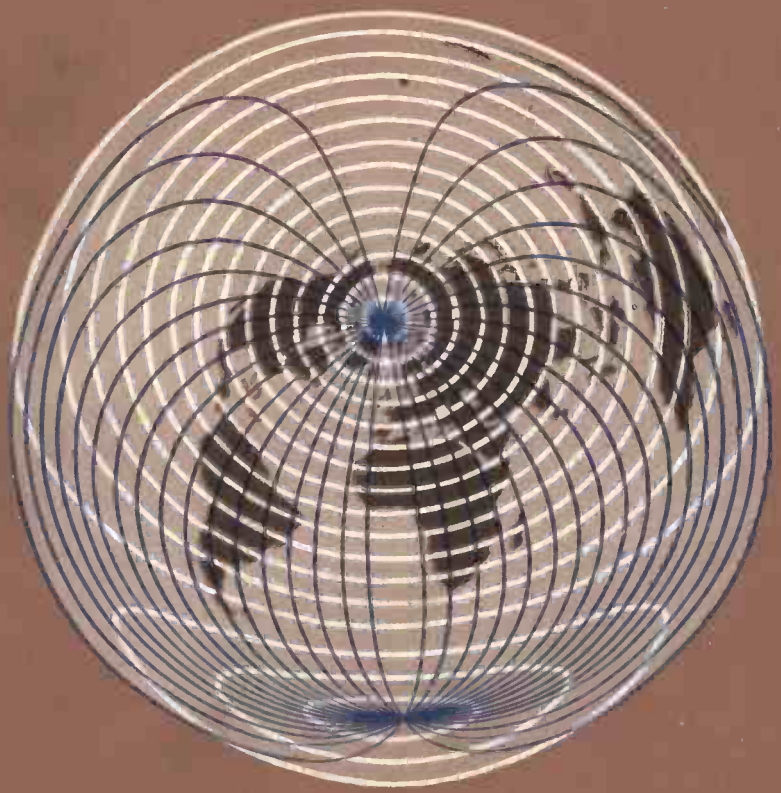
FEBRUARY 1957

TWO SHILLINGS

Wireless World

ELECTRONICS

Radio · Television



FORTY-SIXTH YEAR OF PUBLICATION

Wireless World

ELECTRONICS, RADIO, TELEVISION

Managing Editor: HUGH S. POCOCK, M.I.E.E.
Editor: H. F. SMITH
Assistant Editor: F. L. DEVEREUX, B.Sc.

FEBRUARY 1957

In This Issue

VOLUME 63 No. 2

PRICE: TWO SHILLINGS

FORTY-SIXTH YEAR OF PUBLICATION

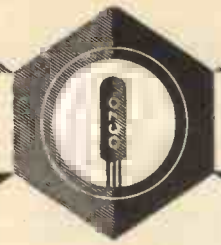
Editorial, Advertising and Publishing Offices:
Dorset House, Stamford Street, London, S.E.1

Telephone:
WATerloo 3333 (60 lines)

Telegraphic Address:
"Ethaworld, Sedist, London".

PUBLISHED MONTHLY (4th Tuesday of preceding month) by ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1. *Telephone:* Waterloo 3333 (60 lines). *Telegrams:* "Iliffepres, Sedist, London." *Annual Subscription:* Home and Overseas, £1 12s. 6d. U.S.A. and Canada $5.00. BRANCH OFFICES: *BIRMINGHAM:* King Edward House, New Street, 2. *Telephone:* Midland 7191. *COVENTRY:* 8-10, Corporation Street. *Telephone:* Coventry 5210. *GLASGOW:* 26B Renfield Street, C.2. *Telephone:* Central 1265. *MANCHESTER:* 260, Deansgate, 3. *Telephone:* Blackfriars 4412. OVERSEAS OFFICES: *U.S.A.:* 111 Broadway, New York, 6, N.Y. *Telephone:* Digby 9-1197. *CANADA:* 74, College Street, Toronto, 2, Ontario. *Telephone:* Walnut 4-5631

A Transistor Controlled Regulated Power Unit



The circuit diagram of the regulated power unit, shown below, demonstrates a novel application of transistors as control devices. They are especially suited for this type of circuit because of the high voltage gains which can be obtained with them when they are operated with large collector loads from high voltages. In the power unit described, a Mullard OC73 is used to control the current flowing through an EL38 series valve. One advantage of using a transistor in this type of regulated power unit is that a separate negative h.t. supply is eliminated.

The power unit has an output impedance of less than three ohms, and will deliver 100mA at any voltage between 40 and 84 volts regardless of quite large changes in the mains input voltage. For instance; if the mains input voltage rises from 198V to 242V, the output voltage will increase by only 0.4V at full load. Reducing the load from 100mA to zero produces a rise in output voltage of only 0.3V at 220V mains input.

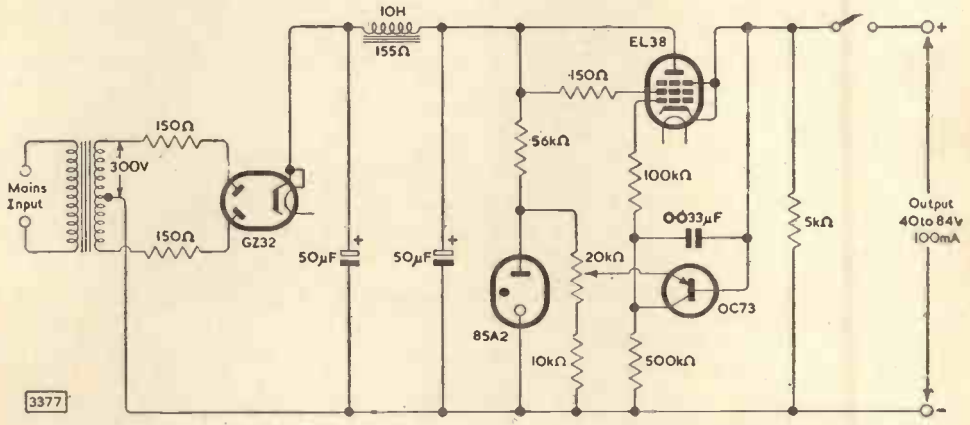
CIRCUIT OPERATION

By connecting the transistor as shown in the circuit diagram it compares the output voltage with the reference voltage, and any difference produces a large change in collector current due to its high effective mutual conductance.

Since a transistor can be operated at very low currents, very high voltage gain is obtained by connecting the collector to negative h.t. through a load of 500kΩ. The collector is connected also to the control grid of the EL38 through a 100kΩ grid stopper. Therefore the collector-to-base voltage of the transistor is equal to the grid-to-cathode bias of the valve and is practically independent of the output voltage setting.

The output voltage is approximately equal to the reference voltage and can only differ from it by the base-to-emitter voltage of the transistor, which will be less than 0.1V. So the maximum output which can be obtained is determined only by the reference voltage. Although an 85V reference level is used in the circuit described, the design is almost identical for any reference level. The minimum output voltage of this supply unit cannot be set below the bias voltage of the series valve and therefore it is limited to about 40V.

When the power unit is working, a drop in output voltage will cause the base of the OC73 to become negative with respect to the emitter. As a result, the collector current increases and the collector voltage becomes more positive, thus reducing the bias on the EL38 and compensating for the original change. Equilibrium will be reached when the output voltage reaches the same value as the emitter voltage.



Variations in the mains voltage have only a slight effect on the reference voltage, which is stabilised by the 85A2, and therefore the output voltage remains substantially constant.

CIRCUIT DESIGN

The full-wave rectifier circuit is of conventional design, with choke smoothing to give a ripple-free output to the series valve, an EL38, and to the voltage reference tube, an 85A2. The 85A2 is operated at a low burning current to minimise the change in the reference voltage when the circuit is loaded and the poor regulation of the rectifying circuit causes the unstabilised voltage to fall.

An EL38 was chosen for the series valve because it has a comparatively short grid base. This is important since it governs the maximum collector-to-base voltage when no current is being taken from the supply. To prevent the collector voltage exceeding the — 30V collector-to-base rating of the OC73, the output must be permanently loaded to about 10mA; 5kΩ forms the permanent bleeder resistor.

The stability of the output is limited by the stability of the reference source, and by using an independent reference voltage or running the 85A2 from a 150B2, the stability could be increased, and the output impedance reduced to at least half the value given.

Changes in temperature have negligible effect on the output voltage and impedance but an appreciable increase in ambient temperature raises the minimum transistor leakage current and slightly increases the minimum output voltage to which the supply can be set. This effect limits the maximum value of collector resistance which can be used. For operation at higher temperatures a smaller collector load resistance should be chosen.

Instability may occur when the power supply is first switched on if it is connected directly to a high current load, so a switch has been included in the circuit and should not be closed until the reference tube has ignited. The 0.033μF capacitor between the base and collector prevents high frequency oscillation which can occur under certain conditions.

EDITORIAL COMMENT

Wireless World

FEBRUARY 1957

Vol. 63 No. 2

GUARANTEES AND GOODWILL

Some time ago there was a newspaper story about a disgruntled owner of a television receiver. After suffering from a series of breakdowns and failures to get satisfactory repairs, he took the set back to the dealer's shop and hurled it through the plate-glass window. Happily, the state of affairs revealed in the subsequent court proceedings hardly reflects the typical public attitude towards radio dealers, or, for that matter, towards broadcast receiver manufacturers. All the same, it goes to show there is not so much goodwill as we would all like to see.

Part of this lack of goodwill must be attributed to the unsatisfactory nature of the guarantees given by makers of broadcast receivers. As our contributor "Diallist" points out, these are far too complicated and in some respects appear to the purchaser to be ungenerous, to say the least, particularly in regard to valves and c.r. tubes. It will be interesting to watch the effect on the public of the recent announcement by the makers of Ambassador and Baird television sets, who are now giving an extra year's guarantee with the c.r.ts.

During last autumn there was a somewhat bitter correspondence in *The Times* on the onerous nature of guarantees. Though some of the letters were directed against makers of "consumer durables" in general, the radio industry got rather more than its share of reproach.

It may be argued that there is virtually no difference between the terms of the guarantees commonly given with broadcast sets and with other comparable articles. That may be true enough, but would *Wireless World* be excessively starry-eyed in thinking the time may well have come for the radio industry to lead the rest in trying to establish a brand-new kind of relationship between seller and buyer? The old legal maxim "let the buyer beware" seems to be utterly outmoded in a world where the complex products of modern technology go into the homes of buyers whose lack of knowledge leaves them completely in the hands of the sellers.

RADIO MILESTONES

Heinrich Hertz was born exactly one hundred years ago. Over-simplifying a little, it is often said that Marconi, by connecting an effective aerial to Hertz's oscillator, made the first significant step towards a workable radio system. It is true enough to say, in the same vein, that the second fundamental advance was made in 1906 when de Forest put a grid into Fleming's diode.

During the past year Dr. Lee de Forest has received many well-deserved honours to mark the jubilee of his invention. But the triode made virtually no impact on radio technique for at least six years. It was not until regeneration was introduced in 1912 that the triode offered outstanding advantages over existing devices. The regenerative receiver, with a sensitivity vastly greater than anything known before, opened up a new world, and also paved the way for the oscillating valve generator.

According to Armstrong, who opposed de Forest during prolonged patent litigation in America, the oscillating triode was the greatest of all radio inventions.

High-Power Transistor Audio

DEMONSTRATIONS of audio amplifiers built round a new range of transistors were given recently by the General Electric Company. The demonstrations were preceded by some discussion of the preferred basic design features of the amplifiers.

Suitable collector bias conditions are chosen from the current/voltage characteristics and it is then thought best to measure the small signal a.c. relationships at these conditions in order to derive equivalent circuit parameters. By this method the internal feedback, which in transistors can be significant at all frequencies, can be more easily taken account of. This procedure is not as complicated as it may seem, for several of the equivalent circuit parameters are found to be roughly the same in many circumstances.

Advantages of Class B Operation.—As regards the choice between class A or class B operation, there are stronger reasons for preferring class B with transistors than with valves. In transistors the collector dissipation, and the way in which this varies with the input signal, are both considerably different for the two types of operation. Thus if we take the maximum power limit as that determined by the maximum allowable mean collector dissipation, we find that the maximum available power for two transistors operating in class B push-pull is five times that for the same pair in class A; and is, in fact, five times the allowable collector dissipation. If we take the power limit as being that at which the distortion starts to increase rapidly (caused by alteration of current gain with peak current) similar ratios and powers are also obtained.

Another important consideration is the input power required. Owing to the characteristics of transistors they can be operated to much lower voltages relative to the h.t. supply than the corresponding pentode valves so that the maximum theoretical efficiencies for class A and class B operation of $\frac{1}{2}$ and $\frac{\pi}{4}$ respectively can be very nearly achieved using transistors. Under quiescent conditions the power drain with class B operation of transistors is of the order of 0.1 of the maximum output power rising to 1.3 times the maximum power when this is being delivered. With class A operation there is a continual drain of about four times the maximum power.

Having regard to these two factors of available power and power input required, the best use of a.f. transistors will be made in class B battery amplifiers, i.e., in public address or in ordinary commercial battery receivers. Other factors supporting this view are their compactness and the low voltage supplies required. Furthermore, when a push-pull class B transistor amplifier is overloaded the "clipping" distortion produces little loss of clarity for public address purposes.

The common emitter type is preferred for both small and large signal amplifiers. This has the highest gain and any disadvantages can be conveniently avoided in circuits which reduce this gain. For example, the input resistance of such amplifiers is often undesirably low (e.g., when using a crystal pickup); and in order to increase this the simple addition of a series resistor is most convenient in spite of the loss of gain.

Phase Splitting Circuits.—In most of the amplifiers mentioned a transformer phase splitter was adopted. This gives a higher gain than if a transistor is used, but the size of the transformer may sometimes be a disadvantage. As the impedances concerned are low the transformer specification will be somewhat different from that in a valve amplifier. Thus the minimum primary inductance required for good l.f. response will be much less, being of the order of 50 millihenrys rather than 50 henrys. On the other hand the d.c. resistance must be very low necessitating thicker wire.

If a transistor is used to provide phase splitting the coupling condensers tend to charge up, and the forward bias on the output transistors necessary to reduce crossover distortion is decreased. The maximum available power is then decreased, though the frequency response is improved.

In such transformer phase splitting circuits with transistors, several new types of distortion arise; but apart from the normal panacea of negative feedback other techniques are available for considerably reducing these. Thus the changing input resistance as one transistor takes over amplification from the other every half cycle (the emitter resistance varies inversely with the emitter current) can be avoided by a small amount of forward bias ($\approx$100 mV) to the emitter-base junction so that a positive emitter current flows under quiescent conditions. Carrier storage effects producing ringing at a high frequency, which occur as well when the signal changes sign, can also be largely eliminated by bifilar winding of the secondary of the phase splitting transformer.

Phase changes in the transformers as well as in the transistors themselves of course limit the amount of feedback that can be supplied; but there is no difficulty in obtaining the roughly 7 dB overall feedback required to reduce distortion sufficiently in class B amplifiers, if an RC feedback loop is used to take some account of these phase shifts. The application of feedback in transistor circuits is also important for reducing the effect of variation among individual transistor characteristics in mass production or replacement.

Complete Amplifiers.—Seven different amplifiers have been made with maximum powers ranging from 250 milliwatts to 20 watts. They consist of an input amplifying stage, the phase splitting transformer, and a push-pull output stage. For the class B amplifiers the total harmonic distortion at maximum power was $\approx$8 %. The 4-watt class A amplifier which was demonstrated (corresponding to the 20-watt class B amplifier using the same transistors) had 0.8 % total harmonic distortion at 4 watts (0.5 % at 2½ watts) with 16 dB overall feedback. This distortion could have been reduced to 0.3 % at 4 watts by using a class A push-pull driver stage. Power gains for both types of amplifier were $\approx$50 dB or greater.

The 250 mW amplifier corresponds to the usual battery radio valve output stage. However, in normal

use the volume control is often set so as to cause overloading; so that an improvement in quality can be effected using a 1-watt amplifier, though a disadvantage is that the quiescent current drain is nearly doubled. There is no corresponding battery valve equivalent in this case.

A very compact battery-operated, 45 r.p.m., record player using the 1-watt amplifier was demonstrated. The battery life when supplying the turntable as well as the amplifier is about 15 hours using 5 U2 batteries. Although this may not seem very much; as the G.E.C. representative remarked, "15 hours worth of records take a very long time to play!"

The 250-mW amplifier for the output of a transistor a.m. receiver which was also shown in a very compact form, used a directly coupled 120-ohm centre-tapped loudspeaker voice coil. This increases the thermal stability in the output stage because of the d.c. resistance, but the application of overall feedback in two balanced loops is difficult. A single-ended push-pull output stage was described as a means of rapidly changing to twice the power supply voltage for a normal push-pull output stage; but there was no direct coupled loudspeaker application for this case.

As regards other applications of these transistors, low-noise pre-amplifiers developed include the usual bass and treble tone controls; and for a normal microphone (600-ohm output impedance) or pickup ("variable reluctance" or crystal) input signal, give signal to noise ratios of about 60 dB. Concerning the possibility of a transistorized tape deck the most difficult problem is the provision of erase power. Two EW70s (one of the new types of transistor) can be used in class B push-pull to deliver 2 watts at 35 kc/s, thus largely solving this problem.

Details of New Range.—The new G.E.C. transistors are all of the germanium junction *p-n-p* type. They are hermetically sealed and of all-metal construction; the metal can provides a heat sink, and facilitates the attachment of a radiator. The low-resistance base connection, which is also integral to the construction, besides providing good thermal contact, also enables the potential h.f. performance to be more fully realized.

Having regard to their general characteristics and maximum allowable collector dissipation there are essentially three new transistor types. These are known as the GET 4 and 6, GET 5 (formerly EW70) and the EW57 (provisional); and have allowable collector dissipations (at 45°C) of 50 mW, 400 mW and 4 watts respectively. The frequency cut-offs are $\approx$ 250 Kc/s for the EW57 and greater than 1 Mc/s for the others.

The GET 6 is a low-noise version of the GET 4 and has a noise level well comparable with that in thermionic valves. The EW57 is also subdivided into three types according to the supply voltage required (6, 12 or 24 volts). All of these transistors have been in pilot production for about two years and should be in quantity production later this year.

With regard to the limiting operating conditions for these transistors there was thought to be good prospects of improvement. At present the maximum operating temperature is 50°C, but this can probably be increased up to about 70°C. If collector leakage currents become embarrassing silicon transistors (samples of which should be available before the end of the year) would be a complete answer and should function to well over 100°C.

The power limit should also see a major improvement with operation at high collector temperatures. Moreover experimental samples which maintain their current gains at high values of emitter current (another limiting factor) have also been produced.

COMMERCIAL LITERATURE

Printed Circuits.—An illustrated booklet for engineers and technicians on the available types of printed circuits and the problems of designing equipment using them. Rigid, flexible and flush-bonded types are discussed, also incorporated components, heating elements, and facilities offered for development and production. From Technograph Printed Circuits, 32, Shaftesbury Avenue, London, W.1.

Tape-to-Disc Transfer Service.—Details and prices in a leaflet from Sound News Productions, 59, Bryanston Street, Marble Arch, London, W.1.

Sound Reproduction Equipment ("New Orthophonic High Fidelity"), including amplifiers, loudspeakers, tuner, transcription unit and pickups. Price list from R.C.A. Great Britain, Lincoln Way, Windmill Road, Sunbury-on-Thames, Middlesex.

High-Conductivity Copper Alloys, containing silver, cadmium, chromium, and tellurium. The last three decrease the conductivity slightly but give other desirable properties such as increased strength, resistance to wear and machinability. An informative booklet of 54 pages, containing many tables of properties, from the Copper Development Association, 55, South Audley Street, London, W.1.

High-Quality Loudspeaker in Helmholtz resonator enclosure measuring 22in × 12in × 13in. Power handling in excess of 6 W for low distortion, and level frequency response over 40-10,000 c/s. Leaflet from RGA Sound Services (Plymouth), 6, Conway Gardens, Enfield, Middlesex.

Radio and Electronics Books including the Philips series on valves, etc., listed in a catalogue from the Cleaver-Hume Press, 31, Wright's Lane, Kensington, London, W.8.

Small Capacitors suitable for loudspeaker crossover networks, claimed to occupy only 25-30% of space required by conventional types. Capacitances between 2 and 16 μF, working voltage 150 V d.c. Leaflet from A. H. Hunt (Capacitors), Wandsworth Road, London, S.W.18.

Variable Output Transformers (Regavolt) with self-aligning brushes to ensure maximum surface contact with winding. Four new types for normal mains voltages, with outputs variable over 0-275 V, currents between 6 and 10 A, and one new type for 115-V mains and output of 0-135 V at 15 A. Leaflets from the British Electric Resistance Company, Queensway, Enfield, Middlesex.

Microphones; crystal, ribbon, carbon and noise-cancelling types; also stands, table bases, transformers and other accessories. Illustrated catalogue from Lustraphone, St. George's Works, Regents Park Road, London, N.W.1.

Strain-Gauge Bridge, giving direct reading in percentage strain over the range 0.001% to 0.5%. Accuracy of measurement, ±1%. Leaflet from the Croydon Precision Instrument Company, Hampton Road, West Croydon, Surrey.

WORLD OF WIRELESS

Organizational, Personal and Industrial Notes and News

I.S.M. Interference

RADIO interference from industrial, scientific and medical equipment is being considered by a committee set up by the Postmaster-General to advise him on the making of regulations prescribing limits of radiation.

The Wireless Telegraphy Act prescribes that the members of such advisory committees should either "possess expert knowledge of the matters falling to be dealt with" or "represent persons whose interests are likely to be affected" by any regulations made. The nineteen-man committee, of which O. W. Humphreys is chairman, therefore covers the interests of those concerned with both the cause and effect and includes representatives of the B.B.C., I.T.A., equipment manufacturers, air navigational specialists, production engineers, the medical profession and the viewer and listener.

V.H.F. Coverage

BY the opening of three more v.h.f. broadcasting stations (Wenvoe, replacing the temporary low-power transmitter, Sutton Coldfield and Norwich) a day or two before Christmas, the B.B.C. made good its promise to complete the first batch of ten stations by the end of 1956. To say "complete" is perhaps a slight exaggeration, for the Cardiganshire station at Blaen Plwy at present has only one of its three transmitters (Home Service) working. An eleventh station, at Penmon, was subsequently added to the original chain, but so far only one transmitter has been installed and this is radiating the Home Service with an e.r.p. of 1 kW.

The service now reaches 84% of the population.

	Light (Mc/s)	Third (Mc/s)	Home (Mc/s)	e.r.p. (kW)
N. Hessary Tor (S. Devon) ...	88.1	90.3	92.5	60
Sutton Coldfield (Warwicks.)	88.3	90.5	92.7	120
Pontop Pike (Co. Durham) ...	88.5	90.7	92.9	60
Meldrum (Aberdeenshire) ...	88.7	90.9	93.1	60
Blaen Plwy (Cardigan.) ...	88.7	90.9	93.1	60
Wrotham (Kent)	89.1	91.3	93.5	120
Holme Moss (Yorks.) ...	89.3	91.5	93.7	120
Penmon (Anglesey)	89.6	91.8	94.0	60
Norwich	89.7	91.9	94.1	120
Wenvoe (Glam.)	89.9	92.1	94.3	120
Divis (N. Ireland)	90.1	92.3	94.5	60

U.K. Display in New York

THE Institute of Radio Engineers' annual convention and show, which last year attracted 714 exhibitors, is being held in New York from March 18th to 21st. The Institute has offered an area of 1,200 sq ft for a collective U.K. display of radio and electronic equipment. Manufacturers interested in participating should communicate at once with the Board of Trade, Exhibitions and Fairs Branch, Lacon House, Theobalds Road, London, W.C.1. (Tel.: Chancery 4411, Extn. 436.)

Tape Recording Patents

THE Armour Research Foundation has carried out extensive research during the past 15 years on all aspects of magnetic recording, and has filed over one hundred American patents; most of these have also been granted in the United Kingdom.

John P. Skinner, manager of the A.R.F. Development Corporation, a subsidiary of the non-profit-making Foundation, stated during a recent visit to this country that to make an effective tape deck it is necessary to use principles contained in at least one of the A.R.F. patents.

It is understood on enquiry that licensing agreements have already been concluded by the A.R.F. Development Corporation, of Chicago, Illinois, with the following companies in this country: Boosey and Hawkes, Collaro, Garrard, E.M.I., Grundig, Simon, Tape Recorders (Electronics), Verdik Sales, Walter (Tape Recorders), and Wright and Weaire.

Amateurs and TV Interference

A NEW policy regarding amateur interference with sound and television reception has been announced by the Post Office. In the past, if complaints were received of an amateur causing interference to television reception due to "blocking," the Post Office prescribed that he must not transmit during television broadcasting hours.

Under the new arrangement if an amateur is otherwise transmitting within the terms of his licence, but causes interference to sound or television reception and it can be demonstrated that a reasonable remedy, such as the fitting of a simple filter, is available to the owner of the receiver, "then the amateur will be allowed to continue operating after an interval of one month from the time at which the cure is explained and demonstrated to the complainant by the Post Office."

It is understood that this will apply to all cases of interference to sound and television reception where the amateur's transmissions are found to be within the terms of his licence.

Although B.R.E.M.A. has been informed of the new policy no official announcement has so far been made on behalf of receiver manufacturers.

NEW YEAR HONOURS

A number of those who played a leading part in the planning, production and laying of the Atlantic telephone cable were recipients of awards in the New Year's Honours List. They include **J. N. Dean,** chairman of the Telegraph Construction and Maintenance Company (Knighthood); **R. J. Halsey,** an assistant engineer-in-chief at the G.P.O. (C.M.G.); **A. H. Roche,** telecommunication engineer in charge of Submarine Cable System Development and Production Division, Standard Telephones & Cables (O.B.E.); **E. F. Neve,** foreman S.T.C. submerged repeater manufacturing shop (B.E.M.); and **E. V. T. Perrins,** technical officer Post

Office Research Station, who has specialized in repeater test equipment (B.E.M.).

Sir Stanley Angwin, who recently retired from the chairmanship of the Commonwealth Telecommunication Board, and **E. M. Jones,** director, the Government Communications Headquarters, Foreign Office, are appointed K.C.M.G.

Three members of the G.E.C. Research Laboratories staff received awards:—**O. W. Humphreys,** director, is appointed C.B.E.; **E. G. James,** head of crystal valve development, O.B.E.; and **W. C. Cropper,** group leader in charge of a special project for the Admiralty, M.B.E.

Among those appointed M.B.E. are **Miss B. K. Chaplin,** executive officer at the D.S.I.R. Radio Research Station; **W. H. Hopkins,** works manager, E.M.I. Factories; **G. W. Kilmster,** first radio officer, R.M.S. *Arundel Castle*; **E. L. Lycett,** assistant, B.B.C. outside broadcasts; **H. Starr,** signals officer, Civil Aviation Telecommunication Directorate, Ministry of Transport and Civil Aviation; and **W. W. Syrett,** export manager of Ekco's Radio Division.

Among overseas radio personalities who received honours are **L. A. G. Hooke,** managing director of Amalgamated Wireless (Australasia), a knighthood for "services to the radio industry in Australia"; **T. W. Chalmers,** formerly director of broadcasting in Nigeria, C.B.E.; **T. V. Hooley,** officer-in-charge, Government Wireless Station, Falkland Islands, M.B.E.; and **E. R. Richardson,** senior assistant controller of telecommunications, Nigeria, M.B.E.

PERSONALITIES

Sir Noel Ashbridge, who retired from the directorship of technical services of the B.B.C. in 1952 and became a director of Marconi's, has been elected an honorary member of the Institution of Electrical Engineers. The election is in recognition of his services to the Institution, of which he was president in 1941, and of "his outstanding contributions in the field of radio engineering, particularly in the development of the British sound and television broadcasting services."

After what must be a record for service with one radio company—over 54 years—**R. D. Bangay** has retired from Marconi's. In 1952 he celebrated his jubilee in the radio industry, the first man to do so. Soon after joining the company in 1902 he went to America for five years and helped in the installation of the first U.S. coastal radio station, at Babylon. He was concerned with the original experiments in air-to-ground communication, and in 1914 was placed in charge of the company's department established for the development of military radio equipment. Mr. Bangay was for some years chief of designs, and since 1935 has been foreign manager. He was the author of two books published by *Wireless World* many years ago: "The Elementary Principles of Wireless Telegraphy" and "The Oscillation Valve."

L. C. Jesty, B.Sc., M.I.E.E., has left Marconi's, where for seven years he led the television research group, and has joined the Sylvania-Thorn Colour Television Laboratories at Enfield, Middlesex. He will be in charge of colour television research. Whilst at Marconi's research laboratories he had been closely concerned with the Anglicized version of the American colour system which has been used experimentally by the B.B.C. From 1927 to 1946 Mr. Jesty was on the staff of the G.E.C. Research Laboratories where in 1933 he started the c.r.t. research group which was responsible for the introduction of the VCR97. For three years prior to joining Marconi's he was in charge of advanced research at the Cinema-Television Laboratories.

The Radio Communication and Electronic Engineering Association has created the new post of technical secretary, to which **J. F. Richardson,** Grad.I.E.E., has been appointed. He will work under H. E. F. Taylor, recently appointed executive secretary. Mr. Richardson began his engineering training in 1939 with S.T.C., and since 1952 has been technical assistant to the director, Electric Lamp Manufacturers' Association.

Reginald A. Yeo has left the Admiralty Signal and Radar Establishment, at Haslemere, where he was head of the electronics division, on being appointed full-time member of the Australian Broadcasting Control Board. He was a principal scientific officer in the Royal Navy Scientific Service, and was concerned mainly with radio matters throughout his government service. He was delegate at the conference of the International Telecommunication Union at Atlantic City in 1947.

G. B. Jeffery, M.A., B.Sc., A.M.I.E.E., has left the Royal Aircraft Establishment, Farnborough, where for four and a half years he has been senior engineer in the data transmission section of the Electrical Engineering Department, and has joined R. B. Pullin and Co. He is technical sales manager of the Pullin-Kearfott Division, which, under a recent licensing agreement with the American Kearfott Company, Inc., will manufacture synchros, servomotors and tachometer generators. During the war Mr. Jeffery was a radar officer, R.N.V.R., and was on the staff of H.M. Radar School, H.M.S. *Collingwood.*

H. L. A. Foy, the new publicity manager of Decca Radar, Ltd., has been engaged on the operational aspects of radar since he joined the company two years ago. He was a specialist navigating officer in the Royal Navy, and since joining Decca has been particularly concerned with the introduction of "True Motion" radar.

C. Hardy and **C. B. Speedy,** Ph.D., B.E., Grad.I.E.E., have been appointed directors of Data Recording Instrument Company, Ltd., of Feltham, Middlesex, which previously operated as a division of Lion Electronic Developments, Ltd. Mr. Hardy was for many years at the Signals Research and Development Establishment of the Ministry of Supply, where he was working on data recording. Dr. Speedy has been engaged since 1945 on the study of electronics especially in relation to computers.

J. N. Macleod and **C. Metcalfe** have been appointed directors of Electric and Musical Industries, Ltd. Together with **E. J. Emery,** who was appointed a director last February, they have been appointed managing directors of the company, responsible, respectively, for the U.K. Record Division and the Oversea subsidiary companies (other than Capitol Records Inc. and its subsidiaries), the E.M.I. Electronics Division (commercial and industrial equipment), and the Domestic Electronics Division.

H. A. Lewis, M.B.E., T.D., B.Sc.(Eng.), A.C.G.I., M.I.E.E., who recently left Marconi's to become personal assistant to E. J. Emery, managing director of the Domestic Electronics Division of E.M.I., has been appointed a director of E.M.I. Sales and Service, Ltd.

D. L. Johnston, who in our October, 1954, issue described a transistor replacement unit for hearing-aid h.t. batteries, has left Fortiphone, Ltd., where he was manager of the component division, and has joined Automation Consultants and Associates, Ltd.

The following appointments are announced by Belling and Lee: **D. W. Rippin,** who has been outside technical representative, becomes export manager; **J. E. Bailey,** B.Sc., and **R. E. Meldrum** join the company as technical representatives to manufacturers, and **A. Fender** is appointed technical sales representative to the trade in the area centred on Newcastle-upon-Tyne.

L. C. Smith has resigned from Plessey's which he joined ten years ago as technical representative. During the last war he was lieutenant-commander in the electrical branch of the Royal Navy and specialized in the maintenance of asdic. Before the war he ran his own service business in Birmingham for five years, prior to which he was a service technician with E.M.I. His address is 122, Whitaker Road, Derby.

Peter E. M. Sharp, A.C.G.I., B.Sc.(Eng.), A.M.I.E.E., whose three-year contract with China Engineers, Ltd., has ended, has returned to this country. He joined the Telegraph Construction and Maintenance Company in 1951, subsequently transferring to their agents in the Far East. His home address is 46, Hyde Vale, London, S.E.10.

OUR AUTHORS

Dr. E. L. C. White, of the research division of E.M.I. Electronics, who recently addressed members of the Television Society on alternatives to the American television system, contributes an article on page 75 covering some of the points discussed. Dr. White has been with E.M.I. since 1933 and was closely associated with the late A. D. Blumlein in developing the Marconi-E.M.I. television system adopted by the B.B.C. During, and to some extent since, the war, he has been concerned with the development of radar display systems, but has more recently worked on colour television. Before joining E.M.I. he was for three years at Cavendish Laboratory, Cambridge, working on pulse methods of ionospheric research. He is 47.

Michael P. Beddoes, contributor of the article on an improved sync separator, went to Canada a few months ago, and is now assistant professor in electrical engineering at the University of British Columbia. After graduating in electrical engineering at Glasgow University he spent seven years in industry, and then in 1953 went to the City and Guilds College where he worked on television band-compressing systems. His industrial experience started at G.E.C., Coventry (as a post-graduate apprentice), and after service as a senior engineer at Plessey's he became assistant chief engineer of McMichael's radio division.

IN BRIEF

During November the number of television licences increased by 142,345 bringing the total to 6,433,417. **Broadcast receiving licences,** including those for television and 310,690 for car radio, totalled 14,424,236 at the end of November.

Brit.I.R.E. Constitution.—An extraordinary general meeting of members of the British Institution of Radio Engineers is being held on January 30th, at which it is proposed to redraft the constitution. It is understood that the whole of the articles of association are being revised to give emphasis to the Institution's coverage of electronics.

"Wireless World" Index.—The publication of the Index for 1956 has been unavoidably delayed; it will be available towards the end of February. Cloth binding cases with index cost 7s 6d (postage 6d). Our Publishers will undertake the binding of readers' own issues, the cost per volume, including the index and binding case, being 22s 6d, plus 1s 6d postage on the bound volume.

Bilingual Television.—The system for transmitting two sound programmes in a single sound channel described on p. 79 has actually been developed for use by the French television service in Algeria, which has both French and Arabic viewers. A complete description, with a photograph of the "decoder" unit, appears in the January issue of the French journal *Télévision.*

American TV in Germany.—Television on American standards is being radiated from two transmitters in Germany for the benefit of U.S. service men. The low-power stations, which operate in Band IV (470-585 Mc/s), are at Bitburg and Landstuhl. They transmit films, provided by the Armed Forces Television centre at Limestone, Maine, for seven hours a day.

The **French Components Show** will be held from March 29th to April 2nd at the Parc des Expositions, Porte de Versailles, Paris.

America's Institute of High-Fidelity Manufacturers is sponsoring a **Hi-Fi Show** in Los Angeles from February 6th to 9th.

An electronic **computing service** for industrialists and scientists has been introduced by the Battelle Institute at Frankfurt/Main, Germany. Enquiries regarding the service and the facilities provided are being handled in this country by the Electronics Division of Remington Rand, Ltd., Commonwealth House, 1-19, New Oxford Street, London, W.C.1.

Interference Suppression.—Another conference on radio interference (the third) is being organized by the Armour Research Foundation of Illinois Institute of Technology. It will be held in Chicago on February 26th and 27th.

Colour Television.—Sales of R.C.A. colour television receivers were expected to reach the forecast 200,000 for 1956. It is anticipated that half a million colour receivers will be produced by R.C.A. this year.

Special courses in **higher technology,** being held during the spring and summer terms at colleges in London and the home counties, are listed in a bulletin issued by the Regional Advisory Council for Higher Technological Education. It costs 1s 6d and covers a wide variety of courses, including radio and allied subjects, being held at twenty-nine colleges.

I.o.M. Television.—A permanent television station, to replace the temporary one which has been in use since December 1953, is to be built by the B.B.C. at Carnane, near Douglas, Isle of Man, by the end of this year. The original plan to build the permanent station on Snaefell has been dropped.

Peterborough is having a three-day audio fair starting on January 22nd. It is being organized by Camera and Cine Centre, of 14, Long Causeway, at the Grand Hotel where lectures and demonstrations are being given by representatives of audio equipment manufacturers.

Each Saturday from 10 to 12 noon **demonstrations** of audio equipment are being given by Pamphonic Reproducers at their showrooms at 17, Stratton Street, London, W.1.

An inexpensive (25s) single-stage **transistor audio amplifier,** intended for working with a crystal receiver is being made by Warren's Radio, 88, Wellington Street Luton, Beds.

A **bibliography** of high-fidelity sound reproduction has been compiled by K. J. Spencer; and is available from the Library Association, Chaucer House, Malet Place, London, W.C.1; price 2s 6d. Approximately three hundred references, mostly later than 1947, are given. A more extensive bibliography of the subject is being prepared.

"Portable Transistor Superhet."—The germanium diode detector in this circuit (January issue) has been drawn with the wrong polarity of connections. It should be reversed, so that a positive-going a.g.c. voltage is applied to the base of the 1st i.f. transistor.

R.S.G.B. Membership.—The annual report of the Radio Society of Great Britain records that whereas during the past five years membership had declined by nearly 5,000, last year's decrease was only 57. The number of licensed amateurs in the Society actually increased by 95, bringing the total to 5,141. Non-transmitting members total 2,961.

Winning Design in the competition sponsored by the British Plastics Federation "to encourage young craftsmen to design articles in plastics materials" was for a 17-in portable television cabinet. The designer, E. J. Arundell, of Liverpool, receives 50 guineas.

Two 16mm **Mullard sound films**—one on cathode-ray tubes (lasting 32 minutes) and another on quality valves (27 minutes) are now available on free loan from the Central Film Library, Central Office of Information, Government Building, Bromyard Avenue, Acton, London, W.3.

The products and services of over seven thousand member firms of the Federation of British Industries, listed alphabetically under more than 5,400 headings, as well as lists of trade marks and trade names, are included in the 1957 edition of the "**F.B.I. Register of British Manufacturers.**" French, German and Spanish glossaries are also incorporated in the Register, which is obtainable from our publishers, price two guineas, post free.

E.I.B.A.—A number of radio manufacturers are listed as donors to the Electrical Industries Benevolent Association in its 1956 Year Book. In addition, the Radio Industry Council gave £500, the B.B.C. £158, and the Radio Industry Clubs of London and Glasgow £350 and £140, respectively. The object of the Association is to assist deserving and necessitous persons who are, or have been, in "any branch of an electrical industry."

BUSINESS NOTES

Nine film scanners, each employing two film projectors and two television cameras, have been ordered by the B.B.C. from **Pye.** A feature of the equipment is that by the use of movable mirrors either camera can be focussed on a projector, thus minimizing the possibility of breaks in transmission.

An underwater television camera, which can be held by a frogman or diver, towed or fitted to a vessel, has been produced by **Pye.** Spherical in shape, it is intended for use at depths down to 3,000 feet. It incorporates a depth indicator from which readings are conveyed to observers on the surface.

Type approval, covering humidity and temperature, has been granted by the Joint Service Radio Components Standardization Committee for **Ferranti's** 2-in sealed instruments—voltmeters, ammeters and milliammeters. Their $2\frac{1}{2}$-in and $3\frac{1}{2}$-in instruments are classified as "design approved."

Communication on six v.h.f. channels is provided in the air traffic control system recently installed by **International Aeradio** at Vickers-Armstrong's airfield at Wisley, Surrey.

Two limiter stages are incorporated in the new Orthophonic high-fidelity f.m. tuner being produced by **RCA Great Britain.** The circuit employs seven valves, two crystal diodes and a tuner indicator.

Sales abroad accounted for £33M of the **E.M.I.** group's £53M turnover during the year ended June, 1956. The year's total was an increase of £11.4M on the previous twelve months.

Orders for millimetre-band telecommunication test equipment valued at over £25,000 have been placed with **Marconi Instruments** by the Ministry of Supply. Each 6-ft rack-mounted assembly comprises electronically regulated power supply and a frequency stabilization system.

A distribution centre, including showrooms and service information department, for **Ambassador and Baird** receivers, has been opened at 131, Great Suffolk Street, London, S.E.1 (Tel.: Hop 0791). K. H. Yandell, sales director of Ambassador Radio and Television, Ltd., and F. Duer, southern area sales manager, are now at this address.

Shirley Laboratories, Ltd., which was formed in 1954 by A. W. Wayne (a contributor to *Wireless World*) for the manufacture of amplifiers, tuners and electronic instruments, has moved to 3, Prospect Place, Worthing, Sussex. (Tel.: Worthing 30536.)

Tape Recorders (Electronics), Ltd., have recently started production at their second factory at 784-788, High Road, Tottenham, London, N.17. The price of their Sound Cadet recorder has been reduced to 39 gns.

S.S. Electronics, Ltd., recently moved from Harrow to Chiltern Works, Severalls Avenue, Chesham, Bucks. (Tel.: Chesham 8909.)

The midland office of **Marconi Instruments, Ltd.,** formerly situated at 19, are now at 24, The Parade, Leamington Spa.

Goodmans loudspeaker cabinet, formerly known as the Viscount and recently renamed Canberra, is now called Sherwood.

OVERSEAS TRADE

Since the formation of Decca Radar og Navigator A/S, Bergen, the Norwegian subsidiary of the Decca Radar and Navigator Companies, in February, 1955, orders have been secured for **radar installations** in more than 300 Norwegian ships. It has also established a chain of service depots. The company's new general manager is F. I. Willoch. He has taken over from E. Tyler who has returned to the London office.

According to a recently completed analysis of places to which Britain exports radio and electronic gear, the **United States** was the largest buyer of British radio equipment in the first six months of last year. The value of U.K. radio exports to the U.S.A. was £1.6M, nearly 8 per cent of the industry's total overseas trade. Incidentally, the bulk of this was for sound reproducing equipment.

Marconi's are installing a temporary 2-kW medium-wave **broadcasting transmitter** at Brunei, on the north-western coast of Borneo, preparatory to setting up a permanent 20-kW transmitter on Tutong, some 35 miles from the town. The permanent transmitter will be fed by a frequency-modulated radio link from Brunei. A receiving station with double reversible rhombic aerials in dual diversity for the reception of B.B.C. and Australian stations, and dipole arrays for the reception of less distant stations, is also being built.

A contract for a v.h.f. multi-channel radio-telephone system for India's Western Railways has been placed with Marconi's. The **radio-telephone links,** which will have a capacity of 48 two-way channels, will be between Bhavnagar and Surat, and Jamnagar and Rajkot.

Pye "Ranger" v.h.f. **radio-telephone equipment,** employing channel spacing of only 15 kc/s, was recently demonstrated in Toronto. This equipment is being made available immediately for those countries where there is intense frequency congestion.

Kelvin-Hughes **echo sounders and radar** have been fitted in the 47,000-ton tanker *Evgenia Niarchos,* the biggest yet built in this country.

Representation of U.K. manufacturers of loudspeakers, selenium rectifiers and tape recorders is being sought by John R. Tilton, Ltd., of 51, McCormack Avenue, Toronto 9, to whom illustrated literature, with ex-works and c.i.f. Canadian port prices in Canadian dollars, should be sent.

Output Transformerless Amplifiers

A GENERAL REVIEW

THOSE of us who are in search of perfection in audio amplifiers must often have looked askance at the output transformer. In general it would be possible to reduce the non-linearities in an amplifier below any desired value by the application of a sufficient amount of feedback. However, as is well known, the output transformer produces undesirable phase shifts at the extreme ends of the audio spectrum which limit the amount of feedback which can be applied before instability sets in. These phase shifts also decrease the effective feedback at these extreme frequencies and this causes increased distortion in these regions. Varying core losses, hysteresis effects, matching variations, and incomplete coupling between the primaries also more directly increase the distortion, and this increase also is more pronounced at the frequency extremes.

Modern transformer design techniques of sectionalized windings, and particularly the use of C-cores, have to a large extent overcome these disadvantages in practice; but this has naturally given rise to an increase in price, and the fundamental limitations still remain.

Increased Possibility of Class B Operation.—Using loudspeakers of normal efficiency and impedance (15-ohm) in an average living room an accepted peak power requirement from the amplifier is of the order of fifteen watts. In this case if there is no output transformer we will obviously require currents of the order of one ampere from the output valves.

The problem of obtaining these currents is somewhat eased because in transformerless amplifiers class B operation of the output valves becomes more feasible than such operation is in an amplifier with an output transformer. Normally in class B operation using an output transformer incomplete coupling between the two half primaries produces transients when the valves cut off. These transients produce distressing audible distortion and are very difficult to eradicate, though a special bifilar transformer with both cathode and anode feeds designed by McIntosh and Gow[1] does succeed in doing so.

In class B operation owing simply to the higher outputs the general distortion is higher but this is not seriously so and can, of course, be reduced by increased feedback.

High-Impedance Loudspeakers?—Allied to the difficulty of obtaining sufficient current from the output valves is that of matching, without too much distortion, the comparatively high valve impedance (of the order of a few thousand ohms) to the low impedance of the loudspeaker voice coil.

An obvious solution to both these problems is to use loudspeakers of higher impedance, but here the necessity of using thinner wire to keep the voice coil weight down produces its own problems. A few speakers of impedances in the range of 200-500 ohms have, however, been marketed, but there is not the usual variety of models available. Readers will realize the possibility that the newer electrostatic speakers will fit more smoothly into such a system, though their capacitive nature increases the matching problem.

In general by suitably paralleling output valves a transformerless amplifier for high-impedance loudspeakers can be adapted for low-impedance ones, so that the general features of the various designs can be considered without regard to the voice-coil impedance.

Straightforward Methods.—A first approach is simply to use normal circuits with the loudspeaker directly replacing the output transformer or load,[2] bearing in mind that it will often be more convenient to connect the speaker in the cathode or low-voltage side of the valve.

Such designs generally involve capacitive coupling to the loudspeaker or direct current through the voice coil. Capacitive coupling requires almost impossibly high values of condenser for good low-frequency response and small phase shift in the case of low impedance loudspeakers, and may produce distortion due to hysteresis in the condenser.

Direct current in the voice coil would move it toward the positions of non-linearity for the suspension and non-uniformity of the magnetic field and in practice give a considerable increase in distortion. The possibility of increasing the linearity of the suspension (and thus decreasing the distortion), while maintaining sufficient restoring force to allow the required audio power to be developed, has already been largely exhausted in the design of conventional loudspeakers.

Distortion caused by a non-uniform magnetic field could be avoided by making the voice-coil longer than the field so that the same length is always immersed in the field. This arrangement is often used in bass loudspeakers where the increased weight of the voice-coil is less important. An equivalent method would be to lengthen the magnetic field but the larger magnets required would increase the cost. The alternative of having the voice-coil initially asymmetrical with respect to the magnetic field would require a change in the initial displacement for different amplifiers and is thus rather impracticable.[3]

This simple approach also unfortunately needs a centre-tapped voice coil for normal push-pull operation. For "ultra-linear" operation two more tappings are even necessary! From the point of view of requiring as little and as practical a change as possible in existing loudspeaker design this approach is seen to be inadequate.

Some sort of balanced arrangement whereby direct current in the voice coil is avoided would be an improvement. A straightforward circuit along

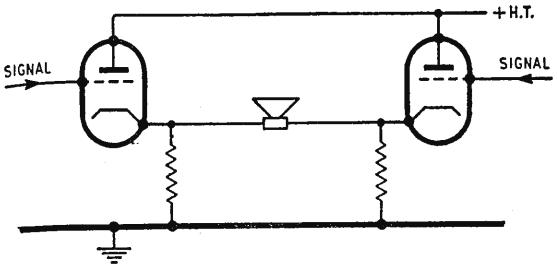


Fig. 1. Fletcher-Cooke output stage.

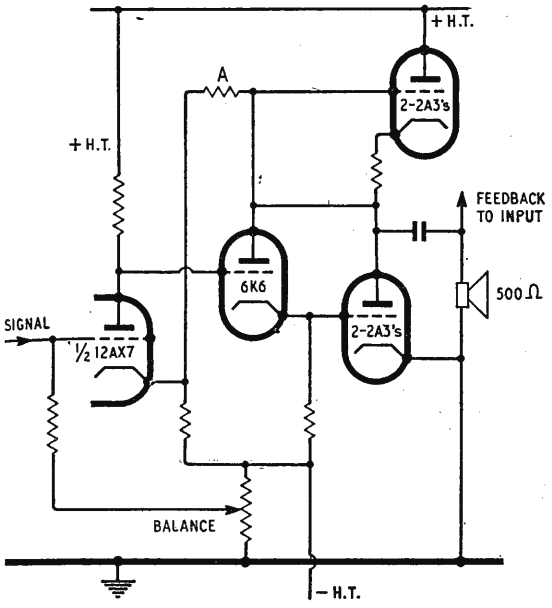


Fig. 2. Stephens amplifier.

this line is described by Fletcher and Cooke.[4] The authors use a simple push-pull cathode follower arrangement shown schematically in Fig. 1. In order to obtain 12 watts of peak power in a 16-ohm loudspeaker 16 6AS7Gs were necessary. No distortion figures were quoted, and the damping was not very good (the output impedance was 23 ohms) but the authors did not use any overall negative feedback. In such cathode follower circuits low-impedance loudspeakers have an advantage in that the voltage requirements from the driver are not so serious as is usually the case.

Series Connected Output Stages.—Most other circuits use a series connected output stage, with either a single or push-pull input to this stage. In either case since the valve outputs in the load add together the optimum value for this load is less than half of that in the conventional push-pull arrangement. This type of circuit thus considerably eases the matching problem. It is also often easier to arrange d.c. connections between earlier stages and the output valves which improves the low frequency response and decreases the phase shift in this region.

Using a single input, series connected, output stage two commercial amplifiers have been developed, by Stephens[5] and Philips,[6] both for capacity connected high-impedance loudspeakers. Schematic diagrams for these are shown in Figs. 2 and 3. In both cases the signal from the lower output valve is fed to the grid of the upper so that the input signal varies the voltage across the output valves in opposite directions. More complicated power supply arrangements could have avoided the necessity of capacity connections to the loudspeakers. The circuit of the Stephens amplifier shows how d.c. connections between early stages may be arranged in this type of circuit. The resistor A provides negative feedback and serves to stabilize the bias on the 2A3s. With about 40 dB of feedback 3rd harmonic distortion is of the order of 0.4 per cent for 20 watts r.m.s. output into the 500-ohm load. Unfortunately, in both these amplifiers the voice coil does not provide a sole common load for the two output valves because they also partially load each other. Although cancelling of even harmonic distortion products could still be obtained by arranging for the output valves to give equal amounts of such distortion in the voice coil, this balancing would be difficult if not impossible, with the few variables available.

Push-Pull Series Connected Output Stages.—The last-mentioned disadvantage does not apply if the

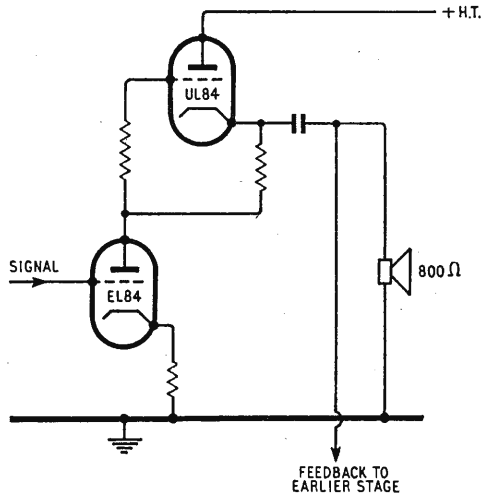


Fig. 3. Philips output stage.

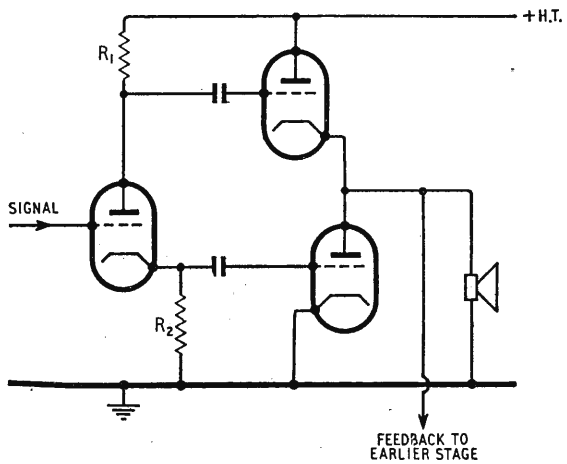
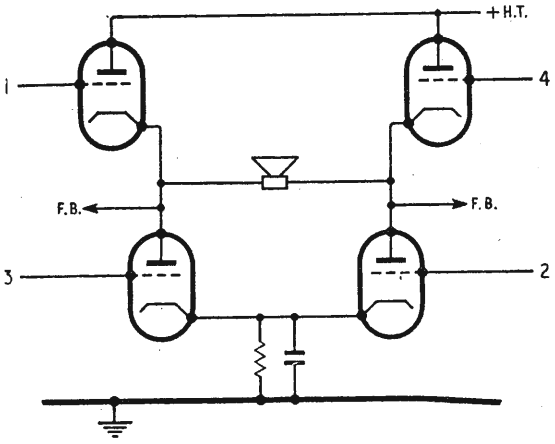


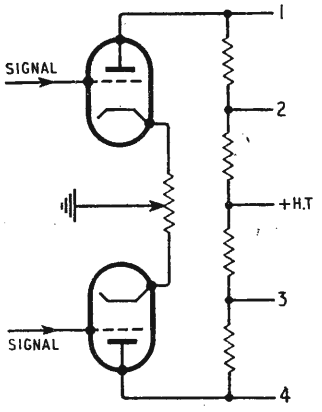
Fig. 4. Dickie-Macovski output stage.

output valves are series connected with push-pull input. In this case the optimum output impedance is one quarter of that for normal push-pull operation. If, however, the phase splitter and output valves are not correctly designed together it is difficult to retain equal drive in the output valves as the loudspeaker impedance changes.

An example of this difficulty arises in an amplifier described by Dickie and Macovski.[7] Omitting a push-pull driver stage the phase splitter and output stages are schematically as in Fig. 4. Here it will be seen that the voice-coil load is coupled so that it provides feedback to the grid of the upper valve. Thus the input to this valve has to be increased and the resistor R_1 is made greater than R_2. However the variation of voice-coil impedance over the frequency range (which may easily be of the order of 5 to 1) prevents exact adjustment by this means except over a narrow frequency band. In this amplifier the effect of this impedance variation is reduced by suitably shunting the voice coil; an example of such a shunt being simply a .01-μF condenser and a 16-ohm resistor in series. This prevents the rise in impedance at high frequencies produced by the inductive voice coil and thus avoids instability caused by increased feedback and phase shift. The anode loads of the push-pull driver stage could also be adjusted to give better balance.

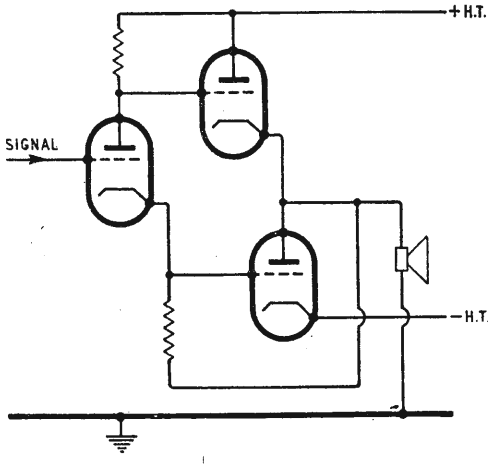


Above: Fig. 5. Onder output stage.



Left: Fig. 6. Onder driver stage.

Below: Fig. 7. Futterman output stage.



In this amplifier there is one voltage amplifying stage before the phase splitter and 3 6082 valves (26.5 volt versions of the 6AS7G) operating nearly in class B in the output stage. With 40 dB of overall feedback the harmonic distortion was 0.4 per cent for 25 watts r.m.s. into a 16-ohm load.

Essentially the same balancing difficulty arises in a variation of the circuit of Fig. 4 described by Onder.[8] Here instead of simply paralleling output valves to give increased power they are arranged in a bridge circuit (shown schematically in Fig. 5) which increases the optimum load to four times that for a parallel arrangement. Diagonal valves are run in phase, suitable driving voltages being obtained from a push-pull stage as in Fig. 6, this arrangement giving the necessary greater input to the upper tubes. An ordinary "concertina" phase splitter with suitable tappings on the loads could, of course, also be used. Here again using a balancing potentiometer as in Fig. 6, d.c. connections become possible.

In this amplifier there is a "see-saw" type of phase inverter before the driver, and 2 6AS7G valves operating in class A in the output stage. With about 15 dB overall feedback the intermodulation distortion was 0.7 per cent for 9 watts into a 400-ohm load.

Equalization of Drive in the Output Valves.—If we return now to Fig. 4 equal drive in the output valves can be obtained very simply as described by Futterman,[9] by returning the earthy end of R_2 to the junction of the output valves as in Fig. 7. In this case both output valves are acting as cathode followers so that the voltage requirements from the phase splitter are large. However, the load is in the input to this valve in the correct sense to provide positive feedback so that a much lower voltage is actually required.

In the amplifier described in this reference (Ref. 9) there is a pentode, high gain, voltage amplification stage before the phase splitter. The cathode return from this pentode is taken to the tap of a potentiometer across the load so that varying amounts of negative feedback may be applied. There was in fact some difficulty in obtaining sufficient gain to give enough feedback to reduce the distortion sufficiently, but a phase splitter giving gain could be used. Using 14 type 12B4 valves operating in class B in the output stage, with 48 dB of overall feedback the harmonic distortion was 0.1 per cent for 20 watts into a 16-ohm load. Square wave tests on this and the amplifier of reference 7 already described give very impressive results even at

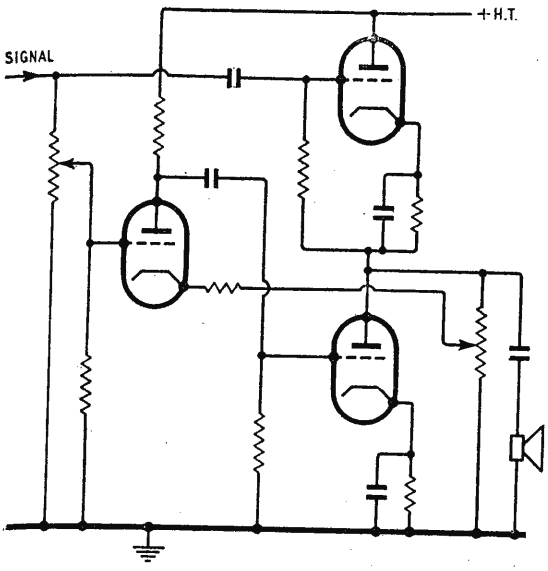


Fig. 8. Coulter output stage.

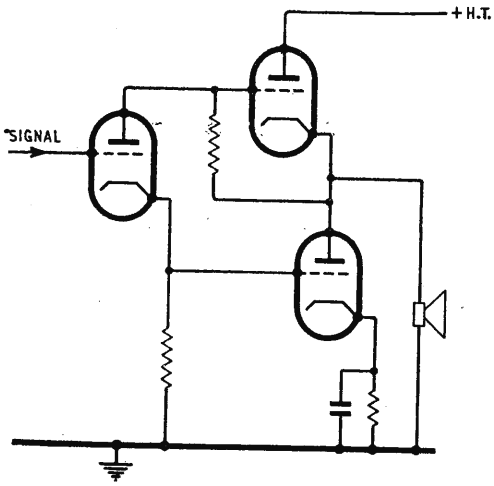


Fig. 9. Peterson-Sinclair output stage.

20 kc/s, with very short rise times and no overshoot.

A more complicated way of obtaining this equal balance, by applying extra feedback to the lower output valve in Fig. 4 is described by Coulter[10] and illustrated in Fig. 8. Here the upper output valve is fed directly from the input. A suitable fraction of this input has its phase inverted by another valve and is then applied to the grid of the lower output valve. By taking the cathode feed for the phase inverter from the tap of a potentiometer across the load, negative feedback is applied to this inverter and thus to the lower output valve. The amount of this negative feedback is adjusted to compensate for that produced by the load in the upper valve.

A disadvantage of this arrangement is that the distortion in the input to the lower valve is greater than that to the upper as this input has to pass through an extra voltage amplifying stage (the phase inverter); and the even harmonics of this extra distortion cannot be cancelled in the output stage. Furthermore, the degeneration caused by the speaker varies with its impedance, whereas the feedback is a constant fraction of the output voltage.

This general type of output stage has been recently applied to a transistor circuit by Cossor's.[11] Transistors have an encouraging future in transformerless amplifiers as their voltage requirements are much lower, and a considerably higher overall efficiency should be possible. In the Cossor circuit equal drive in the output transistors is obtained by an input transformer. This transformer also avoids d.c. unbalance in these transistors but is contrary to the general philosophy of such amplifiers.

Returning again to Fig. 4, perhaps the best way of obtaining balanced inputs to the output valves is, as described by Peterson and Sinclair,[12] to take the anode supply for the phase-splitter from the junction of the output valves as in Fig. 9. In this case the input voltages to the output valves are always developed between cathode and grid, so that the load does not produce a cathode follower effect in either valve and there is no unbalance. A disadvantage is the negative feedback produced by the load on the supply voltage for the phase-splitter. This circuit also is susceptible to d.c. connection.

The authors give a general discussion of this type of amplifier using transformers solely as matching devices. No practical details of a strict transformerless amplifier are given.

Extended Class A?—Another novel type of circuit that may perhaps be of value in these amplifiers was given the name, "extended class-A," by the author.[13] Here a triode and tetrode are run in parallel with their grids and anodes directly connected. The valves are biased for normal class A operation for the triode and this usually cuts off the tetrode, so that the arrangement acts as a triode for small signals. When the signal becomes sufficiently large (usually about one third of the maximum) the tetrode starts drawing current and increasingly controls the operation. This gives the transfer characteristic a slight curve but this is not serious. The circuit should combine the advantages of the low output impedance of triodes with the high current carrying characteristic of tetrodes. The idling anode current also is only about one third of the usual amount; or, in other words, for a given valve the maximum power obtainable is greatly increased.

Power Supplies.—It will be noted that the schematic diagrams in many cases envisage more than the usual number of power supplies, especially when those for screens and grids are worked out, and particularly if d.c. connections are desired. This complication is not as great as may be imagined when voltage doubling circuits, the avoidance of mains transformers, and direct series running of the heaters are considered. Moreover, due to the large amounts of negative feedback used, the hum in the output is generally reduced so much that chokes need not be used in the supplies. In fact, such chokes are often undesirable, as the impedance of the h.t. supply to the output valves must be low compared with the load to avoid loss of power.

Practical Choice of Output Valves.—To return to

some earlier remarks, one of the biggest practical difficulties is simply that of obtaining output valves that can pass the necessary current. Here from the cost point of view more than one valve will almost certainly be required for each side of the output stage. Bearing in mind that certain valves can be obtained very cheaply, it may be more economical to use a large number of one valve rather than fewer of another. Valves made primarily for other purposes, such as television line scan or current stabilization, can also sometimes be of use. The resultant optimum load should, of course, be made as small as possible, though increased distortion due to mismatch may be removable by sufficient feedback.

REFERENCES

[1] F. H. McIntosh and G. J. Gow, "Description and Analysis of a New 50-watt Amplifier Circuit," *Audio Eng.*, Vol. 33, December 1949, p. 9.

[2] V. Brociner and G. Shirley, "The Output-Transformer-less Amplifier," *Audio Eng.*, Vol. 36, June 1952, p. 21.

[3] For another method see H. A. Watt, "The Post-ultimate Amplifier," *High Fidelity*, Vol. 6, April 1956, p. 62.

[4] E. W. Fletcher and S. F. Cooke, "Cathode-follower Loudspeaker Coupling," *Electronics*, Vol. 24, November 1951, p. 118.

[5] F. H. Gilbert, "Commercial O-T-L Amplifier of Unique Design," *Audio Eng.*, Vol. 36, August 1952, p. 46; and F. H. Gilbert, "An A.F. Amplifier Without Output Transformer," *Radio and Television News*, March 1953, p. 45.

[6] *Wireless World*, Vol. 62, October 1956, p. 475, and *Wireless and Electrical Trader*, Vol. 103, September 1st 1956, p. 618.

[7] D. P. Dickie, Jr., and A. Macovski, "A Transformer-less 25-watt Amplifier for Conventional Loudspeakers," *Audio Eng.*, Vol. 38, June 1954, p. 22.

[8] K. Onder, "A New Transformerless Amplifier Circuit," *Journal of the Audio Eng. Soc.*, Vol. 1, October 1953, p. 282; and K. Onder, "Audio Amplifier Matches Voice-Coil Impedance," *Electronics*, Vol. 27, February 1954, p. 176.

[9] J. Futterman, "An Output-Transformerless Power Amplifier," *Journal of the Audio Eng. Soc.*, Vol. 2, October 1954, p. 252.

[10] W. H. Coulter, "Amplifier Circuit having Series-connected Tubes," U.S. Pat. No. 2,659,775, Brit. Pat. No. 688,273. This patent is described in *Audio Eng.*, Vol. 38, March 1954, p. 2.

[11] *Electrical and Radio Trading*, Vol. 32, October 6th 1956, p. 54.

[12] A. Peterson and D. B. Sinclair, "A single-ended Push-pull Audio Amplifier," *Proc.I.R.E.*, Vol. 40, January 1952, p. 7.

[13] H. T. Sterling, "Extended Class-A Audio," *Electronics*, Vol. 24, May 1951, p. 101.

B.B.C. Facts and Figures

OVER 20% of the 14,519 members of the B.B.C. staff are classified as being in technical engineering.

The total staff engaged exclusively on work for the television service is 3,700—about 25% of the whole.

Nearly 24% of the £11M spent during the last financial year on the sound services (excluding overseas transmissions) was devoted to engineering. Of this sum £237,269 went to the Post Office for rental of lines.

Of the £7M expended on television, 42% (£2.95M) was debited to engineering. Over half a million pounds was paid to the Post Office for lines.

The Post Office received, in all, nearly £1M from the B.B.C. for the rental of lines during the year ended last March.

During 1955-56 the gross licence income was £25.736M. Of this sum the Treasury took £2.75M and the Post Office retained £1.784M, leaving the B.B.C. £21.2M.

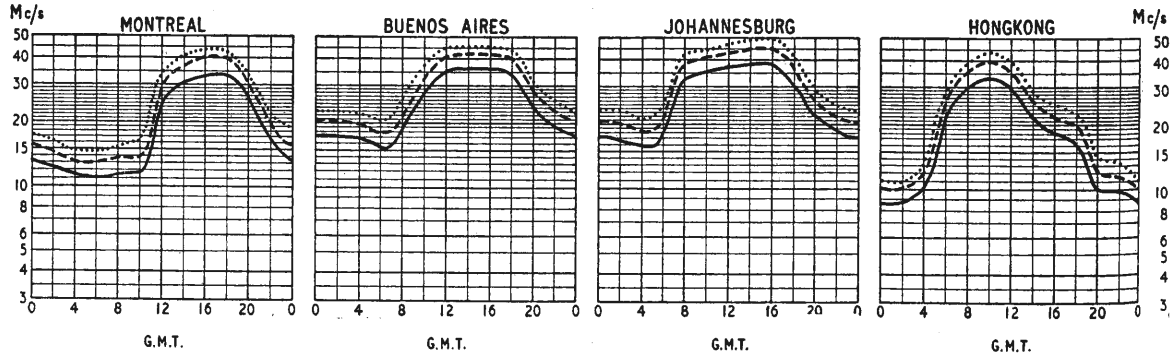
Thirty-nine high-power, short-wave transmitters and 177 aerials are used for the B.B.C.'s external services.

Over 20,000 hours of B.B.C. recordings were transmitted in 1955, and during the last five months of the year tape accounted for 70% of the total.

These facts and figures are culled from the "B.B.C. Handbook, 1957" (B.B.C. 5s), and the "Annual Report and Accounts of the B.B.C., 1955-56" (H.M.S.O. 6s).

SHORT-WAVE CONDITIONS

Prediction for February



THE full curves given here indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during February.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.

Automatic Component Assembly

By K. M. McKEE*
B.Sc., A.M.I.E.E.

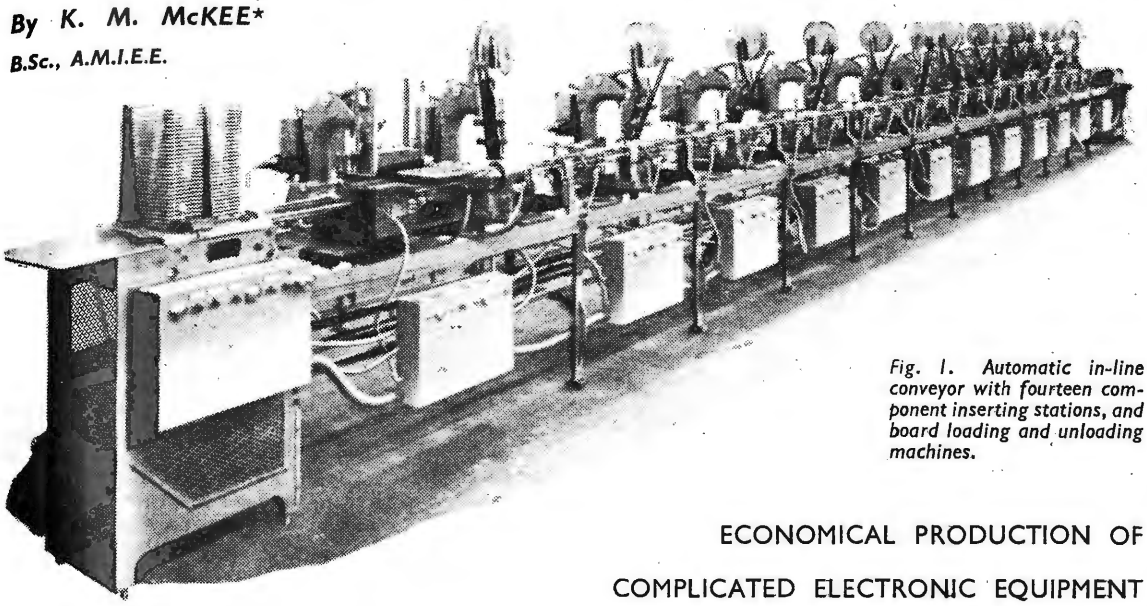


Fig. 1. Automatic in-line conveyor with fourteen component inserting stations, and board loading and unloading machines.

ECONOMICAL PRODUCTION OF COMPLICATED ELECTRONIC EQUIPMENT

WITH the remarkable rate of growth of the electronic industry during the past twenty years it is not really surprising that the production side has had little time to investigate fundamentally new methods of circuit construction. Development engineers have been more than fully occupied incorporating in their designs improved components and rapidly developing circuit techniques, and at the same time in maintaining prices at a level which compared favourably with competitors.

The conventional form of the electronic circuit appears to have been derived from the larger and more robust electrical power installation, in so far as both consist essentially of independently manufactured units interconnected by wires. While this form of electronic circuit offers flexibility in construction, its reproduction in quantity involves a multitude of point-to-point wires, terminals, insulators and metal fittings. The result has been a high labour content and the existence of numerous possible sources of error in assembly. It is significant that on a normal assembly line in the radio and television industry one inspector is required for every five operatives.

A further difficulty lies in the fact that random effects due to minor differences in wiring layout make it hard to obtain consistent standards of performance, particularly where high frequencies are involved. Moreover, the variable and complex nature of the layout itself allows very limited scope for employing mechanical aid to improve the rate and general efficiency of assembly.

Advent of the Printed Circuit.—It has become clear that if industry is to meet the demand for an increased volume of more complicated electronic circuits at reduced cost, the basic form of circuits would have to undergo a radical change in order to introduce the machine into every stage of production. Various schemes have been evolved using a variety of methods, several of which have involved producing complete electronic circuit assemblies from basic material. In this connection it has proved not at all easy to reproduce in the circuit elements that go to make up these assemblies the reliability and tolerances associated with orthodox components. After all, the characteristics of standard components have been built up as a result of years of development and production experience.

The form of assembly that has now gained wide acceptance is the combination of standard components and printed-wiring boards. Printed-wiring boards etched from copper-clad phenolic laminate have the great merit from the production standpoint that all conductor terminations are fixed in position and in a single plane. Above all, mechanized processing can be applied in turning out identical wiring boards, so forming a suitable basis for automatic assembly and subsequent mechanized operations.

It has been estimated in the report[1] of a comprehensive survey conducted on behalf of the U.S. Navy that with assemblies produced in this way, the labour content is reduced thirty times in comparison with conventional methods; in both cases production capacity and rate were assumed to be constant. To assist in achieving this remarkable saving in human effort, the report recommends the adoption of automatic multi-station in-line machinery for the assembly of standard components on the printed-wiring boards.

Automatic Assembly Machinery.—Fully automatic assembly machinery may be divided into two types; programmed single-station machines and multi-station in-line conveyor systems. Programmed

*Geo. Tucker Eyelet Co. Ltd.

single-station machines have a relatively low rate of output, are costly, and complicated in concept and action. Accurate programmed tapes are necessary; though once the tapes have been made, no other machine setting-up routine is necessary. The field of application lies chiefly in the assembly of batches of very short production runs.

The alternative is the multi-station in-line conveyor system where the intricate assembly operation is broken down into a number of easy stages, which in turn implies a series of simple and reliable mechanisms. Separate pre-set machines are mounted on a transfer conveyor, each machine (or station) inserting a single type of component into the printed-wiring boards as they pass down the line. The machines are arranged to operate simultaneously so that on completion of each machine inserting cycle an assembled wiring board emerges at the end of the line. Although the movements of an in-line transfer conveyor could hardly be described as fast, surprisingly high output rates of up to 1,200 assembled boards an hour can be regularly maintained. What is more, the conveyor may be extended to accommodate any number of additional machines without change of output rate; though a line of forty stations is now regarded as the practical upper limit.

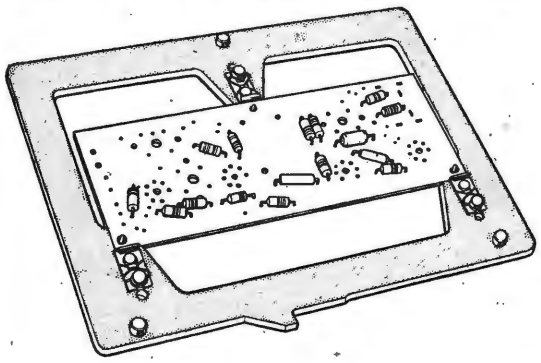


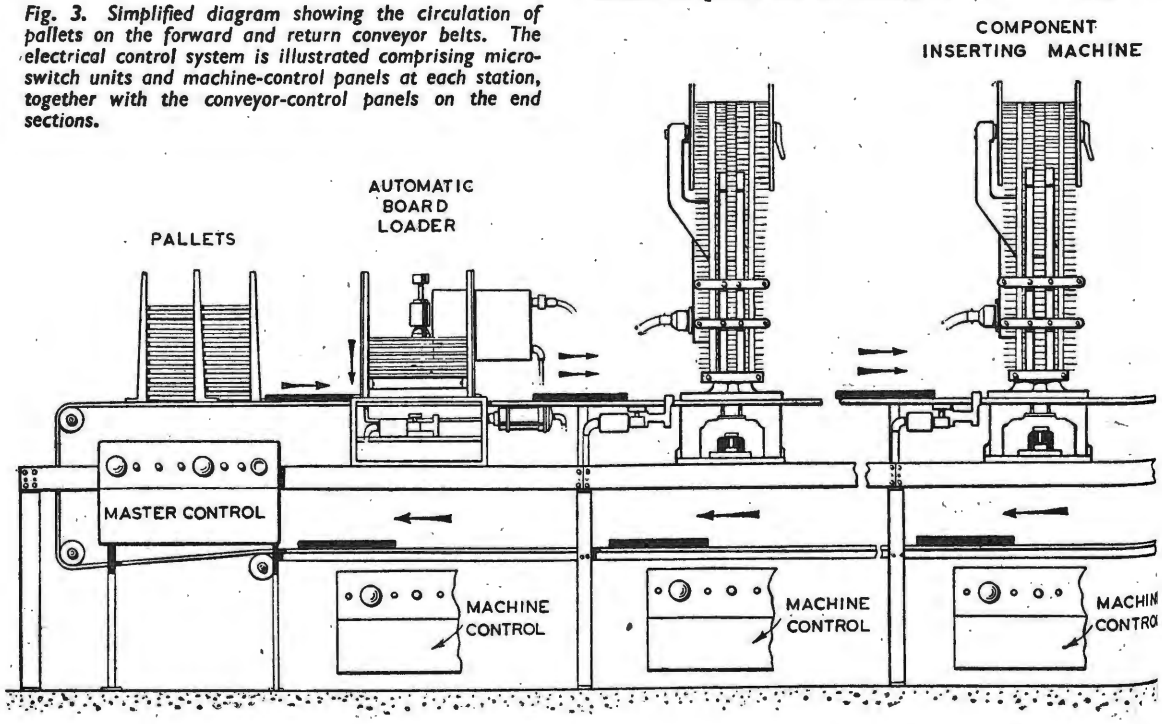
Fig. 2. Conveyor pallet complete with printed-wiring board and assembled axial-lead components.

Application in Industry.—Early in 1956, eighteen in-line transfer conveyors were in regular operation in the factories of leading United States electronic manufacturers. The most widely used system was that incorporating "Dynasert" automatic equipment. This machinery[2] is now being developed and manufactured in this country, and is being made available to the British electronic industry by the Geo. Tucker Eyelet Company under the "Dynasert" trade mark.

The first of these conveyors to be installed in the United Kingdom is at present in production on a commercial basis at the Ekco factory at Southend, and a second is shortly to be in operation in the works of another well-known British radio and television manufacturer. During the past year, as a preliminary step to full automatic assembly, six other manufacturers have purchased machines modified as manually operated bench machines. These machines (which will later be described in greater detail) can readily be converted for use on a fully automatic conveyor.

Conveyor Operation.—The conveyor, Fig. 1, consists essentially of a transfer machine for transporting the printed-wiring boards, and bringing each in turn into an accurately located and firmly locked position beneath the inserting machine heads at every station. The phenolic laminate material of the printed-wiring board is unfortunately inclined to be dimensionally unstable, particularly after having been subjected to unavoidable temperature cycles during the etching and punching process. It has been found that mounting the board on a light alloy frame or pallet for assembly, as shown in Fig. 2,

Fig. 3. Simplified diagram showing the circulation of pallets on the forward and return conveyor belts. The electrical control system is illustrated comprising micro-switch units and machine-control panels at each station, together with the conveyor-control panels on the end sections.



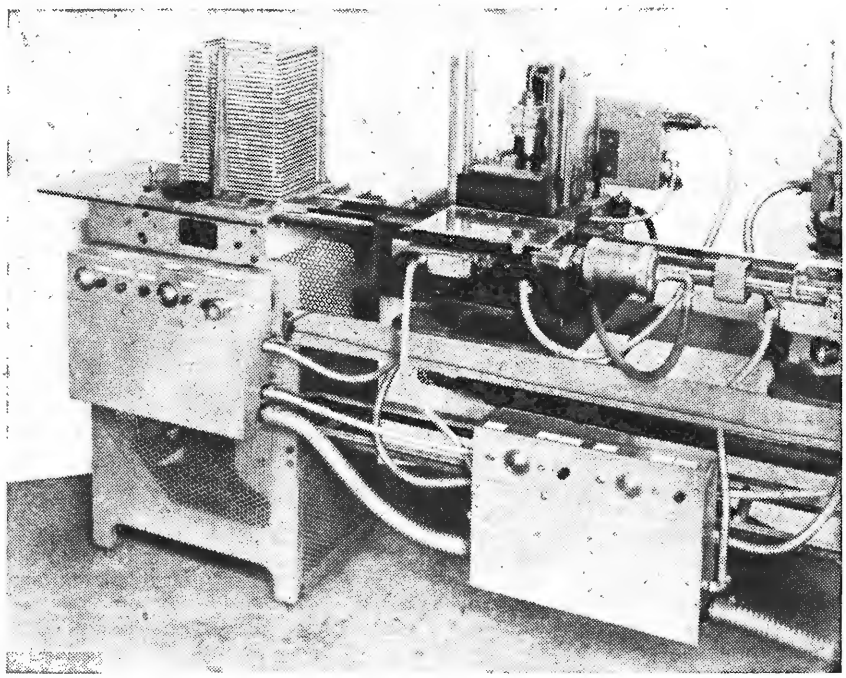


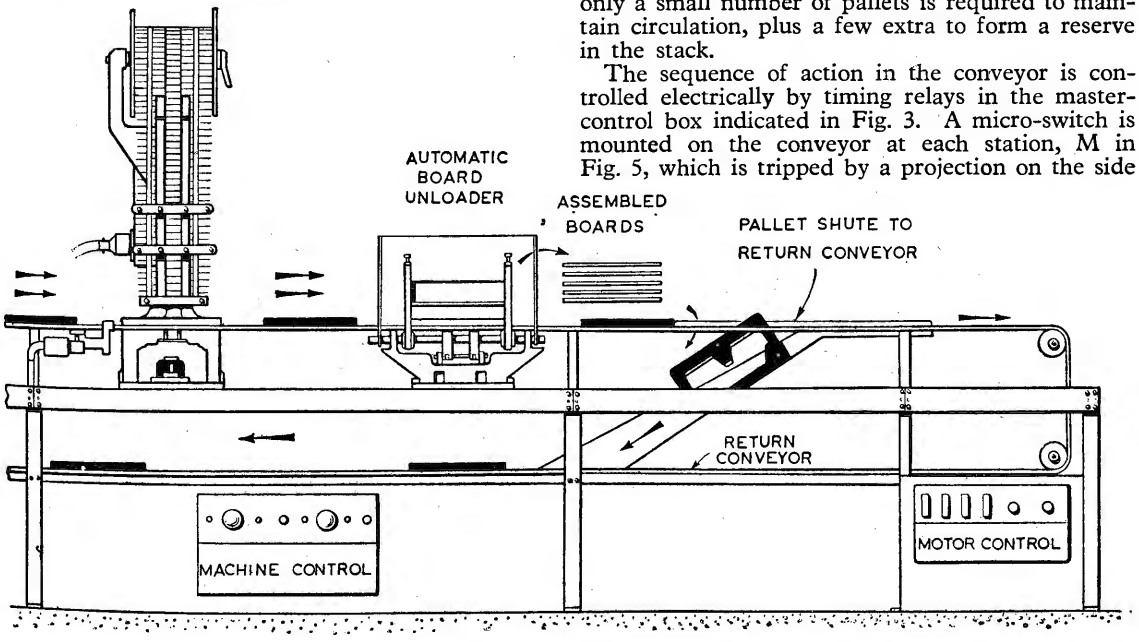
Fig. 4. Loading end of the conveyor with stack of empty pallets and loading unit for mounting printed-wiring boards on pallets prior to component assembly.

assists accuracy of location and enables a range of board shapes and sizes to be accommodated without adjustment to the conveyor.

A simplified drawing illustrating the action of the conveyor and the circulation of the pallets is shown in Fig. 3. Pallets are stacked at the left-hand end of the conveyor and are released one at time on to a set of twin conveyor belts (see C in Fig. 5) which are continually in motion while the conveyor is in operation. At the next station, printed-wiring boards are automatically fed beneath the ram plate of a pneumatic press, Fig. 4, which thrusts the board downwards between the spring clips on the pallet. The board is firmly held on the pallet by steel pins which fit into accurately punched location holes at the edges of the board, Fig. 2. One of the holes must be round, the remainder may be drawn to allow for any change that may have taken place in the lateral dimensions of the board.

The pallet with the board is now released and transported by the conveyor belts to the first inserting station, where it is lifted from the belts and solidly locked beneath the machine head. On completion of the inserting cycle, the pallet is once more released. In this way, a series of pallets carrying printed-wiring boards proceeds down the line until the board-unloading station is reached at the distant end. Here the reverse of the loading process takes place, with the boards being pushed from the pallets by a ram press acting from underneath. Fingers on arms incorporated in the unloader unit lift the boards, which then slide off down a chute (not shown). The empty pallets are tripped off the forward moving belts and descend by another chute to the lower return conveyor, where they pass back to the head of the line. It will be observed that only a small number of pallets is required to maintain circulation, plus a few extra to form a reserve in the stack.

The sequence of action in the conveyor is controlled electrically by timing relays in the master-control box indicated in Fig. 3. A micro-switch is mounted on the conveyor at each station, M in Fig. 5, which is tripped by a projection on the side



of each pallet, Fig. 2, when the pallet reaches a station. The micro-switches are connected in a series circuit, so that only when every pallet has arrived at its station will the circuit be complete, and the timing relay actuated in order to allow the insertion cycle to commence. The circuit thus serves as an interlock to arrest action should a serious conveyor stoppage occur, in which event a signal light on the machine control box in question is illuminated to attract attention. Switches fitted to each machine control box enable units to be operated independently or isolated from the main control circuit.

Component Inserting Units.—Over 70% of the components used by the electronic industry for radio and television equipment are of the axial-lead type, and the vast majority of these are of the $\frac{1}{4}$-W resistor size or smaller. In considering the design of automatic inserting machines, it was obviously essential to develop a rugged and reliable unit at reasonable price to handle this particular range. The No 1 "Dynasert" component inserting machine illustrated in Figs. 5 and 6 has proved to be capable of maintaining an insertion reliability of better than 99.8%.

A high insertion reliability of this order is vital if the operation of a line of automatic machines is to be a practical proposition. For instance, if the machine insertion reliability was only 95%, according to the laws of probability with ten machines in line, 40% of the assembled printed-wiring boards would contain a misplaced component. On a similar conveyor having a machine insertion reliability of 99.8%, the corresponding figure would be less than 2%. Good mechanical design and precision workmanship in making machine inserting head parts are required for high insertion efficiency.

Apart from axial-lead components, machines are in course of development for handling flat and disc radial-lead capacitors, and a wide variety of printed circuit valve bases. Another machine of this type is also being developed for inserting printed circuit sub-assemblies, consisting of a number of components mounted on a small printed-wiring board. The sub-assembly may be made up on a conveyor with the manufacturer's own choice of components, or, alternatively, purchased as a packaged item from a component maker. Sub-assemblies when mounted vertically on a larger printed-wiring board introduce a third dimension to the layout, and their application in certain circuits leads to economy in board area.

A further range of conveyor machines has been planned for placing eyelets, tags and special terminals, which are often needed for interconnecting wiring between one printed-wiring board and another, and from them to the larger units used with electronic equipment.

Axial-lead Component Machines.—Machines for axial-lead components will be made in three sizes, which depend mainly on the dimensions of the component body to be handled and the corresponding lead-hole spacing on the printed-wiring board. The two sizes of unit at present available will handle components of the smallest body length and a minimum body diameter of $\frac{3}{32}$in up to approximately 1in body length and $\frac{1}{8}$in diameter. The third unit is being designed to insert components with maximum body dimensions of $2\frac{1}{2}$in in length and 1in in diameter.

Also, a modified version of the axial-lead component machine has been developed for inserting jumper wires. Jumper wires are cut from a reel of plain or coated wire; then formed, inserted, and clinched in a similar manner to axial-lead components. Circuit designers have found jumper wires of special value in solving printed-wiring layout problems, as they are able to form a useful bridge connection between any two printed conductors.

For feeding purposes, axial-lead components are belted on reels before being loaded on to the machine. It is hoped that component manufacturers will soon make their standard axial-lead components available in belted form. "Dynasert" belting machines which straighten out slight bends and kinks in the leads and belt-up the components on reels, are soon to be available for use by both component and electronic equipment manufacturers. It is now generally accepted that reels of belted components with straight leads provide a most economical and efficient method of packaging for all applications.

The machine shown in Figs. 5 and 6 is a typical example of the units used for inserting belt-fed components. Components on leaving the reel slide down the guide bars G, which are of sufficient length to allow reels to be changed without interfering with continuity of operation. The leads are then engaged either side of the body by grooves cut round the peripheries of two feed wheels, Fig. 7, and drawn under the inserting tools in the head. On air being released in to a pneumatic cylinder, Fig. 6, which is mounted in the frame, F in Fig. 5, the tools are thrust downwards towards the printed-wiring board. In the process, excess length is trimmed from the leads, which are then formed through a right-angle at each end, and driven down and through the pre-punched holes in the board. The remaining wire trimmings are carried clear of the inserting mechanism by the tray T, Fig. 5, still attached to the tapes.

The pneumatic cylinder through a separate lever system raises two anvils, Fig. 7. The leads on emerging from the underside of the board are clinched over by the anvils in any pre-set direction, the ends being normally arranged to lie along the printed conductors, as indicated in Fig. 8. Experience of many millions of insertions in the U.S.A. has shown that leads clinched in this way greatly assist the formation of sound dip-soldered connections to the printed wiring.

Referring to Fig. 7, a resistor is represented in three of the stages of insertion and clinching.

The overall cut-off length

$$l' = \mathrm{L} + \mathrm{D} + d + 2\ (t + s + c)$$

Substituting the values of dimensions in the brackets, which are recommended in the majority of cases:

$$l' = \mathrm{L} + \mathrm{D} + d + 2\ (\tfrac{1}{16} + \tfrac{1}{8} + \tfrac{1}{16}) \text{ inches}$$

i.e., $l' = \mathrm{L} + \mathrm{D} + d + \frac{1}{2}$ inches.

Production Change-over.—Lack of flexibility in production change-over has in the past rendered some previous systems of automatic assembly impractical under modern working conditions. This could scarcely be said of the multi-station in-line system, where adjustment from one layout of printed-wiring board to another usually takes less than six minutes per station.

Inserting machines are secured in position on

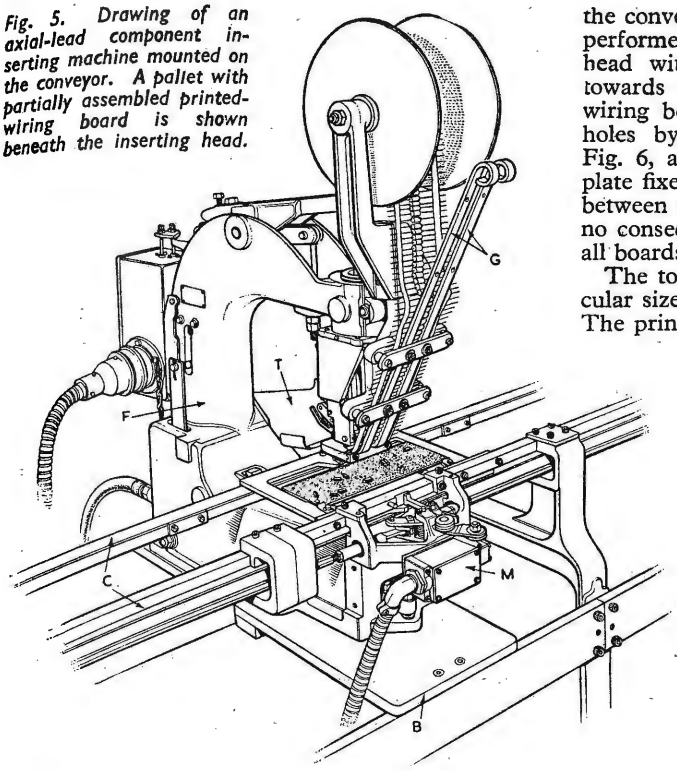


Fig. 5. Drawing of an axial-lead component inserting machine mounted on the conveyor. A pallet with partially assembled printed-wiring board is shown beneath the inserting head.

the conveyor by a single clamping screw. Setting is performed by lowering the tools in the inserting head with the leads of a component projecting towards the appropriate set of holes in a sample wiring board. The leads are aligned against the holes by rotating the head about a vertical axis, Fig. 6, and adjusting the unit itself about a base plate fixed to the conveyor frame. Punching errors between sets of component lead holes are clearly of no consequence provided the error is consistent on all boards.

The tools in the head are designed for one particular size of component body and lead-hole spacing. The principle adopted is that the lead-hole spacing

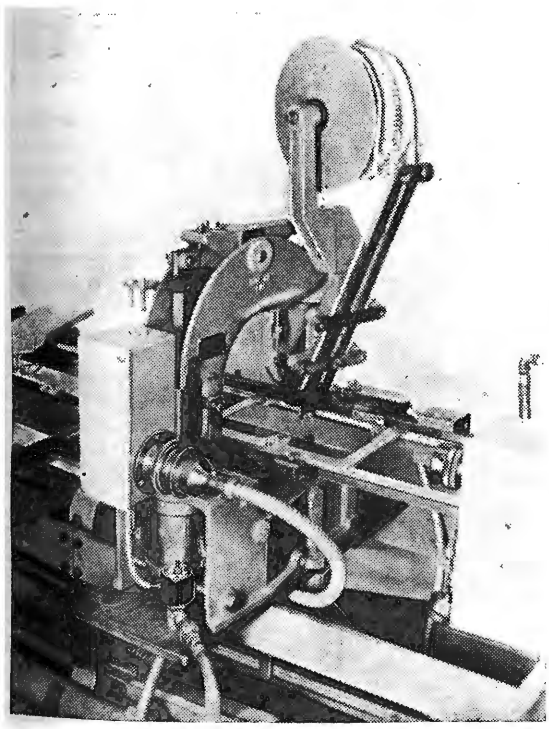


Fig. 6. Rear view of an axial-lead component inserting machine about to place a component. The inserting head has been rotated to align the component leads to the pre-punched holes in the printed-wiring board.

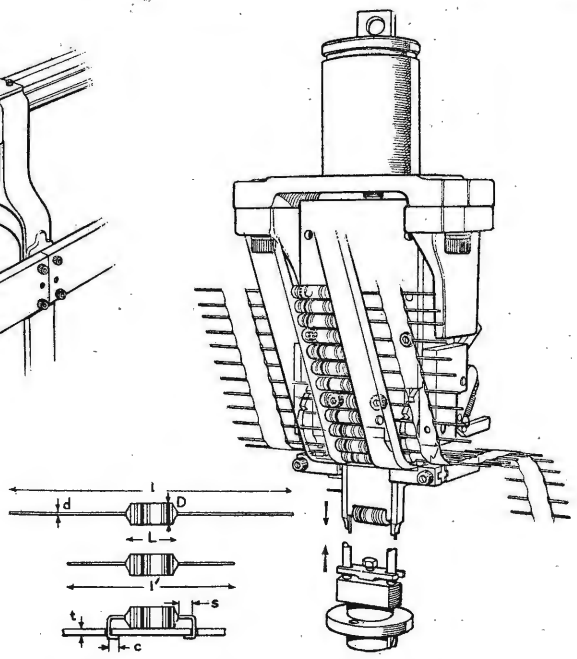


Fig. 7. Inserting mechanism of axial-lead component machine including anvils, with the feed wheels in the head shown through the tapes carrying components down for insertion. Note how the remaining wire trimmings are transported clear of the mechanism by the tapes. On the left, a resistor is represented in three of the stages of insertion and clinching to the printed-wiring board.

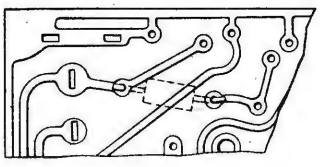


Fig. 8. Portion of a typical printed-wiring board viewed from the printed circuit side. A resistor is shown in position with the end of its leads clinched over to follow the direction of the printed conductors.

is a function of the component dimensions rather than the printed circuit. To avoid mechanical difficulties and the high cost associated with small variable setting devices, it was decided to produce tools for a range of standard hole spacings, with dimensions of the most used components in mind. Special tools can, however, be made for any lead-hole spacings within the limitations imposed by the dimensions of the component and machine head.

A conveyor station may be converted from feeding

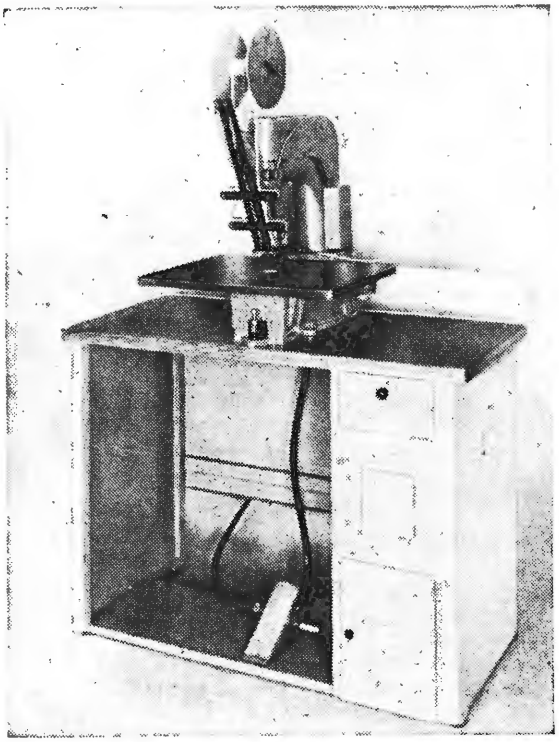


Fig. 9. Machine modified for bench operation showing the operator's foot control and with the safety cover guards in position on the machine.

one component to another of different dimensions by substitution of (i) the machine, or (ii) the inserting head, Fig 7, or (iii) the tools in the inserting head. The change-over in (i) and (ii) may be carried out by an unskilled operator in a matter of minutes, (iii) involves the services of a skilled mechanic for about 20 minutes.

Semi-automatic Production.—For short production runs conveyor machines may be mounted on a work table, Fig. 9, and employed as individual bench units. Only minor modification is required to the air control system of the conveyor model, for foot operation. Several such units could be adapted to cover a large percentage of the components needed for the circuits on most printed-wiring boards. Furthermore, by stripping the component-feed fittings from the head, a bench machine may be converted to a component cutting and forming unit, which is occasionally required by manufacturers for the preparation of special components prior to manual insertion.

Fig. 10 shows a close-up view of an optical location attachment fitted to the bench machine in Fig. 9. The arrangement projects two narrow beams of light on to a mirror, which reflects the light and produces two bright spots on the printed-wiring board. The board is quickly manipulated until the spots of light disappear down the required pair of holes, the foot pedal is depressed and the machine inserts and clinches the component. For a large batch of boards, it is preferable to use the arrangement as a setting-up aid for magnetic stops attached to the metal table, subsequently using the stops as a location jig for positioning the boards.

In comparison with manual performance of the same work, the machine shows a marked saving in time, and practically no operator fatigue has been experienced over long periods of operation.

Designing for Automatic Assembly.—Perhaps the most satisfactory feature of the new automatic production techniques from the point of view of the designer is that he has now almost complete control over the final performance of the circuit that he designs. If he succeeds in obtaining good results from a prototype in his laboratory, there is no reason why that performance should not be repeated in practically every model produced on the factory floor. On the other hand his responsibility is now much greater than it used to be. His design must be entirely free from error because it will often be an extremely costly matter to rectify a mistake once production has commenced. In the author's experience, most designers in the industry have welcomed the change and are only too willing to accept the increased responsibility entailed.

Many firms are now in the difficult stage of transition, where they are attempting to adapt designs and layouts that were intended for conventional wiring. This is nearly always a most difficult task to accomplish satisfactorily, and it is usually quicker to scrap the original layout and start again. In the United States, where now nearly 90 per cent of the mass-produced electronic equipment is on printed wiring, it has been found that three to five boards are most suitable for a television receiver, and one or two for a radio receiver. Hole-positional errors outside the tolerances required for automatic assembly, servicing problems, and breakages in punching, have turned the scales against the use of large-size wiring boards. It is now generally recognized in all fields of production engineering that the product must be designed with automatic production in mind.

Component manufacturers have also realized that parts developed for flexible wiring create serious mechanical problems in their assembly on printed circuits. The new tendency is for leads to become stouter and shorter, with larger and awkwardly shaped components fitted with snap-in type connections. Physical dimensions will have closer tolerances and a high degree of standardization among

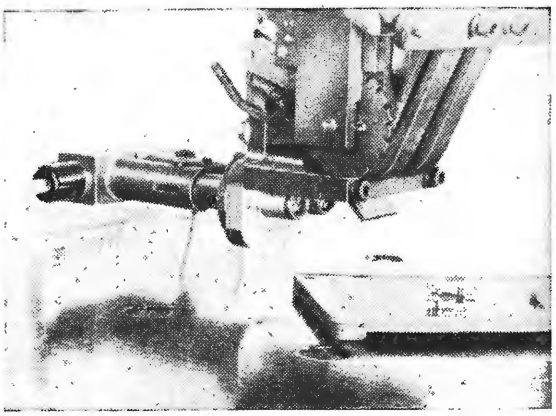


Fig. 10. Optical .ocation attachment fitted to a bench machine to facilitate positioning of the printed-wiring board before insertion of a component.

various manufacturers' products will become increasingly important.

Advantages for the Future.—It might well be asked what is on the credit side for the effort and capital that will be expended in changing from the old to the new manufacturing techniques. There is little doubt that substantial financial savings will be possible in production costs, not so much by considering any single process on its own, such as automatic assembly, but by evolving a complete flow-through production system commencing with mechanized processing of printed wiring and followed by automatic assembly, mechanized dip-soldering, and automatic electrical testing. Among other outstanding advantages are increased uniformity and reliability of the final product with far less inspection, rapid production change-overs and a massive production potential available to meet any emergency or unforeseen increase in demand.

REFERENCES

[1] "New Horizons for Electronic Assembly." Navord Report 5143 compiled by Stavid Engineering Inc., for the Dept. of the Navy, Bureau of Ordnance, Washington 25, D.C.

[2] A description of "Dynasert" machinery was first published in articles by the author entitled "Automatic Component Assembly for Printed Circuits." *Journal I.E.E.*, Vol. 2, Sept. 1956, and "Dynasert Automatic Component Assembly Machines for Printed Circuits," *Machinery*, Vol. 89, Nov. 16th, 1956.

B.B.C. F.M. Transmitter Performance

SOME insight into the standards of quality specified by the B.B.C. and provided by the manufacturers of the transmitters now being installed for the v.h.f. service is given in papers* recently read at the Institution of Electrical Engineers and to be published in the Proceedings (1957, Vol. 104, Part B).

Two systems of modulation are being used: the transmitters supplied by Standard Telephones and Cables make use of balanced reactance-valve modulation of a free-running oscillator whose centre frequency is controlled by reference, after frequency division, to a low-frequency crystal standard, and those supplied by Marconi's Wireless Telegraph Company rely on the "FMQ" system in which a low-frequency crystal-controlled oscillator is directly modulated by a balanced susceptance circuit† and followed by frequency multiplication.

The published figures for the performance of these two systems summarized below are expressed in different ways and are not directly comparable, but they indicate the high standards achieved in the frequency-modulated v.h.f. service.

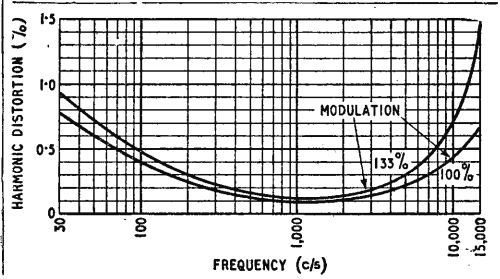
* "Frequency-Modulated Quartz Oscillators for Broadcasting Equipment." W. S. Mortley, A.M.I.E.E. "Frequency-Modulated V.H.F. Transmitter Technique." A. C. Beck, B.Sc.(Eng.), A.M.I.E.E., F. T. Norbury, A.M.I.E.E., and J. L. Storr-Best, B.Sc.(Eng.), A.M.I.E.E.

† "FMQ," W. S. Mortley, A.M.I.E.E., *Wireless World*, October, 1951.

"FMQ"

Frequency	Source distortion	Deviation			
		25 kc/s	50 kc/s	75 kc/s	100 kc/s
kc/s	%	%	%	%	%
0.03	0.2	0.62	1.0	1.2	1.4
1.0	0.16	0.16	0.33	0.48	0.75
7.5	0.13	0.19	0.21	0.42	0.83
10.0	0.18	0.2	0.28	0.38	0.75
15.0	0.13	0.22	0.45	0.6	1.1

REACTANCE MODULATOR



A.F. RESPONSE (without pre-emphasis)

kc/s	dB	kc/s	dB
0.03	−0.6	4	−0.1
0.06	−0.1	8	−0.5
0.12	0	10	−1.0
0.4	0	12	−1.4
1	0	15	−3.3
2	0	20	−11.0

Within ± 0.5 dB of 400 c/s level between 30 c/s and 15 kc/s

F.M. NOISE (relative to 75 kc/s)

−62 dB	−68 dB

A.M. NOISE (relative to unmodulated carrier)

−60 dB	−56 dB

CENTRE FREQUENCY STABILITY

2 parts in 10^6 for deviations at 30 c/s and 10 kc/s between 0 and 100 kc/s	<2.5 parts in 10^6 between 20 c/s and 15 kc/s with modulation 133% (75 kc/s = 100%)

Limiters and Discriminators

2—Foster-Seeley Discriminator; Designing for Minimum Distortion

By G. G. JOHNSTONE*, B.Sc.

THE basic type of Foster-Seeley discriminator is shown in Fig. 1. A number of variants exist in practice, and these are discussed later. The audio output is the difference between the output voltages developed by the two diodes D1 and D2. At the centre frequency of the circuit, this output is zero, and the output swings above or below zero as the frequency of the applied signal shifts from its centre value. We shall assume initially that the diodes have 100 per cent rectification efficiency; the audio output is then equal to the difference of the peak values of the two r.f. voltages applied to the diodes.

Now let us analyse the r.f. side of the circuit. The transformation we shall employ is that shown in Fig. 2, the development of which was given in the first part of this article. The phase-difference transformer of Fig. 1 is then identical in performance with the arrangement of three tuned circuits shown. The "ideal" transformer T serves only to ensure that the current fed to its centre tap divides equally between the branches connected to its ends. We shall concentrate initially on the two tuned circuits connected between terminals 2, 3 and 2, 4. The parameters used are $x = 2Q_s df/f_o$ and $R_s/2$, the dynamic resistance of the tuned circuits. In the expression for x, df is the shift of the signal from its centre frequency f_o, whilst the value of Q_s is given by R_s/L_s. The centre frequency f_o is given by $f_o = 1/2\pi\sqrt{L_sC_s} = 1/2\pi\sqrt{L_pC_p}$. The special values of $x = \pm x_1$ give the displacement of the resonant frequencies of each of the two circuits from the centre frequency. In the circuit shown in Fig. 2, the resonant frequency of one tuned circuit is given by $\left(1+\frac{M}{2L_p}\right)^{-\frac{1}{2}} f_o$ and that of the other by $\left(1-\frac{M}{2L_p}\right)^{-\frac{1}{2}} f_o$. These values are equal approximately to $\left(1-\frac{M}{4L_p}\right) f_o$ and $\left(1+\frac{M}{4L_p}\right) f_o$ respectively, and hence $x_1 = 2Q_sM/4L_p = Q_sM/2L_p$. This can be rearranged into a more convenient form as follows.

$$x_1 = \frac{Q_sM}{2L_p}$$

$$= \frac{Q_sk\sqrt{L_sL_p}}{2L_p} \text{ where } k \text{ is the coupling coefficient}$$

$$= \frac{kQ_s}{2}\sqrt{\frac{L_s}{L_p}}$$

It is shown in the Appendix that if E_p and E_s are peak values voltages across the primary and secondary winding of the phase-difference transformer at resonance, then

$$x_1 = (E_s/2)/E_p$$

With a constant-current input I/2 to each of the two tuned circuits connected between terminals 2, 3 and 3, 4 the difference between the peak r.f. voltages between terminals 2, 3 and 2, 4 is given by

$$E = IR_s/4\,(a_1x + a_3x^3 + a_5x^5 \ldots)$$

where

$$a_1 = 2x_1(1 + x_1^2)^{-3/2}$$

$$a_3 = x_1(2x_1^2 - 3)(1 + x_1^2)^{-7/2}$$

$$a_5 = \tfrac{1}{4}x_1(8x_1^4 - 40x_1^2 + 15)(1 + x_1^2)^{-11/2}$$

E is equal to the a.f. output provided that rectification efficiency is 100 per cent.

Except for the special case when the elements of the tuned circuit connected between terminals 1 and 2 become of infinite impedance, the input current, I, to the centre tap of the "ideal" transformer T is not constant. Its value can however be calculated. If the input current to terminals 1, 2 is I_{in}, then I is equal to I_{in} less the current flowing in the tuned circuit connected between terminals 1 and 2.

In order to simplify the treatment, we shall assume that the Q-values of the two circuits of the phase difference discriminator transformer are equal. Additionally, we shall employ the relationship $p = L_s/L_p$. The equivalent circuit can then be redrawn as shown in Fig. 3.

The relationship between I and I_{in} is then given by

$$I = I_{in}\,\frac{1 + x_1^2}{\frac{1}{4} + x_1^2}\left[\frac{1 + 2x^2\frac{(1-x_1^2)}{(1+x_1^2)^2} + x^4\frac{1}{(1+x_1^2)^2}}{1 + 2x^2\frac{(1-n^2)}{(1+n^2)^2} + x^4\frac{1}{(1+n^2)^2}}\right]^{\frac{1}{2}}$$

where $n = kQ$ (see Appendix).

At first sight it would appear that the output

* B.B.C. Engineering Training Department.

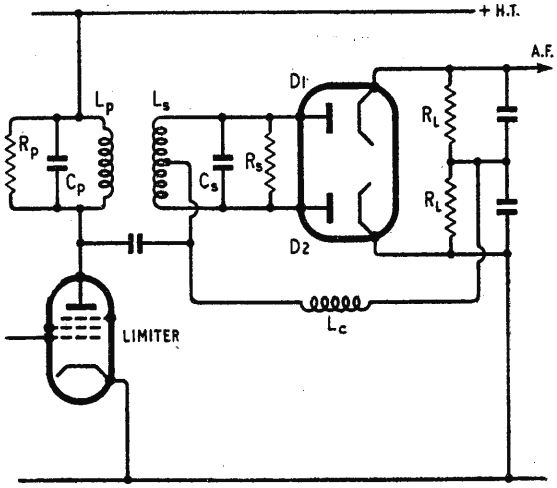


Fig. 1. Basic Foster-Seeley discriminator circuit.

for F.M. Receivers

In the first article of this series an equivalent circuit for the phase-difference transformer employed with the Foster-Seeley discriminator and the ratio detector was derived. This equivalent circuit enables these two forms of detector to be treated in the same manner as the Round-Travis circuit, already discussed, and in this part we shall discuss the Foster-Seeley circuit in greater detail.

voltage depends upon three variables, x_1 p and n. This is however, not true because

$$x_1 = \tfrac{1}{2}\, kQ\sqrt{\frac{L_s}{L_p}} = \tfrac{1}{2}\, n\sqrt{p}.$$

Thus there are only two independent variables.

From the equation for I, it will be apparent that I is independent of x only if $x_1 = n$. This is the special case referred to above, when the inductance L′ becomes infinite, capacitor C′ becomes zero, and R′ becomes infinite. In these conditions $\sqrt{p} = 2$, and hence $I = I_{in}$ as would be expected.

It was shown in Part I that the coefficient a_3 in the expression of the output voltage is zero when $x_1 = \sqrt{1.5}$. In the phase-difference transformer, the same conditions apply when $n = \sqrt{1.5}$, and $L_s = 4L_p$.

In the general case, when x_1 does not equal n, we can express I as a power series in x, as follows

$$I = I_{in}\,\frac{1 + x_1^2}{\frac{p}{4} + x_1^2}\,(b_o + b_2 x^2 + b_4 x^4 \ldots)$$

where

$$b_o = 1$$

$$b_2 = \frac{1 - x_1^2}{(1 + x_1^2)^2} - \frac{1 - n^2}{(1 + n^2)^2}$$

$$b_4 = \frac{2x_1^2}{(1+x_1^2)^4} + \frac{1-4n^2+n^4}{(1+n^2)^4} - \frac{1 - x_1^2}{(1+x_1^2)^2} \cdot \frac{1 - n^2}{(1+n^2)^2}$$

Inserting this value for I in the expression for E gives

$$E = \frac{I_{in}R_s}{4} \cdot \frac{1 + x_1^2}{\frac{p}{4} + x_1^2}\,(c_1 x + c_3 x^3 + c_5 x^5 \ldots)$$

where

$$c_1 = (a_1 b_o)$$
$$c_3 = (a_1 b_2 + a_3 b_o)$$
$$c_5 = (a_1 b_4 + a_3 b_2 + a_5 b_o)$$

The distortion introduced is represented by the terms in x^3 and x^5. To minimize distortion, therefore, it is desirable that the coefficients of these terms should be as small as possible. The dominant term is the coefficient of x^3, and this can be made equal to zero by appropriate choice of parameters. For this condition, $a_1 b_2 + a_3 b_o = 0$, and substituting values this gives

$$-x_1^2(2x_1^2 - 3)(1 + x_1^2)^{-7/2} = 2x_1(1 + x_1^2)^{-3/2} \times [(1 - x_1^2)(1 + x_1^2)^{-2} - (1 - n^2)(1 + n^2)^{-2}]$$

This reduces to

$$\frac{1}{(1 + x_1^2)^2} = \frac{2(n^2 - 1)}{(1 + n^2)^2}$$

The graph of x_1 plotted against n is given in Fig. 4. This shows that if n is less than 1, c_3 cannot equal zero. It also shows that if n is between 1 and 1.2 approximately, there is little margin for error in

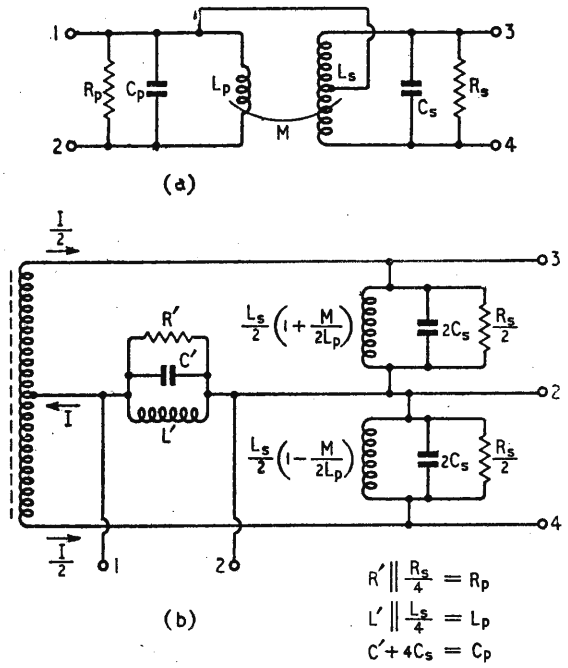


Fig. 2. (a) Phase-difference transformer, and (b) its equivalent circuit.

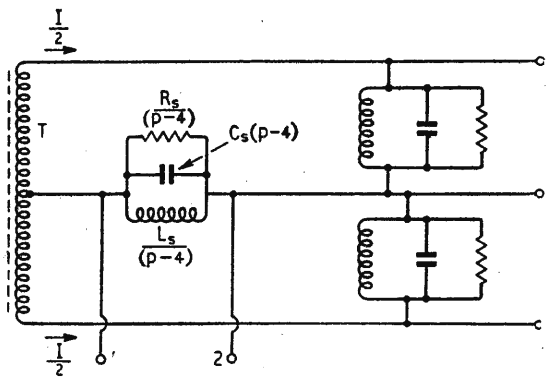


Fig. 3. Equivalent circuit of phase-difference transformer for $Q_s = Q_p$; $p = L_s/L$.

adjustment of n, since x_1 is varying rapidly. The minimum value of x_1 occurs when $n = \sqrt{3}$; at this value $x_1 = 1$. Above $n = \sqrt{3}$, the slope of the curve is positive. This is of some importance, since x_1 is itself proportional to n. If n departs from its correct value, it is desirable that x_1 should change in the same sense to minimize the value of c_3.

The graph of x_1 plotted against n does not indicate any specific optimum value for n and x_1. However,

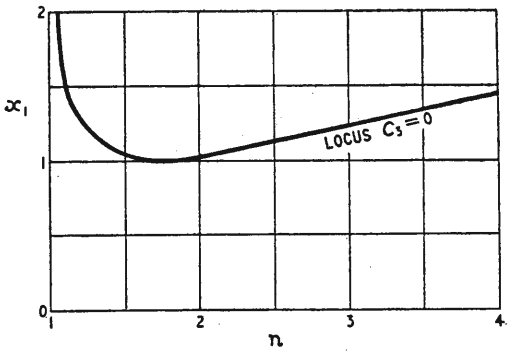


Fig. 4. Graph of x_1 against n for $c_3 = 0$.

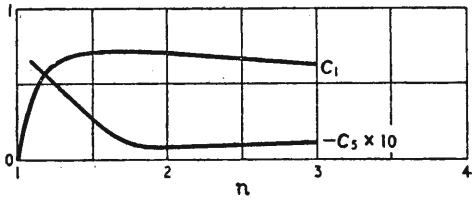


Fig. 5. Variation of c_1 and c_5 with n, for $c_3 = 0$.

this can be found by considering the coefficient of x^5 in the expansion. The value of this coefficient is plotted in the Fig. 5; at each value of n the value of x_1 is that which makes $c_3 = 0$. Additionally the graph shows the value of the coefficient of x; minimum distortion occurs when the ratio of the coefficient of x^5 to that of x is minimum. The optimum values would appear to be near $n = 2.0$. Consider $n = 2$; in this region the coefficient of x^5 is approximately -0.008. From Fig. 4, $x_1 = 1$ approximately. From $x_1 = \frac{1}{2} n\sqrt{p}$, $p = 1$, i.e. the two tuned circuits of the phase difference discriminator transformer are equal. From Fig. 5, the coefficient of x is 0.7 approximately.

The expression for the audio output voltage is then

$$E = 0.4\ I_{in} R_s\ (0.7x - 0.008x^5\ \ldots)$$

The range of validity of this expression can be seen from Fig. 6. In this graph are two curves. Curve (a) is that obtained from the orthodox graphical solution for the Foster-Seeley response curve, which does not give any precise means of evaluating distortion; curve (b) is that derived from the expression above. It will be seen that the two curves are in very close agreement up to the value of $x=1.4$. This then is the limit of validity of the expansion above.

To evaluate the distortion present with the circuit constants chosen, consider an input signal $x_s \cos\omega_a t$. The a.f. output is then

$$E = 0.4\ I_{in} R_s \{0.7x_s \cos\omega_a t - 0.008\ (x_s \cos\omega_a t)^5\}$$

We can expand $\cos^5\omega_a t$ by means of the identity

$$\cos^5\theta = \frac{1}{16}\left\{\cos 5\theta + 5\cos 3\theta + 10\cos\theta\right\}$$

giving

$$E = 0.4\ I_{in} R_s \left\{ (0.7x_s - 0.005x_s^5)\cos\omega_a t - 0.0025\ x_s^5 \cos 3\omega_a t \right\} - 0.0005\ x_s^5 \cos 5\omega_a t$$

The reduction of the fundamental frequency component is negligible for the range of values of x_s of interest, i.e. $x_s < 1$. The percentage of third harmonic distortion is thus given by $\dfrac{0.0025 \times 100 \times x_s^4}{0.7}$. At $x_s = 1$, this is 0.35 per cent. By employing a smaller value of x_s a lower value of distortion is obtained, the distortion decreasing with x_s^4.

Consider a broadcast signal, with a deviation of 75 kc/s. If it is desired to operate the discriminator with 75 kc/s corresponding to $x_s = 1$, the parameters of the circuit are determined by $x = 2Q\ df/f_o$. With $df = 75$ kc/s at $x = 1$, and a centre frequency f_o of 10.7 Mc/s, the value of Q is 71. If we assume the two tuned circuits of the phase-difference transformer each employ a tuning capacitor of 50 pF, the dynamic resistance (R_s) is 22 kΩ. The input current I_{in}, is the peak value of the fundamental frequency component in the output of the preceding limiter stage; a typical value is 1 mA. The peak audio output is given by $0.28\ I_{in}R_s$, and in this example is 6.2 volts approximately.

It can be seen, from the expression for E, that the audio output is proportional to $I_{in}x$, where I_{in} is the input current, and x is a measure of the frequency

(*Continued on page 73*)

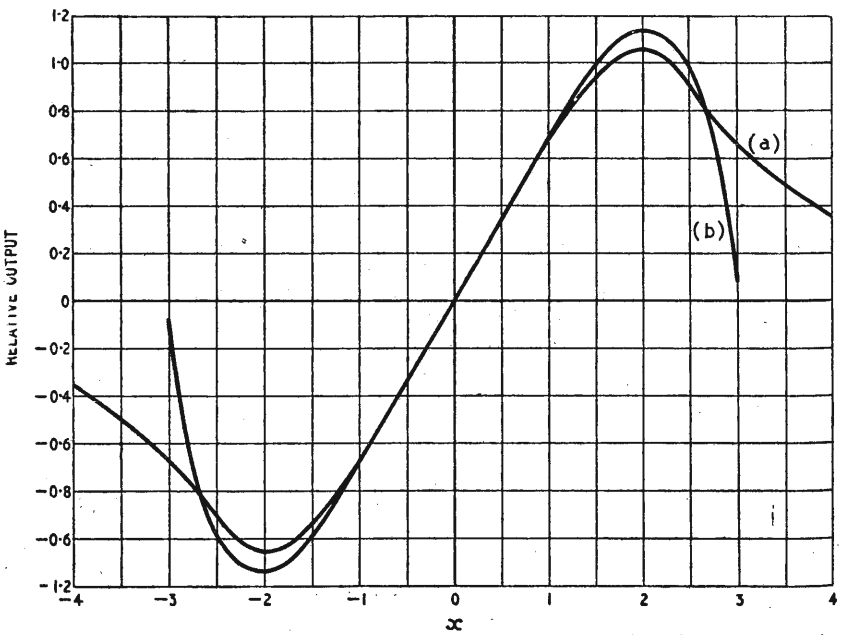


Fig. 6. Response of Foster-Seeley discriminator derived by (a) orthodox graphical solution (b) expansion given in text.

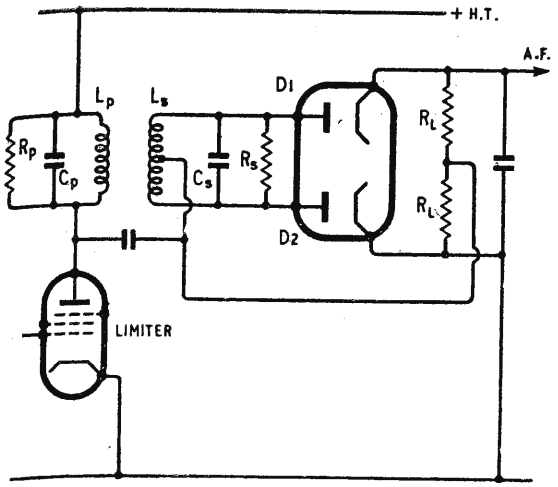
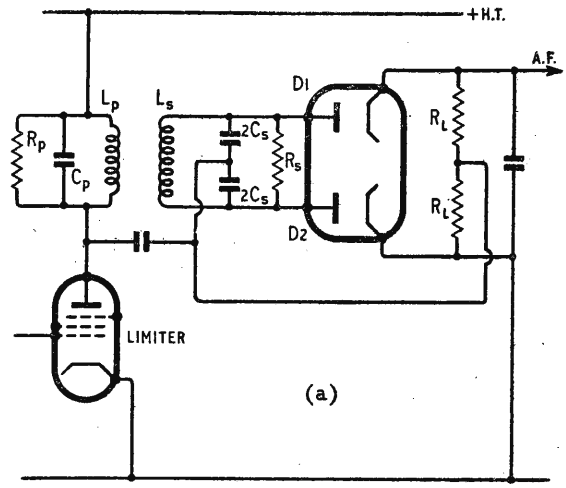


Fig. 7. Alternative form of Foster-Seeley discriminator.

shift. If there is amplitude modulation present, the magnitude of I_{in} varies, but if $x = 0$, i.e. the signal is at the centre frequency there is no output due to a.m. For any other value of x, i.e. if the signal is mistuned or frequency-modulated, there is an output due to the amplitude modulation. Because the output is proportional to $I_{in}x$, the a.m. and f.m. signals are multiplied together and there is complete cross-modulation. Thus a Foster-Seeley discriminator must be preceded by a limiter stage.

To complete the survey of the Foster-Seeley circuit, there are a number of practical points to be considered. The first of these concerns the diode load resistors. These should not be too large, as otherwise "diagonal clipping" can occur. Briefly this happens if the input to one diode falls rapidly. If the time constant of the load circuit is too great, the cathode potential cannot fall sufficiently quickly, and the diode may be cut off. For this reason, the diode load resistors are usually limited to 100 kΩ, and the shunt capacitors to 50 pF.

This relatively low value of diode load in turn means that the damping imposed in the tuned circuits cannot be neglected. The input resistance of each diode at r.f. is $R_L/2\eta$, where R_L is its load resistance and η is the rectification efficiency. In the equivalent circuit of Fig. 3, the relationship between the resistances of the two tuned circuits connected between terminals 2, 3 and 2, 4 and that connected between terminals 1, 2 then differs from that postulated. The condition can, however, be re-established if an additional resistor equal to $R_L/(p-4)$ is connected between terminals 1 and 2, i.e. across the primary winding of the original circuit. However, the values of p employed in practice are often less than 4, implying that a negative resistance is required. This obviously cannot be realised in practice. It suggests, however, that the Q values can be equalized if the secondary Q value without the diodes connected is lower than the primary Q value. Given equal initial Q values, a



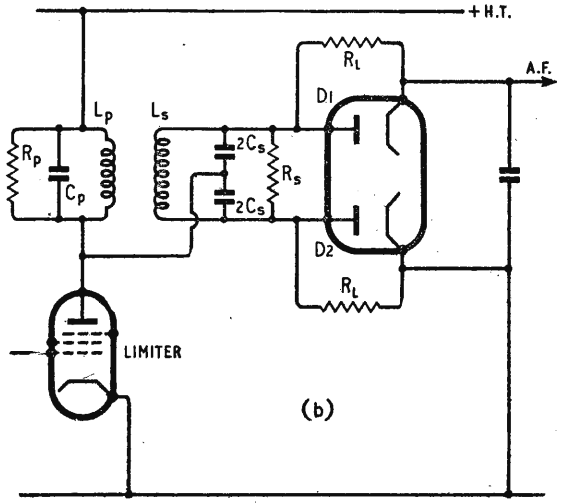
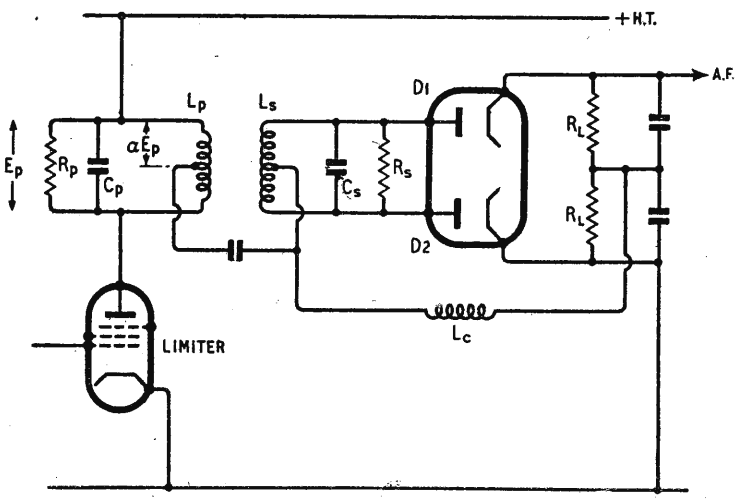


Fig. 8. Further alternative forms of Foster-Seeley circuit, with the secondary circuit centre taps produced by the capacitors.

Fig. 9. Foster-Seeley discriminator with tapped primary circuit.



resistor can be connected in parallel with the secondary circuit to achieve this result. Its value can be calculated if it is remembered that the damping imposed on the primary circuit is $R_L/4\eta$, whilst that imposed on the secondary circuit is R_L/η. In the example considered above, with equal primary and secondary circuit, the resistance would be $R_L/3\eta$.

It is common practice to omit the r.f. choke L_c shown in Fig. 1, giving the circuit of Fig. 7. In this case it must be remembered that there is then additional damping equal to $R_L/2$ imposed on the primary circuit, since the primary circuit can "see" the two resistors R_L in parallel.

An alternative form of Foster-Seeley circuit is that shown in Figs. 8(a) and 8(b). In the arrangement, the secondary centre-tap is provided by the capacitors. Because there is no longer d.c. continuity for the diodes of Fig. 8(b), the diodes are shunt-fed. The damping imposed on the secondary circuit is the R_L/η in parallel with $2R_L$, whilst that on the primary is $R_L/4\eta$ in parallel with $R_L/2$. In one other variant the primary as well as the secondary is tapped, as shown in Fig. 9. If the ratio of voltage tapped off to the total primary voltage is a, then this circuit can be analysed by replacing the primary circuit by a single un-tapped circuit, with parameters as follows:

$$\begin{array}{llll} L'_p = L_p a^2 & & E_p' = aE_p \\ C'_p = C_p/a^2 & & M' = Ma \\ R'_p = R_p a^2 & & k' = k \\ I' = I/a & & Q' = Q \end{array}$$

This circuit has one particular advantage. If $a = \frac{1}{2}$, i.e. the primary circuit is centre-tapped, the damping applied to primary and secondary circuits by the diode loads is automatically equalized. In such a circuit, the value of p in the equivalent circuit is equal to 4, i.e. the analysis simplifies to the case when the tuned circuit in parallel with the input terminals vanishes. For this condition of operation, the optimum value of $n = \sqrt{1.5}$.

APPENDIX

The equivalent diagram for two circuits coupled by mutual inductance is shown below. The circuit equations are

$$\begin{aligned} E_s &= jX_{cs}i_s \\ E_p &= jX_{cp}(i-i_p) \\ 0 &= Z_p i_p - j\omega M i_s - jX_{cp}i \\ 0 &= Z_s i_s - j\omega M i_p \end{aligned}$$

where $X_{cs} = 1/\omega C_s$

$X_{cp} = 1/\omega C_p$

$$Z_p = jL_p\omega + \frac{1}{j\omega C_p} + r_p$$

$$Z_s = jL_s\omega + \frac{1}{j\omega C_s} + r_s$$

In the region near the resonants frequency (f_o) of the two circuits, $i_p > i$. Then

$$E_s = -jX_{cp}X_{cs}\frac{\omega M}{Z_pZ_s + \omega^2M^2}i$$

$$E_p = X_{cp}^2\frac{Z_s}{Z_pZ_s + \omega^2M^2}i$$

Near resonance $\omega L_s - 1/\omega C_s$ is approximately equal to $2L_s\delta\omega$, where $\delta\omega$ is the departure from $\omega_o(= 2\pi f_o)$. Similarly, $\omega L_p - 1/\omega C_s = 2L_p\delta\omega$. This gives

$$E_s = jX_{cp}X_{cs}\frac{\omega M}{(r_p + 2jL_p\delta\omega)(r_s + 2jL_s\delta\omega) + \omega^2M^2}\cdot i$$

$$E_p = X_{cp}^2\frac{r_s + 2jL_s\delta\omega}{(r_p + 2jL_p\delta\omega)(r_s + 2jL_s\delta\omega) + \omega^2M^2}\cdot i$$

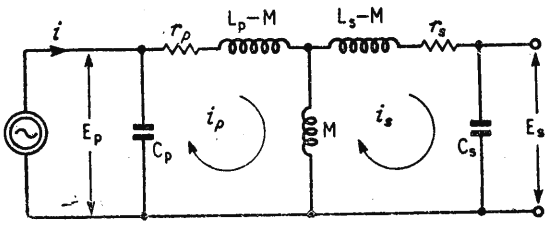
Let

$$\frac{L_p\omega_o}{r_p} = \frac{X_{cp}}{r_p} = Q_p;\quad \frac{L_s\omega_o}{r_s} = \frac{X_{cs}}{r_s} = Q_s;\quad y = 2\frac{\delta\omega}{\omega_o} = 2\frac{\delta f}{f_o}$$

and $n = k\sqrt{Q_pQ_s}$ where $k = M/\sqrt{L_pL_s}$

$$E_s = \frac{-jQ_pX_{cp}}{(1 + jQ_py)(1 + jQ_sy) + n^2}\cdot kQ_s\sqrt{L_s/L_p}\cdot i$$

$$E_p = \frac{Q_pX_{cp}}{(1 + jQ_py)(1 + jQ_sy) + n^2}\cdot(1 + jQ_sy)\cdot i$$



whence $E_s = \dfrac{-jkQ_s\sqrt{L_s/L_p}}{1 + jQ_sy}E_p$

let $p = L_s/L_p$, and $y = 0$, i.e., the circuits are at the resonant frequency. Then if $|E_s|$ is the magnitude of E_s, and $|E_p|$ is the magnitude of E_p,

$$\tfrac{1}{2}kQ_s\sqrt{p} = (\cdot|E_s|/2)/|E_p|$$

Finally if $Q_p = Q_s$, $Q_pX_{cp} = R_p$, and $Qy = \dfrac{2Q\delta\omega}{\omega_o} = x$

$$E_p = \frac{R_p(1 + jx)}{(1 + jx)^2 + n^2}i$$

In the equivalent circuit discussed in the text, this voltage is that applied to the tuned circuit connected between terminals 1 and 2 when $i = I_{in}$. In the text $p = L_s/L_p = R_s/R_p = C_p/C_s$. Thus the tuned circuit between terminals 1 and 2 consists of three branches in parallel; (a) inductor $L_s/(p-4)$; (b) capacitor $(p-4)C_s$; (c) resistor $R_s/(p-4)$ (see fig. 3). Then the current I' flowing into the three elements is given by

$$I' = E_pY$$

where $Y = (p-4)/j\omega L_s + j\omega C_s(p-4) + (p-4)/R_s$

$$= (1/j\omega L_s + j\omega C_s + 1/R_s)(p-4)$$

$$= \frac{p-4}{R_s}(1 + jx)$$

Thus $I' = \dfrac{R_p(1 + jx)}{(1 + jx)^2 + n^2}\cdot\dfrac{p-4}{R_s}(1 + jx)\,I_{in}$.

$$= \frac{p-4}{p}\cdot\frac{(1 + jx)^2}{(1 + jx)^2 + n^2}I_{in}$$

But the current I fed to the centre-tap of transformer T is equal to $I_{in} - I'$. Hence

$$I = I_{in}\left\{1 - \frac{p-4}{p}\cdot\frac{(1 + jx)^2}{(1 + jx)^2 + n^2}\right\}$$

$$= I_{in}\frac{pn^2 + 4(1 + jx)^2}{pn^2 + p(1 + jx)^2}$$

$$= I_{in}\frac{4}{p}\frac{x_1^2 + (1 + jx)^2}{n^2 + (1 + jx)^2}$$

$$= I_{in}\frac{1 + x_1^2}{\frac{p}{4} + x_1^2}\cdot\frac{1 - x^2/(1 + x_1^2) + 2jx/(1 + x_1^2)}{1 - x^2/(1 + n^2) + 2jx/(1 + n^2)}$$

If $|I|$ is the magnitude of I and $|I_{in}|$ that of I_{in} then

$$|I| = |I_{in}|\frac{1 + x_1^2}{\frac{p}{4} + x_1^2}\left\{\frac{1 + 2x^2(1 - x_1^2)/(1 + x_1^2)^2 + x^4/(1 + x_1^2)^2}{1 + 2x^2(1 - n^2)/(1 + n^2)^2 + x^4/(1 + n^2)^2}\right\}^{\frac{1}{2}}$$

In the absence of a really cheap and simple colour display device for domestic receivers —on which the success of colour television so much depends—it may be considered somewhat profitless to discuss the question of transmission systems. There is, however, one point of view which should be heard. This argues that the system should not be tailored to fit the display device (as with the N.T.S.C. system and the three-gun shadow-mask c.r.t.) but should be made as perfect as possible in the expectation that display and receiving equipment will eventually be developed to match it. Such is the theme of this article.

N.T.S.C. Colour Information

Where the System Fails Through Expediency

By E. L. C. WHITE,* M.A., Ph.D., M.I.E.E.

FROM the vast body of work that has been done on colour television in the last few years a number of principles have emerged which now find very wide acceptance.

First is the idea of "compatibility." This means that the colour signals must be sufficiently similar in form to existing monochrome standards to give good black-and-white pictures, with no untoward effects, on monochrome receivers of normal design. Thus colour can be added to selected programmes, and the proportion increased as warranted by the increasing numbers of colour receivers.

Secondly, it has been recognized that a compatible system can be achieved by rearranging the primary red, green and blue signals into three other signals, one of which is representative of the brightness and therefore contains some of each of red, green and blue in suitable proportions. This brightness signal has the synchronizing pulses added to it, and is all that is needed for monochrome receivers.

The third principle is that the other two signals should only carry the colour information, as distinct from the brightness, and need only have a bandwidth which is a fraction of that of the brightness, or "luminance," signal.

Fourthly, there is the technique of adding the narrow-band colour signals, in the form of modulated sub-carriers, to the brightness signal within its normal frequency band. By adopting special frequency and phase relationships of the sub-carrier relative to the line scan, the objectionable effects of dot pattern on monochome receivers and loss of detail resolution on colour receivers can be minimized. This technique has been, and still is, the subject of much controversy. In spite of its drawbacks, it will probably have to be accepted because of the scarcity of bandwidth in the radio-frequency spectrum available to television.

The fifth principle is the method of carrying the colour information, consisting essentially of two independent variables, on a single sub-carrier, by simultaneous phase and amplitude modulation. This is the subject which will be discussed here, with particular emphasis on the exact nature of the information carried.

As the N.T.S.C. system is now generally well known, it is a useful standard of comparison. Its salient features have already been discussed in *Wireless World*† but a short recapitulation of some of the relevant points will be useful here.

At the transmitting end, the primary red, green and blue signals from the camera, after individual gamma correction, are applied to proportional adding circuits to form three other signals E_Y', E_I' and E_Q'. (Here the tick indicates that the signals are not linear but are formed from gamma-corrected primaries. This gamma correction is to compensate for the non-linear light output characteristic of the receiver c.r.t., which usually follows a power law, so that the correction has to be an inverse power law). E_Y' is the luminance signal already mentioned, while E_I' and E_Q' are known as "chrominance" signals.

E_I' and E_Q' are used to modulate two orthogonal phases of a sub-carrier. Its frequency is an odd multiple of half the line scan frequency, to give dot interlace. The final output, which also includes sync pulses and a colour sync "burst," is formed by adding to E_Y' the modulated sub-carrier. The signals are band limited in varying degrees, on principles already discussed in the previous *Wireless World* articles.

The Colour Sub-Carrier

An important feature of the system is that the vector diagram of the colour signal is very similar in form to the standard chromaticity diagram (the international reference frame for colour specification), with the origin shifted to white. This is shown in Fig. 1, where the sub-carrier vector is superimposed on the chromaticity diagram‡. Hue becomes related to phase, and saturation to amplitude, and for white the sub-carrier has zero amplitude.

Another feature, and one which is not always realized, is that the amplitude of the colour signal is not dependent only on saturation, but also on

*E.M.I. Electronics, Research Division. This article is based on a lecture given recently by the author to the Television Society

†See "American Colour Television," Nov 1953, "Colour Television Standards" and "Transmitting Colour Information," Aug. 1955.

‡For an explanation of chromaticity and the chromaticity diagram see "Colour Fundamentals" in the Aug. 1956, issue, p.363.

brightness. This is a notable departure from the third principle enumerated above, and is, in fact, the main reason why the nature of the colour information transmitted by the N.T.S.C. system is open to question.

According to simple philosophy, the information should be pure chromaticity. This means dominant wavelength (or hue) and purity (or saturation), and corresponds to the familiar concept of colour quality, as distinct from quantity of light. This chromaticity information can be given, for example, by the x and y co-ordinates in Fig. 1, or suitable linear transformations of them. These are essentially functions of ratios, as already explained in *Wireless World*,‡ and are independent of brightness.

The signals transmitted by the N.T.S.C. system, however, are not truly representative of chromaticity. They are " colour-difference " signals, as mentioned in previous articles† and have been given the name " chrominance " by the N.T.S.C. to distinguish them from the idea of pure chromaticity.

There is another way in which the N.T.S.C. system departs from straightforward principles. This arises from the process of gamma correction. As already mentioned, the transmission system corrects for the non-linear electron-gun characteristics, or gamma, of the three-gun picture tube by interposing stages with an inverse power law between the linear signal sources and the proportional adding circuits.

From the short view, the reason is sound enough, as the alternative is to put the gamma correction immediately before the picture tube, which is uneconomical because it would be necessary in every receiver. However, the technique has several disadvantages, especially near saturated colours, and these are: (1) loss of luminance detail; (2) the system is no longer " constant-luminance," i.e. noise and interference in the sub-carrier band will produce brightness fluctuations as well as colour variations; (3) there is a non-linear relationship between the sub-carrier signal and the reproduced chromaticity,

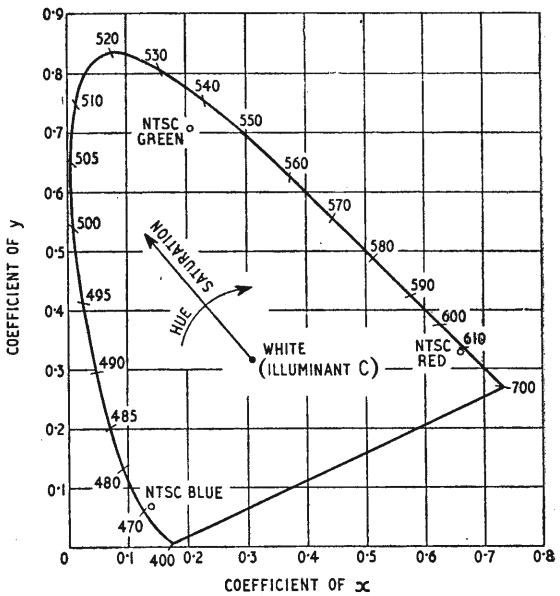


Fig. 1. Standard chromaticity diagram, with spectrum wavelengths in millimicrons and N.T.S.C. primaries. The vector representing the colour sub-carrier is superimposed to show its relationship.

which, for example, renders the hue near the complementary colours much more critical with regard to sub-carrier phase inaccuracy than is that near the primary colours.

Fig. 2 shows how the loss of luminance detail arises near saturated colours. Gamma is taken to be 2.0—that is, a square-law characteristic. The effect of the narrow-band chrominance circuits on a step waveform is simplified by showing the output as a ramp function.

For a transition from red to blue at constant luminance, it will be seen that the square-law effect of the three-gun display-tube causes a dip in the displayed luminance. More striking, perhaps, is the blurring of the edge in a transition from dark blue to light blue. This is not due to the non-linearity, but to the fact that the colour signal is chrominance or colour-difference rather than chromaticity or colour ratio. Thus the major portion of the brightness change is carried over the narrow-band chrominance signal.

American Modifications

The solution to all these problems is to send a pure chromaticity signal for the colour information, but first some palliatives suggested by the N.T.S.C. will be mentioned.

The first arrangement entails a correction to the transmitted signal which removes the loss-of-detail fault shown at the bottom of Fig. 2. Unfortunately this leads to poor compatibility since the correction is not required by monochrome receivers, and on these the edges would be unnaturally emphasized.

The next step considered by the N.T.S.C. was to see what could be done at the cost of introducing one non-linear circuit in a three-gun receiver. This also modified only the luminance signal. It has the advantage of being correct for monochrome receivers, but still gives non-linear colour-difference signals on the sub-carrier.

Finally, schemes were considered in which more than one non-linear circuit might be required in an ideal receiver. This led to the use of a true luminance signal, as mentioned above, and a linear type of colour signal. Three possibilities were considered.

In the first, the chromaticity information was to be transmitted linearly in terms of the sub-carrier amplitude. Because of possible objection to a large sub-carrier amplitude at low brightness levels (giving, for example, reduction of contrast on monochrome receivers) a second alternative was discussed in which a linear chrominance signal was to be used. Besides being no longer a ratio type of system, this went to the other extreme, and the N.T.S.C. favoured a compromise in which chromaticity multiplied by a gamma-corrected luminance signal was used.

In general the receiving equipment required to take advantage of these modifications is either somewhat complex and expensive, or, if simplified, has a tendency to introduce new faults, such as errors in brightness and hue.

From the above discussion, then, it emerges that the N.T.S.C. system, as at present practised, is tailored to give good large-area colour rendering on a three-gun type of tube driven from a receiver having no intentionally non-linear circuits, and that, nevertheless, the system has a number of failings which are probably more easily observed than colour inaccuracies would be.

While it is essential to aim at a low-cost receiver—the absence of which is at present the main brake on the development of colour television—it may be questioned whether in the long run the three-gun tube is the best basis for this. Not only do three guns add to the expense of manufacture, but they bring with them all the problems of registration, which are by no means solved in existing designs, and necessitate two extra wideband video output stages capable of providing about 100 volts swing and a stable black level.

Fundamentally what is required is a single electron gun controlled by a brightness signal, and a screen consisting of a mosaic of differently coloured phosphor dots or strips, with some mechanism which ensures that the spot only excites appropriately coloured dots or strips depending on the colour signal.

Two types of single-gun tube have been successfully demonstrated using this broad principle. One is the Chromatron, or "Lawrence" tube, using a beam deflecting grid near the screen (see July, 1953, issue, p. 329) and the other is the Philco beam-indexing tube, in which the colour signal is applied to the gun in accordance with the position of the beam across the phosphor strips (see January, 1957, issue, p. 2). Both of these tubes have been used on the N.T.S.C. system. The receivers have needed somewhat greater complexity than those for the three-gun tube, but this is largely due to the N.T.S.C. system being tailored to suit the last-mentioned.

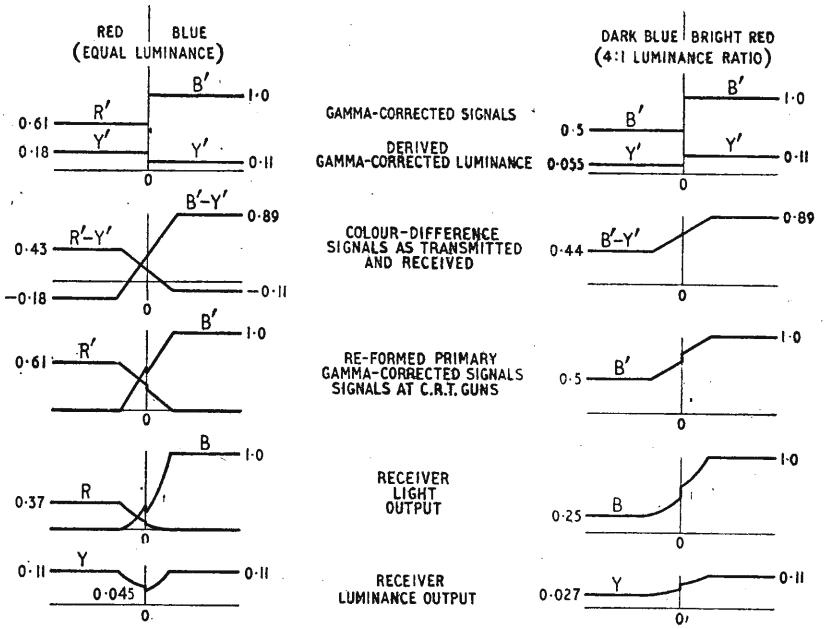
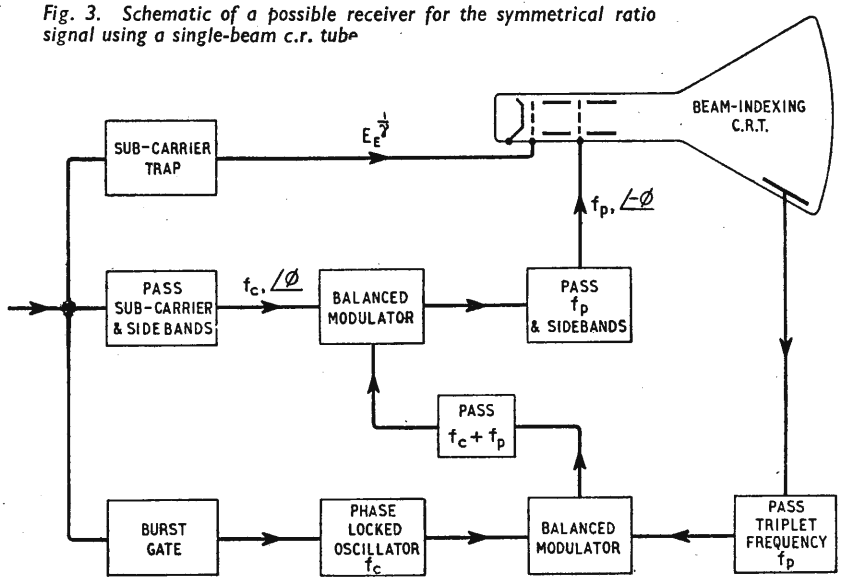


Fig. 2. Illustration of how gamma-correction causes loss of luminance detail near saturated colours. Read from top (transmitting end) to bottom (receiving end).

Fig. 3. Schematic of a possible receiver for the symmetrical ratio signal using a single-beam c.r. tube



Consider the basic requirements of these single-gun tubes, in which the beam excites the three primary phosphors sequentially and the colour is controlled by gating the beam on and off at appropriate times. For peak-white the brightness signal is a maximum, and it is reasonable to adjust the phosphor efficiencies so that the desired reference white (e.g., Illuminant C on Fig. 1) is obtained when each phosphor is equally excited. The symmetry of this arrangement necessitates a brightness signal which is given by $E_E = \frac{E_R + E_G + E_B}{3}$. The symbol E_E is used because this "brightness" corresponds more to total energy than to total luminosity. The signal E_E is preferably gamma-corrected at the transmitter for the receiver electron-gun characteristic, and is transmitted instead of the signal E_Y' in the N.T.S.C. system.

To accompany this "symmetrical" brightness signal, a symmetrical colour signal is also required at the receiver. Such a signal could consist of a sub-carrier modulated in three different phases 120° apart by the three linear colour components E_R, E_G and E_B.

If the tube has a single beam control electrode, as in the existing Philco beam-indexing tube, then the colour signals, if they are to be used with the

minimum of processing, must be such that when added to the brightness signal in correct proportion they form the complete brightness and gating signal to be applied to the tube. This implies that the colour signal amplitude is non-linearly dependent on brightness, as in the N.T.S.C. system. Such a system, therefore, has the faults of the N.T.S.C. system, and in addition is not a constant-luminance system even near white.

Schemes are possible in which the colour signals gate or select the beam after it has been generated under the control of the brightness signal. Such schemes, in which the phosphor-selecting signals depend on hue and saturation, but not on brightness, require a signal which is both symmetrical, as explained immediately above, and a ratio signal as described earlier.

Symmetrical Ratio Receiver

In Fig. 3 is shown how simple, at least in principle, could be a receiver for a beam-indexing tube with this "symmetrical ratio signal." The regenerated sub-carrier frequency f_c, locked in phase to the colour sync burst, is mixed with the beam index frequency f_p to produce $f_c + f_p$. This is again heterodyned with the colour signal E_c of frequency f_c and instantaneous phase ϕ, the lower side-band giving f_p, phase $-\phi$. Thus we now have a signal of beam-index frequency, of amplitude proportional to E_c and phase $-\phi$, which can be used to turn on the beam, to an amount controlled by the gamma-corrected E_B, at the appropriate times to excite the desired combination of phosphors. The gun would require two independent control electrodes (e.g. a hexode gun), giving a direct multiplication of the two signals.

A linear ratio system such as the N.T.S.C. modified system mentioned above preserves detail brightness resolution under all conditions, and the hue variation with phase of sub-carrier is independent of saturation. The latter feature is true also of the symmetrical ratio system, but as it is not a constant-luminance system, there is luminance distortion at any edges where the chromaticity changes. It is, however, less subject to brightness noise originating in the colour transmitting channel than was, for example, the original RCA dot sequential system, which was similar in many respects except that it was not a ratio system.

Thus the average amplitude of the colour signals is greater in the proposed system, and the extra brightness noise, especially in the medium brightness areas, where noise is most visible, is not expected to be noticeable. In comparing it with the present N.T.S.C. system, it must be remembered that the last-mentioned is only nominally a constant-luminance system, and departs radically from this principle in or near saturated regions.

The fact that the symmetrical ratio system is not constant-luminance in operation can be shown to be due entirely to the use of gamma-corrected E_B instead of gamma-corrected E_Y for the brightness signal, and does not depend on the form of the sub-carrier modulation so long as this is linear. Another effect of using gamma-corrected E_B is that the luminance displayed on monochrome receivers will be incorrect, but as the signal is still panchromatic the resulting monochrome picture is likely to be perfectly acceptable. Incidentally, it is important to note that good results can be obtained on a three-gun tube with this system.

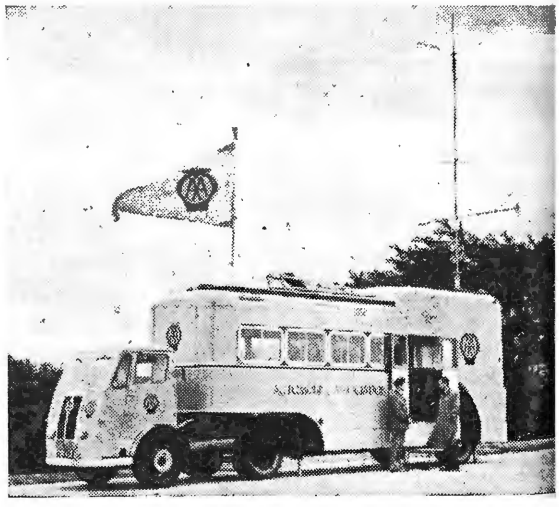
Summarizing the differences between the N.T.S.C. system and the symmetrical ratio system, the fact that with a three-gun tube decoding is performed outside the tube permits independent weighting of the red, green and blue signals, while for single-gun tubes with internal decoding symmetrical signals are preferable. In the N.T.S.C. system the facility of independent weighting is used to construct a nominally constant-luminance system, but because the signals thus weighted are not linearly related to the light intensities, constant luminance is only achieved near white.

It is clear from the discussion above that there is no perfect combination of system and tube. In these circumstances it might be best to forget about expediency, which is always a doubtful guide, and look for a system which is itself as perfect as possible, in the expectation that tube and receiver design will then develop along the necessary lines to match the system, so as to give overall optimum economy and performance.

It may be assumed that such a system would have a true luminance signal, corrected for normal gamma, but it is not so obvious what the colour signal ought to be, beyond the fact that it should be linearly related to chromaticity. It is preferably symmetrical in the sense that any of the three saturated primaries should give equal amplitude, and preferably white is zero, but these two conditions cannot be realized simultaneously unless the divisor used to form the ratios is E_B and not E_Y.

Thus no firm suggestion is made, but a useful purpose will have been served if it is now appreciated that the N.T.S.C. system is not ideal. It is designed to fit a particular type of tube, which is not a really sound basis for choosing a system which must remain valid for many years to come.

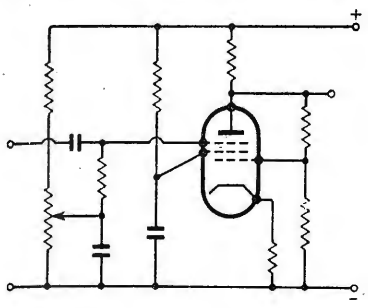
Finally, several colleagues must be thanked for many helpful discussions during the preparation of this article, particularly I. J. P. James and E. J. Gargini.



A TELESCOPIC AERIAL, which can be raised hydraulically to a height of 55ft giving a radio range of about 30 miles under normal conditions, is fitted to this second mobile office recently brought into service by the Automobile Association. It is being used for the co-ordination of the A.A.'s road weather reporting service.

Technical Notebook

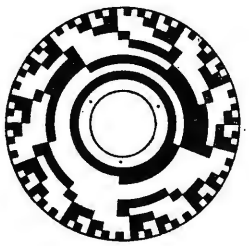
Single-Pentode Flip-Flop, devised by T. E. Ivall, operates by using the valve as a pair of triodes connected in series—the bottom one acting as a cathode follower. A negative trigger pulse applied to the suppressor drives the anode, and hence the control grid, positive. Current is drawn through the screen grid, the cathode also goes positive, and, by virtue of the increased current through the cathode resistor, the suppressor is driven even more negative. A rapid cumulative action takes place, cutting off the top "triode" and rendering the bottom one fully conducting. A positive-going trigger pulse reverses the action. Because of the complete 360° phase shift round the loop the



circuit can be operated as a sinusoidal oscillator with, say, an LC circuit in place of the anode load, or a simple RC combination in place of the potential divider connecting anode to grid. A valve with a short suppressor grid base (such as the old EF50) is the most suitable type.

Bilingual Television Transmission, with two different sound accompaniments to the picture, may be a desirable thing for some countries. A method of achieving this technically, devised by the French firm Radio-Technique, has been reported by the European Broadcasting Union. The two audio signals are arranged to amplitude modulate two interlaced trains of pulses transmitted in the normal sound channel —on the time-division multiplex principle The time spacing of the pulses in each train is equal to the duration of a line scan, and the trains are phase locked to the line sync pulses. At the receiving end the method of separation is to apply a gating signal to one of the sound-channel i.f. valves in such a way that only the pulses carrying the wanted sound accompaniment are allowed through. The gating signal is generated by shock exciting an oscillatory circuit (tuned to the line frequency) from the line scanning circuits and then limiting the resultant complex waveform to provide the required gating voltage levels. By simply reversing the excitation leads either one or the other of the sound accompaniments is gated as required. It is claimed that a very simple and inexpensive "decoder" unit, using no valves, is all that is required to change an ordinary television set into a "bilingual" receiver.

Binary Coded Scales are now being used on electronically controlled machine tools and other equipment where it is necessary to measure a mechanical displacement with great accuracy. They convert the analogue type of indication, such as a pointer against a scale, into a series of digits which can be read off quickly so that the task of the human operator is greatly eased. The circular scale in the sketch (made by Hilger & Watts) is for indicating angular displacement in binary digital form. The binary scale is more economical in displacement detection than other scales (e.g., 0 to 9 in decimal re-



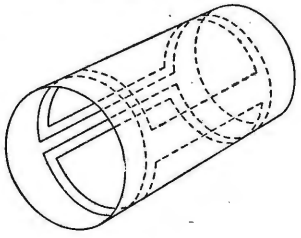
quires ten elements compared with four in binary) and because there are only "0" and "1" elements involved it is easy to devise electrical pick-off systems for feeding the information into digital computers or other electronic data processing equipment. As well as the pure binary code, it is possible to use binary-coded decimal and other special arrangements.

"Too Old At—?" in our September, 1956, issue certainly revealed some interesting facts about people's hearing, but it didn't tell you at what stage of development or decay you have to be to hear electrical signals direct without an acoustic transducer. According to a report in the October, 1956, issue of *Proc. I.R.E.*, engineers have experienced an audible response when standing six feet away from the horn of a radar set working at 1300 Mc/s with a peak power of half a megawatt. The pulse length was 2μsec and the p.r.f. was 600 c/s. The most sensitive part of the head proved to be at the sides at a point midway between the ears and eyes and slightly above them. The sounds heard were mostly high-frequency components without much of the 600-c/s fundamental, and people whose ear responses cut off at 5 kc/s heard them much less strongly than those who went up to 15 kc/s. A deaf man with a bone-conduction hearing-aid heard nothing at all. Unfortunately, such experiments can be dangerous because high-power microwave radiation can produce cataracts of the eye.

Aluminium-Wire Speech Coils, used in loudspeakers to reduce the mass of the vibrating system, bring with them the problem of soldering the wire ends. Wharfedale Wireless Works, in collaboration with Mullard, have solved the problem by dipping the wires into a small bath of molten solder agitated by ultrasonic energy. A cavitation effect in the solder removes the oxide film from the aluminium and effective tinning is achieved. Afterwards the tinned wires can be soldered in the ordinary way. A solder compound of 90 per cent tin and 10 per cent zinc is used in the bath at a temperature of about 230°C and the tinning operation takes 2-3 seconds. A recent improvement to the technique

has been a simplified method of maintaining the ultrasonic energy at the optimum frequency to ensure maximum soldering efficiency under all conditions.

Simple Linearity Control for television line scanning, devised by J. C. MacKellar and K. E. Martin of Mullard, consists of short-circuited turns made of foil underneath the line scanning coils on the c.r. tube neck. During scanning the e.m.f. induced in the short-circuited turns is proportional to the rate-of-change of scanning flux. It causes a current to flow which, because of the R and L of the turns, changes exponentially. The flux produced by this induced current opposes the scanning flux and, if the time constant of the turns is small compared with that of the generating circuit, the waveform of the correcting flux is



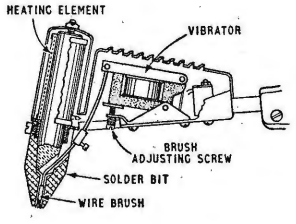
more curved than that of the scanning flux. Thus the curved sections of the waveforms can be arranged to roughly match each other so that a substantially linear scan is obtained with very little decrease in amplitude. Adjustment of linearity is achieved by moving the short-circuited turns in relation to the scanning coils so that the flux linkage, and hence current induced, is varied. No "ringing" is caused, as with other types of linearity control. The sketch shows how a pair of the short-circuited turns can be constructed. They are actually joined at adjacent edges as this simplifies manufacture to producing one foil stamping instead of two. Non-linearity can be reduced to less than 5% and the efficiency compares favourable with existing types of control.

Efficient Rectifier Cooling is the reason for the unusual "mouth-organ" construction of the new Siemens & Halske selenium h.t. rectifiers recently shown to us by R. H. Cole (Overseas). The plates are held at the edges and are arranged in groups with spaces between to give a series of "chimneys" for convection cooling. Then the edge-mounting gives a direct conduction cooling for each set of plates on to the aluminium case, which, in turn, is contact-cooled when it is held flat against a chassis by the fixing lugs. This edge-mounting of the plates has a distinct advantage over the more conventional contact-cooled rectifiers, where the plates are stacked parallel with the case side, since it cools all of the

plates equally instead of just those at the outsides. The rectifier illustrated is a 220-V 300-mA type and measures only $3\frac{7}{8}$in × $1\frac{1}{4}$in × $\frac{3}{4}$in.

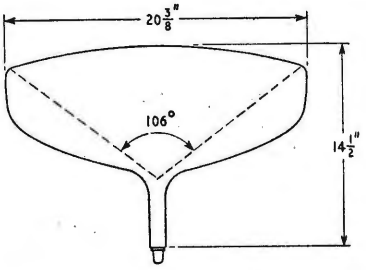
Simple Transistor Testing, using d.c. methods, may not give complete and detailed information, but it can still be useful in providing a general indication of characteristics. With this in mind, Mullard have introduced a simple instrument by which it is possible to check three of the more important junction transistor parameters, and the measurements are presented as direct meter readings. For the first parameter, base-collector short-circuit current gain, advantage is taken of the approximately linear relationship between collector current and base current. This permits finite changes of current to be used to measure the parameter with an accuracy high enough for all practical purposes. Measurement is thus reduced to observing the collector current produced by a convenient known base current and transcribing it into a direct meter reading of base-collector current gain. The second parameter is the d.c. collector current for zero base current. Here, since the d.c. collector current is sensibly independent of collector voltage, direct metering of this parameter can be made. Finally, for collector turnover voltage, the tester measures the collector-emitter turnover voltage for zero base current. A relatively high voltage is applied to the collector via a resistance, and the turnover voltage is read directly from the meter.

Aluminium Soft-Soldering, normally very difficult because of the tenacious oxide film which prevents "wetting" of the metal surface, should be made much easier by a special tool introduced by the Belark Tool and Stamping Company. With this, the surface of the aluminium is mechanically cleaned by a small steel-wire brush vibrating at 100c/s in the centre of the soldering bit (see illustration). Re-oxidization is



prevented by working with a pool of molten solder round the bit which excludes the air while tinning is taking place. No flux is used, but the solder has to be the special blowpipe type (80% tin and 20% zinc) with a melting point of 220°C. The soldering bit is actually heated to approximately 500°C, and this is sufficient for soldering sheet metal up to 12 s.w.g. thickness and small castings. Two pieces of aluminium which have been tinned with this vibratory tool can afterwards be joined together by orthodox soldering methods.

Wider than Wide-Angle television c.r. tube recently introduced by RCA in America makes one wonder if the flat "picture-on-the-wall" display device will really be necessary after all. The tube is a 21-inch rectangular type (21EP4) and has a diagonal deflection angle as large as 110° (or a line scan angle of 106°, as shown)! This has reduced the overall length by about $5\frac{1}{2}$ inches over comparable tubes with the same size of screen and 90° deflection angles. Another feature is a narrow neck diameter ($1\frac{1}{8}$in), which makes



it possible to deflect the beam through the extra wide angle with only slightly more power than is required to scan a tube with a 90° angle. An electrostatic focusing system is incorporated for maintaining uniformity of focus over the whole screen. Other American tube manufacturers are following suit with the new angle.

Printed Magnetic-Cell storage device for holding binary information has recently been developed by RCA. An experimental unit has a capacity of 2,560 bits in a volume of only 2 cubic inches. It works on the magnetic-cell matrix principle described in the December, 1956, issue (p. 596) but consists of a series of thin plates of ferromagnetic material with printed conductors joining the holes. This is possible because the ferromagnetic storage medium is a ceramic-type material and therefore an insulator. The idea offers a great simplification in manufacture over the conventional matrix stores in which a complex pattern of wires has to be threaded through a great many tiny ferrite cores.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents

Transistor Symbols

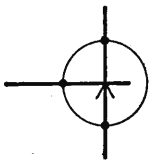
I HESITATE to add yet another transistor symbol to the great scrap-heap of suggestions that has accumulated already, but I think H. J. Cooke (December, 1956, issue) is working in the right direction and a simplification of his ideas might be worth considering. The following criticisms come to mind:

(1) The point transistor is practically finished, so why bother about it? Even its negative resistance characteristic, so useful for switching, can now be produced in junction devices.

(2) The graphical distinction between *p-n-p* and *n-p-n* junction types is not really essential, since this is usually obvious from the polarity of the transistor's power supply.

(3) Anything which involves rectangles or triangles, especially blacked-in ones, takes time to draw. (The ultimate choice of symbol will almost certainly be influenced by technicians who have to sketch it rapidly on the backs of old envelopes.) In any case, enclosed areas do not capture the interest of the eye and suggest function so effectively as the active line.

(4) Mr. Cooke's arrow for identifying the emitter of the junction transistors suggests that this arrow is in itself the emitter—whereas in reality the emitter is the left-hand junction between *n*- and *p*-type materials indicated by the adjoining rectangles in his drawing. Here again we have an element of redundancy and possible confusion.



A logical outcome of these criticisms would be a symbol something like that in the accompanying sketch. I am not particularly fond of it, but at least it is simple and has a familiar look about it without suggesting the physical construction of the point transistor.

London, S.E.5. JAMES FRANKLIN.

Transistor Chaos

"CATHODE RAY" (November-December, 1956, issues) would find transistor symbols almost as chaotic here as in Britain. However, I would recommend to him the adoption of β for the common emitter current gain, since it is already used by the majority of American manufacturers. The symbol α can then be allowed to waste away.

Which of the resistor systems should be adopted is seemingly being decided by ease of measurement. No doubt this simplifies the work of the quality control section, but surely more emphasis should be placed on the easing of circuit design. The great advantage of the r_e, r_b, r_c system is that external impedances can often be added in directly. With the other systems the external values must be inserted in equations which often obscure the relative importance of the various components.

M. O. FELIX.

Canadian Westinghouse Company,
Hamilton, Ontario.

"High-Quality" Demonstrations

WHILE I agree with Mr. H. Glover (October issue) that the electronic organs are of limited value as test material for high-quality sound systems, I feel that he has overlooked one of their most important features.

It is well known that those organs produce low pedal notes. This makes them particularly useful for demonstrating the bass capabilities of a loudspeaker. In particular the records of Lenny Dee, which a number of demonstrators used, have excellent pedal notes.

A larger than usual cone area seems necessary for their reproduction, and anything less than an 18-in unit or, say, two 12-in units in a suitable enclosure would appear to be inadequate.

Crowborough. E. R. ASLIN.

Spare Parts

THE increasing complexity of the modern television and sound broadcast receiver prompts me to ask whether the time is not fast approaching when the manufacturers should, in fairness to the buyers of their products, be willing to supply spare parts directly to the private customer in the cases where he is willing and able to fit them.

I have been employed in the radio industry for over 21 years and I well know the arguments against supplying the general public with spares. These, I submit, were perfectly valid in the days when the dealers required only a reasonable ability as repairers and when circuits were simpler. Also, in those far-off happy days the general public knew very little of radio servicing and possibly cared less.

The position today is entirely different. There are now literally hundreds of firms employing radio "technicians"—for want of a better term—whose daily work involves far more ability than required to repair a radio receiver of half-a-dozen valves.

On the other side, there is reputed to be a shortage of 50,000 service technicians in the retail radio trade. This simply means that having paid possibly £100 for a television receiver, the customer is unable to obtain efficient servicing if and when it breaks down.

I would, therefore, respectfully suggest, sir, that there is a case for the manufacturers to supply parts at normal prices to anyone wishing to buy, provided he quotes the serial number of his receiver. This would prevent spare-time repairers stealing too much business from the dealers, some of whom show at times a lamentable lack of enthusiasm for service work.

The owner of a television receiver would surely not order and pay for spares unless he thinks he knows what he was doing. Even if he made a mess of the job, it's his own property he is spoiling.

It seems ludicrous to me that a man whose working day is spent among complex electronic devices should be compelled to take his five-valve receiver to the local village radio shop to be repaired by someone who probably fills in time mending punctures!

Fakenham, Norfolk. "TECHNICIAN."

Tape Amplifier Design

I HAVE just seen R. C. Marshall's letter in your June, 1956, issue, commenting on my tape amplifier design (November, 1954, issue). The changes suggested by Mr. Marshall certainly represent a sound approach to the design of this particular feedback amplifier, although it may be mentioned that the record amplifier was found to be absolutely stable even with the original values.

It is possible to replace the triode outfit valve V_2 in the recording amplifier by a pentode. Using a large screen decoupling condenser, the amplifier oscillates with the recording head disconnected, but is stable if the recording head is connected. If a compara-

tively small screen decoupling condenser is used, the amplifier will be unconditionally stable. In the latter case, V_2 operates at low frequencies as a triode, which eliminates the cause of instability. At high frequencies, in particular at the bias frequency, the screen is effectively bypassed, and the high internal impedance is preserved. At low frequencies, the additional feedback owing to the unbypassed screen resistor is negligible and has practically no influence on the frequency response of the recording amplifier.

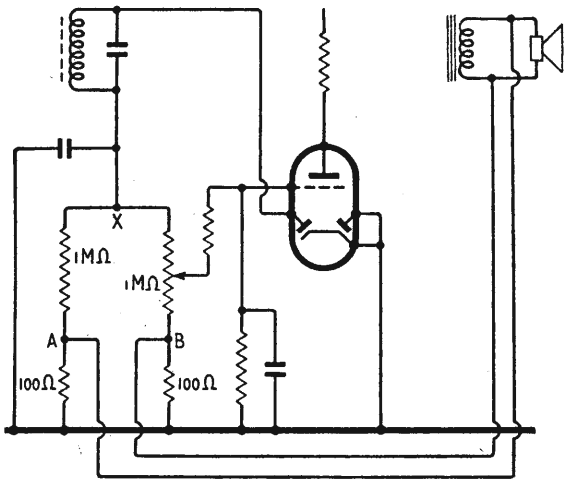
In my own equipment I am using a 6SH7 with a screen resistor of 1MΩ and a condenser of 0.025μF between screen and cathode. R_1, R_2 and R_{12} remain unchanged.

Tel Aviv, Israel. ARIEH F. FISCHMANN.

"*Economy in Receiver Design*"

THE objections raised by G. N. E. Pasch (your October, 1956, issue) to the injection of a negative feedback voltage to the grid of the first audio amplifier via the diode-load-cum-volume-control can be completely overcome, without otherwise rearranging the circuit, if a simple bridge network is used. The accompanying circuit diagram shows the arrangement; component values are suggested, but these are, of course, fairly arbitrary.

The feedback voltage being developed across AB, point X will, of course, be at earth potential so far as feedback voltage is concerned and the operation of the diode is not disturbed. On the other hand, the maxi-



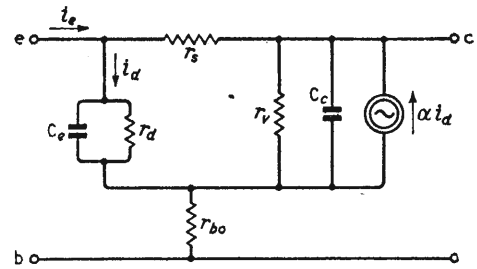
mum voltage fed back to the triode grid when the volume control is at its lowest point is reduced by 6 dB in this arrangement, but this is unlikely to be a serious disadvantage in a simple receiver of this type.

London, N.10. IAN LESLIE.

"*Transistor R.F. Amplifiers*"

IN his article in the October issue, D. D. Jones presents low- and high-frequency equivalent circuits related in a way which we feel is misleading. The low frequency value of r_e is not necessarily given by $25/I_e$. This is true only if the low-frequency base resistance r_b and the high-frequency base resistance r_{bo} are equal; in practice r_b is usually significantly higher than r_{bo}, so that with I_e= 1mA, the low-frequency r_e may range down to the order of 2 ohms.

An equivalent circuit* from which Figs. 1 and 2 in the article may be derived is shown in the accompanying diagram At high frequencies r_s may for all practical



purposes be neglected and the circuit reduces to the high-frequency form given by Jones. To obtain his low-frequency T circuit, however, the parameter r_s cannot be neglected in the transformation. The resulting low-frequency r_e is not in general equal to r_d ($=25/I_e$).

A further point relates to the choice of d.c. operating conditions for the transistor. Jones mentions the reduction of C_c resulting from an increased V_c; a further benefit is that $f\alpha$ is increased.

A. R. BOOTHROYD.
Imperial College, A. R. MOLOZZI.
London, S.W.7. D. F. PAGE.

Supply Voltage

I WONDER what the chairman of the South Eastern Electricity Board would do if his garage charged him for 100- and supplied him with 75-octane petrol?

Would he say, "Ah, well, the quantity is correct and the calorific value the same, so I will pay"? I somehow doubt it.

But already my voltage has been as low as 199 instead of 230, and winter hasn't started yet. Seldom is my television picture quality worth watching between 7 and 9 p.m.

Last February it dropped to 177 volts and all the mains engineer can tell me is that they can't find room for a sub-station anywhere.

Banstead, Surrey. A. R. TURPIN.

But What About "Agenda"? [ED.]

"FREE GRID," whom I have long regarded as a firm and sure upholder of the classical basis of our language, seems to be losing his grip. Not once but twice in the January instalment of his incisive comments he treats "data" as singular. It is hardly surprising that in these days of very optional Latin this solecism should be increasingly common in technical circles, but one expects better of "Free Grid." He must surely know that "g_m=3.6" and "μ=47" *are* valve data, and "r_a=13" *is* valve datum? Or will he soon be writing about "a phenomena" or "a cherubim"? If he lets the humanities down again I shall have to consider writing the "Second Thoughts on Love Theory" (large negative values) he so much dreads.

While on this tack may I also reproach—though more gently—"Diallist" (who, if I'm not mistaken, is another classical scholar) for referring to the present type of British TV as "monochrome"? White, as he well knows, is as far removed from monochrome as it could be, and would more aptly be named "panchrome." At the same time I do sympathize with his reluctance to keep on using the clumsy and (if the contrast control is properly set) inaccurate expression "black-and-white." It is time we had a better word.

Finally, B. E. Jackson might care to note that single-setting resistance-current-voltage-power nomograms are less uncommon than he suggests. One by W. A. Barclay was published in *Wireless World* as long ago as February 17th, 1932, and repeated several times since; there is one in "Radio Data Charts" (5th edn.), and one in "Radio Laboratory Handbook" (6th edn.).

"CATHODE RAY."

* R. L. Pritchard, "Electr-Network Representation of Transistors—a Survey." *I.R.E. Transactions*, Vol. CT-3, No. 1, pages 5-21, March, 1956.

Improved Sync Separator

Single-Pulse Frame Synchronizing for Good Interlacing

By MICHAEL P. BEDDOES,* B.Sc.(Eng.), D.I.C., A.M.I.E.E.

THE composite synchronizing signal for British television consists of alternating trains of line and frame pulses.[1] During the period in which the frame is being scanned, line pulses only are transmitted. In the small interval between the end of the frame scan and the frame flyback a group of pulses at twice line frequency is transmitted to provide a trigger for the fly-back of the frame timebase and also to maintain synchronous operation of the line timebase. In

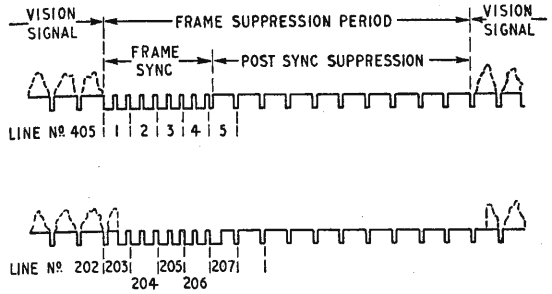


Fig. 1. B.B.C. vision waveform at the end of the frame scan; for even frames (above) and odd frames (below).

American television practice, on the other hand, the group of frame pulses is preceded and followed by "equalizing pulses" to facilitate accurate synchronising of the frame timebase in the receiver.

At first sight, it might appear that a single RC integrating network could produce satisfactory frame sync pulses from the composite synchronizing signal. According to Patchett,[2] this is not possible because without equalizing pulses this method produces frame-sync pulses which differ slightly on odd and even frames. The slight difference makes accurate synchronizing of the frame-timebase and hence good interlacing difficult, if not entirely impossible to achieve. Various improved methods[3, 4] have been developed for separating the frame pulses from the composite synchronizing signal. It is well known that, in certain cases, such methods can produce excellent interlacing.

However, suppose that the timebase fires slightly irregularly for odd and even frames. This would cause the initiation of flyback to vary between, for example, the first and second pulses of succeeding trains of sync pulses. Thus, although the frame lock might be considered to be satisfactory, perfect interlacing would only be possible over a strictly limited region within the locked range. According to Haantjes and Kerkhof[5], even though a timebase has a tendency towards irregular firing, a single, narrow and perfectly regular pulse will be conducive to the best interlacing. The single pulse frame sync separator described here is rather more elaborate than that developed by Haantjes and Kerkof.

The process of obtaining the frame-sync signal from the video signal is normally done by cascading two separators. The output of the first (the picture/sync separator) is the composite sync signal, and that of the second (the frame/sync separator) is the frame sync signal. During each frame, the corresponding sync signal may be arbitrarily divided into a group of 202½ line pulses and one of 8 frame pulses (Fig. 1). In order to provide a frame sync signal, the frame sync separator must have an output which is produced by the sudden transition from the line pulses to frame pulses, but not vice versa. The essentials of this particular circuit are shown in Fig. 2.

The triode V_1 is driven by the composite synchronizing signal. Its anode current is completely cut off by any sync pulse; in the conduction periods between pulses the full current flows. Thus, for the purposes of explanation, the circuit of Fig. 2 can be replaced by the simpler equivalent of Fig. 3 in which a resistance R (equal to the anode resistance of the triode) in series with a switch replaces V_1. The switch is held open during sync pulses only.

Taking the line pulses first, imagine that the switch (Fig. 3) has been closed for a considerable time, and

* University of British Columbia.

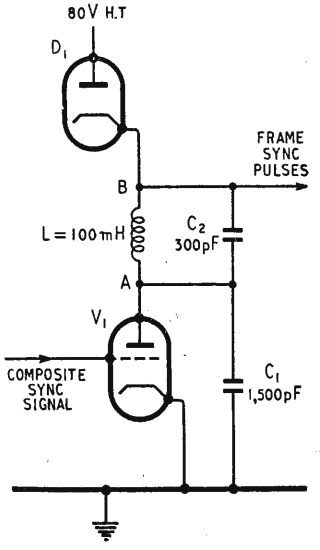


Fig. 2. Essential elements of the improved frame sync separator.

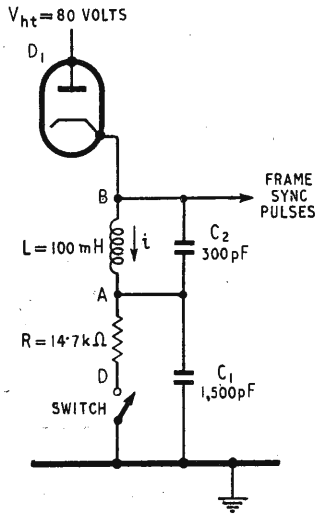


Fig. 3. Simpler version of Fig. 2, with a resistance and a switch representing the triode valve.

that the current i in the inductor has reached its steady value given by

$$i = I = \frac{V_{h.t.}}{R} = \frac{80}{14.7} = 5.43 \text{ mA} \quad .. \quad (1)$$

In the first line pulse, the switch is opened for 10 μsec. During this period, the damping is removed from the tuned circuit and i will decay as part of a sinusoidal oscillation whose period, T_1 (governed by L and C_1+C_2), is 83 μsec. However, because the switch is open for considerably less than $T_1/4$, the current in the inductor cannot reach zero.

Following the line pulse, the switch is closed for 90μ sec. During this period very heavy damping is again applied to the tuned circuit and the inductive current rapidly asymptotes to the steady value I. Thus, in the period of the second line pulse, the inductive current follows a pattern similar to that outlined for the first pulse. This pattern is repeated for each line pulse in the long train of 202½ line pulses.

Experimentally, it was easier to observe the voltage waveforms at A and B than the current in the inductance. From Fig. 4, during a line pulse v_A is elevated, implying the decay of i. In the subsequent period, the waveform of v_A indicates, also by implication, that the steady value I is reached at about the middle of the line scan. Nowhere within this cycle has the current in the inductor or in the diode reversed sign and therefore no output should, nor indeed does, appear at B.

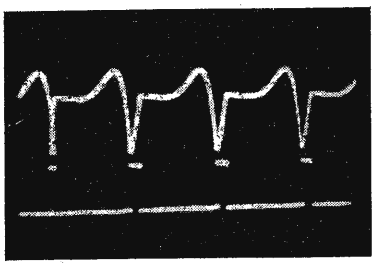


Fig. 4. Waveforms during a long train of line pulses; (above) line sync signal, (below) corresponding v_A.

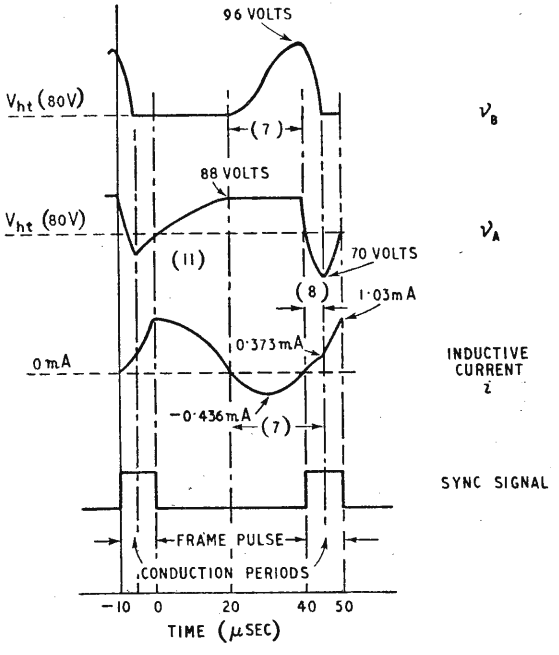


Fig. 5. Section of a long train of frame pulses. The numbers in brackets refer to the corresponding formulæ in the text.

Frame Pulse Pattern

Taking the frame pulses next, at the instant of the middle of the frame pulse, assume that the current i in the inductance is zero (Fig. 5) but the voltage across it, v_A–v_B, maintained by the charge in C_2, is positive. The switch (Fig. 3) is open. The potential v_A will be held constant by the charge in C_1. Although the potential v_B cannot be decreased because of the diode action, it can be increased. Therefore, during the decay of the charge in C_2, voltage v_B is elevated as part of a sinusoidal oscillation with a period T_2 (governed by L and C_2) of 37 μsec.

The switch remains open for 20 μsec, in which period approximately half a cycle of the oscillation can take place. At the end of this period the potential difference, v_B–v_A, is now a maximum but beginning to diminish. During the ensuing conduction interval, the switch is closed for 10 μsec, and the current through R rapidly reduces the potential v_A. Concurrently, v_B–v_A is also diminishing. In the middle of this conduction period* the potential of B falls to h.t. voltage and the diode closes. Immediately the mode of operation changes. The current in the inductance increases in the remaining 5 μsec of the conduction period.

During the period of the next frame pulse, the switch is opened for 40 μsec. The charge in C_1 reduces the current in the inductance and, simultaneously, the potential of A is elevated as part of a sinusoidal oscillation of period T_1 (83 μsec). In the instant a quarter of this period (20 μsec) later, the current in the inductance will be zero, and the voltage across it, v_A–v_B, will be positive. Thus, after this instant, a pattern follows which is similar to that already outlined. This pattern will be repeated for each frame pulse in the train of 8 frame pulses.

Experimentally, it was easier to observe the voltage waveforms v_A and v_B than the current i in the inductance. From Fig. 6, the potential v_A is elevated during the first half of the frame pulse, implying the decay of i. During the second half v_A is seen to be sensibly constant, held thus by the charge in C_1. During the subsequent conduction period v_A is seen to decay rapidly. It is elevated once again during the first half of the subsequent frame pulse.

From Fig. 7, during the first half of the frame pulse, when the inductive current and also the diode current are falling to zero, the potential v_B is seen to be constant, held thus by the action of the diode. During the second half of the frame pulse when the diode is open, this potential can be seen to increase rapidly, but it decays even more rapidly during the ensuing conduction period. In steady-state, therefore, a single narrow pulse of voltage appears during each frame pulse and at first sight it might appear that what has been described is but one more circuit for separating the trains of frame pulses[3,4] from the composite sync signal. This impression, however, is misleading, as will be shown below.

During the line pulses, the power supplied to the circuit (from considerations of the mark-to-space ratios) is 36 times that during the frame pulses.

* See appendix.

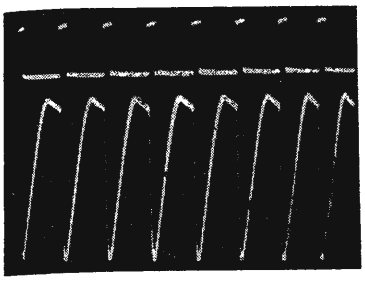


Fig. 6. Waveforms during a long train of frame pulses; (above) frame sync signal, (below) corresponding v_A.

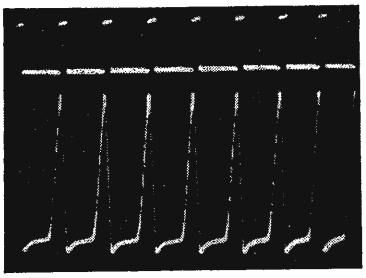


Fig. 7. Waveforms during a long train of frame pulses; (above) frame sync signal, (below) corresponding v_B.

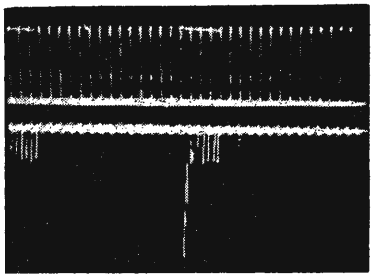


Fig. 8. Waveforms during the frame sync period; (above) composite sync signal, (below) frame sync pulse, v_B.

During a succession of frame pulses, the magnitude of the voltage pulses at B is, of course, proportional to the current (approximately, because of the non-linear elements, proportional to the square root of the power) from the valve. It is therefore to be expected that in the transition, line to frame, the first frame pulse should exceed its fellows by a factor of $\sqrt{36} = 6$. This prediction appears to be verified from Fig. 8. After the train of frame pulses, the operation of the circuit very soon† approximates to the steady-state conditions for a succession of line pulses for which there is no appreciable output at B.

Complete Separator Circuit

The circuit for a complete line and frame sync separator is given in Fig. 9. A multiple valve, V(a) and (b), performs most of the necessary operation. The pentode portion, V(a), is a classical picture/sync separator. Its input is the vision-plus-sync signal, while its output consists of the composite sync signal only. This signal synchronizes the line timebase. The triode V(b) is the frame/sync separator. Its input is the composite sync signal from V(a), while its output consists of narrow pulses which are employed to synchronize the frame timebase.

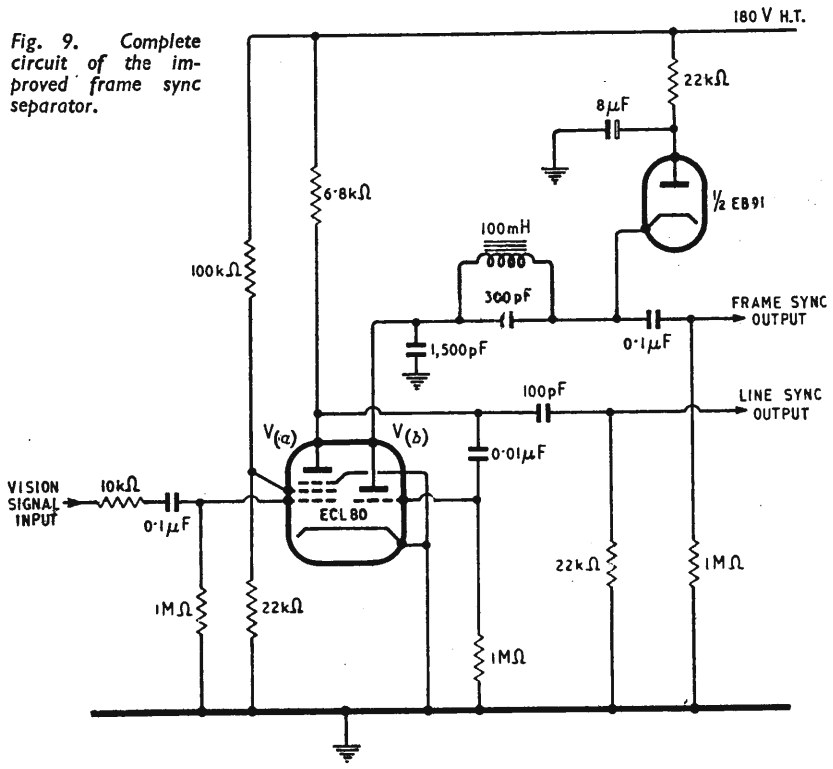
In order to limit the anode dissipation of V(b) it is fed with reduced h.t. During normal operation this valve consumes 6 mA at 80 volts: when the drive is removed the current consumption falls to 4 mA.

In discussing the performance of the circuit, one must consider the effects of interference by noise. If the frame sync-separator is either the simple RC integrator[2], or the more elaborate "train separator"[3,4], the derived sync-signal is 400 μsec or more in duration. Therefore, in order to completely mask the frame pulse by noise, a burst of such interference must last continuously for a period which is much longer than 400 μsec, and must coincide with the period when the sync pulses would normally occur.

For the new separator, the critical period in the composite sync signal is considerably shorter: a much shorter continuous burst of noise will therefore be sufficient to destroy the frame lock. Now the probability of obtaining a continuous burst of noise must vary inversely as its duration. Thus, in order to achieve increased precision of frame synchronism by this method, one of the prices to be paid is *reduced* noise immunity.

There is also the question of variations of performance between samples of the circuit manufactured by normal mass-production techniques. This frame sync circuit was employed in a production run of over a thousand television receivers with satisfactory results. The tolerances allowed on the component values were the usual ±20% of

Fig. 9. Complete circuit of the improved frame sync separator.



† All the time-constants in these circuits are very short: 22, 37 and 83 μsec respectively

nominal, while the permitted variation in the value of the inductance L (Fig. 2) was even greater, only a minimum value of 100mH being specified‡. Such variations in the circuit values naturally produced observable changes in the waveforms. Between different receivers there was a variation in the *number* of minor pulses which followed the primary sync pulse; also, there appeared to be a small variation in the actual magnitude of this pulse. In spite of these variations, however, the resulting frame lock remained very precise, and the range of excellent interlace appeared to be substantially independent of the setting of the frame hold adjustment, provided of course that operation was within the synchronous range.

REFERENCES

[1] Blumlein, A. D., Browne, C. O., Davis, N. E. and Green, E. "The Marconi-E.M.I. Television System," *Journal I.E.E.*, 83, pp. 758–766 (1938).

[2] Patchett, G. N. "Faulty Interlacing," *Wireless World*, July 1952, pp. 250–254 and August 1952, pp. 315–319.

[3] Townsend, G. B. "On overcoming the Non-Interlacing of Television Receivers which are accurately Synchronized," *Proc. I.E.E.*, Part *IIIA*, 1952, p. 643.

[4] Attew, J. E. "A Frame Sync Separator," *Electronic Engineering*, February 1955, pp. 70–71.

[5] Haantjes, J. and Kerkhof, F. "Deflection Circuits," *Proc. I.R.E.*, 36, March 1948, p. 407.

[6] Jaegar, J. C. "Introduction to the Laplace Transformation with Engineering Applications," mimeographed copy reproduced by C.S.I.R. Melbourne, 1946, p. 24.

[7] *ibid*, p. 26.

APPENDIX

TWO numerical analyses will be made, one for the line pulses and the other for the frame pulses. In each analysis, a particular set of initial conditions will be assumed for a particular instant in the cycle; this set will then be shown to be repeated at an instant one period later.

For the line pulses, imagine that just previous to a line pulse the current i in the inductance (Fig. 3) has reached the steady value I (formula 1). During the line pulse, the switch (Fig. 3) is held open for 10 μsec and the charges in the capacitances C_1 and C_2 will drive a current into the inductance given by the familiar oscillatory equation

$$i = I \cos \omega_1 t \quad .. \quad .. \quad .. \quad .. \quad (2)$$

where ω_1 is the resonant angular frequency of L in shunt with the parallel combination of C_1 and C_2 and I = 5.43 mA. The period T_1, $\left(= \frac{\omega_1}{2\pi}\right)$ is 83 μsec. Thus, although the current in the inductance is reduced, by the end of the 10-μsec line pulse it is not zero and consequently current still flows in the same direction in the diode (Fig. 3). Therefore, the potential at B must remain at h.t., held there by the diode action. The potential at A during this time is given by

$$\begin{aligned} v_A &= v_B + \text{voltage of A relative to B} \\ &= V_{h.t.} - L\frac{di}{dt} \\ &= V_{h.t.} + \omega_1 LI \sin \omega_1 t \quad .. \quad .. \quad (3) \end{aligned}$$

From (3), v_A is elevated 12 volts above h.t. at the instant at the end of the line pulse. After the pulse is over, the switch is again closed. A representation of this part of the cycle may be obtained from Fig. 10, which shows the equivalent circuit. At $t = 0-$ (i.e., *just* before the switch is closed), a charge equivalent to 12 volts is maintained by the capacitances C_1 and C_2. At $t = 0$, however, a voltage step of − 80 volts is applied suddenly at point D. If e is the Laplace Transform of the voltage between

‡ Values of certain pass inductances exceeded twice nominal.

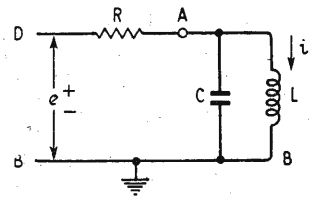


Fig. 10. Equivalent circuit for Fig 3 when the diode is conducting. Here C = $C_1 + C_2$ = 1800 pF (from Fig. 3), while L = 100 mH and R = 14.7 kΩ.

B and D, and i is the transform of the current in the inductance, then it is easy to show[6] that

$$i = \frac{e}{p^2LCR + pL + R}$$

Mathematically, the initial 12 volts can easily be accounted for by the following device. Consider that for all time 12 volts is applied between B and D but that a step of − 92 volts is applied suddenly superimposed at $t = 0$. Then, for $t>0$, the − 92 volts and the steady + 12 volts add to produce the same effect as applying the − 80 volts step, while, for $t<0$, the effect is that produced by +12 volts alone. Thus the current in the inductance is given by

$$i = \frac{92}{p[p^2LCR + pL + R]} - \frac{12}{pR} \quad .. \quad (4)$$

the first main term being the contribution from the − 92 volts step, while the second term is the contribution from the steady + 12 volts. The inversion of (4) is readily performed using standard Laplace Transform techniques,[7] whence

$$i = \frac{92}{R} + \frac{92}{R}\left[\frac{\sin t\sqrt{\frac{1}{LC} - \frac{1}{4C^2R^2}}}{\sqrt{4\frac{CR^2}{L} - 1}} + \cos t\sqrt{\frac{1}{LC} - \frac{1}{4C^2R^2}}\right] \exp - \frac{t}{2CR} - \frac{12}{R} \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (5)$$

where t is in microseconds from the closing of the switch and i is in milliamps. Because of the heavy damping, the transient terms in (5) decay extremely rapidly. For example, after 90 μsec (the time for the line scan) the net current is 5.43 + 0.023 = 5.47 mA, where the value 0.023 is the contribution from transient terms. Thus, the initial conditions assumed one period ago have substantially been repeated and the reasoning has completed a full circle.

On even frames, a conduction pulse of 90-μsec duration precedes each train of frame pulses. On odd frames, however, the corresponding conduction pulse is only 40 μsec, and the inductive current immediately before the frame signal is obtained by substituting $t = 40$ in (5). This gives i = 5.35 mA. Now, the current in the inductance immediately before the frame pulses can be regarded as proportional to the height of the first frame pulse. Therefore, the slight variation of this current (5.47 and 5.35 mA) ought to produce a corresponding variation in the magnitude of the frame pulse. Such variation was indeed observed but the small amount of this effect (2.5% computed) would probably not affect the quality of interlace. This variation could be reduced still further by using a valve with a lower anode resistance (Fig. 2).

For the frame pulses, at an instant in the middle of a frame pulse (Fig. 5) assume the following.

(1) The current in the inductance is zero.

(2) The potential at A is elevated 8 volts above h.t.

(3) The potential at B is still at h.t., but the diode current is zero.

The voltage difference across the inductance is only

(*Continued on page 87*)

maintained by the charge in C_2. Because the potential of A (Fig. 3) is fixed by the charge in C_1, the potential of B, or v_B, will increase rapidly as part of an oscillation whose period T_2 is governed only by L and C_2. Here $T_2 = 37$ μsec. Thus, if time t is measured in microseconds from the commencement of the frame pulse

$$v_B = (v_{h.t.} + 8) - \cos\frac{2\pi}{T_2}\left[t - 20\right] \quad .. \quad (6)$$

where the first main term is the voltage at A and the second term is the voltage of B relative to A.

In a low-loss oscillatory LC circuit, the peak kinetic energy in the inductance very nearly equals the peak potential energy stored in the capacitance; i.e., $\frac{1}{2}LI_1^2 = \frac{1}{2}C_2V^2$ where V is the peak voltage across the capacitance and I_1 is the peak current in the inductance. Thus, the peak current which will flow into the inductance is given by $I_1 = 8\sqrt{\frac{L}{C_2}} = 0.436$ mA, and therefore the current in the inductance is given by

$$i = -I_1\sin\frac{2\pi}{T_2}\left[t - 20\right]$$

$$= -0.436\sin\frac{2\pi}{37}\left[t - 20\right] \quad .. \quad .. \quad (7)$$

From (6), it is clear that v_B can complete rather more than half of the cycle at T_2 in the 20 μsec remaining in the frame pulse; and at the end of this ($t = 40$), B will be elevated about 16 volts above h.t.; while, from (7) the inductive current will be approximately zero.

During the 10 μsec of the next conduction period, the switch is closed. Because there is no diode conduction, the potential of A can fall exponentially:

$$v_A = 88\exp -\left[\frac{t - 40}{T_3}\right] .. \quad .. \quad .. \quad (8)$$

where T_3 is the time-constant formed by R and C_2 and has the value of 22 μsec. During this time also

$$v_B = v_A + \text{voltage of B relative to A}$$

$$= 88\exp -\left[\frac{t - 40}{22}\right] +$$

$$8\left[1 - \cos\frac{2\pi}{37}[t - 20]\right] \quad .. \quad .. \quad (9)$$

The instant that $v_B = V_{h.t.}$, the diode again conducts and the mode of operation changes. From (9) this instant occurs at $t = 45$; i.e., 5 μsec after the start of the conduction period; while from (7) the corresponding inductive current is + 0.373 mA. Also at this instant

$$v_A = 88\exp -\left[\frac{45 - 40}{22}\right] = 70 \text{ volts} \quad .. \quad (10)$$

In the 5 μsec remaining in the conduction pulse the diode is closed, and consequently the inductive current will be given by formula (5), though with the initial constants appropriately altered:

$$i = 5.45 - \frac{70}{14.7}\left[0.265\sin 0.716\,(t - 45) + \cos 0.716\,(t - 45)\right]\exp\left[-0.0198\,(t - 45)\right]$$

At the end of the conduction period ($t = 50$)

$$i = 5.45 - 4.76[0.265\sin 16.35^\circ + \cos 16.35^\circ]\times \exp(-0.0794)$$

$$= 1.03 \text{ mA}$$

In the next frame pulse, the switch is again opened. The current in the inductance and the voltage at A are respectively given by (2) and (3) with I reduced to 1.03 mA.

Thus $i = 1.03\cos\frac{2\pi}{83}(t - 50)$

and

$$v_A = V_{h.t.} + \frac{2\pi}{83}L1.03\sin\frac{2\pi}{83}(t - 50) \times 10^{-3} \quad .. \quad (11)$$

where t is once again measured from the beginning of the previous frame pulse and L = 100 mH.

At $t = 70$, from (11) $i \simeq 0$ and $v_A = 88$ volts. These conditions obtain at the middle of the frame pulse and therefore the reasoning has completed the full circle correctly.

During the train of frame pulses, it has been shown that the current in the inductance immediately before a frame pulse is 1.03 mA, whereas the corresponding current immediately before the first frame pulse is of the order of 5.4 mA. Thus, the first frame pulse should exceed its fellows by a factor of 5.4. This in fact seems to be supported experimentally and closely follows the ratio derived by energy considerations alone in the main text.

BOOKS RECEIVED

Mathematics for Electronics with Applications by H. M. Nodelman and F. W. Smith. The mathematical processes useful in electronic engineering are discussed in theory and their application to specific problems is illustrated. Sections are devoted to the use of dimensions in checking formulæ, the solution of networks by determinants and matrices, the applications of series in non-linear circuits (e.g., intermodulation testing), methods of transient analysis. and the use of Boolean algebra in the analysis of switching circuits. Pp. 391; Figs. 131. Price 52s 6d. McGraw Hill Publishing Co., Ltd., 95, Farringdon Street, London, E.C.4.

The Application of Phase-coherent Detection and Correlation Methods to Room Acoustics: B.B.C. Engineering Division Monograph No. 9 by C. L. S. Gilford, M.Sc., F.Inst.P., A.M.I.E.E. and M. W. Greenway, M.Sc. (Eng.), D.I.C., A.C.G.I., Grad.I.E.E. Describes modifications of the pulsed gliding tone technique of displaying the transient response of rooms, designed to reveal more clearly the "singularities" responsible for coloration of the sound. Pp. 14; Figs. 14. Price 5s. B.B.C. Publications, 35, Marylebone High Street, London, W.1.

The Gramophone Handbook by Percy Wilson, M.A. Guide to the choice, installation and maintenance of equipment for the reproduction of gramophone records, with chapters on the care of discs and an introduction to tape recording and reproduction. Pp. 227; Figs. 56. Price 15s. Methuen and Co., Ltd., 36, Essex Street, London, W.C.2.

Television Explained by W. E. Miller, M.A., M.Brit.I.R.E. Sixth edition, revised by E. A. W. Spreadbury, M.Brit.I.R.E., of a guide to the functioning of the component parts of the modern television receiver, together with a chapter on installation and initial adjustment. Pp. 184; Figs. 87. Price 12s 6d. Iliffe and Sons Ltd., Dorset House, Stamford Street, London, S.E.1.

The Morse Code for Radio Amateurs by Margaret Mills. Advice on learning the code together with a graded series of exercises designed to give fluency up to a speed of 12 words per minute or more, and a glossary of amateur abbreviations. Pp. 18. Price 1s. Radio Society of Great Britain, New Ruskin House. Little Russell Street, London, W.C.1.

Wideband V.H.F. Convertor

PREPARING FOR THE INTERNATIONAL GEOPHYSICAL YEAR

By G. P. ANDERSON, A.M.I.E.E.*

As readers of *Wireless World* are aware, we are approaching a maximum in the 11-year cycle of sunspot numbers, and present indications are that this maximum is going to be higher than ever previously recorded, at least during the time that it has been possible to correlate activity on the sun with its effect on radio propagation on the earth. To the average enthusiast, the most interesting and easily observable effects are to be found on the frequencies ranging from 20 to 60 Mc/s or thereabouts, and this article describes apparatus that will enable the reader to extend the tuning range of a shortwave receiver to include this band.

During the last period of "sunspot maximum", signals from all over the world were being heard on frequencies up to about 50 Mc/s; many trans-Atlantic contacts were made by amateurs on frequencies of the order of 50 Mc/s, but attempts on frequencies only a few megacycles higher (56 Mc/s) did not meet with the same success. During last winter American signals were being heard regularly on frequencies up to 36 Mc/s, and sometimes higher, with very simple indoor aerials, and, of course, the 28-Mc/s amateur band was open to the world almost daily.

Apart from possible ionospheric paths, a fair indication of tropospheric propagation conditions on v.h.f. can be obtained by monitoring the B.B.C. television channels, and a French TV station on about 41 Mc/s will serve as a useful sign that the 145-Mc/s amateur band is open in that direction. Final plans for the International Geophysical Year have not yet been published, but it is possible that some interesting signals may be radiated on v.h.f. in connection with this event.

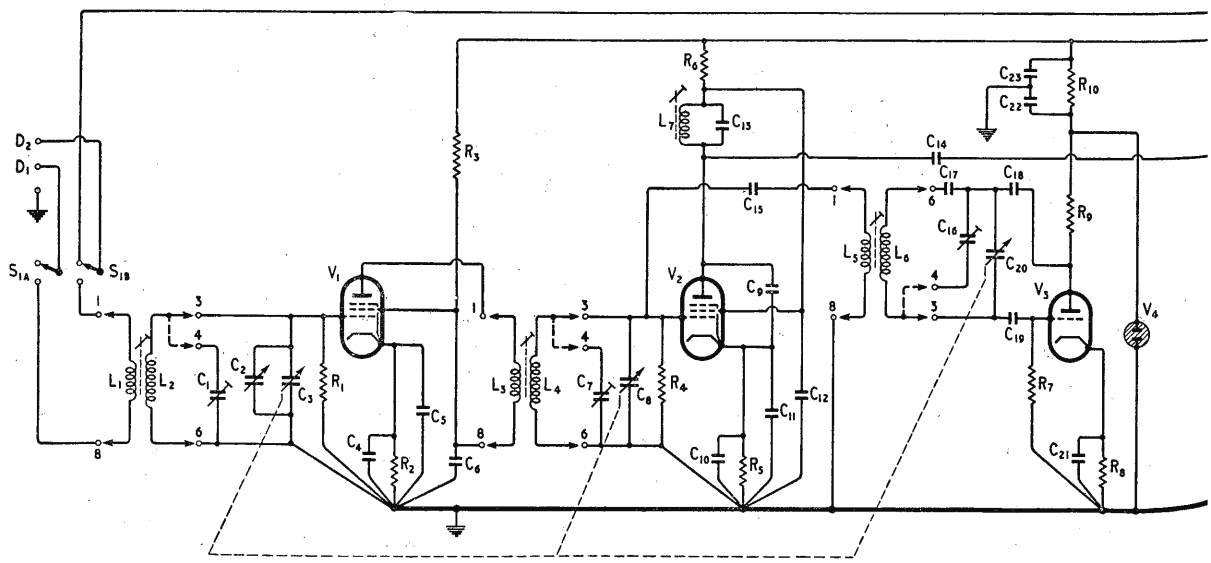
Design of V.H.F. Convertors.—Due to the strength of signals when propagation conditions are favourable, fairly simple apparatus is often quite satisfactory, and a t.r.f. or "straight" receiver using modern valves could be used. However, a superheterodyne convertor used in conjunction with a shortwave receiver, or a broadcast receiver with a shortwave range, will produce much more satisfactory results. Such a convertor changes the frequency of an incoming signal on, say, 50 Mc/s, to a lower frequency, that can conveniently be about 5 Mc/s, and this "converted" or "translated" signal is then passed to a receiver tuned to 5 Mc/s.

In order to include the frequencies likely to be of most interest, the tuning range of the convertor should extend up to at least 60 Mc/s; the lower limit can conveniently be arranged to overlap the upper frequency of the existing receiver, thus, in effect, extending its tuning range. Although it is possible to use a switched system of coil changing, the writer preferred to use plug-in coils to minimize switching and other losses.

The simplest method of changing the frequency

* Amateur Radio Station G2QY.

Fig. 1. Theoretical circuit of the 5-valve convertor. The power supply is built on the same chassis.

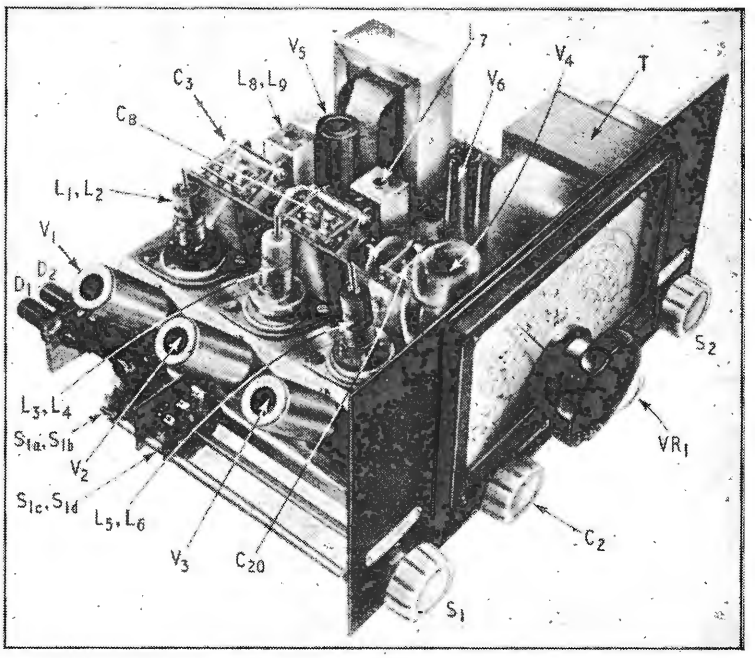


of the incoming signal is by means of a single valve of the heptode, triode-hexode, or similar type, in which one part of the valve serves as an oscillator and the voltage produced is injected into the electron stream of the other section, which functions as a mixer. Whilst such a unit is perfectly capable of giving a good performance, it suffers from the severe drawback that a strong signal is radiated from the oscillator. This may fall in the television bands and cause interference on local TV sets.

We can minimize this trouble, and at the same time obtain a useful improvement in performance, by inserting an r.f. amplifier between the aerial and the mixer; still further isolation of the oscillator voltages may be obtained by using separate valves for the oscillator and the mixer, and using loose coupling between them for ocsillator voltage injection. A further refinement is a stage of amplification at the translated frequency, thereby isolating the mixer from the effects of any changes in the main receiver, as well as giving some additional amplification. For convenience of operation all stages should be ganged, and it is useful to have an aerial trimmer and a gain control available on the front panel of the convertor.

The unit shown incorporates the features dis-

This view of the 5-valve convertor shows the inclined valves, plug-in coils, tuning capacitors and other recognizable components.



LIST OF COMPONENTS

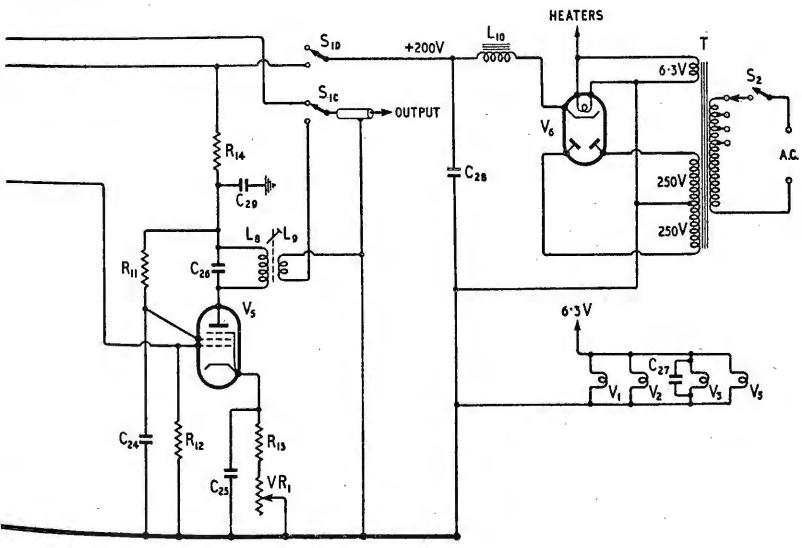
Capacitors

C_1, C_7, C_{16}	20 pF trimmer
C_2	10 pF variable
C_3, C_8, C_{20}	50 pF variable
C_4, C_6, C_{10}, C_{17}, C_{21}, C_{22}, C_{23}	470 pF
C_5, C_{11}, C_{12}, C_{24}, C_{25}, C_{27}, C_{29}	1000 pF (Hi-k)
C_9	10 pF
C_{13}, C_{18}, C_{26}	100 pF
C_{14}, C_{19}	47 pF
C_{15}	4.7 pF
C_{28}	16 μF, 350V, wkg. electrolytic.

(Unless otherwise specified, capacitors can be silvered-mica or ceramic.)

Resistors

R_1, R_4	4.7 MΩ ¼W
R_2, R_{13}	270 Ω ¼W
R_3, R_6, R_{14}	4.7 kΩ ½W
R_5	6.8 kΩ ½W
R_7	22 kΩ ¼W
R_8	100 Ω ¼W
R_9	10 kΩ ½W
R_{10}	8 kΩ 1W (see text)
R_{11}	1 kΩ ¼W
R_{12}	470 kΩ ¼W



VR_1	10 kΩ 1W, variable
V_1, V_2, V_5	6AK5
V_3	6C4
V_4	VR105/30
V_6	6X4
S_1	4-pole 2-way Yaxley-type switch
S_2	Mains "on-off" switch
L_1–L_6	See Table 1
L_7	50 turns No. 32 s.w.g.
L_8	50 turns No. 32 s.w.g.
L_9	10 turns, ditto.

(L_9 is wound over "earthy" end of L_8.) Insulation, enamel.

L_7, L_8 and L_9 *wound on* 0.3*in diam formers, Neosid Type* 5000/6*E; dust iron core Drg* 500; *top plate Drg* 5001. *John Dale Screening Can Type DTV*2.

L_{10}	20 H 40 mA choke
T	250-0-250V, 40 mA; 6.3V, 1.3A.

Chassis
7¾in x 7¾in x 1½in deep.
Panel
10in x 5¾in deep.

cussed here, and includes simple voltage stabilization of the h.t. supply to the local oscillator. The power supply for the convertor is included in the unit. Plug-in coils are used, the range from 15 to 85 Mc/s being covered with four sets of three coils. The tuning capacitors are ganged and an aerial trimming control is provided on the front panel to compensate for the loading effect of different aerials. The trimmer also simplifies the "tracking" problem in a three-circuit tuner of this type. The other controls are: i.f. gain; convertor in/out switch, for changing the aerial over to the main receiver, and a mains on/off switch.

The circuit is shown in Fig. 1, and it will be seen that 6AK5 valves are used for the r.f. amplifier, mixer and i.f. pre-amplifier. A 6C4 valve serves for the oscillator. The h.t. voltage to the latter is stabilized by a VR105/30, the value of R_{10} depending on the voltage of the h.t. line. The value shown is suitable for an h.t. voltage of about 200. The circuit is fairly orthodox, but the need for R_1 and R_4 may not at first be apparent; they provide a d.c. path to earth for the grids of their respective valves when the coils are removed for changing the range. The capacitor C_9 across the mixer valve was not found to be necessary in the model shown, but from experience the writer has had with other v.h.f. convertors, it may be needed to prevent oscillation at the mixer output frequency. The power consumption of the convertor is 1.3A, at 6.3V, and 40 mA at 200V.

The main points to watch when constructing apparatus for the higher frequencies have frequently been stressed; summarized they amount to this; keep all leads short and the wiring rigid. The convertor shown is constructed with the valves inclined relative to the rest of the chassis in order to facilitate short wiring. A copper chassis should be used and the earth returns of each stage brought to one point, as indicated in the circuit diagram. Separate tuning capacitors are used and mechanically coupled, but electrically insulated from each other. Both sides of C_{20} are "live" to r.f. and consequently this capacitor must be insulated from the chassis. It is advisable to wire the heaters with screened lead, bonded at intervals to the chassis, and unless the lead connecting the convertor to the main receiver is reasonably short, it also should be screened. A good slow-motion dial is desirable, although a certain amount of fine tuning can be carried out on the main set.

The coils are wound on $\frac{1}{2}$-in diameter formers, provided with $\frac{3}{8}$-in dust cores for adjustment of inductance. The particular type specified in the schedule is made of polystyrene, and use may be made of the low softening temperature of this material to secure the turns of wire during the winding process. The writer found it convenient, after soldering one end of the wire in Pin 3, to bend it at right angles just above the flange of the former (see Fig. 2), and to hold the wire so that it is resting against the body of the former. If now the wire is heated by carefully applying a soldering iron to it at a point near to the body of the former as shown, it will be found that after a very short time the wire begins to sink into the polystyrene. The iron should now be removed, and the wire and former held in position for a few seconds to allow the polystyrene to harden. Winding the coil may then proceed, keeping the wire taut, separating the turns, and, if felt necessary, repeating the heating process at intervals. After the required number of turns has been put on, the last turn should be secured in the same way as the first and the end inserted into Pin 6 and soldered. The other winding may be added in the same way, and to complete the coil a coating of polystyrene varnish should be applied, which will effectively "embalm" the windings, and prevent any risk of turns moving during handling. If formers of clear polystyrene are used they may be colour coded by applying a coat of paint to the inside of the former.

The coils used in the prototype unit plug into standard octal sockets, which may be colour coded to correspond to the appropriate coils. These sockets, like the valveholders, should be of high-grade ceramic or similar material, with good v.h.f. properties. Details of the windings are given in Table I, from which it will be seen that certain ranges are "padded" with extra capacitance in order to spread the tuning over the more populated frequencies; with one exception these capacitors are fitted in the wiring of the convertor (at C_1, C_7 and C_{16}) and are brought into circuit by joining tags 3 and 4 of the appropriate coils. It may also be observed that Band B includes both the 21- and the 28-Mc/s amateur bands.

Provided the layout and coil data are followed fairly closely, no difficulty should be encountered in aligning the convertor to provide an output signal for a set tuned to 5 Mc/s. The first step is to adjust the i.f. pre-amplifier to this frequency, and this may be done by setting "i.f. gain" to maximum (with the convertor switched on and connected to the receiver), and adjusting the dust cores in L_7, L_8 and L_9 for maximum "noise" in the loudspeaker. The ranges covered by the oscillator may then be set using a signal generator or a grid-dip oscillator, and remembering to adjust the inductance at the low frequency end of each range, and the capacitance trimmer at the high frequency end, if necessary. In the prototype unit one value of capacitance served for most ranges, but due to differences in wiring it may be necessary to use different values for each range, in which case the capacitors could be mounted on each coil; this was done in the case

TABLE I. COIL WINDING DETAILS

Range	Coverage	L_1 Turns	L_2 Turns	L_3 Turns	L_4 Turns	L_5 Turns	L_6 Turns	Notes
A	15–22 Mc/s	2	8¼	4	8¼	2	7½	Pins 3 and 4 joined.
B	21–30 Mc/s	1	5¼	2	5¼	2	4½	Pins 3 and 4 joined.
C	30–53 Mc/s	1	2⅔	2	4⅓	2	3	L_6 has 13pF across it.
D	40–85 Mc/s	1	3	2	3⅓	2	3½	

All are wound with 22 s.w.g. tinned copper wire, on ¼-in diam slug-tuned formers (Denco Maxi-Q, 6-pin octal based). Enamelled wire may be used if preferred. Turns are spaced by the diameter of the wire.
Individual pairs of coils for each range (i.e. L_1 and L_2; L_3 and L_4; L_5 and L_6) are wound on the same former, end to end with about $\frac{1}{16}$in spacing between them.

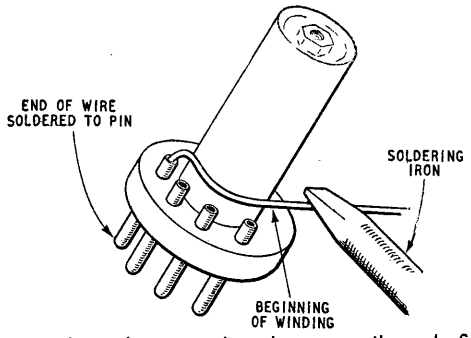


Fig. 2. The end turns on the polystyrene coils can be fixed in position by applying a hot soldering iron as shown here.

of L_6 (Range C), where an additional 13 pF was needed. The value of the padder capacitor C_{17} appears to be a good compromise and gives satisfactory tracking over all bands. However, some experiments may be useful in individual cases to obtain optimum results.

Having adjusted the oscillator range, the signal frequency circuits may be aligned, again adjusting the inductors for maximum signal near the low frequency end of each range, and the capacitors at the h.f. end. (This subject has been dealt with thoroughly in a number of publications and the reader is referred to them if he should require further information.)

Switch S_1 enables the convertor to be put in or out of circuit without having to manually change-over plugs, and in the "out" position the aerial is connected to the main receiver, and the convertor is disconnected.

Aerials.—The unit may be used with more or less any length of wire as an aerial, and if a single "long wire" aerial is used, it should be connected to terminal D_2 of the convertor, D_1 being strapped over to the earth terminal E. Care should be taken to make these connections correctly, so that the aerial is connected to the output socket when S_1 is set to "out."

On the higher frequencies, however, greatly improved results can be obtained by using resonant aerials; that is, aerials the lengths of which are chosen to tune to the particular frequencies in which one is interested. A convenient length consists of a half-wavelength of wire, that is, one 5 metres long for reception on 10 metres, and although such an aerial connected as described for a "long wire" will give good results, its efficiency is severely limited by the fact that, being only a short length of wire, most of it will be screened by being inside a room. It is preferable, therefore, to place the half-wavelength of wire as high and as clear of buildings as possible, and connect it to the receiver by a transmission line, that will convey signals from the aerial with little loss, and at the same time pick up minimum signal itself, thus reducing the effects of man-made static. Much information has been published on aerial design, but for the purpose of this article it will be sufficient to give the formula for determining the length of a half-wave aerial; this is

$$l\ (\text{feet}) = \frac{462}{f\ (\text{Mc/s})}$$

If the wire is cut at the centre and an insulator inserted to separate the two halves, and a length of suitable feeder used to connect it to the receiver, it can be erected well away from the house. Balanced feeder of the correct characteristic impedance of 75 or 80 ohms is available, but an alternative may be made from electric light "flex," preferably plastic insulated, which has approximately the same impedance. It is, however, more "lossy," and is liable to be even more so in damp weather. In either case the ends of the two conductors forming the feeder should be connected to D_1 and D_2, the strap from D_1 to E not being required; terminal E may be connected to earth. Coaxial feeder of the type used for connecting TV aerials and receivers would be satisfactory also, the centre conductor being connected to D_2, and the sheath to D_1.

The half-wave aerial favours reception of signals from directions at right angles to its length, and this factor can be made use of if reception is required mainly from a particular direction; but for general (or omni-directional) coverage the aerial may be erected in a vertical position. As a half-wavelength at 28 Mc/s is about 16 ft and at 50 Mc/s only about 9 ft it is quite a practical proposition to erect such an aerial. The design of more elaborate aerials and arrays is beyond the scope of this article, and in any case such aerials are unnecessary for the listener who only wants to hear "what's going on" on the very high frequencies.

CLUB NEWS

Birmingham.—A demonstration of high-quality sound reproduction will be given to members of the Slade Radio Society by a representative of Whiteley Electrical Radio Company on February 15th. At the first meeting in February (1st) G. A. Swinnerton (G6AS) will speak on operating in the DX bands. In addition to the fortnightly meetings held at 7.45 at Church House, High Street, Erdington, there are instructional and constructional classes every Tuesday and Wednesday evening, and the club station (G3JBN) is available every day for use by members. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Bradford.—The subjects to be covered by speakers at the meetings of the Bradford Amateur Radio Society on February 12th and 26th are, respectively, oscilloscopes (by G. F. Craven), and transformers (by P. Howarth). Meetings are held at 7.30 at Cambridge House, 66, Little Horton Lane. The fortnightly meetings are preceded by half-hour morse classes. Sec.: F. J. Davies (G3KSS), 39, Pullan Avenue, Eccleshill, Bradford, 2.

Bury.—The February meeting of the Bury Radio Society will be held at 8.0 on the 12th at the George Hotel, Kay Gardens, when H. A. Rothwell (G6QT) will demonstrate an all-transistor broadcast receiver. Sec.: L. Robinson, 56, Avondale Avenue, Bury.

Leicester.—Dekatrons and other counter tubes will be covered by M. H. Kind (G3GXZ) in his lecture to the Leicester Radio Society on February 11th at 140, Highcross Street. Sec.: J. Tranmer, 4, Grocot Road, Evington, Leicester.

Newbury.—J. H. Etheridge, of Cinema-Television, will speak about the flying-spot particle resolver at a meeting of the Newbury and District Amateur Radio Society on February 22nd. Meetings are held at 7.30 at Elliott's Canteen, West Street. Particulars are obtainable from 83, Newtown Road, Newbury.

Sidcup.—The next meeting of the Cray Valley Radio Club will be held at the Station Hotel, Sidcup, on January 22nd at 8.0. C. Usher (G2CCD) will give a talk entitled "Antennas for the amateur." Sec.: S. W. Coursey (G3JJC), 49, Dulverton Road, New Eltham, London, S.E.9.

Wellingborough.—On February 28th G. Abrams will address members of the Wellingborough and District Radio and Television Society on "Basic audio amplifiers." Arrangements are being made for a Mullard lecture and film on valve manufacture on the 21st. Meetings are held each Thursday at 7.30 at Silver Street Club Room. Sec.: P. E. B. Butler, 84, Wellingborough Road, Rushden.

NEGATIVE RESISTANCE

The Answers to Last Month's Questions

By "CATHODE RAY"

A FRENCH reviewer* has remarked that it is my custom to take supposedly simple things and show how obscure they are; and then, when the fog has become really dense, to wave a magic wand and clear it away. That may be all very well when the fog obeys, but last month it tended to thicken continuously, necessitating a postponement of the trick. In case you haven't meanwhile found your own way out or lost interest, the attempt will now be made, with apologies for any inconvenience.

The problem, you may remember, concerned negative resistance—as provided, for example, by dynatron or transistor—in circuit with positive resistance. Both kinds of resistance can be represented as voltage/current graphs. Fig. 1 shows the

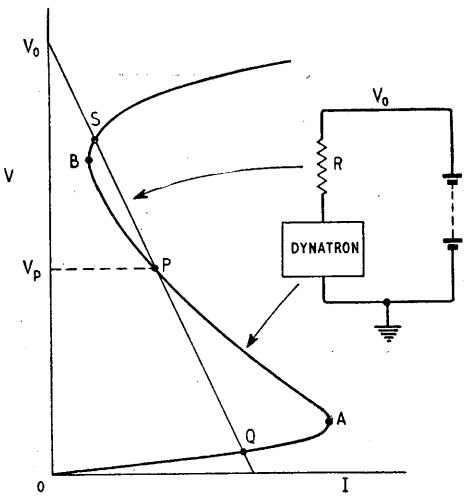


Fig. 1. Voltage/current graphs of the two resistive elements in the circuit shown. The curved line QAPBS represents, to the scales beginning at the normal origin O, the resistance of the dynatron, which is negative between A and B. The straight line V_0SPQ represents the wholly positive resistance R, to an inverted voltage scale beginning at V_0.

characteristic curve of a dynatron; between A and B its resistance is negative, indicated by the line sloping the "wrong" way—current *decreasing* with rise in voltage. The straight line represents the linear positive resistance R; and to see how the total voltage V_0 is shared between it and the dynatron we plot it to an inverted voltage scale, beginning at V_0 as its zero and increasing positively downwards. So the downward slope of this line indicates positive resistance all the way. The amount of resistance appears as steepness of slope. The only points on the diagram corresponding to equal current through both resistances are those which are common to both lines. With two positive resistances only one such point is possible, but a peculiarity of negative resistance is that the same total voltage can sometimes be divided between the two resistances in more than one way, with different currents; for example, P, Q and S in Fig. 1.

We found by experiment that we could set the circuit to point P by tying down the junction between positive and negative resistances to a tapping V_p on the voltage source, but that this point was unstable, because immediately the tapping was disconnected the voltage flipped to Q or S and stayed there. If, however, R was lower, as in Fig. 2, only one situation was possible.

Again by experiment we found that the negative resistance provided by a point-contact transistor with common base bias has a different kind of V/I curve, as in Fig. 3; but that in spite of the fact that at and near P the relative slopes of the positive and negative resistance are the same as in Fig. 2, this circuit turns out to be unstable and flips to Q or S just like Fig. 1. So our theory, based on Figs. 1 and 2, that the circuit is unstable when R is greater than the negative resistance and stable when it is less, broke down, and we were faced with Thomas Roddam's poser—how can the circuit, set to P, know whether it is stable or unstable without going to see which way the negative resistance bends? And how can it do that if it is stable? And how can it do it anyway, seeing that it can't move from P without there being more than one current or voltage in the same place at the same time, which is impossible?

We had been given a possible clue to the last of these questions by Mr. Roddam, when he pointed out that no real circuit is free from reactance. In practice

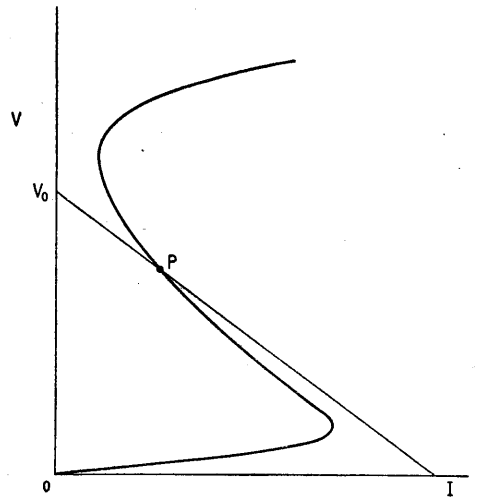


Fig. 2. As Fig. 1, except that R is less than the negative resistance of the dynatron.

*F.A. *Toute La Radio*, November 1955. p. 391.

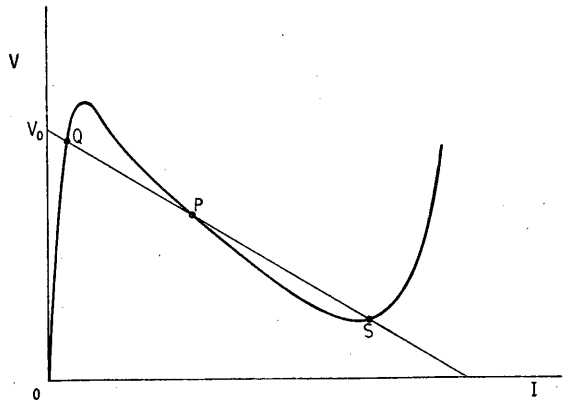


Fig. 3. Here the curved line represents the input resistance of a transistor circuit (Fig. 6).

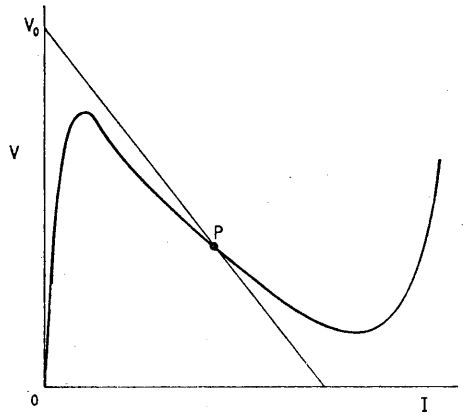


Fig. 4. As Fig. 3, except that R is greater than the negative input resistance of the transistor circuit.

there is always some stray capacitance across the dynatron in Fig. 1, and the current from this as its voltage changes between P and S or Q is in the right direction to bridge the current gap between the two lines during this change, and the amount of current required controls the speed of the change. We demonstrated this by making the capacitance large, slowing the process down so much that we could easily follow it on milliammeters.

That particular problem seemed to have been disposed of very neatly until we applied it to the transistor circuit. Because the two lines above and below P in Fig. 3 are on opposite sides of one another as compared with Fig. 1, the capacitance current is only in the right direction to bridge the gap between the two lines when the voltage is moving *towards* P, which therefore ought to be a stable point. But experiment showed that even with as much as 300μF across the transistor it was most definitely unstable!

Meanwhile we had got no nearer the answer to Roddam's question; and our shunt capacitance theory, demonstrable though it was in connection with Fig. 1, led us into the most frightful dilemma with Fig. 4, which illustrates the transistor in series with a high resistance and shunted by a capacitance. Near P it is identical with Fig. 1, so presumably the slightest displacement causes capacitance current that displaces it more, and so on, just as happened with the dynatron; but the current gap, instead of closing up at Q or S, widens continuously, causing the capacitance voltage to change faster and faster; but the negative resistance characteristic makes that impossible, for the voltage change actually reverses! We tried it, and found that the current and voltage oscillate continuously to and fro between the bends. But how does it manage to get into reverse there, contrary to our current-gap theory? And how is P in Fig. 4 unstable in spite of there being only one intersection, as in the stable Fig. 2?

Two Kinds of Resistance

It was with all these awkward questions unanswered that I was callous enough to leave you last time. In the meanwhile I have thought up some answers, which I hope will have been worth waiting for.

It is difficult to know where to start, but first of all let us tackle the question why P in Fig. 2 represents a stable condition whereas in Fig. 3—which in the region of P is absolutely the same—it is unstable. That was the original Roddam problem.

Because diagrams of various kinds are such valuable mental aids, there is a danger of relying on them too completely, overlooking their limitations. Our ideas (if you will pardon my assuming that you, too, were taken in) last month were heavily based on voltage/current graphs, in which negative resistance appears as a slope downward from left to right. From this point of view there is no difference whatsoever between a portion of negative-resistance characteristic plotted from a dynatron and one from a transistor, provided their slopes are both the same. Yet they behave quite differently in practice. Since negative resistance is a particular relationship between current and voltage, and it is that relationship which is expressed by the graph, can two identical pieces of graph possibly represent different kinds of negative resistance?

The difficulty in seeing a difference between two resistances that appear identical may perhaps be that we are too much under the spell of Ohm's law. If we increase the e.m.f. applied to a 500-ohm resistor by 10 volts we know that the current through it will rise by 20 milliamps. We also know that if we increase the current through it by 20 milliamps the p.d. across it will rise by 10 volts. Cause and effect are interchangeable. It is the same with pressure and rate of water flow through a pipe. But if a fireman uses the water to knock a man down, cause and effect are not interchangeable. A man falling down doesn't necessarily cause water to gush out of a hose. And because the relationship between current and voltage in a valve or transistor can be graphed in the same way as for a resistor, it does not entitle us to assume that the same reversible cause-and-effect holds good. We have already seen that although the passing of I_p milliamps through the device illustrated in Fig. 5 necessarily causes the p.d. across it to be V_p volts, applying V_p volts to it doesn't necessarily drive I_p milliamps through it. It might be I_q. Or I_s. In this case it is only by regarding current as the cause and voltage the effect that we can get an unambiguous result. This kind of negative resistance is therefore called current-controlled. Conversely, the dynatron is a voltage-controlled negative resistance.

The persistent inquirer will object that distinguishing them by these names doesn't properly

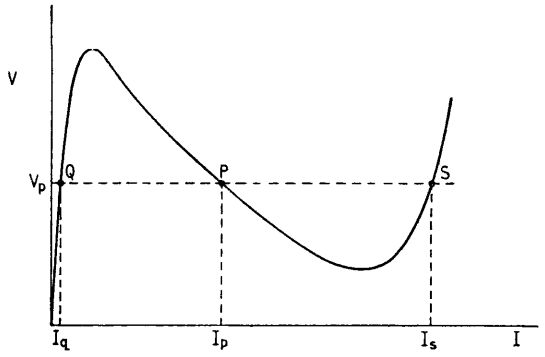


Fig. 5. This is the characteristic curve of a current-controlled negative resistance, because the value of current definitely decides the potential drop, whereas the reverse is not true.

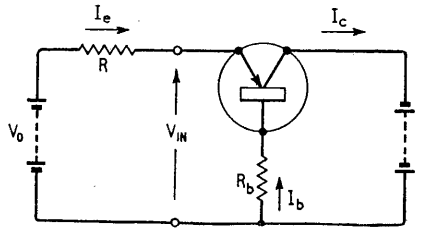


Fig. 6. Diagram of transistor circuit used to experiment with current-controlled negative resistance.

answer the question, for in order to name them we had to take a look at the bends in the curve, whereas the actual circuit appears to know the difference while it is still on the straight near P. So we shall have to go into the matter more closely.

Treating the transistor characteristic in Figs. 3 and 4 in the same way as for ordinary resistance, we would conclude that raising the input current from point P was bound to make the voltage fall, and reducing the voltage was bound to make the current rise. But let us look at the circuit represented by this graph: Fig. 6. Here, I_e and V_{in} are the current and voltage defining the transistor input resistance. Suppose we raise the input current I_e, either by raising an already large V_o through an R sufficiently large for any changes in the potential of the emitter to have only minor influence on I_e, or by reducing R. These alternative procedures are represented in Fig. 4 by raising V_o, keeping the slope of the R line the same, or by decreasing the slope of the R line, keeping V_o the same. In either case, the diagram shows that P is shifted downwards, indicating the rise in current we aimed at, and also a fall in voltage. The same result can be predicted from Fig. 6 by a knowledge of point-contact transistor action. The rise in I_e, which, without I_c, would cause the voltage drop across R_b to increase, so increasing V_{in}, actually causes a bigger rise in I_c, which passes through R_b the opposite way, so the net result is a fall in V_{in}. The circuit behaves as the graph predicts.

Now let us reduce V_{in} directly, by reducing V_o through a comparatively low R as in Fig. 3. Fig. 3 predicts a resulting rise in I_e. And so it would be if cause and effect were reversible, as with ordinary resistances. But let us consider it with Fig. 6. The first effect of a small reduction in V_{in} is to reduce the voltage available for driving current from emitter to base. So I_e falls. That immediately causes a bigger fall in I_c, which makes the base less *negative*; that is, the base potential rises to meet the falling emitter potential, further reducing I_e. So the slightest reduction in V_{in} causes I_e to fall with a trigger action, the rate of cut-off being limited only by the time taken by the electrons and holes inside the transistor to do their stuff, as studied by us in the last September issue. The process is only saved from going on for ever by the top bend, where the transistor input resistance becomes positive and a stable position Q is taken up. If the trigger had been pulled in the other direction—as it can be now, by raising V_o until the hump above Q has been cleared—it flies to the alternative stable point S.

Effect Follows Cause

We see, then, that an actual transistor circuit reacts to a voltage change near P in exactly the opposite way to that predicted by the V/I diagram. This is because it is a current-controlled negative resistance, so is affected by the applied voltage change only in so far as that changes the input current, which in turn changes the input voltage in the opposite direction. But it can't work in the reverse order, any more than the man falling down can make water come out of the hose. It is true that if, when we lowered V_o, some playful demon had intervened for a microsecond or two, increasing I_e just in advance of us, our action would have sustained this result after the demonic influence had disappeared, for the increase in I_e would by then have made the base move considerably more negative than the emitter, so *increasing* the voltage between them and hence also I_e and I_c, in accordance with Fig. 3. Presumably also a shunt capacitance would then have acted always in such a way as to turn any excursions back towards P, so making it a point of stability. But science is based on the assumption that demons, if any, do not interchange cause and effect in this way; and Fig. 3 is invalid for control by voltage. Hence the complete and instant failure of every experiment I could devise to hold the circuit at P.

Incidentally, my fanciful closing remark last month (about my having to see this month's issue to get the answers) was really a rather subtle clue, because the only reason for its fancifulness was its reversal of cause and effect.

The problem of the gap between the two lines when moving from P to Q or S does not arise, because the extremely brief period of the journey is occupied by the internal electronic processes I mentioned, during which time the transistor has no static characteristic curve that one can draw on a V/I diagram.

In the same way it can be seen that because the negative resistance of a dynatron is voltage controlled it is unstable with a resistance *greater* than the negative slope, as at P in Fig. 1, whence there would be a flip to Q or S even if all shunt capacitance could be completely removed. The fact that the capacitance explanation is also true for this particular arrangement is just one of those awkward coincidences that make it so easy to confuse two different issues and draw fallacious conclusions. Fig. 1 is just Fig. 3 with current and voltage interchanged; it is,

(*Continued on page 95*)

in fact, the dual* of Fig. 3, and since the dual of shunt capacitance is series inductance we would expect series inductance to have the stabilizing influence we sought from shunt capacitance in the transistor circuit. The diagram with which we "proved" the stability of P in Fig. 3 also serves for inductance in Fig. 1 if dualized by interchanging current and voltage (Fig. 7), for the current-bridging effect of the changing voltage across the shunt capacitance becomes a voltage-bridging effect due to a changing rate of current through the series inductance. But, as with the transistor, this stabilizing effect is of academic interest only, for it is overridden by the impossibility of effect preceding cause.

In short, the answer to our original question (How does the circuit know whether it is unstable, as in Figs. 1 and 3, or stable, as in Figs. 2 and 4, without departure from P to see whether the negative resistance curve closes in to a Q and S or opens out?) is that a given negative slope around P in a V/I graph can represent either of two different kinds of negative resistance—current-controlled and voltage-controlled—and since this nature of the negative resistance in the actual circuit determines which is cause and which is effect, and effect is bound to follow cause, the stability or instability is determined. We have already studied Fig. 3 at length and seen why P is unstable. In Fig. 2, where the diagram at P is identical, the situation represented is nevertheless different, because a slight lowering of voltage is a direct cause in its own right, which increases the current, which admittedly drops somewhat further the voltage available for the valve and so extends the original action, but (with the relatively low positive resistance represented in Fig. 2) only to a limited degree. An infinitesimal displacement from P is sufficient for the nature of the negative resistance to be tested and for the circuit to flip or stay put as the case may be.

But what, you may ask, if a current-controlled negative resistance had a characteristic curve as in Fig. 2—or just continued negative all the way, without bends—and flipped madly on at goodness knows how many volts and milliamps per microsecond, trying in vain to find a stable point that did exist?

The continuous negative resistance can be ruled out for a start, because negative resistance is not a thing that can come from a passive component like a resistor; by its nature it delivers more power than it receives, and since there is no such thing as "perpetual motion" the power must come from somewhere, such as a battery, which of course is limited; and usually the device through which this power is administered—the valve or transistor—is even more limited, and sooner or later in both directions its resistance must revert to positive—hence the bends. The bends being granted, they must be such as to make possible more than one current at a given voltage, or more than one voltage for a given current, as in Fig. 2. If the former, voltage cannot be the controlling interest, else there would be no ambiguity; the negative resistance must be current-controlled. Vice versa for Fig. 2. So there is no fear of our nightmare coming true.

If you suppose that by this time the now celebrated Roddam question has been completely and satisfactorily answered from all possible angles and we can go home, may I remind you of two little things. The first is that although some of us jibbed at Roddam's own answer as being not entirely obvious to the dim-witted, we never questioned its correctness. His answer, if you remember, was based on the existence of circuit reactance. Now our following up of this clue was rather unfortunate, because it led us quite a long way up the garden, and it was only when we dismissed reactance altogether as the determining factor in the problem that we got somewhere. Was Roddam wrong, then? Or are we?

Oscillations or Flips?

It seems (I hope so, anyway) that we are both right as far as we go. The discrepancy is removed if we recognize two kinds of instability: the kind we have been considering, which we might call flip instability; and the kind Roddam was considering, which we might call oscillation instability. Our kind is the inability of a circuit with negative-resistance to stay at the middle point of three; for example, P in Figs. 1 and 3. The reason is the fact that effect comes after cause, not before; a fact that over-rides anything that reactance can do. The gap between the negative and positive resistance characteristic curves needs no filling, because during the flip the negative-resistance characteristic is in a state of flux and doesn't really exist as a static curve.

The second thing to recall is that in attempting to set the circuit an impossible and absurd task we stumbled across oscillation instability—with capacitance across the transistor and a high resistance in series, as represented by Fig. 4. (Incidentally, the same thing happens with a dynatron and low resistance (Fig. 2) if there is inductance in series—as the dualists among us would expect.) Theory seemed to indicate that the nightmare "irresistible-force-and-immovable-object" situation would take charge, the speed of flip increasing to infinity and even beyond. But the thing oscillated to and fro,

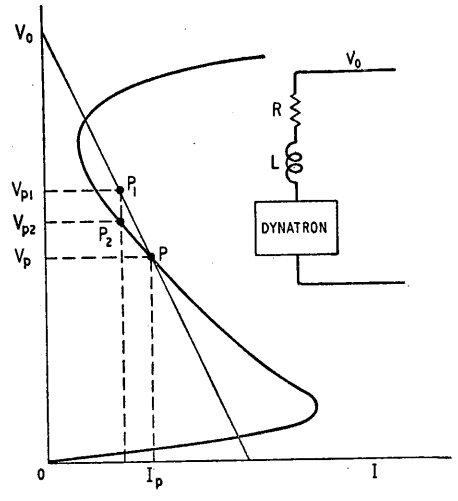


Fig. 7. A series inductance L makes possible a gap V_{p1}—V_{p2} between the voltages across dynatron and resistance R, provided that the current through all three circuit elements is changing in the direction away from P.

*Wireless World, April 1952; also *Second Thoughts on Radio Theory*, Chap. 35.

and we haven't yet found any explanation for the reversal at each bend.

When I put an oscilloscope across R_b in the transistor circuit it showed that the speed of flip was indeed very great. One could tell not only by the fact that during it the trace was as near vertical as one could see, indicating an immeasurably small time period, but this vertical trace was almost invisible, showing that the ray was moving at very high speed. However, the speed of current change could never actually reach infinity, for at least two reasons. The first is the already-mentioned finite speed of electronic action inside the transistor, which renders the negative-resistance curve invalid at very high rates of change. The second is that every circuit has some inductance, and however small it was it would set up an infinitely large voltage if the current changed infinitely fast. So the current from the shunt capacitance not only causes an increasing horizontal separation of the two working points P_1 and P_2 but also a vertical separation, representing the voltage of self-induction. One can therefore visualize the two points starting off side by side; then one rising above the other, overtaking it horizontally, and driving the other in the opposite direction, where it follows.

In a transistor circuit without added inductance, in which oscillation is of a sawtooth and pulse (or relaxation) type, my guess is that the electronic time delay is likely to be the larger influence. If inductance is added in series with the capacitance, one gets an acceptor circuit which is in effect a low-impedance dynamic load in parallel with R, swinging it round from the Fig. 4 position to the flip-unstable position (Fig. 3). But now it is not merely flip-unstable, for being a dynamic or oscillatory load the inductance reverses the motion smoothly at the end ot each half-cycle, and oscillation is more nearly sinusoidal.

The behaviour of the dynatron, with series inductance to convert the stable Fig. 4 into oscillation instability, is the dual of what I have just described. But the electronic action is much swifter in the dynatron, and the inductance is invariably shunted by at least some self-capacitance, making a rejector circuit, so my guess is that capacitance is here the main reversing influence. The effect of the high-impedance oscillatory circuit in series with the comparatively low R in Fig. 2 is to swing the load line up to the Fig. 1 position.

So in the end we find that, out of Figs. 1-4, 1 and 3 are the unstable ones, and 2 and 4 the stable. This is on the understanding that 2 and 4 do not have hidden about them enough reactance to bring the load line at some frequency or other into the 1 or 3 position.

If R in Figs. 1 and 3 is a simple positive resistance it is effective at all frequencies down to zero, and there is no reversing agent, so it just flips once to a stable point, Q or S. Supposing there could be no reactance at all the speed of slip would be governed entirely by the speed of electronic processes in the negative-resistance device. During this short period its characteristic curve would be changing in such a way as to eliminate any gap between itself and the resistance line. Reactance slows the flip by filling a current or voltage gap.

If R is the dynamic resistance of a resonant circuit it depends on frequency. The simplest sort, having one lumped inductance L and one capacitance C, in addition to inevitable resistance, is over-all resistive at only one frequency. If L and C are in series, the result is an acceptor circuit, which at resonance is a low resistance, and therefore likely to form an unstable combination with a current-controlled negative resistance. If indeed its resistance is lower than the negative resistance, continuous oscillation will take place at the frequency of resonance, for the interchange of current and voltage twice during each cycle causes reversal at the bends by a combination of the current-gap effect studied last month and the voltage-gap effect illustrated in Fig. 7. Because current is the thing common to both L and C in a series circuit, it is easy to remember (even apart from Fig. 3) that it is the appropriate kind for oscillation with current-controlled negative resistance.

Conversely, the parallel-resonant or rejector circuit, in which the same voltage is across both L and C, is the one for voltage-controlled negative resistance; it provides the high dynamic resistance which Fig. 1 shows is needed for instability. In spite of the appearance of Fig. 1, it is effectively in parallel with the negative-resistance device; the battery V_0 is there simply as bias, and at the frequency of oscillation can be regarded as a short-circuit.

The dynatron and the point transistor with base bias resistance are not much more than technical curiosities, which would hardly justify the time we have given to them. But they typify the much more used devices in which negative-resistance is created by positive feedback. So the same principles apply to all kinds of positive-feedback circuits, which would be quite something even if we didn't remember that most *negative* feedback is positive at some frequencies.

Chromium Nitride Resistors

RESISTORS of small dimensions and very high stability are sometimes required for special types of equipment, and investigations at the Battelle Institute in America[1] have shown that it is possible to meet these requirements with resistors constructed of films of chromium nitride (Cr-N), or of chromium-titanium nitride (Cr-Ti-N). Films of these materials are deposited on ceramic bases by the vacuum-evaporation method and resistors of up to several megohms can be made having temperature coefficients of resistance less than 0.01% per degree C.

Nitriding is carried out at temperatures ranging from about 950°C to 1250°C and the films so treated exhibit wide ranges of temperature coefficient and of resistance per square.[2] Under certain conditions the temperature coefficient changes from positive to negative and the investigations point to the possibility of producing a wide range of resistors with near-zero temperature coefficients. The stability is greatly improved by mounting the resistors in sealed glass containers.

[1] Reported in the (American) *Journal of the Electrochemical Society* Vol. 102, No. 2. February, 1955.

[2] The normal expression for resistance of a conductor is given by:—

$$R = \frac{\rho \times l}{t \times w}$$

where R = resistance in ohms, ρ = resistivity in ohm-cm, l = length, t = thickness and w = width in cm. Resistance of films of constant t and $l = w$ is known as "resistance per square."

FEBRUARY MEETINGS

LONDON

4th. I.E.E.—"The importance of research in hearing and seeing to the future of telecommunication engineering" by Dr. E. C. Cherry at 5.30 at Savoy Place, W.C.2.

8th. Television Society.—"Scatter propagation and its application to television" by Dr. J. A. Saxton (D.S.I.R. Radio Research Station) at 7.0 at 164 Shaftesbury Avenue, W.C.2.

12th. I.E.E.—"The ultimate performance of the single-trace high-speed oscillograph" and "The design and performance of a new single-transient oscillograph with very high writing speed" by M. E. Haine and M. W. Jervis at 5.30 at Savoy Place, W.C.2.

13th. Radar Association.—"Automation: computer-controlled machine tools for small quantity production" by D. T. N. Williamson (Ferranti) at 7.30 at the Anatomy Theatre, University College, Gower Street, W.C.1.

14th. British Kinematograph Society.—"Photo-electronic aids to photography" by Professor J. D. McGee at 7.15 at the Royal Society of Arts, John Adam Street, Adelphi, W.C.2.

15th. B.S.R.A.—"Some recent developments in amplifiers" by F. Langford-Smith at 7.15 at the Royal Society of Arts, John Adam Street, W.C.2.

15th. Institute of Navigation.—"Navigation and traffic control over the north Atlantic" by D. O. Fraser at 5.15 at the Royal Geographical Society, 1, Kensington Gore, S.W.7.

15th. Physical Society and Institute of Physics.—"Acoustics in non-destructive testing" by Dr. R. W. B. Stephens at 6.30 at 47 Belgrave Square, S.W.1.

20th. I.E.E.—"The Stereosonic recording and reproducing system" by H. A. M. Clark, Dr. G. F. Dutton and P. B. Vanderlyn at 5.30 at Northampton Polytechnic, St. John Street, E.C.1.

21st. Television Society.—"The design of oscilloscopes for television laboratory work" by O. H. Davie (Cossor) at 7.0 at 164 Shaftesbury Avenue, W.C.2.

26th. I.E.E.—Discussion on "The analysis of waveforms" opened by A. Cooper and D. A. Drew at 5.30 at Savoy Place, W.C.2.

27th. Brit. I.R.E.—"Some applications of nucleonics in medicine" by E. W. Pulsford and N. Veall at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

BELFAST

12th. I.E.E.—"Electronics and automation" by Dr. H. A. Thomas at 6.30 at the Engineering Department, Queens University.

BRISTOL

25th. I.E.E.—"Germanium and silicon power rectifiers" by T. H. Kinman, G. A. Carrick, R. G. Hibberd and A. J. Blundell at 6.0 at Electricity House, Colston Avenue.

27th. Institution of Production Engineers.—"Automation" by S. P. Woodley at 7 15 in the Small Lecture Theatre, University Engineering Laboratory, University Walk.

CAMBRIDGE

19th. I.E.E.—"Electronics and automation" by Dr. H. A. Thomas at 8.0 at Cavendish Laboratory, Free School Lane.

CARDIFF

20th. Brit. I.R.E.—"Radioactivity and its measurement" by E. W. Pulsford at 6.30 at the Cardiff College of Technology and Commerce, Cathays Park.

CHESTER

27th. Society of Instrument Technology.—"Computer-controlled machine tools" by G. S. Kermack (Ferranti) at 7.0 in the Board Room of Chester and District Hospital Committee, 5 Kings Buildings, King Street.

EDINBURGH

22nd. Brit. I.R.E.—"The field evaluation trials of electronic equipment" by H. Holmes and "The electronic manipulation of digits applied to statistics" by J. Kyles at 7.0 at the Department of Natural Philosophy, University of Edinburgh.

GLASGOW

14th. Brit. I.R.E.—"The earth satellite project" by P. H. Tanner at 7.0 at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent.

LINCOLN

28th. Institution of Production Engineers.—"Electronic control" by J. A. Stokes at 7.30 at the Ruston Club.

LIVERPOOL

14th. Brit. I.R.E.—"Radioactivity and its measurement" by E. W. Pulsford at 7.0 at the Chamber of Commerce, 1 Old Hall Street.

MANCHESTER

7th. Brit. I.R.E.—"Electronics in medicine" by R. F. Farr at 6.30 at the Reynolds Hall, College of Technology, Sackville Street.

12th. Society of Instrument Technology.—"Computing technique applied to measurement and control" by J. Wills at 7.30 at the College of Technology.

13th. I.E.E.—"Frequency-modulated quartz oscillators for broadcasting equipment" by W. S. Mortley at 6.45 at the Engineers' Club, Albert Square.

NEWCASTLE-ON-TYNE

18th. I.E.E.—"The use of transistors in radio and television" by Dr. A. J. Biggs at 6.15 at Kings College.

RUGBY

26th. I.E.E.—"The B.B.C. sound broadcasting service on very-high frequencies" by E. W. Hayes and H. Page at 6.30 at the College of Technology and Arts.

WOLVERHAMPTON

13th. Brit. I.R.E.—"An automatic system for electronic component assembly" by K. M. McKee at 6.0 at the Wolverhampton and Staffordshire Technical College, Wulfruna Street.

January Amendment

In place of the I.E.E. discussion on January 29th on the performance of d.c. amplifiers, mentioned last month, four papers will be read, including "A bridge network for the precise measurement of direct capacitance" by A. C. Lynch, and "A simple transformer bridge for the measurement of transistor characteristics" by W. F. Lovering and D. B. Britten.

RANDOM RADIATIONS

By "DIALLIST"

Guarantees

TO ME it has always seemed ridiculous that a new sound or television receiver should not be covered by a single comprehensive guarantee. As it is, there is a twelve months' set-maker's guarantee, but this does not cover the valves and cathode-ray tube for which there are separate three- and six-month guarantees. And there's another absurd point. The purchaser isn't covered at all for consequential damage caused by the failure of a particular component. Suppose, for example, that the breakdown of a capacitor damages several valves. Then the only free replacement to which you're entitled is that of the capacitor. The valves, you see, didn't blow up through any defect in their materials or manufacture. That kind of guarantee isn't worth having.

Twelve Months' Comprehensive

What I'd like to see is a comprehensive 12-month guarantee for the whole set covered by a single registration card, returnable by the purchaser to the manufacturer of the set. After all, the set manufacturers pay the piper and they can call the tune. If they stuck out for comprehensive twelve-month guarantees to them by valve and cathode-ray tube makers, they'd get them. I'm sure that the result would be increased sales. A hesitant customer is much more likely to take the plunge if he can feel that he knows exactly where he is with his set for the next twelve months. I've heard not a few people say that they won't buy a television set with its big array of valves and its cathode-ray tube until valve and tube makers show sufficient confidence in their products to guarantee them for more reasonable periods.

An Old Stager

THE OTHER day I was shown what must be one of the oldest wireless receivers still at work. Built in 1923 or 1924, it had originally five "R" valves—and what the output from its horn loudspeaker must have sounded like one shudders to think! It now has four 2-volt triodes and a power valve feeds a moving-coil loudspeaker. These are almost the only alterations that have been made. Few repairs had been needed, I was told; but valve replacements had naturally been necessary at intervals. Still in its original home-made cabinet, it is a strange looking thing and vastly bigger than the five-valve set of to-day. I imagine that the sets—both sound and television—that we think so neat to-day will look just as cumbersome and as weird to those who see them in museums thirty odd years from now. Transistors will undoubtedly reduce the size of both, and flat cathode-ray tubes will slim television sets till they measure no more than five or six inches from back to front.

Direct or Projection?

THE FLAT cathode-ray tube will undoubtedly be perfected both in this country and in America. But are big tubes the best answer to the demand for big pictures? Myself, I very much doubt it. I've always thought projection the sounder and more scientific way of providing a large-sized television image. One wonders why it has not caught on better with the viewing public. It hasn't, for the number of projection sets seems to grow less at each succeeding Radio Show. Amongst its advantages are that, size for size, the projected picture is usually a good deal less liney than the directly viewed. Then there's the difference in cost when a new cathode-ray tube is needed. I believe that what has hindered the progress of the projection receiver is that the optical system needs rather skilful adjustment and that servicemen capable of carrying this out are too few and far between.

Holme Moss or Emley Moor?

A FRIEND who has recently been in Leeds tells me that he heard one or two complaints of interference by the v.h.f. sound transmissions from Holme Moss with television programmes from the same station. This, if it's a fact, is rather a curious business. The television frequencies are 48.25 Mc/s (sound) and 51.75 Mc/s (vision). Those used for v.h.f. sound are 89.3, 91.5 and 93.7 Mc/s. Further, vertical polarization is used for TV and horizontal for v.h.f. One imagines, too, that the v.h.f. carrier frequencies must have been carefully chosen to avoid any chance of their interfering with television reception. Will any reader living in those parts and who can throw light on the matter please let me know? I'd have thought myself that interference would be more likely to come from the I.T.A. Emley Moor station, working in Channel 10

(sound 196.25 Mc/s, vision 199.75 Mc/s). Holme Moss television aerials would mostly be designed for the mid-frequency, which is 50 Mc/s. It doesn't seem unlikely that they might be excited by a 199.75 Mc/s signal at short range and with 200 kW behind it.

Seeing Into the Past

WHAT an interesting pursuit the new branch of science, radio astronomy, must be. As Professor A. C. B. Lovell pointed out in his Kelvin Lecture it was the wartime advances in electronics in general and radio in particular that gave it a start. Though it was discovered in 1932 that radio waves from outer space were reaching the earth, it was not until 1950 that the first radio telescope came into action. Since then over 2,000 centres of radiation have been tracked down and this number is sure to be enormously increased when the giant telescope at Jodrell Bank gets to work next year. What I find specially interesting is that some of these centres are nebulæ, which are all that is left of stars which once grew rapidly to abnormal brilliance and finally blew up. One of these nebulæ is the remains of such a supernova recorded in A.D. 1054. Since it is 4,000 light (or radio wave) years away the explosion must have occurred about 3000 B.C. and the radiations now reaching radio telescopes began their long journey some time before the first stone was put into place at Stonehenge.

French TV System

THE MAP in the December *W.W.* showing the locations of European television transmitters gives one the impression that those of the French system are rather queerly distributed. Except for Paris and Bourges all the stations seem to be near the north coast and the northern and eastern frontiers. Many important towns must be very much in fringe areas, if they get a TV service of any sort. I'm sure there's some very good reason for the odd looking distribution of the transmitters, for the French authorities undoubtedly know their business and are determined to make television a success in their country. A possible explanation is that the map only takes account of stations that were actually in use last July and that what now look like gaps will soon be filled by transmitters still under construction.*

*R.T.F. plans to have some twenty stations operating by the end of 1957.—ED.

UNBIASED

By FREE GRID

Crystal Jubilee

I SPEAK subject to correction but, to the best of my knowledge and belief, last year we should have celebrated the jubilee of the crystal detector which first came into use in 1906. As we all know, the crystal followed the valve which in the form of a diode rectifier was patented by Fleming on November 16th 1904. The crystal subsequently came into its own as it had a better characteristic curve than Fleming's diode and so was more sensitive.

I have little doubt that many of you veterans will tell me that I am all wrong and that you used a crystal rectifier long before 1906. What I really have in mind is its commercial use which in 1906 meant in ship and shore stations.

It is always difficult to fix a date for the first use of a particular technique. For instance it is generally agreed that the magnetic detector started to come into commercial use in 1902 when it rapidly displaced the coherer. But this particular magnetic detector was really only the first commercial version fathered by Marconi; the one with the continuously moving iron band. Rutherford used a magnetic detector of sorts to receive signals across Cambridge in 1897.

A Bucolic Bugbear

WRITING in a journal which circulates only among members of the radio trade, a dealer calls attention to the large number of battery sets in use in country districts which have no electric power supply.

Owing to the high cost of using dry cells continuously for L.T. supply, two-volt accumulators still flourish to a remarkable extent, and this dealer alone handles over 100 each week. I must confess that this rather surprises me as accumulators are messy things to have in the house but, worse still, have to be lugged periodically to the charging station and brought home with the week's shopping.

Surely the obvious thing to use as a substitute for a dry l.t. cell is the parent from which it sprang; namely, the ordinary wet Leclanché cell. It is true that this can be equally as messy as an accumulator but it does not have to be taken to the charging station. Whatever can be done by the small dry cell can be done very much more economically by a wet one as it only needs a new zinc electrode at very infrequent intervals.

Polarization is the bugbear of Leclanché cells, wet or dry, but the l.t. demand of a modern battery set is so small that the depolarizer in the porous pot of the wet cell is more than ample to keep it going. Even if it were not, it would be an easy matter to rig up two cells and a change-over switch so that one could have a rest while the other was working.

Another advantage of the Leclanché is that it does not need a voltage-dropping resistance when used with 1.4-volt valves as does a 2-volt accumulator.

Teledynamics ?

THE EDITOR and I have, in recent months, both written about the transmission of power by radio. No doubt it will be many years before serious consideration is given to this question. But one day power transmission by wireless will "arrive" and we ought to coin a proper portmanteau word for it. We don't want to be caught napping as we were in the case of television and have a horrible hybrid word like "dynamission" foisted on us by the lay press.

I cannot think of a good and correct word offhand; all that suggests itself is "teledynamics." While correctly derived, this word doesn't suggest the idea of *radio* transmission any more than "telearchics" suggests *radio* control.

I am not too fond of any of these "tele" words in any case. The word "telephone" does not, for instance, suggest the idea of transmission by wire or by any form of electrical energy. It would be equally correct to apply the word "telephone" to a speaking tube.

Newnham Nymph

Now it is up to some of you classical boffins from Balliol to lend me a hand and justify your existence. I feel sure the "Greeks had a word for it" but it needs a lot of excavating by some of the Bodleian boys. However, it is really women who never seem to be at a loss for words, and so perhaps I had better call on the Newnham nymphs for help in this matter.

Destaticizing

I HAVE previously denounced as mere superstition the dainty little trailing chains which many motorists used to destaticize (what a word!) their car bodies and so eliminate the travel sickness to which many people are prone. If it be other than superstition why is it that railway travellers are not immune from sickness, for few things are more firmly earthed to the rails than a railway carriage? Why, too, don't cyclists suffer from sickness for their machines are as much insulated from the road as a car?

A correspondent has, however, put forward an argument which to him seems to prove that the destaticizing chain is really effective in preventing travel sickness even in cases where the psychological effect of autosuggestion can be ruled out.

It appears that a dog owned by a colleague of my correspondent, which has always been prone to car sickness, has been completely denauseated by the fixing of one of these dangling chains. Therefore, argues my correspondent, the chain must work by physiological rather than by psychological means as the dog does not know that its sickness is caused by ambient static which the dangling chain removes.

Now whatever our views about the *modus operandi* of telepathy it is well known that a dog readily picks up the mood of a human being, and more especially that of its master. It is also well known that this phenomenon is due, not to telepathy, but to teleolfaction. Human and other beings exude a certain amount of perspiration even in an arctic temperature, and the odour of the perspiration varies with the emotions.

We have all heard of the "odour of sanctity" and Shakespeare speaks of the "disodour of impiety." There is, in fact, a characteristic odour associated with every emotion, and a dog, with its keen sense of smell, sorts them out. Thus a strange dog is apt to attack people who are afraid of it as they emit an odour of fear.

Obviously my correspondent's colleague, who owns this particular dog, has great faith in the dangling chain and he must, therefore, exude a strong odour of faith—not necessarily akin to the odour of sanctity—which his dog readily picks up.

for FOR RADIO RELAY SERVICES - VIBRATION TEST EQUIPMENT - TRANSMITTER MODULATORS

MY3-275

Power Triode

Mullard

Mullard

The MY3-275 triode has been introduced by Mullard for audio power amplification at high levels.
It has a thoriated tungsten filament and its maximum anode dissipation is 275W. Under typical class 'AB2' conditions, two of these valves in push-pull will provide an output of more than 1kW. Further data for the MY3-275 and other large output valves and details of Xenon and Mercury Vapour rectifiers for associated power supplies are readily obtainable from the address below.

Abridged Data for the MY3-275 (Services Type Numbers CV1252 and CV1619)			
V_f	14.0 V	Typical operation for two valves in class 'AB2' push-pull	
I_f	6.5 A	V_a	3000 V
P_a	275 W	I_a (o)	2x60 mA
*g_m	8.5 mA/V	I_a (max. signal)	2x 280 mA
*μ	16	R_{a-a}	13,800 Ω
*r_a	1900 Ω	P_{out}	1300 W
*Measured at Va=2000V, Ia=160 mA		D_{tot}	3 %

MULLARD LIMITED, COMMUNICATIONS & INDUSTRIAL VALVE DEPARTMENT
Mullard House, Torrington Place, London, W.C.1.

MVT 186

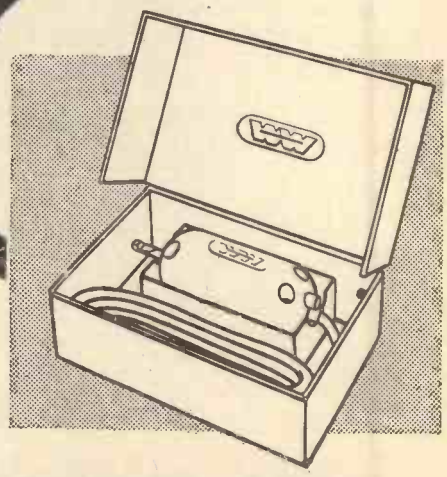
End background hiss..

with the NEW WEARITE DE-FLUXER

—a simple, easily operated trouble-free device for ***depolarising*** the heads of tape recorders and players.

- ★ It ensures the maximum signal/noise ratio from *any* tape recorder.
- ★ Protects valuable recorded tapes from cumulative background noise and the gradual attenuation of the higher frequencies.
- ★ Is extremely simple to use without removing head screening cans.
- ★ Permits selective tape erasure during editing.

The Wearite Defluxer is a "must" for all tape recorder hi-fidelity enthusiasts and for the professional recordist.

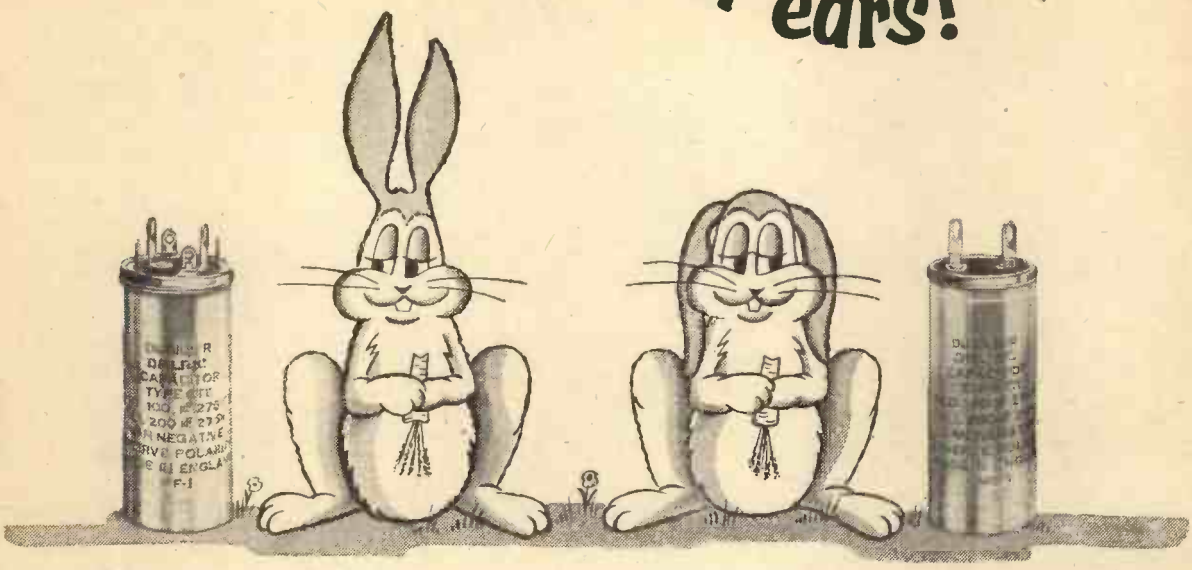


Price: **£2 . 10 . 0**

WRIGHT & WEAIRE LTD

131 SLOANE STREET · LONDON · S.W.1 · Tel: SLOane 2214/5 & 1510

With or without ears!



Whether you are a radical and like to use modern methods of assembly or whether you are a conservative and prefer the tried and trusted methods, Dubilier can supply you with the capacitors you require.

For example, Dubilier can supply you with electrolytic capacitors for television receivers made either for ear mounting* or clip mounting. In either case they are manufactured with the high ripple current sections required for this purpose. These capacitors are assembled and sealed in seamless drawn aluminium cans.

**For fixing ear mounting types, only four slots are required in the chassis. The capacitor is dropped into these slots and a slight twist of the ears secures capacitor firmly. Alternatively, a bakelite mounting plate can be supplied for use in those cases where isolation of the capacitor can from chassis is required.*

Capacitance (μF)	D.C. Wkg. Voltage	Dimensions	Ripple Current (mA)
100—200	275—275	4″ x 1⅜″	700—300
50	280	3″ x 1⅜″	500
100	280	2″ x 1⅜″	550
50—100	350—280	3″ x 1⅜″	500—200
50—100	280—280	3″ x 1⅜″	450—200
200—500	350—350	4″ x 2″	700
64—120	350—350	4″ x 1⅜″	500
100—200	350—280	4″ x 1¾″	900—300
100—200	350—280	4″ x 1⅜″	700
60—100	350—350	4″ x 1⅜″	500—200
60—250	350—350	4″ x 1¾″	700—400
100—100	350—350	4″ x 1⅜″	550—200
100—200	350—350	4″ x 1¾″	900—300

DUBILIER

DUBILIER CONDENSER CO. (1925) LTD., DUCON WORKS, VICTORIA ROAD, NORTH ACTON, W.3
Telephone: ACOrn 2241 Telegrams: Hivoltcon Wesphone, London

DV165A

MARCONI

SURVEYED

PLANNED

LONG-DISTANCE ISB TELEPHONY SYSTEMS ISB telephony has made long-distance word-of-mouth communication possible between subscribers on widely separated local land-line or radio-telephone systems which are linked to a national or international HF radio-telegraphy service. Marconi's have been pioneers in developing ISB telephony facilities. As with other types of communication systems, Marconi's can offer unrivalled facilities and experience to those contemplating ISB telephony. From the initial technical consultations to the maintenance of the system in service and the training of the staff to operate it, Marconi's alone can undertake the whole project.

INCREMENTAL INDUCTANCE BRIDGE

Designed to measure the value of iron cored chokes and similar inductors in the range 0·01H to 1000H of Q value not less than 2.

Provision is made for passing any current up to 1 Amp d.c. through the winding and selectable a.c. excitation voltages of 1, 2, 5, 10 and 20V r.m.s. are provided.

Full technical information is available on request.

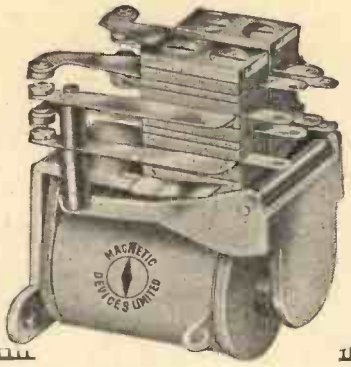
CINEMA TELEVISION LTD

A COMPANY WITHIN THE RANK ORGANISATION LIMITED

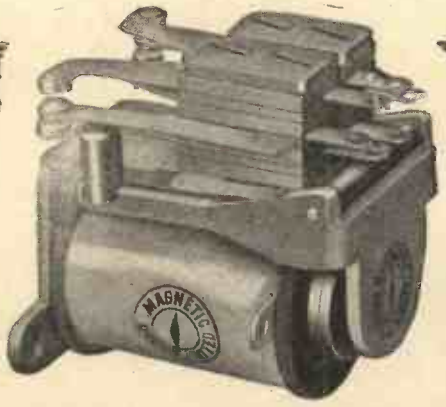
WORSLEY BRIDGE ROAD · LONDON · S.E.26
HITHER GREEN 4600

SALES AND SERVICING AGENTS :
Hawnt & Co. Ltd., 59 Moor Street, Birmingham 4
F. C. Robinson & Partners Ltd., 122 Seymour Grove, Old Trafford, Manchester 16
Atkins, Robertson & Whiteford Ltd., Industrial Estate, Thornliebank, Glasgow

When it's **RELAYS** contact



Magnetic Devices LTD.



Upper Illustration; Series 596. D.C. operated, Max. V. 140. Contact rating up to 5A. continuous. Switching: One to six poles in various combinations. Overall size: 1 7/16″ long by 1 3/32″ wide by 1 25/32″ deep. Coil consumption 0.5 to 3 watts.

Lower Illustration; Series 590. A.C. operated, Max. V. 250. Contact rating up to 5A. continuous. Switching: One to four poles in various combinations. Overall size: 1 7/16″ long by 1 3/32″ wide by 1 25/32″ deep. Coil consumption 2 or 4VA.

Coils are wound for standard voltages up to 250V.A.C. and 140V.D.C. Coils can be supplied vacuum impregnated if required.

Please write for illustrated leaflet.

MAGNETIC DEVICES LIMITED

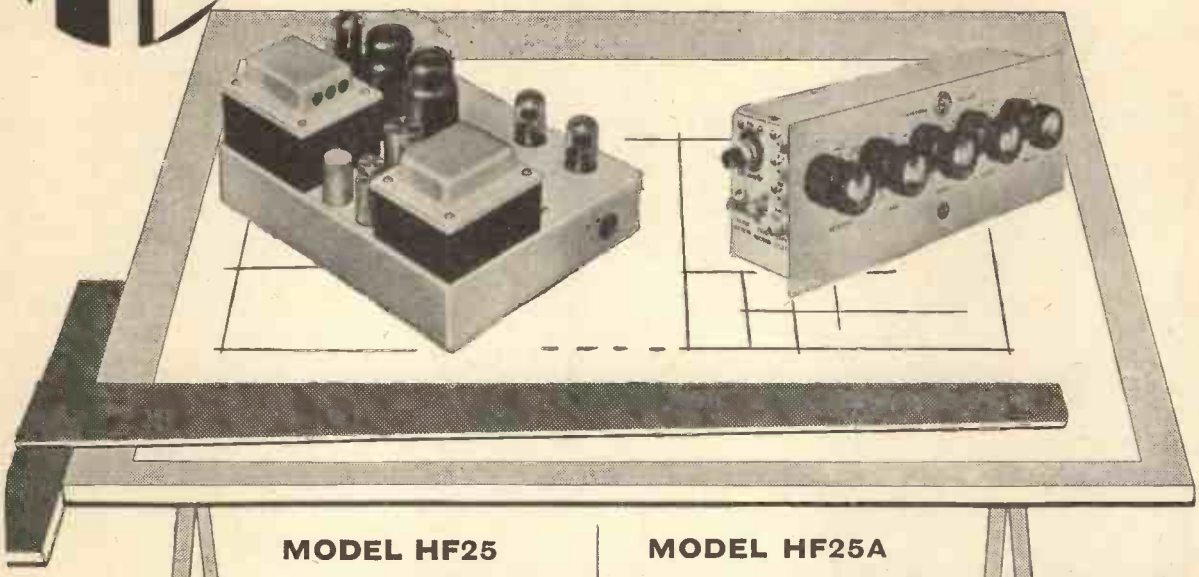
Magnetic Devices LTD.

EXNING ROAD NEWMARKET

Telephone: Newmarket 3181/2/3

Telegrams: Magnetic Newmarket.

HIGH FIDELITY STARTS HERE



MODEL HF25

The amplifier has been critically designed to give living expression to recent improvements in recording and broadcasting techniques. Clear life-like reproductionis ensured by the low harmonic distortion and by the infinite damping factor. 25 watts undistorted output is ample for any home system.

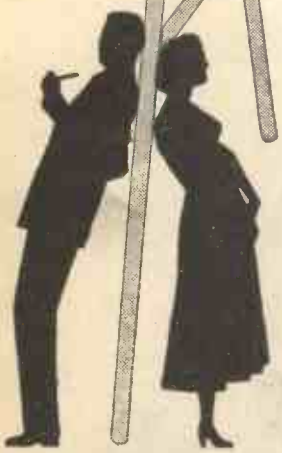
MODEL HF25A

The pre-amplifier has phono-jack inputs for radio, microphone, pick-up, tape recording and 4 equalisation positions for U.S. LP, EUR. LP (R.I.A.A.,) U.S. 78 and EUR. 78. Amplifier can be controlled from distances of 20 ft. without loss of performance. In walnut and sycamore veneered cabinet or chassis form.

The highest standard of performance and reliability is ensured by neat chassis layout and superlative workmanship.

Very wide frequency range, 2—160,000 c.p.s. 26 db of negative feedback over the entire audible range.

A range of plug-in pick-up compensators allows quick and easy matching of any type of pick-up.



PACKAGED HI-FI

These small matching Pye plug-in units are bringing high fidelity to the ordinary listener *at a price he can afford*. They're simple to operate, install in minutes and blend at once with modern furnishings.

HIGH FIDELITY SYSTEMS

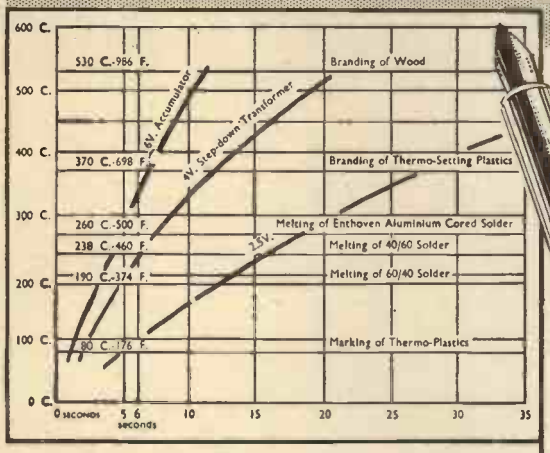
Pye Limited, Auckland, New Zealand
Pye (Ireland) Ltd., Dublin, Eire
Pye Ltd., Stuttgart, West Germany
Pye Ltd., Tucuman 829, Buenos Aires

Pye Limited, Mexico City
Pye Canada Ltd., Toronto, Canada
Pye Pty. Ltd., Melbourne, Australia

Pye Corporation of America, 270 Park Avenue, New York
Pye Radio & Television (Pty) Limited, Johannesburg, South Africa.

PYE LIMITED • CAMBRIDGE • ENGLAND

The Superspeed SOLDERING IRON



TIME/TEMPERATURE CURVE CHART from the SUPERSPEED SOLDERING IRON TIP/TEMPERATURE TIME CHECK

The effect of different voltages on initial heating-up time is shown. Whilst 4V is the standard voltage normally employed, 6V will cause no harm, and accumulators are a useful source of current supply.

heats up from cold in 6 seconds!

Manufactured for Enthoven Solders Ltd., by Scope Laboratories, Melbourne, Australia.

Designed on an entirely new principle, this light-weight, versatile iron is eminently suitable for soldering operations in the radio, television, electronic and telecommunication industries. For test bench and maintenance work it is by far the most efficient and economical soldering iron ever designed. Ideally suitable for use with Enthoven Aluminium Cored Solder (melting point 260°C. 500°F.).

LIST PRICES	
IRON	39/6
TRANSFORMER	35/6

All prices and trade discounts subject to revision

* Activated by light thumb pressure on the switch ring. When pressure is released, current is automatically switched off — thus greatly reducing electricity consumption, wear on copper bit and carbon element.
* Length, 10"; weight, 3½ ozs.; can be used on 2.5 to 6.3 volt supply (4 volt transformer normally supplied) or from a car battery.
* More powerful than conventional 150-watt irons; equally suitable for light wiring work or heavy soldering on chassis.
* Simple to operate; ideal for precision work.
* Requires minimum maintenance — at negligible cost; shows lowest operating costs over a period.

For full particulars, including guarantee terms and free trial facilities, please write to the sole concessionaires in this country :—

ENTHOVEN SOLDERS LTD. (Industrial Equipment Division)
Dominion Buildings, South Place, London, E.C.2. MONarch 0391

Switch to the

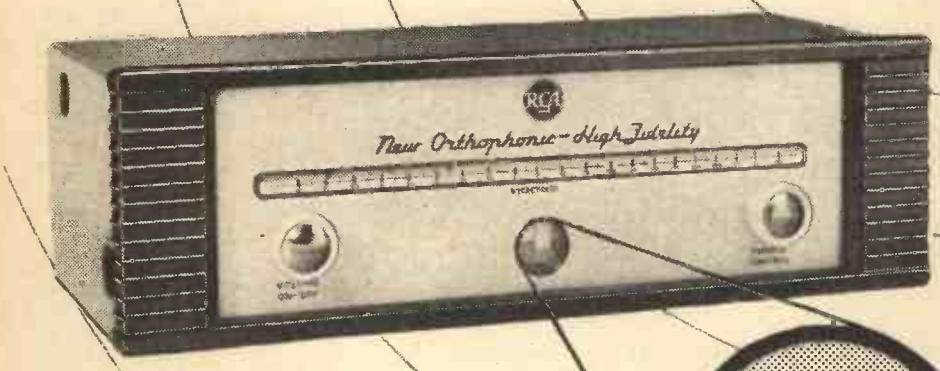
Superspeed

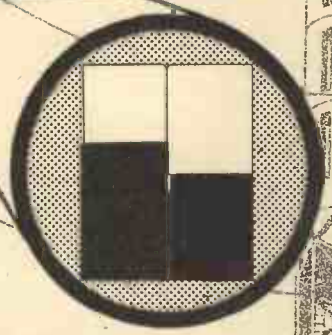
Soldering Iron

as being used by the Royal Society Antartic Expedition for the International Geophysical Year.

NOW

New Orthophonic High Fidelity FROM VHF/FM





The RCA FM Tuner incorporates many new refinements, enables you to realise the great advances made in broadcasting bringing into your home a thrilling, living, realism.

★ **Precision Tuning**
The new RCA Electron Ray Tuning Indicator makes exact tuning simplicity itself.

★ **No interference**
The FM system coupled with RCA circuitry results in exceptional signal-to-noise ratio.

★ **Extended Tuning Range**
87.5-108 *Mc/s covers the entire international F.M. broadcasting band.*

★ **Great Sensitivity**
2 *microvolts for* 20 *db quietening—extends the 'fringe'* 7 *valves plus* 2 *crystal diodes and Electron Ray tuning indicator.*

★ **High Fidelity**
Wide range response within 1 *db from* 20-15,000 *c/s for true High Fidelity reproduction.*

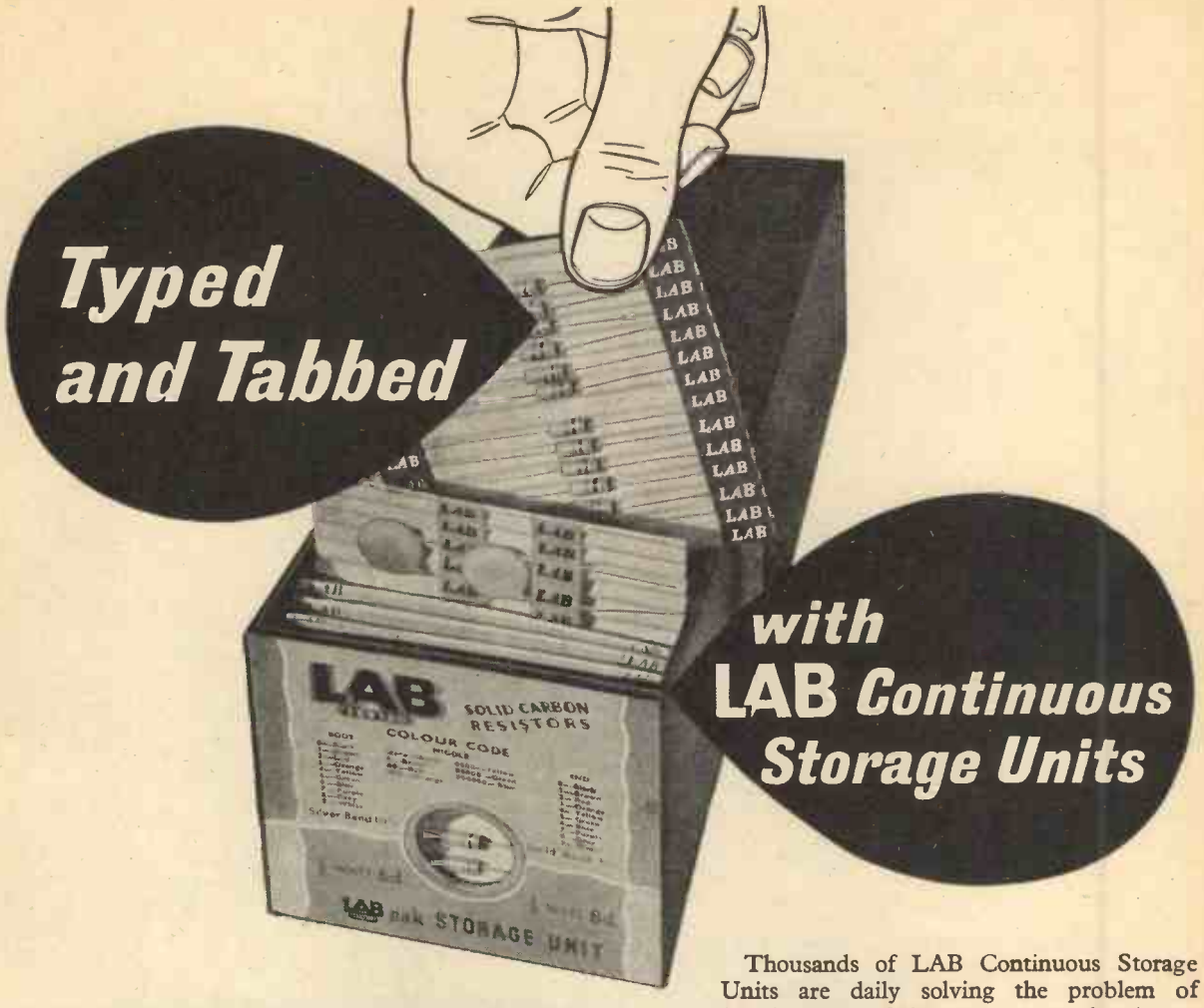
★ **No Matching Problems**
Adjustable output levels.

★ **Automatic Frequency Control**
Ensures complete freedom from drift.

★ **Power Requirements**
230-390 *volts D.C. at* 40 *milliamps H.T. supply.* 6.3 *volts,* 2.25 *amps heater supply (available from RCA New Orthophonic High Fidelity power amplifier).*

RCA

RCA GREAT BRITAIN LTD.
(An associate Company of Radio Corporation of America)
Lincoln Way, Sunbury-on-Thames, Middx.
Tel. : Sunbury-on-Thames 3101.



REF.	WATTS	MAX. VOLTS	OHMS	MIN. ORDER FOR FREE UNIT	UNIT STORAGE CAPACITY
			RESISTORS		
T	½	250	10 to 10M	240	720
R	1	500	10 to 10M	180	500
			Tolerances available ±20% 10% 5%		
			HIGH STABILITY RESISTORS		
HS3	½	750	1 to 500M	93	500
			Tolerances available ±5% 2% 1%		
			WIREWOUND RESISTORS		
LM	5 & 10	—	5 to 100K	72	300
LP	5 & 10	—	5 to 100K	72	300
			CERAMICAPS		
CER	Tubular	500	3 to 470pf	141	500
HK	Tubular	500	470 to 5000pf	141	500
HKD	Disc	500	470 to 5000pf	141	500
			Tolerances available ±2% 10%		

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

FREE with any purchase of the LABpak range, these units are the complete answer to the storage problems of small production units, laboratories, etc.

MAKE UP YOUR ORDER TODAY — DELIVERY EX-STOCK

All LABpak resistors are carded in ohmic value, rating and tolerance, colour indexed and tabbed for easy selection.

The LAB Continuous Storage Units are available from your normal source of supply, but more detailed information and literature can be obtained from

THE RADIO RESISTOR COMPANY LIMITED

50 ABBEY GARDENS, LONDON, N.W.8 • *Telephone:* Maida Vale 5522

It is gratifying to know that in a world of rising prices our policy of maintaining, and, in many instances, reducing prices has resulted over the years, and especially at this period, in ever increasing sales.

We carry a stock of 2,000 types of receiving, transmitting and special purpose tubes, and invite your enquiries not only for commercial grade tubes but also for those tested to C.V., JAN and MIL specifications.

Our Organisation is A.R.B. Approved.

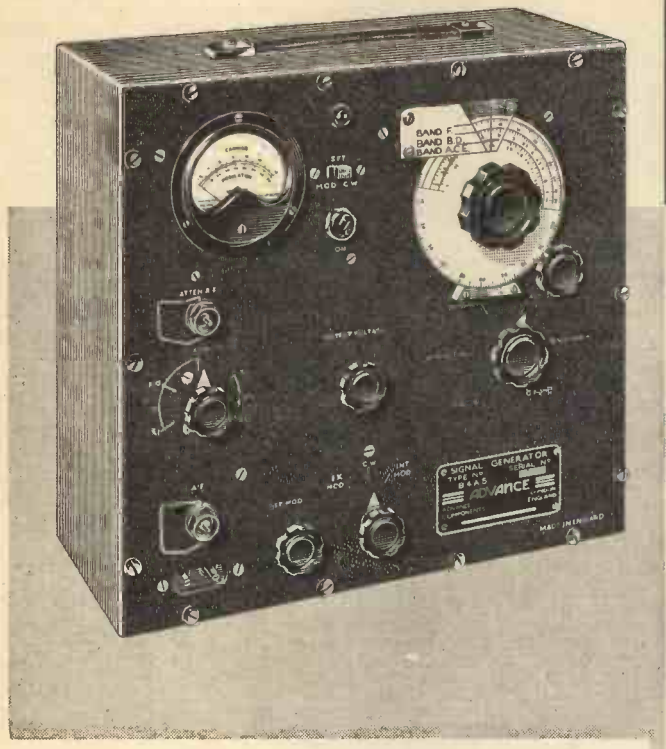
If you are not already on our Mailing List, please send for latest Price and Stock Lists.

HALL ELECTRIC LTD

Haltron House, 49/55 Lisson Grove, London, N.W.1

Telephone:
AMBassador 1041 (5 lines)
Cables:
Hallectric, London
TELEX 2-2573

ADVANCE COMPONENTS LTD., ROEBUCK ROAD, HAINAULT, ILFORD, ESSEX. Telephone : HAInault 4444



MODEL A 100 kc/s—80 Mc/s in six bands

MODEL B 30 kc/s—30 Mc/s in six bands

Calibration accuracy of both models is ±1%

ADVANCE TYPE B4

Nett price in U.K. £60 . 0 . 0

The Advance type B4 is a tried and proven generator which is essentially simple to use. One special feature is the accuracy of the R.F. output over the entire frequency range, achieved by the use of a crystal voltmeter and the subsequent elimination of all circuits having poor frequency characteristics.

Full technical details in Folder W38

Advance
signal generator

QUESTION *"Why don't dealers stock and recommend our Amplifiers and Tuners, etc?"*

ANSWER *"Because they cannot afford to as we give their discount to YOU (the public)."*

This direct trading explains why our products, though in the top class, are so much cheaper than our competitors'.

What we are and what we do.

Firstly we are quite large manufacturers of Audio Amplifiers, Radio Feeder Units, Portable Record Players, Speaker and Amplifier Cabinets and custom built Complete High Fidelity Radio and Record Reproducers.

Secondly we are Retailers of Gramophone Units, Autochangers, Speakers, Tape Recorders, etc., etc.

We recommend only that which we know to be of good performance and of sound construction. We are not in the group of traders who sell job lines at apparently low prices because they are obsolete or faulty. On the other hand our finances are such that we do not have to sell you an expensive article if we know that a less expensive unit will do your job perfectly.

If any reader should have his mind set on a high-priced amplifier of another make and would like to save money if possible, we should like to make the following clear-cut offer: If he buys one of our "Symphony" Amplifiers or Tuners and is not entirely satisfied with it he may return it for full credit against *any other amplifier or tuner on the market.* It should be emphasised at this stage that we can supply any Amplifier, Radio Tuner, etc., advertised.

Our chief Engineer, who is operating a Technical Guidance Service, is available daily including Saturdays from 10 a.m. to 6 p.m. or will deal with enquiries by return of post.

Our new illustrated Catalogue and supplement will be a great boon to those desiring quality equipment for modest expenditure. Send two 2½d. stamps for your copy now. It may well save you pounds! All our equipment is on demonstration at our showroom in conjunction with a variety of Pickups, Speakers, etc. If you can possibly call we shall be pleased to see and help you. H.P. facilities available.

It is essential to mention "Wireless World" when requesting Catalogue or when ordering.

The New No. 1 "SYMPHONY" AMPLIFIER MARK III is a 3-channel 5-watt Gram/Radio Amplifier with astonishingly flexible tone control. You can lift the treble, the bass, or—and here is the unique feature—the middle frequencies to suit your own ear characteristics and the record or radio programme being heard. It is thus possible to arrange frequency-response of the amplifier to a curve equal and opposite to the resultant curve of the other items in the chain so what finally registers in the brain is as per original. This flexibility of control is even more important than the nominal linear response of the amplifier, as the pickup speaker, etc., are not linear. Independent Scratch-Cut is also fitted and special negative feedback circuit employed. The Amplifier can accommodate a wide variety of records from old 78s to new L.P.s, and there is full provision for Radio Tuner, Tape take-off and Playback. It is available to match 2/3 or 15 ohms speakers. Price **12 gns.** (carriage 7/6). Fitted in portable Steel Cabinet, **2 gns.** extra.

The New No. 2 "SYMPHONY" AMPLIFIER MARK III, as No. 1 but with 10-watt Push-Pull triode output and triodes throughout. Woden mains and output transformers and choke. Output tapped 3, 7.5 and 15 ohms. Provision for Tuner and Tape. Competes with the most expensive amplifiers on the market yet costs only **16 gns.** (carriage 7/6). Fitted in portable Steel Cabinet **2 gns.** extra.

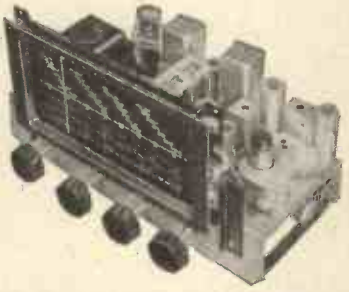
"SYMPHONY" AMPLIFIERS WITH REMOTE CONTROL

Remote Control Panel

Both the above model Amplifiers are available with all controls on a separate Control Panel with up to 4ft. flexible cable which simply plugs into the amplifier. Enables the Amplifier proper to be sat in the bottom of a cabinet whilst the controls are mounted conveniently higher up. Extra cost **2 gns.**

No. 1 "SYMPHONY" F.M. TUNER. High grade instrument with extremely silent background. Based on the latest type of permeability-tuned Coil Assembly of advanced design housed in anti-radiation shroud giving extreme sensitivity and high music/noise ratio Suitable for amplifiers in the highest fidelity class. **£15/8/-.** Power Pack **£3/7/6.** Magic eye **£1** extra if required.

No. 2 "SYMPHONY" AM/FM TUNER. Combining all the specifications of our Long, Medium and Short wave Superhet AM Tuner and our No. 1 FM Tuner. Separate Coil Assemblies and IFs Fully self-powered on one chassis. **26 gns.**



N.R.S. EMPRESS FM/VHF TUNER/ADAPTOR Fine little job, will plug into any radio and add F.M. **£13/15/-.** Magic eye assembly £1 extra if required. Ditto mounted in beautiful dark walnut cabinet complete with magic eye **17 gns.** Carriage 7/6.

"SYMPHONY" AM/FM RADIOGRAM CHASSIS Very high grade radiogram chassis combining Long, Medium and Short and V.H.F. bands. Large engraved dial. Push/pull output for high quality Complete with 10in. Goodmans speaker **26 gns.** Carriage and packing 7/6

RECOMMENDED GRAMOPHONE UNITS

All current Collaro Units in stock for immediate delivery

NEW MODEL GARRARD RC88 AUTOCHANGER £15/11/4. RC98 £17/10/3. Prices less head.

Variety of pickup cartridges available in Garrard shell to fit RC88 and RC98 Leaflets on Collaro and Garrard Gram. Units on request.

DIAMOND STYLI.

We can supply Diamond Styli in place of Std. or L.P. sapphires fitted to any cartridge or gram units we supply for £4/14/4 extra.

LENCO GL50, 4-speed continuously variable from above 78 r.p.m. to below 16 r.p.m. Special Aurostop. Price with Studio "O" or "P" head or Goldring variable reluctance head. **£21/17/10.**

LENCO GL55, as above but without pickup and auto-stop but fitted with Special Device for Groove Location and knob which completely disengages drive-wheel. Suitable for use with any pickup, especially transcription types and B.J. Arm. Price **£17/10/4.** Immediate delivery guaranteed

LENCO GL56, as GL55 but with Studio or Goldring 500 pickup, **£23/7/-.**

GOODMANS "SHERWOOD" (VISCOUNT) ENCLOSURES Walnut or mahogany, complete with Acoustical Resistance Unit, **19 gns.** or less A.R.U., **16½ gns.**

MIDAX/TREBAX CABINET. To match "Sherwood" (Viscount) **£7/10/-.**

"SYMPHONY" BASS REFLEX CABINET KITS. 30in. high, consist of fully-cut ¾in. thick, heavy, inert, non-resonant, patent acoustic board, deflector plate, felt, all screws, etc., and full instructions. 8in. speaker model, 85/-. 10in speaker model, 97/6. 12in. speaker model, **£5/7/6.** Carriage 7/6. Ready built, 15/- extra.

As above but fully finished in figured walnut veneer with beautiful moulding and speaker grille. 10in. **£11**, 12in **£11/10/-** Other veneers to order.

CONSOLE AMPLIFIER CABINETS. 33in. high, lift-up lid with piano hinge, take Tape Deck, Gram Unit or Autochanger, Amplifier, Pre-Amplifier, and Radio Feeder Unit, finished medium walnut veneer. De luxe version, price **12 gns.** Oak or mahogany veneers and special finishes to order. Carriage according to area. We will quote by return.

NORDYK CABINETS. Speaker Enclosure **£5/17/6.** Table Model Amplifier/Gram Unit Cabinet **£5/19/6.** Table Model Tape Recorder, Tape Amplifier or Radio Tuner Cabinet **£5/19/6.** Record Storage Cabinet holding 150 records **£4/17/6.** All above cabinets measure (internally) 19in. wide x 13in. high x 13in. deep and finished in polished walnut, thus enabling a complete installation to be built up unit by unit in matching style cabinets and added to as required. Any of our Amplifiers, Tuners, Gram Units, Tape Decks and Speakers can be supplied in these cabinets for small extra cost. Examples on demonstration.

TAPE RECORDER DEPT. We are specialists in the supply of tape gear for use in conjunction with High Fidelity Equipment. We are familiar with all worth-while Tape Recorders and Decks on the market and are in a unique position to advise on Tape Recorders, Tape Decks Tape Amplifiers and Tape Pre-Amplifiers and give unbiased opinions and demonstrations. All those intending buying a Tape Recorder or adding Tape facilities to their present systems are advised to consult us before spending money, as we might well be able to save you money and dissatisfaction. Call for a demonstration, or write.

THE "SYMPHONY" DE-LUXE TAPE RECORDER. 2-speed, twin-track, microphone, radio and external amplifier inputs. Facilities for playback through high quality internal elliptical speaker or through external high fidelity speaker or through external high fidelity amplifier. Automatic head demagnetisation. Wide frequency range heads. Housed in handsome polished walnut cabinet. Fantastic value for money at 49 gns. or 9 monthly payments of 6 gns. De luxe model with built-in revolution counter, 52 gns. or 9 monthly payments of £6/13/0. Plus carr. and pkg. £1. Full details in catalogue.

NORTHERN RADIO SERVICES

DEPT. WW., 11, KINGS COLLEGE ROAD, ADELAIDE ROAD, LONDON, N.W.3. *Phone: PRImrose 3314*

Tubes: Swiss Cottage and Chalk Farm Buses: 2, 13, 31, 113 and 187

LOW NOISE TRAVELLING WAVE TUBES

The range designed by English Electric Valve Company includes low noise, voltage amplifier and power tubes, with outputs from 1mW to 16W.

Type N1005M illustrated is a low noise tube specially designed to operate over a frequency range of 3600-4200 Mc/s. It permits the use of r.f. amplification in radar, tropospheric scatter and other microwave equipment.

Full particulars of this tube and other units specially designed for use in the higher frequency bands are available on application.

E.E.V. Type	Function	Centre Frequency (Mc/s)	Maximum Output	Noise Factor (dB)	Gain (dB)	Helix Volts	Collector Current	Focusing Field (Gauss)
N.1001	Power	2000	16W	–	26	2600	40mA	600
N.1002	Low Noise	2000	1mW	10	24	550	200μA	200
N.1004	Power	4000	4W	–	21	2600	20mA	450
N.1005M	Low Noise	4000	1mW	11	22	360	200μA	350
N.1013	Voltage Amplifier	2000	200mW	20	32	650	4mA	300
N.1017M	Low Noise	1200	1mW	10	20	700	200μA	200
N.1018M	Voltage Amplifier	4000	100mW	20	30	630	2mA	350

'ENGLISH ELECTRIC'

ENGLISH ELECTRIC VALVE CO. LTD. *Waterhouse Lane, Chelmsford*
Telephone: Chelmsford 3491

B

A remarkable new instrument for Physicists

50 micro-ohms to 10,000 megohms ·0002 picofarad

WAYNE KERR
UNIVERSAL BRIDGE
B.221

THE B.221 is a highly accurate transformer ratio arm bridge of very advanced design. It provides facilities for the two, three, or four-terminal measurement of impedance or transfer admittance over an extremely wide range at an operating frequency of 10,000 radians/sec. (1592 c/s).

Measurement is unaffected by the impedance of the test leads, which can therefore be of any length. Consequently the instrument is ideally suitable for the determination of temperature coefficient of components under test conditions or, in fact, any remote in-situ measurement.

A novel mechanism automatically displays the cyphers, decimals and units of measurement. This gives direct reading and avoids any confusion which might be caused by the large multiplying factors involved.

The basic range of the instrument covers impedances from 10,000 megohms to 10 ohms and this is extended to 50 micro-ohms by the use of the Low Impedance Adaptor. Other adaptors have been designed for measurement of conductivity, dielectric constant and loss factor of solids and liquids.

SPECIFICATION

BRIDGE ONLY: Capacitance: 0.0002 pF to 10 μF in 7 ranges. Accuracy ± ½%. Conductance: 0 - ± 100 mmho in 7 ranges. Inductance: 1 mH to infinity in 7 ranges. Measuring Frequency: 10,000 radians/sec. (1592 c/s.) Power Supply: 110/115 and 200/250 V 40/60 c/s. Dimensions: 17" x 7" x 11½" high. Weight: 25 lbs. approx.

WITH LOW IMPEDANCE ADAPTOR: Capacitance, 1μF – 100,000μF in 4 ranges. Resistance: 0-100Ω in 4 ranges: Discrimination on lowest range 50μΩ. Inductance: 0-10 mH in 4 ranges. Discrimination on lowest range 5mμH.

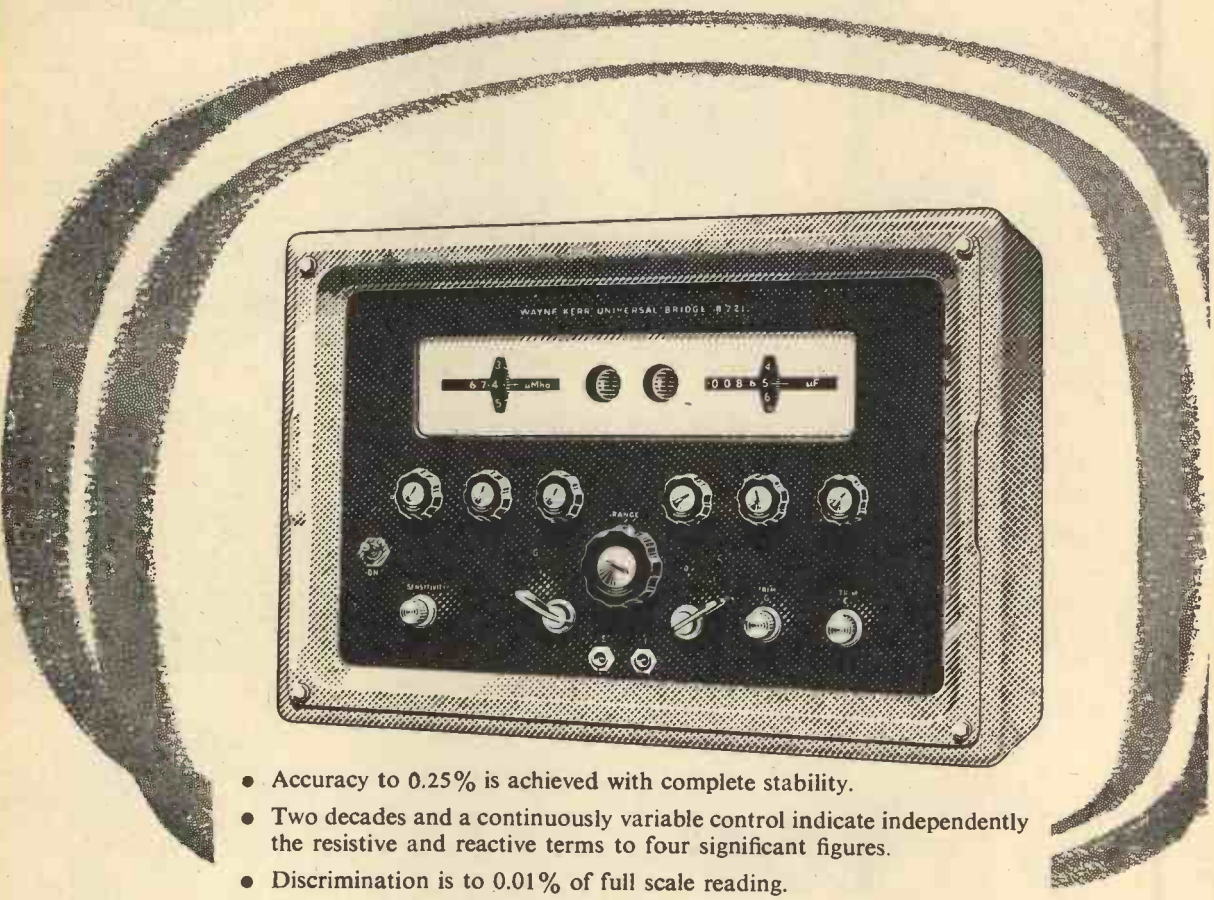
PRICES: Bridge, £175. Low Impedance Adaptor £15.

WAYNE KERR

THE WAYNE KERR LABORATORIES LIMITED,

and Chemists

to 100,000 microfarads, 5 millimicrohenries to infinity



- Accuracy to 0.25% is achieved with complete stability.
- Two decades and a continuously variable control indicate independently the resistive and reactive terms to four significant figures.
- Discrimination is to 0.01% of full scale reading.
- Test leads of any length do not affect accuracy.
- Transformer ratio arm principle allows measurement in any quadrant of the complex plane.
- Adaptors for measurement of conductivity, dielectric constant and loss factor of solids and liquids.
- Lowest capacitance range is 0-1 pfd. with ·0002 pfd. first scale reading.
- Low Impedance Adaptor extends resistance and inductance range to 50 micro-ohms and 5 millimicrohenries. This covers:
- Dry joints, earth-bonding efficiency, switch contact resistance, cable connectors, valve base connections, and general circuit strays.

ROEBUCK ROAD, CHESSINGTON, SURREY. TELEPHONE: LOWER HOOK 1131

Single pillar lampholder supplied completely prewired with 3 ft. leads ready for immediate installation. Reference No. 80/10/0155

Thorn pillar lampholders for the illumination of instrument panels . . .

Originally designed for aircraft control panels (and widely used throughout the British aircraft industry) these Thorn pillar and bridge piece lampholders are of universal application for industrial use wherever instrument panels require illumination. A full range of these components is available.

. . . and bridge pieces

The special advantage of Thorn pillar and bridge pieces is their notable economy of panel space and the clear illumination they provide. Wiring arrangements are extremely simple and bridge pieces can be quickly added to existing control panels without any difficulty.

Bridge pieces are supplied with double entry leads for emergency stand-by lighting if required.

The present range of bridge lighting units is as follows:—

TYPE A	Mk. G4B Gyro Compass	4 lamps
TYPE B	Artificial Horizon	2 lamps
TYPE C	Large S.A.E. Case (4BA screws)	2 lamps
TYPE D	Small S.A.E. Case (4BA screws)	2 lamps
TYPE E	Horizontally mounted Double Desynn	2 lamps
TYPE F	Large S.A.E. Case (2BA screws)	2 lamps
TYPE G	Small S.A.E. Case (2 BA screws)	2 lamps
TYPE H	Large Air Ministry Case	2 lamps
TYPE J	Instruments with 3″ P.C.D. fixing	2 lamps
TYPE K	Double Desynn mounted vertically	2 lamps

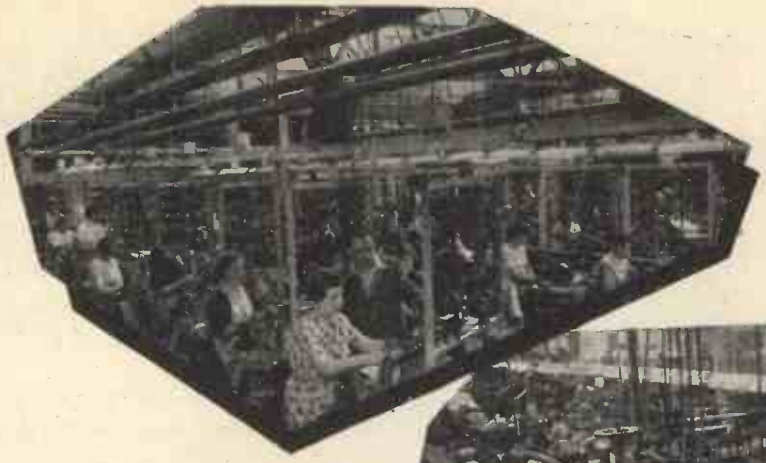
SPACE SAVING: All these components are of minimum size because they are designed round the unique Atlas Midget lamp only 0.575″ long and 0.249″ in diameter.

Three types of Thorn midget panel bulbs are available.

28 volts 0.04 amps
12 volts 0.1 amps
6 volts 0.1 amps

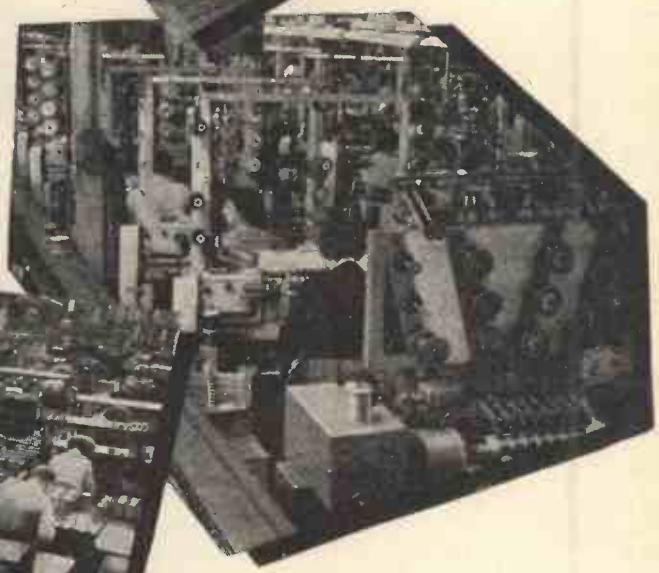
Write for illustrated brochure giving full details

Thorn Electrical Industries, Aircraft Components Division, Great Cambridge Road, Enfield, Middlesex. Tel.: Enfield 5340



It is no
exaggeration to term
Parmeko's Leicester factories
"the most extensive specialised
small-transformer plant in Europe".
Neither is it an overstatement to say
that most electronic and electrical
engineers translate the word
TRANSFORMER into

PARMEKO



PARMEKO

PARMEKO LIMITED, Percy Road, Leicester, England

. . . a loudspeaker typical of Goodmans fine Full Range High Fidelity Loudspeakers . . . the Axiom 150 Mk. II

AXIOM 150 Mk.II

A Full Range High Fidelity Loudspeaker. Power capacity 15 watts. Precision-built unit incorporating twin cone assembly giving extremely smooth coverage from 30-15,000 c.p.s. Bass modulation reduced to absolute minimum.

Nominal diameter 12 inches; fundamental resonance 35 c.p.s.; voice coil impedance 15 ohms at 400 c.p.s.; maximum power capacity 15 watts peak A.C.; flux density 14,000 gauss.

AXIOM 22 Mk.II

Similar to the Axiom 150 Mk.II loudspeaker but employs a more powerful magnet system resulting in extremely high electro-acoustic efficiency giving clear realistic reproduction up to the full rated power of 20 watts. Frequency range of 30-15,000 c.p.s. free from sub-harmonics and bass modulation effects.

Fundamental resonance 35 c.p.s.; voice coil impedance 15 ohms at 400 c.p.s.; maximum power capacity 20 watts peak A.C.; flux density 17,500 gauss.

The SHERWOOD Loudspeaker Cabinet

Designed to load the Axiom 150 Mk.II or the Axiom 22 Mk.II loudspeakers. When mounted, the response of these loudspeakers is extended down to 20 c.p.s. free from any objectionable resonances above this frequency. **This Cabinet incorporates an Acoustical Resistance Unit as the essential component in this system of loudspeaker loading.** Available in mahogany and walnut veneers.

Post the coupon for full details and prices.

Goodmans

GOODMANS INDUSTRIES, LTD., AXIOM WORKS, WEMBLEY, MIDDX.

Telephone: WEMbley 1200 Cables: Goodaxiom, Wembley, England.

BELGIAN AGENT : JEAN IVENS, 10 RUE TRAPPE, LIEGE.

GOODMANS INDUSTRIES, LTD., AXIOM WORKS, WEMBLEY, MIDDX.

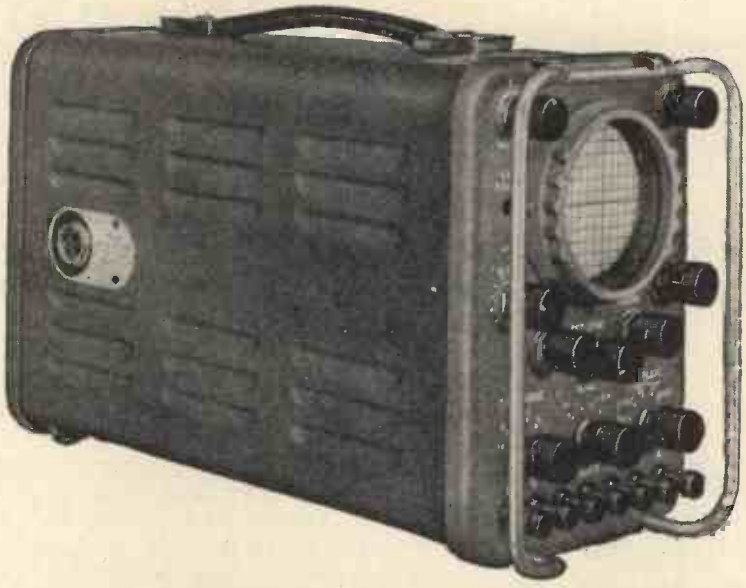
Full details and prices please.

Name.....

Address .....

WW/2/57

MINIATURE OSCILLOSCOPE



Type CT84

Type CT52

Weight—approx. 15 lb. Size—13½″×8″×5½″ approx. Finish—Dark Battleship Grey.

Designed as a general-purpose instrument, the Metrovick miniature oscilloscope is particularly useful for radar servicing. Its light weight and compact construction result in a portable and robust instrument designed to withstand rough use, so that it has now become standard equipment for the fighting services.

SPECIFICATION

SUPPLY: With A.C. Power Pack (CT52)—100/125 v., 200/250 v., 50/60 c/s.; 180 v., 500 c/s. With D.C. Power Pack (CT84) —28 volts D.C. Power consumption 50 VA approx.

CATHODE RAY TUBE: Hard tube—2¾in. diameter screen. Standard tube fitted has Green screen with medium afterglow. Alternative tubes can be fitted.

TIME BASE: Free-running linear time base, paraphase amplifier and synchronising. Repetition range 10 c/s. to 40 Kc/s. Single-sweep linear time base with paraphase amplifier, triggered by 30-volt pulse. Repetition range—50 c/s. to 3,000 c/s. Sweep range—50 milliseconds to 3 microseconds.

Y PLATE ATTENUATOR: Resistance attenuator, capacitance compensated. Flat response—3 db. from D.C. to 100 kc/s. Fixed attenuation of 14 db. (5 times).

Y PLATE CONNECTION: Direct or series capacitor connection.
Input resistance—2.5 megohms. Input capacitance—50 pf. approx.

Y PLATE AMPLIFIER: 1. Max. gain of 38 db. (80 times) flat to 3 db from 25 c/s. to 150 Kc/s. 2. Max. gain of 28 db. (25 times) flat to 3 db. from 25 c/s. to 1 Mc/s.

CALIBRATION: An internal supply of 50-volt peak ± 10%, sine wave, at the supply or vibrator frequency.

DELAY LINE: A delay network brought to the Y plate switch, and the displayed signal is delayed by approximately 0.5 microseconds, having its source impedance of 75 ohms.

RATING: Continuous operation at ambient temperatures between—32° C. and + 50° C.

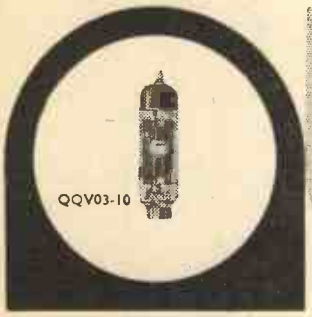
Write for leaflet 652/14-1 for technical details

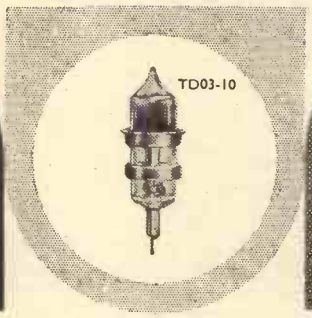
METROPOLITAN-VICKERS
ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER 17

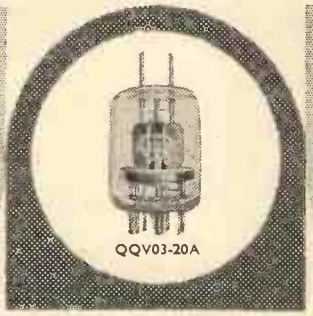
Member of the A.E.I. group of companies

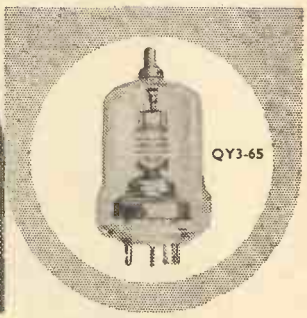
R/E603

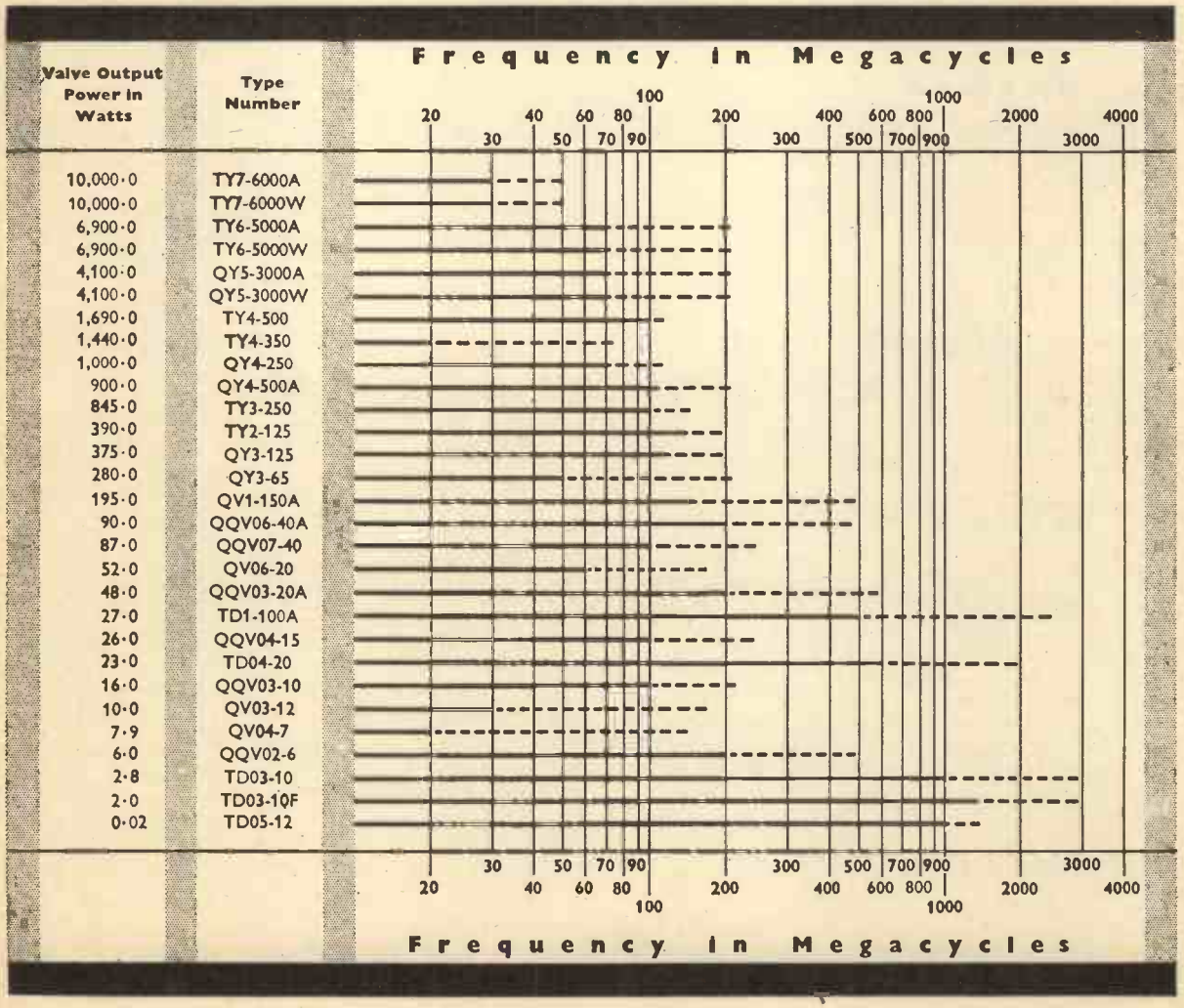
a transmitting all communications











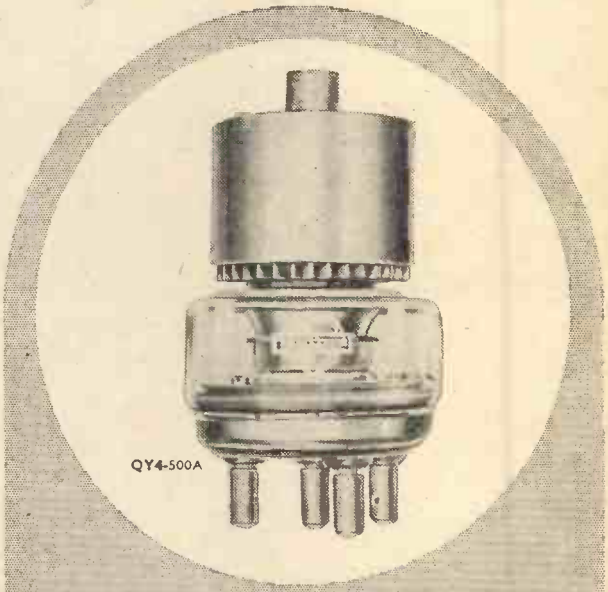
valve range for equipment

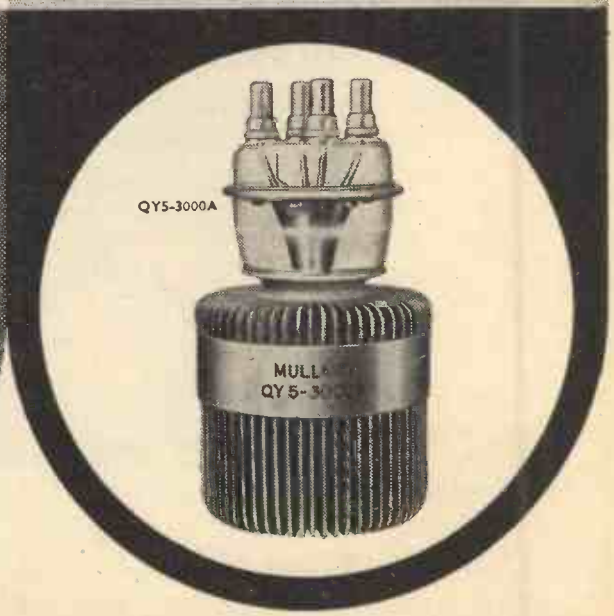
This extensive range of work-proven transmitting valves fills the wide and diverse needs of communications equipment manufacturers. The performance of this valve group extends to frequencies as high as 3,000 Mc/s for 0.5W and to powers up to 6.9kW at lower frequencies.

The Mullard technical advisory service is always at the disposal of manufacturers to answer questions relating to the applications and suitabilities of these valves.

Transmitting Valve Data

The chart on the left has been compiled to acquaint designers with the range and scope of Mullard transmitting valves available for communication purposes, and to facilitate the selection of suitable types for given applications.
The power quoted is the maximum valve output available with Class C telegraphy operation up to the frequency indicated by the junction of the solid and broken lines. The extent to which a valve may be used at higher frequencies with reduced ratings is given by the broken line.
More detailed information may be obtained from a leaflet on this range of valves and from individual data sheets—all of which are available on request at the address below.





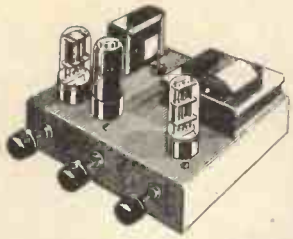
Mullard

COMMUNICATIONS AND INDUSTRIAL VALVE DEPARTMENT

MULLARD LIMITED · MULLARD HOUSE · TORRINGTON PLACE · LONDON · W.C.1

MV305a

with PREMIER



4 WATT AMPLIFIER

MAY BE BUILT FOR **£4.10.0** Plus 2/6 Pkg. & Postage

Instruction Book 1/- post free.

A steel case is now available, complete with engraved panel, for 15/6 extra. The amplifier may be supplied complete for £5/5/- plus pkg. and post 3/6, or fitted in case at £6 plus pkg. and post 3/6. Engraved panel 3/6. Post Free.

2-BAND TRF RECEIVER MAY BE BUILT FOR £5.15.0

plus pkg. & post 3/-

3 BAND SUPERHET RECEIVER

MAY BE BUILT FOR **£7.19.6** Plus 3/- Pkg. & Postage

These two receivers use the latest type circuitry and are fitted into attractive cabinets 12in. × 6½in. × 5½in. in either walnut or ivory bakelite or wood. Individual instruction books 1/- each, post free.

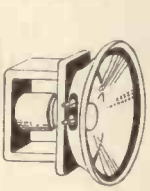
T.S.L., LORENZ SOUND SYSTEM

Type LP 312-2

Consists of a 12in. Unit and two LPH65 Treble Units, Co-axially placed to give the widest listening angle. Bass and treble Units have magnetic systems of the highest efficiency.

This speaker system gives a frequency response that is not excelled by any speaker that is at present available. Leaflet available giving full details. Price £14/19/6. H.P. Terms available. Postage and packing 7/6 extra.

Cross-over Unit designed for the LP 312-2 £2/2/- plus p. & p. 1/6.



SINGLE TREBLE UNITS available separately at 39/6 each plus packing and postage 1/- extra. Improve your existing Speaker system with this Unit which will give added brilliance to the higher frequency.

A range of High Fidelity Amplifiers, Speakers and Record Players the following makes in stock—Leak, E.A.R., Rogers, Goodmans, Wharfedale, W.B. Stentorian, Lorenz, B.S.R., Collaro, Garrard, Lenco, Connoisseur.

We shall be only too pleased to demonstrate any of the above equipment.

THE NEW "WHARFEDALE" SFB/3

3-SPEAKER SYSTEM

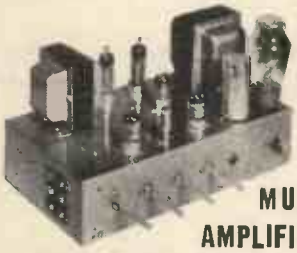
Consists of Speakers W12CS, Bronze 10CSB, Super 3HF and a special Crossover Unit fitted into a very attractive Cabinet, size 34in. × 31in. × 12in. Weight 60 lb. Cash £39/10/-. Credit deposit £5/0/0 and 8 monthly payments of £4/17/-, or H.P. deposit £19/15/- and 12 monthly payments of £1/16/8. Packing and carriage 21/-.

New GOODMAN TREBLE UNIT THE TREBAX

At £6/4/- is a high efficiency pressure driven reproducer covering 2,500 c.p.s. to 16 kc/s. It makes an excellent 2-speaker system when used with the Axiom 150 Mark II at £10/15/9. A special Crossover Unit type X05000 is available at £1/19/-. The complete system £18/18/9 cash. Credit terms deposit £2/7/9 and 8 monthly payments of £2/6/6, or H.P. Terms deposit £9/9/4 and 11 monthly payments of £1/1/-. Packing and carriage 7/6.

THE NEW TSL FM TUNER HIGH STABILITY MODEL

6 Valves including Magic Eye and Power Supply using the latest type Gorler permeability Unit complete with first audio stage and preset output volume control. Maximum radiation less than 10 microvolts per metre. Sensitivity better than .5 microvolts. Cash price £17/10/- (inclusive) or on H.P. terms, deposit £8/15/- and 9 monthly payments of £1/1/8. Credit terms deposit £2/3/9 and 8 monthly payments of £2/3/4. Postage and packing 5/- extra.



Why not make the best !

MULLARD AMPLIFIER KIT

NOW SUPPLIED WITH ULTRALINEAR OUTPUT TRANSFORMER.

All the components for model 510, PLUS pre-amplifier on one chassis (total six valves) chassis gold hammer finished. May be purchased for £12/12/- plus pkg. & post 7/6, or pre-amplifier and tone control in a separate unit £14/14/- plus pkg. and post 7/6.

ALL DRY BATTERY PORTABLE RADIO RECEIVER

MAY BE BUILT FOR **£7.8.0** Plus 3/- Pkg. & Postage

4 Miniature valves in a superhet circuit covering medium and long waves, Rexine-covered cabinets 11¼in. × 10in. × 5¼in., in two contrasting colours, wine with grey panel Instruction book 1/6 post free, which includes full constructional details and list of priced components.

WILLIAMSON AMPLIFIER

MAY BE BUILT FOR **£15.15.0** Plus 7/6 Pkg. & Postage

Supplied completely wired and tested for £20, or available on H.P. or Credit terms, postage and packing 10/-.

PRE-AMPLIFIER & TONE CONTROL UNIT

Available completely constructed, £5/5/- plus 2/6 packing and postage.

SPECIAL OFFER—*Limited Quantity.*

The Imperial AM/FM Radiogram Chassis

CASH

£16.19.6

or H.P. Terms — £8/9/9 deposit and 8 monthly payments of £1/3/9. Credit Terms £2/2/6 deposit and 8 monthly payments of £2/2/2. *Packing and carriage charge in each case* 7/6. This latest type Chassis is made by a leading Continental Manufacturer, it has 5 valves plus a Metal Rectifier, piano type push buttons for long, medium, F.M. and Gram, separate tuning on F.M. and A.M. Output 4 watts. Dial size 12in. × 2½in., overall size 13in. long, 7¼in. deep and 7¼in. high.

SPECIAL OFFER! GOODMANS AUDIOM 50. £4/17/6 plus pkg. and post 5/-.

AM/FM RADIOGRAM CHASSIS

The latest "Dulci" Model H.4

7 Valves (including Magic Eye). Ferrite Rod Aerials on medium and long "Gorler" permeability Unit on F.M. A.C. mains 200/250 volts. Cash price £27/16 or on H.P. or Credit Terms. Plus packing and carriage 7/6 extra.

AM/FM TUNER CHASSIS

DULCI MODEL H4T (Self Powered)

4 Wavebands. V.H.F. Short, Med., Long. "GORLER" F.M. Unit. Preset output Volume Control. Cash Price £20/17/- or on Hire purchase or credit terms. Plus packing and postage 5/- extra.

207, EDGWARE RD., LONDON, W.2. Tel: Ambassador 4033 & Paddington 3271

PREMIER RADIO COMPANY

PORTABLE TAPE RECORDER CABINETS

All Rexine Covered

Tape Deck	Amplifier	Type	Price
Lane Mk. VI	Premier	Mk. VI	£4 19 6
Lane Mk. VI	Premier	de Luxe	£4 19 6
Truvox Mk. III	Truvox C	T.D.3	£4 4 0

Plus Postage and Packing 5/-.

ILLUSTRATED LIST AVAILABLE GIVING FULL DETAILS OF BUREAU TYPE CABINETS

BARGAIN OFFER

LATEST TYPE RUBBER ESCUTCHEON SUITABLE FOR 17in. RECTANGULAR TUBES AT A SPECIAL PRICE OF 10/-. PLUS PACKING AND POST 1/6.

THE NEW COLLARO TAPE TRANSCRIPTER

SPEEDS 3¾, 7½ & 15 inches per Second £20 plus pkg./post 7/6

We carry a comprehensive stock of components by all leading manufacturers.

CABINETS—PORTABLE

MODEL PC/2

Grey Lizard Rexine covered 45/-
Overall dimensions 15in. × 13in. × 6in. Clearance under lid when closed 3in.

MODEL PC/2 DE LUXE

Two colours, wine and grey, with cutout for speaker and amplifier 55/6
Dimensions as above.

MODEL PC/3

Grey Lizard Rexine covered 69/6
Overall dimensions 16½in. × 14½in. × 10½in. Clearance under lid when closed 6½in.

MODEL PC/3 DE LUXE

As above but with cutouts for Speaker and Amplifier 79/6
Dimensions as above.

THE ABOVE CABINETS ARE COMPLETE WITH CARRYING HANDLE FASTENERS AND PANEL.
Packing and Postage 3/- each.

A RANGE OF BAND 3 AND F.M. AERIALS IS NOW AVAILABLE

Air spaced co-axial wire, 1/9 per yard.

Teletron Ferrite Rod Aerials. Medium Wave 8/9. Medium Long Wave 12/9.

PREMIER VARIABLE IMPEDANCE "MATCHMAKER" M.O.IS OUTPUT TRANSFORMERS

Designed to meet the demand for an efficient variable ratio output Transformer, 11 ratios from 13 : 1 to 80 : 1, all centre tapped and can be used to match any output valves either single or push-pull. Class "A," "AB1," "AB2" or "B" to any low impedance speech coil or combination thereof. Primary Inductance 50 henries 15 watts audio 100 mA. Price 45/-.

PREMIER MAINS TRANSFORMERS

All primaries are tapped for 200-230-250 v. mains 40-10 cycles. All primaries are screened.

SP175B, 175-0-175, 50 mA., 4 v. @ 1 a., 4 v. @ 2-3 a. 15/-
SP350A, 350-0-350, 100 mA., 5 v. @ 2-3 a., 6.3 v. @ 2-3 a. 21/-
SP351A, 350-0-350, 150 mA., 4 v. @ 2-3 a., 4 v. @ 3-6 a., 4 v. @ 1-2 a., 4 v. @ 1-2 a. 30/-
SP352 350-0-350 150 mA., 5 v. @ 2-3 a., 6.3 v. @ 2-3 a. 6.3 v. @ 2-3 a. 30/-
SP425A, 425-0-425, 200 mA 6.3 v. @ 2-3 a., 6.3 v. @ 3-5 a., 5 v. @ 2-5 a. 52/6
250-0-250, 80 mA. 6.3 v. @ 4 a., 5 v. @ 2 a. 22/6
350-0-350, 80 mA., 6.3 v. @ 4 a., 5 v. @ 2 a. 22/6
200-230-250 output 3 v.-30 v. @ 2 a. 17/6

PUSH-PULL OUTPUT TRANSFORMERS. 2×6V6 into 2/3 ohms, 5/6 post free.

JUNCTION TRANSISTORS
10/- EACH
Equivalent of the OC70 Type

★ **IT WILL PAY YOU TO VISIT OUR NEW HI-FI DEMONSTRATION ROOM.**

MAKE YOUR OWN ROD AERIAL

Ferrite rod 6in. × 5/16in., complete with descriptive constructional details. These aerial rods are suitable for medium and long wave reception. Price 5/3, post free.

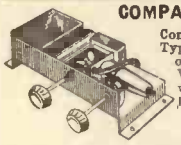
THE JASON "ARGONAUT" MW/FM DESIGN

All Premier Components are designer approved

The very latest FM Receiver design PLUS a medium waveband, as described in "The Radio Constructor." ALL components to build the complete Receiver, including output stage, may be purchased for £15/5/-, or all components less output stage but including Power Supply, for £13/19/6, plus packing and postage 3/6 on each. The chassis, front plate, dial flywheel drive assembly special tuning condenser-and wavechange switch (which includes mains switch) supplied completely assembled. This is also available separately at £4/4/- plus packing and postage 2/6.

SEND 2½d. STAMP FOR OUR NEW 1957 CATALOGUE

COMPACT GRAM AMPLIFIER



Complete, ready to connect to any Type of Pick-up and Speaker (3 ohms) A.C. Mains 200/250 volts. Volume and tone control fitted with knobs. Overall size 7½in. long × 3½in. wide × 2½in. high.
£2.19.6
Plus packing and postage 2/6

WHY BUY SURPLUS OR RE-CONDITIONED TUBES WHEN THESE FULLY GUARANTEED WIDE ANGLE TUBES ARE AVAILABLE? THE LATEST TYPE 17" RECTANGULAR TUBE MW43/64 BY TELEFUNKEN AT £17 (INC. TAX) POST AND PACKING 21/- EXTRA.

A LARGE RANGE OF TEST METERS IN STOCK

T.S.L. ELECTROSTATIC SPEAKERS

Type LSH75 ..... Price 12/6
Type LSH100 ..... Price 21/-
Type LSH518 ..... Price 17/6

LATEST B.S.R. MONARCH 4-SPEED AUTOCHANGER

Designed to play 12in. 10in., and 7in. Records intermixed in any order at 16, 33⅓, 45 or 78 r.p.m. Capacity 10 Records. New reversible. Dual Styfus Crystal Pick-up, for use on 100/250 v. 50 cycle A.C. mains, £9/15/- plus packing and postage 5/-. Deposit 25/- and 8 monthly payments of 25/-.

B.S.R. TU8 3-speed Record Player £4/12/6 plus 2/6 post and packing.

LATEST TYPE 3-SPEED SINGLE PLAYER B.S.R. H.F.100

With crystal turnover head, for use on 100-250 v. 50 cycle A.C. mains. £6/10/- Plus pkg. and carr. 5/-.

LOUDSPEAKERS

ELAC ELLIPTICAL 7in. × 4in. 21/10
ELAC—8in. dia. Moving Coil 3 ohms imp. 21/-
PLESSEY 8in. dia., Mains Energised, 3 ohms imp. (600 ohms field) with Pentode Transformer 10/6
PLESSEY—8in. dia. Mains Energised, 3 ohms imp. (600 ohms field) 7/6
PLESSEY—2½in. dia. Moving Coil, 3 ohms imp. 18/9
GOODMANS—Audiom 60 ..... £9/2/9
Plus 5/- packing and carriage.
GOODMANS—Axiom 150 ..... £10/15/9
Plus 5/- packing and carriage.

TUNING CONDENSERS (SMALL TYPE)

2-gang .0005 mfd. with trimmers, 5/-.

METER RECTIFIERS

Miniature type with leads 1-5 mA. 5/-, post paid.

WEYMOUTH MINIATURE COIL PACK

Covering Med./Long/Short Wave Bands. Iron Cored Coils. Dimens.: Ht. 1¾", length 3¾", width 2¾". Price 29/6.

TERMS OF BUSINESS:

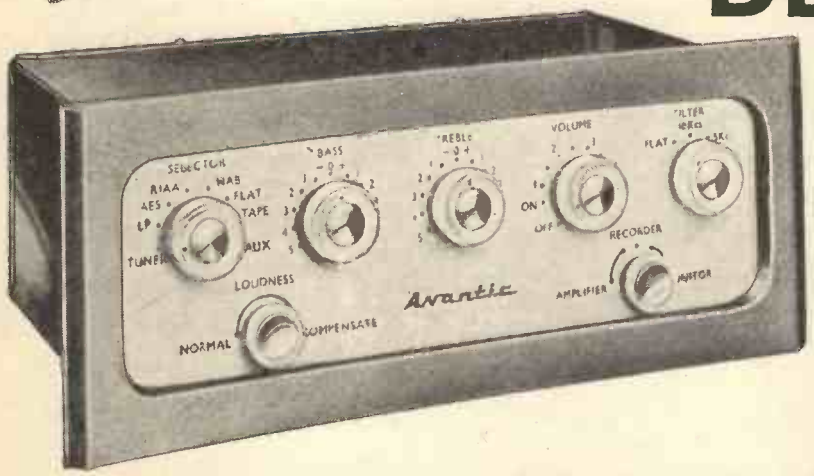
Cash with order or C.O.D. over £1. Please add 1/- for Post Orders under 10/-. 1/6 under 40/-. unless otherwise stated.

PREMIER PERSONAL PAYMENTS PLAN ITEM	CASH PRICE	CREDIT TERMS DEPOSIT	CREDIT TERMS MONTHLY PAYMENTS	H.P. TERMS DEPOSIT	H.P. TERMS MONTHLY PAYMENTS
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Premier Bureau Cabinet	12 12 0	1 12 0	(8) 1 12 6	6 6 0	(8) 18 3
Premier Bureau de Luxe Cabinet	17 6 6	2 3 4	(8) 2 2 10	8 13 0	(12) 16 1
Rogers Amplifier and Pre-amp.	26 0 0	3 4 6	(8) 3 4 0	13 1 3	(12) 1 4 0
Mullard EAR/5/13	18 18 0	2 7 3	(8) 2 6 6	9 9 3	(8) 1 6 3
Mullard EAR/6/10P	24 3 0	3 0 6	(8) 2 19 5	12 2 0	(12) 1 2 4
Leak TL10	28 7 0	3 11 0	(8) 3 9 9	14 3 0	(12) 1 6 4
Garrard Transcription Type 301 less P/U	26 8 3	3 6 0	(8) 3 5 0	13 4 0	(12) 1 4 6
Garrard Changer Type RC80M AC/DC	26 3 5	3 5 5	(8) 2 10 1	13 1 9	(12) 1 4 3
Garrard Changer Type RC98H AC	19 17 7	2 9 1	(8) 2 9 0	9 19 4	(9) 1 4 6
Lenco-Transcription Unit Model F50-8 complete with P/U	21 16 2	2 14 6	(8) 2 13 3	10 18 8	(12) 1 0 2
Goodmans Axiom 102 Speaker	10 7 9	1 5 0	(8) 1 6 6	5 3 9	(6) 1 0 8
Goodmans Axiom 150 MK. 1	10 15 9	1 7 1	(8) 1 7 4	5 7 9	(6) 1 1 4

207 EDGWARE RD., LONDON, W.2.

Tel: AMBassador 4033 and PADdington 3271

FACTS about the new Avantic DL7-35



This amplifier needs no "sales talk"—the specification speaks for itself

Announcing the Avantic 'GLYNDEBOURNE'

The DL7-35 with wide range speaker system can be supplied in two superb cabinets finished in natural mahogany at £144.5.0. net. Provision is made for any of the following items which can be fitted as optional extras: 4-speed single or automatic record player; Avantic vhf-fm or mw-am/vhf-fm radio feeder unit; Avantic tape player.
The Avantic loudspeaker system comprises a 12″ diameter low frequency unit and two 2½″ high frequency units. The frequency range of the system is 20—22,500 cps. and the peak power ratings are 40 watts (l.f.) and 10 watts (h.f.).

Please send me illustrated leaflets on the DL7-35 and 'Glyndebourne'; also the name of my nearest Avantic dealer.

NAME.....

ADDRESS .....

.....

.....

..... W.1

POWER AMPLIFIER

Push-pull distributed load output stage producing an output of 27 watts at ± 0.1% total distortion.
Frequency response: ± 1 dB 1 c/s. to 100 Kc/s.
Damping factor: 50. **Sensitivity:** 255 mV. for 27 watts output.
Hum & noise: —89 dB relative to 20 watts output.
Output impedances: 4Ω, 8Ω & 16Ω switch selected; automatic feedback adjustment. Built-in volume control and two audio input sockets.

PRE-AMPLIFIER CONTROL UNIT

Output: 200 mV. at 0.1% and 2.0V. at 0.2% total distortion.
Intermodulation distortion: power & pre-amplifier combined: 1% for 20 watts output.
Noise: —64 dB on radio or tape inputs; —53 to —56 dB on pick-up inputs.
Radio power-outlet: 6.3V. 2.5A., 440V 30 mA. **Tape recorder outlet.**
8-Inputs: Tuner (2 levels) Pick-up (3 levels) Tape & Auxiliaries (2 levels).
Controls: 8 position selector switch incorporating 5 record play-back characteristics.
Loudness control providing compensation for low level reproduction of high level inputs in accordance with Fletcher-Munson loudness curves.
Bass Control: —15 dB at 30 c/s. to +16 dB at 50 c/s.
Treble control: —15 dB to +15 dB at 10 Kc/s.
Low-pass filter: 3-positions: 20, 10 & 5 Kc/s. Slope: 12 dB/octave.
Rumble filter: 40 c/s. turnover frequency. Slope: 12 dB/octave.
Monitor/Record switch: 3 positions.
Price: Power amplifier and pre-amplifier control unit complete £55.

Avantic
HIGH FIDELITY REPRODUCERS MANUFACTURED BY
Beam-Echo Limited
Witham, Essex.
Telephone: Witham 3184. Telegrams: Parlon, Witham

Wireless World

ELECTRONICS, RADIO, TELEVISION

Managing Editor: HUGH S. POCOCK, M.I.E.E.
Editor: H. F. SMITH
Assistant Editor: F. L. DEVEREUX, B.Sc.

FEBRUARY 1957

In This Issue

VOLUME 63 No. 2

PRICE: TWO SHILLINGS

FORTY-SIXTH YEAR OF PUBLICATION

Editorial, Advertising and Publishing Offices:
Dorset House, Stamford Street, London, S.E.1

Telephone:
WATerloo 3333 (60 lines)

Telegraphic Address:
"Ethaworld, Sedist, London".

PUBLISHED MONTHLY (4th Tuesday of preceding month) by ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1. *Telephone:* Waterloo 3333 (60 lines). *Telegrams:* "Iliffepres, Sedist, London." *Annual Subscription:* Home and Overseas, £1 12s. 6d. U.S.A. and Canada $5.00. BRANCH OFFICES: *BIRMINGHAM:* King Edward House, New Street, 2. *Telephone:* Midland 7191. *COVENTRY:* 8-10, Corporation Street. *Telephone:* Coventry 5210. *GLASGOW:* 26B Renfield Street, C.2. *Telephone:* Central 1265. *MANCHESTER:* 260, Deansgate, 3. *Telephone:* Blackfriars 4412. OVERSEAS OFFICES: *U.S.A.:* 111 Broadway, New York, 6, N.Y. *Telephone:* Digby 9-1197. *CANADA:* 74, College Street, Toronto, 2, Ontario. *Telephone:* Walnut 4-5631

A Transistor Controlled Regulated Power Unit

The circuit diagram of the regulated power unit, shown below, demonstrates a novel application of transistors as control devices. They are especially suited for this type of circuit because of the high voltage gains which can be obtained with them when they are operated with large collector loads from high voltages. In the power unit described, a Mullard OC73 is used to control the current flowing through an EL38 series valve. One advantage of using a transistor in this type of regulated power unit is that a separate negative h.t. supply is eliminated.

The power unit has an output impedance of less than three ohms, and will deliver 100mA at any voltage between 40 and 84 volts regardless of quite large changes in the mains input voltage. For instance; if the mains input voltage rises from 198V to 242V, the output voltage will increase by only 0.4V at full load. Reducing the load from 100mA to zero produces a rise in output voltage of only 0.3V at 220V mains input.

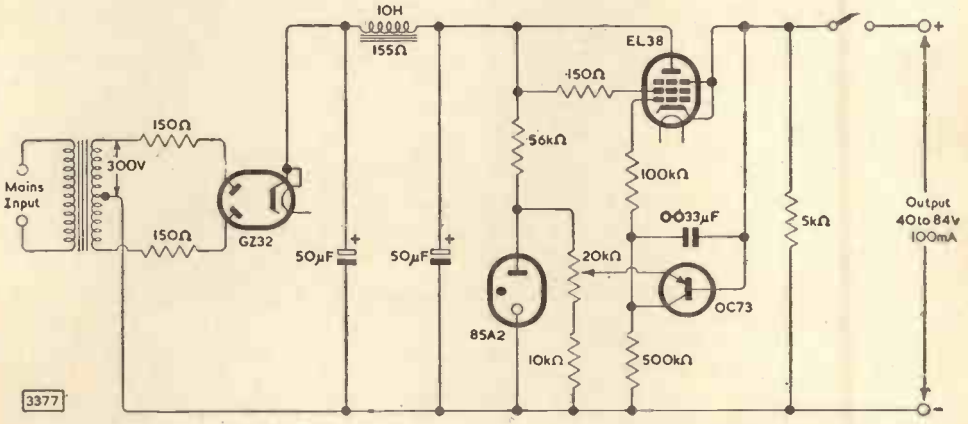
CIRCUIT OPERATION

By connecting the transistor as shown in the circuit diagram it compares the output voltage with the reference voltage, and any difference produces a large change in collector current due to its high effective mutual conductance.

Since a transistor can be operated at very low currents, very high voltage gain is obtained by connecting the collector to negative h.t. through a load of 500kΩ. The collector is connected also to the control grid of the EL38 through a 100kΩ grid stopper. Therefore the collector-to-base voltage of the transistor is equal to the grid-to-cathode bias of the valve and is practically independent of the output voltage setting.

The output voltage is approximately equal to the reference voltage and can only differ from it by the base-to-emitter voltage of the transistor, which will be less than 0.1V. So the maximum output which can be obtained is determined only by the reference voltage. Although an 85V reference level is used in the circuit described, the design is almost identical for any reference level. The minimum output voltage of this supply unit cannot be set below the bias voltage of the series valve and therefore it is limited to about 40V.

When the power unit is working, a drop in output voltage will cause the base of the OC73 to become negative with respect to the emitter. As a result, the collector current increases and the collector voltage becomes more positive, thus reducing the bias on the EL38 and compensating for the original change. Equilibrium will be reached when the output voltage reaches the same value as the emitter voltage.



Variations in the mains voltage have only a slight effect on the reference voltage, which is stabilised by the 85A2, and therefore the output voltage remains substantially constant.

CIRCUIT DESIGN

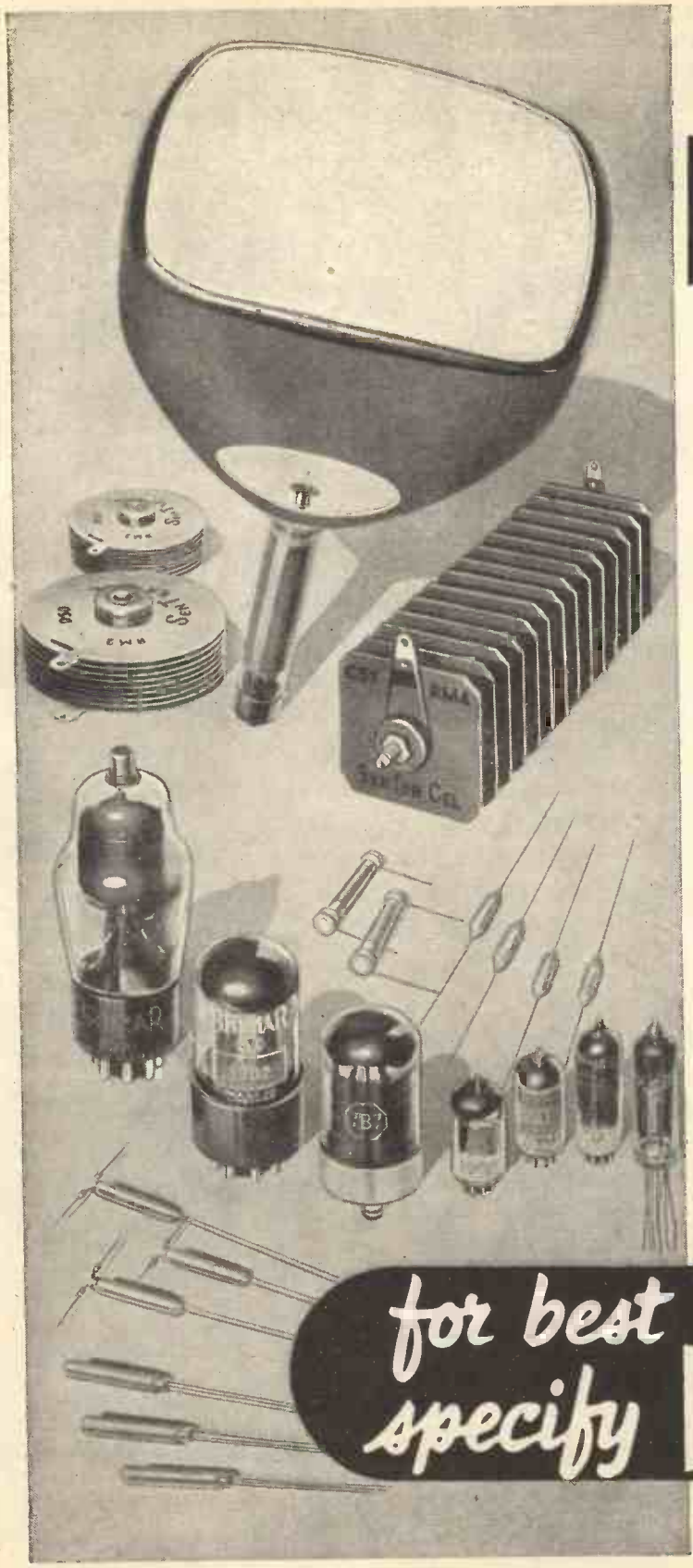
The full-wave rectifier circuit is of conventional design, with choke smoothing to give a ripple-free output to the series valve, an EL38, and to the voltage reference tube, an 85A2. The 85A2 is operated at a low burning current to minimise the change in the reference voltage when the circuit is loaded and the poor regulation of the rectifying circuit causes the unstabilised voltage to fall.

An EL38 was chosen for the series valve because it has a comparatively short grid base. This is important since it governs the maximum collector-to-base voltage when no current is being taken from the supply. To prevent the collector voltage exceeding the — 30V collector-to-base rating of the OC73, the output must be permanently loaded to about 10mA; 5kΩ forms the permanent bleeder resistor.

The stability of the output is limited by the stability of the reference source, and by using an independent reference voltage or running the 85A2 from a 150B2, the stability could be increased, and the output impedance reduced to at least half the value given.

Changes in temperature have negligible effect on the output voltage and impedance but an appreciable increase in ambient temperature raises the minimum transistor leakage current and slightly increases the minimum output voltage to which the supply can be set. This effect limits the maximum value of collector resistance which can be used. For operation at higher temperatures a smaller collector load resistance should be chosen.

Instability may occur when the power supply is first switched on if it is connected directly to a high current load, so a switch has been included in the circuit and should not be closed until the reference tube has ignited. The 0.033μF capacitor between the base and collector prevents high frequency oscillation which can occur under certain conditions.



Use BRIMAR

Teletubes
Radio Valves
and
Special
Components

- METAL RECTIFIERS
- BRIMISTOR CURRENT SURGE RESISTORS
- GERMANIUM DIODES
- TRANSISTORS

for best results specify **BRIMAR**

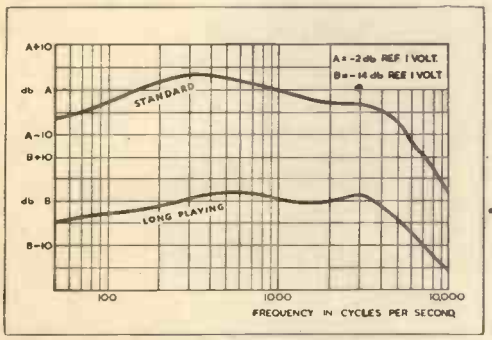
Standard Telephones and Cables Limited FOOTSCRAY, SIDCUP, KENT. Footscray 3333

Acos G.P. 61 ceramic pick-up cartridges pass B.S.I. tropical test with flying colours

A batch of ACOS GP61 Ceramic Cartridges was recently tested by an independent user under the BSI Test No. BF 2011, Class 112, "Basic Climatic and Durability Test for radio and allied equipment." The result shown on the right speaks for itself. Further, the GP 61 has great mechanical robustness, smooth response, low harmonic and intermodulation distortion, high needle tip compliance, replaceable "X 500" styli and very good output.

16 HOURS
at 55°c (131°F)
and 95% humidity

Sensitivity	*Shape of Response*
-1db	**No change**



always well ahead

ACOS devices are protected by patents, patents applications and registered designs in Great Britain and abroad.

THE ACOS G.P. 61 FITTED WITH 'X 500' STYLI IS THE HIGH PERFORMANCE CARTRIDGE FOR MANUFACTURERS WITH WORLD MARKETS

COSMOCORD LIMITED, ELEANOR CROSS ROAD, WALTHAM CROSS. Telephone: Waltham Cross 5206

"BELLING-LEE" NOTES

Photo by courtesy of the Scotsman.

A recent photograph of the I.T.A. site at Blackhill showing the commencement of the main mast on the right, and in the centre the " Belling-Lee " " Skytower " acquired by the Authority and which will be used for the early test signals. This mast has now been completed and signals scheduled to commence early in March. On the left is Mr. A. P. Hale, Grad.I.E.E., and Mr. Boyd, both of Belling & Lee, whose riggers are seen at work. The sheet of water in the background is the Airdrie Coatbridge and District Reservoir.

In these uncertain times it is always dangerous to look into the future, but many Scottish readers will be glad to know that an alternative television programme is definitely on the way. The " Belling-Lee " " Skytower," recently purchased by the Independent Television Authority is seen being erected. It was completed before the photograph was printed. This aerial will be used for the pilot transmitter, scheduled to be on the air in March. The Scottish public will be given the opportunity of " seeing what they are buying," what kind of programmes they can expect. Scottish Television Ltd., the programme company, is organising a series of exhibitions throughout the service area commencing in February.

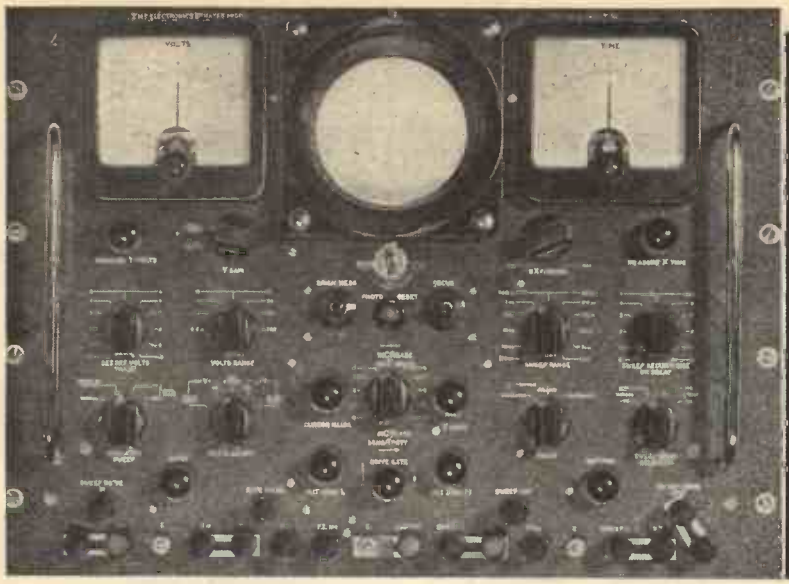
Radio dealers will be able to tell their friends all about them, and when one will be in any particular district. The dealer will also be able to give guidance on the type of aerial that will probably be required or what modifications will be needed to an existing B.B.C. aerial. Most " Wireless World " readers know that the reception of band III presents greater difficulties than the reception of band I. For example on band III the loss in any cable is about twice as much as it is on band I. It is important only to use solid cable on short runs. Cellular type is recommended for general use, and semi-air-spaced for long runs or anywhere outside the transmitter service area. On a 50 foot run, the gain obtained by using air spaced feeder instead of solid is 1.7 dB which is approximately the difference between a 3 and a 6-element array. The difference in price between the aerials is 18/-, the difference in price between 50 foot of solid and semi-air-spaced feeder is £1/3/4. The superior aerial can help you to get rid of ghosts and interference, the better feeder can only help with gain. In difficult locations the better aerial should be specified and the better feeder.

Radio Wave Propagation and the problems of Television Bands IV and V.

By R. L. SMITH-ROSE, C.B.E., D.Sc., F.C.G.I., M.I.E.E.

In a recent issue of the Journal of the Television Society a paper was published under the above heading. It includes a wealth of information of great value to all technical readers interested in television signal propagation. We are indebted to the author and the Society for permission to reprint this paper, a copy of which will gladly be sent on request.

Written 20th December, 1956



THE NEW W-I-D-E R-A-N-G-E OSCILLOSCOPE TYPE WM5A (25Mc/s)

- Precision time, voltage a.c./d.c. measurements without arbitrary graticules or calibrating waveforms.
- Sweep delay or return sweep displayed as extra trace gives continuous time display.
- Display expansion greater than 2500:1 on a given range.
- Photo sweep and voltage reference trace with auto-blackout.
- High brilliance fine focus EMITRON C.R.T. with full 10 cms. deflection.
- Variable E.H.T. (1 to 10 kV) gives 10 to 1 display expansion with unmodified bandwidth.
- Add-on sub-units give performance extension.
- Additional stabilised supplies and waveforms for external use.
- Voltage measurements—100 mV to 500 V (2½%), unaffected by variations in supply, C.R.T. or amplifier linearity, or degree of expansion.
- Time measurements—20 mμS to 100 mS (2½%) direct from meter.

Fully descriptive literature available from

E. M. I. ELECTRONICS LTD.

Instrument Division

HAYES · MIDDLESEX

Telephone SOUthall 2468 (Ext. 1013 & 655)

8E30

55 volts- a really low voltage stabiliser

MECHANICAL DATA

Maximum overall length	66.7	mm
Maximum seated height	60.3	mm
Maximum diameter	19.1	mm
Base	B7G	
Net weight	8.5	g

CHARACTERISTICS

Maximum striking voltage	90	V
Stabilising voltage	55	V
D.C. operating current	2 to 30	mA
Maximum peak current (10 seconds max.)	75	mA
Nominal regulation 2 to 30 mA	3	V
Maximum regulation 2 to 30 mA	5	V
Ambient temperature range	−55 to +90	°C

The G55/1K is a miniature cold-cathode, gas-filled, voltage stabiliser for use in industrial and radio equipment where a stable source of voltage is required. The outstanding feature of this valve is the low maintaining voltage of 55 volts.

Type G55/1K

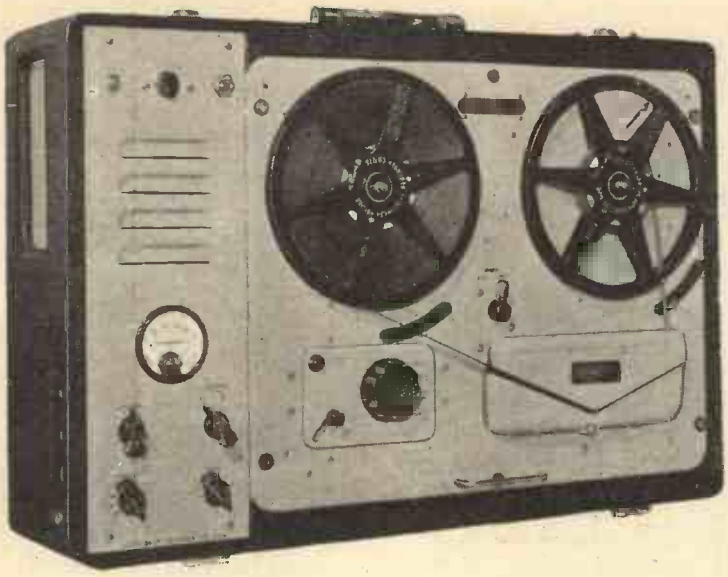
data sheet available from:

Standard Telephones and Cables Limited

VALVE AND TRANSISTOR SALES DEPARTMENT

CONNAUGHT HOUSE · 63 ALDWYCH · LONDON W.C.2.

Vortexion TAPE RECORDER



★ The total hum and noise at 7½ inches per second 50-12,000 c.p.s. unweighted is better than 50 dbs.

★ The meter fitted for reading signal level will also read bias voltage to enable a level response to be obtained under all circumstances. A control is provided for bias adjustment to compensate low mains or ageing valves.

★ A lower bias lifts the treble response and increases distortion. A high bias attenuates the treble and reduces distortion. The normal setting is inscribed for each instrument.

★ The distortion of the recording amplifier under recording conditions is too low to be accurately measured and is negligible.

★ A heavy mu-metal shielded microphone transformer is built in for 15-30 ohms balanced and screened line, and requires only 7 micro-volts approximately to fully load. This is equivalent to 20ft. from a ribbon microphone and the cable may be extended 440 yds. without appreciable loss.

★ The .5 megohm input is fully loaded by 18 millivolts and is suitable for crystal P.U.s, microphone or radio inputs.

The amplifier, speaker and case, with detachable lid, measures 8¼in. x 22½in. x 15¾in. and weighs 30lb.

PRICE, complete with WEARITE TAPE DECK £84 0 0

★ A power plug is provided for a radio feeder unit, etc. Variable bass and treble controls are fitted for control of the play back signal.

★ The power output is 3.5 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

★ The play back amplifier may be used as a microphone or gramophone amplifier separately or whilst recording is being made.

★ The unit may be left running on record or play back, even with 1,750ft. reels, with the lid closed.

FOUR CHANNEL ELECTRONIC MIXER

is almost essential for the professional or semi-professional where a number of different items have to be mixed on one tape recording.
It is recommended by a number of tape recorder manufacturers for this purpose.
Any normal input impedance can be supplied to order, balanced or unbalanced, the standard being 15-30 ohms balanced.
The normal output is 0.5 volt on 20,000 ohms or more, but 600 ohms is available as an alternative.
The steel stove enamelled case is polished and fitted with an engraved white panel suitable for making temporary pencil notes.
An internal screened power pack and selenium rectifier feed the five low noise non-microphonic valves.
Used in many hundreds of large public address installations and recording studios throughout the world.

PRICE £36 15 0

Manufactured by

VORTEXION LIMITED, 257-263, The Broadway, Wimbledon, London, S.W.19

Telephones: LIBerty 2814 and 6242-3 Telegrams: "Vortexion, Wimble, London."

Britain's finest Hi-Fi Equipment . . .

It was in 1945 that H. J. Leak revolutionised the performance standards for audio amplifiers by designing the original "Point One" series, and we became the first firm in the world to market amplifiers having a total distortion content as low as 0.1 per cent. This claim was received with incredulity, but it was subsequently confirmed by the National Physical Laboratory and since then hundreds of TL/12 amplifiers have been used by the B.B.C., and Commonwealth and foreign broadcasting authorities, and thousands have been used by recording studios, leading musicians and music-lovers throughout the world.

Further development work resulted in our producing, at a much lower price but with the same high performance standards, the TL/10 amplifier. The output of the TL/10 is ample for high fidelity home music systems, and the quality of reproduction obtained is equal in every respect to that of the TL/12. We always use the TL/10 amplifier and "Point One" pre-amplifier for our public demonstrations of high fidelity reproduction of gramophone records and radio. The TL/10 amplifier, when used with the best available complementary equipment, gives to the music-lover a quality of reproduction unsurpassed by any equipment at any price. Even when the complementary equipment falls below that of the best obtainable the use of these amplifiers will enable one to obtain very marked improvements in reproduction.

We shall be pleased to send you full details of

LEAK

HIGH FIDELITY EQUIPMENT

The

B.B.C. MONITOR LOUDSPEAKER UNIT

uses a

LEAK TL/12 AMPLIFIER

Price £28.7.0

Below:

LEAK TL/10 10-watt Amplifier, 17gns. and "Point One" Pre-amplifier, 10gns.

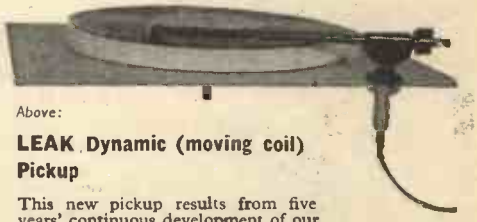
Prices made possible only by world-wide sales

Harmonic Distortion 0.1% 1,000 c/s, 7.5 watts output.

On Left:

LEAK TROUGH-LINE F.M. Tuner, £25 plus 10 gns. P.T.

A Trough-line inductor and AFC eliminate drift. Very high sensitivity for fringe area listening. Quieting control plus high fidelity discriminator. Cathode-follower output. Self powered to operate with any amplifier.



Above:

LEAK Dynamic (moving coil) Pickup

This new pickup results from five years' continuous development of our first moving-coil design. Reports from users have justified our earlier belief that the pickup might earn recognition as the best in the world.

Leak dynamic pickup: Arm ...	£2.15.0	p.t. £1.3.1
LP head with diamond stylus	£5.15.0	p.t. £2.8.4
78 head with diamond stylus	£5.15.0	p.t. £2.8.4
Mumetal cased transformer...	£1.15.0	

FREL is the trade name of the Leak Full-range Electrostatic Loudspeaker which will be available to the public in 1957. The design is original and has great theoretical and practical advantages over previously described electrostatic loudspeaker systems. It is the result of intensive research and development work carried out by H. J. Leak, M.Brit.I.R.E., and A. B. Sarkar, M.Sc., who are the authors of a paper, describing the basic design principles of this loudspeaker, which was published in the "Wireless World," October 1956. A reprint of this paper will be supplied on request.

The first name in High Fidelity . . .

LEAK

H. J. LEAK & CO. LTD., BRUNEL ROAD, WESTWAY FACTORY ESTATE, ACTON, W.3, ENGLAND

Telephone: SHEpherds Bush 1173 4/5 *Telegrams: Sinusoidal, Ealux, London* *Cables: Sinusoidal, London*

T.V. Commercialising Outfit

DO IT YOURSELF IT'S REALLY QUITE EASY

You will manage it in an evening and we guarantee

SUCCESSFUL RESULTS OR MONEY BACK

Our parcel contains: *I.T.A. Aerial, 36ft. I.T.A. Down Lead, I. T. A. / B.B.C. Interference Eliminator, I.T.A. Converter.* A special bargain price for all the above items if bought together is £8/10/-. Or £1/10/- down and 8 monthly payments of £1. Post and ins. 4/6 Full details with illustrations 1/6.

ELECTRIC BLANKET WIRE

Waterproof P.V.C. covered, so blanket washable, 16½ ohms per foot—1/6 per yard. 14 yards, ideal for average blanket. £1, post free.

PHILLIPS TRIMMERS

0-30 pf. 1/- each.
11/- per doz.
£6 per gross.

THIS MONTH'S SNIP

Midget ceramic condensers, tubular wire ended. 2,000 pf. 5/- per doz. 500 pf. 4/6 per doz. 1,000 pf., lead through ceramics, 8/- per doz. All post free. Special quote for 1,000 lots.

TRANSISTORS

Red spot replaces Mullard OC71, etc., 10/-. Blue spot suitable R.F. up to 1.6 Mc/s, 15/- each

POCKET TRANSISTOR RECEIVER

All the parts to build cigarette box receiver, £2/17/6, includes Ferrite aerials but not the earpiece, battery or case.

INDUSTRIAL OVERHEAD HEATER

This overhead heater warms only the area within its radiant rays, and so effects a considerable saving of fuel. Its benefits are felt immediately, there is no warming-up period. It is essentially a personal type of heater, having controls within easy reach of the operative. The controls give four variations of heat and "Off." At maximum heat the unit consumes 1 kW.

The Infray Major is of particular use:—

(a) In large rooms, warehouses, lofts, machine shops, etc., where the cost of heating the whole room to a comfortable level would be too great.

(b) In rooms which in the main have to be kept cool, e.g., food storage chambers, beer cellars, etc.

(c) In any situation where local heating is required quickly.

Price is £7/10/-, carriage paid.

BLACK HEAT ELEMENTS

Ideal to use as a heating unit for airing cupboard, clothes dryer, bathroom towel cabinets, etc. Complete in outer metal case which is designed to keep at a "non-burning" temperature. 5 year guarantee.

500 watt, size approx. 24×4×4in..... 30/-
1,000 watt, size approx. 48×4×4in..... 50/-
Carriage and insurance 500 watt 3/6, 1,000 watt 5/-.

THE "CRISPIAN" BATTERY PORTABLE

A 4-valve truly portable battery set with very many good features as follows:

- **Ferrite Rod Aerial.**
- **Low consumption valves (DK96 range).**
- **Superhet circuit with A.V.C.**
- **Ready built and aligned chassis if required.**
- **Beautiful two-tone cabinet.**
- **Guaranteed results on long and medium waves anywhere.**

All parts, including speaker and cabinet, are available separately or if all ordered together the price is £7/15/- complete. Post and insurance 3/6. Ready built chassis 30/- extra. Instruction booklet free with parts or available separately 1/6.

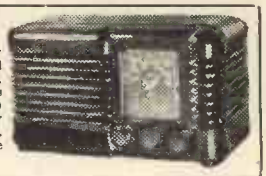
METER MOTORS

These are very small A.C. mains operated motors which have many applications for driving toys or other light loads. All are in good condition, but not new, having been stripped from electric light meters. Final speed of approx. 1 rev. per hour.
Price 8/6 each. Post and insurance 2/-.

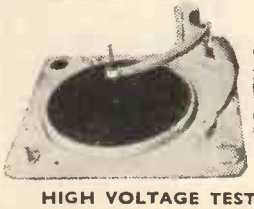
OFFERED FOR LESS THAN THE VALUE OF ITS COIL PACK

This set, a product of one of our famous manufacturers, has H.F. stage, covers 5 wavebands including short waves to 11 metres. Offered less valves, power-pack, scale and drive, otherwise complete and unused. Price £3/15/-, plus 7/6 carriage.

NEW CIRCUIT



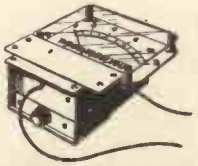
OCCASIONAL 56—we have evolved a new T.R.F. circuit and have had really good results, equal in fact to many superhets. You really should try this circuit. All parts including valves (6K7, 6J7, 6F6 and 6X5) and Bakelite case with back cost only £5/10/-, plus 2/6 post and insurance. Data included with the parts is also available separately, price 2/-.



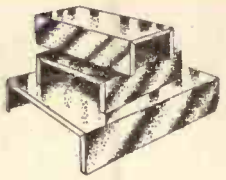
4-SPEED & 3-SPEED GRAMOPHONE AUTO-CHANGER

Latest types by all famous makers are invariably in stock at competitive prices. B.S.R. Monarch, Garrard, etc. Latest models from £7/15/-, plus 5/- carriage and insurance.

HIGH VOLTAGE TESTER



An instrument that will measure voltages up to 10,000 but which draws no current from the source, will probably be a valuable addition to your workshop equipment. It can be made entirely from odds and ends. Booklet giving full instructions plans, etc., 2/6 post free.



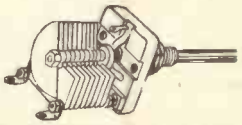
'BLANK CHASSIS 18 S.W.G. Aluminium

7×3½×2 ..	3/9	14×10×3 ..	7/9
9½×4½×2½	5/-	16×10×3 ..	8/3
10×8×2½ ..	5/6	16×12×3 ..	8/8
10×5½×2½	5/-	19½×9×2½ ..	8/3
12×9×2½ ..	7/-	20×10×3 ...10/-	
14×9×2½ ..	7/6		

R1155 YOURS FOR £2

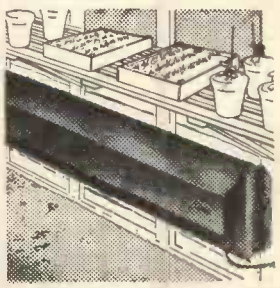
The R1155 is considered to be one of the finest communication receivers available to-day. Its frequency range is 75 kc/s. to 18 Mc/s. It is complete with 10 valves and is fitted in a black metal case. Made for the R.A.F. so obviously a robust receiver which will give years of service. Completely overhauled and guaranteed in perfect working order. Price £9/19/6 or 5 payments of £2 each. Carriage and Transit case 15/- extra. Mains Power Pack, with built-in speaker, £5/10/-, or in polished cabinet, £6/15/-.

FINE TUNERS



Ceramic trimmers all with ¼in. spindle of fair length. 5, 10, 15, 30, P.F. at 2/3 each or 24/- per dozen.

INSTANTUS HEATER



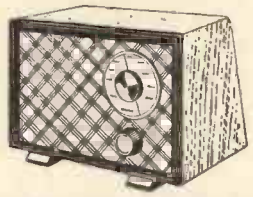
Convector heater, 1 kW. rating, 4ft. long, made from heavy gauge sheet steel (galvanised). Can be used for greenhouse, workshop, aviary, etc., etc. Price £2/10/-, or with thermostat, £4/5/-, carriage 5/-. Write for Horticultural list. GUARANTEED 5 YEARS.

DON'T STUMBLE IN THE DARK

Instal 2-way switches.
Our outfit comprises: 30 yrds. Multicore cable, 100 cable clips, two 2-way switches, two wood blocks. Full instructions. 19/6 each (post and insurance 2/6).

Wrap our heater cable around the pipes in your loft to prevent a freeze up. Minor pack 14 yards £1.0.0. Major pack 21 yards £1.10.0.

THE SKYSEARCHER
An all mains set for 19/6



This is a 2-valve plus-metal rectifier set useful as an educational set for beginners, also makes a fine second set for the bedroom, workshop, etc. All parts, less cabinet, chassis and speaker, **19/6**. Post & ins. 2/6. Data free with parts or available separately 1/6.

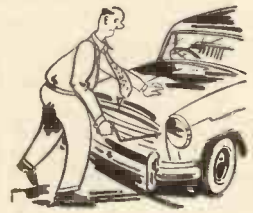
ECONOMY THREE

A 3-valve battery version of above. All components less cabinet, chassis and speaker, **19/6**, plus 2/6 post and insurance. Data free with parts or available separately **1/6**.

FLUORESCENT LIGHTS

These are complete fluorescent lighting fittings. Built-in ballast and starters—stove enamelled white and ready to work Ideal for the kitchen, over the workbench and in similar locations.
Single 40. 4ft. 3in. long, uses a 40 watt tube. Price **39/6** complete with tube. Carriage and ins. 5/6.
Twin 20. Uses 2 20-watt standard tubes. Price **29/6** less tubes. Carriage and ins. 4/6.

DON'T BE CAUGHT LIKE THIS.



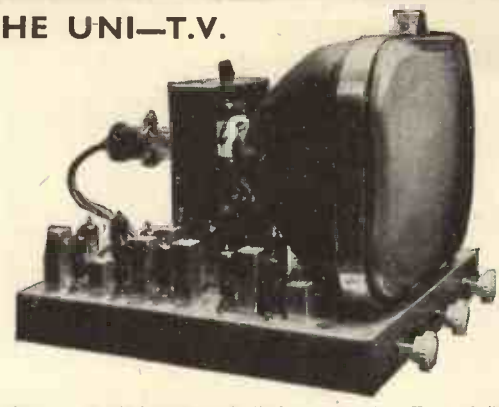
CAR STARTER CHARGER KIT

All parts to build 6- and 12-volt charger which can be connected to a "flat" battery and will enable the car to be started instantly. Kit comprising the following.

Mains transformer	22/6
5-amp. rectifier	17/6
Regulator Stud Switch	3/6
Resistance Wire	2/-
Resistance Former	2/6
Mains on/off Switch	2/6
0-5 am. Moving Coil Meter	12/6
Constructional Data	1/6

or if bought all together price is **62/6**, plus 2/6 post and packing.

THE UNI—T.V.



Undoubtedly the most up-to-date televisor for the home constructor. You can build all or only part and the set when finished will be equal to a factory made equivalent. What other constructor T.V. has all these features?

- Made up units if required.
- All miniature valves.
- Metal rectifier.
- No expensive transformers.
- 13-channel circuitry.
- Multi-vibrator time bases.
- Ferrox cube, E.H.T. and scan coils.
- 34/38 mc/s. I.F.
- Suitable for any modern 12, 14 or 17in. tube.
- Modern contemporary cabinet if required.

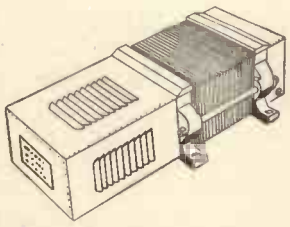
The building cost (less tube) is only £29/10/- plus 10/- carriage and insurance. All parts guaranteed twelve months. Full information and data free with parts or available separately, price 3/6.

HALF-PRICE OFFER
BEETHOVEN CHASSIS

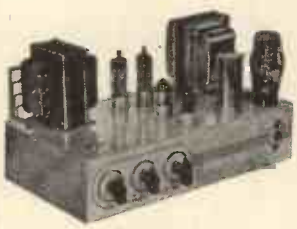
Extremely well built on chassis size approx. 9½ × 7½ × 8½, using only first-class components, fully aligned and tested, 110-240 volt A.C. mains operation. Three wave bands covering medium and two shorts. Complete with five valves, frequency changer, double diode triode, pentode output and full wave rectifier. Special cash-with-order price this month, £5/19/6, carriage and insurance 7/6. Polished cabinet, 49/6.

CONSTANT VOLTAGE TRANSFORMERS

Made by the famous Advance Company, all brand new and unused. Specification: Type No. MTZ 267U, input 85-110 volts, 50 c.p.s., output 350 volts R.M.S. output current .83 amps.
Price 37/6 each. Carriage and insurance 5/-.

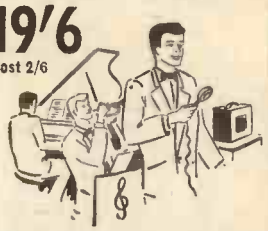


THE MULLARD 510 AMPLIFIER



A High Quality Amplifier designed by Mullard engineers. Robust high fidelity with a power output exceeding 10 watts and a harmonic distortion less than .4% at 10 watts. Its frequency response is extremely [illegible] and level being almost flat from 10 to 20,000 C.P.S.—three controls are provided and the whole unit is very suitable for use with the Collaro Studio and most other good pick-ups. The price of the unit completely made up and ready to work is £12/10/-, plus 10/- carriage and insurance. Alternatively, if you wish to make up the unit yourself we shall be glad to supply the components separately. Send for the Mullard amplifier shopping list.

19/6
Post 2/6



Powerful three-valve Mains amplifier, ideal for dances, parties, etc. Complete less chassis cabinet and speaker (available if required)—data 1/6 (free with parts).

"CHIMELITE"

It is a hall light as well as a double chime and you can make it in a couple of evenings for the total cost of only **19/6** including instructions, post, etc., 2/—data available separately price 2/-.

CONNECTING WIRE

P.V.C. covered in 100ft. coils—most colours—four coils different colours, 10/- post free.

MINI-RADIO

Uses high-efficiency coils—covers long and medium wavebands and fits into the neat white or brown Bakelite cabinet—limited quantity only. All the parts, including cabinet, valves, in fact, everything, £4/10/-, plus 3/6 post. Constructional data free with the parts, or available separately, 1/6.

CIRCUIT DETAILS

Diagrams and other information extracted from official manuals. All 1/6 per copy, 12 for 15/-.

American Service Sheets	R.109
A.1134	78 receiver
BC.348	76 receiver
BC.312	R28/ARC5
R.103A	R1116/A
B.C.342	RA-1B
RA-1B	AR88D
R-208	AN/APA-1
R-1155	78
R-1124A	76
R-1132A/R-1481	R.T.18
R-1147	CAY-46-AAM-RADAR
R-1224A	A.S.B.-3
R-1082	Indicator 62A
R-1355	Indicator A.S.B.3
B C.1206-A/B	Indicator 62
B-455-A (or -B)	Indicator 6K
B-454-A (or -B)	R.F. unit 24
B-453-A (or B)	R.F. unit 26
Transmitter T1154/ B.D.J.N.	R.F. unit 25
Fifty-eight walkie-talkie	R.F. unit 27
Frequency meter B.C.221.	Wireless set No. 19 Demobbed valves

ELECTRONIC PRECISION EQUIPMENT LTD.

266 London Road, Croydon.
Phone: CRO. 6558
Half-day Wednesday.

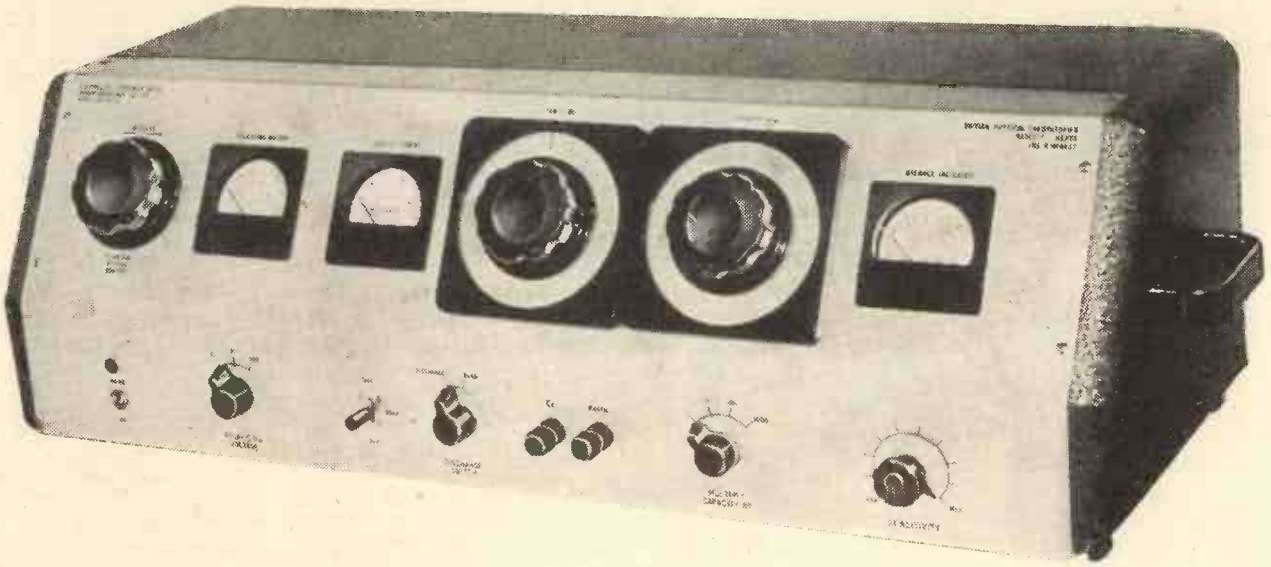
249 Kilburn High Road, Kilburn.
Phone: MAI 4921
Half-day Thursday.

42-46 Windmill Hill, Ruislip, Middlesex.
Phone: RUISLIP 5780
Half-day Wednesday.

152-153 Fleet St., E.C.4.
Phone: FLEET 2833
Half-day Saturday.

29 Stroud Green Road Finsbury Park, N.4.
Phone: ARCHWAY 1049
Half-day Thursday.

Post orders should be addressed to E.P.E. LTD., M.O. Dept. 2, SUTTON ROAD, EASTBOURNE.
All enquiries to Eastbourne address and please enclose S.A.E., terms are cash with order.



Capacitance Bridge specifically designed to measure

ELECTROLYTIC AND TANTALUM CONDENSERS

Capacitance Range: 0.1 to 11,000 μFd, Power Factor Range: 0.1 to 30%. Polarising Voltage: 0.5 to 600 volts.

This is one instrument from our range which includes:

VALVE VOLTMETERS · OSCILLATORS · PULSE GENERATOR · ATTENUATORS · MEGOHMMETER
BREAKDOWN TESTER · BRIDGES FOR MEASUREMENT OF R.C.L.

Your enquiries for our comprehensive range of sensitive METERS are invited.

BRITISH PHYSICAL LABORATORIES · RADLETT · HERTS

Telephone: RADLETT 5674.

RADIO · TELEVISION · HI-FI · ELECTRONICS · RECORDERS

LASKY'S RADIO

3-SPEED AUTO-CHANGERS

BRAND NEW IN MAKERS' CARTONS

GARRARD RC.120/H. 3 speed. Complete with t.o. crystal pick-up. Incorporates manual and auto control enabling records to be played singly or automatically as desired. Cabinet space required: 14 × 12½ × 4¾in. above and 2¾in. below. Cream/brown finish. Limited number only. List £12/15/-.
LASKY'S PRICE £7.19.6
Carr. 3/6. Cabinets available.

GARRARD RC.80. Full length arm with two XMS heads or GC2 t.o. crystal head. List £20/15/-.
LASKY'S PRICE £13.19.6
Carr. 5/-.

B.S.R. 4 Spd. with t.o. crystal pick-up. Incorporates auto and manual control enabling records to be played singly.
LASKY'S PRICE £8.15.
Carr. 5/-.

T.O. CRYSTAL CARTRIDGES
B.S.R. complete with two styli.
LASKY'S PRICE 18/6, post free.

ACOS type **HGP.37,** as used in latest radiograms. L.P. and standard. Complete with styli, 22/-. Post 1/-.

DECCA PICK-UPS
3-speed with t.o. crystal head HI/G, and rest. Brown plastic.
LASKY'S PRICE 32/6. Post 2/6.

The New **WEARITE "DE-FLUXER,"** 50/-. Post 2/6.

CONTINENTAL AM/FM RADIOGRAM CHASSIS

LASKY'S PRICE £16.19.6
Carr. 10/6.

Very special offer of a limited number only at wonderful bargain price! Built throughout of latest high grade components. 5 valve plus metal rect., gram socket and switch, piano key wavechange tone control, independent AM/FM tuning. Covers med., long and V.H.F. wavebands. Valve line-up: ECC85, ECH81, EF89, EABC80, EL81. For A.C. mains 100-250 v.

SPECIAL P.A. OFFER!

TRUVOX "SENIOR" SPEAKER DRIVING UNIT (Pressure type) **WELL BELOW HALF PRICE!**

New and unused in makers' cartons. A P.M. moving coil loudspeaker driving unit with a power handling capacity of 15 watts peak. Provides substantially linear response from 200 to 10,000 c.p.s. With a 12ft. cinema horn the unit will reproduce down to 17 c.p.s. The Throat has an 18 t.p.i. thread with an external diameter of 1⅜in.

LISTED AT £7/15/- | **LASKY'S PRICE 59/6** Carr. 5/-.

SINGLE RECORD PLAYERS

B.S.R. type TU.8, as illustrated. 3-spd. motor and pick-up with HGP.59 t.o. crystal complete with styli.
LASKY'S PRICE 92/6
Post 3/6.
Above motor and turntable less pick-up, available at 57/6. Post 2/6.

COLLARO RC.3/554. 3-spd. Single Record Player with Studio t.o. crystal pick-up and styli.
LASKY'S PRICE £6.10.
Post free.

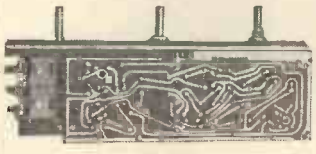
HI-FI SPEAKERS
Large stocks. Goodmans, Wharfedale, G.E.C., Lorenz, etc., including the NEW WHARFEDALE 3-SPEAKER SYSTEM SFB/3.

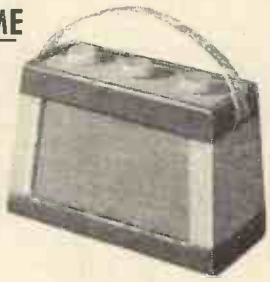
HI-FI AMPLIFIERS
Full range in stock. Quad, Rogers, Leak, R.C.A., Pamphonic, Unitelex, W.B., etc. Demonstrations at Tottenham Court Road.

IGRANIC JACK PLUGS, 2/6.

LASKY'S BATTERY PORTABLE FOR HOME CONSTRUCTION ON PRINTED CIRCUIT

You can build it complete with valves and case for only
£7.7.0
Post 3/6 extra.





10 STAR FEATURES make this the finest portable radio ever offered to the home constructor. Peak value for money has been achieved without any sacrifice of quality or design.

SIMPLICITY OF CONSTRUCTION. The use of all the latest innovations gives maximum simplicity of construction combined with fine quality performance. In particular, the PRINTED CIRCUIT greatly simplifies construction and completely eliminates the possibility of wiring errors. The veriest novice can build this portable radio easily and quickly and the cost complete, less batteries, is only £7/7/-. Plus 3/6 postage.

Demonstration models at both our addresses.

SEND FOR CIRCUIT DIAGRAM
with assembly data, all instructions, illustrations and full shopping list. Price 1/6 post free.

- ★ PRINTED CIRCUIT size 7¼in. × 2¼in.
- ★ 4-valve Superhet, med. and long waves.
- ★ Low consumption Valves. Double Battery Life.
- ★ Ferrite Rod Internal Aerial.
- ★ 5in. P.M. Moving Coil Speaker.
- ★ Brand new T.C.C. Capacitors.
- ★ Automatic Volume Control.
- ★ New style Contemporary Case.
- ★ Lightweight and Handsome Appearance.
- ★ Every Component available separately

YOU CAN BUILD A POWER SUPPLY UNIT FOR THIS PORTABLE.
For 200-250 v. A.C. mains. Made for the new low consumption valves. COMPLETE KIT containing printed circuit, brand new TCC condensers, latest STC metal rectifiers, all components, and full instructions, 45/-. Post 2/-. Also suitable for most other portables. Full details on request.

SEND 3d. STAMP FOR OUR LATEST BARGAIN LIST.

TAPE DECK CASES ALMOST HALF-PRICE

Strongly made and finished with light grey leatherette with black/silver bands, finger-shaped handle for easy carrying, strong hinges and clasps. Pocket in lid for tapes and spools, door for microphone, etc. Overall dim.: 15½in. long, 13¾in. wide, 9in. deep. Inside dim.: 14¾in. × 12½in. × 5¾in. A real general purpose job; will take almost any type of Deck including Collaro Tape Transcriptor, also almost any type of Record Changer including RC.80, etc.
LASKY'S PRICE 59/6
Post 3/6.

LARGE SELECTION OF CABINETS for TV and radiograms, carrying cases for record players, tape recorders, etc. Your enquiries invited.

MORE MONEY-SAVING LASKY BARGAINS ON NEXT PAGE

There is always a fine selection of equipment at

3 cm. TEST SET

TYPE 263

Containing transmission type w/meter complete with detector unit 9280-9480 Mc/s, attenuator unit, 2 coaxial to waveguide feeders, impedance matching unit, medium power dummy load, standing wave indicator with lock using CV.263 indicator valve, metered indicator unit, various connectors. Suitable for testing medium and low power radar installations. Price **£20** carriage paid.

WAVEMETER TYPE W.1310

Coverage 155 to 230 Mc/s. continuous, complete with Test Prod. Input 230 v. 50 cycles. New condition, £3/10/-, plus 7/6 carr.

BLOCK CONDENSERS

8 mfd. 600 v. W., 5/6 each, post paid. 4 mfd. 400 v. W., 4/- each, post paid.

AN/APN.1 TRANSDUCER

This Unit consists of Magnet, and Coil which is attached to an aluminium diaphragm suspended freely and perforated to prevent air damping. Mounted on a Ceramic cover which sits over the diaphragm is a form of 2-Gang capacitor which has a swing from 10-50 pF.

The above unit is used as part of Wobbulator described on page 252 of the June "Wireless World." PRICE 7/6 p.p.

APQ.2. RADAR/JAMMING UNIT

Freq. 450-710 Mc/s. Containing 931a Photo Multiplier Cell complete with resistance network and light proof box. Wide band amplifier 2 6AC7, 1 6AG7, 2 388a. This unit is similar to the A.P.Q9 Jamming Unit. **Brand new £5** plus 10/- carriage.

MORSE SIGNALLING LAMPS

(Aldis type) 5in. dia. with sighting arrangement, 2 handles, keying switch, and 2 yards cable. In wood carrying case, 10/- plus 3/- p.p.

MINIATURE I.F. STRIPS

Size 10¾ × 2¼ × 3in. Frequency 9.72 Mc/s. 2 EF.92s and 1 EF.91 I.F. amps. EB.91. DET/AGC. EF.91 AGC. Amp. and EF.91 Limiter. Circuit supplied.

Price **8/-** less valves. Post paid.

TRANSMITTER Type T1131-L

Frequency 100 to 156 Mc/s. Output 50 W. Crystal controlled. 200-240 v., 50 c.p.s. Power supply. Housed in 6ft. standard on 19in. rack. In new condition complete with valves.

Send for full details.

EDDYSTONE 358X

COMMUNICATION RECEIVERS (B34)

Range 40 kc/s. to 31 Mc/s. covered with 10 plug-in coils; only 4 coils available covering 600-1,250 kc/s., 1,250-2,100 kc/s., 2,100-4,500 kc/s., 9,000-22,000 kc/s. Selectivity: 2 kc/s at 2.5 db down; 5 kc/s at 35 db down; 150 c/s. at 5 db down with crystal. Supply required: 6 v. 1.4 a.; 175/200 v. 65 m/a. CIRCUIT: variable mu pentode H.F. amplifier, triode-hexode frequency changer, two I.F. amplifiers (450 kc/s.), crystal filter, A.V.C./detector/A.F. amplifier, output stage, B.F.O. valve check meter.

£8.10.0 With power supply, plus £1 packing and carriage.

POWER UNIT Type 173

24 volt D.C. input, 120 v., 60 m/a. output. Containing Vibrator Transformer, 12 volt Vibrator, two 120 volt Selenium Rectifiers. Chokes and Condensers. Size 10½in. × 6in. × 3in. Price 12/6 post paid.

BENDIX TRANSMITTERS

TYPE T.A. 12B Master oscillator type transmitter. 4 channel 40 W. operation provide telephone, CW or MCW in frequency ranges of 300-600 kc/s, 3-4.8 Mc/s., 4-6.4 Mc/s., 4.37-7 Mc/s. Each of the 4 channels has its own oscillator and uses a 12.SK.7. The IPA stage consists of an 807, while the PA is two 807s in parallel. Size 10½in. × 6½in. × 15½in. Price £3/15/-, plus 10/- carr.

INVERTERS

Miniature 3-phase (ex-compass unit) 24 v. input with 17 v. 3-phase, 400 c/s. output. These have been used by model makers as motors and are known as the "5/- Motor." Will run quite successfully on 12 volts. 5/- plus 2/- p.p.

I.F. AMPLIFIER UNIT

460 kc/s. with IT4. Brand new and boxed. Fully screened in plug-in box. Size 2½in. × 1in. × 4½in.

Price, with circuit, **10/-** each, plus 1/- p.p.

POST OFFICE COUNTERS

500 ohm, 4 figure no reset; size 5 × 1¼ × 1in. 5/- each, p.p.

BUZZERS

6 volt A.C., with tone adjuster, size 2 × 1 × 2½in., 4/- p.p.

BOOST GAUGES

2in. dia.; suitable after minor adjustment as car induction manifold meter. 2/6 p.p.

INDICATOR LAMPS

American panel type complete with 6 v. bulbs in set of 4, 3 green jewels and 1 red jewel, 10/6 post paid.

R.F. UNITS

R.F.24 20-30 Mc/s. Switched Tuning. Valved 9/6 each.

R.F.25 40-50 Mc/s. Switched Tuning. Valved, 9/6 each.

R.F.26 50-65 Mc/s Variable tuning, valved. Damaged dials 20/- each: perfect dials 25/- each.

Packing and postage 3/- each type

All these fine offers are on display at ➔

Stern's NEW!! "fidelity"

A TAPE RECORDER WITH EVERYTHING — EXCEPT A HIGH PRICE

BEFORE CHOOSING YOUR RECORDER YOU MUST HEAR THIS NEW "fidelity" MODEL . . . IT HAS . . . The BRENELL 3-speed Tape Deck and a "fidelity" Tape Amplifier, based on a new design by the MULLARD TECHNICIANS and which we consider to be one of the best now available . . . Truly HIGH FIDELITY RECORDINGS are obtainable.

If you cannot call and hear this Recorder send a stamped addressed envelope for fully descriptive leaflet

PRICE of COMPLETE RECORDER £46'0'0

INCLUDING MOVING COIL MIKE and 1,200ft. REEL of TAPE.

(*Plus* £1 *carriage and insurance of which* 10/- *refunded on return of packing case.*)

CREDIT TERMS. Deposit £11/10/- and 9 monthly payments of £4/4/4.
HIRE PURCHASE. Deposit £23 and 12 monthly payments of £2/2/8.

- ★ **High Quality Output Transformer by Gilson**
- ★ **3 Speeds, 3¾, 7½ and 15in., TWIN TRACK**
- ★ **Position provided for use as straight amplifier**
- ★ **Efficient Tone Control arrangement**
- ★ **High-grade Components throughout**
- ★ **Two position equaliser for 3¾ and 7½in.**
- ★ **Monitor and Extension Speaker Sockets are provided**
- ★ **Beautiful styling and cabinet**

HOME CONSTRUCTORS

YOU CAN BUILD THE COMPLETE RECORDER FOR £42'10

(*Plus* £1 *carriage and insurance of which* 10/- *refunded on return of packing case.*)

CREDIT SALE TERMS. Deposit £10/12/6 and 9 monthly payments of £3/17/11.
HIRE PURCHASE TERMS. Deposit £21/5/- and 12 monthly payments of £1/19/5.

The BRENELL TAPE DECK and the "fidelity" TAPE AMPLIFIER are supplied tested and ready for use and the actual assembly of the recorder is extremely simple involving only a few connections for which a step-by-step chart is supplied.

IF YOU HAVE YOUR OWN CABINET WE WILL SUPPLY . . .

THE BRENELL TAPE DECK, the "fidelity" TAPE AMPLIFIER, MATCHED P.M. SPEAKER and 1,200ft. REEL PLASTIC TAPE.

ALL FOR **£36'0'0**

CREDIT SALE TERMS. Deposit £9 and 9 monthly payments of £3/6/-. HIRE-PURCHASE TERMS. Deposit £18 and 12 monthly payments of £1/13/5.

(*Plus* £1 *carriage and insurance of which* 10/- *refunded on return of packing case.*)

TAPE RECORDER EQUIPMENT—IN STOCK . . .

(a) The BRENELL 3-SPEED TAPE DECK £18/18/-.
(b) The TRUVOX MK. III and MK. IV DECKS (from) £24/3/-.
(c) The COLLARO TRANSCRIPTOR "TAPE DECK" £20 (see note below).
(d) The LUSTRAPHONE MOVING COIL MIKE, HIGH IMPEDANCE, £3/7/6.
(e) The ACOS CRYSTAL MIKE, HIGH IMPEDANCE, £2/10/-.

(a) The "fidelity" TAPE AMPLIFIER (as used in above Tape Recorder, including matched P.M. Speaker. £16/16/-.
(b) The TRUVOX MODEL "C" TAPE AMPLIFIER, £17/17/-.
(c) The ARMSTRONG P.A.B.O. TAPE PRE-AMPLIFIER, £12/10/- (suitable for nearly all tape decks).

All types of PLASTIC TAPE by E.M.I., SCOTCH BOY and GRUNDIG, Standard and Long play ARE IN STOCK.

NOTE. We recommend that a CORRECTLY MATCHED PRE-AMPLIFIER is purchased with the COLLARO Transcriptor. We can supply it with the pre-amplifier actually assembled on Tape Deck. £37/10/-.
HIRE PURCHASE and CREDIT TERMS are available on all above equipment.

STERN'S "fidelity" F.M. TUNING UNIT

A 5 Valve Tuner incorporating the latest Mullard Permeability Tuned Unit. Price assembled less Power Supply:

£14/10/0

(Plus 7/6 carr. and ins.)

TERMS: (a) H.P. Deposit £7/5/- and 9 monthly payments of 18/4:
(b) Credit Deposit £3/12/6 and 9 monthly payments of £1/6/7.
Provides "Hi-Fi" reprodnction with any make of Amplifier and many Radio Receivers. It incorporates: ● The latest Valve Line-up—ECC85, 2 type EF85, EF91 and EM80. ● A "Magic Eye" Indicator. ● Power consumption is 1.7 amps. at 6.3 volts and 25 m/a. at 250 volts.

STERN'S "fidelity" COMBINED A.M. and F.M. TUNING UNIT

This is IDENTICAL to the Stern's F.M. Tuner illustrated above, but in addition incorporates the MEDIUM WAVE-BAND and thereby also provides a selection of foreign stations.

Price **£18/18/0** (Plus 7/6 carr. and ins.)

TERMS:—(a) H.P. Deposit £9/9/- and 10 monthly payments of £1/1/-; (b) Credit Deposit £4/15/- and 9 monthly payments of £1/14/7. Send S.A.E. if further data required.

THE LEAK "TL/10" AMPLIFIER and "POINT ONE" PRE-AMPLIFIER

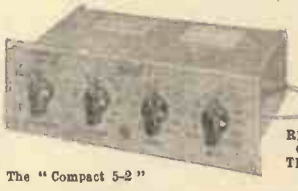
Provides a maximum output of 10 watts, maintains in every respect the renowned Leak reception for precision engineering, fine appearance and fastidious wiring. PRICE COMPLETE **£28/7/0**

(Plus 7/6 carr. and ins.)

TERMS: Credit: Deposit £7/7/- and 9 monthly payments of £2/11/4. H.P. Deposit £14/4/- and 12 monthly payments of £1/6/-. Send S.A.E. for fully illustrated leaflet.

STERN'S "COMPACT 5" AMPLIFIERS

EXPRESSLY DEVELOPED FOR VERY HIGH QUALITY REPRODUCTION OF GRAM. RECORDS AND PARTICULARLY SUITABLE FOR HIGH QUALITY REPRODUCTION OF THE F.M. TRANSMISSIONS:



The "Compact 5-2"

A 2-stage high sensitivity amplifier having SEPARATE BASS and TREBLE CONTROLS and designed to give up to approx. 5 watts with very pleasing quality. PRICE £5/15/-.

The "Compact 5-3" A 3-stage version of the "5-2" model but in this case having an additional stage and incorporating negative feedback. PRICE £6/16/-.

The Amplifiers are compact and very attractively designed having a "Hammered/Gold" finish with a fully engraved front panel by which the entire Amplifier is conveniently mounted into a Cabinet, occupying no more space than a conventional Tone Control Unit. Send S.A.E. for illustrated Leaflet.

POWER SUPPLY. Is obtainable from a small separate Unit which apart from supplying power to either Amplifier, also has additional supply available for a Radio Tuning Unit. PRICE (additional to above). £2/10/-.

Open Monday to Friday 9 a.m.—6 p.m. Saturday 9 a.m.—1 p.m.

STERN RADIO LIMITED

AMPLIFIERS
PRE-AMPLIFIERS

HIGH FIDELITY FOR THE HOME CONSTRUCTOR

TUNING UNITS
RADIO RECEIVERS

—COMPLETE KITS OF PARTS FOR THE "Hi-Fi" ENTHUSIAST—

QUALITY OF THIS NATURE HAS NEVER BEFORE BEEN OFFERED AT SUCH LOW COST.

The MULLARD '5-10' MAIN AMPLIFIER

This is the very latest design and needs no recommendation from us. Our Kit is complete to Mullard's specification, including the latest GILSON ULTRA LINEAR OUTPUT TRANSFORMER and the entire MULLARD Valve line up. ALL SPECIFIED COMPONENTS are supplied.
PRICE OF COMPLETE KIT OF PARTS (Plus 5/- carr. and ins.). **£11/11/0**

THE full SPECIFICATION and BUILDING INSTRUCTIONS for these three Units are available for 1/6 each. THEY include COMPONENT PRICE LISTS and simple "wire-to-wire" PRACTICAL DIAGRAMS.

STERN'S "fidelity" PRE-AMPLIFIER TONE CONTROL UNIT

"A design for the music lover"

Briefly it has inputs for all types of MICROPHONES, HIGH and LOW GAIN PICK UPS and a RADIO TUNING UNIT. It incorporates (a) GRAM EQUALISING CONTROL. (b) STEEPCUT FILTER; (c) Continuously variable BASS and TREBLE CONTROLS and a variable OUTPUT CONTROL which enables its use with any type of Amplifier.
PRICE OF COMPLETE KIT OF PARTS
WE ALSO OFFER IT ASSEMBLED READY FOR USE, £8/-/- (Plus 5/- carr. and ins.). **£6/6/0**

A COMPLETE KIT OF PARTS STERN'S "HIGH QUALITY" 8-10 WATT AMPLIFIER

Has power supply available for Radio Tuning Unit.
Price of COMPLETE KIT OF PARTS (plus 5/- carr. and ins.). **£7/10/0**

WE ALSO OFFER IT ASSEMBLED and READY FOR USE for (plus 5/- carr. and ins.) **£9/10/0**

This amplifier has proved one of the most popular models yet offered to the HOME CONSTRUCTOR. It provides really excellent reproduction up to 8 watts, employing 6V6's in push-pull and incorporating negative feedback. Provides for the use of both 3 and 15 ohm Speakers. The Complete SPECIFICATION and BUILDING INSTRUCTIONS are available for 1/6.
"Wire-to-Wire" Diagrams are included and all Components are available separately.

SPECIAL PRICE REDUCTIONS . . . FOR PURCHASERS OF A COMPLETE "Hi-Fi" AMPLIFIER

WE WILL SUPPLY (a) COMPLETE KIT OF PARTS to build THE MULLARD "5-10" MAIN AMPLIFIER and the STERN'S "fidelity" PRE-AMPLIFIER-TONE CONTROL UNIT for £16/16/- or we will supply THE TWO UNITS MADE UP and READY FOR USE for £19/19/-. Terms: Deposit £9/19/6 and 12 monthly payments of 18/7, or £5 Deposit and 9 monthly payments of £1/16/7.

"MODERNISE YOUR OLD RADIOGRAM"

IT IS MUCH CHEAPER THIS WAY!!

THE LATEST DESIGN OF COMBINED AM/FM REPLACEMENT RADIOGRAM CHASSIS and a NEW 4-SPEED RECORD PLAYER

STERN'S NEW "Fidelity" COMBINED AM/FM RADIOGRAM CHASSIS

A genuinely hand-made chassis providing really high quality on both Radio and Gram.

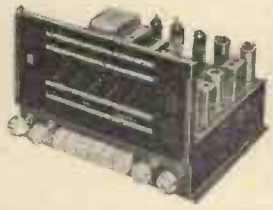
PRICE **£26/15/0** (Plus 7/6 carr. and ins.).

TERMS: Credit Deposit £6/14/- and 9 monthly payments from £2/9/-. H.P. Deposit £13/7/6 and 12 monthly payments of £1/4/10.

BRIEFLY IT HAS:—
An 8 valve line up incorporating the latest MULLARD preferred-type valves. ● Provides complete coverage of the VHF/FM waveband plus the SHORT, MEDIUM and LONG waves. ● Has EL84's in Push-Pull, with negative feedback of 6 watts output. ● Employs "Piano Key" Selector Switch and a Variable Tone Control. ● Contains Gram input socket for both Crystal and Magnetic Pick-ups. ● Provides for use of either 3 or 15 ohm Speakers. ● Has "Magic Eye" Tuning Indicator. ● Dimensions 13in. × 9¼in. × 8in. high, Dial size 11¼in. × 5¼in.

THE NEW ARMSTRONG P.B. 409 AM/FM RADIOGRAM CHASSIS

A "de luxe" Chassis for those who want the highest possible quality



PRICE **£29/8/0** (Plus 7/6 carr. and ins.).

TERMS: Credit Deposit £7/7/- and 9 monthly payments of £2/14/-. H.P. Dep. £14/14/- and 12 monthly payments of £1/7/3.

BRIEF SPECIFICATION:—
A 9 valve line up employing the latest MULLARD preferred-type valves. ● Provides complete coverage of the VHF/FM Transmissions, plus the SHORT, MEDIUM and LONG waves. ● Has Push-Pull output, with negative feedback, for 6 watts Peak output. ● Quick action "Piano Key" Selectors and separate Bass and Treble Controls. ● Has "Magic Eye" Tuning Indicator. ● Two Gram Inputs are provided, one for Crystal Pick-ups and the other for Magnetic types. ● Dimensions 13in. × 9¼in. × 8in. high, Dial size 11¼in. × 5¼in.

THE NEW MODEL "H" COMBINED AM/FM RADIOGRAM CHASSIS

Designed for first rate reproduction of Radio and Gram Records.

PRICE **£24/6/6** (Plus 7/6 carr. and ins.).

TERMS: Credit Deposit £6/3/0 and 9 monthly payments of £2/4/7. H.P. Dep. £12/3/3 and 12 monthly payments of £1/2/7.

BRIEF SPECIFICATION:—
Full AVC on LONG, MEDIUM and SHORT wavebands and amplitude limitation on FM bands. ● Incorporates internal aerial (Ferrite Rods) for local station reception on MEDIUM and LONG WAVES. ● Coverage is FM 87 to 101 Mc/s, Short 16 to 50 metres, Medium 187 to 540 and Long Waveband 1000 to 2000 metres. ● Recently developed Valve line up of ECC85, ECH81, EF89, BABC80, EL84, EZ80 and EM80 Tuning Indicator. ● Output is 4 watts and any 3 or 15 ohm P.M. Speaker can be used. ● Connection Sockets on the Chassis (a) Pick-up, (b) Extension Speaker, for 3 or 15 ohm types. ● Overall size 12in. × 9in. × 7¼in. high. Dial, 11¼in. × 6in.

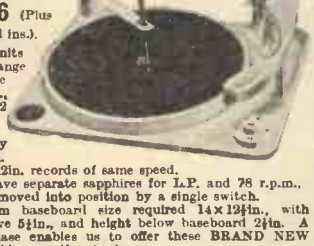
SEND S.A.E. IF FURTHER INFORMATION IS REQUIRED ON THESE CHASSIS.

To complete a GENUINELY HIGH QUALITY RADIOGRAM . . . We recommend THE NEW COLLARO MODEL 456 4-speed Autochanger, and if a LOUDSPEAKER is required . . . We recommend THE 8- or 10-inch W.B. STENTORIAN "Hi-Fi" MODELS. We have SPECIALLY REDUCED PRICES for purchasers of a CHASSIS and RECORD PLAYER (and SPEAKER if required). SEND S.A.E. FOR DETAILS.

CASH ONLY OFFER!!

This latest B.S.R. MONARCH 4-SPEED AUTOCHANGER

£7/19/6 (Plus 5/- carr. and ins.).



● These units will autochange on all three speeds, 7in., 10in. and 12 in.

● They play MIXED 7in. 10in. and 12in. records of same speed.

● They have separate sapphires for L.P. and 78 r.p.m., which are moved into position by a single switch.

● Minimum baseboard size required 14 × 12½in., with height above 5½in., and height below baseboard 2½in. A bulk purchase enables us to offer these BRAND NEW UNITS at this exceptional price.

109-115 FLEET ST., LONDON, E.C.4.

Phone: FLEet Street 5812-3-4.

RECORD PLAYERS

THE VERY LATEST MODELS ARE OFFERED AT

GREATLY REDUCED PRICES

● TRANSCRIPTION UNITS. ● 3- and 4-SPEED AUTOCHANGER ● AUTOCHANGERS with MANUAL CONTROL POSITION. Send S.A.E. for ILLUSTRATED and DESCRIPTIVE LEAFLET.

SPECIAL CASH OFFER

A good quality 2 Stage (plus Rectifier) GRAM AMPLIFIER together with a 6½in. P.M. Speaker and this attractive PORTABLE CASE.

ALL FOR ONLY £8/7/6. The Amplifier incorporates the latest B.V.A. Valves, types ECC83, EL84 with EZ80 Rectifier and has separate BASS and TREBLE CONTROLS.

The CASE is attractively finished in Rexine, maroon and grey, and has space for almost any make of Autochanger.

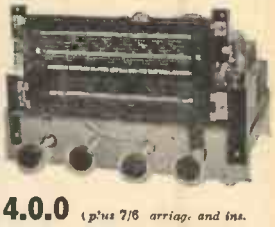
We also sell the two separately:
(a) AMPLIFIER and 6½in. SPEAKER £4 12 6
(b) PORTABLE CARRYING CASE £3 17 6

FOR CALLERS ONLY

We have in stock various KITS OF PARTS including F.M. Tuners, AM/FM Tuners, Midget Battery Portable and Mains Units, etc., etc. . . We also have the most comprehensive stock of WIRELESS and ELECTRICAL COMPONENTS.

STERN'S "SUPER SIX"

6 Valve
3 Waveband
Superhet



Provides good selection of stations and really good reproduction on both RADIO & GRAM.

PRICE ONLY **£14.0.0** (*plus 7/6 carriage and ins.*

CREDIT TERMS: Deposit £3/10/- and 9 monthly payments of £1/5/8. H.P. TERMS: Deposit £7 and 10 monthly payments of 16/-.

BRIEF SPECIFICATION . . .
★ Delayed AVC on all wavebands
★ Preselection feedback
★ Latest valve line-up: 12AH8, 6BA6, 6AT6, two 6AQ5s and 5Z4 (or equivalents)
★ Push-pull output gives approx. 6 watts
★ Connections on chassis for extension speaker, gram and mains supply to gram.
★ Coverage 18-50 metres, 190-560 and 800-2,000
★ Overall size 11 × 7½ × 8½in. high, dial 8½ × 4½in.
★ A bronze dial escutcheon is available for 4/6.

CLYNE RADIO LTD.

18, TOTTENHAM COURT ROAD, LONDON, W.1

MUSeum 5929/0095
(50 yards only from Tottenham Court Road Tube)
All post orders please to:—24-26, HAMPSTEAD RD., LONDON, N.W.1
EUSton 5533/4/5

LOOK ! ! ! A first-class SIGNAL GENERATOR that YOU can afford. The "Weyrad" type S.G.M.L. covers 100 kc/s to 70 mc/s. in 6 bands, on Fundamentals, with an accuracy better than ±2%. Switched Audio Mod.: 500 c/s. For use on A.C. Mains 100/250 v. 50 cycles. Fully illustrated leaflet available. Price ONLY £12/10/- plus 2/6 P. & P. H.P. available.

ACOS TYPE 7 Crystal Microphone Inserts. Brand New, 7/6 each, post free.

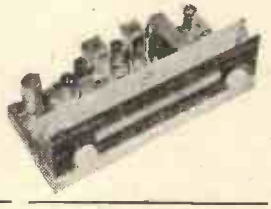
THE JASON FM TUNER

Based on the booklet by Data Publications Ltd., 2/- post free, including our individually priced Parts List. Highly sensitive free from drift. Incorporates 4 valves 6AM6 and 2 specially graded G.E.C. Crystals. The kit supplied includes drilled chassis with tuning condenser, scale calibrated in m/cs., and attractive bronze stove-enamelled front plate already mounted (illustrated). Front plate size 8in. × 5in. chassis 7in. × 4½in. × 1½in. Complete standard kit **£6/15/-** plus 2/6 P. & P. Fringe area kit **£7/15/-**, plus P. & P.

FM POWER PACK KIT. We can now supply complete kit for power pack suitable for the above F.M. tuner or any other similar type. Price for the complete kit is 37/6 only, or 52/6 for ready assembled unit. This pack is extremely small, incorporating valve rectifier type 6X4 and built on chassis size only 6 × 4 × 1½in. Optional extra for power pack. Bulgin Octal Plug 2/3.

THE T.S.L. FM TUNER !

We can now supply this FM/VHF adaptor either in kit form or fully assembled, wired and tested. Our price for the ready-built unit, which incorporates its own power supply is £13/15/- only, tax paid, plus 5/- P. & P. or H.P. terms. Magic tye tuning indicator, just plug in, 19/- extra. Or the kit complete as specified **£10/19/6** plus 3/6 P. & P. The booklet "FM TUNER CONSTRUCTION" (32 pages) with full technical data and point-to-point wiring diagrams together with our separately priced parts list, is available at 2/6 post free.



THE T.S.L. AM/FM CHASSIS !
Exceptional value. Covers L.M. and S.W. plus FM! 8-valve push-pull output. Ferrite rod aerial. Valve line-up ECC85, ECH81, EF89, EABC80, ECC82, two 6BW6s plus 5Y3 Large full-vision dial, size 14½ × 6in. Chassis size, overall: 15 × 7½ × 8in. high. Tax paid, 26 guineas, plus 5/- packing and carriage. A supplementary extra is magic eye EM34, complete with escutcheon and fixing cable at 26/-. H.P. terms available. Demonstrations at 18 Tottenham Court Road!

INTRODUCING THE NEW T.S.L. FM TUNER UNIT.
This compact unit with built-in power supplies has been designed by craftsmen to standards which will satisfy the most critical enthusiast. Brief specifications: Valve line-up: ECC85, 2-EF89, EABC80, 6X4 and EM80. Overall size: 10½in. W. × 5½in. H × 6½in. D. Dial size 10½in. × 5½in. Attractive plastic dial in Black and Gold with easy-to-read calibration. Controls: Switch. OFF FM & GRAM. and tuning. Pre-set gain control at rear of chassis. Connections: Co-Axial output socket, 300 ohm aerial input socket and pick-up input socket on rear of chassis. Price **£17/10/-**, plus 5/-. P. & P.

THE DULCI FM TUNER. Incorporates own power supply, suitable for use with any amplifier. Valve line-up. ECC85, two EF89, EABC80, 6X4 and EM80 indicator! Overall size: 9 × 6 × 5½in. high. Pre-Budget price **£16/16/-**, plus 5/- P. & P. Illustrated leaflet available, also H.P. terms.

THE R.E.P. 1-VALVE RECEIVER. All-dry battery operation, for use with headphones. The complete kit is available at 42/-, less batteries plus 2/- P. & P. or full instructions at 9d. post free

COIL PACKS. Manufacturers' Surplus, Miniature size, only 2½in. × 2½in. × 1½in. deep Iron-cored. For L., M. and S.W. with gram. position. Switch has 2in. spindle. Absolutely brand new, complete with circuit. Price only 27/6, plus 1/6 P. & P. A snip!

TELEVISION TURRET TUNERS 12 CHANNEL—"TELENG"
We have six types now available from stock, to cover Bands I and III—fully illustrated and descriptive leaflet available on request. Each unit is fully aligned and thoroughly tested before despatch. Valves employed are PCF80, PCC84 for AC/DC and ECF80 and ECC84 for A.C. Price complete **£7/7/-**, 2/6 P. & P.

Type	Sound MC/s	Vision M/Cs	Heater
TT34S	38.0	34.5	Series
TT34P	38.0	34.5	Parallel
TT16S	19.5	16.0	Series
TT16P	19.5	16.0	Parallel
TT13S	10.5	14.0	Series
TT13P	10.5	14.0	Parallel

We have a large selection of in-built converters for all areas from 92/6: also aerials low-loss co-axial cable at 9d. per yard Are you on our mailing list?

THE FAMOUS UNIVERTER—COMPARE THE PRICE
Handsome walnut cabinet. Suitable all areas. Contains own power supply. Simply connect to aerial. Four-valve circuit. Complete with all instructions. **£6/19/6** plus 3/6 P. & P

JUST ARRIVED !

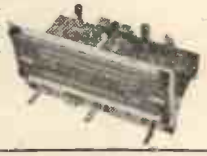
The "Imperial" AM/FM Radiogram Replacement Chassis. Overall measurements 13in. × 6in. × 7in. high. Dial cut-out required only 10½in. × 2½in. Covers long, medium and F.M. Features include very attractive black and gold dial, 4-button, push button unit, gram position, separate FM tuning, continuously variable tone control, A.C. mains 110/230 v. Valve line-up EL41, ECC85, EABC80, EF89, ECH81, plus metal rectifier. Price complete **£16/19/6** tax paid. H.P. terms available.

DULCI AM/FM CHASSIS H4

Illustrated leaflet available. L., M. and Short Waves plus F.M. This is a quality chassis 6 latest B.V.A. Mullard Valves, including magic eye. High Q inductances throughout, also Ferrite rods. Price is **£24/6/-** cash—or H.P. terms.

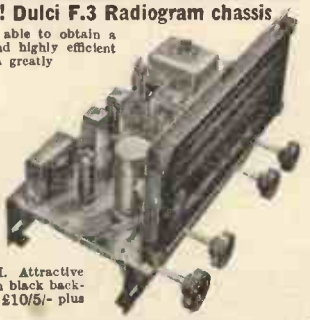
SPECIAL PURCHASE ! MANUFACTURER'S SURPLUS

Owing to favourable purchase we can offer strictly limited quantity of these handsome chassis. AC/DC 200/250 v. for Medium and Long Waves, plus gram position. Incorporates own frame aerial. Valve line-up: U107, N108, DH107, W107 and X109. Overall chassis size 12 × 5½ × 7½in. high. Attractive bronze dial with gold and cream lettering. Dial size 11½ × 4½in. Scale length 7½in. Logging scale provided. Price **£7/19/6** only, tax paid, plus 3/6 P. & P. H.P. terms, £4 deposit plus four monthly payments of 22/-.



Splendid unrepeatable offer ! ! Dulci F.3 Radiogram chassis

We have been very fortunate in being able to obtain a limited quantity of this well known and highly efficient chassis which we are able to offer at a greatly reduced price.



Specification:
Three waveband: long 1,000-2,000 metres: medium 187-540 metres; short 16-50 metres. Valve line-up: X79, 6BA6 or W7A7, 6AT6 or DH77, EL84 or N709, 6X4 or U78.

Four controls, tone/on-off.

Volume wavechange.

Tuning: output 4 watts matched to 3-5 ohms. Incorporates latest Ferrite Rod Aerial. Pick-up sockets and mains supply for Gram motor. Overall dimensions: 12in. L. × 7in. D. × 7½in. H. Attractive dial with red, gold and green lettering on black background. Size 11½in. × 4½in. Price only **£10/5/-** plus 3/6 P. & P.

JUST RELEASED ! ! !
THE NEW R.C. TRANSISTOR/CRYSTAL RECEIVER KIT

This receiver, covering medium waveband, which can be assembled in about 1 hour, will give amazing volume and tonal quality when used in conjunction with a good aerial and earth. Incorporating PNP Transistor and Germanium Diode. For headphone reception.
Included with the kit of parts is a handsome plastic case in black and white, measuring 4½ × 2½ × 1½in. This case accommodates the complete receiver, including battery.
PRICE OF COMPLETE KIT: 25/- plus 1/3 P. & P.
Lightweight high resistance headphones can be supplied separately at **15/-** pair. If, however, the kit is purchased complete with headphones this will be supplied at a **SPECIAL INCLUSIVE PRICE OF 37/6** plus 1/6 P. & P. Optional extra, 100ft. coil single 7/36 coloured P.V.C. covered wire, suitable for both aerial and earth. 2/6 only.

TRANSISTORS ! ! ! Now available, manufacturers surplus transistors. Suitable for use in Audio stages, etc., and for experimental purposes. P.N.P. type. Only 10/- each, post free. Blue spot type available for R.F. up to 1.6 Mc/s., 15/- each.

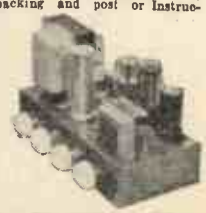
AM/FM KIT

Introducing the JASON AM/FM KIT for medium waves and F.M.!
As illustrated this is a very high quality chassis incorporating 8 of the latest miniature valves, plus DM70 magic eye. Kits are available for chassis complete with output stage at **£15/5/-**. Also less output stage but with own built-in power pack at **£13/19/6** only. These are high fidelity units and exceptional value at these prices which include all required components and full constructional details. Fully illustrated Data Booklet with full construction details, plus individually priced component list, available per return of post at 2/- post free. Both plus 3/6 P. & P.

DULCI H4T AM/FM TUNER

This unit has been designed for Quality Reproduction and built to the highest technical standards. Contains own power supplies. Brief specifications: four wavebands: VHF 87-101 mc/s. Short, 16-50 metres. Medium, 187-540 metres. Long, 1,000-2,000 metres. Intermediate Frequencies: 10.7 mc/s. and 471 Kc/s. Full A.G.C. on all A.M. Bands and amplitude limitation on F.M. Band. Three controls: ON/OFF, Volume, Tuning and Wavechange. Valve line-up: ECC85, ECH81, EF89, EABC80, EM80 and EZ80. Attractive dial in Black with Red, Green and Gold lettering, size 11½in. × 5½in. Chassis size (overall) 12in. W. × 7½in. H. × 8½in. D. A low impedance of 47K ohm output makes matching to amplifier non-critical. Weight 12lb. Price is **£20/17/-**, plus 5/- P. & P.

THE R.C.3/4 WATT AMPLIFIER KIT
Compare the advantages!

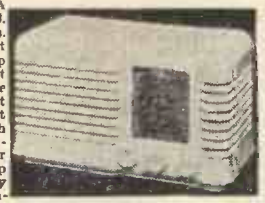


Treble bass. AND middle controls! For crystal or magnetic pick-up! A.C. Mains 200/250 v. Valve line-up: 6V6GT, 6SG7, metal 6X5GT. Negative feedback. Built on stove enamelled steel chassis, measuring only 8in. × 4in. × 1½in. Four engraved cream knobs are included in the price of the complete kit with all necessary practical and theoretical diagrams at £4/5/- only, plus 2/6 packing and post or Instruction Book, fully illustrated for 1/-. Post free! This amplifier can be supplied assembled, tested, and ready for use at £5/5/- plus P. and P. Hearing is believing.

Our advantageous H.P. terms are available on any single item over £5. Let us have your enquiries.

Please add postage under £1, or Cash with order. C.O.D. charge extra—open 9 a.m. to 6 p.m. Monday to Friday. Sorry but we close 1 p.m. on Saturday

THE "ECONOMY FOUR" T.R.F. KIT. A three-valve plus metal rectifier receiver. A.C. mains 200/250 v. Medium and Long waves. We can supply all required components right down to the last nut and bolt. Valve line-up 6K7, 6J7 and 6V6. Chassis ready drilled-Cabinet size 12in. long by 6in. high by 5in. deep—Choice of ivory or brown Bakelite, or wooden walnut finish cabinet. Complete instruction booklet with practical and theoretical diagrams. Each component brand new and tested prior to packing. Our price £5/10/- complete—Remember this set is being demonstrated at our shop premises! We proudly claim that our fully illustrated instruction booklet is the most comprehensive available for this type of receiver—Booklet available at 1/6 post free. This is allowed if kit is purchased later. Plus 2/6 packing and carriage for complete kit.



THE "SUPERIOR" FOUR KIT. Our new four-valve receiver. A.C. mains, 200/250 v. M. and Long waves. As with our very successful "Economy Four" all required components as supplied. Valve line-up: 2 6SG7, 6 X5GT and 6 V6GT. Chassis ready drilled. Cabinet size 10½in. × 10in. wide. Maximum depth at base 5in. tapering to 3½in. at top. Sloping front. Very attractively finished in light walnut and peach. Each component brand new and tested prior to packing. Complete instruction booklet with practical and theoretical diagrams is provided. Booklet available at 1/6 post free. Our price for complete kit, £6/9/6! Please add 2/6 packing and carriage. If preferred, we can supply Cabinet Assembly only, comprising Cabinet and bracket wave-change switch, dial, pointer, drum pulleys, drive spindle, drive spring and knobs, at 45/-, plus 2/6 packing and carriage. N.B.—Our kits are even supplied with sufficient solder for the job.

N.B.—All our T.R.F. Kit circuits now include specially wound Denco "Max-Q" coils on polystyrene formers, improved performance! Price remains the same.

SURPLUS BARGAINS

METERS

F.S.D.	Size	Type	Fitting	Price
50 microamp	D.C. 2in.	M.C.	R.P.	50/-
50 microamp	D.C. 5in.	M.C.	Rectangular	120/-
50 microamp	D.C 4in.	M.C.	Rectangular	110/-
50 microamp	D.C. 3½in.	M.C.	F.R.	95/-
100 microamp	D.C. 2½in.	M.C.	F.R.	45/-
200 microamp	D.C. 2in.	M.C.	F.R. (Tropicalised)	30/-
200 microamp	D.C. 3½in.	M.C.	F.R.	65/-
500 microamp	D.C. 2in.	M.C.	F.R.	18/6
1 mA.	D.C. 2in.	M.C.	F.R.	17/6
1 mA.	D.C. 2in.	M.C	F. Sq.	22/6
1 mA.	D.C. 2in.	M.C.	F. Sq. (1954 manufacture by Elliott)	25/-
1 mA.	D.C. 2½in.	M.C.	Desk Type	30/-
50 mA.	D.C. 2in.	M.C.	F. Sq.	8/6
500 mA.	D.C. 3½in.	M.C.	F.R.	10/-
.5 amp.	R.F. 2in.	Thermo	F. Sq.	6/6
1 amp.	R.F. 2½in.	M.C.	F.R.	10/-
120-0-120 amp.	D.C. 2in.	M.C.	F. Sq. (shunt required)	15/-
150 amp.	A.C. 4in.	M.I.	R.P.	45/-
1 amp.	R.F. 2½in.	Thermo	R.P.	7/6
3 amp.	R.F. 2in.	Thermo	F. Sq.	6/-
20 amp.	D.C. 2in.	—	R.P. (with shunt)	10/6
25 amp.	D.C. 2½in.	M.I.	F.R.	6/6
30 amp.	D.C. 2½in.	M.I.	F.R.	12/6
15 volt	A.C. 2½in.	M.I.	F.R.	10/-
15-0-15 volt	D.C. 2½in.	M.C	F.R.	17/6
300 volt	A.C. 2½in.	M.C.	F.R.	35/-
300 volt	A.C. 3½in.	M.I.	F.R.	30/-

SPECIAL U.S. 0-1 mA. 2½in. taken from equipment but perfect, 22/6 each. R.P. = Round Projection. M.C. = Moving Coil. Thermo = Thermo-coupled. F. Sq = Flush Square. F.R = Flush Round. M.I. = Moving Iron.

METER RECTIFIERS. 1 mA. by G.E.C., at 6/6, also 5 mA. by G.E.C. at 6/6.

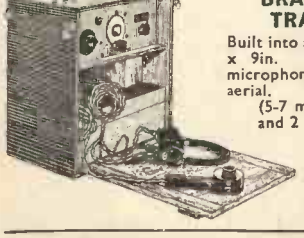
METER SPECIAL. We have a limited quantity of aircraft electrical thermometers. Brand new, by Weston, 2in. moving coil meter, flush square fitting. These meters have a luminous scale graduated 40-140 degrees centigrade, but the full scale deflection is approximately 150 microamps! Price 12/6 each only, plus 1/- P. & P.

24 VOLT ROTARY CONVERTOR. Input 24 v. D.C. Output 200/250 v. A.C. 100 watts. Complete in black steel box 18½in. × 11½in. × 8in. Weight approx. 30lb. Completely smoothed, incorporates Sodium Lamp transformer Brand new. 92/6.

HEADPHONES. Low resistance. Brand new ex-W.D. type CLR., 7/6 per pair, plus 1/6 p. & p. Brand new ex W.D. type DHR, 4,000 ohms, 15/- per pair. High resistance, 4,000 ohms brand new lightweight, 15/- per pair plus 1/6 P. & P.

TRANSISTORS! MULLARD TYPE O.C71. Available ex stock at new list price of 24/- each also O.C.71 at 21/- and O.C.72 at 30/-. All post free.

No. 38 TRANSMITTER/RECEIVER WALKIE-TALKIE. Range approx. 5 miles. Coverage 7.4-9 Mc/s. The set only complete with valves at 25/-. In very good condition We also have available "38" sets absolutely complete with junction box, aerial headphones, microphone, spare set of valves, with full operating instructions, absolutely brand new in original sealed packing cases, at 99/6 each complete station, plus 5/- carriage. Export enquiries invited.



SPECIAL PURCHASE from Ministry BRAND NEW No. 17 Mk. II TRANSMITTER/RECEIVER

Built into strong wooden cabinet 15in. x 14in. x 9in. Complete with headphones and microphone. Range 5-8 miles with simple aerial. Frequency coverage: 44-61 mc/s. (5-7 metres). Uses standard 120 v. H.T. and 2 volt L.T. batteries. Complete with full operating instructions. 59/6, plus 3/6. C. & P.

No. 17 Mk. II, as above, but secondhand, in good condition and complete, 45/- plus 3/6 C. & P.

HEAVY DUTY VARIABLE AUTO TRANSFORMER. Input: Variable from 110 to 250 volts. OUTPUT: 110 and 230 v. at 1.2 kVA. Contained in grey metal case with carrying handle. Overall size: 10in. W. × 8in. D. × 12in. H. Weight 1 qtr. 19lb. Brand new! £8/10/-, plus 7/6 carriage and packing.

THE R.C. RAMBLER ALL-DRY PORTABLE KIT

Full assembly details with practical and theoretical diagrams can be supplied at 1/6 post free. This is a truly professional 4-valve superhet—all dry—for medium and long waves A cream plastic top panel, with dial engraved in red and green adds to the very imposing appearance of this model which is housed in an attractive cream and grey leatherette covered attache-case type cabinet: measuring only 9in. × 7in. × 5½in. Weight less batteries 4½lb., with batteries 6½lb. This set really has everything. Built-in frame aerial, high quality, extremely sensitive and very adequate volume from the 5in. speaker. Valve line-up 3V4, 1R5, 1S5, 1T4. Also the required components, exactly as specified, including cabinet, can be supplied from stock at the special inclusive price of £7/7/- plus 2/6 p. and p. (less batteries). Uses Ever-Ready 90 v. H.T. type B126 at 10/-. Also L.T. 1.5 v. A.D. 35 at 1/6.

RAMBLER MAINS UNIT! At last we are able to offer our special mains units kit for using our popular all-dry "Rambler" on A.C. Mains. Complete kit, which when assembled fits snugly into battery compartment, can be supplied at 47/6 plus 1/6 packing and postage. Price includes all required components, and full assembly instructions. N.B.—This unit is completely self-contained in a metal box measuring 7in. × 2½in. × 1½in. and is ideally suitable for ANY all-dry battery portable requiring 90 v. H.T. and 1.5 L.T.

THE R.C. 2 AMP. BATTERY CHARGER KIT. Our new 2 amp. charger kit is now available. Includes handsome well-ventilated black stove-enamelled steel box, size 7¼in. × 3¼in. × 3¼in. Fully shrouded first quality transformer, brand new G.E.C. rectifier. Mains use, etc., or charging 6 or 12 v. batteries at 2 amp. Absolutely complete kit with full practical and theoretical instructions. Price 33/6 plus 2/6 P. & P. Can be supplied assembled and tested at 41/6 plus P. & P. Heavy duty crocodile clips suitable for car battery lugs, optional extra at 1/6 per pair.

POWER PACK. By leading manufacturer. Input 200/250 v. Output 350-0-350 280 mA., 6.3 v., 8 a., 6.3 v. 2 a., 4 v. 7 a., 5 v. 2 a. Fully smoothed. Incorporates valve rectifier GZ32. Chassis measures 13in. × 7in. × 5½in. Wt. 22lb. Few only at £4/19/6, plus 3/6 P. & P.

6 v. VIBRATOR PACK RCA. Input 6 v. Output 300 v. at 80 mA. D.C. fully smoothed. Incorporates 6-pin Vibrator, 0Z4A Rectifier, heavy-duty transformer, etc. Variable output. Dimensions 4 × 4¼ × 6in. Brand new. Limited quantity only, 35/-, plus 2/- P. & P.

6-VOLT VIBRATOR PACK. Ex-W.D. 6-volt input, output 140 v. 30 mA. Fully smoothed and rectified, incorporating 6-volt 4-pin vibrator. Unit size only 6½ × 5in. × 2½in. Price 15/-, plus 2/- P. & P. New condition.

VIBRATOR PACK. Brand new, by Mallory, 12-volt input, 150 v. 40 mA. output. Complete with synchronous vibrator, 12/6, plus 2/- P. & P.

FOUR-SPEED CHANGERS! The new B.S.R. 4-speed auto-changer in attractive cream and gold finish now available from stock at £9/15/- only, plus 3/6 p. and p. H.P. terms available.

GARRARD 120H ! ! ! 3-speed, mixer, auto-changer unit with crystal t/o head and sapphire stylii. Provided with Manual control for single records. Finished in Cream and Brown. Brand new in sealed manufacturers carton with fitting and operating instructions. £7/19/6 plus 5/- P. & P.

VALVES

We have perhaps the most up-to-date valve stocks in the trade. A stamp will bring complete list but the following is a selection only of brand new imported valve types, fully guaranteed. Purchase tax paid.

EABC80	10/-	DAF96	10/6	PL83	11/6
EAF42	10/-	DF96	10/6	PY80	10/6
EB41	7/6	DK92	10/6	PY81	10/-
EB91	7/6	DK96	10/6	PY82	9/6
EBC41	10/-	DL96	10/6	PY83	11 6
EBF80	11/6	or39/6perset		UBC41	10/6
ECC81	9/-	of four		UCH42	11/3
ECC82	9/-	DM70	9/-	UF41	10/6
ECC83	9/	EL41	10/6	UL41	10/6
ECC84	15/-	EL84	11/6	UY41	9/-
ECC85	10/-	EM80	9/-	6AQ5	8/6
ECF82	15/-	EY51	12/-	6AT6	8/-
ECH42	11/6	EY86	14/6	6AU6	9/6
ECH81	11/6	EZ40	8/6	6BA6	8/6
ECL80	11/6	EZ80	8/0	6BE6	9/-
EF41	10/6	PCF80	12/6	6BW6	8/6
EF80	10/6	PCF82	12/6	6X4	7/6
EF85	10/6	PCC84	12/6	35W4	7/6
EF86	12/6	PL81	13/6	50B5	10/-
EF89	10/-	PL82	10/6	50C5	10/-

In addition we naturally have all usual surplus types available such as 6V6GT, etc. All in our valve price list!

INEXPENSIVE INTERCOMM! A pair of ex-W.D. high-grade sound powered brand new microphone/receivers and 15 yds. of twin wire. Simply connect for one-to-one working. No batteries required. Only 8/6 pr., plus 1/- P. & P.

SOUND POWERED TELEPHONE HANDSETS. The luxury version of the above! No batteries required, simply connect with twin wire and use as telephone, 35/- per pair including 15 yds. flex, plus 2/6 P. & P. 100 yds. of twin flat transparent P.V.C. flex, suitable for long distance, or all radio or electrical work, at 22/6 per coil, plus 1/- P. & P.

MAINS TRANSFORMER BARGAINS. Limited quantities. Manufacturer's Surplus 350-0-350, 80 mA., 6.3 v. 3 a., 5 v. 2 a. Half shrouded, drop-through, 14/6 only, plus 1/6 P. & P. 230 v. input, 300-0-300 80 mA., 6.3 v. 3 a., 4 v. 2 a. Tropicalised drop-through type, 9/6 only, plus 1/6 P. & P. Input 110/230 v. Auto load 230 v. 750 mA., 350-0-350 130 mA. Tapped filament winding 6 v. 3 a., 15 v. 3 a., 21.5 v. 6 a., also 5 v. 2 a. Tropicalised drop-through type, 21/- plus 2/6 P. & P. 270-0-270, 100 mA. 6.3 v. 3 a., 5 v. 2 a. 200/250 v. input universal mounting, 16/6 plus 1/6 P. & P. Primary: 10-0-200-220-240v. Secondary windings: 375-200-0-200-375 v. at 250 mA. Double wound 230 v. at 6 amp., 6.3 v. at 3 amp., 8 v. at 0.25 amp. Unshrouded, fully impregnated drop-through type. 50/-, plus 1/6 P. & P.

RECORD PLAYERS CABINETS—to suit all types of single record and auto-changer units. Priced from 45/-. Send stamp for fully illustrated list.

THE "R.C. STALLION." This is the latest addition to our range of gramophone amplifiers and is supplied complete with high flux 8in. P.M. speaker and baffle. Incorporating three octal-type valves, 6Q7, 6V6 and 6X5, this robust and well-made unit is ideal for use in the larger type of record player or radiogram, and is equally suitable for use in conjunction with a radio feeder unit. Separate bass and treble controls are provided; also provision is made for an extension speaker and mains supplies to gram. motor. Output approx. 4 watts. Size (overall): 13in. × 4in. × 9in. high. For use on A.C. mains 100/200/250 v. Price £5/19/6, plus 2/6 P. & P. This amplifier will fit our portable cabinet type "G" without modification. Cabinet price 85/-, plus 6/6 P. & P. Will also accommodate any standard Record Changer!

BUREAU CABINET. Handsome walnut finish, French polished. 33½in. high × 31½in. × 15½in. Already cut out for B.S.R. Monarch but suitable for RC54, etc. Uncut board for amplifying portion measures 14½in. × 10½in. Two record storage compartments. Price £15/15/- plus 15/- carr. H.P. TERMS AVAILABLE.

We have a large selection of all type cabinets. A stamp will bring list.

R.S.C. BATTERY CHARGING EQUIPMENT

All for A.C. MAINS 200-250v., 50 c/s. Guaranteed 12 months.

ASSEMBLED CHARGER
6 v. or 12 v. 2 amps.
Fitted Ammeter and selector plug for 6 v. or 12 v. Louvred metal case, finished attractive hammer blue. Ready for use with mains and output leads, Double Fused.
Only **47/9** carr. 3/6.

ASSEMBLED CHARGERS
6 v. 1 amp. 19/9
6 v. or 12 v. 1 amp. 25/9
6 v. 2 amps. 29/9
6 v. or 12 v. 2 amps. .. 38/9
6 v. or 12 v. 4 amps. .. 56/9
Above ready for use. Carr. 2/9.

HEAVY DUTY KIT
12 v. 30 amp. Suitable for garage or firm with a number of vehicles. Mains input 200/250 v. 50 c/s. Outputs 12 v. 15 amp. twice. Consists of Mains Trans. 2 Metal Rectifiers. 2 Meters. 4 Fuses. 4 Terminals. 2 Rheostats and circuit. Only 9 gns. carr. 15/-.

BATTERY CHARGER KITS
Consisting of Mains Transformer, F.W. Bridge, Metal Rectifier, well ventilated steel case, Fuses, Fuse-holders, Grommets, panels and circuit. Carr. 2/6 extra.
6 v. or 12 v. 1 amp. 22/9
6 v. 2 amps. 25/9
6 v. or 12 v. 2 amps. .. 31/6
6 v. or 12 v. 4 amps. .. 49/9

BATTERY CHARGER KIT
Consisting of F.W. Bridge Rectifier 6/12 v. 5 a. Mains Trans., 0–9–15 v. 6 a. output, and variable charge rheostat with knob. Only 45/9. Post 3/-

Assembled 6 v. or 12 v. 4 amps.
Fitted Ammeter and variable charge selector. Also selector plug for 6 v. or 12 v. charging. Double fused. Well ventilated steel case with blue hammer finish. Ready for **69/6** use with mains and output leads. Carr. 3/9.

SELENIUM RECTIFIERS

L.T. Types		6/12 v. 6 a. ..	19/9
2/6 v. ½ a.h.w.	1/9	6/12 v. 10 a. ..	25/9
6/12 v. ½ a.h.w.	2/9	**H.T. Type H.W.**	
F.W. Bridge Types		120 v. 40 mA.	3/9
6/12 v. 1 a. ..	4/11	250 v. 50 mA.	5/9
6/12 v. 2 a. ..	8/9	250 v. 80 mA.	7/9
6/12 v. 3 a. ..	11/9	250 v. 150 mA.	9/9
6/12 v. 4 a. ..	14/9	300 v. 275 mA.	12/11

CO-AXIAL CABLE. 75 ohms, ½in., 8d. yard. Twin screened feeder, 11d. yard.

5 CORE FLEX. Henleys circular rubber 14/36. Each lead colour coded. 1/6 yd.

DIAL BULBS, M.E.S., 8 v. 0.2 a., 6/9 doz. 6.5 v. 0.3 a., 6/9 doz.

ELECTROLYTICS (current production). NOT Ex Govt.

Tubular Types		Can Types	
8 mfd. 450 v..	1/9	16 mfd. 350 v.	1/11
8 mfd. 500 v...	2/6	16μF 450 v. ..	2/9
16μF 350 v. ..	2/3	16 mfd. 500 v.	3/9
16μF 450 v. ..	2/9	32μF 350 v. ..	2/11
16μF 500 v. ..	3/9	32 mfd. 450 v.	4/9
8-16μF 500 v.	4/11	100 mfd. 450 v.	4/9
25μF 25 v. ..	1/3	8-8μF 450 v. ..	2/9
50μF 12 v. ..	1/3	8-16μF 450 v.	3/11
50 mfd. 25 v...	1/9	16-16μF 450 v.	3/11
50μF 50 v. ..	1/9	32-32μF 350 v.	4/9
100 mfd. 12 v.	1/9	32-32μF 450 v.	5/9
100 mfd. 25 v.	2/3	64-120 mfd. 350 v.	7/6
6,000 mfd. 6 v.	3/11	100-200 mfd. 275 v.	6/11

Many others in stock.

VOLUME CONTROLS with long spindles, all values less switch, 2/9; with S.P. switch, 3/9.

EX GOVT. STEP UP/STEP DOWN TRANSFORMERS. Double wound 80/100 watts. 10-0-100-200-220-240 v. to 5-0-75-115-125-135 v. or Reverse. Only 11/9, plus 2/9 post.

EX GOVT. METAL BLOCK PAPER CONDENSERS

4 mfd. 500 v...	2/3	8 mfd. 500 v...	4/6
4 mfd. 1,000 v.	3/9	10 mfd. 500 v.	4/9
4 mfd. 1,500 v.	5/9	8-8 mfd. 500 v.	5/11
4 mfd. 400 v. plus 2 mfd. 250 v.			1/11

EX GOVT. VALVES. VR137, EA50, EB34, **11d.;** SP61 2/3; 4SHA 1/3; EL32 3/9; VS110 1/11; KT44 4/9; 6J5 3/9; 6V6G, 5U4G 5/9; 6K7G 2/11; 35Z4, 6X4 5/9; EZ80, EF80 7/9.

EX GOVT. UNITS, type RDF1 in original sealed cartons with 14 valves including 5Z4G, etc., trans., L.F. choke, Rectifier, etc., etc. We cannot enter into correspondence regarding these units which represent a really exceptional bargain at 29/9. Carr. 7/6.

OIL FILLED BLOCK CONDENSERS
Bryce 11-7 mfd. 500 v. New unused Govt. surplus, only 5/9 each.

THE SKY FOUR T.R.F. RECEIVER

A design of a 3 valve 200-250 v. A.C. Mains L. & M. wave T.R.F. receiver with selenium rectifier. For inclusion in cabinet illustrated above or walnut veneered type. It employs valves 6K7, SP61, 6F6G, and is specially designed for simplicity in wiring. Sensitivity and quality is well up to standard. Point-to-Point wiring diagrams, instructions and parts list, 1/9. This receiver can be built for a maximum of £4/19/6 including cabinet. Available in brown or cream bakelite or veneered walnut.

EX GOVT. MAINS TRANSFORMERS
All 230 v. 50 c/s. input

120-0-120 v. 40 mA.	5/9
300-0-300 v. 150 mA., 4 v. 3 a.	9/9
250-0-250 v. 80 mA., 6.3 v. 3 a., 6.3 v. 1 a. Potted 4½-3½-3in.	11/9
460 v. 200 mA., 6.3 v. 5 a.	22/9

MANUFACTURERS SURPLUS TRANSFORMERS
Fully shrouded upright. Primary 200-230-250 v. Sec. 425-0-425 v. 150 mA. 6.3 v. 3 a., 5 v. 3 a., 33/9. Clamped type 325-0-325 v. 100 mA., 6.3 v. 3.5 a., 5 v. 2 a. Wearite 19/9. 230-0-230 v. 60 mA., 6.3 v. 2.5 a. Midget, 2½ × 3 × 2½in. approx., 11/9. Post 2/9 on any of above.

EX GOVT. SMOOTHING CHOKES

250 mA., 5 H., 50 ohms	12/9
250 mA., 3 H., 50 ohms	8/9
150 mA., 10 H., 50 ohms	10/11
100 mA., 10 H., 100 ohms, Parmeko ...	6/9
100 mA., 5 H., 100 ohms, Tropicalised..	3/11
50 mA., 50 H., 1,000 ohms	6/9
L.T. type 1 amp., 2 ohms	2/9

EX-GOVT. CASE. Well ventilated, black crackle finished, undrilled cover. Size 14—10—8½in. high IDEAL FOR BATTERY CHARGER OR INSTRUMENT CASE. COVER COULD BE USED FOR AMPLIFIER. Only 9/9, plus 2/9 post. **SPECIAL OFFERS.** Small 2 gangs .0005 mfd., 4/9. Electrolyctics 32-32-32 mfd. 250 v. 2½ × 1⅝ins. In lots of six, 2/3 ea.

R.S.C. BATTERY TO MAINS CONVERSION UNITS

Type BM1. An all dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.4 v. and 90 v. where A.C. mains 200-250 v. 50 c/s. is available. **Suitable for all battery portable receivers requiring 1.4 v. and 90 v.** This includes latest low consumption types. Complete kit with diagrams 39/9, or ready for use, 46/9.

Type BM2. Size 8 × 5½ × 2½in. Supplies 120 v., 90 v., and 60 v., 40 mA. and 2 v. 0.4 a. to 1 amp. fully smoothed. **THEREBY COMPLETELY REPLACING BOTH H.T. BATTERIES AND L.T. 2v. ACCUMULATORS** when connected to A.C. mains supply 200-250 v. 50 c/s. SUITABLE FOR ALL BATTERY RECEIVERS normally using 2 v. accumulator. Complete kit with diagrams and instructions 49/9 or ready for use 59/6.

MINIATURE MOTORS. 24/28 v. D.C. or A.C. Size only 2⅜ × 1½ins. Spindle 1½ins. long, ¼in. diam. Made by Hoover Ltd., Canada. Price only 9/9.
VIBRATORS. Oak 2 v. 7 pin. synchronous, 7/9.
M. E. SPEAKERS, 2—3 ohms R. A. 8in. Field 600 ohms, 11/9.

T.V. CABINETS. For 15, 16 or 17in. tube. Table model with doors, 79/6, carr. 7/6.

R.S.C. TRANSFORMERS

FULLY GUARANTEED. INTERLEAVED AND IMPREGNATED

MAINS TRANSFORMERS
Primaries 200-230-250 v. 50 c/s.

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250 v. 60 mA., 6.3 v. 2 a., 5 v. 2 a., Midget type, 2½-3-3in.	17/6
350-0-350 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.	19/9
250-0-250 v. 100 mA., 6.3 v.-4 v. 4 a., c.t., 0-4-5 v. 3 a.	25/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
250-0-250 v. 100 mA., 6.3 v. 6 a., 5 v. 3 a., for R1355 conversion	31/-
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
300-0-300 v. 100 mA., 6.3 v. 4 v. 4 a. c.t., 0-4-5 v. 3 a.	26/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
300-0-300 v. 130 mA., 6.3 v. 4 a., c.t., 6.3 v. 1 a., suitable for Mullard 510 Amplifier	33/9
350-0-350 v. 100 mA., 6.3 v.-4 v., 4 a., c.t., 0-4-5 v. 3 a.	26/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	33/9
350-0-350 v. 150 mA., 6.3 v. 2 a., 6.3 v. 2 a., 5 v. 3 a.	33/9
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t., 6.3 v. 4 a. c.t., 5 v. 3 a., suitable Williamson Amplifier, etc.	49/9
450-0-450 v. 250 mA., 6.3 v. 6 a., 6.3 v. 6 a., 5 v. 3 a.	69/6

TOP SHROUDED DROP-THROUGH TYPE

260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.	16/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.	18/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	22/9
300-0-300 v. 100 mA., 6.3 v.-4 v. 4 a., c.t., 0-4-5 v. 3 a.	23/9
350-0-350 v. 100 mA., 6.3 v. 4a., c.t., 5v. 3a.	22/9
350-0-350 v. 100 mA., 6.3 v.-4 v. 4 a. c.t., 0-4-5 v. 3 a.	23/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	29/9
E.H.T. TRANSFORMERS, 2,500 v. 5 mA., 2-0-2 v. 1.1 a., 2-0-2 v. 1.1 a., for VCR97, VCR517	36/6

FILAMENT TRANSFORMERS
Primaries 200-250 v. 50 c/s.

6.3 v. 1.5 a. ..	5/9	0-2-4-5-6.3 v.	
6.3 v. 2 a.	7/6	4 a.	16/9
0-4-6.3 v. 2 a.	7/9	6.3 v. 6 a.	17/6
6.3 v. 3 a.	8/11	12 v. 3 a. or 12 v. 1 a.	7/9
24 v. 1.5 a. ..			17/6

CHARGER TRANSFORMERS
All with 200-230-250 v. 50 c/s. Primaries: 0-9-15 v. 1½ a., 11/9; 0-9-15 v. 3 a., 16/9; 0-3.5-9-17 v. 3 a., 17/9; 0-9-15 v. 5 a., 19/9; 0-9-15 v. 6 a., 23/9.

ELIMINATOR TRANSFORMERS
Primaries 200-250 v. 50 c/s.

120 v. 40 mA., 5-0-5 v. 1 a.	14/9
90 v. 15 mA., 6-0-6 v., 250 mA.	9/11

OUTPUT TRANSFORMERS

Midget Battery Pentode 66:1 for 3S4, etc.	3/6
Small Pentode 5,000Ω to 3Ω	3/9
Standard Pentode, 5,000Ω to 3Ω	4/9
Standard Pentode, 8,000Ω to 3Ω	4/9
Multi-ratio 40 mA. 30:1, 45:1, 60:1, 90:1, Class B Push-Pull	5/6
Push-Pull 8 Watts 6V6 to 5 ohms.....	8/9
Push-Pull 10-12 Watts 6V6 to 3Ω or 15Ω	15/9
Push-Pull 10-12 Watts to match 6V6 to 3-5-8 or 15Ω	16/9
Push-Pull 15-18 Watts, sectionally wound, 6L6, KT66, etc., to 3 or 15 ohms	21/9
Push-Pull 20 Watt high-quality sectionally wound, 6L6, KT66, etc., to 3 or 15Ω	47/9
Williamson type exact to spec.	85/-

SMOOTHING CHOKES

250 mA., 5 H., 100 ohms	11/9
150 mA., 7-10 H., 250 ohms	11/9
100 mA., 10 H., 200 ohms	8/9
80 mA., 10 H., 350 ohms	5/6
60 mA., 10 H., 400 ohms	4/11

R.S.C. A6 ULTRA LINEAR 30 WATT AMPLIFIER

NEW 1956 DESIGN. HIGH FIDELITY PUSH-PULL UNIT EMPLOYING SIX VALVES. Tone Control Pre-amp stages are incorporated. Sensitivity is extremely high. Only 30 millivolts minimum input is required for full output. **THIS ENSURES THE SUITABILITY OF ANY TYPE OR MAKE OF MICROPHONE OR PICK-UP.** Separate Bass and Treble controls give both "lift" and "cut" with ample tone correction for long playing records. **AN OUTPUT SOCKET WITH PLUG IS INCLUDED FOR SUPPLY OF 300 v. 20 mA. and 6.3 v. 1.5 a. FOR A RADIO FEEDER UNIT.** Price in kit form with easy-to-follow wiring diagrams. **9 GNS.** Only carr. 10/-. Or Factory built with 12 months' guarantee, 50/- extra. **TERMS ON ASSEMBLED UNITS** with extra input. **DEPOSIT** 28/9 and 9 monthly payments of 28/9. If required an extra input with associated vol. control can be provided so that two separate inputs such as "mike" and gram., etc. etc., can be simultaneously applied for mixing purposes. Extra cost of this 13/-. Cover as illustrated 17/6 extra.

Type 807 output valves are used with High Quality Sectionally wound output transformer specially designed for Ultra Linear operation. Negative feedback of 17 D.B. in main loop. **CERTIFIED PERFORMANCE FIGURES ARE EQUAL TO MOST EXPENSIVE UNITS AVAILABLE.** Frequency response ± 3 D.B., 30-20,000 c/cs., 12 D.B. "lift" at 50 c/cs., 12 D.B. "lift" at 12,000 c/cs., Hum and noise 70 D.B. down. Good quality reliable components used. Chassis finish blue crackle. Overall size 12 × 9 × 9in. approx. Power consumption 150 watts. For A.C. mains 200-230-250 v. 50 c/cs. Outputs for 3 and 15 ohm speakers. **EQUALLY SUITABLE FOR THE CONNOISSEUR OR FOR LARGE HALLS, CLUBS, or OUTSIDE FUNCTIONS. IDEAL FOR USE WITH MUSICAL INSTRUMENTS SUCH AS STRING BASS, ELECTRONIC ORGAN, GUITAR, etc. FOR DANCE BANDS, GARRISON THEATRES, etc. etc.**

We can supply Microphones, Speakers, Rotary Converters, etc., at keen cash prices or on terms with amplifiers.

EXPORT ENQUIRIES INVITED

R.S.C. TA1 HIGH QUALITY TAPE DECK AMPLIFIER

FOR ALL DECKS WITH HIGH IMPEDANCE RECORD/PLAYBACK AND ERASE HEADS. Such as Lane, Truvox, etc., or matched to low impedance erase heads as fitted latest COLLARO TAPE TRANSCRIPTOR. Chassis size 12-7-3in. Overall size 12-7-6¼in. For 230-250 v. 50 c/cs. A.C. mains. Output for standard 2-3 ohm speaker. Only 15 millivolts input required for full recording. Only 2 millivolts minimum input required from recording head. Magic Eye recording level indicator. Provision for feeding P.A. amplifier. Can be used as gram. amplifier with input of 0.75 v. R.M.S. Negative feedback equalisation. Linear frequency response ± 3 D.B. 50-11,000 c/cs. Facilities for recordings at 15in., 7½in. or 3¾in. per second. Automatic equalisation at the turn of a knob. When switching from record to playback position automatic demagnetisation of heads is assured. PERFORMANCE IS COMPARABLE WITH UNITS AT OVER TWICE THE COST. LEAFLET 6d.

11 Ready for use **GNS.** Carr. 7/6.

H.M.V. LONG PLAYING RECORD TURNTABLE COMPLETE WITH CRYSTAL PICK-UP (SAPPHIRE STYLUS). 8peed 33⅓ r.p.m. BRAND NEW. CARTONED. Only £3/19/6 (approx. half price). Carr. 5/- (for 200-250 v. A.C. Mains).

R.S.C. 4-5 WATT HIGH GAIN AMPLIFIER TYPE A5

A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 50 millivolts input is required for full output so that it is suitable for use with the latest high-fidelity pick-up heads in addition to all other types of pick-ups and practically all mikes. Separate Bass and Treble controls are provided. These give full long playing record equalisation. Hum level is negligible, being 71 D.B. down. 15 D.B. of negative feedback is used. H.T. of 300 v. 26 mA. and L.T. of 6.3 v. 1.5 a. is available for the supply of a Radio Feeder Unit or Tape Deck pre-amplifier. For A.C. mains input of 200-230-250 v., 50 c/s. Output for 2-3 ohm speaker. Chassis is not alive. Kit is complete in every detail and includes fully punched chassis (with baseplate) with the blue hammer finish, and point-point wiring diagrams and instructions. Exceptional value at only £4/15/-, or assembled ready for use 25/- extra, plus 3/6 carriage.

R.S.C. A7 3-4 WATT QUALITY AMPLIFIER

A highly sensitive 4-valve amplifier using negative feedback and having an excellent frequency response. Pre-amplifier and Tone Control stages are incorporated with separate Bass and Treble controls giving full tone compensation for Long Playing records. Suitable for any kind of pick-up including latest high fidelity types. H.T. of 250 v. 20 mA. and L.T. 6.3 v. 1 a. available for supply of Radio Feeder Unit, etc. ONLY 40 millivolts input required for full output. Fully isolated chassis with baseplate. For A.C. mains 200-250 v. 50 cycles. Output for 2-3 ohm speaker. Complete kit of parts with point-to-point wiring diagrams and instructions. Only £3/15/-, carr. 3/6 or factory built 22/6 extra.

P.M. Speakers recommended for use with above amplifiers.

Plessey 10in. 3 ohm with high flux density magnet. Only 28/9.

P.M. SPEAKERS. 2-3 ohm, 5in. Goodmans, 17/9. 7 × 4in. Elliptical, 19/6. 6½in. R.A., 15/9. 8in. Rola, 19/9. 10in. R.A., 26/9. 12in Plessey, 29/11. 12in. Plessey 15 ohms, 10 watts 3 gns

GARRARD 3-SPEED AUTOMATIC RECORD CHANGERS.

Latest Model Mixer Type RC110. Fitted high fidelity turnover crystal pick-up head with dual point sapphire stylus. Baseboard size 14 × 12½in., height above, 4in. Below, 2½in. For 200-250 v. A.C. mains. Limited number. Brand new cartoned. Only £7/19/6, plus 3/6 carriage.

LINEAR L45 MINIATURE 4/5 W. QUALITY AMPLIFIER. Suitable for use with Garrard, B.S.R. or any other record playing unit, and most microphones. Total negative feedback 12 db. Separate Bass and Treble Controls. For convenience when mounted in cabinet, mains switch is incorporated in control. For A.C. mains input of 200-250 v. 50 c.p.s. Output for 2/3 ohm speaker. Three miniature Mullard valves used. Size of unit only 6 × 5 × 5in. high. Chassis is fully isolated from mains. Guaranteed 12 months. Only 25/19/6.

MICROPHONES. High fidelity crystal types. Acos 33-1 hand or desk type, 50/-. Piezzo with heavy floor base and telescopic stem, £6/19/6.

ROTARY CONVERTERS. 200 watts. Input 12 v. D.C. Output 230 v. 50 c/cs. A.C. Only 7 gns. Carr. 7/6.

PLESSEY DUAL CONCENTRIC 12 in. P.M. SPEAKERS

(15 ohms), consisting of a high quality 12in. speaker, of orthodox design supporting a small elliptical speaker ready wired with choke and condensers to act as tweeter. This high fidelity unit is highly recommended for use with our A8 or any similar amplifier. Rating is 10 watts. Price only £5/17/6.

R.S.C. ULTRA LINEAR 12-WATT AMPLIFIER

NEW 1956 MODEL A8 HIGH-FIDELITY PUSH-PULL AMPLIFIER WITH "BUILT-IN" TONE CONTROL, PRE-AMP. STAGES

High sensitivity. Includes 5 valves (807 outputs), High Quality sectionally wound output transformer, specially designed for Ultra Linear operation, and reliable small condensers of current manufacture. INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut." Frequency response ± 3 db. 30-30,000 c/cs. Six negative feedback loops. Hum level 71 db. down. ONLY 70 millivolts INPUT required for FULL OUTPUT. Suitable for use with all makes and types of pick-ups and practically all microphones Comparable with the very best designs. For STANDARD or LONG PLAYING RECORDS. For MUSICAL INSTRUMENTS such as STRING BASS, GUITARS, etc. OUTPUT SOCKET with plug provides 300 v. 20 mA. and 6.3 v. 1.5 a. For supply of a RADIO FEEDER UNIT. Size approx. 12-9-7in. For A.C. mains 200-230-250 v. 50 c/cs. Output for 3 and 15 ohm speakers. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagrams supplied.

Unapproachable value at **£7/15/-** or factory built 45/- extra. Carriage 10/-. If required louvred metal cover with 2 carrying handles can be supplied for 17/6. Where an extra input socket with associated volume control is required for mixing purposes this can be provided for 13/- extra. TERMS ON ASSEMBLED UNITS with extra input as mentioned above. DEPOSIT 25/6 and nine monthly payments of 23/4.

LINEAR "DIATONIC" 10-WATT HIGH FIDELITY AMPLIFIER. Incorporating pre-amp. For A.C. Mains input 200-230-250 v. 50 c.p.s. A compact attractively finished unit with two separately controlled inputs, and outputs for 3 and 15 ohm speakers. Separate Bass and Treble controls. Five latest type miniature Mullard valves. Only 12 Gns. Carr. paid. Send S.A.E. for leaflet.

W.B. "STENTORIAN" HIGH FIDELITY P.M. SPEAKERS. HF1012, 10 watts, 15 ohm (or 3 ohm) speech coil. Where a really good quality speaker at a low price is required, we highly recommend this unit with an amazing performance, £4/10/9. Please state whether 3 ohm or 15 ohm required.

SUPERHET RADIO FEEDER UNIT

Design of a high quality Radio Tuner Unit (specially suitable for use with any of our Amplifiers). A Triode Heptode F/changer is used. Pentode I.F., and double Diode Second Detector. Delayed A.V.C. Ae./Grid F/C Coupling is by bottom end Condenser Coupling giving freedom from alignment troubles when Ae. of varying lengths and capacity are used. Both Frequency Changers and I.F. valves are A.V.C. controlled from the very low distortion Double Diodes so arranged that very high Percentage modulation of the Transmitter can be handled without distortion. The Feed for the delayed A.V.C. is arranged so that A.V.C. distortion is avoided. The W. Ch. Sw. incorporates Gram. position. Controls are Tuning, W., Ch., and Vol. Output will load most Amplifiers requiring 300 M.V. input depending on Ae. location. Only 250 v. 15 mA. H.T., and L.T. of 6.3 v. 1 amp. required from amplifier. Size of unit approx. 9-6-7in. high. Send S.A.E. for illustrated leaflet. Total building cost is £4/15/-. Point-to-point wiring diagrams and instructions. 2/6.

Radio Supply Co. (LEEDS) LTD.

32 THE CALLS. — LEEDS, 2.

Terms C.W.O. or C.O.D. No C.O.D. under £1. Postage 1/9 extra on *all* orders under £2, 2/9 extra under £5 unless carriage charge stated. Full Price List 6d. Trade List 5d. Open to Callers: 9 a.m. to 5.30 p.m. Saturday until 1 p.m.

C.R.T. ISOLATION TRANSFORMERS

For Cathode Ray Tubes having Heater/Cathode short circuit for C.R. Tubes with falling emission.
Type A. Low leakage windings. Ratio 1:1.25 giving a 25% boost on Secondary.

2 volt	10/6 each	With Tag
4 volt	10/6 each	Panel and
6.3 volt	10/6 each	Solder Tags
10.8 volt	10/6 each	
13.3 volt	10/6 each	

Ditto with mains primaries 12/6 each.
Type B. Mains input 220/240 volts. Low Capacity. Multi Output 2, 4, 6.3, 7.3, 10 and 13 volts. Input has two taps which increase output volts by 25% and 50% respectively. This transformer is suitable for all Cathode Ray Tubes. With Tag Panel 21/- each.
Type C. Low capacity wound transformer for use with 2 volt Tubes with falling emission. Input 220/240 volts. Output 2-2½-2½-2½-3 volts at 2 amps. With Tag Panel 17/6 each.
All Isolation Transformers are individually boxed, labelled and clearly marked with relevant data.
NOTE:—It is essential to use mains primary types with T.V. receivers having series connected heaters.

RESISTORS. All values. 10 ohms to 10 meg., ½ w., 4d.; ¼ w., 6d.; 1 w., 8d.; 2 w., 1/-.
HIGH STABILITY. ½ w., 1%, 2/-. All preferred values 100 ohms to 10 meg.
5 watt, 10 watt, 15 watt } WIRE-WOUND RESISTORS 25 ohms—10,000 ohms ..... { 1/3 / 1/6 / 2/-
15,000 ohms—50,000 ohms, 5 w., 1/9; 10 w..... 2/3
WIRE-WOUND POTS. 3 WATT LAB. COLVERN, ETC.

Pre-set Min. T.V. Type Knurled Slotted Knob. All values 25 ohms to 30 K. 3/- ea. 50 K., 4/-. Ditto Carbon Track 50 K. to 2 Meg., 3/-.	Standard size Pots., 2½in. Spindle High Grade. All Values, 100 ohms to 50 K., 5/6; 100 K., 6/6. W/W EXT. SPEAKER CONTROL 10Ω, 3/-.

O/P TRANSFORMERS. Heavy Duty 50 mA., 4/6. Multi-ratio push pull, 6/6. Tapped small pentode, 3/9. Hygrade Push Pull 7 watts, 15/6.
L.F. CHOKES 15/10 H. 60/65 mA., 5/-; 25/20 H. 100/120 mA., 11/6; 20/15 H., 120/150 mA., 12/6; 5 H. 250 mA., 15/-.
MAINS TRANS. 350-0-350, 80 mA., 6.3 v. tapped 4 v. 4 a. 5 v. tapped 4 v. 2 a., ditto 250-0-250 80 mA., etc., 21/-.

I.F. TRANSFORMERS 7/6 pair

465 Kc/s Slug tuning Miniature Can. 2½ × ½in. × ½in. High Q and good band width. By Pye Radio. Data sheet supplied.

HEATER TRANS. Tapped 200/250 v. 6.3 v. 1½ amp., 7/6
COPPER PLATED AERIAL RODS. ¼×12in. push fitting, 3/- oz. Post 1/-.
ALADDIN FORMERS and cores. ½in., 8d.; ¾in., 10d. .3in. FORMERS 5937/8 and Cans TV1/2. ½in. sq. × 2½in. and ½in. sq. × 1¾in., 2/- complete with cores.
SLOW MOTION DRIVES. Epicyclic ratio 6:1, 2/3.
TYANA. Midget Soldering Iron. 200/220 v. or 230/250 v. 16/9. SOLON MIDGET IRON. 25 w., 24/-.
MIKE TRANS. Ratio 50:1, 3/9 ea., new and boxed.
MAINS DROPPERS. 3×1½in. Three Adj. Sliders, .3 amp. 750 ohms, 4/3. .2 amp., 1,000 ohms, 4/3.
LINE CORD. .3 amp., 60 ohms, per foot, .2 amp., 100 ohms, per foot, 2 way, 6d. per foot, 3 way, 7d. per foot.

CRYSTAL MIKE INSERT by Acos

Precision engineered. Size only 1½×3/16in. Bargain. Price 6/6. No transformer required.

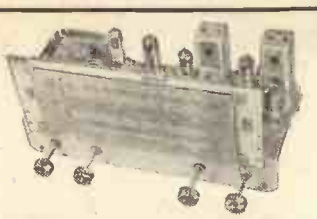
LOUDSPEAKERS P.M. 3 OHM. 2½in. square 17/6.
5in R.A. 17/6. 7in. × 4in. Goodmans 21/-.
3½in. Square Elac., 21/-. 8in. Elac, 22/6.
7½in. Goodmans, 18/6. 10in. R.A. 30/-.
TSL TWEETER LSH75, 8/6. 12in. Plessey 30/-.
8in. M.E. 2.5 k. field tapped O.P. transformer, 24/6.
CRYSTAL DIODE. G.E.C., 2/-. GEX34, 4/-.
CRYSTAL SET CONSTRUCTION. Kit 12/6.
H.R. HEADPHONES. 4,000 ohms, brand new, 16/6 pair.
SWITCH CLEANER Fluid, squirt spout, 4/3 tin.
TWIN GANG CONDENSERS. 365 pf. midget, 1⅜in. × 1½in. × 1¾in., 10/-. .0005 Standard with trimmers, 9/-; less trimmers, 8/-; solled, 2/6; 3-gang 500 pf., 7/6.

SUPERHET COIL PACK 27/6

Miniature size 2½×2½×1½in. High Q dust cored coils. SHORT, MED., LONG. GRAM switching with connection diagram and circuit.

VALVE HOLDERS. Par int. Oct., 4d. EF50, EA50, 6d. B12A, CRT, 1/3. Eng. and Amer. 4, 5, 6, 7 and 9 pin, 1/-.
MOULDED Mazda and Int. Oct., 6d., B7G, B8A, B8G, B9A, 9d., B7G with can, 1/6, VCR97, 2/6. B9A with can, 2/6.
CERAMIC, EF50, B7G, Int. Oct., 1/-. B7G with can, 1/9.
SPEAKER FRET. Gold Cloth 18in.×25in., 5/-. 25in.× 36in., 10/-. Expanded metal, Silver 15½×9½in. 2/- each. 6in. Speaker Baffle, silk covered, 1/- each.
WAVECHANGE SWITCHES.
2 p. 2-way 3 p. 2-way, short spindle 2/6
5 p. 4-way 2 wafer, long spindle 6/6
2 p. 6-way, 4 p. 2-way, 4 p. 3-way, long spindle 3/6
3 p. 4-way, 1 p., 12-way, long spindle 3/6
TOGGLE SWITCHES. S.P., 2/-. D.P., 3/6. D.P.D.T. 4/-
NUTS, BOLTS. 12 of each, 2, 4 or 6BA 1/-

KNOBS, GOLD ENGRAVED. Walnut or Ivory. 1½in. diam., 1/6 each. "Focus," "Contrast," "Brilliance," "Brilliance—On/Off," "On-Off," "Volume," "Volt-On-Off," "Tone," "Tuning," "Treble," "Bass," "Wavechange," "Radio Gram," "S.M.L. Gram," "Record-Play," "Brightness." ditto, not engraved, 1/-.



1957 RADIOGRAM CHASSIS

THREE WAVEBANDS FIVE VALVES
S.W. 16 m.—50 m. LATEST MULLARD
M.W. 200 m.—550 m. ECH42, EF41, EBC41,
L.W. 800 m.—2,000 m. EL41, ELZ40
12 month Guarantee. A.C. 200/250 v. 4-way switch. Short-Medium-Long-Gram. A.V.C. and Negative feedback. 4.2 watts. Chassis 13½in. × 5½in. × 2½in. Glass Dial 10 × 4½in., horizontal or vertical available. 2 Pilot Lamps. Four Knobs, Walnut or Ivory, aligned and calibrated. Chassis isolated from mains.
T.S.L. Tweeter supplied free.

BRAND NEW £10.10.0 Carr. 4/6.
TERMS: Deposit £5/5/- and 6 monthly payments of £1.

AM/FM RADIOGRAM CHASSIS

Measurements 13in. × 6in. × 7in. high. Dial cut-out required only 10½in. × 2½in. 5 valve plus metal rect., gram. socket, piano key wavechange, tone control, med., long and V.H.F. wavebands. Valve line-up: ECC85, ECH81, EF89, EABC80, EL41. For A.C. mains 100-250 v.
PRICE **£16.19.6** Carriage 10/6.
MATCHED SPEAKERS FOR ABOVE CHASSIS 8in., 19/6; 10in., 25/-; 12in., 30/-.

Collaro Autochanger RC531 for 78 R.P.M. 10in. and 12in. Records. Brand new in maker's boxes! High impedance, light-weight pickup with sapphire needle, will match any amplifier or radio. Less than half price. Terms: deposit £2-15-0 and 6 monthly payments of 10/-. **5 GNS.** Post free. No C.O.D.

FAMOUS MANUFACTURER'S 4-SPEED AUTOMATIC RECORD CHANGERS 1957 MODELS

Brand new and fully guaranteed 12 months.

NOT JOB LINE REJECT STOCK

Designed to play 16, 33, 45, 78 r.p.m., Records 7in., 10in., 12in. Lightweight Xtal pick-up, turnover head, two separate sapphire styli, for Standard and L.P. each plays 2,000 records. Voltage 200/250 A.C.

OUR PRICE **£8.15.0** each. Post free.
Terms: Deposit £5 and 5 monthly payments of £1. Space required 14in. × 12½in. 5in. above and 3in. below. single record players, 1957 models, lightweight Xtal P.U. Independent sapphire stylus for Standard and Long Play 7in., 10in., 12in., Records; 33, 45, 78 r.p.m. 200/250 v. A.C. silent motor free of wow! Complete unit mounted on baseplate with auto-stop. Space required 14in. × 12½in. 3in. above and 3in. below.

OUR PRICE **£7.15.0** each. Post free.
Handsome Player Cabinets for the above units, 49/6, post 2/6. Larger type with space for small amplifier and speaker, 63/-. post 3/8.

B.S.R. MONARCH. 3-speed Motor and Turntable with selecting switch for 33, 45 and 78 r.p.m. records 100-120 v. and 200-250 v. A.C. 50 c.p.s. Also B.S.R. MONARCH Lightweight Pick-up with Acos Xtal turnover head, separate Sapphire stylus for L.P. and standard records. SPECIAL OFFER, THE TWO £4/12/6. post 2/6. Player Cabinet 49/6, post 2/6.

Teletron Band III Converter

London, Midland and Northern for all T.V. Makes. T.R.F. or Superhet
Ready wound coils, two EF80 valves, all components, punched chassis, circuit diagram, wiring plans. COMPLETE KIT for mains operation. 200-250 v. A.C. £3/10/-.
AS ABOVE less POWER PACK. Requires 200 v. 20 mA. H.T. 6.3 v. 0.6 a. L.T. £2/5/-.

ALLDRY UNIT POWER PACK. Replaces Battery B114, etc., 69 v. plus 1½ v. Size 4½in. × 3½in. × 1½in. 4-pin Socket. Same as battery. Only 1/- a year to run on A.C. 200-250 v. FAMOUS MAKE. LIST PRICE 65/-. OUR PRICE 39/6. Ready for use

T.V. PRE-AMP. (McMICHAEL)
Will amplify output of your Band 3 Converter. Tunable Channels 1 to 5. Midget size. High gain fringe model. B.V.A. Valve. Full instructions supplied. READY FOR USE. (H.T. 200V., L.T. 6.3V., .3 amp. required). PRICE 25/- each. BRAND NEW. SPECIAL MAINS POWER PACK for above, 25/- extra.

Volume Controls

Midget size
Long spindles. Guaranteed 1 year. All values 10,000 ohms to 2 Meg. No. Sw. S.P.Sw. D.P.Sw.
3/- 4/- 4/9
Lin or Log Tracks

80 ohm CABLE Coaxial

Semi-air spaced Polythen insulated ½in. dia. Stranded core. Ideal Band III. Losses cut 50%....9d. yd.
STANDARD ½in. Coaxial....8d. yd.

COAXIAL PLUGS 1/- DOUBLE SOCKET 1/3
SOCKETS 1/- OUTLET BOXES 4/6
BALANCED TWIN FEEDER per yd., 6d. 80Ω or 300Ω.
TWIN SCREENED BALANCED FEEDER 1/- yd., 80 ohms.
TRIMMERS, Ceramic, 30, 50, 70 pf., 9d. 100 pf., 150 pf., 1/3. 250 pf., 1/6. 600 pf., 750 pf., 1/9.

ALUMINIUM CHASSIS. 18 s.w.g. Plain, undrilled, with 4 sides, riveted corners and lattice fixing holes, with 2½in. sides. 7×4in., 4/6; 9×6in., 5/9; 11×7in., 6/9; 13×9in., 8/6; 14×11in., 10/6; 15×14in., 12/6 and 18×16×3in., 16/6.

CHROMIUM PEN TORCHES with battery and bulb, 2/6.
BLACK CRACKLE PAINT. Air drying, 3/- tin.
P.V.C. CONN. WIRE, 10 colours, single or stranded, 2d. yd.
5in. RADIO SCREWDRIVERS, 4½d. each.
NEON MAINS TESTER SCREWDRIVERS, 5/6.
MULTICORE SOLDER 60/40, 18 s.w.g., 3d.; 16 s.w.g., 4d. yd.

PURETONE RECORDING TAPE, 12/6

1,200ft. on standard fitting 7in. Plastic reels
Brand new, boxed, 12/6.
Spare Spools 5in. metal, 1/6. 7in. Plastic, 4/3.
FERROVOICE PLASTIC TAPE 25/-
First Quality. Highly Recommended. Brand new. 1200ft. on 7in. plastic Reels. 25/-.

SENTERGEL RECTIFIERS. E.H.T. TYPE FLY-BACK VOLTAGES. K3/25 2 kV., 5/-; K3/40 3.2 kV., 7/-; K3/45, 3.6 kV., 7/6; K3/50 v. 4 kV., 8/-; K3/100 8 Kv., 14/6.
MAINS TYPE, RM1, 125 v.; 60 mA, 5/-; RM2, 100 mA., 6/-; RM3, 120 mA., 8/-; RM4, 250 v. 275 mA., 16/-.
MINIATURE CONTACT COOLED RECTIFIERS. 250 v. 50 ma., 8/6; 250 v. 85 ma., 9/6.
COILS. Wearite, "P" type, 3/- each. Osmor Midget "Q" type adj. dust core, 4/- each. All ranges.
TELETRON. L. & Med., T.R.F., A/HF., 7/- pair.
H.F. Chokes RFC4 2/6 each.
M.W. XTAL COIL MAX., 3/-, L.W. 3/6.

JASON F.M. TUNER COIL SET. 22/6. H.F. coil, aerial coil, Oscillator coil, two I.F. Transformers 10.7 Mc/s., Detector transformer and heater choke. Circuit and component book using four 6AM6, 2/- J.B. Chassis and Dial, 19/6. Complete Kit, £5/18/6. With Jason superior calibrated dial, £6/15/-.

CONDENSERS. New stock. .001 mfd. 7 kV. T.C.C., 5/6. Ditto 20 kV., 9/6; 100 pf. to 500 pf. Micas, 6d.; Tubular 500 v. .001 to .01 mfd., 9d.; .05, .1, 1/-; .25, 1/6; .5, 1/9; .1/350 v., 9d.; 1/600 v., 1/3; .1 mfd. 2,000 v., 4/-.
CERAMIC CONDS. 500 v., .3 pf. to .01 mfd., 10d.
SILVER MICA CONDENSERS. 10% 5 pf. to 500 pf., 1/-; 600 pf. to 3,000 pf., 1/3. DITTO 1% 1.5 pf. to 530 pf. 1/9; 515 pf. to 5,000 pf., 2/-.

NEW ELECTROLYTICS. FAMOUS MAKES.

TUBULAR		TUBULAR		CAN TYPES	
1/350 v.	2/-	100/25 v.	3/-	8+16/450 v.	5/-
2/450 v.	2/3	8+8/500 v.	4/6	16+16/500 v.	6/-
4/450 v.	2/-	16+16/500 v.	6/-	6,000 mfd. 6 v.	6/6
8/450 v.	2/3	CAN TYPES		32+32/350 v.	4/6
8/500 v.	2/9	Clips	3d.	32+32/450 v.	6/3
16/450 v.	3/6	16/450 v.	3/6	64+120/275 v.	7/6
16/500 v.	4/-	32/350 v.	4/-	60+100/350 v.	11/6
32/450 v.	5/6	64/350 v.	5/6	100+200/257 v.	10/6
25/25 v.	1/9	100/275 v.	5/6		
50/25 v.	1/9	50+50/350 v.	7/-	1,000+1,000/6 v.	6/6
50/50 v.	2/-	500/12 v.	3/-		

FULL WAVE BRIDGE SELENIUM RECTIFIERS. 2, 6 or 12 v. 1½ amp., 8/9; 2 a., 11/3; 4 a., 17/6.
CHARGER TRANSFORMERS. Tapped input 200/250 v. for charging at 2, 6 or 12 v. 1½ amp. 13/6; 4 amp., 21/-.
All BERNARDS books in stock.
VALVE MANUALS I, II & III. 5/- each part.
ACID HYDROMETER. New ex. Govt. Unbreakable. Packed in metal case 7×1½in., 4/6.

VALVES

All Boxed. New & Guaranteed

8/6	5/6	1/6 EA50	6/6	10/6
1R5	6B8	954	6AL5	5Z4
1T4	9D2		6J5	12AT7
185	EF50	2/6	6K6	EBC41
3S4	Equip.	EL148	6K7G	ECL80
3V4	8P61	EB34	EB91	ECH42
5U4	8P41	3/6	HVR2	EF41
6AM6	EF92	3D6 (near)		EF80
6AT6		6H6M	EF36	EL41
6K8				EL84
6SL7	7/6	7/6	7/6	EZ40
6SN7	6BE6	6V6G	EL32	MU14
6V6GT	6BW6	6X4	HVR2A	12Q7
EBC33	6F6	6X5	PEN25	PY81
EF50	6K6GT	807	VP23	
Sylv. Red		EF39		35Z4
EF91		11/6		6Q7
EZ80		EY51—U25 PL81		X79

We have no connection with any other firm. Please address all Mail Orders correctly as below.

RADIO COMPONENT SPECIALISTS

307 WHITEHORSE RD., WEST CROYDON
OPEN ALL DAY—(Wed. 1 p.m.) 10-page list 3d.

Tel. THO 1665. Buses 133 or 68 pass door. S.R. Stn. Selhurst. 48-hour postal Service. P. & P. 1/-, £2 orders post free (Export extra). C.O.D Service 1/6

RADIO-GRAM CHASSIS

5 VALVE SUPERHET, LATEST B.V.A. MIDGET SERIES VALVES

3 WAVEBANDS:—*L.W. 800m-2000m, M.W.200m. 550m, SW. 16m-50m.* Chassis size 13½ × 5½ × 2½in. Attractive Glass Dial 10 × 4½in. edge lit by 2 pilot lamps. Horizontal or Vertical Station Names and 4 control knobs, walnut or ivory to choice, 4 position W/C switch, L.M.S. and Gram. P.U. sockets. Modern circuitry, all coils adjustable, dust cored and only quality components used throughout. Delayed A.V.C. and neg. feedback. A.C. mains 200-250 v. Double wound transf. isolates chassis from mains. Aligned and calibrated ready for use.

BRAND NEW & GUARANTEED £9.19.6 Carr. and ins. 4/6.

8" and 10" speakers suitable for this chassis available.

7-Valve De Luxe, push-pull version 7-watt output £12.10.0. Carr. & ins. 5/-

MULLARD "3—3" QUALITY AMPLIFIER

An ideal companion unit to the JASON Tuner. A really first-class 3-valve, 3-watt Amplifier giving Hi-Fi quality at a reasonable cost. Mullard's latest circuit. Valve line up: EF86, EL84, EZ81. Extra HT and LT available for Tuner Unit addition.

Variable treble cut and bass boost controls sensitivity 100 MV. for 3-watt output. Frequency response + or — 1 db, 40 c/s to 25 kc/s.

Complete amplifier wired and tested with quality sectionalised output transformer to Mullard specification (less speaker) £8/8/-. Carr. and ins. 4/6.

ELECTROLYTICS *Leading Makes New Stock*

TUBULAR		CAN TYPES	
25/25 v., 50/12 v.	1/9	8+8/450 v.	4/6
50/50 v. 4/500 v.	2/-	8+16/450 v. ..	5/-
100/25 v.....	1/9	8+16/500 v. ..	5/6
8/450 v.	2/3	16+16/450 v...	5/6
8/500 v.	2/9	16+16/500 v...	6/-
8+8/500 v.....	4/6	16+32/350 v...	5/-
8+16/450 v...	5/-	32+32/350 v...	5/6
16/450 v.....	3/6	32+32/275 v...	4/6
16+16/450 v...	5/6	50+50/350 v...	6/6
32/350 v.	4/-	60/350 v.....	6/6
32/500 v.	5/-	60+250/275v...	12/6
32+32/350 v...	5/6	64+120/275v...	11/6
32+32/450 v...	6/6	100+200/275 v.	12/6
		100/270	6/6

CONDENSERS.—Mica, Silver Mica. All pref. values, 3 pf. to 1,000. 6d. each. Ditto ceramics 9d. each. Tubulars, 450 v. Hunts and T.C.C. .001 mfd.-.01 and .1/350 v., 9d. each. .02-1/500 v., 1/- each. .25 Hunts, 1/6. .5 Hunts, 1/9.

80 ohm CABLE CO-AXIAL

SPECIAL.—Semi-air spaced polythene standard ¼in. diam. Stranded core. Feeder losses cut 50%. 9d. yard.

Standard ¼in., Grade A, 8d. yard.

COAX PLUGS 1/2. SOCKETS 1/-. COUPLERS 1/3. OUTLET BOXES 4/6.

BALANCED TWIN FEEDER per yd., 6d.

Special 300 ohm TWIN FEEDER 8d.

TWIN SCREENED FEEDER per yd., 1/3.

50 OHM COAX CABLE 8d. per yd., ½in.

ATTENUATORS 6db, 12db, etc. from 4/6. Band 1-3 Cross-over filter unit from 7/6.

SPEAKER FRET.—Expanded Bronze anodised metal 8 × 8in., 2/3; 12 × 8in., 3/-; 12 × 12in., 4/3; 12 × 16in., 6/-; 24 × 12in., 8/6, etc.

TYGAN FRET (Murphy pattern) 12in. × 12in., 2/-; 12 × 18in., 3/-; 12 × 24in., 4/-, etc.

JASON F.M. TUNER UNIT 87-105 m/cs

Kit of parts to build this modern and highly successful unit complete with drilled chassis and J.B. dial, wound coils and screening cans, 4 BVA miniature valves and all necessary quality components, etc., for only £6/10/- post free. Superior dial calibrated mc/s, edge lit by 2 pilot lamps, 12/6 extra, as illustrated. Power Pack components kit including double wound mains transformer, £2/5/- extra.

Tested and approved by "Radio Constructor," etc. Illustrated handbook with full details, 2/-, post free.

RESISTORS

Carbon type. Pref. values 10 ohms-10 megohms. 20% Tol. ½ w. 3d.; ¼ w. 5d. 1 w. 6d.; 2 w. 9d.; 10% Tol. ½ w. 9d. 5% Tol. ½ w. 1/-; 1% Hi-stab. ½ w. 2/-.

WIRE WOUND TYPES

Wire ends. Silicone coated. 25 ohms-10,000 ohms, 5 w., 1/3. 10 w. 1/6. 15 w. 2/-.

LINE CORD .3a. 60 ohms per ft., .2a. 100 ohms per ft., 2 way 6d. per ft., 3 way 7d. per ft.

LOUDSPEAKERS

P.M. 3 OHM. 5in. Celes., 17/6; 6in. Celes., 18/6; 7 × 4in. Goodman's Elliptical, 18/6; 8in. Elac., 20/-; 8in. Goodman's special, 21/6; 10in. R. and A., 25/-; 12in. Plessey, 35/-; 2½in. Plessey 16/6; 3½in. Elac, 17/6.

S.T.C. RECTIFIERS

E.H.T. types. K3/25 2 Kv., 5/-; K3/40 3.2 Kv., 6/9; K3/45 3.6 kV., 7/3; K3/50 4 kV., 7/9; K3/100 8 kV., 12/9, etc. Mains types. RM1 125 v. 60 mA., 4/-; RM2 125 v. 100 mA., 4/9; RM3 125 v. 120 mA., 5/9; RM4 250 v. 250 mA., 16/-.

RM4B type 250 v. 275 mA., 17/6. LT types F/W bridge 6-12 v. 1½ a., 8/9; 3 a., 15/6; 4 a., 18/6; 6 a., 24/6 each.

PRE-SET W/W POTS

T.V. knurled slotted knob type. 25 ohms to 30,000 ohms, 3/-; 50,000 ohms, 4/-; 50,000 ohms to 2 Megohms (carbon), 3/-.

VOLUME CONTROLS

Midget log type, long spindles, all values 10,000 ohms to 2 Megohms. Less sw., 3/-; S.P. sw., 4/-; D.P. sw., 4/9. Linear types all values 10,000 ohms to 2 Megohms less witch 4/-. Guaranteed 12 months.

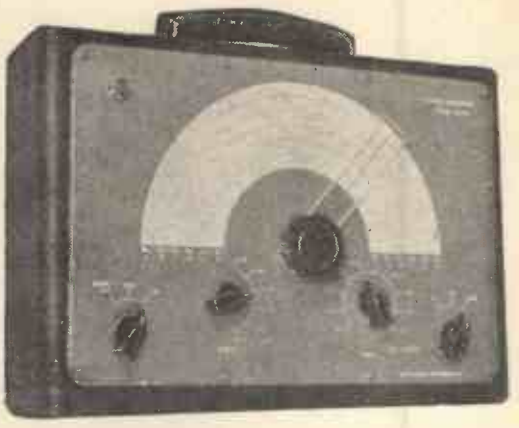
TRS RADIO COMPONENT SPECIALISTS

TRS

70 BRIGSTOCK RD., THORNTON HEATH, SURREY

Phone: THO 2188. Hours 9 am.—6 pm., 1 pm. Wed. Open all day Saturday. BY THORNTON HEATH STATION. BUSES 130A, 133, 169, 166, 190.

Terms: C.W.O. or C.O.D. Kindly make cheques, P.O.s, etc., payable to T R S. Post & Packing up to ½lb. 7d., 1lb. 1/1, 3lb. 1/6, 5lb. 2/-, 10lb. 2/9. Bargain Lists, 3d.



SG50 SIGNAL GENERATOR covers 100 kc/s to 80 Mc/s in six continuous ranges on fundamentals (not harmonics) either modulated 400 cps. or CW. Frequency accuracy 2%. Uses EF91, 6C4 and RM1 with double wound mains transformer. The scale is directly calibrated on all ranges with total scale length over 60 inches. Housed in de luxe olive green metal case with carrying handle with scale of engraved Perspex. Size 9in. × 13in. by 4in. deep. Only £8/10/-, plus 6/- carriage and packing.

VV50 VALVE VOLTMETER measures up to 250 volts A.C., R.F., and A.F. with input impedance of 11 Megohms. Complete with probe unit ready for mains operation at £7/19/6, plus 4/6 carr./packing.

CR50 BRIDGE measures from 10 pFd to 100 mFd and from 1 ohm to 10 Megohms in fourteen ranges, having total scale length of over 120 inches. Indication of balance is given by a magic eye fed from a high gain pentode amplifier. Leakage test for condensers. Internal standards are "Constanta" 1% resistors. In case specially designed for bench use with sloping panel. Complete and ready for operation from A.C. mains. ONLY £7/18/- plus 4/6 carr./packing.

Further details sent by return of post on receipt of self addressed, stamped envelope. Trade supplied direct.

RUSH your order now to:—

GRAYSHAW INSTRUMENTS

126 SANDGATE HIGH STREET, FOLKESTONE, KENT.

'Phone : Folkestone 78618

CHAS. H. YOUNG, LTD.

3IN. AERIAL INSULATORS. Ribbed glass. 1/6 each or 6 for 7/6. 12 or more post free.

CONDENSERS. TCC type III, 8 mfd. 1,000 v. List over £3. Only 10/6. Post 1/9. 8 mfd. 750 v. 5/6 each. Post 1/6.

SHADED POLE MOTORS. Heavy duty type totally enclosed made for professional tape deck. 35/- each. Post 2/6.

AMERICAN 807 VALVES. New, boxed, 7/6 each; 4 for 25/-.

ELECTRON MULTIPLIERS. Type 931A. Only 35/- each, or 2 for £3. Holders available at 2/- each.

CRYSTAL HAND MICROPHONES with polished grille and handle, four foot of screened lead. Only 21/-. P. & P. 1/-. WORTH DOUBLE.

POWER UNITS IN BLACK METAL CASE. 200/260 v. input, 200/250 v. 60/80 m.a. output, fully smoothed and filtered, also gives 31 v. D.C. and 6.3 v. .3 a. A.C., fitted with 6X5 rectifier. Only 50/- each. Carr. paid.

COPPER AERIAL WIRE. 14 g. H/D 140ft., 17/-. 70ft. 8/6. P. & P. 2/-. Stranded 7/25, 140ft. 10/-. 70ft. 5/-. P. & P. 2/-.

RACK MOUNTING PANELS, all 19in. long by 5¼in., 7in., 8¾in. or 10½in., 5/9, 6/6, 7/6, 9/- respectively. Post 2/-.

ABSORPTION WAVEMETERS. 3 to 35 m/c. in 3 switched bands, complete with indicator bulb. 15/-. Post 1/-.

TRANSMITTER TUNING CONDS., by Johnson U.S.A. 500 pf. 1,550 v. rating, ceramic insulation. 15/- each. Post free.

HEADPHONES. High resistance (4,000 ohms.), very sensitive. Bargain price only 12/6 pair. P. & P. 1/6.

AMERICAN BREAST MIKES. Swivel head. Push to talk and lock on switch. Beautiful job. Only 12/6. P. & P. 1/6.

BRITISH BREAST MIKE UNIT, complete with pair of 4,000-ohm phones in strong wooden carrying case, 8½ x 4½ x 7½. Ideal for mobile operators. Only 17/6. P. & P. 2/-.

LOW RESISTANCE HEADPHONES. New ex-W.D. stock. C.L.R. type. Only 8/6 pair. P. & P. 1/6. Special Terms Quantities.

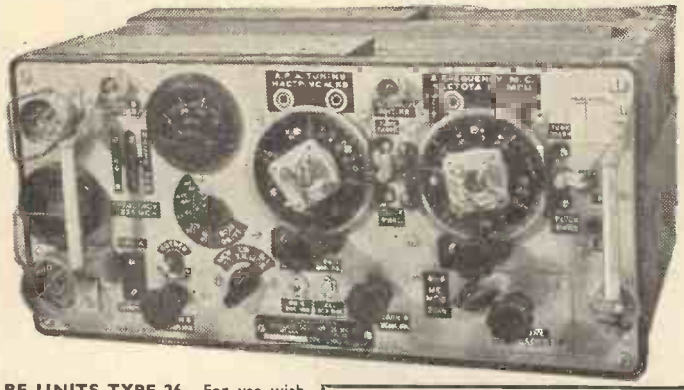
Most comprehensive stock of HiFi Equipment in the Midlands, including QUAD, LEAK, W.B., R.C.A., ROGERS, WHARFEDALE, GOODMANS, etc. Details and demonstrations with pleasure.

NO C.O.D. UNDER £1.

All Mail Orders to Dept. "W." Please print your name and address.

CHAS. H. YOUNG LTD., 110 DALE END, BIRMINGHAM, 4.

Phone CENTRAL 1635



WIRELESS SET
No. 19 MK II

The famous Army Tank Transmitter-Receiver. Just released by the Ministry of Supply. Incorporates "A" set (TX/RX covering 2.0-8.0 mc/s., i.e. 37.5-150 metres); "B" Set (VHF TX/RX covering 230-240 mc/s., i.e. 1.2-1.3 metres), and Intercomm. Amplifier. Complete with 15 valves as follows: 6 of 6K7G, 2 of 6K8G, 2 of 6V6G, and 1 ea. 6B8G, 6H6, E1148, EF50, 807, and booklet giving circuits, notes, etc.
Size 17¼in. x 8¼in. x 12¼in. Magnificently made by famous American firms.

IN BRAND NEW CONDITION. ONLY £4/19/6 (carriage, etc. 10/6). OR with 12 volt Rotary Power Unit £5/10/– (carriage, etc., 15/–.).

RF UNITS TYPE 26. For use with the R.1355 or any receiver with a 6.3 v. supply. This is the variable tuning unit which uses 2 valves EF54 and 1 of EC52. Covers 65-50 Mc/s. (5-6 metres). Complete with valves, and BRAND NEW IN MAKER'S CARTONS. ONLY 25/- each.

MARCONI BAND III CRYSTAL CALIBRATORS. Frequency range 170-240 Mc/s. Incorporates 5 Mc/s. crystal for better than .001 per cent. accuracy. Directly calibrated dial, internal A.C. mains pack. Complete with spare set of valves and instruction manual in maker's transit cases. BRAND NEW. ONLY £4/19/6.

CLASS D WAVEMETER
Another purchase of this famous crystal-controlled wavemeter which has been repeatedly reviewed and recommended in the "R.S.G.B." Bulletin as being suitable for amateur transmitters. Covers 1.9-8.0 Mc/s., and is complete with 100/1,000 kc/s. crystal, 2 valves ECH35, two 6-volt vibrators and instruction manual. Designed for 6 v. D.C. operation, but simple mod. data for A.C. supplied. BRAND NEW IN MAKER'S TRANSIT CASES. ONLY £5/19/6. Transformer for A.C modification, 7/6.

A.C./D.C. BLOWERS. 220/250 volts, 300 watts. 1¼in. diam. outlet. Complete with filter pads. BRAND NEW. ONLY £4/19/6.

INSULATION TESTERS (MEGGERS). By Record Electrical. Read up to 20 megs. at 500 volts pressure. Overhauled, and in perfect order. ONLY £8/10/–.

POWER UNIT TYPE 3. Primary 200/250 v. 50 cycles. Outputs of 250 v. 100 mA. and 6.3 v. 4 amps. Fitted with H.T. current meter, and voltmeter. For normal rack mounting and has grey front panel size 19in. x 7in. ONLY 90/- (carriage, etc. 7/6).

EHT TRANSFORMERS. 5.5 kV. (Rect.) with 2 v. 1 a., 79/6. 7 kV. (Rect.) with 2 v. 1 a., 89/6. 2.5 kV. (Rect.) with 2-0-2 v. 1.1 a., 2-0-2 v. 2 a. (for VCR 97 tube, etc.), 42/6 (postage 2/- per trans.).

TRAWLER BAND R 1155s.

The latest version of this famous Communications Receiver to be released by the Air Ministry. Covers 5 wave ranges: 18.5-7.5 Mc/s., 7.5-3.0 Mc/s., 3.0-1.5 Mc/s., 1.5 Mc/s- 600 kc/s., 500-200 kc/s. As used by Coastal Command, Air-Sea Rescue Launches, etc. All sets thoroughly tested and in perfect working order before despatch, and on demonstration to callers. Have had slight use, but are in excellent condition. ONLY £12/19/6.
"A" Models, as above, but with 200-75 kc/s range instead of 3.0-1.5 Mc/s. BRAND NEW IN MAKER'S TRANSIT CASES. ONLY £11/19/6.
A.C. MAINS POWER PACK OUTPUT STAGE, In black metal case, enabling the receiver to be operated immediately, by just plugging in, without any modification. Can be supplied as follows: WITH built-in 6½in. P.M. speaker, £5/5/-, LESS speaker, £4/10/-. With 8in. P.M. speaker, £6/10/-.
DEDUCT 10/- IF PURCHASING RECEIVER AND POWER PACK TOGETHER.
Send S.A.E. for illustrated leaflet, or 1/3 for 14-page booklet which gives technical information, circuits, etc., and is supplied free with each receiver.
Add carriage; 10/6 for Receiver, 5/– for Power Unit.

FREQUENCY METERS TYPE L.M.

The United States Navy version of the BC221. Frequency range 125-20,000 kc/s with better than 0.01% accuracy. Contains a Crystal Controlled Oscillator, a Heterodyne Oscillator, and an Audio Frequency Amplifier. Can be used as Signal Generator, having CW-MCW control. BRAND NEW and UNUSED. Quotation on request.

METERS

F.S.D.	SIZE AND TYPE	PRICE
50 microamps D.C.	2½in. Flush circular	59/6
500 microamps D.C.	2in. Flush square	27/6
1 m.a. D.C.	2in. Flush square	22/6
10 m.a. D.C.	2½in. Flush circular (blank scale)	10/6
150 m.a. D.C.	2in. Flush square	7/6
200 m.a. D.C.	2½in. Flush circular	12/6
4 amp. D.C.	2½in. Flush circular	15/–
20 amp. D.C.	2in. Proj. circular	7/6
40 amp. D.C.	2in. Proj. circular	7/6
30-0-30 amp. D.C.	Car type moving iron	5/–
15 volts A.C.	2½in. Flush circular moving iron	9/6
2 Kilovolts A.C.	2½in. Proj. circular electro-static	22/6
300 volts D.C.	2in. Flush square	10/6

Enquiries invited for types not listed, 7-14 days delivery on "specials".

L.T. HEAVY DUTY TRANSFORMERS. Ex-Admiralty, with 230 v. 50 cycles primary. 1. Secondaries 5, 10, 15, 20, 25 30 volts at 5 amps. ONLY 29/6. 2. Secondaries 7, 14, 21, 28 volts at 12 amps. ONLY 42/6. (Postage on either 2/9).

MARCONI SIGNAL GENERATORS TF-390G
Frequency coverage 16-150 Mc/s. BRAND NEW IN MAKER'S ORIGINAL TRANSIT CASES, with instruction manual. For normal A.C. mains operation. A unique opportunity to acquire Laboratory Equipment at a fraction of original cost. ONLY £27/10/-.

159 RECEIVER UNIT. Contains 1 each valve, types EF50, EA50, SP61, RL37 and 24 v. selector switch. ONLY 7/6.

RCA 8in. P.M. SPEAKER, mounted in heavy black crackled metal cabinet with chromium grill, and padded feet. Size 11¼in. w. x 10⅛in. h. x 6in. d. Ideal for use with receivers or as an extension. BRAND NEW IN MAKER'S CARTONS. ONLY 45/-.

100 MICROAMPS METERS. 2½in. circular flush mounting. Widely calibrated scale of 15 divisions marked "yards" which can be rewritten to suit requirements. These movements are almost unobtainable today and being BRAND NEW IN MAKER'S CARTONS are a snip at ONLY 42/6.

100-0-100 VOLTS METERS by Sangamo Weston. 2½in. circular, basic movement being 500-0-500 microamps. A really first-class centre zero meter for hundreds of uses. BRAND NEW IN MAKER'S CARTONS. ONLY 27/6.

POCKET VOLTMETERS. Not ex-Govt. Read 0-15 v. and 0-300 v. A.C. or D.C. BRAND NEW AND UNUSED ONLY 18/6.

WALKIE TALKIE TYPE 18. Covers 6.0-9.0 Mc/s. Transmitting and receiving units in metal case, complete with valves in excellent condition. ONLY 79/6.

12-WAY SCREENED CABLE. In 10ft. lengths, fitted with plugs, originally made for use with the 19 Set. UNUSED. ONLY 17/6 per lead.

TR1196 TRANSMITTER SECTION, complete with valves EL32, EF50, CV501, and all components. BRAND NEW. Price ONLY 12/6.

TRANSFORMERS. H.T. Fully shrouded upright, mounting, 250-0-250 v. 60 mA., 6.3 v. 3 a., 5 v. 2 a. ONLY 21/-. 250-0-250 v. 100 mA., 6.3 v. 6 a., 5 v. 3 a. ONLY 37/6. 350-0-350 v. 180 mA. 6.3 v. 5 a., 5 v. 3 a. ONLY 37/6 (postage 2/- per trans.).

Cash with order please, and print name and address clearly

PLEASE ADD POSTAGE OR CARRIAGE COSTS ON *ALL* ITEMS

U.E.I. CORPORATION

Radio Corner, 138 Gray's Inn Road, London, W.C.1. *Phone :* TERMINUS 7937

(Open until 1 p.m. Saturdays. We are 2 mins. from High Holborn (Chancery Lane Station) and 5 mins. by bus from King's Cross)

MAINS TRANSFORMERS

Primary, 200-250 v. P. & P. 2/-. 300-0-300 100 mA., 6 v. 3 amp., 5 v. 2 amp., 22/6.

Semi-shrouded drop-through 380-0-380 v., 120 mA., 6.3 v. 4 amp. 5 v. 2.5 amp., 22/6.

Drop thro' 350-0-350 v. 70 mA., 6 v. 2.5 amp. 5 v. 2 amp., 14/6.

Chassis mounting or drop thro'. Pri. 110-150 v. Sec. 350-0-350, 250 mA., 6.3 v. 7 amp., 6.3 v. 0.5 amp., 5 v. C.T., 0.5 amp. 4 v. 3 amp. P. & P. 3/6. 32/6.

Chassis mounted and fully shrouded, 80 mA. 6 v. 3 amp., 5 v. 2 amp., 14/6.

Drop thro' 270-0-270 60 mA., 6 v. 3 amp., 11/6.

250 v. 350 mA., 6.3 v. 4 a., twice 2 v. 2 a., 19/6.

Auto-trans. Output 200-250 H.T. 500 v. 250 mA., 6 v. 4 a., twice. 2 v. 2 a., 19/6.

Auto-trans. Input 200-250. H.T. 350 v. 350 mA. Separate L.T. 6.3 v. 7 a., 6.3 v. 1½ amp., 5 v. 3 amp., 25/-. P. & P. 3/-.

Mains transformer, fully impregnated. Input 210, 220, 230, 240. Sec. 350-0-350 100 mA., with separate heater-transformer. Pri. 210, 220, 230, 240 sec. 6.3 v. 2 amp., 6.3 v. 3 amp. 4 v. 6 amp., and 5 v. 2 amp., 30/-. P. & P. 5/-.

350-0-350 75 mA. 6.3 v. 3 a. tap 4 v. 6.3 v. 1 a., 13/6.

500-0-500 125 mA. 4 v. C.T. 4 a., 4 v. C.T. 4 a., 4 v. C.T. 2.5 a., 27/6.

500-0-500 250 mA. 4 v. C.T. 4 a., 4 v. C.T. 5 a., 4 v. C.T. 4 a., 39/6.

R. & T.V. Energised 6½in. Speaker, with O.P. trans. field coil. 175 ohm, 9/6. P. & P. 2/6.

R. & A. 6½in. M.E. Speaker, with O.P. trans. field 440 ohms, 10/6. P. & P. 2/6.

Volume Controls. Long spindles, less switch, 50K, 500K, 1 meg., 2/6 each. P. & P. 3d.

Volume Controls. Long spindle and switch, ¼, ½, 1 and 2 meg., 4/- each. 10K and 50K, 3/6 each. ¼ and 1 meg., long spindle, double pole switch, miniature, 5/-. P. & P. 3d. each.

Trimmers. 5-40 pf., 5d. 10-110, 10-250, 10-450 pf., 10d.

Twin Gang .0005 Tuning Condenser 5/-. With trimmers, 7/6.

Twin Gang .0005, with feet, size 3½ × 3 × 1½in., 6/6.

3-gang .0005, with feet, size 4½ × 3 × 1½in., 7/6.

T.V. Coils, moulded former, iron-cored wound for re-winding purposes only. All-can 1½ × 1½in., 1/- each. 2 iron-core All-can 2½ × ½in., 1/6 each. The above coil formers are suitable for the "Wireless World" F.M. tuner.

Used Metal Rectifier, 250 v. 150 mA., 6/6. Metal Rectifier, 250 v. 45 mA., 6/-.

Metal Rectifier, RM2, 125 v. 100 mA., 3/6.

Valve Holders, moulded octal Mazda and loctal, 7d. each. Paxolin, octal Mazda and loctal, 4d. each. Moulded B7G, B8A and B9A, 7d. each. B7G moulded and B9A with screening can, 1/6 each.

GARRARD RC/110

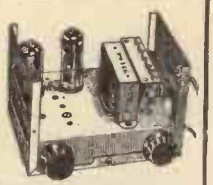
3-SPEED AUTOMATIC MIXER CHANGER

Will take 10 records, 7in., 10in. or 12in Mixed, turnover crystal head, brand new, current model. A.C. mains 200/250 v. (list price £14/10/-).

£7 - 19 - 6 P. & P. 3/6.

COMMERCIAL TELEVISION CONVERTER

SUITABLE ANY T.V.
using lower side band
NO ALTERATIONS TO SET



Complete with built-in power supply, 230-250 v. A.C. mains. Case 5½in. long, 3½in. wide, 4½in. high. Incorporating gain control and hand switch.

£3 - 19 - 6 Plus Post & Packing 2/6.

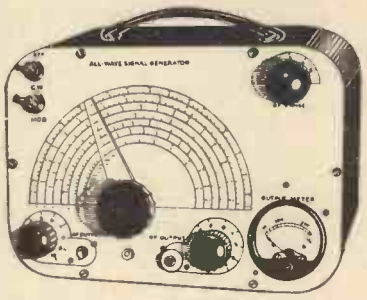
Illustrated with cover removed.

AC/DC MULTI-METER KIT

Comprising 2in. moving coil meter, scale calibrated in A.C./D.C. volts, ohms and milliamps. Voltage range A.C./D.C. 0-10, 0-100 and 0-500. Milliamps 0-10, 0-100; ohms 0-10,000. Front panel, range switch, wire wound pot (for ohms zero setting), two toggle switches, resistors and meter rectifier. Point-to-Point wiring diagram 1/-. Free with complete kit.

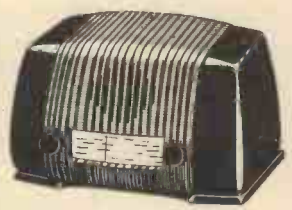
Complete in case, grey hammer finish. **19/6** P. & P. 1/6.

COMPLETELY BUILT SIGNAL GENERATOR



Coverage 120 Kc/s.-230 Kc/s., 300 Kc/s.-900 Kc/s., 900 Kc/s.-2.75 Mc/s., 2.75 Mc/s.-8.5 Mc/s., 8 Mc/s.-28 Mc/s., 16 Mc/s.-56 Mc/s., 24 Mc/s.-84 Mc/s. Metal case 10in. × 6½in. × 4½in. Size of scale, 6½in. × 3½in. 2 valves and rectifier. A.C. mains 230-250 v. Internal modulation of 400 c.p.s. to a depth of 30 per cent., modulated or unmodulated R.F., output continuously variable 100 milli-volts. C.W. and mod. switch, variable A.F. output and moving coil output meter. Grey hammer finish case and white panel. Accuracy plus or minus 2%. £4/19/6. or 34/- deposit and 3 monthly payments 25/-. P. & P. 4/6 extra.

T.R.F. KIT IN PLASTIC CABINET



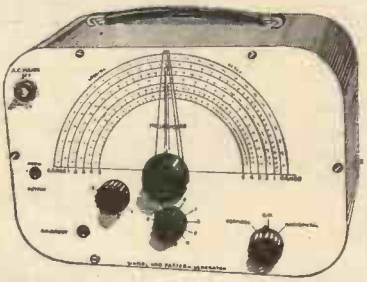
3 valve plus metal rectifier, A.C. mains 200-250 v. Medium and long waves. In pastel blue or brown. Valve line-up: 3 VR65S and VT52. Size 15½in. long by 9in. high by 7in. deep.

£3 - 19 - 6 P. & P. 4/6

A point-to-point wiring diagram, 1/6. Free with complete kit.

All parts supplied separately.

SIGNAL & PATTERN GENERATOR



Coverage 7.6 Mc/s-210 Mc/s. in five bands, all on fundamentals, slow motion tuning, audio output, 8 vertical and horizontal bars, logging scale. In grey hammer finished case with carrying handle. Accuracy ± 1%.
A.C. mains 200-250 v.

£6 - 19 - 6

P. & P 5/6.

Or £3 deposit. P. & P. 5/6 and 3 payments of 30/-.

RADIO AND T.V. COMPONENTS (ACTON) LTD.

23 ACTON HIGH STREET, LONDON, W.3

GOODS NOT DESPATCHED WHERE CUSTOMS DECLARATION IS APPLICABLE

Terms of Business: Cash with order. Where post and packing charge is not stated please add 1/6 up to 10/-, 2/- up to £1, and 2/6 up to £2. All enquiries S.A.E., lists 5d. each.

Germanium Crystal Diode. 1/6. post paid.

Line O.P. Transformer in aluminium can mounted in rubber, 12/6.

Line and E.H.T. Transformer, 14 Kv., using ferrocart core, complete with line and width control, and corona shields U37 rectifier winding, 35/-.

Line and E.H.T. Transformers, 9 Kv. using ferrocart core, complete with built-in line and width control. Mounted on small all-chassis. Overall size 4½ × 1½in. EY51 rec. winding, 27/6.

Scan coils, low line low impedance frame, complete with frame transformer to match above 27/6. P. & P. 2/-.

Line and E.H.T. Transformers, 9 Kv. ferrocart core, EY51, heater, winding, complete with scan coils and frame output transformer, and line and width control, 35/-. P. & P. 3/-.

As above, but complete with line and frame blocking transformers, 5 Henry 25 mA. choke, 100 mfd. and 150 mfd. 250 wkg. 380 mA. A.C. ripple, 22/9/6. P. & P. 3/-.

P.M. Speaker, 6½in. closed field, 18/6. 8in. closed field, 20/6. 10in. closed field, 25/-. 12in. closed field, 25/-. P. & P. on each 2/-.

Extension Speaker, in polished walnut complete with 8in. P.M. P. & P. 3/-. 24/6.

COLLARO RC54

3-speed automatic changer, current model. Brand new. 10 records mixed. Studio "O" pick-up. A.C. mains, 200-250 v.

£7-19-6 Plus P. & P. 5/-.

Standard Wave Change Switches. 4-pole, 3-way, 1/9; 5-pole, 3-way, 1/9; 3-pole, 3 way, 1/9; 9-pole 3-way, 3/6. Miniature type, long spindle. 3-pole, 4-way, 4-pole 3-way and 4-pole 2-way, 2/6 each. 2-pole 11-way, twin wafer, 5/-; 1-pole 12-way single wafer, 5/-. P. & P. 3d.

Ion Traps for Mullard or English Electric tubes, 5/-, post paid.

Standard 465 Kc. iron-cored I.F.s, 4 × 1½ × 1½in., per pr., 7/6.

1,200ft. High Impedance Recording Tape on plastic spool, 12/6. Plus 1/-. P. & P.

Miniature wire ends moulded. 100 pf. 500 pf. and .001, each 7d.

Combined 12in. mask and escutcheon in lightly tinted Perspex. New aspect edged in brown. Fits on front of cabinet, 12/6. As above for 15in. tube, 17/6.

Frame Oscillator Blocking Trans., 4/6.

Line Osc. Blocking Trans., 4/6.

Wide Angle P.M. Focus Units. Vernier adj. state tube, 15/-.

P.M. Focus Unit for Mullard tubes with vernier adjustment. P. & P. 2/-. 15/-.

FAMOUS MAKE TURRET "TELETUNER"

99/6
Post 2/6.
Knobs 3/6.

Covers all Channels, Bands I and 3. Valves used: PCC84, R.F. double triode, cascode R.F. amplifier. PCF80, triode pentode f.c. and mixer. I.F. output 33-38 Mc/s. Easily modified to other I.F. outputs. Full instructions and circuit diagram supplied. Complete with 12 Coil Sets.

Best Buy at Britain's

WIRELESS SETS NO. 17, Mk. 2. A portable 2-valve transceiver for R/T communication, freq. 44-61 Mc/s. Easily converted to the new 70 Mc/s band! Complete with valves, HR headphones and microphone. Requires 120 v. H.T. and 2 v. accumulator. Brand new Ex-Govt. surplus, tested. With circuit diagram and operating data. In wooden cabinet, with carrying handle. 15½in.x14in.x9in. Wt. app. 35 lb. **ONLY 59/6.**

MEDIUM WAVE COMMAND RECEIVERS. 550-1,500 Kc/s. Ideal for car radio. These have not been on the market for years! Few available. First class condition. ONLY **79/6.** Still available, BC453 (Q5'er), **59/6,** and BCXXX (Top band) 1.5-3 Mc/s. NEW, BOXED, **75/-.** FREE CIRCUIT WITH EACH RECEIVER. **TRANSMITTERS.** Complete with 1626, 1629, and 2 1625's and crystal. BC457 4-5.3 Mc/s., **22/6.** NEW ditto, **29/6.** BCZZZ 2.1-3 Mc/s., unboxed, **29/6.**

PYE 45 Mc/s IF STRIPS. Complete with 7 valves and CIRCUIT. New. ONLY **39/6.**

MINIATURE 9.72 Mc/s IF STRIPS. Only 10¾ x 2¾ x 3in. Ideal for FM conversion. 2 EF92's and 1 EF91 IF Amps., EB91 Det/AVC, EF91 AVC Amp., and EF91 noise limiter. Brand new, with circuit, **45/-,** or less valves, **7/6.**

RT37/PPN2 BEACON TRANSMITTER-RECEIVER. 214-234 Mc/s. Size 13in. x10in. x 5in. Contains 5 3A5, 3 1S5, 1 1R5 and 2 2V. synchronous vibrators. Operates from 2 v. accumulator via 2 built-in vibrapacks. Complete with telescopic mast antenna system (9½ft.), lightweight headphones, Technical Manual, super quality carrying haversack, cords, co-ax. cables, plugs, etc. Total wt. 28lb. BRAND NEW, boxed, American equipment, **72/6.**

TWO-WAY MORSE TRAINING SETS, W/T Mk. 3. Consists of 2 valve oscillators (ARP12's) (one with pitch control), for 1 or 2 operators. Has provision for creating "atmospherics." In polished oak case 12½in. x 10in. x 8in., wt. 16lb. Complete with valves, leads, 2 keys, 7-way terminal board, circuit and instructions, but less batteries and phones. Ideal for Cadets, Scouts, etc. SNIP, **19/6.**

COMMUNICATIONS RECEIVER CR100. Covers 60 Kc/s to 30 Mc/s in 6 ranges. 2 RF's and 3 IF's, variable selectivity, B.F. Osc., etc. Operates from 210-250 v. A.C. mains. Size 16in. x 12½in. x 16½in. deep, wt. 82lb. S.A.E. for illustrated details. Overhauled, first class condition, **£21.** CR100/2 with side-tone facility, superb condition, **£25.** Naval version with noise limiter, unused, **£30.** Plus £2 carr. and pkg. (£1 refund when pkg. case returned).

RF UNITS. ALL BRAND NEW AND BOXED. RF24 **10/-,** RF25 **12/6,** RF26 **25/-.** Post 2/6.

LORAN INDICATOR UNIT CHASSIS. Complete with 5CP1 C.R.T. and screen, but less valves and crystal. New condition, price **29/6.**

MARCONI SIGNAL GENERATORS. Brand new, in original transit case, complete with spares, instruction manual and calibration charts. Type TF390G, 4-32 and 50-100 Mc/s. **£25.**

HEAVY DUTY BLOWERS. For AC/DC mains 200-250 v. 300 watts. 1¼in. diam. outlet. Suitable for industrial use, forges, etc. With filter pads. Brand new. **£4/19/6.**

SOUND-POWERED HANDSETS. Similar to telephone handset. Balanced armature microphone and earpiece. No batteries required, 10/6 each. Breast mike and headphones, as above, 12/6 set.

FIELD TELEPHONES. Army type D, Mk. 5. Buzzer calling. Ideal for building sites, farms, workshops, etc. Complete with handset and batteries. Tested, **39/6** each.

CRYSTALS. 200 Kc/s American GEC, **10/-** each, 100 Kc/s R.C.A. bars, **19/6** each.

5FT. P.O. TYPE 19in. RACKS. "U" channel, heavy angle base, **59/6.**

RCA SPEAKERS. 8in. P.M. unit in handsome black crackled cabinet. For AR88's, CR100's, etc. BRAND NEW, **45/-.**

TOP BAND R1155 L's!

Superior version of the R1155 with super slow-motion drive. 200 kc/s to 18.5 mc/s. in 5 ranges, covering the 100-200 metre trawler and shipping bands. Although not packed in original transit cases, these are in every way equal to BRAND NEW, and are fully guaranteed. Never before available at the low price of ONLY **£12/19/6.** Carriage 10/6. R1155 A's. Condition equal to new and fully guaranteed. **£10/10/-.**

ALL R1155's are supplied with free booklet, re-aligned, and tested before despatch, and gladly demonstrated. Send S.A.E. for details of receivers and power packs, or 1/3 for 14-page booklet.

A.C. MAINS POWER PACKS WITH OUTPUT STAGE. Just plug in, NO modifications. Heavy duty quality job, guaranteed 6 months. Type A, **£4/10/-.** Type B, with 6½in. speaker, **£5/5/-.** Type C, in specially designed black crackled steel cabinet, with 8in. speaker, the de luxe model, **£6/10/-.**

SAVE £££s. DEDUCT 10/- WHEN PURCHASING R1155 AND POWER PACK TOGETHER.

WIRELESS SET No. 19, Mk. 2.

Two transmitter-receivers and an Intercomm. amplifier in one case. "A" set covers 2-8 Mc/s. R/T and CW, and "B" set 240 Mc/s R/T only. Complete with dynamotor for 12 V DC operation, 6 6K7G, 2 6K8G, 2 6V6G, 6B8G, 807, EF50, EB34 and 500 microamp check and tuning meter. S.A.E. for full details and specification. Technical data available. Made in Canada, in first class condition, **£5/10/-** plus 15/- Carr. and Pkg. Or, less dynamotor, **£4/19/6.**

METER BARGAINS

RANGE	TYPE	SIZE		PRICE
50 Microamp.	D.C. M/C	2½in.	Flush circ., scaled 0-100	59/6
100 Microamp.	D.C. M/C	2½in.	Flush circ., scaled 0-1,500	39/6
500 Microamp.	D.C. M/C	2in.	Flush square, Weston	27/6
500-0-500 Microamp.	D.C. M/C	2½in.	Flush circular, scaled 100-0-100 V.	25/-
1 Milliamp.	D.C. M/C	2in.	Flush square, Fe/NFe	22/6
1 Milliamp.	D.C. M/C	2½in.	Desk Mounted type	32/6
10 Milliamp.	D.C. M/C	2½in.	Flush circular, blank scale	10/6
100 Milliamp.	D.C. M/C	2½in.	Flush circular	10/6
150 Milliamp.	D.C. M/C	2in.	Flush square	7/6
200 Milliamp.	D.C. M/C	2½in.	Flush circular	10/6
1 Amp. Thermo-couple		2½in.	Projecting circular	6/9
4 Amp. Thermo-couple		2in.	Flush square	6/9
20 Amp.	D.C. M/C	2in.	Projecting circular	7/6
30-0-30 Amp.	D.C. M/I	2in.	Proj. circ., car type	5/-
15 Volts	A.C. M/I	2½in.	Flush circular	8/6
300 Volts	A.C. M/I	3½in.	Flush circular	30/-
300 Volts	D.C. M/C	2in.	Flush square	10/6

METER RECTIFIERS. Salford Instruments, 1 mA., 8/6; 5 mA., 6/9; S.T.C., 2 mA., as used in E.M.I. Output Meter, 5/6. All are full wave bridge and brand new.

RCA AMPLIFIERS

MODEL MI-11220. Employs 2 6L6G, 4 6J7, and 1 5U4G. Output 12 watts at 5-7.5-15-600 ohms. For 190/250 v. A.C. mains. In grey crackled case, 17 x 11 x 9in. Wt. 38lb. Brand new and boxed. Price, less valves, **£9/19/6.** Circuit supplied. OR, ready converted for use with pick-up or microphone, with tone control, **£2** extra. Set of new boxed valves, **59/6.**

CALLERS CORNER

VCR97's from..	2/6
Indicator chassis	5/-
10 mfd. paper	2/6
8 mfd. paper ..	3/-
8 mfd. 500 v. Elec.	1/3
EF50's, from..	2/6
EA50's, NEW ..	6d
EB34's, NEW..	6d
12H6's, NEW..	6d
Eddystone 358 Rx's 79/6	
Meters, from....	6d

INDICATING UNIT 277. Case size 5½in. x 7in. x 12in. deep. Contains 11in. C.R. tube type VCR522 (same as that used in G.E.C. "Miniscope"), 4 VR91, 2 VR92, and a host of useful modern components. Fitted with "Focus" and "Brightness" controls, etc. Should convert to useful miniature oscilloscope. All tubes tested. **39/6.**

HIGH VOLTAGE POWER PACKS ex-U.S.A. Brand new. Input 115 volts A.C. output 1,000 volts at 250 mA. Complete with 2 1616 valves and 1 spare. Double choke and paper smoothing. **£5/5/-.**

EDDYSTONE ROTARY POWER UNITS. In grey metal case. Input 12 v. D.C. Output 180 v. at 60 m/a. Complete with all smoothing and filtering. Size 12in. x 6in. x 5in. Wt. 16lb. BRAND NEW, **19/6.**

BLOCK PAPER CAPACITORS, T.C.C. 8 mfd., 1 kV. wkg., upright mtg., size 4in. x 2½in. x 5in. high. Brand new and boxed. TWO for **15/-.**

THREE-CORED CABLE. 23/36, rubber ins., circular, padded, cotton covered, maroon. 12 yds., **9/-,** or 100 yds., **59/6.**

AR77 MAINS TRANSFORMERS. Fully shrouded, drop-through, 3¾in. x 3¼in. Primary 110/125/150/210/240 v., 50-60 c/s. Secs., 325-0-325 v. 100 m/amp., 6.3 v., 3.5 amp., and 5 v. 2 amp. BRAND NEW ex-U.S.A., **29/6.**

REPLACEMENT MAINS TRANS., for R.C.A. Amplifiers, Pri. 105/115/125 v., 50-60 c/s., Secs., 380-350-0-350-380 v., 170 m/amp. 6.3 v., 3 amp., C.T. and 5 v., 3 amp. 4½in. x 4¾in. x 4¾in. high. Fully shrouded, **16/6.**

TRANSFORMER BARGAINS. Brand new ex-manufacturer's surplus drop-through. Primary 200-250 volts 50 cps. Secondary 310-0-310 v. 70 mA., 6.3 v. @ 3 a., 4 v. @ 2 a. Can be used with either 4 v. or 6.3 v. rectifier. Only 9/6 plus 1/6 post. A similar type transformer 325-0-325 100 mA., 6.3 v. 4 a., 4 v. 3 a. only **12/6.**

INSTRUMENT TRANSFORMERS. Parmeko. 230 v. A.C. input. 0-65-130-195 v. 85 m/amp. 6.3 v. 5 amp. and 6.3 v. .3 amp. Shrouded 3¼in. x 3¼in. x 3¾in. high. **15/-.**

HEAVY DUTY LT TRANSFORMERS. 230 v. A.C. mains input. Secs. 5-0-5 v., 5-0-5 v., and 5-0-5 v., all at 5 amps., each winding. 5, 10, 15, 20, 25, or 30 v. at 5 amps., or other possible combinations. 4¾in. x 4¼in. x 6in. high. Wt. 12lb. BRAND NEW, **29/6.** ANOTHER, 230 v. A.C. mains input, Two separate secondary windings, each 14 v. C.T. 12 amps. 7, 14, 21, or 28 v. at 12 amps., or other possible combinations. Wt. 24lb. Ex-Admiralty. Brand new, **42/6.** G.E.C. 200-250 v. A.C. mains input. 30 v. (tapped at 10 v.) 36 amps. output. 5½in. x 6in. x 7in. high. Wt 24lb., **55/-.** U.S.A. potted type, input 210/220/230 v., 5 secondaries, 7.5 v 4 a., 7.5 v. 4 a., 7.5 v. 8 a. and 2.5 v. 5 a., ALL centre tapped, and 6.3 v. 4 a. These can be connected to give many useful voltages up to 31 v. 4 a. Size 6in. x 5in. x 4in. Wt. 14½lb., price 35/-.

SELENIUM BRIDGE RECTIFIERS. Funnel cooled. A.C. input 45 v. R.M.S. D.C. output 30 v. 10 amp. 47/6 each.

HEAVY DUTY SLIDER RESISTORS. 250 watts. Rated to carry 25 amp. .4 ohm resistance. For charging boards, etc. Worm drive. On metal stand 9in. x 4in. x 6in. high. BRAND NEW 7/6 each. ANOTHER, 12 amps., 1 ohm, 150 watts, 6/6. ALSO 14 ohms, graded 1 to 4 amps., 7/6.

RESISTORS. Latest miniature insulated Dubilier ½ watt type B.T.S. Wire ends. Useful values. ONLY 10/- for 100 assorted! Erie, etc., ½ and ¼ watt, 1 gross assorted, 10/-.

PLEASE ADD POSTAGE OR CARRIAGE ON ALL ITEMS

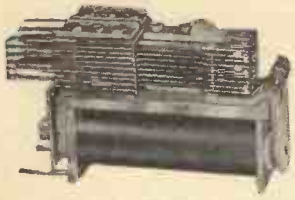
CHARLES BRITAIN (Radio) Ltd.

11 UPPER SAINT MARTIN'S LANE, LONDON, W.C.2. TEMple Bar 0545

One minute from Leicester Square Station (up Cranbourn Street)

Shop Hours: 9-6 p.m. (9-1 p.m. Thursday). *Open all day Saturday*

RELAYS P.O. TYPE 3000



BUILT TO YOUR SPECIFICATION

QUICK DELIVERY

KEEN PRICES

CONTACTS UP TO 8 CHANGE OVER

METERS GUARANTEED

F.S.D.	Size	Type	Price
100 Microamp	2½in.	MC/FR	50/–
250 ,, (multirange scale)	3½in.	MC/FR	55/–
500 ,,	2in.	MC/FS	27/6
500 ,, (scaled 0/15 KV)	2in.	MC/FR plug type	18/6
1 Milliamp	2in.	MC/FS Elliott 5Q/87	27/6
30 ,,	2½in.	MC/FR	12/6
100 ,,	2½in.	MC/FR	12/6
200 ,,	2½in.	MC/FR	12/6
500 ,,	2½in.	MC/FR	12/6
20 Amp.	2½in.	MI/FR	25/–
25 ,,	2½in.	MI/FR DC	7/6
50 ,,	5in.	MI/PR	60/–
50-0-50 Amp.	2in.	MC/FS	12/6
15 Volt	2½in.	MI/FR	15/6
10 ,,	2½in.	MCR/FR	30/–
20 ,,	2in.	MC/FS	10/6
40 ,,	2in.	MC/FS	10/6
300 ,,	2in.	MC/FS	10/6
300 ,,	2½in.	MI/FR	25/–
300 ,,	5in.	MI/PR	60/–
2,000 volt	2½in.	ES/FR	40/–

INSTRUMENT RECTIFIERS. Full Wave Bridge 1 m/a. 8/6, 5 m/a. 7/6. 50 m/a. 5/–. Post 6d.

TELEPHONES—SOUND POWERED—NO BATTERIES REQUIRED. Just connect with twin flex for clear speech. Transmitter/receiver units 9/– per pair. Twin flex 4½d. yard. Post 1/–.
If 2 units are connected in series and one used for speaking and one for listening, perfect 2-way conversation can be made.
Alternative offer. 2 similar units connected in series and fitted with cord and plug. 12/6. Sockets for plug 1/3. Post 1/6.

RADIATION MONITORS. Philips Type 1092c. A portable self-contained unit in haversack, measuring Gamma Radiation. Scaled 0 to 10 milli-rontgens per hour, using Mullard Geiger Counter MX115. £25.

INSTRUMENT LAMPS. 3 volt miniature, for Aircraft Inst., Sextants, etc. 25 in box, 36/– doz.

JACK PLUGS and Sockets, 2 Contact, 5/6 per pair, post 9d.

HEADPHONES. Sensitive Balanced Armature Type DHR, 17/6 per pair. Post 1/6.

HEADPHONES. High resistance 4,000Ω Type CHR new 12/6 pair, post 1/6.

TRANSFORMERS. Normal primaries. 350-0-350 v. 120 m/a. 2×6.3 v. and 5 v. tropicalized, 25/–. Also 150 m/a. with extra 6.3 v. 30/–. Post 2/6.

VARIAC TRANSFORMERS. Oil filled type. 80 CO 7.5 amps enables 230 v. A.C. mains to be kept constant. 130/–. Cge. 7/6.

RACKS—POST OFFICE STANDARD. 6ft. high with U-channel sides drilled for 19in. panels, heavy angle base. 4ft. 10in. also in stock.

INSPECTION LAMP. Fits on forehead leaving hands free, battery case clips on belt 7/6. Post 1/6. Takes E.R. Battery No. 1215 2/9, post 9d.

PHOTOMULTIPLIER No. 931A. Ideal for film scanning, spectography, Alpha counting, colorimetric measurement, etc., supplied complete in lightproof chamber with lamp, wired with the resistor network, 70/–.

VERNIER DRIVES. Muirhead scaled 0/180 deg. Ratio 38 to 1. Diam 3in. 10/6. Post 1/6.

SLOW MOTION DIALS. 6in. Scaled 1/100 reduction 200 to 1 or direct. 5/6. Post 2/–.

MASTS TELESCOPIC. Extending to 12ft. in 7 sections. 15/6. Post 2/6.

HANDSETS SOUND POWERED. No batteries required, just connect with twin flex and they are ready for use. 50/– per pair. Post 2/6.

TELEPHONE SETS. For perfect communication between 2 or more positions. Wall Type, one, pair of units, £5. Batteries 5/6. Twin wire 5d. yard. Desk Type, now available, latest modern style. Two complete units ready for use, £8/17/6. Wire 5d. per yard. Post 3/–.

ROOM THERMOSTAT. Adjustable between 45 and 75 deg. Far. 250 v. 10 amp. A.C. Ideal for greenhouses, etc., 35/–. Post 2/–.

GEARED MOTORS for the model maker. Small but very powerful. 12/24 volts D.C. 4/8 R.P.M. 35/–. Post 2/–.

VENT-AXIA FANS—EXTRACTION OR INTAKE. 230/250 volts A.C. 6in. diam. blades 130/–. 12 volt D.C. 90/–, post 2/9.

RATIO ARM UNITS. Sullivan. 600 ohms + 600 ohms, 50/–. Post 2/–.

WHEATSTONE RESISTANCE BRIDGE. 1 to 10,000 ohms. Plug type £5.

ELECTRO MAGNETIC COUNTERS

Post Office type 11A, counting up to 9,999, 2 to 6 volts D.C. 3 ohm coil, 12/6 each. Post 1/–. Many other types in stock.

ROTARY CONVERTERS. Input 24 volt D.C. Output 230 volt A.C. 50 cy., conservatively rated at 100 watts, 92/6. Also available in a strong ventilated metal case with switch, input plug and output socket, 105/–. Cge. 7/6.

CHARGING RECTIFIERS. Full wave Bridge 12 volts 2 amps., 13/6, 4 amps., 22/6, suitable transformers 2 amp. 24/–, 4 amp., 27/3, post 2/–.

VARIABLE RESISTANCE. 160 ohms, 2 amps., on 10½in. Twin formers, gearing with control handle. Suitable for dimming, 35/–, post 2/9.

TERMINAL BLOCKS 2-way fully protected. No. 5C/430. 4/– doz. or box of 50 for 15/–, 3-way, 8/– doz., post 1/6.

L. WILKINSON (CROYDON) LTD.

19, LANSDOWNE ROAD, CROYDON

Phone: CRO. 0839 **Telegrams: "WILCO," CROYDON**

RADIO TRADERS LTD.

23 WARDOUR ST., LONDON, W.1. (Coventry Street end)
Phone No. GERrard 3977/8 *Grams: "Radiotrade"*

B.T.H. CRYSTAL DIODES, 1/3. Very special price for large quantities.

RESISTORS. ¼ watt, 2/6 doz; ½ watt, 3/- doz; 1 watt, 4/- doz.; 2 watt, 6/- doz

MANUFACTURERS PLEASE NOTE YOUR ENQUIRIES ARE INVITED FOR ERIE RESISTORS TYPES 0, 1, 2, 8, 9, 16, 7b AND 5b.

WW RESISTORS. 5 watt, 1/6; 10 watt, 2/6; 15 watt, 3/-; 20 watt, 3/6. We carry stocks of resistors from 2 watt to 150 watt W.W. Your enquiries invited.

HIGH STABILITY RESISTORS. ¼ watt 5%, 6d.; ½ watt 5%, 9d.; 1 watt 5%, 1/-. A few values in 1% and 2% still available.
ALL ORDERS FOR RESISTORS C.O.D. PLEASE, AS WE CANNOT GUARANTEE TO STOCK ALL VALUES.

W.W. V/CONTROLS. ALL WELL-KNOWN MAKES. Pre-set types, 2/6; Spindle types, 3/-; Carbon type, less switch spindle and pre-set, 2/-. With switch, 3/6 each

SEMI-MIDGET 2-GANG. .0005 Condenser, size 2¾ x 2 x 1¾in., 6/9 each.

SPECIAL OFFER OF CURRENT MANUFACTURE ELECTROLYTIC CONDENSERS
8 mfd. 450 v., 2/6 each; 16 mfd. 450 v., 3/-; 32 mfd. 450 v., 4/-; 8 x 8 mfd. 450 v., 3/9; 8 x 16 mfd. 450 v., 4/-; 16 x 16 mfd. 450 v., 4/6; 32 x 32 mfd. 350 v., 5/-. Bias Condensers: 25 mfd. 25 v., 1/6; 50 mfd. 50 v., 1/9.
Please note we can offer special discounts for quantities.

ELECTROLYTIC CONDENSERS. Manufacturers' Surplus, in perfect condition.
16 mfd. 375 v., 2/-; 24 mfd. 350 v., 1/6; 24 mfd. 450 v., 2/3.

BIAS CONDENSERS: 1,000 mfd. 12 v. 1/6; 25 mfd. 25 v., 1/3; 50 mfd. 12 v., 1/-.

BLOCK PAPER CONDENSERS. 12 mfd. 250 v., 7/6; 8 mfd. 600 v., 7/6; 4 mfd. 400 v., 3/6. We carry a large stock of block paper type condensers. We invite your enquiries.

MIDGET MICA CONDENSERS. .0001, .0002, .0003, .0004, .0005 5/- per dozen.
200 Assorted Moulded Mica Condensers, popular values..... £2 10 0
200 Assorted Silver Mica Condensers, popular values..... £2 10 0
200 Assorted Carbon Resistors, ¼, ½ and 1 watt. Good selection £1 10 0

PAXOLIN SHEET. 18 v., 4½ x 1/16in., 1/6; 10 x 10 x 3/32in., 1/6; 20 x 10 x 3/32in., 3/-; 10 x 10 x 1/16in., 2/-; 20 x 10 x 1/16in., 4/-. Minimum P. & Pkg. 1/6

BARGAIN OFFER OF BATTERIES

4½ v. Heavy Duty Bell Battery. Size 6½ x 4½ x 2½in.....	2/6
72 v. H.T. 1.5 v. L.T. Size 6 x 5 x 1⅜in.....	2/6
150 v. H.T. Size 2¾ x 5½ x 1⅜in.....	5/6
67½ v. Size 2¾ x 3⅜ x 2¾in.....	6/6
60 v. H.T. 1.5 v. L.T. 3¼ x 3¾ x 1½in.....	4/6

All batteries sealed and unused. All plus 1/6 post and pkg. Special reduction for quantities.

4-way Push Button Units, 2/6 each. Knobs for same, 3/- per doz.

5-way Push Button Units, 5/6 each, complete with knobs.

WEARITE COILS. PA4, PO4, PA5, PO5, 1/3 each.....doz. 12/–

VALVE HOLDERS. Moulded B9A, 7/6; B7G 6/-; Int. Oct., 9/-; Eng. Oct. .....doz. 4/6

VALVE HOLDER FITTED WITH LOWER CAN, 1/6 per doz. extra. Screening Cans for B7G and B9A.....doz. 6/–

Paxolin V/H Int. Oct. B9A, B7G, 5/- per doz.; Eng. Oct., 5-pin, 7-pin .....doz. 3/–

BELLING-LEE PLUGS AND SOCKETS, 5-pin, 1/9; 7-pin, 2/-; 10-pin .....each 2/6

AIR-SPACED TRIMMERS, 5, 10, 15, 20, 25, 50; and 75 of pre-set and spindle types, 2/- each.....doz. 21/–

PYE PLUGS AND SOCKETS, 1/6 per pair, "Tee" pieced...each 1/9

GROMMETS, 1 grs. assorted grommets, ¼in. to 1in.....gross 8/6

POST OFFICE LAMP JACKS No. 10, 1/- each.....doz. 9/–
Lamp Covers for same.....doz. 3/–
P74 2-pin plugs and sockets are now available, 3/6 each.

OUTPUT TRANSFORMERS. Multi-ratio, 5/- each; Pentode or power .....each 4/–

WESTECTORS. WX6, WX12, W12, W4, 1/- each.....doz. 9/–

SIGNAL LAMP HOLDERS. Panel mounting, complete with adjusting lampholder, 2/- each.....doz. 21/–

TAG STRIPS. 3-way, 2/-; 4-way, 2/6; 5-way, 3/-; 7-way, 4/-; 28-way .....doz. 12/–

Please send S.A.E. for complete list of components available.

POINTER KNOBS. Small black with white line, standard ¼in. spindle .....doz. 7/6

WANDER PLUGS. Red and black.....doz. 2/–

PHILIPS TRIMMER TOOLS. 1/- each.....doz. 10/6

CASH WITH ORDER OR C.O.D. ALL ORDERS DEPT. W.I.
ALL ORDERS FOR LESS THAN £2 ADD POSTAGE

We invite your enquiries for items not listed

Trade Counter open 9 to 6 Monday to Friday

Also 9 to 1 Saturdays. Callers Welcomed.

WHOLESALE MANUFACTURERS' AND EXPORT ENQUIRIES INVITED

TRANSFORMER DEVELOPMENT

A Junior Development Engineer is required to assist in the design and development of coils and small transformers for use on domestic radio and television receivers and other electronic equipment. A sound technical background is essential together with an interest in the economical aspects of design and development. Some experience is desirable but not essential. Applicants should write, quoting (Ref. TD) and giving details of experience and qualifications to the

Personnel Manager,
The General Electric Co., Ltd.,
Radio and Television Works,
Spon Street, Coventry.

ELECTRONIC DEVELOPMENT ENGINEER

Applications are invited from young men interested in a post as Development Engineer to work on the development of transistor and printed circuit techniques with a view to their application principally to domestic radio and television receivers. Applicants should have a degree in Electrical Engineering or its equivalent and some experience of development work. Those interested should write, quoting (Reference TPC) and giving details of their qualifications and experience to the

Personnel Manager,
The General Electric Co., Ltd.,
Radio and Television Works,
Spon Street, Coventry.

BRITISH INSULATED CALLENDER'S CABLES LTD.

An Engineer with a telecommunications background is required for an interesting post in the Systems Engineering Department of the Company's Telephone Cables Division at Prescot. The successful applicant will be engaged primarily in the design of telephone cables, including plastic types, and in the preparation of associated manufacturing specifications, but will also be required to become familiar with the broad engineering aspects of telephone cable systems. Suitable specialised training will be given, if required.

Applications quoting reference P/69/56 should be forwarded to the

Staff Officer, B.I.C.C. Ltd., Prescot, Lancs.

ENGLISH ELECTRIC COMPANY LIMITED

STEVENAGE HERTS

have immediate vacancies for

TELEMETRY ENGINEERS

in the newly formed Test Department of the Company's Guided Weapons Division.

Applications are invited from engineers who are experienced in Instrumentation Planning and in the preparation and testing of Missile Telemetry Systems.

Housing assistance available.

Apply to Dept. C.P.S. 336/7 Strand, W.C.2, quoting Ref. WW1312A.

VACANCIES IN GOVERNMENT SERVICE

A number of vacancies, offering good career prospects, exist for:—

Radio Operators—Male
Cypher Operators—Male and Female

Apply, giving details of education, qualifications, and experience to:—

Personnel Officer,
G.C.H.Q. (FOREIGN OFFICE),
53 Clarence Street,
Cheltenham, Glos.

BUSH RADIO LIMITED

Development Laboratories—KEW

Vacancies exist in all grades of work on colour television and associated test gear.

Write for application form to Personnel Dept. (Ref. CTV), Bush Radio Ltd., Power Road, Chiswick, W.4.

GUIDED WEAPON TRIALS

Trials Engineers and Assistants are required for Flight Trials of Guided Weapons, including preparation of equipment for firing and reporting on defects. These posts, based at Feltham, Coventry and Aberporth (Wales), entail some travelling in the United Kingdom and "away-from-base" expenses are re-imbursed. Excellent salaries and pension scheme. The work is practical, but an understanding of theoretical factors involved is vital. Engineers should be professionally qualified with a knowledge of Electronics, and Assistants are preferred with National Certificates and practical experience of an electro-mechanical or electronic kind.

Enquiries invited by the Personnel Manager, (Ref. W.W.12.)
SPERRY GYROSCOPE COMPANY LIMITED,
Great West Road, Brentford, Middlesex.

TEST ENGINEERS

required for interesting work in connection with Radar, Television Film Projectors, Camera Channels, Microwave Links and similar electronic equipment.

Applicants must have sound theoretical knowledge of electronics backed by practical experience in H.M. Forces or Industry. Staff positions and Superannuation Scheme. Single accommodation available.

Apply giving full details to the :-
Personnel Dept. (C.E./21).

E.M.I. LTD., Hayes, Middx.

JUNIOR TEST EQUIPMENT ENGINEER

required to take charge of small workshop servicing electrical and electronic test equipment. To work initially at Croydon and subsequently at new Research Laboratories at Caterham, Surrey. Qualifications O.N.C. or equivalent and experience of repair and calibration of multirange meters, oscilloscopes, pulse generators, etc. Write stating age, qualifications and experience to

PERSONNEL MANAGER,
POWERS-SAMAS ACCOUNTING MACHINES, LTD.,
RESEARCH DIVISION,
AURELIA RD., CROYDON.

SIEMENS BROTHERS & CO. LTD.

Transmission Equipment Engineers

required for work on carrier telephone and telegraph apparatus contracts at our MAIN WORKS in LONDON.

Increased activities offer wide scope and prospects for applicants with some experience, civilian or service, in the installation and maintenance of telecommunication equipment.

Educational qualifications up to Final City & Guilds or H.N.C. standard desirable but not essential. Candidates must have completed National Service.

Where previous industrial background is lacking suitable training will be provided.

Salaries according to age and experience. Liberal staff pension scheme, sports and canteen facilities.

Give brief details to **Staff Officer, Ref. 744/62, SIEMENS BROTHERS & CO. LIMITED, WOOLWICH, S.E.18.**

Wireless World Classified Advertisements

Rate 7/- for 2 lines or less and 3/6 for every additional line or part thereof, average lines 6 words. Box Numbers 2 words plus 1/-. (Address replies: Box 0000 c/o "Wireless World" Dorset House, Stamford St., London, S.E.1.) Trade discount details available on application. Press Day March 1957 issue, Thursday, January 31st. No responsibility accepted for errors.

WARNING

Readers are warned that Government surplus components and valves which may be offered for sale through our displayed or classified columns carry no manufacturers' guarantee: Many of these items will have been designed for special purposes making them unsuitable for civilian use, or may have deteriorated as a result of the conditions under which they have been stored. We cannot undertake to deal with any complaints regarding any such items purchased.

NEW RECEIVERS AND AMPLIFIERS

SHIRLEY LABORATORIES, Ltd., 3, Prospect Place, Worthing, Sussex. Tel. 30536.
THE TWA/1515 stereosonic tape recording and replay amplifier, separate meter monitoring on record and playback on both channels, 13watts O/P each channel, 96gns; TWA/15 tape recording and reproducing amplifier, 13watts O/P, for Wearite and Collaro decks, 45gns; TW/PA recording and replay pre-amplifier, 30gns; both with valve voltmeter monitoring; type SB/1-15E high-fidelity amplifier, exceptionally wide tone-control system, 40mv sensitivity, 20gns; with two inputs and 3-position gram filter, 22gns; specialized amplifiers for the musical and scientific industries including the Mullard 20watt. [0095

ARMSTRONG chassis, all models in stock.—157, Bromsgrove St., Birmingham. Mid. 1054. [6563

SPENCER-WEST Distribution and Communal Reception Amplifiers cater for all requirements.—Full data and leaflets on request to Spencer-West, Ltd., Quay Works, Great Yarmouth, Norfolk. Tel. 4794. [0007

RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

HRO Rx's and coils in stock, also AR88, BC348R, CR100, etc.—Requirements please to R. T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0053

DYNAMOS, MOTORS, ETC.—SURPLUS AND SECONDHAND

BRIDGE connected rectifier units (large), 12 and 24V charging auto cut-outs, 300 amp starter relays, 12 and 24V working, heavy duty starter pushes; please see advert of October's "Wireless World," page 176.
T. W. PEARCE, 66, Great Percy St., W.C.1. [0012

TEST EQUIPMENT—SURPLUS AND SECONDHAND

SIGNAL generators, oscilloscopes, output meters, valve voltmeters, frequency meters, multi-range meters in stock; your enquiries are invited.—Requirements to R.T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0056

NEW GRAMOPHONE AND SOUND EQUIPMENT

3-SPEED portable transistor gram (operates on 4½volt battery); 27gns.
200mW Transistor amplifiers; 10gns.
4-WATTS Hi. Fi. models soon.
TRANSISTOR pre-amps; still £9/15.
COLLARO decks £20, amps 23gns and 25gns.
WEARITE, Reflectograph decks, and amps available.
HARDING ELECTRONICS, 120a, Mora Rd., Cricklewood, London, N.W.2. Gladstone 1770. [0032

SPECIAL tape offer, few only left, prof. tape at 1,200ft. 22/6 (21/- each 6 and above); 1/6 P.P. plastic, not paper, guaranteed; satisfied users everywhere.
RECORDERS by Ferrograph, Leevers-Rich and the new wonder recorder Brenell disk recorders, blank disks, microphones.
TAPE/DISK service, specialists in music recording and editing.
"EROICA" RECORDING STUDIOS (1949), Recorder House, Peel St., Eccles, M/c. Eccles 1624. Director Thurlow Smith, A.R.M.C.M. [0122

CINE-VOX disc recording equipments, type C7J, for high-quality recordings from existing microphone equipment; price from 28gns; also available as a complete channel inclusive of mic., amplifier and playback equipment, at 70gns; type C7 for highest quality professional requirements—recorder mechanism at 48gns, or complete channel at 110gns; demonstrations arranged in London.
PLEASE write for details to K.T.S., Ltd., "Coplow," Park Rd., Braunton, N. Devon. Tel. Braunton 224. Callers by appointment only. [0210

NEW GRAMOPHONE AND SOUND EQUIPMENT

ALL Hi-Fi enthusiasts please note!—We are supplying the Collaro tape transcriptor complete with pre-amplifier and power pack ready to plug into any amplifier for only 36gns—making it one of the lowest-priced quality tape recorders on the market!; all other makes of recorders in stock; easy terms available.—Sound Tape Vision (Dept. W.W.), 71, Praed St., London, W.2. Pad. 2807. [0211

GRAMOPHONE AND SOUND EQUIPMENT—SURPLUS AND SECONDHAND

LENCO GL.56 transcription unit with Goldring 500, as new, in makers' carton.—Offers to Box 5783 (Cheshire). [6678

HIGH quality portable tape recorder, in excellent condition, cost £130; bargain, £55 for quick sale.—Details Box 5784. [6679

NEW COMPONENTS

CRYSTAL microphone inserts (Cosmocord Mic 6/4), in steady demand by Hams and Sound Engineers; guaranteed newly made and boxed; 15/6 post free.—Radio-Aids, Ltd., 29, Market St., Watford. [0169

COMPONENTS—SURPLUS AND SECONDHAND

RADIO CLEARANCE, Ltd., 27, Tottenham Court Rd., London, W.1. Tel. Museum 9188.
ELECTROLYTICS: Capacity, voltage, size, type of mounting, price post paid. 25, 25v, ⅝×1¾, W/E, 1/3; 500, 12v, ¾×¾, W/E 2/1; 1,000+1,000, 6v, 1×3, clip, 3/3; 1,000, 6v, 1×2, clip, 2/3; 1,000+2,000 6v 1×3, clip, 3/9; 100, 12v, ⅝×1¾, clip, 1/9; 2,000, 12v, 1⅜×2, clip, 3/6; 50, 25v, ⅝×1¾, clip, 1/9; 100, 25s, ¾×1¾, 2/-; 1,000, 25v, 1×3, clip, 4/-; 3,000, 25v, 1⅜×4½, 5/-; 5,000, 25v, 1¾×4½, 6/6; 2,500, 50v, 1¾×4½, 6/6; 5, 150v, ⅝×1¼, W/E, 1/3; 8, 150v, ⅝×1¼, clip, 1/3; 40+40, 150v, 1×2, clip, 2/9; 100, 275v, 1⅜×3, clip, 3/-; 60+250, 275/350v, 1¾×4½, clip, 6/-; 8, 450, ¾×2, clip, 1/9; 16+24+8, 450/525v, 1⅜×2, clip, 5/-; 20+10, 450v, 1×3, clip, 4/-; 8, 500v, 1⅜×2¾, clip, 2/3; 32+32+8, 350/425v 1⅜×3, clip, 5/-; 32+32, 350/425v, 1⅜×2, clip, 4/-; 100, 350/425v, 1⅜×3, clip, 4/-; 2, 350v, ⅝×2, 1/3; 16+16, 275v, 1×2, clip, 3/-; 32+32+8, 275v, 1⅜×2, clip, 4/3; 100+200, 350v, 1¾×4½, clip, 7/-; 50+50, 350v, 1⅜×3, lug, 4/6; 200, 250v, 1⅜×3, clip, 3/6; 16+8+4, 275v, lug, 3/-; 200+250+250, 275v, 2×4½, clip, 8/6; all ALI cans, some with sleeves, all voltages WKG, surve V where marked, all new stock guaranteed.
TELEVISION chassis, cadmium plated steel, size 14×13×2¼in. complete with 13 valve holders (9-B9A Pax, 1-B9A Cer, 2-B7G Cer, 1-Int. Oct. amph), 20 various tag strip cut away for metal rect., line trans., etc., 9/11 each, post paid.
FRONT and rear tube mounts to fit above chassis, 3/- pair post paid.
P.M. focus rings, wide angle, tetrode tube, fully adjustable, 9/11, post paid.
SCANNING coils, wide angle, with mounting lugs 19/6, post paid.
T.V. metal rect. 250v 250mA, H.W. size 2¼×4in, 12/6, post paid.
C.T.V.IF's 34Mc/s, 2nd, 3rd, 4th, vision cans 13/16×13/16×2½, slug tuned, set of three 5/6 post paid.
8mf. 600/750v, paper conds., 4in×2in×4½in; 6/6.
100Ω w/w pots. 3w, 1in spindle; 2/6.
RADIO CLEARANCE, LTD., 27, Tottenham Court Rd., London, W.1. Tel. Museum 9188. [0015

SOUTHERN RADIO SUPPLY, Ltd., 11, Little Newport St., London, W.C.2. See our displayed advertisement, page 162.

MAGSLIPS at low prices, fully guaranteed, 3 in Resolver No. 5 (AP 10861), 50v, 50c/s, unused, each in tin, 35/-, post 2/1; large stocks of these and other types.—P. B. Crawshay, 94, Pixmore Way, Letchworth, Herts. Tel. 1851. [0087

WANTED, EXCHANGE, ETC.

WANTED, receivers A.P.R.4, also T.N.16, 17, 18, 19, etc., and any radio test gear.
LESLIE DIXON & Co., 214, Queenstown Rd., Battersea, S.W.8. Macaulay 2159. [0176

WANTED, Voight PM2 speaker, good condition.—F. Barker, 5, High St., Swanscombe, Kent. [6680

FOR SALE AND WANTED ADVERTISEMENT FORM TURN TO PAGE No. 165

WANTED, EXCHANGE, ETC.

4 Dynamotors, 12/24-volt D.C., 500/500 250 MA or near; price and details.—Radiovox. Ltd., Oxford Place, Leeds. [6619

WANTED, valves, TV tubes, televisions, radios, radiograms, tape recorders.—Stan Willetts, 43, Spon Lane, West Bromwich, Staffs. Tel. 2392. [5847

WANTED, HRO coils, RXs., etc., A.R.88s, BS348s, S27s, etc.—Details to R.T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0163

WANTED, B.C.610 Hallicrafters, E.T.4336 transmitters and spare parts for same; best prices.—P.C.A. Radio, Beavor Lane, Hammersmith, W.6. [0079

UNISELECTOR switches, modern types 2 to 8 bank, any quantity; send sample with details of quantity and price.—Davis, Tudor Place, London, W.1. [6650

LARGE funds available for bulk purchase of televisions, radios, tape recorders, and domestic electrical appliances of every description.
SPEARS, 14, Watling St., Shudehill, Manchester. Tel. Blackfriars 1916. Bankers Midland Bank, Ltd. [6696

SPOT cash ready for purchase of surplus and bankrupt stocks of new valves and components; we sell plain valve cartons; list on request.—R. H. S., Ltd., 155, Swan Arcade, Bradford. [0190

URGENTLY wanted, manuals or instruction books, data, etc., on American or British Army, Navy or Air Force radio and electrical equipment.—Harris, 93, Wardour St., W.1. Gerrard 2504. [6479

WANTED, good quality communication RYS tape recorders, test equipment, domestic radios, record players, amplifiers, valves, components, etc., estb. 18 years.—Call, send or 'phone Ger. 4638 Miller's Radio, 38a, Newport Court, Leicester Sq., W.C.2. [6059

WANTED, signal generators, types TF144G, TF762A, TF867, frequency meters types BC221, TS174, TS175, also receivers types R1359 and R1294.—Send price and details to Hatfield Instruments, Ltd., Crawley Rd., Horsham, Sussex. Tel. Horsham 3232/3. [0037

ALL U.S.A. V.H.F. test and communication equipment; TS174, TS175, TS47, B.C.221 freq. meters; receivers 1294, 1359; Hallicrafters S.27, S27CA U.S.A.; APR4 and tuning units TN16, 17, 18 and 19, RCA AR88D-LF, Hallicrafters SX28; valves 707A-707B, 2K28, 2K39, 2K33, 2K41; highest offers given by return.—Ger. 8410 and 4447.—Universal Electronics, 22, Lisle St., Leicester Sq., London, W.C.2. [0229

VALVES

1500 T.T. II valves; best offer the lot or lots of 100.—Box 5844. [6698

ANOTHER amazing valve offer from Waltons! All new stocks and every valve tested before despatch, of special interest to dealers, service engineers, etc.
48 USEFUL type valves for only 45/- post paid. EACH set comprising 6 VR91/EF50 Red, 6 VR91/EF50 Silver, 6 VT52/EL32, 6 VT501/TT11, 6 VR56/EF36, 6 VR92/EA50, 6 VR54/EB54, 6 VU120 or VU120A or CV54.
WALTON'S WIRELESS STORES, 48, Stafford St., Wolverhampton. [0102

VALVES WANTED

ALL types of valves British or American, transmitting and receiving; keenest cash prices paid. What have you to offer?—Write or call Lowe Bros., 9a, Diana Place, Euston Rd., N.W.1. [4485

CABINETS

LEWIS RADIO have the best selection and finest finish.—See page 144. [0224

REPAIRS AND SERVICE

MAINS transformers rewound, new transformers to any specification.
MOTOR rewinds and complete overhauls; first-class workmanship; fully guaranteed.
F.M. ELECTRIC Co., Ltd., Potters Bldgs., Warser Gate, Nottingham. Est. 1917. Tel. 47898. [0113

MAINS transformers, E.H.T.s, chokes, field coils, etc., promptly and efficiently rewound or manufactured to any specification. LADBROKE REWIND SERVICE, Ltd., 820a, Harrow Rd., London, N.W.10. [0222

METERS, all makes, single or multi-range, expertly repaired; prompt service.—R. Hawkins, 6, Constantine Rd., London, N.W.3. Gul. 5374. [6688

TRANSFORMER rewind service mains, E.H.T. transformers and chokes, prompt delivery, range of replacement types ex-stock or manufactured to your specification.
METROPOLITAN RADIO SERVICE Co., 75, Kilburn Lane, London, W.10. Ladbroke 2296.

D. C. BOULTON for repairs to any loudspeaker; specialists on heavy and P.A. types; cone assemblies, field coils, repair accessories, pressure units, microphones; transformers rewound and to specification; motor rewinds.—134, Thornton Rd., Bradford, 1. Tel. 22838. [0171

PAINTS, CELLULOSE, ETC.

PANL, the air-drying black crackle paint; 3/6 per ⅛th pint can.—G. A. Miller, 8, Kenton Park Cres., Kenton, Middx. [0250

WORK WANTED

P.T.F.E. machining and moulding capacity available.—Bel, Marlborough Yard, London, N.19. Tel. Archway 5078. [0187

TECHNICAL query service problems in electronic design and construction advised upon by qualified engineers; nominal fee 5/-; quotation for involved problems.—Box 5598. [6695

CAPACITY AVAILABLE

FACTORY Capacity available for the following categories:
PLASTICS Injection Moulding (3 oz).
ALUMINIUM Die-Casting.
LIGHT Engineering.
ELECTRONIC & Electrical Assembly. Location Wiltshire.—Box 0077. [0114

VACUUM Varnish Impregnation to RCS 214.H2, quick service; enquiries welcomed.—Andec, Ltd., Gosbrook Rd., Caversham, Reading. 71763. [6495

MISCELLANEOUS

TAPE to disc; 12/6.—Mobile Recording Services, 5, New Brown St., Manchester. [6555

FOR sale, coil winding machines, 3 Douglas No. 1, in good condition; £20 each.—Apply: Willesden Transformer Co., Ltd., Manor Park Rd., London, N.W.10. [6694

HAVE your tape recordings transferred to discs, 78s or L.P.s; high fidelity reproduction.—Write Parke, 18, Zulla Rd., Mapperley Park, Nottingham. [6636

TAPE to disc recording, 48-hr. service; L.P. (30 min.) 22/-, 78s 11/-; s.a.e. leaflet.—Comprehensive Recording Service, A. D. Marsh, Little Place, Moss Delph Lane, Aughton, Ormskirk, Lancs. Aug. 3102. [6477

YOUR own tape recording transferred to disc 78s or L.P.s.—Write, call or 'phone Queensway Private Recording Studios, 123, Queensway, W.2. Tel. Bay. 4992. Studio recordings. [6543

METALWORK, all types cabinets, chassis, racks, etc., to your own specification; capacity available for small milling and capstan work up to 1in bar.
PHILPOTT'S METAL WORKS, Ltd., Chapman St., Loughborough. [0208

TAPE/DISC for connoisseurs, use Britain's oldest full-time transfer service; 30 min. 42/-; special prof. qual. tape, 25/- and 21/-.—Sound News Productions, 59, Bryanston St., W.1. Amb. 0091. [0192

TRAIN at home for a better position or a new hobby.—We offer comprehensive modern home tuition courses covering over 100 careers and hobbies, practical equipment supplied with many courses.—Write for free brochure, stating subject of interest, to: E.M.I. Institutes, Dept. WW39, London, W.4. (Associated with H.M.V.) [0180

NOTICES

BRITISH SOUND RECORDING ASSOCIATION. Details of membership, open to the professional sound recording engineer and all others interested in recording high quality reproduction and other branches of audio engineering, together with details of the London lecture programme and the Manchester, Portsmouth and Cardiff Centres, may be obtained from the Hon. Membership Secretary, H. J Houlgate, A.M.I.E.E., 12, Strongbow Rd., Eltham, S.E.9. [0031

PATENTS

PATENT No. 660115 "Loudspeaker Diaphragm Moulding" for sale or licence.—Apply Chatwin & Company, Patent Agents, 253, Gray's Inn Rd., London, W.C.1. [6664A

AGENTS WANTED

PROGRESSIVE electronic manufacturer and D.O. requires free-lance agents with connections in industry to obtain business; exclusive territory arranged.—Box 5846. [6701

PLASTIC moulding company, requires the services of free-lance agents, who have suitable connections with users of mouldings; exclusive territory granted.—Write Box 4636. [6462

SITUATIONS VACANT

TELEVISION and radio.

DEVELOPMENT engineers.
ENGINEERS are required for senior and junior positions in the television and radio development departments of a well known manufacturer in the West London area.
APPLICANTS for senior positions should have academic qualifications and several years' development experience. Junior engineers are required to have either academic qualifications or development experience.
ALL the posts are permanent and carry the benefit of the firm's pension scheme. Generous salaries will be paid to engineers showing initiative and responsibility.
PLEASE write fully, in confidence, stating age, experience, etc., to Box 5117. [6548

PYE TELECOMMUNICATIONS, Ltd., Ditton Works, Cambridge.
HAVE a number of vacancies for sales engineers, interesting work including systems planning for VHF multi-channel, Microwave TV Links and Aeradio, some vacancies cover survey and installation work in the field at home and abroad; excellent salary and prospects.—Apply in writing giving details and quoting ref. CET to the Personnel Manager. [6661

SENIOR development engineer required for work on audio transistor equipment, previous experience essential; South-East London area; please write giving full details.—Box 5757. [6674

SITUATIONS VACANT

ELECTRONICS TRAINING.

THE Ministry of Supply is offering five-year apprenticeships in electronics to boys who will be between the ages of 16 and 17½ years on September 1, 1957, and who wish to become qualified electronic technicians.

APPLICANTS should be in possession of, or be studying to obtain, by September 1, 1957:—(a) GENERAL Certificate of Education with passes at Ordinary Level in English Language, Mathematics and Physics (or other Science subject covering Physics) and one other subject, or (b) QUALIFICATIONS giving exemption from S.1 stage of the Ordinary National Certificate and have reached a corresponding standard in English Language.

APPLICATION forms and further particulars may be obtained from the Departmental Training Officer, Ministry of Supply, 66-72, Gower St., W.C.1. The closing date for receipt of completed application forms is Saturday, March 16, 1957. [6693

FEDERAL Government of Nigeria

SENIOR Telecommunications Engineers.

POST A.—To be responsible to a Principal Telecommunications Engineer for all engineering activities of the Posts and Telegraphs Department in a district comprising two or more areas, including administration and control of engineering staff (African and European), telephone exchange systems (automatic and manual), 3 and 12 channel carrier systems on V.H.F. links, telegraph equipment and teleprinters, or to assist or deputise for the Principal Telecommunications Engineer at Territorial Headquarters.

POST B.—To be responsible to a Principal Telecommunications Engineer for the efficiency of all wireless communications including M.F. H.F. and V.H.F. installations in a major departmental territory and to plan and carry out major overhauls and reconstruction of wireless installation and minor development work.

PENSIONABLE appointments with salary of £1,920 p.a. gross or on contract with salary of £2,244 p.a. gross plus contract gratuity of £37/10 for each three months' satisfactory service; free passages for officer and wife; an allowance of £75 p.a. for each of two children aged under 18 maintained outside Nigeria, and refund of up to the cost of two adult fares for children's passages once in each tour of duty, when the allowance would cease; quarters, if available, at low rental; generous leave.

CANDIDATES should be A.M.I.E.E. and have had not less than four years' responsible experience in telecommunications (radio engineering experience is necessary for Post B) or alternatively have held the rank of executive engineer for at last 2 years (for post B employed on wireless engineering) in the British Post Office.

WRITE Director of Recruitment, Colonial Office, London, S.W.1, giving age, qualifications and experience, quoting Post A or B, BCD 108/14/028. [6675

HER MAJESTY'S Oversea Civil Service.

RADIO engineer—posts and Telegraphs Department, Fiji.

TO be responsible for the preparation of returns required by the International Frequency Registration Board and for overall control of staff in radio stations.

PENSIONABLE or contract appointment for 3-4 years; salary range £675-£1,441 p.a.; disturbance allowance of £36-£54; free passages not exceeding 4 adult fares on first appointment and not more than 3 adult fares on leave, gratuity on completion of contract, quarters, if available, at reasonable rental, 4-5 days' leave for each completed month of resident service.

CANDIDATES must be A.M.I.E.E. and be thoroughly conversant with the installation, operation and maintenance of low powered H.F. and V.H.F. radio stations and have a sound knowledge of the International Radio Regulations and procedure regarding frequency registration.

WRITE Director of Recruitment, Colonial Office, London. S.W.1, giving age, qualifications and experience, quoting BCD 108/49/02. [6660

RADIO Maintenance Technician required by POLICE Department, Government of Northern Rhodesia, for one tour of 36 months in first instance; salary, according to age and experience, in scale £705 rising to £1,200 a year; free passages; liberal leave on full salary; candidates, preferably aged 25 to 30, must possess academic qualifications in mathematics and physics of matriculation standard, together with sound knowledge of installation and maintenance of modern low and medium powered V.H.F. static and mobile equipment, H.F. transmitters and receivers, petrol generators and diesel electric sets.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/41913/W.F. [6704

CHIEF Engineer required, London area, to take charge of developing organization dealing with industrial electronic equipment, electronic components and printed circuits; this appointment demands an engineer with wide knowledge of industrial electronics; of manufacturing methods, both mass production and custom building; and with exceptional drive and organizing ability; age preferably 35 to 45; applications should give very full particulars of education and experience and will be treated in strict confidence.—Box 5690. [6663

SITUATIONS VACANT

AREA Engineers, Posts and Telegraphs Department Federation of Nigeria.
POST A.—In addition to planning and carrying out major overhauls of wireless installations an area engineer will also be required to take charge of all MF, HF and VHF (single and multi channel) wireless installations in a minor Departmental territory and be responsible to a Principal Telecommunications Engineer for the efficiency of all wireless communications in the territory.
POST B.—Will be in charge of all Posts and Telegraphs Department activities in an area, including control of staff, telephone exchange control systems (auto and manual) three and twelve channel carrier systems on open wire line, or VHF links and VF telegraph equipment and teleprinters. He will also be responsible to a Senior Telecommunications Engineer for the maintenance of all telegraph and telephone services in his area.
APPOINTMENT is either pensionable in the salary range £1,458 to £1,680 or on contract in the salary range £1,728 to £1,962 plus a gratuity of £37 10s for each three months satisfactory service. Free first-class passages for the officer and his wife plus an allowance of £75 for each of two children maintained in the United Kingdom and refund of cost of childrens' passages to Nigeria to cost of two adult fares. Generous leave.
CANDIDATES must be A.M.I.E.E. and have not less than two years responsible experience in telecommunications (Wireless engineering experience is necessary for Post B). Executive Engineers in the G.P.O. or Assistant Engineers in the G.P.O. who are also A.M.I.E.E. will be considered.
WRITE Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, stating age, qualifications and experience, quoting Post A or B. BCD108/14/05. [6666

ELECTRONIC Engineer to work on the design and development of electronic and transistor amplifiers for use in servo-mechanisms and computing circuits.
APPLICANTS should have had at least three years' experience of laboratory work on electronic circuits, and preferably those familiar with transistor techniques, but the company are prepared to train suitable applicants in this field, providing they have attained H.N.C. in Electronic Engineering.
ADVANCED rates of pay for competent men; canteen and medical services and sports and social facilities are available together with Service holiday and payment during illness arrangements, also pension provisions.
APPLICANTS can be considered for the tenancy of houses on the company's attractive estate.
APPLICATIONS should be made in writing to the Personnel Manager, Kelvin and Hughes, Ltd., Winchester Rd., Basingstoke, Hants. [6566

APPLICATIONS are invited from suitably qualified engineers for vacancies on the development staff engaged on telecommunication transmission.
ACTIVITIES in this field are being expanded under the control of Dr. J. A. Pim. Ph.D., B.Sc., M.I.E.E., with special emphasis on work connected with:—
(a) ELECTRONIC circuits based on the use of transistors.
(b) NETWORK development including the design of filters and transformers.
These vacancies offer opportunities for wide experience and advancement in a compact working group, experimenting with and applying important new techniques. Senior and Junior positions are available. In both cases qualifications of Honours degree standard in Electrical Engineering. Mathematics or Physics are required but the actual possession of an Honours degree is not insisted upon. For senior grades several years additional practical experience in appropriate fields will be expected.
STARTING salaries are offered in accordance with age and experience from £950 upwards for senior engineers and from £600 upwards for assistant engineers. All are pensionable staff posts with good prospects.
AS the main works are in London the technical staff can participate in the activities of the professional institutions and attend a wide range of lectures and courses. There is a liberal pension scheme in operation and assistance with housing difficulties, if required, may be available in approved cases. Excellent sports club and canteen facilities.
APPLICATIONS giving a preliminary outline of qualifications should be sent to the Staff Officer, Ref. 744/59, Siemens Bros. & Co., Ltd., Woolwich, S.E.18. [6686

CHIEF Inspector required by manufacturers of Electronic Components (London). Suitable for Senior Electrical/Electronic Test Engineer wishing for wider scope.—Write Box 5810. [6689

SIGNAL generator Homelab type 10, 100 kc/s, 100 mc/s, £6/10; Homelab TV pattern generator, type 4, £6; both as new.—Studley Electronics, 29, Studley Drive, Ilford, Essex. Ley. 6851. [6644

TELEVISION Engineers, able to drive, required by leading Murphy dealers; permanency, first-class salary and conditions.—Singer's, 211 Kilburn High Rd., N.W.6. Mal 6408. [6222

DRAUGHTSMEN required for interesting work in connection with layout and detailing small mechanical and electrical components, early prospects of promotion.—Write in first instance giving full details of experience and salary required to Thermionic Products, Ltd., Hythe, Southampton. [6672

SITUATIONS VACANT

MALE Laboratory Assistant required for interesting work on acoustics research; ordinary national certificate or equivalent; housing available for London resident.—Apply Chief Chemist, Revertex, Ltd., Harlow, Essex. [6702

JUNIOR engineer required by electronic instrument manufacturer for development work on specialized transformers and electronic control devices. Higher Nat. Cert. preferred, excellent opportunity in laboratory of progressive company.—Box 5780.

TECHNICAL assistant required by electronic instrument manufacturer to assist engineers in the development of transformers and electronic control devices, National Certificate or equivalent, excellent opportunity in laboratory of progressive company.—Box 5781.

AUDIO engineer required to join technical staff of leading recording company, thorough knowledge of audio techniques required; qualifications not essential.—Write fully, stating age, experience, etc., to Chief Engineer, I.B.C., 35, Portland Place W.1. [6667

McMICHAEL RADIO, Ltd., Slough, Bucks, have vacancies from time to time for electronic engineers to be engaged on Government projects; those wishing to be considered are invited to write fully to the Chief Engineer, Equipment Division. [0198

RADIO mechanic required at Stansted Airport, must be experienced and have good knowledge of aircraft radio equipment, hostel accommodation available.—Apply to Personnel Manager, Skyways, Ltd., Stansted Airport, Essex. [6653

ELECTRICAL test engineer (senior) required by manufacturers of components for electronic equipment, should be interested in life testing and quality control, would also deal with supervision of inspection to Government specifications, London area.—Write Box 5681. [6662

JUNIOR engineer required by well-known group of companies for patents and agreements department, a knowledge of electronics is essential but the work is varied and experience of patent procedure will be advantageous.—Write with information on training and experience to Box 5654. [6654

THE Medical Research Council have a vacancy for an operator to be trained in the running of their 45in Cyclotron at Hammersmith Hospital; duties will include supervision of the production of radioactive isotopes on the cyclotron and co-operation with workers using the machine for medical and biological research. CANDIDATES must be adaptable and willing to learn cyclotron techniques; some knowledge of electronics, including R.F., is essential. SALARY according to age, experience and qualifications. WRITE, stating age and giving full personal details, to the Senior Cyclotron Engineer, Medical Research Council, Hammersmith Hospital, Ducane Rd., W.12. [6682

LIVINGSTON Laboratories, Limited, have vacancies in their laboratories for engineers of H.N.C. standard, aged 22-28. The positions offer unique experience in high grade British and American test instrumentation. Congenial working conditions and non-contributory pension scheme. APPLY for appointment to the Chief Engineer, Livingston Laboratories, Limited, Retcar St., London, N.19. Tel. Arc. 6251. [6687

THE Mullard Southampton Works have a number of openings for University Graduates in Physics, Chemistry, Electrical Engineering and Mechanical Engineering; these posts are on the research, development and production sides of these new works, which are concerned with the development and manufacture of transistors and other semi-conductor devices. THE vacancies offer an excellent opportunity for suitably qualified young men and women to enter this expanding branch of the electronics industry; the commencing salaries paid will be based on qualifications and experience and it will be found that the Company operates a progressive salary policy and that its general conditions of employment are attractive. PLEASE apply in writing to the Personnel Officer, Mullard Southampton Works, Millbrook Industrial Estate, Southampton, quoting reference GBK/S.20. [6664

ELECTRONIC engineer to take charge of small laboratory developing and maintaining control equipment; excellent opportunity for young qualified engineer with ideas able to organise own department; salary according to qualifications and experience.—Apply: Grundy (Teddington), Ltd., Somerset Works, Elmtree Rd., Teddington, Middlesex. [6692

ELECTRICAL, radio and radar mechanics and instrument makers required in department of aircraft electrical engineering for interesting work in the field of guided missiles; 5-day week; generous holiday allowance; staff superannuation and sick pay scheme.—Application forms from Chief Clerk, The College of Aeronautics, Cranfield, Bletchley, Bucks. [6703

SENIOR Laboratory Technician (temporary in the first instance) required at Norwood Technical College, Knight's Hill, S.E.27, in Telecommunications Engineering and Radio dept. for maintenance of equipment and instruments, upkeep and supervision of laboratories, and storekeeping. Salary scale £444 to £556, and to £669 with specified qualifications. Further particulars and application forms (returnable within 14 days) from the Secretary, (2358) [6685

SITUATIONS VACANT

MURPHY RADIO, Ltd., have vacancies in the radio and television laboratories for senior and junior engineers; these posts offer excellent prospects of advancement.—Applications, giving full details of experience and qualifications, should be addressed initially to Personnel Department (R6), Murphy Radio, Ltd., Welwyn Garden City, Herts. [6568

A. C. COSSOR, Ltd., require a technical sales engineer for radar duties; successful applicant will be based in North London but must be prepared to travel within the U.K. and overseas for Liaison duties; good general radio/radar technical background essential; operational and technical knowledge of Gee and airborne radar desirable; pension scheme. WRITE, giving details of education, qualifications and experience, etc., to the Technical Director, A. C. Cossor, Ltd., Highbury Grove, London, N.5. [6683

RADAR and radio experienced men with Higher National or C. & G. Certificates in electrical engineering and telecommunications wanted by a firm of consulting geophysicists; initial salary £660; permanent career offered to men of initiative prepared to accept responsibility and work in camp conditions in all parts of the world; liberal home leave and allowances. —Apply Box 4849. [0188

ELECTRONIC engineers or physicists required for rapidly expanding research department; experience of pulse techniques or ultrasonics desirable but not essential; the work is varied and interesting and offers scope and opportunities for people with initiative; B.Sc. or H.N.C. standard.—Write, giving details of age, experience, salary required, etc. to Ultrasonoscope Co. (London), Ltd., Sudbourne Rd., London, S.W.2. [6451

RADIO technicians required by International Aeradio, Ltd., for overseas service; permanent and pensionable positions; inclusive salary from £894 per annum to £1,373 per annum, tax free, according to marital status; free accommodation; kit allowance; free air fares; generous U.K leave.—Qualified candidates, to whom replies only will be sent, please write, quoting RT to Personnel Officer, 40, Park St., W.1. [0262

TECHNICAL writer required to assist in the preparations of commercial and service handbooks on electronic equipment; while a degree is not essential applicant must have a sound knowledge of radio and radar circuitry, and the ability to write clear and concise English.—Write, stating full details of qualifications, experience, age and salary required to Personnel Department, (E.28), Murphy Radio, Ltd., Welwyn Garden City, Herts. [6659

ELECTRONIC INSTRUMENTS, Ltd., Richmond, Surrey, have a number of vacancies in their test room which offer the prospect of interesting future jobs in this rapidly expanding company, five-day week, pension scheme, staff club room; these vacancies will be filled immediately after Christmas, but application should be made now.—Please write to Electronic Instruments, Ltd., Lower Mortlake Rd., Richmond, Surrey, or 'Phone Richmond 5656. [6700

RECORDING and cutting engineer; a recording and cutting engineer capable of working without supervision is required by a major recording company; duties will involve complete responsibility for the maintenance of all equipment both on the company's premises and on location and development work with the appropriate research departments.—Applications should be made in the candidate's handwriting, giving details of qualifications, past experience, and salaries earned and required, to Box 5366. [6594

M.W.T. Installations. Vacancies exist in the Power Equipment and Installations Division of Marconi's Wireless Telegraph Co., Ltd., of Chelmsford for draughtsmen experienced in electrical installation planning, switchgear, power distribution and wiring. Radio knowledge is not essential. Applicants with rather more limited experienced can also be considered for supplementary training. Please write, giving full details and quoting Ref. 2266, to Mr. J. L. Scott, Dept. C.P.S., Marconi House, 336/7, Strand, W.C.2. [6690

MANAGER, accustomed to workshop servicing of radio and television receivers on a large scale, required for a factory in the London area; applicants should be aged 30-40 years with good technical knowledge and previous administrative experience; knowlege of production methods would be an asset; the position is with a manufacturer and the salary to the successful applicant will be in the region of £1,000 p.a., supported by first-class superannuation and other benefits.—Write, giving details of education and experience to date, to Box 5845. [6699

TRANSISTOR applications.—Three development engineers are required to join expanding team engaged in the development of a number of interesting projects including low-noise d.c. and wide band amplifiers, and high speed pulse circuits; applicants must be experienced in electronic circuit development, not necessarily including transistors; engineering or physics degree, H.N.C. or equivalent qualification is desirable; The posts offer considerable scope in a new and rapidly advancing field; starting salaries according to age and experience; contributory pension and life assurance fund; applications, which will be treated in strict confidence, should be addressed to The Personnel Manager, Ferguson Radio Corporation, Gt. Cambridge Rd., Enfield, Middx. Ref. Quote B. 8990. [6682

SITUATIONS VACANT

OPPORTUNITY for senior electronic engineer, B.Sc. or equivalent, versatile and with design experience of commercial equipment; good salary.—Write Box 5684. [0173

ELECTRONIC/Mechanical development engineer required for work on hearing aid research.—Please apply to Mr. Cohen, Ardente, Ltd., 8-12, Minerva Rd., Acton, N.W.10. Tel. Elgar 3923. [6656

JUNIOR development engineers and technicians are offered an opportunity to broaden their experience and scope to use their initiative in a newly-formed department primarily concerned with the development of electronic equipment for the Services; there are interesting positions for a number of grades of electronic engineers with or without experience in this field of development.—Those interested should write giving details of career to date to the Personnel Manager (REF. JE.), The General Electric Co., Ltd., Spon St., Coventry. [6657

THE RANK ORGANISATION requires the services of a fully qualified electronic engineer to take charge of a laboratory in the London area where work on an interesting new development project is about to start; this will be a permanent appointment carrying a starting salary of £1,100-£1,300 according to experience and qualifications; there is a contributory pension scheme.—Apply in writing giving a concise but complete account of training, qualifications and career so far to the Personnel Adviser, The Rank Organisation, 11, Belgrave Rd., S.W.1. [6673

CHIEF Draughtsman required to take charge of medium-size drawing office of radio telecommunication manufacturers, situated in pleasant country town; applicants should be experienced in the electro mechanical design and development of electronic and communication equipment; experience of Ministry contract requirements would be an advantage; housing assistance if required; staff pension scheme; apply with full particulars of training, experience and approximate salary required to—Secretary, A.T. & E. (Bridgnorth), Ltd., Bridgnorth, Shropshire. [6665

ESTIMATING.—E. K. Cole, Ltd., Malmesbury, Wilts; vacancy for an estimator, company is engaged on electronic equipment, applicant should have had a wide experience in estimating this class of work and small quantity production, good practical shop training is considered essential and engineering apprenticeship desirable; good salary will be offered and there is a possibility of housing accommodation being available to suitable applicant; full welfare facilities and contributory pension scheme.—Please apply in writing with details of education, training and experience to Personnel Manager. [6658

SELENIUM Rectifiers.—Senior Executive required by expanding company in North Midlands area to direct research and production of selenium Rectifiers; a knowledge of Germanium and Silicon Rectification would be useful; this is an important appointment with a progressive organisation and offers exceptional opportunities to the successful applicant with suitable experience, initiative and energy.—Applications marked "Personal" to Managing Director, Box 5146, quoting details of education and training, qualifications, career, age and salary required. All applications will be treated in strictest confidence. [6559

THE WAYNE KERR LABORATORIES, Ltd., Special Products Division, Tolworth Close, Tolworth, Surrey, invite applications from British born engineers for vacancies in a new department for testing resin cast components; applicants must have a sound knowledge of electronic theory, preferably with O.N.C.; experience in any of the following fields would be an advantage: (a) High voltage apparatus, (b) pulse techniques, (c) environmental testing including stratospheric conditions, (d) photography; personnel about to leave H.M. Forces with experience of radar apparatus are also invited to apply [6700

PRACTICAL Electronic Engineers required for the maintenance of production test equipment used in the manufacture of radio components and various electrical products. A certain amount of design and construction is entailed together with the carrying out of routine electrical investigations and production trouble-shooting. Applicants should have a sound basic knowledge of electronic principles and the ability to work from circuit diagrams with the minimum of supervision Servicing knowledge of radio and television an advantage. Practical experience of this type of work will be rated as highly as academic qualifications Good salaries will be paid and a Pension Scheme is in operation.—Please reply in confidence. to Box 4641. quoting T.P.3 [6469

HENRY WIGGIN & Co., Ltd., have a vacancy for a graduate in Physics or Electrical subjects with practical experience in the design or manufacture of valves or magnetic equipment. The successful applicant will be employed in the Technical Service Section to advise on the selection of materials and to develop the sales of the company's high nickel alloys as used in the electronics industry in the United Kingdom and overseas. This is a particularly interesting appointment for an ambitious electronics engineer possessing initiative and keenness and some desire for travel, and who wishes to make a career in technical sales and administration.—Applications should be made to the Director and Sales Manager, Henry Wiggin & Co., Ltd., Wiggin St., Birmingham, and marked "Confidential." [6691

SITUATIONS VACANT

SIGNALS Officers (Inspectors of Police, Grade II), required by Kenya Government, for 2 years on probation for permanent employment, commencing salary according to experience in scale (including inducement pay), £753 rising to £1,095 a year, outfit allowances £40, free uniform, separation allowance payable to married men under certain conditions, free passages, liberal leave on full salary after tour of 30-45 months, candidates, preferably unmarried, aged 25-35 should be at least 5ft 7½in without footwear, intelligent and of good physical strength and development, must be of good education with normal vision and hearing without aids, candidates must have at least 4 years' experience of telecommunications work with a radio firm, Government Dept. or H.M. Forces, knowledge of diesel and/or petrol electric sets an advantage.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M1/45197/WF. [6655

SENIOR Scientific and Scientific Officers, Experimental and Asst. Experimental Officers, required at Government Communications HQ, Cheltenham, for telecommunications and electronic research in following fields: VHF receiver design and microwave techniques; propagation trials; applications of semi-conducting devices; high speed electronic switching; data storage and handling; computer programming; and operational research. Candidates must normally be natural born British subjects of natural born British parents. For S.S.O./S.O., 1st or 2nd class hons. degree in physics, mathematics or engineering or equiv., at least 3 years' post-graduate experience for S.S.O. For E.O./A.E.O., Pass Degree, H.N.C. or near equiv. Salaries for men (provincial rates) S.S.O. £1,075-£1,265, S.O. £565-£995 (according to age and quals.), E.O. £875-£1,075, A.E.O. £350-£755 (according to age). Appointments unestablished but opportunities to compete for established posts.—Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting A 418/6A. [6671

BRITISH OVERSEAS AIRWAYS CORPORATION have vacancies for radio instructors for the instruction of all grades of staff on the maintenance and overhaul of current radio, radar and allied equipment and in preparation for the Aircraft Radio Engineers Licences class "A" and "B" with radar ratings. Duties will include the preparation of technical manuals which will involve liaison with manufacturers' design staff at the prototype or production stage of the equipment. Applicants should have City and Guilds Final Certificate in Telecommunications or equivalent qualification; experience of the operation, maintenance and overhaul of aircraft radio, radar and electronic systems; real ability to express themselves clearly on technical subjects preferably with previous experience as teacher of technical subjects. The salary for these posts will be in the scale £920-£1,190 per annum. In the event of an applicant not having the full qualifications required but who is otherwise suitable, appointment initially in the scale £852 10s-£1,032 10s per annum may be considered. Generous Staff Pension and Insurance Scheme, sick pay and holiday entitlements; excellent sports and social facilities. Applications should be addressed to Ass't. Staff Manager (Appointments). Recruitment Centre. B.O.A.C., London Airport. [6669

SITUATIONS WANTED

INSTRUMENT Maker, able to work with hand and machine tools to fine limits from rough drawings and own designs for prototype and research work, seeks situation as above; production work not considered.—Box 5794. [6684

EXECUTIVE engineer in top level management post seeks change to similar position with company of repute in the electronic or closely allied industry; experienced in industrial applications, development, sales, works methods, M.o.S. contract procedure and complete management; enquiries please from directors and top-level management.—Box 5597. [6646

TECHNICAL TRAINING

LEARN it as you do it—we provide practical equipment combined with instruction in radio television, electricity, mechanics, chemistry, photography, etc.—Write for full details to E.M.I. Institutes, Dept. WW47, London, W.4. [0006

CITY and Guilds (Electrical, etc.) on "No Pass—No Fee" terms, over 95% successes.—For full details of modern courses in all branches of Electrical Technology send for our 144-page handbook, free and post free, B.I.E.T. (Dept. 388A), 29, Wright's Lane, London, W.8. [0117

TUITION

NOTHING succeeds like success! What we have done a thousand times we can do again for you—see the B.N.R.S. advt. page 72. [C172

WIRELESS operating; attendance and postal courses.—Stamp for reply to Manager, The Wireless School, Manor Gdns., London, N.7. [0104

FULL-TIME courses for P.M.G. Certs., C.G.L.I., Telecommunications, Radar Maintenance Cert. and B.Sc.(Eng.); prospectus free.—Technical College, Hull [0111

WIRELESS.—See the world as a radio officer in the Merchant Navy; short training period; low fees, scholarships, etc., available; boarding and day students; stamp for prospectus.—Wireless College, Colwyn Bay. [0018

CLASSIFIED ADVERTISEMENTS

Use this Form for your Sales and Wants

To "Wireless World" Classified Advertisement Dept., Dorset House, Stamford Street, London, S.E.1

PLEASE INSERT THE ADVERTISEMENT INDICATED ON FORM BELOW

- **RATE : 7/- for TWO LINES. 3/6 every Additional Line. Average six words per line.**
- **Name and address to be included in charge if used in advertisement.**
- **Box No. Allow two words, plus 1/-.**
- **Cheques, etc., payable to Iliffe & Sons Ltd., and crossed "& Co."**
- **Press Day, Thursday January 31st for March 1957 issue.**

NAME .....

ADDRESS .....

....

			REMITTANCE VALUE.....ENCLOSED		

Please write in block letters with ball pen or pencil.

NUMBER OF INSERTIONS .....

INDEX TO ADVERTISERS

Printed in Great Britain for the Publishers, ILIFFE & SONS LTD., Dorset House, Stamford St., London, S.E.1, by CORNWALL PRESS LTD., Paris Garden, London, S.E.1. *Wireless World* can be obtained abroad from the following: AUSTRALIA AND NEW ZEALAND: Gordon & Gotch, Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service Ltd.; Gordon & Gotch, Ltd. SOUTH AFRICA: Central News Agency, Ltd., William Dawson & Sons (S.A.), Ltd. UNITED STATES: The International News Co.

UPRIGHT MOUNTING ELECTROLYTICS

Catering for the unusual

The saving of space resulting from the use of these Upright Mounting Electrolytic Condensers is one of the chief reasons for their popularity.

Types CE170 to CE173 include a number of single and dual section capacities in current use in the European markets: a threaded moulded boss of $\frac{5}{8}$" diameter ensures interchangeability with Continental types.

Types 928 and 526 are of particular interest to designers of rectifier units as small and efficient substitutes for large high voltage paper condensers. Type 526 ($\frac{1}{2}$" and $\frac{3}{4}$" diam. boss) will be suitable for the majority of circuits, but in the exceptional cases of higher outputs or where something 'in hand' is required, Type 928 ($\frac{3}{4}$" diam. boss) with 800v. peak working is recommended.

Cap. in μF.	Pk. Wkg. Volts	Surge Volts	Ripple M/A	Dimns. in Ins.		T.C.C. Type No.
				Lgth.	Diam.	
50	350	400	260	$3\frac{7}{16}$	1	CE171LE
16	450	550	120	$2\frac{3}{16}$	1	CE170PEA
25	450	550	150	$2\frac{3}{16}$	1	CE170PE
32	450	550	210	$3\frac{7}{16}$	1	CE171PEA
50	450	550	260	$3\frac{7}{16}$	1	CE171PE
50—50	350	400	300	$3\frac{7}{16}$	$1\frac{1}{4}$	CE172LE
25—25	450	550	180	$3\frac{7}{16}$	1	CE171PEB
50—50	450	550	310	$3\frac{7}{16}$	$1\frac{3}{8}$	CE173PE
8	800	900	150	$4\frac{1}{2}$	$1\frac{1}{2}$	928
8	600	700	100	$4\frac{1}{2}$	1	526
16	600	700	160	$4\frac{1}{2}$	$1\frac{1}{2}$	526
32	600	700	240	$4\frac{1}{2}$	$1\frac{1}{2}$	526

All these condensers have high gain etched foil electrodes and are of "All-Aluminium" internal construction.

The maximum working temperature of all types is 60°C.

THE TELEGRAPH CONDENSER CO. LTD

RADIO DIVISION · NORTH ACTON · LONDON W3 · Tel: ACOrn 0061

PYE FACTORIES REPORT HOW

Ersin Multicore

SAVBIT TYPE 1 ALLOY

REDUCES BIT WEAR AND IMPROVES SOLDERING

Under controlled conditions the bit on left, used with Savbit Alloy, made 10,000 joints. Centre bit, used for 1,000 joints and bit on right for 7,500 joints, were used with standard tin/lead alloy.

After extensive tests, L. W. Jones, Pye Works Director, reports the results from many Pye Factories. Here are a few examples:

"T.V. MANUFACTURING LTD., LOWESTOFT, have carried out tests which show a very considerable reduction in the soldering iron bit wear with a strong improvement in the quality. Also the price advantage is attractive to them."

"ROSEBERY WORKS, TOTTENHAM, state that soldering irons only require 25% maintenance as against the normal maintenance when using ordinary solder."

"LABGEAR (CAMBRIDGE) LTD., find that the soldering iron bit saving is as claimed by you. They are entirely satisfied with it, and all their orders have been amended to take this solder in future."

"HOLLOWAY ENGINEERING WORKS LTD., state that they do find a considerable saving in soldering iron maintenance. As an example at this company, I.F. transformer assembly need the irons dressing twice a day using standard solder, but using Savbit solder they obtain a service of 30,000 joints without attending to the iron other than an occasional wiping with a cloth."

"PYE IRELAND LIMITED, have found improvements in every direction with this Savbit solder, and they report that they like the solder better than the standard solder quite apart from the saving of the soldering bits."

7 LB. REEL

Savbit Type 1 alloy is supplied in 3 gauges on 7 lb. reels for factory use. 6 standard tin/lead alloys of Ersin Multicore 5-core Solder in 9 gauges are also available. Prices on application.

1 LB. REEL

Approximately 170 ft. of 18 s.w.g. Ersin Multicore Savbit Type 1 Alloy is supplied on this 1 lb. reel. It is invaluable to all who are interested in cutting down on bit replacement and maintenance costs. 15/- each (subject).

SIZE 1 CARTON

Supplied containing 53 feet of 18 s.w.g. Savbit Type 1 Alloy or 4 standard tin/lead alloys of Ersin Multicore 5-core Solder as follows:

Catalogue Ref. No.	Alloy Tin Lead	S.W.G.	App. l'gth per carton
C 16014	60/40	14	19 feet
C 16018	60/40	18	51 feet
C 14013	40/60	13	17 feet
C 14016	40/60	16	36 feet

5/- each (subject)

HOME CONSTRUCTOR'S 2/6 PACK

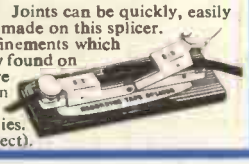
Alternative specifications: 19 ft. of 18 s.w.g. 60/40 alloy wound on a reel or, for soldering printed circuits, 40 ft. of 22 s.w.g. 60/40 alloy wound on a reel. 2/6 each (subject).

Bib WIRE STRIPPER AND CUTTER

This 3 in 1 tool strips insulation without nicking the wire, cuts wire cleanly and splits plastic extruded twin flex. Adjustable to most wire thicknesses. 3/6 each (subject).

Bib RECORDING TAPE SPLICER

Joints can be quickly, easily and accurately made on this splicer. It has many refinements which are usually only found on splicers far more expensive. Soon pays for itself in tape economies. 18/6 each (subject).



MULTICORE SOLDERS LIMITED, MULTICORE WORKS, HEMEL HEMPSTEAD, HERTS. (BOXMOOR 3636)