resulting signal is amplified and applied to a c.r. tube where it is displayed as an image of the object under test in the ultrasonic field.

534.6-8 : 621.395.625.3 **2085**

A Magnetic-Tape Recorder for Ultrasonic Frequencies.—H. Lennartz. (*Elektronische Rundschau*, May 1958, Vol. 12, No. 5, pp. 170–172.) An adaptor unit for tape recorders is described which is capable of recording or reproducing frequencies in the range 0·5–120 kc/s at a tape speed of 30 in./s.

534.76 : 061.3 **2086**

Convention on Stereophony.—(*Wireless World*, May 1959, Vol. 65, No. 5, pp. 239–241.) A report of some of the papers read and equipment demonstrated at the I.E.E. Convention held in London, 19th and 20th March 1959.

534.782 : 621.396.41 **2087**

Simple Multiplex Vocoder.—Billings. (See 2394.)

534.784 **2088**

Measurements of Pitch Distribution in the German Language.—W. Rappaport. (*Acustica*, 1958, Vol. 8, No. 4, pp. 220–225.) Report on statistical measurements made with a specially developed pitch recorder.

534.839 **2089**

Analysis of Impact Noise.—F. M. Savage. (*Electronic Engng*, April 1959, Vol. 31, No. 374, pp. 200–203.) An instrument is described for measuring electronically the peak intensity of dangerous impact noises. The time taken to do this is 50 μs.

534.845 **2090**

Investigations of the Influence of Self Resonances of Measurement Chambers on the Results of Sound Insulation Measurements.—M. Heckl & K. Seifert. (*Acustica*, 1958, Vol. 8, No. 4, pp. 212–220. In German.)

534.88 : 534.15 **2091**

Portable Instrument for Locating Noise Sources in Mechanical Equipment.—D. A. Gilbrech & R. C. Binder. (*J. acoust. Soc. Amer.*, Sept. 1958, Vol. 30, No. 9, pp. 842–846.) A description of a direction finder sensitive to the correlation between signals received by two microphones of a directional array.

621.395.61 **2092**

The Theory of the Cardioid Microphone.—I. P. Valkó. (*Hochfrequenztech. u. Elektroakust.*, May 1958, Vol. 66, No. 6, pp. 185–188.) The combined pressure-type and differential microphone is represented by a three-pole network consisting of three mechanical or acoustic impedances.

621.395.61.089.6 **2093**

Equipment for the Absolute Calibration of Microphones of the Acoustics Department of C.N.E.T.—P. Riety. (*Ann. Télécommun.*, Jan./Feb. 1958, Vol. 13, Nos. 1/2, pp. 16–34.) Thermophone, reciprocity, electrostatic-grille, Rayleigh-disk and pistonphone methods are described.

621.395.614 **2094**

The Gradient Receiver for Intercommunication Installations.—C. Smetana. (*Hochfrequenztech. u. Elektroakust.*, May 1958, Vol. 66, No. 6, pp. 179–185.) The suppression of acoustic feedback by means of differential microphones is discussed (see also 1757 of June). A first-order gradient crystal microphone is described and details are given of the suitable positioning of loudspeaker and microphone; results of tests under operating conditions in an intercommunication network are summarized.

621.395.623.7 + 621.395.625.3] : 061.4 **2095**

London Audio Fair.—(*Wireless World*, May 1959, Vol. 65, No. 5, pp. 225–227.) A review of some of the new equipment on show in London, April 2nd–6th 1959.

621.395.625 : 681.84.081 **2096**

New Electromechanical Two-Component Transducer for Stereophonic Recording by the Sound-on-Disk Method.—H. Redlich & H. J. Klemp. (*Telefunken Ztg*, June 1958, Vol. 31, No. 120, pp. 75–81. English summary, p. 135.) The design of a cutter head for single-groove stereophonic recording on disks is described.

AERIALS AND TRANSMISSION LINES

621.372 **2097**

An Investigation of the Excitation of Radiation by Surface Waves.—K. P. Sharma. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 116–122.) The excitation of radiation at a discontinuity in surface reactance, and at the edge of a metallic strip above a reactive surface, is studied by a graphical method. Both discontinuities cause appreciable radiation, but the radiation from a change in surface reactance is confined to a narrower angle above the surface than that excited at the edge of a metallic strip.

621.372 **2098**

The Power Radiated by a Surface Wave Circulating around a Cylindrical Surface.—H. E. M. Barlow. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 180–185.) An analysis of the radiation from a wave on a highly reactive supporting surface of cylindrical form. When the surface has a finite loss, there is a particular radius of curvature for which the surface wave progresses for a limited distance without attenuation.

621.372.029.6 : 535.8 **2099**

Optical Techniques at Microwave Frequencies.—A. F. Harvey. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 141–157.) A summary of optical techniques applied in radiation and diffraction, artificial dielectrics, surface reflection, and instruments which are especially useful at millimetre wavelengths. 162 references.

621.372.2 **2100**

The Influence of the Dielectric on the Phase Constants of the Spatial Harmonics of a Helix.—V. P. Kiryushin. (*Radiotekhnika i Elektronika*, July 1957, Vol. 2, No. 7, pp. 901–911.) An approximate theory of the tape helix is derived from the dispersion equation for a helix surrounded by a dielectric cylinder of finite thickness. Good agreement is obtained between the calculated values of the dielectric effect for the first inverse harmonic and the measured values for a twin helix made of round wire and secured by means of a quartz tube.

621.372.2-419 **2101**

Nonuniformities in Laminated Transmission Lines.—G. Raisbeck. (*Bell Syst. tech. J.*, March 1959, Vol. 38, No. 2, pp. 477–516.) The effect of certain nonuniformities has been calculated by a perturbation method. These include variation of radius of curvature, systematic variation of effective dielectric constant and random variation in layer thickness.

621.372.2-419 **2102**

An Experimental Clogston 2 Transmission Line.—R. A. King. (*Bell Syst. tech. J.*, March 1959, Vol. 38, No. 2, pp. 517–536.) The construction and termination of a laminated conductor of 100 concentric layers are described. Measurements of the mode pattern and attenuation as a function of frequency up to 25 Mc/s were made.

621.372.8 **2103**

Propagation in Discontinuous Periodic Structures and its Application to Waveguides.—M. Jouguet. (*Câbles & Transm.*, Jan. 1958, Vol. 12, No. 1, pp. 23–36.)

621.372.8 : 537.56 **2104**

Wave Propagation in a Plasma Cable with External Magnetic Field. — G. Bittner. (*Z. angew. Phys.*, March 1958, Vol. 10, No. 3, pp. 117–122.) Phase velocity and attenuation of e.m. waves at frequencies in the range 30–1 000 Mc/s, and the characteristic impedance between 30 and 300 Mc/s, were measured in a coaxial system consisting of the plasma in a gas-discharge tube as centre conductor and a brass outer conductor slotted to accommodate a sliding probe. Tests were made with and without a magnetic field applied parallel to the direction of wave propagation.

621.372.8.001.4 (083.74) **2105**

I.R.E. Standards on Antennas and Waveguides : Waveguide and Waveguide Component Measurements, 1959. —(*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, pp. 568–582.) Standard 59 I.R.E. 2.S1.

621.372.81.09 **2106**

Propagation around Bends in Waveguides.—H. E. M. Barlow. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 11–15.) The use of an inhomogeneous dielectric to minimize mode changes at bends, previously worked out for the circular H_{01} guide (3037 of 1957), is extended to the rectangular H_{01} guide bent in either the H plane or the E plane, and to the dielectric-coated single-wire waveguide. General requirements for smooth propagation are also discussed.

621.372.81.09 **2107**

Use of Circular Waveguides for Long-Distance Transmission of Centimetre and Millimetre Waves.—G. Comte, F. de Carfort, A. Ponthus & J. M. Paris. (*Câbles & Transm.*, Oct. 1957, Vol. 11, No. 4, pp. 342–355.) The attenuation of TE_{01} waves in guides with isotropic and aeolotropic conductivity is studied theoretically and experimentally.

621.372.821 **2108**

Parallel-Plate Transmission Systems for Microwave Frequencies.—A. F. Harvey. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 129–140.) A survey of the various types of parallel-plate or strip lines and their basic characteristics. A photo-etching process for manufacture is outlined. 67 references.

621.372.821 **2109**

Propagation in Ferrite-Filled Microstrip.—M. E. Brodwin. (*Trans. Inst. Radio Engrs*, April 1958, Vol. MTT-6, No. 2, pp. 150–155. Abstract, *Proc. Inst. Radio Engrs*, June 1958, Vol. 46, No. 6, p. 1328.)

621.372.826 **2110**

The Launching of Radial Cylindrical Surface Waves by a Circumferential Slot.—J. Brown & K. P. Sharma. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 123–128.) The launching efficiency is investigated theoretically and experimentally. The radius of the slot has a small effect on the efficiency. An optimum value of 68 % is found with a slot of 2 cm radius above a 58-Ω reactive surface.

621.372.83 **2111**

The Transformation of Admittance through a Matching Section and Lossless Waveguide Junction.—J. R. G. Twisleton. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 175–179.)

621.372.832.43 2112

Properties and Design of Long-Slot Directional Couplers.—E. Schuon. (*Arch. elekt. Übertragung*, May 1958, Vol. 12, No. 5, pp. 237–243.) The coupler is considered as a single waveguide in which two types of field distribution exist, and the boundary conditions at the input of the coupler are satisfied by superimposing the two types of field. Coupling and directivity factors are obtained in terms of cut-off wavelengths determined by analogue measurements.

621.372.832.8 : 538.632 : 537.311.33 2113

The Hall-Effect Circulator—a Passive Transmission Device.—W. J. Grubbs. (*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, pp. 528–535.) Three-part non-reciprocal Hall-effect devices have been made which circulate d.c. and a.c. signals in either a clockwise or anti-clockwise sense. Forward losses of 17 dB and reverse losses of 61 dB have been obtained, giving a transmission ratio of 44 dB. It is shown that the minimum possible forward loss for a Hall-effect circulator is 8·4 dB.

621.372.852.2 2114

A New Class of Broad-Band Microwave 90-Degree Phase Shifters.—B. M. Schiffman. (*Trans. Inst. Radio Engrs*, April 1958, Vol. MTT-6, No. 2, pp. 232–237. Abstract, *Proc. Inst. Radio Engrs*, June 1958, Vol. 46, No. 6, pp. 1329–1330.)

621.372.852.22 2115

Calculation of Phase Shifts of Gyrotropic Inhomogeneities in a Waveguide using a Perturbation Method.—V. V. Nikol'skiĭ. (*Radiotekhnika i Elektronika*, July 1957, Vol. 2, No. 7, pp. 833–842.) A mathematical analysis of waveguides of rectangular and circular cross-section containing ferrite rods, ferrite spheres or diaphragms. Inhomogeneities in a coaxial line are also examined.

621.372.852.22 2116

Circular Waveguide Partially Filled with Ferrite as a Slow-Wave Structure.—R. G. Mirimanov & Yu. V. Anisimova. (*Radiotekhnika i Elektronika*, July 1957, Vol. 2, No. 7, pp. 843–855.) A theory is evolved for a waveguide with ideally conducting walls covered on the inside by a layer of a gyromagnetic material of arbitrary thickness. A dispersion equation is derived which can be applied to a wide range of waveguides. The physical properties of a waveguide and its delay system are examined and some of their characteristics are determined.

621.372.86 2117

Rotating-Loop Reflectometer for Waveguide.—P. J. Houseley. (*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, pp. 585–586.)

621.396.67 : 537.226 2118

Some Investigations on Dielectric Aerials : Part 3.—B. R. Rao, R. Chatterjee & S. K. Chatterjee. (*J. Indian Inst. Sci.*, Section B, Oct. 1957, Vol. 39, No. 4, pp. 143–155.) Two theories for the radiation of a dielectric rod aerial excited in the HE_{11} mode have been verified experimentally using a perspex rod of length $2\lambda_0$–$10\lambda_0$ and diameter $0{\cdot}5\lambda_0$. Part 2: *ibid.*, July 1957, Vol. 39, No. 3, pp. 134–140. See 1030 of 1958 (Chatterjee & Chatterjee).

621.396.67.029.63 : 621.372.51 2119

A Quadruplexer allowing the Simultaneous Transmission of Two Complete Television Stations using a Common Antenna.—G. B. Mackimmie. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 787–791.) Shows how sound- and vision-frequency signals of two television transmitters, on bands 4 and 5 respectively, were combined and made to radiate from a single aerial originally designed for band 4.

621.396.677 : 621.396.933.2 2120

A New Method of Generating a Rotating Radiation Polar Diagram.—H. W. Hawkes. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 158–169.) A rotating aerial array of small dimensions is coupled electrically to a static array of large dimensions acting as the final radiator. The application of the technique in a new and more accurate form of v.h.f. omni-range system (Vorac) is described.

621.396.677 : 621.396.965.4 2121

A Microwave Antenna with Rapid Sawtooth Scan.—J. S. Foster. (*Canad. J. Phys.*, Dec. 1958, Vol. 36, No. 12, pp. 1652–1660.) An account of the development of the Foster aerial. Two systems are described, one with maximum angular scan of 45° and the other 80°. See also 1331 of 1957 (Honey & Jones).

621.396.677 : 621.397.62 2122

A Second Band-III Programme?—The Aerial Problem.—F. R. W. Strafford. (*Wireless World*, May 1959, Vol. 65, No. 5, pp. 235–238.) Continuation of 1775 of June. The efficiency of conventional Yagi arrays used in primary or fringe areas is shown to be poor when the operating frequency is separated by two or three channels from the optimum frequency. Stacked-dipole and corner-reflector wide-band aerials are shown to have satisfactory electrical characteristics but have attendant mechanical problems due to their large size.

621.396.677.85 2123

Theory of Reflection from the Rodded-Type Artificial Dielectric.—A. Carne & J. Brown. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 107-114. Discussion, pp. 114–115.) An artificial dielectric having a wave impedance equivalent to that of free space is described in which an array of thin conducting wires is located parallel to the electric field of the incident wave. Results are given which show good agreement with theory.

621.396.677.852 : 621.396.965.4 2124

The Use of Dispersive Artificial Dielectrics in a Beam-Scanning Prism.—J. S. Seeley & J. Brown. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 93–102. Discussion, pp. 114–115.) Beam scanning is achieved by using a frequency-modulated signal and two types of dispersive dielectric. One consists of an array of rods, and the other of an array of sheets containing a pattern of resonant slots. Experimental values of the electrical constants of the arrays are given with details of the design of the prism.

621.396.677.852 : 621.396.965.4 2125

The Quarter-Wave Matching of Dispersive Materials.—J. S. Seeley. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 103–106. Discussion, pp. 114–115.) "Reflections from the surfaces of dispersive materials used in broad-band aerial systems are highly frequency-dependent. A technique for matching such materials is described, and results are included of a successful application to the input surface of a dispersive prism."

AUTOMATIC COMPUTERS

681.142 2126

A New Concept in Computing.—R. L. Wigington. (*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, pp. 516–523.) The phase of a sine-wave signal is used as an information-bearing medium which together with majority logic permits the realization of logic operations. Nonlinear reactances are employed. Computing can be carried out more rapidly than by present techniques if microwave frequencies are used.

681.142 2127

A New High-Speed Digital Technique for Computer Use.—D. Eldridge. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 229–236. Discussion, pp. 237–239.) Square-loop ferrite cores and transistors are used, operating at digit rates of 500 kc/s. Only two low-voltage d.c. supplies are required and the system is not critically dependent on voltage and component variations.

681.142 2128

The Automatic Computing Engine at the National Physical Laboratory.—J. H. Wilkinson & D. W. Davies. (*Nature, Lond.*, 3rd Jan. 1959, Vol. 183, No. 4653, pp. 22–23.)

681.142 2129

Digital Memory System keeps Circuits Simple.—T. C. Chen & O. B. Stram. (*Electronics*, 13th March 1959, Vol. 32, No. 11, pp. 130–133.) A magnetic disk memory of 50 to 100 words capacity using simple control and selection circuits.

681.142 2130

A General Approach for Obtaining Transient Response by the Use of a Digital Computer.—P. E. Lego & T. W. Sze. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 1031–1036.) Adaptation of digital computers to the inverse Laplace transformation process and the Fourier integral method is shown to have major advantage in determining the transient response of linear control systems.

681.142 : 538.632 **2131**

The Use of Hall Generators in Analogue Multipliers.—J. Oxenius. (*Nachrichtentech. Z.*, May 1958, Vol. 11, No. 5, pp. 263–268.) Experimental equipment incorporating an InAs-crystal Hall generator is described.

681.142 : 621.314.7 **2132**

Operating Experience with a Transistor Digital Computer.—R. C. M. Barnes & J. H. Stephen. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 222–228. Discussion, pp. 237–239.) A description of the performance of a small laboratory-model digital computer over a period of a year, with analyses of serviceability and transistor failures. The failure rate of point-contact transistors was higher than expected, but was of the same order as that quoted by other workers for standard thermionic valves in digital computers.

681.142 : 621.317.79 **2133**

Quadratic Interpolation in Tapped-Potentiometer Function Generators.—E. M. Deeley. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 102–107.) The quadratic variation of the resistance to ground from the slider of an auxiliary potentiometer interpolating between the tapping points on the function-generating potentiometer is utilized to achieve quadratic interpolation.

681.142 : 621.318.57 : 621.395.4 **2134**

Verification of the Logic Structure of an Experimental Switching System on a Digital Computer.—D. C. Leagus, C. Y. Lee & G. H. Mealy. (*Bell Syst. tech. J.*, March 1959, Vol. 38, No. 2, pp. 467–476.) "The verification problem is concerned with the construction on a computer of a logical program which satisfies all the design specifications prescribed for an experimental switching system and with the process of putting calls through the computer simulation to evaluate the system's logical structure."

681.142 : 621.385.832 **2135**

Stable High-Speed Digital-to-Analogue Conversion for Storage-Tube Deflection.—C. F. Ault. (*Bell Syst. tech. J.*, March 1959, Vol. 38, No. 2, pp. 445–465.) Discussion of the design of access circuitry for a barrier-grid-tube temporary storage system which converts a 14-bit binary address into the analogue voltage necessary to deflect the electron beam to a specific storage area defined by the address. A special feedback circuit and raster reference tube control the size and centring of the array of storage spots.

CIRCUITS AND CIRCUIT ELEMENTS

621.319.4.011.21 **2136**

Study of the Impedance of Capacitors as a Function of Frequency.—J. P. Mayeur. (*Câbles & Transm.*, Jan. 1957, Vol. 11, No. 1, pp. 22–31.) Strip, stacked and disk-type capacitors have been studied. The natural resonant frequency is almost entirely dependent on the capacitance value and the connections.

621.319.45 **2137**

Solid-Electrolyte Tantalum Capacitors.—R. Aries. (*Electronic Engng*, April 1959, Vol. 31, No. 374, pp. 230–231.) The manufacturing process is described and the temperature characteristics and results of life tests are given.

621.372.01 **2138**

Elements of Electronic Circuits: Part 2—Clamping or D.C. Restoration.—J. M. Peters. (*Wireless World*, May 1959, Vol. 65, No. 5, pp. 231–232.) Part 1 : 1795 of May.

621.372.2.029.6 : 512.831 **2139**

The Physical Realizability of a Microwave Junction.—G. C. Corazza & G. Zoldan. (*Note Recensioni Notiz.*, July/Aug. 1958, Vol. 7, No. 4, pp. 445–449.) The conditions are derived which must be satisfied by a matrix to represent the admittance, impedance or scattering matrix of a junction at a given fixed frequency. See also 1060 of 1958 (Corazza & Serracchioli).

621.372.41 : 621.318.424 **2140**

The Ferroresonant Circuit.—G. E. Kelly, Jr. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 843–848. Discussion, p. 1061.) A theoretical and experimental treatment of the resonance obtained by varying the voltage applied to a circuit containing an iron-cored inductance.

621.372.41 : 621.318.424 **2141**

Behaviour of the Ferroresonant Series Circuit containing a Square-Loop Reactor.—R. H. Dennard. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 903–911.)

621.372.412.002 **2142**

The Present State of Crystal-Resonator Techniques.—H. Awender. (*Nachrichtentech. Z.*, May 1958, Vol. 11, No. 5, pp. 225–237.) Review of production techniques with details of performance obtained in recent applications of crystal resonators in frequency standards, filters and delay lines. 112 references.

621.372.413 **2143**

The Expansions of Electromagnetic Fields in Cavities.—K. Kurokawa. (*Trans. Inst. Radio Engrs*, April 1958, Vol. MTT-6, No. 2, pp. 178–187. Abstract, *Proc. Inst. Radio Engrs*, June 1958, Vol. 46, No. 6, p. 1329.)

621.372.414 : 621.372.8 **2144**

Travelling-Wave Resonators.—L. J. Milosevic & R. Vautey. (*Trans. Inst. Radio Engrs*, April 1958, Vol. MTT-6, No. 2, pp. 136–143. Abstract, *Proc. Inst. Radio Engrs*, June 1958, Vol. 46, No. 6, p. 1328.) See also 1325 of 1956 (Sferrazza).

621.372.5 **2145**

Gyrators and Nonreciprocal Systems.—M. Prudhon. (*Câbles & Transm.*, Jan. 1957, Vol. 11, No. 1, pp. 66–73.) Discussion of the conditions necessary for a linear four-terminal network containing only passive elements and gyrators, to have different attenuations in either direction.

621.372.5 **2146**

A New Synthesis Procedure for Two-Terminal-Pair Networks using the Symmetrical Lattice Structure.—S. S. Forte. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 112–114.)

621.372.5 **2147**

Synthesis of *LC* Networks.—J. T. Allanson. (*Electronic Radio Engr*, May 1959, Vol. 36, No. 5, pp. 182–184.) "A method is outlined for the synthesis of certain voltage transfer functions by means of asymmetrical, balanced *LC* networks terminated at the load end by a resistance."

621.372.5 : 621.376.3 **2148**

A Simplified Analysis of Transients in Linear Circuits caused by the Frequency Modulation of an Input Signal.—V. G. Segalin. (*Radiotekhnika i Elektronika*, July 1957, Vol. 2, No. 7, pp. 856–869.) A simplified method of investigation of transients is described with the introduction of the concept of the transmission frequency coefficient. An explanation is provided for the mechanism of dependence of the time constant of the frequency transient on the frequency of modulation of the input signal. The frequency coefficients of transmission for aperiodic and differentiating circuits are also considered.

621.372.5.029.64 **2149**

Wave Matrices of a Quadripole.—L. P. Yavich. (*Radiotekhnika i Elektronika*, July 1957, Vol. 2, No. 7, pp. 870–882.) The use of scattering and transmission matrices for cm-wave quadripoles is considered and the essential properties of these wave matrices are determined. The method is illustrated by a practical example in which an examination is made of the modulus and phase of the reflection coefficient of a waveguide filter consisting of two equal inhomogeneities and separated by a section of waveguide propagating an H_{10} wave.

621.372.54 **2150**

Interchange of Infinite-Attenuation Elements in Ladder Filter Structures.—J. E. Colin. (*Câbles & Transm.*, Jan. 1958, Vol. 12, No. 1, pp. 10–22.) Formulae are given for interchanging series antiresonant and shunt resonant circuits.

621.372.54 **2151**

Branched Filters.—J. Oswald. (*Câbles & Transm.*, Jan. 1958, Vol. 12, No. 1, pp. 37–79.) The theories of Cauer and Piloty relating to constant-impedance branched networks are supplemented and applied using image-attenuation functions instead of Cauer's insertion-loss function. An eight-terminal network using two low-pass and two high-pass filters without a differential transformer is described.

621.372.54 **2152**

The Reactance Transformation of Low-Pass into Band-Pass Ladder Networks.—A. Ahačić. (*Arch. elekt. Übertragung*, May 1958, Vol. 12, No. 5, pp. 203–208.) The low-pass network is subdivided into quadripole elements which are then combined to form the band-pass network.

621.372.54 **2153**

Development of Filter Technique in France during the Last Ten Years.—J. E. Colin. (*Câbles & Transm.*, Oct. 1957, Vol. 11, No. 4, pp. 302–313.)

621.372.54 : 534.1 **2154**

Flexural Vibrations in Mechanical Filters.—M. Börner. (*Telefunken Ztg*, June & Sept. 1958, Vol. 31, Nos. 120 & 121, pp. 115–123 & 188–196. English summary, pp. 137–138, 206.) Matrix methods are used for calculating the characteristics of flexural vibrations in rods, and the results are compared with those measured by an experimental method described. The design of mechanical filters with torsional and longitudinal vibrations and free from flexural waves is discussed.

621.372.543.2 : 538.652 **2155**

Mechanical Filters for Communications Technique.—M. Börner, E. Kettel & H. Ohnsorge. (*Telefunken Ztg*, June 1958, Vol. 31, No. 120, pp. 105–114. English summary, p. 137.) The principle of operation and the design of filters consisting of magnetostrictive transducers and mechanical resonators are described. Details are given of a 525-kc/s i.f. band filter and a s.s.b. filter for a carrier frequency of 200 kc/s.

621.372.543.3 : 621.375.4 **2156**

Transistor Active Filters using Twin-T Rejection Networks.—A. E. Bachmann. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 170–174.)

621.372.6 **2157**

A Topological Investigation of Network Determinants.—P. R. Bryant. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 16–22.) The main result gives the determinant of the nodal admittance matrix of a *RLC* network without mutual inductance or ideal transformers.

621.372.6 : 621.3.018.1 **2158**

The Practical Design of Two-Phase Networks.—G. Wunsch. (*Nachr Tech.*, April 1958, Vol. 8, No. 4, pp. 154–158.) An example illustrating the theory given in 395 of 1958.

621.372.62 : 621.317.727 : 681.142 **2159**

Linear Multitapped Potentiometers with Loaded Outputs.—K. C. Garner. (*Electronic Engng*, April 1959, Vol. 31, No. 374, pp. 192–199.) "An analysis of multitapped linear potentiometers is given for the type in which shunt resistors are connected between adjacent tapping joints and in the presence of an output load resistance."

621.373.42.029.4 **2160**

A Simple Very-Low-Frequency Oscillator.—J. F. Young. (*Electronic Engng*, April 1959, Vol. 31, No. 374, pp. 218–220.) Amplitude limitation is effected by a Zener diode and a selective circuit filters out the resulting harmonics, giving amplitude stabilization that is not frequency-selective.

621.373.52 : 621.374 **2161**

Transistorized Generator for Pulse Circuit Design.—L. Neumann. (*Electronics*, 3rd April 1959, Vol. 32, No. 14, pp. 47–49.) The generator produces pulses of 25–35 mμs duration at repetition frequencies from 3 to 20 Mc/s. The maximum amplitude is 2 V into a 50-Ω load. Type-2N501 switching transistors are used.

621.373.52 : 621.396.66 **2162**

Transistor Phase-Locked Oscillators.—K. A. Edwards, O. Golubjatnikov & D. J. Brady. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 1043–1051.) An analysis followed by detailed design data for two systems, one operating at 10·5 kc/s and the other at 30 Mc/s.

621.374.3 **2163**

Greater Gain Bandwidth in Trigger Circuits.—M. Brown. (*Rev. sci. Instrum.*, March 1959, Vol. 30, No. 3, pp. 169–175.) A special series connection of two valves produces a gain-bandwidth product per stage of up to three times that of a conventional amplifier without introducing the unwanted time delay associated with a distributed amplifier.

621.374.34 **2164**

Cathode-Follower for a D.C. Reference Level.—S. Krishnan. (*Electronic Radio Engr*, May 1959, Vol. 36, No. 5, pp. 192–193.) Describes the use of a cathode follower to provide a variable reference-voltage source with a low output impedance.

621.375.024 : 621.318.43 **2165**

Design Criteria for Low-Level Second-Harmonic Magnetic Modulators.—E. J. Kletsky. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 1013–1019.) Detailed analysis of a device suitable for low-level d.c. amplification.

621.375.121.2 **2166**

How to Design Pulsed Distributed Amplifiers.—S. K. Meads. (*Electronics*, 20th March 1959, Vol. 32, No. 12, pp. 56–58.) Principles of operation are discussed and basic design equations are listed. Details of design procedure and performance of a power amplifier operating around 200 Mc/s are given.

621.375.13.01 : 517.93 **2167**

The Effect of Reaction on the Gain of Nonlinear Amplifiers.—I. Gumowski. (*Ann. Télécommun.*, Jan./Feb. 1958, Vol. 13, Nos. 1/2, pp. 45–47.) An analysis in which it is shown that in certain conditions the nonlinear differential equation may be reduced to a linear equation of infinite order with constant coefficients.

621.375.2.029.3 **2168**

Performance of Class-B Audio Amplifiers with Random Noise Signals.—T. Usher, Jr. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 939–943.) Two basic limitations on performance are considered; average anode power dissipation is the same as that for sinusoidal modulation but the positive-grid operation permitted is slightly different.

621.375.221 **2169**

Construction of a Logarithmic Wide-Band Amplifier.—H. Schwahn. (*Nachr-Tech.*, April 1958, Vol. 8, No. 4, pp. 158–167.) The equipment described has a gain of about 1 000. Amplification is linear for input voltages up to 1 mV, and proportional within ± 0·5 dB to the logarithm of the input voltage from 1 mV to 10 V. Frequency response is linear from 50 c/s to 100 kc/s.

621.375.3 **2170**

'Variable-μ' Magnetic Amplifier.—C. C. Whitehead. (*Wireless World*, May 1959, Vol. 65, No. 5, pp. 219–224.) A method is described for varying the current gain by means of a variable impedance in parallel with the feedback rectifiers.

621.375.3 **2171**

Volt-Second Transfer Efficiency in Fast-Response Magnetic Amplifiers: Part 1—N^2/R and Control.—T. J. Pula. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 861–867.) Analysis for the case of finite control-circuit resistance and non-ideal core characteristics. N^2/R, defined as the summation of the quotients of the square of the number of turns and the circuit resistance for all control circuits, is shown to be a basic reactor parameter.

621.375.3 **2172**

On Feedback in Magnetic Amplifiers: Part 1—Single Feedbacks.—L. A. Finzi & J. J. Suozzi. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 1019–1030. Discussion, pp. 1030–1031.) Feedback configurations associated with two-core full-wave self-saturating amplifiers are analysed and compared.

621.375.3 : 621-526 **2173**

Magnetic Amplifiers for Servo Systems.—S. Davis. (*Electronics*, 13th March 1959, Vol. 32, No. 11, pp. 134–135.) Tabulated comparison of seven different combinations of push-pull magnetic-amplifier units.

621.375.3 : 621.318.57 : 621.314.7 **2174**

Linear Power Amplifiers using Dynistors or Trinistors.—F. J. Hierholzer, Jr. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 892–898.) The use of two- or three-terminal semiconductor switching devices with a pulse network in series with the output of a magnetic-amplifier transducer, acting as an amplitude/phase converter, is described. These amplifiers are much smaller than conventional magnetic amplifiers of comparable maximum output power. Resistive or inductive loads can be used.

621.375.4 : 621.395.625.3 : 621.3.087.9 **2175**

Transistor Amplifier for Magnetic Tape and Drum Playback.—A. E. Bachmann. (*Electronic Engng*, April 1959, Vol. 31, No. 374, pp. 213–217.) The amplifier operates from a 2-mV input over the range 2–400 kc/s and from 0 °C to +70 °C. Rise time of the output pulse is less than 1 μs. Details are given of the design and full performance.

621.375.4.024 : 621-526 **2176**

A Stable Direct-Coupled Transistor Servo Preamplifier.—A. N. DeSautels. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 943–947.) Capable of d.c. operating-point stability and high gain at >125 °C.

621.375.9 : 538.569.4.029.6 **2177**

The Three-Level Solid-State Travelling-Wave Maser.—R. W. DeGrasse, E. O. Schulz-DuBois & H. E. D. Scovil. (*Bell Syst. tech. J.*, March 1959, Vol. 38, No. 2, pp. 305–334.) Theoretical comparison is made between the characteristics of the travelling-wave maser and those of the cavity maser and the general requirements for slow-wave structures are discussed. Theoretical analysis and experimental results are presented for the comb-in-waveguide slow-wave structure.

621.375.9 : 538.569.4.029.6 **2178**

A U.H.F. Ruby Maser.—G. K. Wessel. (*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, p. 590.) The maser is tunable over the range 380–450 Mc/s and consists of a ruby crystal at the centre of a teflon loaded cavity which is excited in a TE_{011} pump mode.

621.375.9 : 538.569.4.029.6 : 536.8 **2179**

Three-Level Masers as Heat Engines.—Scovil & Schulz-DuBois. (See 2212.)

621.375.9 : 538.569.4.029.6 : 621.317.3 **2180**

Calculation and Measurement of the Noise Figure of a Maser Amplifier.—Helmer & Muller. (See 2343.)

621.375.9 : 538.569.4.029.63 **2181**

Stimulated R.F. Amplifiers Working on Hyperfine Levels of Paramagnetic Atoms.—K. A. Valiev & Sh. Sh. Bashkirov. (*Zh. eksp. teor. Fiz.*, July 1958, Vol. 35, No. 1(7), pp. 302–303.) A note on the possibility of obtaining signal amplification in the frequency range 100 Mc/s–1 kMc/s using crystals of salts containing bivalent ions of the Cu^{64} isotope. With $H_0 = 5\ 000$ oersteds, $T = 2$ to 4 °K and $N = 10^{19}$ (number of paramagnetic ions) the stored energy for one pair of hyperfine levels will be of the order of 1 to 2 ergs. For a pulse duration of 10^{-4} sec the output power may reach 10^{-3} W.

621.375.9.029.6 : 621.3.011.23 **2182**

Parametric Devices Tested for Phase-Distortionless Limiting.—F. A. Olson, C. P. Wang & G. Wade. (*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, pp. 587–588.) Tests on two devices are described: one is a 100-Mc/s amplifier and the other an S-band converter; both use variable-capacitance diodes.

621.375.9.029.6 : 621.3.011.23 : 621.314.63 **2183**

Directional-Bridge Parametric Amplifier.—L. U. Kibler. (*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, pp. 583–584.) A description is given of the operation and performance of a directional bridge system using variable-reactance diodes.

621.375.9.029.64 : 538.221 **2184**

Gain Measurements on a Pulsed Ferromagnetic Microwave Amplifier.—R. D. Haun, Jr, & T. A. Osial. (*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, pp. 586–587.) The amplifier operates in the 'quasi-degenerate' mode in which one cavity serves as the resonant circuit for both the signal and the idle frequency fields. A second cavity is used for the pump signal which is pulsed.

621.375.9.029.64 : 621.3.011.23 **2185**

Low-Noise Parametric Amplifier.—R. C. Knechtli & R. D. Weglein. (*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, pp. 584–585.) A note of preliminary analytical and experimental results obtained with a cavity-type amplifier for the S band in which, through variable coupling, the effect of diode losses on noise figure can be minimized at the expense of pump power.

621.376.2/.3 **2186**

A Comparison of the Transient Response of Amplitude-Modulated and Frequency-Modulated Signals.—S. J. Cotton. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 91–96.) The performance of *RC* and *RL* circuits, filters, and transmission lines is analysed.

621.376.3 : 621.385.2 **2187**

The Diode Reactance Modulator.—G. F. Montgomery. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 980–983.) A detailed analysis of the control of current through a capacitor by one or more diodes.

621.376.56 : 621.375.3 : 621.398 **2188**

A Magnetic-Amplifier Commutating and Pulse-Width Encoding Circuit.—W. H. Lucke. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 884–892.) Description of a circuit designed for telemetry applications.

GENERAL PHYSICS

534.2 : 537.3 **2189**

Acoustoelectric Effect.—R. H. Parmenter. (*Phys. Rev.*, 1st Jan. 1959. Vol. 113, No. 1, pp. 102–109.) Three general approaches to the theory of the effect are discussed, and a development of the phenomenological approach is given in detail for metals and semiconductors. See 2281 of 1953.

535.223 : 538.566.029.65 **2190**

A New Determination of the Free-Space Velocity of Electromagnetic Waves.—K. D. Froome. (*Proc. roy. Soc. A*, 9th Sept. 1958, Vol. 247, No. 1248, pp. 109–122.) A full description of the experiments briefly described in 2048 of 1958.

535.33-1 **2191**

The Theory of Interference Modulation for Double-Beam Interference.—L. Genzel & R. Weber. (*Z. angew. Phys.*, March 1958, Vol. 10, No. 3, pp. 127–135. Infrared interferometry is discussed. See also 88 of 1958 (Strong).

535.33-1 **2192**

Spectroscopy in the Far Infrared by means of Interference Modulation.—L. Genzel & R. Weber. (*Z. angew. Phys.*, April 1958, Vol. 10, No. 4, pp. 195–199.) Practical application of the principle discussed in 2191 above.

537.21 **2193**

A Simple Method of Calculating Electrostatic Capacity.—C. J. Bouwkamp. (*Physica*, Special Issue, 16th June 1958, Vol. 24, No. 6, pp. 538–542.) Attention is drawn to a simple theorem for evaluating the capacitance of certain conductors in free space such as a system of two spheres in contact with each other or a 'ring without hole'.

537.311.1 **2194**

Diamagnetism of Conduction Electrons in Metals.—J. E. Hebborn & E. H. Sondheimer. (*Phys. Rev. Lett.*, 15th Feb. 1959, Vol. 2, No. 4, pp. 150–152.) Calculation made by using a reasonably simple form for the field-independent part of the susceptibility.

537.312.62 **2195**

A Superconductor in a High-Frequency Field.—A. A. Abrikosov, L. P. Gor'kov & I. M. Khalatnikov. (*Zh. eksp. teor. Fiz.*, July 1958, Vol. 35, No. 1(7), pp. 265–275.) An equation is derived which describes the behaviour of a superconductor in a high-frequency field, and the frequency and temperature dependence of the impedance of a bulk superconductor are evaluated.

537.5 : 061.3 **2196**

Electrical Discharges.—J. Dutton & E. Jones. (*Nature, Lond.*, 10th Jan. 1959, Vol. 183, No. 4654, pp. 91–93.) Report of a Conference held by the Physical Society in Swansea 17th–20th Sept. 1958.

537.533 **2197**

Theoretical Total-Energy Distribution of Field-Emitted Electrons.—R. D. Young. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 110–114.)

537.533 **2198**

Experimental Measurement of the Total-Energy Distribution of Field-Emitted Electrons.—R. D. Young & E. W. Müller. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 115–120.)

537.533.73 : 621.317.42 **2199**

Magnetic Analysis with Electron Beams.—S. Yamaguchi. (*Z. angew. Phys.*, March 1958, Vol. 10, No. 3, pp. 138–140.) A device based on the Lorentz effect is used to estimate remanent magnetism. See also 3041 of 1958.

537.56 **2200**

An Extension of Townsend's Approximation Formula for Ionization in a Homogeneous Electric Field.—H. Neu. (*Z. Phys.*, 5th Sept. 1958, Vol. 152, No. 3, pp. 294–305.) The use of an additional parameter improves the approximation and extends the range of validity for lower field strengths. A general approximation formula is proposed for ionization dependent simultaneously on both field strength and voltage.

537.56 : 538.56 **2201**

On the Damping of Electromagnetic Waves in a Plasma Situated in a Magnetic Field.—K. N. Stepanov. (*Zh. eksp. teor. Fiz.*, July 1958, Vol. 35, No. 1(7), pp. 283–284.) Using expressions derived by

Sitenko & Stepanov (2418 of 1957) for the components of the permittivity tensor an expression for the damping coefficient is obtained.

537.56 : 538.566.029.6 **2202**

Conductivity of Plasmas to Microwaves.—P. H. Fang. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 13–14.) Plasma conductivities for electrons with a Maxwellian energy distribution are evaluated for the cases in which the collision cross-section s (*a*) independent of the velocity and (*b*) inversely proportional to the velocity. The corresponding distribution functions of relaxation times are discussed.

537.56 : 538.569.4.029.64 **2203**

Microwave Investigation of Disintegrating Gaseous Discharge Plasmas.—H. J. Oskam. (*Philips Res. Rep.*, Aug. & Oct. 1958, Vol. 13, Nos. 4 & 5, pp. 335–400 & 401–457.) The phenomenon of afterglow is investigated both theoretically and experimentally by considering the shift of the resonance frequency of a microwave cavity enclosing the plasma. Measurements using binary gas mixtures show the production of a considerable number of atomic ions of the admixture even at low concentrations. The process concerned in helium-neon is a charge-transfer one between a He_2^+ ion and a neon atom, the relevant cross-section being $Q_{ce} \approx 1 \cdot 5 \times 10^{-15} cm^2$. In other mixtures the atomic ions are produced by the Penning effect and possibly the charge transfer process.

538.566 + 534.2 **2204**

Guided Propagation in a Slowly Varying Medium.—D. E. Weston. (*Proc. phys. Soc.*, 1st March 1959, Vol. 73, No. 471, pp. 365–384.) Formulae are derived for the propagation of elastic or e.m. waves in a variable stratified medium, with particular application to underwater sound transmission.

538.566 **2205**

Absorption of Electromagnetic Waves by means of Lossy Resonant Slots.—F. Wiekhorst. (*Z. angew. Phys.*, April 1958, Vol. 10, No. 4, pp. 173–178.) Very thin microwave absorbers can be constructed by using a sheet of resistive material with tuned slots at a distance $\leqslant \lambda/4$ in front of a metal plate. The bandwidth can be increased by the insertion of a grid of dipoles, and the effects of polarization are minimized if circular slots are used. See also 1846 of June (Schmitt & Futtermenger).

538.566 : 535.42 **2206**

Phase Object Diffraction Patterns in Microscopes and Microwave Fields.—O. Bryngdahl & E. Ingelstam. (*Physica*, Special Issue, 16th June 1958, Vol. 24, No. 6, pp. 445–456.) Optical phase diffraction patterns are interpreted by analogy with patterns obtained by a microwave technique at 5·15 cm λ.

538.567.4 **2207**

Velocity Modulation of Electromagnetic Waves.—F. R. Morgenthaler. (*Trans. Inst. Radio Engrs*, April 1958, Vol. MTT-6, No. 2, pp. 167–172. Abstract, *Proc. Inst. Radio Engrs*, June 1958, Vol. 46, No. 6, p. 1329.)

538.569.3 **2208**

Propagation of an Electromagnetic Impulse in a Medium with Dielectric Losses.—M. Cotte. (*C. R. Acad. Sci., Paris*, 27th Oct. 1958, Vol. 247, No. 17, pp. 1324–1327.)

538.569.4 : 535.34 : 621.372.413 **2209**

High-*Q* Stark Cavity Absorption Cell for Microwave Spectrometers. — A. Dymanus. (*Rev. sci. Instrum.*, March 1959, Vol. 30, No. 3, pp. 191–195.) Design, description and performance data are given of a large pillbox-shaped Stark cavity absorption cell for the 1·25-cm-λ region. The cavity can be used in any TE_{om1} mode with *m* ranging from about 5 to 12.

538.569.4 : 538.221 **2210**

Theory of the Anisotropy of the Width of Ferromagnetic Resonance Absorption Lines.—G. V. Skrotskiĭ & L. V. Kurbatov. (*Zh. eksp. teor. Fiz.*, July 1958, Vol. 35, No. 1(7), pp. 216–220.) The dependence of the width of a radio-frequency resonance absorption line on the internal field is derived from the Landau-Lifshits equation and examples of ferrites with single-axis and cubic symmetry are examined.

538.569.4.029.6 : 535.33 **2211**

Microwave Spectrometer tests Electron Resonance.—R. R. Unterberger. (*Electronics*, 13th March 1959, Vol. 32, No. 11, pp. 142–144.) A method of measuring the absorption properties of paramagnetic materials in which a sample is immersed in a d.c. field whose strength is varied to determine the value at which r.f. energy is absorbed by the sample.

538.569.4.029.6 : 621.375.9 : 536.8 **2212**

Three-Level Masers at Heat Engines.—H. E. D. Scovil & E. O. Schulz-DuBois. (*Phys. Rev. Lett.*, 15th March 1959, Vol. 2, No. 6, pp. 262–263.) It is shown that a three-level maser can be regarded as a heat engine, and its limiting efficiency is that of a Carnot engine. The possibility of treating masers as heat engines represents a fundamental difference between masers and parametric amplifiers.

538.569.4.029.65 **2213**

Absorption and Refraction of Ammonia as a Function of Pressure at 6-mm Wavelength.—F. W. Heineken & A. Battaglia. (*Physica*, July 1958, Vol. 24, No. 7, pp. 589–603.) Description of measurements made using a resonant-cavity technique.

539.2 : 538.221 **2214**

Exact Foundations of the Theory of Spin Waves.—F. Bopp & E. Werner. (*Z. Phys.*, 9th April 1958, Vol. 151, No. 1, pp. 10–15.) The validity of equations of the type of Bloch's spin-wave equations is proved for the multi-electron problem, disregarding spin interactions.

539.2 : 548.0 **2215**

Theory of Electron-Phonon Interactions.—G. D. Whitfield. (*Phys. Rev. Lett.*, 1st March 1959, Vol. 2, No. 5, pp. 204–205.) The theory has been formulated for non-polar crystals in terms of a new set of basic states whose wave functions are essentially Bloch functions that deform with the lattice. A result of this is a generalization of the deformation potential theorem [3032 of 1950 (Bardeen & Shockley)].

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.16 **2216**

Possible Mechanism by which Terrestrial Corpuscular Radiation Arises in Response to the Action of Cosmic Rays.—S. N. Vernov, N. L. Grigorov, I. P. Tvanenko, A. I. Lebedinskiĭ, V. S. Murzin & A. E. Chudakov. (*Dokl. Ak. Nauk S.S.S.R.*, 11th Feb. 1959, Vol. 124, No. 5, pp. 1022–1025.) Expressions are derived giving the total number of protons and electrons generated per second at the equator in a tube of 1 cm² cross-section. The dependence of the intensity of the earth's corpuscular radiation on height and latitude is shown graphically. Experiments show that the intensity near the equator is approximately 100 times less than that calculated, which indicates the existence of supplementary 'leaks' from 'magnetic traps' especially noticeable at high latitudes.

523.16 : 550.389.2 : 629.19 **2217**

Possible Explanation of the Radiation Observed by Van Allen at High Altitudes in Satellites.—P. J. Kellogg. (*Nuovo Cim.*, 1st Jan. 1959, Vol. 11, No. 1, pp. 48–66. In English.) The possibility is considered that the radiation is due to the decay electrons and protons from neutrons produced by cosmic rays and stored in the earth's magnetic field.

523.164 **2218**

Radiation Transfer and the Possibility of Negative Absorption in Radio Astronomy.—R. Q. Twiss. (*Aust. J. Phys.*, Dec. 1958, Vol. 11, No. 4, pp. 564–579.) Conditions are discussed under which negative absorption can arise at radio wavelengths, when the medium will behave like an amplifier to the incident radiations. The necessary conditions can be met in cases where the dominant radiation process is due to (*a*) the Cherenkov effect, (*b*) gyro radiation, or (*c*) synchrotron-type radiation.

523.164 **2219**

Radio Interferometry at Three Kilometres Altitude above the Pacific Ocean.—G. Reber. (*J. geophys. Res.*, March 1959, Vol. 64, No. 3, pp. 287–303.) A Lloyd's mirror type of interferometer, using the surface of the sea as a mirror, is described whose effective spacing changes in a continuous manner from zero to 6 km during about one half hour. The fluctuations caused by the ionosphere are discussed and the measurements of the fine structure details of Cassiopeia, Cygnus, Hydra, the sun and Jupiter are described.

523.164.3 **2220**

A Pencil-Beam Survey of the Galactic Plane at 3·5 m.—E. R. Hill, O. B. Slee & B. Y. Mills. (*Aust. J. Phys.*, Dec. 1958, Vol. 11, No. 4, pp. 530–549.) "A survey has been made of the galactic plane region from $l = 223°$ through the galactic centre to $l = 13°$ between $b = +4°$ and $-6°$ using the 3·5-m-λ cross-type aerial (beamwidth 50 min of arc) near Sydney. Contour diagrams of brightness temperature have been prepared. The preparation of contours is described in detail, and a detailed discussion of the accuracy of the temperatures is given."

523.164.3 **2221**

Radio Emission from the Vela-Puppis Region.—H. Rishbeth. (*Aust. J. Phys.*, Dec. 1958, Vol. 11, No. 4, pp. 550–563.)

523.164.4 **2222**

The Radio Emission from Centaurus-A and Fornax-A.—C. A. Shain. (*Aust. J. Phys.*, Dec. 1958, Vol. 11, No. 4, pp. 517–529.)

523.164.4 **2223**

A Search for Radio Emission at 3·5 m from the Local Supergalaxy.—E. R. Hill. (*Aust. J. Phys.*, Dec. 1958, Vol. 11, No. 4, pp. 580–583.)

523.5 **2224**

Approximations for the Electron Density in Meteor Trails.—A. A. Weiss. (*Aust. J. Phys.*, Dec. 1958, Vol. 11, No. 4, pp. 591–594.) Improved approximate expressions for describing conditions near the point of maximum electron density for both fast and slow meteors are compared with Herlofsen's exact solution (see 3401 of 1948).

523.5 : 621.396.9 **2225**

Oblique Echoes from Over-Dense Meteor Trails.—L. A. Manning. (*J. atmos. terr. Phys.*, April 1959, Vol. 14, Nos. 1/2, pp. 82–93.) Ray paths are computed for waves refracted by meteor trails. Curves are derived showing how the echo duration depends on the trail orientation; these curves show that the $\sec^2\phi$ law applies for overdense trails only if the plane of propagation contains the trail axis. If not, the effective secant exponent may be as small as 0·3. The theory is in agreement with duration measurements of McKinley & McNamara (923 of 1957) and gives results similar to the more complex wave solutions of Keitel (see 234 of 1956).

523.5 : 621.396.9 **2226**

Investigation of the Drifts of the Effective Point of Radio Reflection along a Meteor Train.—M. S. Rao & R. L. Armstrong. (*Canad. J. Phys.*, Dec. 1958, Vol. 36, No. 12, pp. 1601–1623.) Experimental evidence is given to support the postulate of the drift of the effective point of reflection along a meteor train towards the maximum echo duration level. Drift velocities tend to have higher values in the case of shorter echo durations and vice versa. From theoretical considerations it is predicted that maximum echo durations always occur at about 2·46 km below the height of maximum ionization. The degree of turbulence is considered to be slightly greater than that suggested by Manning (2720 of 1958) but less than that by Booker & Cohen (1417 of 1957). See also 3798 of 1958 (Rao).

523.53 : 621.396.9 **2227**

The Limitations of Narrow-Beam Radio Equipments in the Detection of Weak Meteor Showers.—A. A. Weiss. (*J. atmos. terr. Phys.*, April 1959, Vol. 14, Nos. 1/2, pp. 19–30.) Fluctuations in background activity, diffuseness of shower radiants and the short interval over which some showers are active are the chief limitations. A significance test for use as a search method for weak showers is developed.

550.384.4 **2228**

First Results on the Lunar-Diurnal Variation of the Horizontal Component of the Geomagnetic Field at Tamanrasset.—F. Duclaux & R. Will. (*C. R. Acad. Sci., Paris*, 20th Oct. 1957, Vol. 247, No. 16, pp. 1220–1222.)

550.385 : 551.513 **2229**

An Apparent Relationship between Geomagnetic Disturbances and Changes in Atmospheric Circulation at 300 Millibars.—D. D. Woodbridge, N. J. Macdonald & T. W. Pohrte. (*J. geophys. Res.*, March 1959, Vol. 64, No. 3, pp. 331–341.) 'Contour length' and 'trough' indices were used as measures of atmospheric disturbance over North America and the eastern Pacific Ocean. These features were studied for periods following geomagnetic disturbances from October 1956 to March 1957. There appears to be a significant relation between geomagnetic activity and the development some days later of wave phenomena at the 300-mb level.

550.389.2 : 629.19 **2230**

Radio-Electronics and Cosmic Flight.—(*Radio, Mosk.*, Feb. 1959, No. 2, pp. 6–7.) A brief description of the flight of the Russian cosmic rocket launched on the 2nd January 1959. The scientific equipment carried in the 361·3-kg last stage and the possibilities open to these rockets for interplanetary space investigation are also examined.

550.389.2 : 629.19 **2231**

Study of Cosmic Rays and Terrestrial Corpuscular Radiation by Cosmic Rocket.—S. N. Vernov, A. E. Chudakov, P. V. Vakulov & Yu. I. Logachev. (*Dokl. Ak. Nauk S.S.S.R.*, 11th March 1959, Vol. 125, No. 2, pp. 304–307.) A preliminary examination of data obtained by the cosmic rocket at distances between 8 and 150×10^3 km from the centre of the earth. Graphs show that a maximum intensity of terrestrial corpuscular radiation is found at a distance of 26×10^3 km, and that at 55×10^3 km this intensity falls to zero. The density of cosmic rays was found by Geiger counter to be $2·3 \pm 0·1$ particles/cm²․sec and by scintillation counter to be 1·9 particles/cm²․sec.

550.389.2 : 629.19 **2232**

Methods for Predicting the Orbits of Near Earth Satellites.—D. G. King-Hele & D. M. C. Walker. (*J. Brit. interplan. Soc.*, Jan./Feb. 1959, Vol. 17, No. 1, pp. 2–14.) "Methods are described for predicting the times and positions of the daily transits of a satellite and the geometry of its orbit. The methods depend upon maintaining an accurate record of the period of revolution from which the other orbital elements are deduced theoretically."

550.389.2 : 629.19 **2233**

The Effect of the Earth's Oblateness on the Orbit of a Near Satellite.—D. G. King-Hele. (*Proc. roy. Soc. A*, 9th Sept. 1958, Vol. 247, No. 1248, pp. 49–72.) "The equations of motion of a satellite in an orbit over an oblate earth in vacuo are solved analytically, by a perturbation method. The solution applies primarily to orbits of eccentricity 0·05 or less. The accuracy of the solution for radial distance should then be about 0·001 %, and the error in angular travel about 0·001 % per revolution. A brief comparison is made between theory and observation for Sputniks 1 and 2."

550.389.2 : 629.19 **2234**

Earth Oblateness in terms of Satellite Orbital Periods.—L. Blitzer. (*Science*, 6th Feb. 1959, Vol. 129, No. 3345, pp. 329–330.) An equation relating the earth's oblateness to the anomalistic and nodical periods and orbit parameters of a satellite is given.

550.389.2 : 629.19 **2235**

Changes in the Inclination of Satellite Orbits to the Equator.—R. H. Merson, D. G. King-Hele & R. N. A. Plimmer. (*Nature, Lond.*, 24th Jan. 1959, Vol. 183, No. 4656, pp. 239–240.) An extension of earlier investigations [792 of March (Merson & King-Hele)], taking into account the spread of atmospheric resistance around perigee. See also 1542 of May (Bosanquet).

550.389.2 : 629.19 **2236**

Vanguard Measurements give Pear-Shaped Component of Earth's Figure.—J. A. O'Keefe, A. Eckels & R. K. Squires. (*Science*, 27th Feb. 1959, Vol. 129, No. 3348, pp. 565–566.) Calculations indicate that the periodic variations in the eccentricity of orbit of satellite 1958 $\beta 2$ can be explained by the presence of a third zonal harmonic in the earth's gravitational field.

550.389.2 : 629.19 **2237**

Radio Observations at 20 Mc/s of the First Russian Earth Satellites.—H. K. Paetzold & H. Zschorner. (*Telefunken Ztg*, June 1958, Vol. 31, No. 120, pp. 100–104. English summary, p. 137.) Report on observations in Germany of satellites 1957 α and β. The various types of amplitude and bearing fluctuations are interpreted and the wave propagation mechanism is discussed.

550.389.2 : 629.19 **2238**

Radio Observations with Satellite 1958 ϵ.—J. A. Van Allen, C. E. McIlwain & G. H. Ludwig. (*J. geophys. Res.*, March 1959, Vol. 64, No. 3, pp. 271–286.) The earlier discovery of the great radiation belt around the earth has been confirmed and extended by the use of improved detector equipment. This preliminary report suggests that visible aurorae and other geophysical phenomena are closely related to the reservoir of charged particles trapped by the earth's magnetic field.

550.389.2 : 629.19 **2239**

Space Vehicles, Satellites, and Missiles—a Symposium.—(*Elect. Engng, N.Y.*, Dec. 1958, Vol. 77, No. 12, pp. 1077–1095.) Verbatim report of a symposium sponsored by the Feedback Control Systems

Committee of the American Institute of Electrical Engineers, Buffalo, New York, 22nd–28th June 1958.

551.510.52 : 621.396.9 **2240**

Radio Echoes from some Invisible Objects in the Troposphere.—A. G. Gorelik & V. V. Kostarev. (*Dokl. Ak. Nauk S.S.S.R.*, 1st March 1959, Vol. 125, No. 1, pp. 59–61.) A regular scanning of the troposphere was carried out by the Central Aerology Observatory of the U.S.S.R. from 1956 to 1958 at 3·2 cm λ using a 20-m parabolic reflector and a 100-kW pulse transmitter. During the investigation radio echoes at heights up to 7 km were recorded. Film recordings show the distribution of echo sources as functions of height and time.

551.510.535 **2241**

Variations in Ionospheric F-Region Characteristics.—N. M. Brice. (*Aust. J. Phys.*, Dec. 1958, Vol. 11, No. 4, pp. 587–591.) Analysis of *h'f* records obtained at Macquarie Island (geomagnetic latitude 60 °S) since 1950.

551.510.535 **2242**

Study of Horizontal Drifts in the F_1 and F_2 Regions of the Ionosphere at Waltair (17°43′N, 83°18′E, mag. lat. 9°30′N).—B. R. Rao & E. B. Rao. (*J. atmos. terr. Phys.*, April 1959, Vol. 14, Nos. 1/2, pp. 94–106.) The diurnal and seasonal changes of drifts in the F- region are given in detail. The reversal of direction relative to movements at high latitudes is consistent with Martyn's drift theory.

551.510.535 **2243**

Some Measurements of Horizontal Movements in Region F_2 using Widely Spaced Observing Stations.—L. Thomas. (*J. atmos. terr. Phys.*, April 1959, Vol. 14, Nos. 1/2, pp. 123–137.) Vertical-incidence recordings at stations some 200 km apart were compared. The results show a correlation between velocity magnitude and the degree of magnetic activity, and a positive height gradient of velocity.

551.510.535 **2244**

Investigation of the Inhomogeneous Structure of the F Region of the Ionosphere.—E. G. Proshkin & B. L. Kashcheev. (*Radiotekhnika i Elektronika*, July 1957, Vol. 2, No. 7, pp. 819–825.) Results of vertical incidence soundings at Khar'kov from June 1954 to May 1956 have shown that in 90 % of cases the reflection from the ionosphere has a static character and that the regular diurnal and seasonal variation of the degree of inhomogeneity of the F region does not arise.

551.510.535 : 523.745 **2245**

Geomagnetic Influence on the F_1 and F_2 Regions of the Ionosphere—Effect of Solar Activity.—R. G. Rastogi. (*J. atmos. terr. Phys.*, April 1959, Vol. 14, Nos. 1/2, pp. 31–40.) Noon critical frequencies for the F_1 and F_2 layers are examined for different seasons and levels of solar activity. It is found that the F_1 layer exhibits a geomagnetic control at periods of high solar activity only, whilst the equatorial trough in f_0F_2 is most marked during periods of low solar activity.

551.510.535 : 550.385 **2246**

Geomagnetic Distortion of Region E.—W. J. G. Beynon & G. M. Brown. (*J. atmos. terr. Phys.*, April 1959, Vol. 14, Nos. 1/2, pp. 138–166.) An analysis of the behaviour of the normal E region suggests that departures from the classical Chapman theory can be attributed to vertical drift of ionization resulting from the interaction of the geomagnetic field and the Sq-current system flowing in or near the E region. Perturbations of f_0E under magnetically disturbed conditions and near the auroral zone are also discussed.

551.510.535 : 550.385.2 **2247**

On the Seat of the L Currents causing Geomagnetic Tides.—K. S. Rajo Rao. (*J. geophys. Res.*, March 1959, Vol. 64, No. 3, pp. 384–385.) A note on some ionospheric and geomagnetic data which support the view that the seat of the L current system is situated in the F_2 layer.

551.510.535 : 550.385.4 **2248**

A Study of the Morphology of Ionospheric Storms.—S. Matsushita. (*J. geophys. Res.*, March 1959, Vol. 64, No. 3, pp. 305–321.) A study of variations of the maximum electron density in the F_2 layer for the period 1946–1955 at 38 stations between 60·4 °N and 60·4 °S geomagnetic latitude. Storm-time variations and disturbance daily variations during each six-hour period were obtained and the changes of these with latitude were examined.

551.510.535 : 621.3.087.4 **2249**

A Rapid Method of Obtaining Accurate Virtual Heights from an Ionogram.—W. R. Piggott. (*J. atmos. terr. Phys.*, April 1959, Vol. 14, Nos. 1/2, pp. 175–177.) The variation of apparent vertical height with the amplitude of the reflected signal depends on constants of the equipment. These constants are used to construct a transparent slider which corrects for this variation and enables virtual heights to be obtained accurately.

551.510.535 : 621.396.11 **2250**

The Reflexion of Radio Waves from a Stratified Ionosphere Modified by Weak Irregularities.—M. L. V. Pitteway. (*Proc. roy. Soc. A*, 26th Aug. 1958, Vol. 246, No. 1247, pp. 556–569.) "Consideration is given to the scattered wave which accompanies reflexion from a stratified ionosphere in which there are weak irregularities. By considering these irregularities to be confined to a thin layer near a given height, the possibility is examined that they might produce considerably enhanced scattering if they were situated near the reflexion level calculated on the basis of geometrical optics. It is found that they would not have a very much greater effect at this level. It is also shown that, if the electron collision frequency is of the order likely to be encountered in the real ionosphere, there would be little enhancement by 'resonance' effects of the kind suggested by Herlofson [403 of 1952]."

551.510.535 : 621.396.11 **2251**

Irregularities in Refraction of Radio Waves and Large Inhomogeneities in the Ionosphere.—V. V. Vitkevich & Yu. L. Kokurin. (*Radiotekhnika i Elektronika*, July 1957, Vol. 2, No. 7, pp. 826–832.) Description of the method and results of measurements of the vertical refraction of radio waves at 4 m λ in the ionosphere. The irregularities of refraction are produced by inhomogeneities of dimensions about 200 km in the F region. The diurnal variation of inhomogeneities is analysed and it is shown that their presence is related to solar activity.

551.510.535 : 621.396.11 **2252**

Ionospheric Self-Demodulation and Self-Distortion of Radio Waves.—J. W. King. (*J. atmos. terr. Phys.*, April 1959, Vol. 14, Nos. 1/2, pp. 41–49.) Demodulation was observed only at low modulation frequencies. The magnitude of the effect agreed with that predicted by theory and was also what would have been expected from results obtained in cross-modulation experiments.

551.594.21 **2253**

Preliminary Results of an Experiment to Determine Initial Precedence of Organized Electrification and Precipitation in Thunderstorms.—B. Vonnegut, C. B. Moore & A. T. Botka. (*J. geophys. Res.*, March 1959, Vol. 64, No. 3, pp. 347–357.) It is shown that electrification of clouds begins before any radar echo is observed; this raises doubts about the assumption that precipitation is the primary cause of charge generation.

551.594.5 : 621.396.9 **2254**

Determination of the Angle of Arrival of Auroral Echoes.—L. Harang & J. Tröim. (*J. atmos. terr. Phys.*, April 1959, Vol. 14, Nos. 1/2, pp. 107–110.) An interference method is used at Kjeller to measure the angle of arrival, θ, of auroral echoes. As θ varies from 15° to 6·5° the range increases from 400 to 730 km and it is shown that the height of the reflection area must be 100–120 km.

551.594.5 : 621.396.96 **2255**

Horizontal Motions in Radar Echoes from Aurora.—G. F. Lyon & A. Kavadas. (*Canad. J. Phys.*, Dec. 1958, Vol. 36, No. 12, pp. 1661–1671.) Observations at Saskatoon at 48·2 Mc/s show a systematic motion of echoes towards the west before midnight and towards the east after midnight, the mean velocity in either direction showing a statistical relation to variations in the earth's magnetic field.

LOCATION AND AIDS TO NAVIGATION

621.396.93 **2256**

The Physical Properties of Various Cathode-Ray Direction Finders for Short Waves.—A. Troost. (*Telefunken Ztg*, June 1958, Vol. 31, No. 120, pp. 84–89. English summary, pp. 135–136.) A comparison of the five basic d.f. systems in present-day use. The answers to questions on suitability and operational facilities are given in tabular form, showing the relative advantages of the two-channel system.

621.396.93 **2257**

The Telefunken Short-Wave Cathode-Ray Direction Finder.—G. Schmucker. (*Telefunken Ztg*, June 1958, Vol. 31, No. 120, pp. 90–97. English summary, p. 136.) The equipment described operates in the range 1·35–25·2 Mc/s.

621.396.93 **2258**

Evaluation Improvement with the Two-Channel Cathode-Ray Direction Finder.—K. Baur. (*Telefunken Ztg*, June 1958, Vol. 31, No. 120, pp. 97–99. English summary, p. 136.) An integrating method of eliminating errors in evaluating d.f. bearing indications is described.

621.396.932/.933 : 061.3 **2259**

Convention on Radio Aids to Aeronautical and Marine Navigation.—(*Proc. Instn elect. Engrs*, Part B, 1958, Vol. 105, Supplement No. 9, pp. 193–398.) The following papers were included among those read at the I.E.E. Convention held in London 27th-28th March 1958.

(*a*) A Review of Radio Aids to Aeronautical and Marine Navigation.—C. Williams (pp. 196–212).

Discussion (pp. 212–215).

Medium and Long-Range Aids:

(*b*) Survey of Long-Range Radio Navigation Aids.—J. C. Farmer (pp. 216–224).

(*c*) The Decca Navigator System for Ship and Aircraft Use.—C. Powell (pp. 225–234).

(*d*) Doppler Navigation.—J. E. Clegg & T. G. Thorne (pp. 235–247).

(*e*) An Airborne Doppler Navigation Equipment.—G. E. Beck & T. G. Thorne (pp. 248–257).

(*f*) Low-Power C.W. Doppler Navigation Equipment.—J. E. Clegg & J. W. Crompton (pp. 258–265).

(*g*) The Combination of Inertial Navigation and Radio Aids.—A. Stratton (pp. 266–276).

Discussion (pp. 277–283).

Range and Bearing Systems:

(*h*) General Aspects of Short-Range Rho-Theta Systems.—C. E. Strong (pp. 284–297).

(*i*) TACAN: A Navigation System for Aircraft.—W. L. Garfield (pp. 298–306).

(*j*) Current Direction-Finding Practice.—H. G. Hopkins & B. G. Pressey (pp. 307–316).

(*k*) The Practical Evolution of the Commutated Aerial Direction-Finding System.—C. W. Earp & D. L. Cooper-Jones (pp. 317–325).

Discussion (pp. 326–332).

Airfield and Harbour Approach:

(*l*) A Survey of Approach and Landing Aids.—W. J. Charnley (pp. 333–343).

(*m*) Precision Approach Radar.—G. J. Moorcroft (pp. 344–350).

(*n*) A Survey of Harbour Approach Aids.—A. L. P. Milwright (pp. 351–357).

(*o*) The Application of Radio Altimeters to Aircraft Approach and Landing.—M. P. G. Capelli, A. E. Outten & K. E. Bücks (pp. 358–364).

Discussion (pp. 365–369).

Marine and Ground Radar:

(*p*) Advances in Ground Radar for Civil Aviation.—E. Eastwood & C. D. Colchester (pp. 370–379).

(*q*) Survey of Recent Developments in Marine Radar.—A. L. P. Milwright (pp. 380–384).

(*r*) A Mathematical Analysis of Collision-Course Prediction by Doppler Radar.—H. R. Whitfield & C. M. Cade (pp. 385–391).

Discussion (pp. 392–398).

621.396.933.2 : 621.396.677 **2260**

A New Method of Generating a Rotating Radiation Polar Diagram.—Hawkes. (See 2120.)

621.396.96.089.6 : 621.317.7 **2261**

Precision Generator for Radar Range Calibration.—Broderick, Hartke & Willrodt. (See 2353.)

MATERIALS AND SUBSIDIARY TECHNIQUES

533.5 **2262**

Grades of Vacuum in Electronic and Ionic Tubes.—A. I. Vishnievsky. (*J. Indian Inst. Sci.*, Section B, July 1958, Vol. 40, No. 3, pp. 139–144.) The most important factor that qualifies the grade of vacuum is not the pressure of the residual gases but the ratio of the mean free path of the molecules to the distance between the cathode and the anode of the device.

535.215 : 537.311.33 **2263**

Quenching of Photoconductivity and the Lifetime of Conduction Electrons.—F. Matossi. (*Z. Phys.*, 9th April 1958, Vol. 151, No. 1, pp. 5–8.) A simple general model is considered with a minimum number of assumptions including that of monomolecular transitions. See also 3486 of 1957.

535.215 : 546.431-3 **2264**

Exciton-Induced Photoemission from BaO near 80°K.—E. Taft, H. Philipp & L. Apker. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 156–158.)

535.215 : 546.482.21 **2265**

Analysis of Mixed Ambipolar and Exciton Diffusion in CdS Crystals.—G. Diemer, G. J. van Gurp & W. Hoogenstraaten. (*Philips Res. Rep.*, Oct. 1958, Vol. 13, No. 5, pp. 458–484 & Feb. 1959, Vol. 14, No. 1, pp. 11–28.) A detailed report of photodiffusion experiments and of the various effects interfering with the interpretation of the results. In crystals having special photoconduction and fluorescence properties, excitons can contribute to the diffusion of photoconduction over distances of several millimetres into non-excited parts of the crystal.

535.376 : 546.472.21 **2266**

Particle Size and Efficiency of Electroluminescent Zinc Sulphide Phosphors.—W. Lehmann. (*J. electrochem. Soc.*, Oct. 1958, Vol. 105, No. 10, pp. 585–588.) Experimental data show that efficiency, i.e., the ratio of brightness to electrical power absorption, increases with decreasing particle size.

535.37 : [546.482.21 + 546.472.21 **2267**

Polarization of Fluorescence in ZnS and CdS Single Crystals.—A. Lempicki. (*Phys. Rev. Lett.*, 15th Feb. 1959, Vol. 2, No. 4, pp. 155–157.) The fluorescence was excited by filtered 3 650 Å radiation incident perpendicularly to the plate-like surface of the crystals. Simple dipole theories fail to account for the results.

535.37 : [546.482.21 + 546.472.21 **2268**

Polarization of Fluorescence in CdS and ZnS Single Crystals.—J. L. Birman. (*Phys. Rev. Lett.*, 15th Feb. 1959, Vol. 2, No. 4, pp. 157–159.) The 6 200Å emission in CdS, and 4 500Å emission in ZnS, are interpreted on the basis of the Lambe-Klick model (3274 of 1955).

535.37 : 546.482.21 **2269**

Nature of Blue Edge Emission in CdS.—G. Diemer & A. J. Van der Houven van Oordt. (*Physica*, Aug. 1958, Vol. 24, No. 8, pp. 707–708.) See also 3106 of 1958 (Diemer et al.).

535.37 : 621.317.39 : 631.76 **2270**

The Measurement of Extremely Short Afterglows of Electronically Excited Luminophores.—Heine. (See 2350.)

537.226 : 537.311.6 **2271**

Impedance of Dielectric Layers.—P. Winkel & D. G. de Groot. (*Philips Res. Rep.*, Oct. 1958, Vol. 13, No. 5, pp. 489–498.) Experimental results are given to confirm that a correlation exists between the real and imaginary components of the impedance of a dielectric layer as indicated by the general theory on amorphous dielectrics of Gevers & du Pré (2798 of 1947). Oxide layers of Al, Ta and Al-oxide layers containing boehmite have been investigated.

537.226.2 : 549.514.51 **2272**

The Dielectric Properties of Quartz Sands at High and Ultra High Frequencies.—E. Löb. (*Z. angew. Phys.*, April 1958, Vol. 10, No. 4, pp. 178–185.) Measurements were made in the wavelength range 3 cm–800 m.

537.227 **2273**

Radiation Damage Effect in Ferroelectric Triglycine Sulphate.—A. G. Chynoweth. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 159–166.)

537.227 : 546.431.824-31 **2274**

Effect of Space-Charge Fields on Polarization Reversal and the Generation of Barkhausen Pulses in Barium Titanate.—A. G. Chynoweth. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 280–285.) Further experimental investigation (see also 3488 of 1958) indicates that the rate of nucleation of new domains is determined by the field near the electrodes which, in turn, is the resultant of the applied field and a relaxing space-charge field. This result follows directly if the Barkhausen pulses represent individual nucleations.

537.227 : 546.431.824-31 : 621.318.57 **2275**

Pulse Width Dependence of the Switching Velocity in $BaTiO_3$ Crystal.—K. Husimi & K. Kataoka. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 323–324.)

The maximum switching velocity is discussed as a function of the applied pulse field and the pulse width.

537.227 : 546.48.882.5 **2276**

The Preparation of Cadmium Niobate by an Anodic Spark Reaction.—W. McNeill. (*J. electrochem. Soc.*, Sept. 1958, Vol. 105, No. 9, pp. 544–547.)

537.228.1 : 534.133 : 621.3.029.64 **2277**

Piezoelectric Production of Microwave Phonons.—E. H. Jacobsen. (*Phys. Rev. Lett.*, 15th March 1959, Vol. 2, No. 6, pp. 249–250.) Propagation of elastic waves along a quartz rod at a frequency of 9 370 Mc/s has been observed at temperatures below 77°K.

537.228.1 : 546.482.21 **2278**

Some Electric Properties of Hexagonal Cadmium Sulphide.—H. Gobrecht & A. Bartschat. (*Z. Phys.*, 26th Sept. 1958, Vol. 152, No. 4, pp. 417–424.) The resonance frequencies for the thickness-shear mode as a function of thickness were determined on synthetic single crystals cf CdS which are piezoelectric (see 1814 cf 1954). The temperature coefficient of the resonance frequency for this mode is negative in the temperature range + 20°C to − 180°C.

537.311.33 **2279**

Correlation between Mobility and Effective Mass in Semiconductors.—R. W. Keyes. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, p. 454.)

537.311.33 **2280**

Theory of Transport Phenomena on a Semiconductor Surface.—G. M. Avak'yants. (*Izv. Ak. Nauk Uz. S.S.R., ser. fiz.-mat. nauk*, 1958, No. 5, pp. 23–41.) Mathematical treatment of electrical and thermal conduction and different thermal and magnetic effects at the surface of a semiconductor. Formulae derived are generalized for the case of charge transfer when collisions of carriers with the 'walls' of channels are more frequent than collisions with impurities or with lattice vibrations. See also 3519 of 1954.

537.311.33 **2281**

Properties of a Semiconductor Surface as Determined from a Modified Drift-Mobility Experiment.—N. J. Harrick. (*Phys. Rev. Lett.*, 1st March 1959, Vol. 2, No. 5, pp. 199–200.) Information may be obtained on the type, barrier potential, relaxation effects, and possibly mobility of the surface.

537.311.33 **2282**

Nonequilibrium Processes in Impurity Semiconductors.—V. P. Shabanskiĭ. (*Zh. eksp. teor. Fiz.*, July 1958, Vol. 35, No. 1(7), pp. 143–153.) Analysis is presented of the kinetic equations which describe transitions from impurity levels to conduction band including the effect of recombination and ionization. Expressions are derived for the energy and kinetic coefficient for cases when the lifetime of electrons in conduction bands is determined by photorecombination and triple-collision recombination processes. The equation obtained can be used to calculate the electron temperature and number o electrons in the conduction band in various non-equilibrium processes.

537.311.33 : 538.615 **2283**

Zeeman-Type Magneto-optical Studies of Interband Transitions in Semiconductors.—E. Burstein, G. S. Picus, R. F. Wallis & F. Blatt. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 15–33.) In the presence of a magnetic field the quasi-continuous levels of simple energy bands coalesce into one-dimensional sub-bands and the 'time-reversal' degeneracy of the levels is split. The energy levels are characterized by three quantum numbers, details of the theoretical treatment being given. The selection rules, polarization effects, and the character of the absorption spectra for interband transitions in the presence of a magnetic field are discussed and illustrated by experimental data for Ge and InSb.

537.311.33 : 539.2 **2284**

Vibration Spectra and Specific Heats of Diamond-Type Lattices.—J. C. Phillips. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 147–155.)

537.311.33 : 546.23 : 537.226 **2285**

The Dielectric Behaviour of Hexagonal Selenium in the Decimetre Wave Range.—J. Jaumann & E. Neckenbürger. (*Z. Phys.*, 9th April 1958, Vol. 151, No. 1, pp. 72–92.) Impedance measurements were made in the range 312–4 300 Mc/s and the dielectric constant was determined as a function of frequency, temperature, and annealing time. Results are compared with those of other authors.

537.311.33 : [546.28 + 546.289 **2286**

Lattice Vibrations in Silicon and Germanium.—B. N. Brockhouse. (*Phys. Rev. Lett.*, 15th March 1959, Vol. 2, No. 6, pp. 256–258.) Dispersion curves for lattice waves travelling in the [001] directions in a Si single crystal are given for the various modes of vibration. The results are discussed with reference to those of other workers, and to similar data on Ge.

537.311.33 : [546.28 + 546.289 **2287**

Specific Heat of Germanium and Silicon at Low Temperatures.—P. H. Keesom & G. Seidel. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 33–39.) The specific heats of several samples of Si have been measured between 1·2°K and 4·2°K. The Debye characteristic temperature θ_0 at 0°K is estimated to be 636°K. Measurements on Ge between 0·5°K and 4·2°K yield $\theta_0 = 363$°K. From knowledge of the electronic specific heat and carrier concentration of several degenerate samples of Ge and Si, information is deduced concerning the energy band structure of the crystals.

537.311.33 : 546.28 **2288**

Technique for Preserving Lifetime in Diffused Silicon.—S. J. Silverman & J. B. Singleton. (*J. electrochem. Soc.*, Oct. 1958, Vol. 105, No. 10, pp. 591–594.) Lifetimes improved by a factor of ten can be obtained if, prior to diffusion, a metal-silicon liquid phase, acting as a getter, is formed on the surface of the material. Ni, Ag and Bi have been applied independently with comparable results.

537.311.33 : 546.28 **2289**

Precipitation on a Dislocation.—R. Bullough, R. C. Newman, J. Wakefield & J. B. Willis. (*Nature, Lond.*, 3rd Jan. 1959, Vol. 183, No. 4653, pp. 34–35.) A study of the effect of heat treatment on Si crystals containing up to 10^{17} Al atoms per cm^3.

537.311.33 : 546.28 **2290**

Gold in Silicon.—G. Bemski & J. D. Struthers. (*J. electrochem. Soc.*, Oct. 1958, Vol. 105, No. 10, pp. 588–591.) Experimental results indicate that changes in electrical characteristics after heat treatment in excess of 900°C are due to the introduction of gold concentrations. These can be removed, preferably by a Ni-Si liquidus on the surface of the sample (see 2290 above) or by vacuum heat treatment.

537.311.33 : 546.28 **2291**

Lattice Vibrations in Silicon by Scattering of Cold Neutrons.—H. Palevsky, D. J. Hughes, W. Kley & E. Tunkelo. (*Phys. Rev. Lett.*, 15th March 1959, Vol. 2, No. 6, pp. 258–259.)

537.311.33 : 546.28 **2292**

Density Change in Silicon upon Melting.—R. A. Logan & W. L. Bond. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, p. 322.)

537.311.33 : 546.28 **2293**

Impurity Compensation and Magnetoresistance in *p*-Type Silicon.—D. Long, C. D. Motchenbacher & J. Myers. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 353–362.) A new method is proposed for determining the separate concentrations of acceptor and donor impurities in crystals of *p*-type Si. The method involves finding the total concentration of impurities in a sample from a measurement of the weak-field magnetoresistance and combining this result with the excess of acceptors over donors.

537.311.33 : 546.28 **2294**

Some Effects of Oxygen on Resistivity in Silicon.—D. H. Roberts & B. L. H. Wilson. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 447–448.) Oxygen concentration has been determined from measurements of the absorption coefficient and the effect of heat treatment has been investigated.

537.311.33 : 546.28 **2295**

Strain-Optic Coefficient of Silicon for Infrared Light.—S. Prussin & A. Stevenson. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 452–453.) The coefficient has been found for birefringent patterns in a non-isotropic plate.

537.311.33 : 546.28 : 621.793 **2296**

Bonding Materials for Making Contacts to *p*-Type Silicon.—D. R. Mason & J. C. Sarace. (*J. electrochem. Soc.*, Oct. 1958, Vol. 105, No. 10, pp. 594–598.) A technique is described for bonding a Si wafer to a molybdenum base plate using Al or Al-Si eutectic, applied by rolling, as a bonding agent.

537.311.33 : 546.281.26 **2297**

Infrared Properties of Hexagonal Silicon Carbide.—W. G. Spitzer, D. Kleinman & D. Walsh. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 127–132.)

537.311.33 : 546.281.26 : 539.23 **2298**

Infrared Properties of Cubic Silicon Carbide Films.—W. G. Spitzer, D. A. Kleinman & C. J. Frosch. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 133–136.)

537.311.33 : 546.289 **2299**

Fine Structure in the Zeeman Effect of Excitons in Germanium.—K. J. Button, L. M. Roth, W. H. Kleiner, S. Zwerdling & B. Lax. (*Phys. Rev. Lett.*, 15th Feb. 1959, Vol. 2, No. 4, pp. 161–162.) A discussion of the results of an experimental study of exciton formation in Ge, based in the transmission of infrared radiation at 1·5°K at field strengths up to 38 900 oersteds.

537.311.33 : 546.289 **2300**

Magnetic Susceptibility of Photo-generated Current Carriers in Germanium.—J. O. Kessler & A. R. Moore. (*Phys. Rev. Lett.*, 15th March 1959, Vol. 2, No. 6, pp. 247–249.) A new method is described for measurement of the susceptibility of free carriers. The change in magnetism of the crystal due to photo-generated hole-electron pairs is measured, and requires a much higher detection sensitivity than previously achieved.

537.311.33 : 546.289 **2301**

Influence of Atomic Hydrogen on the Conductivity of Cleaned Germanium Surfaces.—G. Heiland & P. Handler. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 446–447.) Atomic hydrogen increases the *p*-type conductivity of a Ge surface cleaned by argon bombardment and annealing.

537.311.33 : 546.289 **2302**

Microwave-Induced Carrier Multiplication in Germanium.—K. Seeger. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 443–444.) The microwave breakdown of Ge at low temperatures has been investigated.

537.311.33 : 546.289 **2303**

Recombination Centres on Ion-Bombarded and Vacuum Heat-Treated Germanium Surfaces.—S. Wang & G. Wallis. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 285–290.) It was confirmed that after annealing of the bombardment damage, a large number of acceptor-type surface states essentially fixed the surface potential. Two types of recombination centre were identified: type 1, located near the middle of the gap, and type 2, located near the valence band.

537.311.33 : 546.289 **2304**

Lattice Vibrations in Germanium by Scattering of Cold Neutrons.—A. Ghose, H. Palevsky, D. J. Hughes, I. Pelah & C. M. Eisenhauer. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 49–52.) The dispersion relations for the optical and acoustical vibrations in the [100] and [110] directions in Ge have been determined. An improved experimental method is described.

537.311.33 : 546.289 **2305**

Thermal and Radiation Annealing of Ge.—J. W. Mackay, E. E. Klontz & G. W. Gobeli. (*Phys. Rev. Lett.*, 15th Feb. 1959, Vol. 2, No. 4, pp. 146–148.) It was found that about 50% of the defects produced by 1·10-MeV electron irradiation of Ge at 10°K could be annealed either by heating or by irradiation at lower energies.

537.311.33 : 546.289 **2306**

Length and Resistivity Changes in Germanium upon Low-Temperature Deuteron Irradiation and Annealing.—F. L. Vook & R. W. Balluffi. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 62–69.) Simultaneous measurements of the length change and resistivity of high-purity Ge single crystals were made upon irradiation and annealing. The specific length expansion was $\Delta L/L = (1\cdot5 \pm 0\cdot3) \times 10^{-21}$/(deuteron/cm^2). The annealing showed a gradual recovery of the expansion which was observable only after warming to above 200°K.

537.311.33 : 546.289 **2307**

Lattice Parameter Changes in Deuteron-Irradiated Germanium.—R. O. Simmons. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 70–71.) A lattice expansion of 3×10^{-5} was measured in Ge irradiated by $1\cdot5 \times 10^{17}$ 9-MeV deuterons/cm^2 at low temperature and annealed to 320°K. The results provide confirmatory evidence that structural damage in deuteron-irradiated Ge consists of well-localized centres of dilatation.

537.311.33 : 546.289 **2308**

Structure of Deuteron-Irradiated Germanium.—F. L. Vook & R. W. Balluffi. (*Phys. Rev.*, 1st Jan. 1959, Vol. 113, No. 1, pp. 72–78.) Discussion in the light of recent experiments (2306 and 2307 above) together with low-angle X-ray scattering measurements at liquid-nitrogen temperatures. A model of the damage at liquid-nitrogen temperature consisting of separated clusters of vacancies and interstitials is proposed.

537.311.33 : 546.289 **2309**

Anomalous Transmission of X-Rays by Single-Crystal Germanium.—L. P. Hunter. (*Proc. kon. ned. Akad. Wetensch.*, *B*, 1958, Vol. 61, No. 3, pp. 214–219. In English.)

537.311.33 : 546.289 **2310**

The Reaction of Germanium with Nitric Acid Solutions.—M. C. Cretella & H. C. Gatos. (*J. electrochem. Soc.*, Sept. 1958, Vol. 105, No. 9, pp. 487–496.)

537.311.33 : 546.621.86 **2311**

Preparation and Properties of Aluminium Antimonide.—A. Herczog, R. R. Haberecht & A. E. Middleton. (*J. electrochem. Soc.*, Sept. 1958, Vol. 105, No. 9, pp. 533–540.) The known properties of AlSb are compared with those of other high-energy-gap semiconductors and features which suggest its suitability for use in high-temperature devices are discussed. Techniques are described for growing AlSb crystals by the Czochralski method. The resistivity of *p*-type crystals can be decreased by doping with C or increased by adding small amounts of Se or Te. Various surface treatments are described and brief data on point-contact and *p-n* junction diodes are given.

537.311.33 : 546.682.24 **2312**

Indium Monotelluride.—H. C. Wright & J. C. Brice. (*Nature, Lond.*, 3rd Jan. 1959, Vol. 183, No. 4653, pp. 27–28.) A report of measurements which reveal the anomalous properties of the compound. Certain electrical properties indicate a metallic nature, but the large value of the thermal e.m.f., the computed Wiedemann-Franz ratio and the large variation of resistivity are more characteristic of a semiconductor.

537.311.33 : 621.317.3 **2313**

Technique for Measuring Particle Drift Mobilities in Near-Intrinsic and Narrow-Band-Gap Semiconductors.—N. J. Harrick. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 451–452.)

537.311.62 : 537.312.62 **2314**

The Variation with Frequency of the Resistance of Superconducting Tin and Indium.—M. D. Sturge. (*Proc. Roy. Soc. A*, 26th Aug. 1958, Vol. 246, No. 1247, pp. 570–581.) The ratio of the superconducting to the normal resistance of tin has been measured calorimetrically at frequencies between 220 and 8 500 Mc/s, as a function of temperature, crystal orientation and purity. Some approximate measurements on indium indicate that the superconducting resistance varies as the square of the frequency up to 5 kMc/s.

537.323 **2315**

Effect of Oxide Impurities on the Thermoelectric Powers and Electrical Resistivities of Bismuth, Antimony, Tellurium, and Bismuth-Tellurium Alloys.—R. A. Horne. (*J. appl. Phys.* March 1959, Vol. 30, No. 3, pp. 393–397.) The thermoelectric properties of Bi and Sb are only slightly changed by the presence of oxide but small concentrations of TeO_2 greatly increase the thermoelectric power of Te.

537.533.8 **2316**

Secondary Electron Emission from MgO Thin Films.—N. R. Whetten & A. B. Laponsky. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 432–435.) The properties of MgO films have been measured by pulse and d.c. methods. The high yields observed are due primarily to the properties of bulk crystalline MgO.

538.22 : 538.569.4 **2317**

Spin-Phonon Interaction in Ruby.—N. S. Shiren & E. B. Tucker. (*Phys. Rev. Lett.*, 1st March 1959, Vol. 2, No. 5, pp. 206–207.) An experiment is described which shows that 'hot phonon' theories of paramagnetic relaxation are inapplicable to ruby.

538.221 **2318**

Ferromagnetic Granular Structures.—P. M. Prache. (*Câbles & Transm.*, Jan. & April 1957, Nos. 1 & 2, pp. 32–65 & 128–166.) 83 references.

538.221 **2319**

Domain Boundary Configurations during Magnetization Reversals.—J. J. Becker. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 387–390.) The signal produced by applying an alternating field while a magnetization reversal is occurring is a measure of the total domain boundary area. The technique is used for measurements on 65 Permalloy tape cores and 3¼% silicon-iron crystal.

538.221 **2320**

Ferromagnetic After-Effect in Mumetal.—L. Castelliz & W. W. H. Clarke. (*Brit. J. appl. Phys.*, March 1959, Vol. 10, No. 3, pp. 142–147.) Measurements of the response of c.r. tube deflection yokes with thin mumetal laminations to a step-function current have revealed a magnetic after-effect in addition to that caused by eddy currents. It is suggested that the new phenomenon is similar to nuclear magnetic time delay.

538.221 **2321**

Magnetic Moments of Alloys and Compounds of Iron and Cobalt with Rare-Earth Metal Additions.—E. A. Nesbitt, J. H. Wernick & E. Corenzwit. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 365–367.) Data on the Co-Gd system indicate that antiferromagnetic exchange coupling exists in this system.

538.221 : 538.632 **2322**

Hall Effect in Pure Nickel at Helium Temperatures.—N. V. Volkenshteĭn, G. V. Fedorov & S. V. Vonsovskiĭ. (*Zh. eksp. teor. Fiz.*, July 1958, Vol. 35, No. 1(7), pp. 85–88.) Investigations carried out on 99·99% pure Ni in the temperature range 300°–14°K show that the ferromagnetic constant drops sharply with temperature showing a minimum at 20°–30°K. Experimental results are shown graphically.

538.221 : 621.3.042.15 **2323**

Iron Powders for Cores.—(*Electronics*, 13th March 1959, Vol. 32, No. 11, p. 141.) Typical properties of pressed and sintered cores are tabulated.

538.221 : 621.318.124 **2324**

Magnetic Materials with Perminvar Effect: Part 3—The Relation between Overstoichiometric Oxygen Content and Perminvar Effect in Ferrites containing Cobalt.—A. v. Kienlin. (*Z. angew. Phys.*, April 1958, Vol. 10, No. 4, pp. 167–169.) Parts 1 & 2: 1284 of April.

538.221 : 621.318.134 **2325**

Magnetic Viscosity Displayed on Hysteresis Loop Traces.—R. G. George. (*Nature, Lond.*, 24th Jan. 1959, Vol. 183, No. 4656, p. 245.) Results are given of measurements on a polycrystalline Mg-Mn ferrite, using superposed pulse and a.c. magnetizations. They are in agreement with those obtained by Galt (175 of 1955).

538.221 : 621.318.134 **2326**

Calculation of the Square Hysteresis Loop of Ferrites.—K. Ganzhorn. (*Z. angew. Phys.*, April 1958, Vol. 10, No. 4, pp. 169–172.) Evaluation of a hysteresis loop, by means of an electronic computer, on the basis of a theory founded on pure spin processes and a statistical distribution of crystal orientations. A comparison with experimental results is made.

538.221 : 621.318.134 **2327**

Relation between Disaccommodation and Magnetic Properties of Manganese Ferrous Ferrites.—U. Enz. (*Physica*, July 1958, Vol. 24, No. 7, pp. 609–624.) Initial permeability, crystalline anisotropy, and magnetostriction have been measured on a single crystal and compared with corresponding measurements for polycrystalline material. See 3179 of 1958.

538.221 : 621.318.134 **2328**

Variation of the *g*-Factor of Yttrium Garnet in which Cr^{3+} Ions have been Substituted for Fe^{3+} Ions.—R. Vautier & A. J. Berteaud. (*C. R. Acad. Sci., Paris*, 27th Oct. 1958, Vol. 247, No. 17, pp. 1322–1324.) The value of *g*, measured in the 3-cm-λ band and extrapolated to a specimen diameter of zero, increases with the percentage of chromium, but in a non-uniform manner. See 3181 of 1958 (Villers & Loriers) for study of saturation moment.

538.221 : 621.318.134 **2329**

Variation of the Width of the Absorption Curve of Yttrium-Iron Garnet with the Substitution of Cr^{3+}.—R. Vautier & A. J. Berteaud. (*C. R. Acad. Sci., Paris*, 10th Nov. 1958, Vol. 247, No. 19, pp. 1574–1577.) The variations can be explained by a variation of density with the percentage of chromium.

538.221 : 621.318.134 : 538.569.4 **2330**

Line Widths in Polycrystalline Yttrium-Iron Garnet.—L. G. Van Uitert, F. W. Swanekamp & S. E. Haszko. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3 pp. 363–365.) Measurements at 16 kMc/s show the dependence of resonance line width upon iron content in dense samples.

538.221 : 621.318.134 : 548.0 **2331**

Some Properties of Mixed Dysprosium-Yttrium, Dysprosium-Gadolinium and Dysprosium-Erbium Garnets.—G. Villers & J. Loriers. (*C. R. Acad. Sci., Paris*, 13th Oct. 1958, Vol. 247, No. 15, pp. 1101–1104.)

538.569.4 **2332**

High-Frequency Susceptibilities of some Paramagnetic Alums at Liquid-Hydrogen Temperatures.—J. C. Verstelle, G. W. J. Drewes & C. J. Gorter. (*Physica*, Aug. 1958, Vol. 24, No. 8, pp. 632–638.) Samples of Cr and Fe alum were studied at frequencies between 1 and 20 Mc/s.

538.569.4 : 538.222 : 546.824-31 **2333**

Fine Structure, Hyperfine Structure, and Relaxation Times of Cr^{3+} in TiO_2 (Rutile).—H. J. Gerritsen, S. E. Harrison, H. R. Lewis & J. P. Wittke. (*Phys. Rev. Lett.*, 15th Feb. 1959, Vol. 2, No. 4, pp. 153–155.) Resonances observed at 23 800 Mc/s and 9 520 Mc/s in the paramagnetic spectrum are shown as a function of field and crystal orientation.

549.514.51 **2334**

The Anelasticity of Natural and Synthetic Quartz at Low Temperatures.—J. C. King. (*Bell Syst. tech. J.*, March 1959, Vol. 38, No. 2, pp. 573–602.)

549.514.51 : 534.133 **2335**

Multiple-Beam Interferometric Studies on Oscillating Quartz Crystals.—S. Tolansky & A. F. B. Wood. (*Physica*, Special Issue, 16th June 1958, Vol. 24, No. 6, pp. 508–518.) Multiple-beam interferometry is used to study the displacements perpendicular to the surface associated with the longitudinal vibrations of a circular Z-cut quartz disk.

621.315.61 : 537.529 **2336**

Corona Discharge—the Failing of Dielectrics.—C. D. Nail. (*Electronic Ind.*, Sept. 1958, Vol. 17, No. 9, pp. 74–77.) Experimental and theoretical evidence indicates that breakdown is caused primarily by high-energy electron bombardment.

669.046.54/.55 **2337**

Improvement in Floating-Zone Technique.—W. G. Pfann, K. E. Benson & D. W. Hagelbarger. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 454–455.) A note on the use of different stationary zone forms.

MEASUREMENTS AND TEST GEAR

531.76 : 621.374.32 **2338**

Vernier Chronotron.—H. W. Lefevre & J. T. Russell. (*Rev. sci. Instrum.*, March 1959, Vol. 30, No. 3, pp. 159–166.) The instrument is a multichannel time interval analyser with digital output for use in the millimicrosecond region. The analyser consists of two transmission-line circulators of slightly different periods with a single fast coincidence circuit between them and associated gating circuits. Linearity, stability and time resolution are discussed.

531.76 : 621.376.5 **2339**

Encoder measures Random-Event Time Intervals.—R. J. Kelso & J. C. Groce. (*Electronics*, 20th March 1959, Vol. 32, No. 12, pp. 48–51.) The transistorized encoder stores and reads out the elapsed time between consecutive but randomly occurring events. Read-out data are converted to traces on a c.r.o. and recorded photographically.

621.3.018.41 (083.74) **2340**

Circuits employed in the N.P.L. Caesium Standard.—L. Essen, E. G. Hope & J. V. L. Parry. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 240–244.) A description of the circuits used to excite the caesium resonance and to measure the resonance frequency to an accuracy within ± 1 part in 10^{10}. The excitation frequency is derived by multiplication of a 5·0069-Mc/s signal from a quartz oscillator. An alternative, simpler system is described and some comments are made on the problem of frequency synthesis.

621.317.3 : 621.314.63 **2341**

A Method for Testing and Establishing the Rating of Semiconductor Rectifiers under Dynamic Conditions.—J. I. Missen. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 3–10.) Junction temperature is monitored under working conditions at mains frequency, using a synchronous commutator to separate forward and reverse half-cycles. The method is particularly useful for life-testing, and a circuit suitable for testing large quantities is given.

621.317.3 : 621.375.2.024 **2342**

Zeroing of Direct-Current Amplifiers.—R. W. Tolmie. (*Rev. sci. Instrum.*, March 1959, Vol. 30, No. 3, pp. 205–206.)

621.317.3 : 621.375.9 : 538.569.4.029.6 **2343**

Calculation and Measurement of the Noise Figure of a Maser Amplifier.—J. C. Helmer & M. W. Muller. (*Trans. Inst. Radio Engrs*, April 1958, Vol. MTT-6, No. 2, pp. 210–214. Abstract, *Proc. Inst. Radio Engrs*, June 1958, Vol. 46, No. 6, p. 1329.)

621.317.3 : 621.385.1 : 621.396.822 **2344**

A Filament Noise Source for 3 Gc/s.—E. W. Collings. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 97–101.) The construction of an incandescent filament lamp and tuned-waveguide mount is described. The filament temperature and losses in the lamp mounting have been measured. The noise source is useful as a standard in the determination of the noise temperature of gas discharges.

621.317.3 : 621.396.822 : 621.397.8 **2345**

The Measurement of Random Noise in the Presence of a Television Signal.—L. E. Weaver. (*B.B.C. Engng Div. Monographs*, March 1959, No. 24, pp. 5–14.) A substitution method is described, based upon sampling the random noise in the minimum-energy regions of the spectrum. Accuracy of measurement is within ± 1 dB.

621.317.3.089.6 : 621.318.42 **2346**

The Calibration of Inductors at Power and Audio Frequencies.—G. H. Rayner. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 38–46.) Methods of inductance measurement at the National Physical Laboratory are described.

621.317.334 : 621.397.62 **2347**

Video Output Stage with Wire-Wound Anode Resistor for Television Receivers.—K. Hecker. (*Elektronische Rundschau*, June 1958, Vol. 12, No. 6, pp. 191–193.) A method of measuring accurately the inductance of wire-wound resistors with high resistance is described.

621.317.335.029.65 **2348**

Measurement of the Dielectric Properties of Low-Loss Materials at Millimetre Wavelengths.—A. G. Mungall. (*Canad. J. Phys.*, Dec. 1958, Vol. 36, No. 12, pp. 1672–1677.) A free-space technique involving the measurement of the Brewster angle for the determination of the dielectric constant, and a measurement of the transmission loss at this angle for the determination of the loss tangent.

621.317.35 : 519.272.119 **2349**

Technique for Measurement of Cross-Spectral Density of Two Random Functions.—M. S. Uberoi & E. G. Gilbert. (*Rev. sci. Instrum.*, March 1959, Vol. 30, No. 3, pp. 176–180.)

621.317.39 : 531.76 : 535.37 **2350**

The Measurement of Extremely Short Afterglows of Electronically Excited Luminophores.—K. Heine. (*Elektronische Rundschau*, May 1958, Vol. 12, No. 5, pp. 164–167.) The equipment described covers the range 10^{-3} to about 10^{-8} sec; the afterglow decay function is displayed on a c.r.o. screen.

621.317.441 **2351**

Improvement in the Magnetic Detecting Power of Iron-Cored Search Coils.—D. F. Walker. (*Nature, Lond.*, 17th Jan. 1959, Vol. 183, No. 4655, pp. 173–174.) An eight-fold increase in detecting power may be obtained by fitting permeable collector cones to the ends of the rod on which search coils are wound. The increase is related almost linearly to the diameter of the cone.

621.317.7 : 621.396.96.089.6 **2352**

Precision Generator for Radar Range Calibration.—D. Broderick, D. Hartke & M. Willrodt. (*Electronics*, 3rd April 1959, Vol. 32, No. 14, pp. 58–60.) Two delayed pulses are produced with separations of 1–10 000 μs, adjustable in 1-μs steps. The oscillator is crystal-controlled to 1 part in 10^5 from $-10°$ to $+50$ °C.

621.317.7.029.64 : 621.316.72 **2353**

Amplitude Stabilization of a Microwave Signal Source.—G. F. Engen. (*Trans. Inst. Radio Engrs*, April 1958, Vol. MTT-6, No. 2, pp. 202–206. Abstract, *Proc. Inst. Radio Engrs*, June 1958, Vol. 46, No. 6, p. 1329.)

621.317.715.083.5 : 621.383 **2354**

The Measurement Limit of Photocell Compensators.—H. G. Pohl. (*Z. angew. Phys.*, March 1958, Vol. 10, No. 3, pp. 125–127.) The improvement of the performance of photoelectric compensating circuits used for measurements with mirror galvanometers is discussed. This can be achieved by lengthening the time constant of the grid circuit of the amplifying valve at the expense of a somewhat slower system response. See also 2064 and 2065 of 1955 (Kelen).

621.317.725 **2355**

Digital Voltmeter.—H. Sutcliffe. (*Electronic Radio Engr*, May 1959, Vol. 36, No. 5, pp. 160–166.) Voltages in the ranges 0–1 and 0–10 V can be measured with a maximum error of $\pm 0{\cdot}02$ % of full scale reading.

621.317.729 **2356**

Space-Charge Simulation in an Electrolytic Tank.—T. Van Duzer & G. R. Brewer. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 291–301.) A description is given of the theory and design of a system for simulating space-charge effects by means of electric currents injected into the electrolyte through probes in the tank floor.

621.317.75 **2357**

The Recording and Collocation of Waveforms: Part 2.—R. J. D. Reeves. (*Electronic Engng*, April 1959, Vol. 31, No. 374, pp. 204–212.) A detailed description of an instrument for the permanent recording of waveforms is given. The vertical scale accuracy is within 0·5 % and the range covered is 50 V/in.–0·5 V/in. on time scales ranging from 500 μs/in. to 0·1 μs/in. on paper 10 in. × $7\frac{1}{2}$ in. The pen is driven by a bowed tape that can transmit thrust as well as tension forces and requires no return loop. Part 1: 1650 of May.

621.317.789.029.6 **2358**

Broad-Band Calorimeters for the Measurement of Low- and Medium-Level Microwave Power.—(*Trans. Inst. Radio Engrs*, April 1958, Vol. MTT-6, No. 2, pp. 188–202. Abstract, *Proc. Inst. Radio Engrs*, June 1958, Vol. 46, No. 6, p. 1329.)

Part 1—Analysis and Design.—M. Sucher & H. J. Carlin (pp. 188–194).

Part 2—Construction and Performance.—A. V. James & L. O. Sweet (pp. 195–202).

621.317.789.029.64 **2359**

A Wide-Band Double-Vane Torque-Operated Wattmeter for 3-cm Microwaves.—A. L. Cullen, B. Rogal & S. Okamura. (*Trans. Inst. Radio Engrs*, April 1958, Vol. MTT-6, No. 2, pp. 133–136. Abstract, *Proc. Inst. Radio Engrs*, June 1958, Vol. 46, No. 6, p. 1328.)

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

551.508 : 629.19 **2360**

'Moons' aid Weather Research.—(*Electronics*, 20th March 1959, Vol. 32, No. 12, pp. 26–27.) Current research using artificial satellites includes cloud-cover mapping and measurement of heat-balance of the earth. Instrumentation covers infrared sensors, television cameras and radar.

615.84 : 621.396.677.7.029.6 **2361**

A Wide-Band Radiator of Variable Wavelength with Continuously Adjustable Matching in the Range $\lambda = 30$ to 70 cm.—A. Sander. (*Elektronische Rundschau*, May 1958, Vol. 12, No. 5, pp. 155–159.) A microwave radiator for heat therapy is described which is suitable for treatment at close range or at a distance.

621.3.087.4 : 621.385.832 **2362**

System Design of the Flying-Spot Store.—C. W. Hoover, Jr, G. Haugk & D. R. Herriott. (*Bell Syst. tech. J.*, March 1959, Vol. 38, No. 2, pp. 365–401.) The factors which control speed, capacity, number of channels, physical size and probability of error in read-out are discussed.

621.3.087.4 : 621.385.832 **2363**

Optics and Photography in the Flying-Spot Store.—M. B. Purvis, G. V. Deverall & D. R. Herriott. (*Bell Syst. tech. J.*, March 1959, Vol. 38, No. 2, pp. 403–424.) A discussion of the optical and photographic problems to be considered in the construction of a flying-spot store.

621.3.087.4 : 621.385.832 **2364**

Beam-Positioning Servo System for the Flying-Spot Store.—L. E. Gallaher. (*Bell Syst. tech. J.*, March 1959, Vol. 38, No. 2, pp. 425–444.) The characteristics of the basic servo loop and its components are discussed.

621.3.087.9 : 621.374.5 **2365**

Digital Recorder holds Data after Shock.—C. P. Hedges. (*Electronics*, 20th March 1959, Vol. 32, No. 12, pp. 60–62.) A recorder memorizes the instantaneous magnitude of parameters when triggered by a predetermined set of conditions. Ferrite cores store data and subsequent interrogation releases the stored information for processing.

621.3.087.9 : 621.395.625.3 **2366**

Sampling Discriminators for Data Reduction.—P. S. Bengston. (*Electronics*, 27th March 1959, Vol. 32, No. 13, pp. 70–72.) The data are recorded as f.m. signals on one channel of a magnetic tape. The second channel contains a constant reference signal which allows wow and flutter to be eliminated in the playback.

621.362 : 621.385.2 **2367**

Thermionic Diode as a Heat-to-Electrical-Power Transducer.—Nottingham. (See 2434.)

621.362 : 621.385.2 **2368**

Addendum Remarks on a Diode Configuration of a Thermo-Electron Engine.—Nottingham, Hatsopoulos & Kaye. (See 2435.)

621.383.2 : 778.37 **2369**

Shutter Image Converter Tube for Multiple-Frame Photography.—W. O. Reed & W. F. Niklas. (*J. Soc. Mot. Pict. Telev. Engrs*, Jan. 1959, Vol. 68, No. 1, pp. 1–5.) The tube described has a Cs-Sb photocathode, e.s. focusing and e.m. deflection, and is capable of exposure times of about 1 mμs.

621.384.611 **2370**

Stability and Isochronism in Cyclotrons with a Star-Shaped Field.—F. Fer. (*C. R. Acad. Sci., Paris*, 13th Oct. 1958, Vol. 247, No. 15, pp. 1097–1098.)

621.397.3 : 681.142 **2371**

Pattern Recognition by means of Automatic Analogue Apparatus.—W. K. Taylor. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 198–209.) The problem of pattern recognition is discussed. Analogue circuits, rather than digital switching circuits, provide the simpler solution. The results indicate the possibility of recognition of the alphabet and numerals in a variety of styles and sizes, typed or handwritten.

621.397.3 : 681.142 **2372**

A System for the Automatic Recognition of Patterns.—R. L. Grimsdale, F. H. Sumner, C. J. Tunis & T. Kilburn. (*Proc. Instn elect. Engrs*, Part B, March 1959, Vol. 106, No. 26, pp. 210–221.) The pattern is presented to a flying-spot scanner connected to a digital computer which prepares a statement describing the basic features of the pattern. The latter is then recognized by comparing this statement with a number of others already stored and which relate to named patterns.

621.398 : 621.314.7 **2373**

Transistors Improve Telemeter Transmitter.—D. Enemark. (*Electronics*, 13th March 1959, Vol. 32, No. 11, pp. 136–137.) Battery weight of balloon-borne units is reduced and better frequency stability and modulation consistency are obtained.

621.398 : 621.387 **2374**

Telemetering employing the Principle of the Gas-Filled Stepping Tube.—Y. Hatta. (*Electronic Engng*, April 1959, Vol. 31, No. 374, pp. 227–229.) Rotational displacement can be telemetered, without slip, by a digital device using a small frictionless transmitter of low inertia.

PROPAGATION OF WAVES

621.396.11 **2375**

A Comparison of Millington's Method and the Equivalent Numerical Distance Method with the Theory of Ground-Wave Propagation over an Inhomogeneous Earth.—Z. Godziński. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 62–69.) Millington's method (1758 of 1949) is sufficiently accurate for most practical problems; errors are very small for overland paths, and land/sea paths involve errors of 2·7 dB and 5·5 dB for 2- and 3-section paths respectively. In most cases, the 'equivalent numerical distance' method shows considerable errors, and is reliable only for small numerical distances or for longer paths with little inhomogeneity. See also 3949 of 1958.

621.396.11 **2376**

Long-Distance Propagation.—(*Wireless World*, May 1959, Vol. 65, No. 5, p. 234.) General information concerning forthcoming tests between Ascension Island and Slough to investigate modes of propagation and associated aerial design. The frequency of the transmitter in Ascension Island can be stepped by increments of 20 kc/s from 5·5 to 50 Mc/s in about 15 minutes; the receiver tuning is automatically synchronized.

621.396.11 : 551.510.535 **2377**

Ray Paths in the Ionosphere. Approximate Calculations in the Presence of the Earth's Magnetic Field.—J. E. Titheridge. (*J. atmos. terr. Phys.*, April 1959, Vol. 14, Nos. 1/2, pp. 50–62.) The approximate ionospheric ray paths are derived for both linear and parabolic electron-density/height distributions. From these paths values of the horizontal displacement of the reflection point are estimated and are found to be less than 10 km for all angles of propagation provided the transmission frequency is greater than 5 Mc/s.

621.396.11 : 551.510.535 **2378**

Further Results of Sweep-Frequency Oblique-Incidence Pulse Transmissions.—W. Dieminger, H. G. Möller & G. Rose. (*J. atmos. terr. Phys.*, April 1959, Vol. 14, Nos. 1/2, pp. 179–180, plate.) Attention is drawn to the importance of the F_1-layer in oblique-incidence circuits. For summertime European circuits over 2 000 km the F_1-layer m.u.f. is greater than the F_2-layer m.u.f. by about 2 Mc/s for 14 hours of the day.

621.396.11.029.6 **2379**

The Propagation of Ultra Short Waves along Rough Layers.—R. Schünemann. (*Hochfrequenztech. u. Elektroakust.*, May 1958, Vol. 66, No. 6, pp. 171–173.) Theoretical investigation of the propagation mechanism for various types of scattering surface in the atmosphere in relation to field-strength measurements (see 3235 of 1958). Field-strength fluctuations with time can be determined using the probability distribution discussed by Norton et al. (197 of 1956).

621.396.11.029.62 : 523.164 **2380**

Observations of Abnormal V.H.F. Radio Wave Absorption at Medium and High Latitudes.—G. C. Reid & C. Collins. (*J. atmos. terr. Phys.*, April 1959, Vol. 14, Nos. 1/2, pp. 63–81.) Absorption of cosmic noise at 30 Mc/s has revealed two distinct types of abnormal event: (*a*) a night-time phenomenon closely associated with auroral and geomagnetic disturbances; it is suggested that this is due to an increase in the electron collision frequency; (*b*) a daytime phenomenon confined to the auroral zone and occurring several days after a solar flare; this may be due to an increase in the low-level electron density.

621.396.11.029.64 **2381**

Radio Attenuation at 11 kMc/s and some Implications affecting Relay System Engineering.—S. D. Hathaway & H. W. Evans. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 930–938.) Measurements of attenuation have been related to amounts of rainfall; agreement with theory is quite good.

RECEPTION

621.376.23 : 517.512.2 **2382**

Multiple Fourier Analysis in Rectifier Problems.—R. L. Sternberg, J. S. Shipman & S. R. Zohn. (*Quart. appl. Math.*, Jan. 1959, Vol. 16, No. 4, pp. 335–360.) Theory of a cut-off power-law rectifier with up to three signals of different frequency applied simultaneously. The main functions required are shown in graphs and are available in tabular form.

621.396.621.2 **2383**

The Influence of the Top-End Capacitance in Inductive Aerial Couplings.—H. Röbel. (*Elektronische Rundschau*, June 1958, Vol. 12, No. 6, pp. 194–196.) The design of receiver aerial input stages is considered taking account of stray capacitance.

621.396.8 : 551.510.535 : 621.317.373 **2384**

Phase Characteristics of Radio Signals Received via the Ionosphere.—D. W. Morris & C. J. Hughes. (*Nature, Lond.*, 31st Jan. 1959, Vol. 183, No. 4657, pp. 310–311.) A brief description of a phase-measurement system using two spaced aerials and a gate-operated analyser which indicates on counters the phase difference distribution.

621.396.8 : 621.396.666 **2385**

Simplified Frequency-Diversity Method.—H. Völz. (*Elektronische Rundschau*, June 1958, Vol. 12, No. 6, pp. 200–202.) The double-diversity system described is particularly suitable for v.h.f. f.m. reception; the i.f. and subsequent stages are common to both channels.

621.396.823.029.6 : 621.317.3 **2386**

Radio Interference in the Ultra-Short-Wave Range, its Propagation, Forms of Appearance and Measurement.—W. Knopf. (*NachrTech.*, April 1958, Vol. 8, No. 4, pp. 167–173.) Test arrangements and specifications of equipment suitable for interference field-strength measurements are discussed.

STATIONS AND COMMUNICATION SYSTEMS

621.391 **2387**

Binary Communication Feedback Systems.—B. Harris, A. Hauptschein, K. C. Morgan & L. S. Schwartz. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 960–969.) Discussion of different types of decision-feedback and information-feedback systems.

621.391 **2388**

Binary Channels in Cascade.—J. Loeb. (*Ann. Télécommun.*, Jan./Feb. 1958, Vol. 13, Nos. 1/2, pp. 42–44.) A method is described for resolving ambiguities.

621.391 **2389**

Error Probability of Binary Coded Messages with Interference by White Noise.—H. J. Held. (*Nachrichtentech. Z.*, May 1958, Vol. 11, No. 5, pp. 244–249.) The effect of error-correcting codes on the reliability of binary-code transmission systems is investigated.

621.391 : 621.372.54 **2390**

Finite-Duration Signals with Maximum Filtered Energy.—J. A. Ville & J. Bouzitat. (*Câbles & Transm.*, April 1957, Vol. 11, No. 2, pp. 102–127.) A study of the maximum value of power efficiency which can be obtained in the transmission of a signal of finite duration through an ideal low-pass filter having a sharp cut-off at a given frequency. See also 1206 of 1956.

621.391 : 621.372.54 **2391**

On the Interpolation and Prediction of Signals plus Noise for Infinite and Finite Smoothing Times.—D. McDonnell & R. W. Perkins. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 47–54.) Laplace transformations are used to solve the Wiener-Hopf integral equation for the lagging (non-prediction) case. The solution of the optimum filter for minimum error at a given time after switch-on is also derived, the averaging being taken over an ensemble.

621.394.3 : 621.376.3 **2392**

A Frequency-Modulation Digital Subset for Data Transmission over Telephone Lines.—L. A. Weber. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 867–872.) The subset converts digital information to a.f. tones and reconverts incoming information.

621.396.41 **2393**

A 6 000-Megacycle Radio System for Toll Telephone Service.—M. H. Kebby & A. F. Culbertson. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 969–979.) Gives details of construction and performance of a 240-channel (1 200-kc/s baseband) system with frequency division multiplexing and facilities for space or frequency diversity. R.f. channel separation is achieved by a ferrite circulator.

621.396.41 : 534.782 **2394**

Simple Multiplex Vocoder.—A. R. Billings. (*Electronic Radio Engr*, May 1959, Vol. 36, No. 5, pp. 184–188.) Describes a time-division vocoder with a common rectifier for all channels.

621.396.41 : 621.395.665.1 **2395**

A Transistorized Compandor.—J. C. Perkins, Jr, D. A. Perreault & A. F. Perkins. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 791–797.) An instrument for general use in speech transmission circuits.

621.396.41 : 621.396.82 **2396**

Echoes Cause F.M. Intermodulation.—H. E. Curtis. (*Electronic Ind.*, Sept. 1958, Vol. 17, No. 9, *Electronic Operations Section*, pp. 06–07.) A method is described for calculating the degree of intermodulation introduced by mismatched transmission lines in multichannel f.m. systems. See also 3089 of 1955 (Bennett et al.).

621.396.5 : 534.76 **2397**

Recent Developments in Stereo Broadcasting.—J. M. Carroll. (*Electronics*, 3rd April 1959, Vol. 32, No. 14, pp. 41–46.) Some details, including block diagrams, are given for twelve different stereophonic broadcast systems and methods, that have been used or proposed as compatible systems. See also *ibid.*, 10th April 1959, Vol. 32. No. 15, p. 78.

621.396.65 : 621.396.41 **2398**

The Expansion of the Pacific Coast Microwave Network.—R. G. Kuck. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 898–903.)

SUBSIDIARY APPARATUS

621.311.69 : 629.19 **2399**

New Power Sources for Space-Age Electronics.—D. Linden & A. F. Daniel. (*Electronics*, 20th March 1959, Vol. 32, No. 12, pp. 43–47.) Developments are described in chemical, nuclear and solar energy sources which are expected to fulfil requirements for portable electrical power in space. Output characteristics of different types are summarized.

621.314.63 : 621.317.3 **2400**

A Method for Testing and Establishing the Rating of Semiconductor Rectifiers under Dynamic Conditions.—Missen. (See 2341.)

621.316.722.078.3 **2401**

Regulated Power Supplies.—D. J. Collins & J. E. Smith. (*Electronic Engng*, April 1959, Vol. 31, No. 374, pp. 222–226.) A brief review is made of various types of stabilized power supply leading to the closed-loop series regulator for which design details are given.

621.352.7 **2402**

Dry Cells containing Various Aromatic C-Nitroso Compounds as Cathode Materials.—C. K. Morehouse & R. Glicksman. (*J. electrochem. Soc.*, Nov. 1958, Vol. 105, No. 11, pp. 619–624.) The cells have a Mg anode and an aqueous $MgBr_2$ solution as electrolyte. Performance characteristics compare favourably with those of commercial Leclanché-type cells.

621.355.2 **2403**

Self-Discharge Reactions in Lead-Acid Batteries.—P. Rüetschi & R. T. Angstadt. (*J. electrochem. Soc.*, Oct. 1958, Vol. 105, No. 10, pp. 555–563.) In a theoretical and experimental analysis, the rates of seven different reactions which contribute to the self-discharge process have been determined. 54 references.

TELEVISION AND PHOTOTELEGRAPHY

621.397.5 : 535.623 **2404**

On the Quality of Colour-Television Images and the Perception of Colour Detail.—O. H. Schade, Sr. (*J. Soc. Mot. Pict. Telev. Engrs*, Dec. 1958, Vol. 67, No. 12, pp. 801–818. Discussion, pp. 818–819.) A theoretical and experimental examination of the N.T.S.C. colour system shows that contrast range and colour saturation obtained with commercial tricolour kinescopes provide a larger colour space than that provided by colour motion pictures.

621.397.611.2 **2405**

Standard Converter using a Vidicon Camera.—W. Dillenburger. (*Arch. elekt. Übertragung*, May 1958, Vol. 12, No. 5, pp. 209–224.) A special vidicon tube has been developed for use in equipment for the conversion of television standards. Results obtained in converting from 819 to 625 and from 405 to 625 lines are reproduced and discussed and special circuit features are described.

621.397.62 : 621.317.334 **2406**

Video Output Stage with Wire-Wound Anode Resistor for Television Receivers.—Hecker. (See 2347.)

621.397.621.2 : 535.623 **2407**

Afterglow Problems in Colour-Television Picture Tubes.—I. Bornemann. (*Elektronische Rundschau*, June 1958, Vol. 12, No. 6, pp. 204–206.) Methods of modifying the afterglow characteristics of phosphors so as to improve the performance of colour-television tubes are discussed. See also 2251 of 1958.

621.397.8 **2408**

Subjective Impairment of Television Pictures.—L. E. Weaver. (*Electronic Radio Engr*, May 1959, Vol. 36, No. 5, pp. 170–179.) Flat and triangular noise waveforms of known levels were superimposed upon accurately standardized television 405-line and 605-line pictures; a number of observers recorded their opinions of the displays on a 5-point scale of assessment. The results are analysed and discussed.

621.397.8 : 621.396.822 : 621.317.3 **2409**

The Measurement of Random Noise in the Presence of a Television Signal.—Weaver. (See 2345.)

VALVES AND THERMIONICS

621.314.63 **2410**

D.C. Characteristics of a Junction Diode.—I. Ladany. (*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, p. 589.) Theoretical expressions are derived for the characteristics taking account of the field in the base region.

621.314.63 : 546.289 **2411**

The Influence of Geometrical and Physical Factors at the Point Contact of Germanium Diodes on the Characteristic.—E. Hofmeister & E. Groschwitz. (*Z. angew. Phys.*, March 1958, Vol. 10, No. 3, pp. 109–114.) Closer agreement between theory and experiment is obtained by the introduction of form factors which allow for the shape of the *p-n* junction formed at the point contact of the diode.

621.314.63 : 546.289 **2412**

High-Speed Switching Diodes from Plastically Deformed Germanium.—G. L. Pearson & R. P. Riesz. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 311–312.) The degradation of minority-carrier lifetime caused by dislocations generated during plastic deformation greatly reduced the minority-carrier storage effect and permitted fabrication of diodes with turnoff times of the order of 10^{-9} sec.

621.314.63 + 621.314.7] : 621.396.822 **2413**

Theory and Experiments on Shot Noise in Silicon *p-n* Junction Diodes and Transistors.—B. Schneider & M. J. O. Strutt. (*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, pp. 546–554.) New theoretical expressions are derived on the basis of recombination-generation in the depletion layer. They are shown by experiment to be satisfactory for silicon in the case of low-level current injection; at high-level injection deviations occur.

621.314.63 : 621.372.632 **2414**

Proposed Microwave Mixer Diode of Improved Conversion Efficiency.—L. B. Valdes. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 436–439.) The conversion efficiency can be improved by using a spherically symmetrical convergent flow of minority carriers in a semiconductor. The admittance will be small, and over a limited frequency range it may be possible to have a negative conductance.

621.314.632 **2415**

The Determination of the Characteristic Parameters of the Barrier Layer in Metal/Semiconductor Junction Diodes.—V. Andresciani, D. Sette & S. Tiberio. (*Note Recensioni Notiz.*, July/Aug. 1958, Vol. 7, No. 4, pp. 418–433.) Capacitance and thermal methods are compared in investigations of Cu/Cu_2O and Au/Ge junctions.

621.314.7 **2416**

Theory of Transient Build-Up in Avalanche Transistors.—W. Shockley & J. Gibbons. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 993–998.) When biased into the negative resistance range the transistor initially delivers an exponentially increasing current into a capacitor connected between emitter and collector. Finally the current rises abruptly and nearly reaches its peak value before the capacitor is substantially discharged.

621.314.7 **2417**

Stored-Charge Method of Transistor Base Transit Analysis.—L. J. Varnerin. (*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, pp. 523–527.) The transit time, defined as the stored charge per unit emitter current, is particularly applicable to h.f. transistor performance. Analysis of a *p-n-p* transistor shows that shorter transit times can be achieved with retarding fields since smaller base thicknesses are possible.

621.314.7 : 546.28 : 621.318.57 **2418**

Silicon-Controlled Rectifiers from Oxide-Masked Diffused Structures.—R. W. Aldrich & N. Holonyak, Jr. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 952–954.) Description of a two-impurity simultaneous diffusion process for producing structures suitable for two- or three-terminal signal and power *p-n-p-n* switches (controlled rectifiers). Gallium and phosphorus impurities are used.

621.314.7 : 546.289 **2419**

Alloyed Germanium Transistor has Symmetrical Characteristics.—O. Stavik. (*Canad. Electronics Engng*, Nov. 1958, Vol. 2, No. 11, pp. 28–31.) The problems encountered in the production of symmetrical *n-p-n* transistors are discussed and characteristics for normal and reverse operation are given. Specially matched units have deviations $<10\,\%$ for f_α, α_{cb} and I_{co} between normal and reverse operation.

621.314.7 : 621.318.57 **2420**

The Deplistor, a Semiconductor Switching Device.—O. W. Memelink. (*Philips Res. Rep.*, Oct. 1958, Vol. 13, No. 5, pp. 485–488.) A device on near-intrinsic Ge is described which makes use of the depletion region surrounding an alloy contact biased in the reverse direction. Appropriate circuit conditions allow the deplistor to be used as a switching element with a negative differential resistance. Switching times of 5–20 μs have been measured.

621.314.7 : 621.318.57 **2421**

The Controlled Rectifier: Key to the Continuing Control Renaissance.—J. D. Harnden, Jr. (*Commun. & Electronics*, Jan. 1959, No. 40, pp. 1006–1012. Discussion.) A discussion of the principles and applications of the new *p-n-p-n* switching devices Very high operating voltages and current ratings are obtainable.

621.314.7 + 621.385] : 621.396.822 **2422**

On the Noise Generated by Diffusion Mechanisms.—K. M. Van Vliet & A. Van der Ziel. (*Physica*, Special Issue, 16th June 1958, Vol. 24, No. 6, pp. 415–421. Correction, *ibid.*, July 1958, Vol. 24, No. 7, p. 556.) A restatement of Richardson's theory of contact noise (1391 of 1950) and a discussion of later theories.

621.314.7.012.8 **2423**

Experimental and Theoretical Investigations of the Equivalent Circuit of Modern High-Frequency Transistors, in particular Drift Transistors.—W. Guggenbühl & W. Wunderlin. (*Arch. elekt. Übertragung*, May 1958, Vol. 12, No. 5, pp. 193–202.) The transport factor of the base of a drift transistor is derived and compared with experimental results. The high-frequency behaviour of a transistor with uniform base resistivity is discussed for high-level injection. Measurements of drift transistor parameters and methods of evaluating transit time through the base layer are given.

621.385.029.6 **2424**

The Integral Energy Distribution of Electrons beyond the Output Resonator of a Transit-Type Klystron.—I. R. Gekker. (*Radiotekhnika i Elektronika*, July 1957, Vol. 2, No. 7, pp. 895–900.) The energy distribution of electrons in a double- and triple-resonator klystron is examined. An experiment was devised making use of a glass model of a double resonator klystron, in order to verify the theoretical results. Good agreement between the theoretical and experimental results was obtained.

621.385.029.6 **2425**

Electronic Conductance of a Space-Charge Cloud in a Magnetron.—V. P. Tychinskiĭ. (*Radiotekhnika i Elektronika*, July 1957, Vol. 2, No. 7, pp. 912–924.) An examination of small disturbances for a single-flow condition of an electron stream in a plane magnetron with partially filled interaction space. A differential equation for the tangential field component is derived and a formula for the insertion of electron conductivity in the resonator system is deduced. Results of calculations of conductance, field and energy flux are given.

621.385.029.6 2426

Nonlinear Theory of a Travelling-Wave Valve: Part 1—Equations and Laws of Conservation.—L. A. Vaĭnshteĭn. (*Radiotekhnika i Elektronika*, July 1957, Vol. 2, No. 7, pp. 883–894.) Two laws can be deduced from the derived equations for the conservation and transformation of energy. The first law is based on a fixed system of coordinates, the second on a system moving uniformly with the initial velocity of the electrons. Different methods for evaluating the forces of space-charge repulsion of electrons in a beam are also examined.

621.385.029.6 2427

Theory of the Crestatron: a Forward-Wave Amplifier.—J. E. Rowe. (*Proc. Inst. Radio Engrs*, April 1959, Vol. 47, No. 4, pp. 536–545.) A voltage gain is obtained by means of a beating effect between the three small-signal forward waves of travelling-wave-valve theory as they travel along the slow-wave structure. Maximum achievable gain is determined by the injection velocity. A crestatron, embodying this principle, has been constructed and found to give moderate gain (10–20 dB) and high operating efficiency together with very short length (4–6 λ).

621.385.032.213.13 2428

The Conductivity of Oxide Cathodes: Part 6—Conductivity in a Magnetic Field.—G. H. Metson. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 55–61.) The oxide-cathode matrix in an S-type valve exhibits a powerful magneto-resistance effect, but only when electron transfer occurs by free flight through the matrix pores and when the magnetic field is transverse. Part 5: 4019 of 1958.

621.385.032.26 : 537.533 2429

Large Perturbations in Electron Beams from Shielded and Immersed Guns.—T. W. Johnston. (*J. Electronics Control*, Jan. 1959, Vol. 6, No. 1, pp. 75–78.) The assumption made by Chen (4020 of 1958) of laminar flow in electron beams is examined.

621.385.032.269.1 2430

Electron Guns for Producing Solid and Hollow Cone-Type Beams with High Current Density.—S. N. Treneva. (*Radiotekhnika i Elektronika*, July 1957, Vol. 2, No. 7, pp. 925–934.) The apparatus is described and calculations and graphs are given for the determination of the size of the electrodes in the gun in terms of the stipulated parameters of the electron beam. The guns operate at zero potential on the cathode. 98 % to 100 % of the total beam current passes through the anode aperture. These guns may be used in travelling-wave valves, klystrons and other devices where a high-power solid or hollow electron beam is required.

621.385.1.001.4 : 534.1 : 621.396.934 2431

Electron-Tube Evaluation for Guided-Missile Applications.—H. G. Chandler. (*Elect. Engng, N.Y.*, Aug. 1958, Vol. 77, No. 8, pp. 690–692.) A note on vibration tests of subminiature valves.

621.385.2 2432

Space-Charge Neutralization by Positive Ions in Diodes.—P. L. Auer & H. Hurwitz, Jr. (*J. appl. Phys.*, Feb. 1959, Vol. 30, No. 2, pp. 161–165.) Analysis is given with curves for the potential as a function of position for a series of values of the ratio of ion to electron density at the potential minimum.

621.385.2 2433

Azimuthal Electron Flow in a Spherical Diode.—W. E. Waters. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 368–373.) Solutions of Poisson's equation for a space-charge-limited spherical diode, in which electron trajectories are great circles rather than radial lines, are developed. It is shown how Poisson's equation may be separated to yield ordinary differential equations. The radial equation is solved analytically and accurate numerical solutions of the azimuthal equation are given. A method of truncating the flow to produce a 'bowl-shaped' electron gun, leading eventually to an annular electron beam, is presented.

621.385.2 : 621.362 2434

Thermionic Diode as a Heat-to-Electrical-Power Transducer.—W. B. Nottingham. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 413–417.) A vacuum diode can convert heat to electrical power when it has a low-work-function collector, small electrode spacing, and sufficient temperature difference. Conversion efficiency lies between 3% and 4%.

621.385.2 : 621.362 2435

Addendum Remarks on a Diode Configuration of a Thermoelectron Engine.—W. B. Nottingham, G. N. Hatsopoulos & J. Kaye. (*J. appl. Phys.*, March 1959, Vol. 30, No. 3, pp. 440–441.) See 3592 and 4024 of 1958 (Hatsopoulos & Kaye) and 2434 above.

621.385.2[/.3].029.6 2436

The Noise of Space-Charge Diodes in the Transit-Time Region allowing for the Maxwellian Velocity Distribution of Electrons.—K. H. Löcherer. (*Arch. elekt. Übertragung*, May & June 1958, Vol. 12, Nos. 5 & 6, pp. 225–236 & 265–270.) The fundamental equations for shot noise of a planar space-charge diode are deduced, and the quadripole noise parameters of the ideal triode are calculated. See also 1615 of 1957 (Paucksch).

621.385.3.029.6 2437

The Influence of Penetration-Factor Fluctuations on the Input Conductance and Slope of the Triode Type 2C40 in the Transit-Time Region.—H. Fiedler. (*Nachrichtentech. Z.*, May 1958, Vol. 11, No. 5, pp. 269–275.) Measurements on a disk-seal triode were made at 1·5 and 2·4 kMc/s using a tunable cavity resonator in the anode circuit. An approximation method for calculating the parameters is given.

621.385.832 2438

Surface Phenomena associated with Application of Organic Films to Phosphor Screens.—R. W. Dudding & D. J. Finnett. (*J. electrochem. Soc.*, July 1958, Vol. 105, No. 7, pp. 388–392.) "The production of aluminized screens for cathode-ray tubes involves the formation of a temporary organic barrier film on the phosphor coating on which the aluminium may be deposited. Defects in this film produce undesirable blemishes on the finished screen. Certain inherent defects encountered when employing a 'flow filming' technique are described, and the fundamental factors governing their formation and prevention are considered."

621.385.832 : 681.142 2439

Stable High-Speed Digital-to-Analogue Conversion for Storage-Tube Deflection.—Ault. (See 2135.)

621.385.832.032.366 2440

The Effect of Temperature on the Resistance of Long-Persistence Cathode-Ray-Tube Screens.—R. Feinberg. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 77–81.) Increasing temperature reduced the persistence time. The temperature coefficient followed no general rule, being peculiar to the particular type of phosphor used.

621.387 2441

Discharge Modes using Thermionic Cathodes.—R. B. Cairns & G. C. McCullagh. (*J. Electronics Control*, Jan. 1959, Vol. 6, No. 1, pp. 65–69.) "New observations have been made on the structure of discharges from hot cathodes and the relation between different forms, and information obtained about the roles of diffusion and oscillations."

621.387 : 621.316.722 2442

Effects of Argon Content on the Characteristics of Neon-Argon Glow-Discharge Reference Tubes.—F. A. Benson & P. M. Chalmers. (*Proc. Instn elect. Engrs*, Part C, March 1959, Vol. 106, No. 9, pp. 82–90.) The argon content in specially constructed tubes was varied between 0·001% and 10%. Optimum characteristics were obtained using 1% argon.

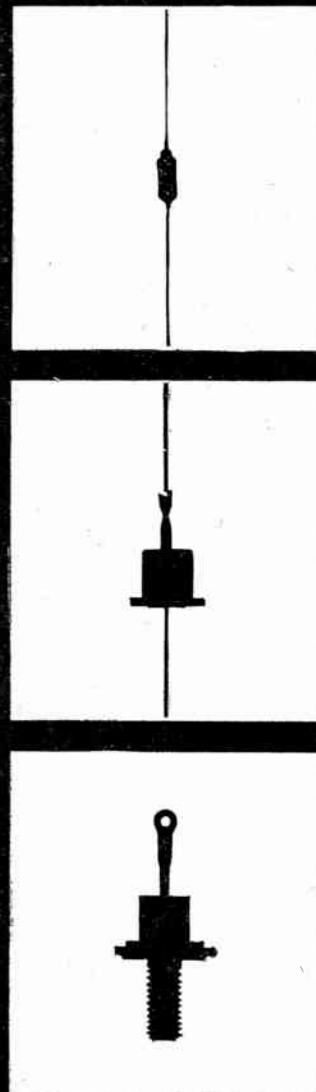
621.387 : 621.318.57 : 621.395.34 2443

Cold-Cathode Voltage-Transfer Circuits.—J. H. Beesley. (*J. Brit. Instn Radio Engrs*, March 1959, Vol. 19, No. 3, pp. 149–161. Discussion, pp. 161–163.) A new method of operating cold-cathode triode switching tubes is described. The departure from conventional operating methods results in some unusual features in the logical design of switching equipment, which are discussed.

SILICON RECTIFIERS

up to 600 Volts P.I.V.

3 amps



Texas Silicon Rectifiers offer excellent high temperature characteristics. For example the stud-mounted type gives an output of 3 amperes at 50°C and will still provide 1 ampere at 150°C with no change in the rated peak inverse voltage. The rugged, welded housing with glass-to-metal seal provides high resistance to shock and vibration. Listed in the table below are the characteristics of representative devices of each type.

Have you received your copy of the latest Texas Application Report "D.C. Power Supply Circuits using Silicon Rectifiers"? If not, or if you require fuller details of Texas Rectifiers, please write your name and address in the margin and return this advertisement to us.

	Symbol	1S001	1S005	tSt11	1S115	1S401 1S401R	tS405 1S405R
MAXIMUM RATINGS							
Peak Inverse Voltage at −65°C to +150°C	PIV	200V	600V	200V	600V	200V	600V
Average Rectified Forward Current at +50°C	I_o	750mA	750mA	† 400mA	† 400mA	*3A	*3A
Average Rectified Forward Current at +150°C	I_o	250mA	250mA	150mA	150mA	*1A	*1A
Recurrent Peak Forward Current at +50°C	i_l	† 2·5A	† 2·5A	† 1·25A	† 1·25A	*10A	*10A
Surge Current for 10 Milliseconds	I_{PK}	16A	16A	6A	6A	33A	33A
Operating Temperature, Ambient	T_A	−65°C to +150°C					
SPECIFICATIONS							
Minimum Breakdown Voltage at +150°C	V_z	240V	720V	240V	720V	240V	720V
Maximum Reverse Current at P.I.V. at +25°C	LI_b	10μA	10μA	0·2μA	0·2μA	10μA	10μA
Maximum Forward Voltage Drop at +25°C	E_b	1·0V	1·0V	1·0V	1·0V	1·1V	1·1V
		(I_o=500mA)		(I_o=400mA)		(I_b=1Amp)	

* Rectifier mounted on 2" x 2" x $\frac{1}{16}$" aluminium Heat Sink † @ 25°C

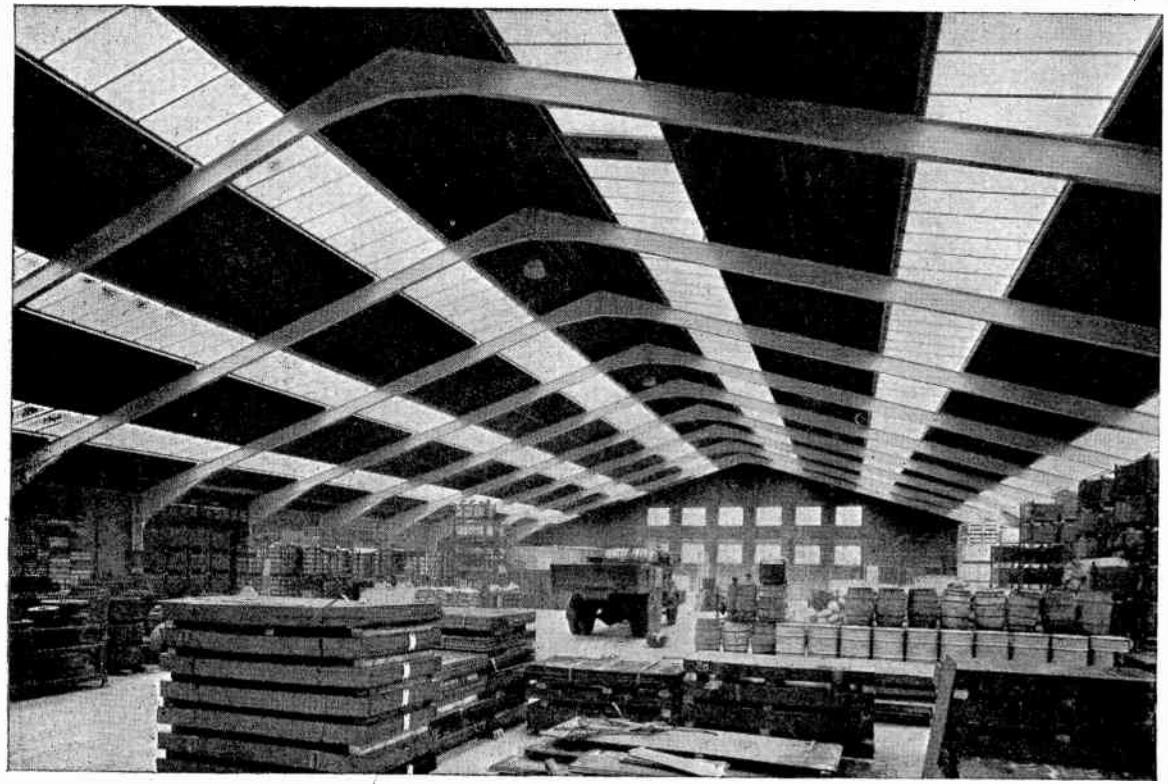
Texas Instruments Limited

TELEPHONE: BEDFORD 68051 DALLAS ROAD BEDFORD CABLES: TEXINLIM BEDFORD

T31

CONDER CLEARSPAN

SLASHES BUILDING COSTS—OUTDATES TRADITIONAL CONSTRUCTION



Warehouse 110 ft. span, Gresham & Craven Ltd., Manchester. *Architects:- Francis Jones & Sons, Manchester.*

CLEARSPAN Buildings have established a brilliant new conception of Industrial Building Design.

Hitherto "Standard" type buildings have been largely confined to the "Shed" variety; and their use limited accordingly.

Now CLEARSPAN brings all the great advantages of Standard Construction to a very wide range of Industrial Buildings. CLEARSPAN sets a new standard of design and efficiency.

- Spans 25 ft. to 150 ft.
- Roof Slopes 12°-17°-22°
- Cranes 5 tons and 10 tons.
- Virtually maintenance free.

(Variations to order)

Brochure with 32 pages of facts, drawings and photographs sent on request.

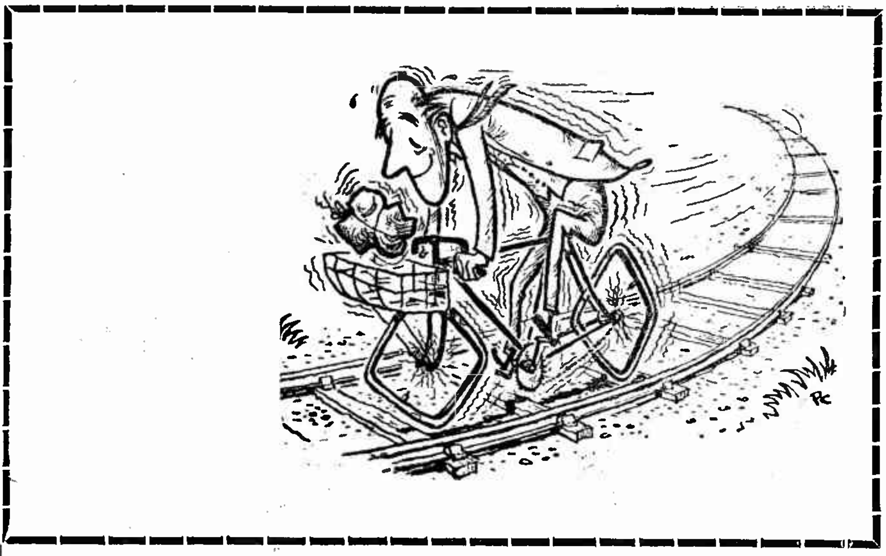
CLEARSPAN **BUILDINGS** are used by many leading Industrial concerns including:—

Atomic Energy Commission.
British European Airways Ltd.
De Havilland Engine Co.
Esso Petroleum Co. Ltd.
Imperial Chemical Industries Ltd.
Imperial Tobacco Co. Ltd.
J. Lyons & Co. Ltd.
Ministry of Works
National Coal Board.
Shell Mex & B.P. Ltd.
Southern Electricity Board.
George Wimpey & Co. Ltd.

CONDER ENGINEERING CO LTD WINNALL WINCHESTER HANTS TEL: 5095
CONDER ENGINEERING CO (MIDLANDS) LTD PEEL HOUSE BURTON-ON-TRENT TEL: 5411

P.3672

VIBRATION TESTING ?



W. BRYAN **Savage**

If you have any problems regarding vibration, consult our Technical Dept.

Today's rapid increase in the speeds of Guided Missiles, Aircraft and various types of machinery has made the Engineer acutely aware of vibration.

Full scale testing is often expensive though ultimately necessary, yet it is possible to assimilate the conditions under which parts will work, by inducing controlled vibration and modifications can then be made at the design stage. In this field, W. Bryan Savage Ltd. has been actively engaged for the past twenty years and is one of the leaders in the manufacture of Power Amplifiers and Vibrators.

W. BRYAN SAVAGE LTD

designers and manufacturers of amplifiers and vibrators for modern industry

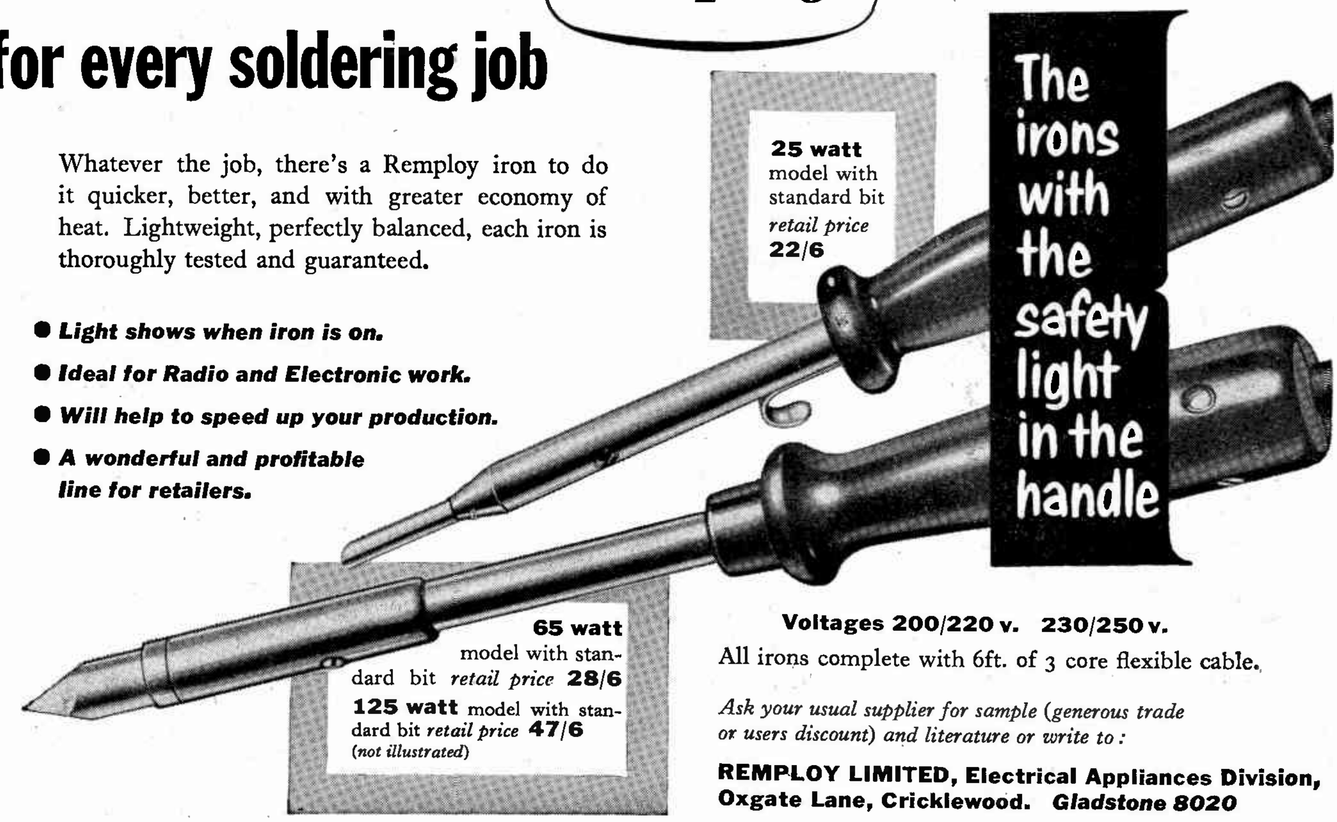
17 Stratton Street, London, W.1. Telephone: GROsvenor 1926

DaS759ERE

You can get the right *Remploy* electric iron for every soldering job

Whatever the job, there's a Remploy iron to do it quicker, better, and with greater economy of heat. Lightweight, perfectly balanced, each iron is thoroughly tested and guaranteed.

- ***Light shows when iron is on.***
- ***Ideal for Radio and Electronic work.***
- ***Will help to speed up your production.***
- ***A wonderful and profitable line for retailers.***



Voltages 200/220 v. 230/250 v.

All irons complete with 6ft. of 3 core flexible cable.

Ask your usual supplier for sample (generous trade or users discount) and literature or write to :

REMPLOY LIMITED, Electrical Appliances Division, Oxgate Lane, Cricklewood. ***Gladstone 8020***

ELECTRONIC & RADIO ENGINEER

CLASSIFIED ADVERTISEMENTS

Advertisement Rates. 6*d. per word, minimum charge* 6/-, *each paragraph charged separately. Remittances payable to Iliffe & Sons Ltd., Dorset House, Stamford St., S.E.*1. *Series discount of* 15% *is allowed for* 12 *consecutive insertions.*

Box Numbers *are available at an additional charge of* 2/- *to defray cost of registration and postage. Replies should be addressed Box No.* 0000, *c/o "Electronic & Radio Engineer", Dorset House, Stamford Street, London, S.E.*1.

Semi-Display *advertisements with centralized lines* £1/15/- *per single column inch—no additional charge for Box Numbers. The Publishers are not responsible for clerical or printers' errors although every care is taken to avoid mistakes.*

SITUATIONS VACANT

THE COLLEGE OF AERONAUTICS

THE Department of Aircraft Electrical Engineering provides post-graduate courses in Aircraft Electrical Engineering and in the Guidance and Control of Guided Missiles. In the next academic year post-graduate courses will also be provided in Industrial Control Engineering and in Flight Control.

APPLICATIONS are invited from Physicists and Electrical Engineers with a good honours degree, and research, design or teaching experience in an appropriate subject for appointment as Senior Lecturers or Lecturers in the following sections. Candidates should be qualified to lecture in the fundamental aspects of the subjects covered and their duties would also include the supervision of a laboratory and student research work. Excellent facilities exist for personal research.

(a) **PHYSICS** and Electronics Section: some knowledge of nuclear physics or a good background in electronics desirable but not essential.

(b) **CONTROL** and Computation Section: experience in industrial or aeronautical control systems essential.

(c) **ELECTRICAL** Machines and Power Section: experience in the design of machines or power distribution systems for aircraft is essential.

APPLICATIONS are also invited for the following appointments:

DEMONSTRATOR. Candidates should have a university degree and preferably have some experience in a field relevant to one of the above subjects. This appointment should appeal to a young graduate who wishes to consolidate his theoretical knowledge and participate in research.

RESEARCH Engineer preferably with experience in one of the above fields. Preference will be given to candidates with a university degree or equivalent professional qualification.

THE salary scales are: Senior Lecturer, £1,700 x £75—£2,150 p.a.; Lecturer, £900 x £50—£1,350 x £75—£1,650; Demonstrator, £600 x £25—£1,000, with superannuation under F.S.S.U. and family allowance. Research Engineer up to £1,200 p.a. with Local Government Superannuation; family allowance depending upon grade of appointment.

IN all cases the commencing salary within the prescribed scale will depend upon age, qualifications and experience. Consideration will be given to housing requirements.

APPLICATIONS giving full particulars and the names and addresses of three referees should be forwarded to the Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks. [1336

ROYAL TECHNICAL COLLEGE, SALFORD

APPLICATIONS are invited for the post of Reader in the Department of Electrical Engineering. The person appointed to this important senior post will have as a primary responsibility the organization and direction of research work. It is not necessary that he be interested in any particular field of investigation at present being pursued in the Department, but it is essential that he shall have made a substantial contribution to some field of research.

SALARY is in accordance with the Burnham Technical Scale, at present £1,627 10s by £52 10s to £1,890 (men). The successful applicant may be placed at an intermediate point in this scale in accordance with previous experience in an equivalent capacity and/or industrial experience.

FURTHER particulars and forms of application may be obtained from the Registrar, Royal Technical College, Salford, 5, Lancs, to whom completed applications should be returned as soon as possible.

R. RIBBLESDALE THORNTON,
Clerk to the Governors,
[1334

ELECTRONICS Authors and Specification Writers required immediately. Permanent positions with well established, expanding company, interesting work on a wide variety of important projects. Write to Technivision Ltd., Braywick House, Braywick Road, near Maidenhead, Berkshire, or telephone Maidenhead 5163. [1332

SITUATIONS VACANT

SCIENTIST
for
ELECTRONIC INSTRUMENTATION DEVELOPMENT

THE United Kingdom Atomic Energy Authority require a 1st or 2nd Class Hons. Graduate in Physics or Electrical Engineering to be directly responsible to the Superintendent of Orfordness Outstation for the general direction and day-to-day management of a team engaged on a programme of advanced electronic instrumentation development and associated complex field trials.

THE team is responsible for the design and prototype production of airborne telemetry equipment and associated ground stations; the organisation and carrying out of field and flight trials and the analysis and evaluation of results. There will be ample scope for original design work.

SEVERAL years' experience in electronics or communication equipment development, including U.H.F. and pulse techniques, is necessary. Some experience in airborne radar and G.W. equipment development will be a distinct advantage. Good organising ability and an interest in technical management are essential.

SALARY: will be assessed within the range £1,260/£2,155.

CONTRIBUTORY Superannuation Scheme.

A house or substantial assistance with house purchase will become available to married officers living beyond daily travelling distance. Assisted travel from Felixstowe, Ipswich and Woodbridge.

POSTCARDS for application forms to the Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks. Please quote ref. A2131/46. [1341

BOROUGH POLYTECHNIC
BOROUGH ROAD, S.E.1
Principal: James E. Garside, M.Sc.(Tech.), Ph.D., F.R.I.C., F.I.M., M.Inst.F.

ARISING from the rapid development of the advanced scientific and technological work of the Polytechnic, the Governors invite applications for the following new appointments:

Department of Electrical Engineering and Physics
Head of Department: V. Pereira-Mendoza, M.Sc.(Tech.), M.I.E.E.

Two Assistant Lecturers (Grade B) in Electrical Engineering

APPLICANTS should be graduates or Chartered Electrical Engineers. For one post, experience in Electronic Engineering is desired and for the other in Electrical Power or Machines. Teaching experience would be a strong recommendation.

SALARY: £650 x £25—£1,025 p.a., plus allowances for training and qualifications. In addition, London Allowance of £36 or £48 is payable and the gross salary is augmented by 5 per cent special addition.

FURTHER particulars and form of application, which should be returned as soon as possible, obtainable from the undersigned.

FREDK. J. PACKER,
Clerk to the Governing Body.
[1337

ELECTRO-ENCEPHALOGRAPHY RECORDIST, GRADE I

APPLICATIONS are invited from experienced technicians. The department also serves other hospitals in the district and a new research unit for neuro-surgery which opens shortly. Whitley Council salary scales and conditions apply. Apply, giving qualifications, experience, and quote two referees to Medical Superintendent, Parkside Hospital, Macclesfield. [1242

DAYSTROM-WESTON Group requires Instrumentation Engineer or Physicist for high-level sales of electronic and electromagnetic control equipment. Knowledge of strip-mills or cable industry an advantage. Write stating age, experience, qualifications and salary required to Managing Director, Daystrom Ltd., Gloucester. [1339

SITUATIONS VACANT

ROYAL TECHNICAL COLLEGE, SALFORD

APPLICATIONS are invited for the following posts in the Department of Electrical Engineering.

(a) **SENIOR** Lecturer. Salary £1,417 10s by £52 10s to £1,627 10s (men).

(b) **LECTURER.** Salary £1,260 by £31 10s to £1,417 10s (men).

SUCCESSFUL applicants may be placed at intermediate points in these scales in accordance with previous experience in an equivalent capacity and/or industrial experience.

THESE vacancies offer an exceptional opportunity for those who wish to participate at the early stages in the current new developments in engineering education. Those appointed will be expected to lecture undergraduate courses and post-graduate courses where appropriate. The greatest importance is attached to the undertaking of original research work of high quality, as an integral part of the work of the staff, time is allowed for this. In consequence, proven research ability is a strong recommendation for these appointments, and considerable weight will be placed upon this factor. For a candidate strongly qualified in this way, previous lecturing experience will be of secondary importance.

FURTHER particulars and forms of application may be obtained from the Registrar, Royal Technical College, Salford, 5, Lancs, to whom completed applications should be returned as soon as possible.

R. RIBBLESDALE THORNTON,
Clerk to the Governors.
[1335

MIDDLESEX COUNTY COUNCIL
Education Committee
BRUNEL COLLEGE OF TECHNOLOGY
Woodlands Avenue, Acton, W.3.
Research Assistant in Electronics

THERE is a vacancy in the Department of Electronics for a graduate Research Assistant, to undertake a programme of research in conjunction with the Head of Department. Preference will be given to candidates with two years industrial experience.

THE appointment will be for an initial period of two years and the Assistant may prepare for a Higher Degree.

SALARY within the range (for men) £799 1s 0d to £1,336 13s per annum.

APPLICATION forms and further particulars from the Registrar.

C. E. GURR, M.Sc., Ph.D.,
Clerk to the Governing Body.
[1333

D.S.I.R. Road Research Laboratory (Traffic and Safety Division), Langley, Bucks, requires Scientific Officers/ Senior S.O.s for work on one or more of the following: Planning of sampling surveys. Theoretical aspects of traffic flow. Application of electronic computers to traffic and safety matters. Application of traffic engineering principles to solution of traffic problems. Development of electronic and other equipment for experimental use in vehicles. Experimental and theoretical investigations into accidents. Relationships between injuries and vehicle design. Qualifications: 1st or 2nd Class Hons. degree or equivalent, qualifications in Physics, Mathematics, Statistics or Civil and Mechanical Engineering. At least three years post-graduate experience for S.S.O. Salary: S.O. £635/£1,120 (with allowance for post-graduate experience and National Service); S.S.O.s £1,200/£1,420. Equal pay scheme. Normal prospects of promotion in mid-thirties to P.S.O. (£1,460/£2,070) with possibilities of higher posts.

FORMS from M.L.N.S. Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting reference A.254/9A. [1340

TUITION

THE COLLEGE OF AERONAUTICS
One Year Post-Graduate Course in
Control Engineering 1959-60

APPLICATIONS are invited for the one year course in Control Engineering which begins on 5 October, 1959. Prospective students must be of graduate status in an appropriate branch of science or engineering and, preferably, have had practical experience in industry or an establishment.

THE purpose of the course is to give instruction in the techniques employed in control engineering as applied in a wide range of industries. Students wishing to do so may specialise in the applications of control engineering to aeronautics.

FURTHER information and forms of application may be obtained from The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks. [1323

TWICKENHAM TECHNICAL COLLEGE,
EGERTON ROAD, TWICKENHAM, MIDDLESEX
(Tel: POPesgrove 7676)
DIPLOMA COURSE IN CONTROL ENGINEERING
(Sandwich Course, four years duration)
I.E.E. PART III COURSES
(Part-time day or evening, two years duration)
SPECIAL LECTURE COURSES (EVENINGS)
Pulse Circuit Design, 22 Lectures.
Computer Programming, 18 Lectures.
Printed Circuit Techniques, 10 Lectures.
Automatic Control of Machine Tools, 13 Lectures.

A Brochure giving full details of the above courses is available from the Principal. [1342

AGENTS WANTED

REPRESENTATIVES wanted for correspondence abroad, high earnings, written instructions. Write Fortuna Publishing Co. Vienna 1/8, Postfach 49. [1324

PATENTS

AMERICAN, Canadian and British Patent Rights (new application) for sale covering method of Dielectric Heating and Fusing Ceramics into Glass. Write Box 4526. [1338

WESTINGHOUSE U.S.A.
HIGH VOLTAGE RECTIFIER
PRIMARY 400v. 3ph. 50 cycles
SECONDARY 27.K.V. 100 M.A.-D.C.
WHITEFIELD MACHINERY & PLANT LTD.
COBDEN STREET
SALFORD, 6, LANCS.

WIRED TELEVISION
An opportunity exists in a rapidly expanding industry for an Engineer, who will test and advise on the performance of wired TV distribution systems throughout England and Wales. A sound knowledge of TV principles is required. Apply to:
Head of Wired T.V. Dept.,
Central Rediffusion Services Ltd.,
Stratton House, Stratton Street, W.1.

BOOKS, ETC.

"TELEVISION Explained." By W. E. Miller, M.A.(Cantab), M.Brit.I.R.E. Revised by E. A. W. Spreadbury, M.Brit.I.R.E. The sixth edition of a book which assumes a knowledge of the ordinary sound radio receiver but no previous knowledge of television circuits. It is non-mathematical, written in simple language, and comprehensively illustrated by many diagrams and photographs. It will prove of great assistance to all students of television, to radio service engineers who wish to embark upon television work and want to understand the principles and circuits involved, and to knowledgeable owners of television receivers who would like to understand the working of their set. 12s. 6d. net from all booksellers. By post 13s. 5d. from Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1.

"RADIO Designer's Handbook" (4th Edition). Editor: F. Langford-Smith, B.Sc., B.E., Senior Member I.R.E.(U.S.A.), A.M.I.E.(Aust.). A comprehensive reference book, the work of ten authors and twenty-three collaborating engineers, containing a vast amount of data in a readily accessible form. The book is intended especially for those interested in the design and application of radio receivers or audio amplifiers. Television, radio, transmission and industrial electronics have been excluded in order to limit the work to a reasonable size. 50s. net from all booksellers. By post 52s. 3d. from Iliffe & Sons, Ltd., Dorset House, Stamford Street, S.E.1.

"BASIC Mathematics for Radio and Electronics." By F. M. Colebrook, B.Sc., D.I.C.A.C.G.I. Revised and enlarged by J. M. Head, M.A. (Cantab.). Presents in readable form a complete course in basic mathematics for engineering students of all kinds and leads on to the more advanced branches of mathematics of increasing importance to radio engineers. In this edition the chapter covering the application of mathematics to radio has been revised and enlarged, while new subjects covered include Stability, Linear Differential Equations, Elementary Statistics. Short Cuts to Numerical Calculations and an Introduction to Matrices. Will be invaluable to those requiring a refresher course as well as to those without previous knowledge of the subject 17s. 6d. net from leading booksellers, by post 18s. 6d. from Iliffe & Sons, Ltd., Dorset House, Stamford Street, S.E.1.

Index to Advertisers

Printed in Great Britain for the Publishers, Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1, by Gibbs & Bamforth, Ltd., St. Albans. Distributed in U.S.A. by Eastern News Company, 306 West 11th Street, New York, 14.

A Transistor for broadcast receiver Frequency Changer Stages

EDISWAN MAZDA XA102 R.F. TRANSISTOR

The XA102 is a germanium PNP junction-type transistor particularly suitable for use as a frequency changer and/or oscillator on the medium and long wave bands. The transistor element is hermetically sealed in a small can.

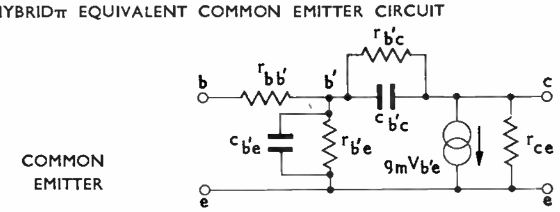
RATINGS (ABSOLUTE VALUES FOR T_{amb}=45°C)

Maximum Peak or Mean Collector/Base Voltage (Common Base Circuit)	(volts)	−20
Maximum Peak or Mean Collector/Emitter Voltage (Common Emitter Circuit)	(volts)	−16
Maximum Peak or Mean/Emitter Base Voltage	(volts)	−12
Maximum Collector Dissipation	(mW)	60
Maximum Junction Temperature	(°C)	65
Maximum Storage Temperature	(°C)	65

GENERAL CHARACTERISTICS (T_{amb}=25°C)

Maximum Collector to Base Leakage Current (Emitter Open Circuit, V_{cb} = − 12v)	(µA)	−5
Maximum Collector to Emitter Leakage Current (Base Open Circuit, V_{ce} = − 10v) ...	(µA)	−70
Maximum Emitter to Base Leakage Current (Collector Open Circuit, V_{eb} = − 12v) ...	(µA)	−10
Thermal Resistance in Free Air	(°C/mW)	0.33

HYBRIDπ EQUIVALENT COMMON EMITTER CIRCUIT

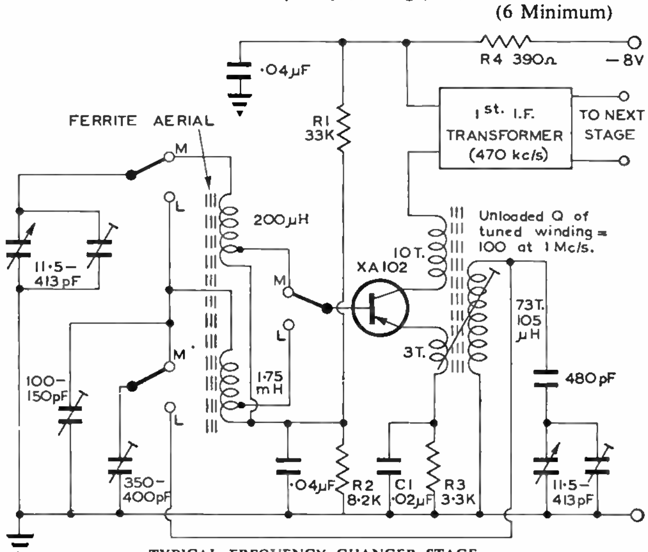


AVERAGE PARAMETER CHARACTERISTICS (T_{amb}=25°C)

Equivalent Hybrid π Network. Small Signal Values.

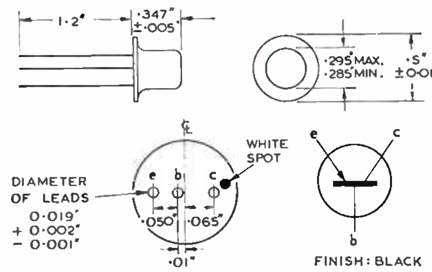
Common Emitter Circuit at V_c = −5V I_c = − 1mA.

$r_{bb'}$, approx.	(Ω)	75
$r_{b'e}$ approx.	(Ω)	1550
$r_{b'c}$ approx.	(MΩ)	6.0
g_m	(mA/V)	38.6
$c_{b'c}$ approx.	(pF)	13.5
$c_{b'e}$ approx.	(pF)	1000
Current Amplification, Common Base α ...		0.984
Current Amplification, Common Emitter β		60 (25 Minimum)
Common Base Cut-off Frequency (Average)	(Mc/s)	8.0 (6 Minimum)



TYPICAL FREQUENCY CHANGER STAGE

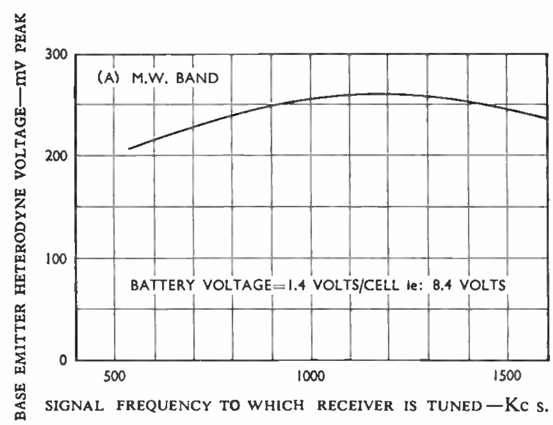
DIMENSIONS AND BASING

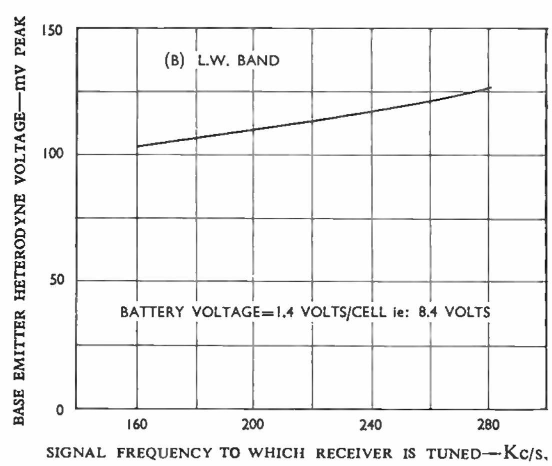


TYPICAL OPERATION AS SELF-OSCILLATING FREQUENCY CHANGER IN THE CIRCUIT SHOWN

Signal Frequency Tuning Coverage, Medium Waves	(kc/s)	530 – 1620
Long Waves	(kc/s)	160 – 280
Intermediate Frequency	(kc/s)	470
H.T. Line Voltage (at 1.4 volts per cell) ...	(volts)	−8.4
Collector Current (at f_{SIG} = 1 Mc/s) ...	(mA)	−0.43
Collector to Emitter Voltage	(volts)	−6.3
Base to Emitter Peak Heterodyne Voltage at (f_{SIG} = 1 Mc/s)	(mV)	250
Conversion Gain at = f_{SIG} 1 Mc/s (not including losses in 1st I.F. transformer) ...	(dB)	31
Input Resistance at Signal Frequency (f_{SIG} = 1 Mc/s)	(ohms)	1,400
Output Resistance at I.F.	(ohms)	35,000

Variation of Heterodyne Voltage with Tuning Frequency in the circuit shown





SIEMENS EDISON SWAN LIMITED *An A.E.I. Company*

Technical Service Department, 155 Charing Cross Rd., London, W.C.2.
Telephone: GERrard 8660. Telegrams: Sieswan Westcent London.

EDISWAN MAZDA

CRC 15/38