BICC make television downleads to meet every requirement. Publication No. 357, giving full details of our up-to-date range of cellular polythene types is available on request.

BRITISH INSULATED CALLENDER'S CABLES LIMITED
21 BLOOMSBURY STREET, LONDON, W.C.1.
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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 186V 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 the emitter 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 500kΩ resistor. 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 power 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 in-
EDITORIAL COMMENT

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.
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 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 $\frac{2}{3}$ 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 transistor 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. 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 transistor) had $0.8$% total harmonic distortion at 4 watts ($0.5\%$ at $2\frac{1}{2}$ 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
Amplifiers

NEW RANGE OF TRANSISTORS

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 kV/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 \( \approx 250 \text{Kc/s} \) 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, tuners, 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 34 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 22½ x 13½ x 13½ in. 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.


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 windings. 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, Redbridge Road, Ilford, E.17.

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.
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.

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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.I. (Tel.: Chancery 4411, Ext'n. 436.)

Organizational, Personal and Industrial Notes and News

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 inquiry 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), Verdisk 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 responsible for 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 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. Wireless Research Station; W. H. Hopkins, works manager, E.M.I. Factories; G. W. Kilmister, first radio officer, R.M.S. Arundel Castle; E. L. Lyckett, assistant, B.B.C. outside broadcasts; H. Stark, signals officer, Civil Aviation Telecommunication Directorate, Ministry of Transport and Civil Aviation; and W. W. Syrett, export manager of Ecko'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, former director of broadcasting in Nigeria, C.B.E.; T. D. Bangay, officer-in-charge, Government Wireless Station, Falkland Islands, M.B.E.; and G. 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 managing director. 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 he was in charge of a special project for the V.C.R. 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 V.C.R.97. 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. P. Taylor, recently appointed executive secretary. Mr. Richardson began his engineering training in 1939 with S. C. & H., 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 Electronic 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 the Precision 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 (Australia) 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, Whittaker 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 has been 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 210,690 for car radio, totalled 14,424,236 at the end of November.

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.

Lo.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 Carnarvon, 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 Camer 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, Male 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.c. voltage is applied to the base of the 1st i.f. transistor.

Wireless World, February 1956
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 for 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 (lastling 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 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 2¾-in and 3½-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. Yandel, sales director of Ambassador Radio and Television, Ltd., and P. 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 59 gns.

S.S. Electronics, Ltd., recently moved from Harrow to Chiltern Works, Severalls Avenue, Chesham, Bucks. (Tel.: Chesham 9009.)

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 and 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 United States was £1.6M, nearly 8 per cent of the industry's total overseas trade. Incidentally, the bulk of this was for sound re-producing 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 Bhanvagar 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 Eugenia Niarchos, the biggest yet built in this country.

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

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...
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 and Philips, 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...
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.

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, 6 by returning the earthy end of R 1 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
always developed between cathode and grid, so that the anode supply for the phase-splitter from the transistors, as described by Peterson and Sinclair, to take d.c. unbalance in these transistors but is contrary to the general philosophy of such amplifiers. 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 a constant fraction of the output voltage. Feedback is a constant fraction of the output voltage. Furthermore, the degeneration caused by the speaker varies with its impedance, whereas the feedback is a constant fraction of the output voltage.

A disadvantage of this arrangement is that the distortion in the input to the lower valve is greater than 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 load in the upper valve. The amount of this negative feedback is adjusted to compensate for that produced by the load in the upper valve.

This general type of output stage has been recently applied to a transistor circuit by Cossor's. 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, 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. 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


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**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.

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**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. 56), and the “Annual Report and Accounts of the B.B.C., 1955-56” (H.M.S.O. 6s).
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 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
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.

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 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,
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 a 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 1/8-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, for example, of disc radial-lead capacitors, and a wide variety of components on leaving the reel slide through a right-angle at each end, and driven down and through the pre-punched holes in the board. 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 preset direction, the leads 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

\[ I' = L + D + d + 2 \left( t + s + c \right) \]

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

\[ I' = L + D + d + 2 \left( \frac{s}{8} + \frac{r}{8} + a \right) \]

i.e., \[ I' = L + D + d + \frac{1}{2} \] 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
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 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
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 worktable, 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
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


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**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.

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**"FMQ"**

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**REACTANCE MODULATOR**

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<tr>
<td>100</td>
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**A.F. RESPONSE (without pre-emphasis)**

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---

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

-62 dB

---

**A.M. NOISE**

-60 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%)
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 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 \( x = 2Q_d f_0 \) 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 \( f_0 \), whilst the value of \( Q \) is given by \( R_s/L \). The centre frequency \( f_0 \) is given by \( f_0 = 1/2\pi\sqrt{L_s/C_s} = 1/2\pi\sqrt{L_p/C_p} \). 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

\[
\frac{1}{2L_p} f_0^2 \quad \text{and that of the other by} \quad \frac{1}{4L_p} f_0^2.
\]

These values are equal approximately to \( \left(1 - \frac{M}{2L_p}\right) f_0 \) and \( \left(1 - \frac{M}{4L_p}\right) f_0 \), respectively, and hence

\[
x_1 = 2QM/4L_p = QM/2L_p.
\]

This can be rearranged into a more convenient form as follows.

\[
x_1 = \frac{QM}{2L_p} = \frac{Q_k\sqrt{L_p/L_0}}{2L_p} \quad \text{where} \quad k = \text{the coupling coefficient}
\]

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

\[
E = IR_s/4 (a_1x + a_2x^3 + a_3x^5 + \ldots)
\]

where

\[
a_1 = 2x_1(1 + x_1^2)^{-3/2}
\]

\[
a_3 = x_1(2x_1^2 - 3)(1 + x_1^2)^{-7/2}
\]

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

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

\[
I = I_{in} \left[ \frac{1 + 2x_1^2}{4 + x_1^2} \left( \frac{1 + x_1^2}{2} \right)^{1/2} \left( \frac{1 + x_1^2}{2} \right)^{1/2} \right]^{1/2}
\]

where \( n = kQ \) (see Appendix).

At first sight it would appear that the output

---

* B.B.C. Engineering Training Department.
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

\[
x_1 = \frac{1}{2} b_0 \sqrt{\frac{1}{L_p} - \frac{1}{L_s}} = \frac{1}{2} b_0 \sqrt{\frac{1}{L_p} - \frac{1}{L_s}} = \frac{1}{2} n\sqrt{p}.
\]

Thus there are only two independent variables.

From the equation for \( I_1 \), it will be apparent that \( I_1 \) 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 \( \sqrt{p} = 2n \) and hence \( I_1 = I_{in} \) as would be expected.

It was shown in Part I that the coefficient \( a_0 \) 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 \( L_s = 4L' \).

In the general case, when \( x_1 \) does not equal \( n \), we can express \( I_1 \) as a power series in \( x_1 \) as follows

\[
I_1 = I_{in} \frac{1 + x_1^2}{b_0 + b_2 x^2 + b_4 x^4}.
\]

where

\[
b_0 = 1
\]

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

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

Inserting this value for \( I_1 \) in the expression for \( E \) gives

\[
E = \frac{I_{in} R_s}{4} \frac{1 + x_1^2}{b_0 + b_2 x^2 + b_4 x^4}
\]

where

\[
c_1 = (a_1 b_0)
\]

\[
c_3 = (a_1 b_2 + a_3 b_0)
\]

\[
c_5 = (a_1 b_4 + a_3 b_2 + a_5 b_0)
\]

The distortion introduced is represented by the terms in \( x^2 \) and \( x^4 \). 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 \( x^2 \), and this can be made equal to zero by appropriate choice of parameters. For this condition, \( a_1 b_2 + a_3 b_0 = 0 \), and substituting values this gives

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

This reduces to

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

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 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,
To evaluate the distortion present with the circuit constants chosen, consider an input signal \( x_3 \cos \omega t \). The a.f. output is then

\[
E = 0.4 I_{vn} R_s \left[ 0.7x_3 \cos \omega t - 0.008 (x_3 \cos \omega t)^3 \right]
\]

We can expand \( \cos^3 \omega t \) by means of the identity

\[
\cos^3 \theta = \frac{1}{4} (\cos 5 \theta + 5 \cos 3 \theta + 10 \cos \theta)
\]

giving

\[
E = 0.4 I_{vn} R_s \left\{ 0.7x_3 \cos \omega t - 0.0025 x_3^3 \cos 3 \omega t \right\} - 0.0005 x_3^4 \cos 5 \omega t
\]

The reduction of the fundamental frequency component is negligible for the range of values of \( x_3 \) of interest, i.e. \( x_3 < 1 \). The percentage of third harmonic distortion is thus given by

\[
\frac{0.0025 \times 100 \times x_3^4}{0.7}
\]

\( x_3 = 1 \), this is 0.35 per cent. By employing a smaller value of \( x_3 \), a lower value of distortion is obtained, the distortion decreasing with \( x_3^4 \).

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 \( x_3 = 1 \), the parameters of the circuit are determined by \( x = 2Q \frac{df}{f_0} \). With \( df = 75 \) kc/s at \( x = 1 \), and a centre frequency \( f_0 \) 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 k\( \Omega \). The input current \( I_{vn} \), 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 \( I_{vn} R_s \), 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 \( I_{vn} x_3 \), where \( I_{vn} \) is the input current, and \( x \) is a measure of the frequency

(Continued on page 73)
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 $I_{in}^2$, 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 $\eta$ 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.

Wireless World, February 1957
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 $R_l/\eta$, whilst that imposed on the secondary circuit is $R_t/\eta$. In the example considered above, with equal primary and secondary circuit, the resistance would be $R_t/3\eta$. 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 $R_l$, 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 $\eta = \sqrt{1.5}$.

**APPENDIX**

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

$$E_p = jX_{cp}i_p$$
$$E_p = jX_{cp}(i_p - i_o)$$
$$0 = Z_{cp}' - j\omega M_{cp} - jX_{cp}i$$
$$Z_{cp} = jL_{cp} + 1/j\omega C_{cp} + R_p$$
$$Z_{cp} = jL_{cp} + 1/j\omega C_{cp} + R_s$$

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

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

$$E_p = -jX_{cp}Z_{cp}oM$$
$$E_p = X_{cp}Z_{cp}oM + \omega^2 M^2 i$$

Near resonance $\omega L_p - 1/\omega C_p$ is approximately equal to 2$L_\delta\omega_0$, where $\delta_0$ is the departure from $\omega = 2\pi f_0$. Similarly, $\omega L_p - 1/\omega C_p = 2L_\delta\omega_0$. This gives

$$E_p = jX_{cp}oM (r_p + 2jL_\delta\omega_0) (r_s + 2jL_\delta\omega_0) + \omega^2 M^2 i$$

Let

$$L_{cp'o}r_p = X_{cp}$$
$$L_{cp'o}r_s = X_{cp}$$

and $n = k\sqrt{Q_p/Q_s}$, where $k = M/\sqrt{L_pL_s}$.

$$E_p = \left(1 + jQ_p\right) \left(1 + jQ_s\right) + n^2 \cdot kQ_s \sqrt{L_p/L_s}i$$

Finally if $Q_p = Q_m$, $Q_mX_{cp} = R_{cp}$, and $Q_p = 2Q_\delta\omega_0/\omega_o = x$

$$E_p = \frac{R_{cp}(1 + jx)}{(1 + jx)^2 + n^2}$$

In the equivalent circuit discussed in the text, this voltage is that applied to the tuned circuit connected between terminals 1 and 2. If $i_1 < i_2$, then $I_1 = (1 + jx) I_{en}$. But the current $I_1$ fed to the centre-tap of transformer $T$ is equal to $I_1 - I_2$. Hence

$$I_1 = I_{en} \left(1 - \frac{p - 4}{p} \cdot \frac{(1 + jx)^2}{(1 + jx)^2 + n^2}\right)$$

and

$$I_2 = I_{en} \left(1 + \frac{p - 4}{p} \cdot \frac{(1 + jx)^2}{(1 + jx)^2 + n^2}\right)$$

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

$$|I| = \left|I_{en}\right| \left|1 + \frac{x^2}{1 + x^2(1 - x^2) + 2jx/(1 + x^2)}\right| \left|1 + \frac{x^2}{1 + x^2(1 - x^2) + 2jx/(1 + x^2)}\right|$$
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 monochrome 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 $E_x$, $E_y$, and $E_z$. (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. $E_x$ is the luminance signal already mentioned, while $E_y$ and $E_z$ are known as "chrominance" signals.

$E_x$ and $E_z$ 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 interface. The final output, which also includes sync pulses and a colour sync "burst," is formed by adding to $E_x$ 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.


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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 no non-linear relationship between the sub-carrier signal and the reproduced chromaticity, 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.

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.
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.

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

$$E_b = \frac{E_R + E_Y + E_B}{3}$$

The symbol $E_b$ is used because this “brightness” corresponds more to total energy than to total luminosity. The signal $E_b$ is preferably gamma-corrected at the transmitter for the receiver electron-gun characteristic, and is transmitted instead of the signal $E_X$ 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 $E_R$, $E_Y$, 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

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**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.
minimum of processing, must be such that when added to the brightness signal in correct proportion they form the complete brightness and gaging 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 subcarrier frequency \( f_{sub} \) locked in phase to the colour sync burst, is mixed with the beam index frequency \( f_b \) to produce \( f_b + f_{sub} \). This is again heterodyned with the colour signal \( E_c \) of frequency \( f_c \) and instantaneous phase \( \phi \), the lower side-band giving \( f_c \) 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 \( E_v \) 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 \( E_v \).

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.
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 “trioode” 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.

Technical Notebook

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 Muland, 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 320°C and the tinning operation takes 2-3 seconds. A recent improvement to the technique

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 requires 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.

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 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 f.s 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 oscillator 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.

“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 2 usec 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.
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 instead of two. Non-linearity can be reduced to less than 5% and the efficiency compares favourably 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 illustrates a 220-V 300-mA type and measures only 3½in x 1¼in x ¾in.

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 the possessor of this pack 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, the tester takes 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 ob­erving 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 2 inches advantage with the same size of screen and 90° deflection angles. Another feature is a narrow neck diameter (1¼in), 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.

WIRELESS WORLD, FEBRUARY 1957
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 will have to sketch it rather than draw it 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 p- 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 ease of circuit design. The great advantage of the $r_o$, $r_e$, $r_e$ 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.

Canadian Westinghouse Company,
Hamilton, Ontario.

M. O. FELIX.

“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-inch unit or, say, two 12-inch 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 old days, but 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 object 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 a five-valve radio 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 claims 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 output valve V 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-
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.

Barnstead, 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 “ga = 3.6” and “n = 47” are valve data, and “rA = 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 genuine “Cathode Ray.”

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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. 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 frames, this would cause the initiation of fly-back to vary between, for example, the first and second pulses of succeeding frames. 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, 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 Kerkhof.

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 202 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

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* University of British Columbia

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Wireless World, February 1957
that the current \( i \) in the inductor has reached its steady value given by

\[
    i = I = \frac{V_{b1}}{R} = \frac{80}{14.7} = 5.43 \text{ mA}
\]

In the first line pulse, the switch is opened for 10 \( \mu \text{sec} \). 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 \( C_1 + C_0 \)), is 83 \( \mu \text{sec} \). 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 90\( \mu \text{sec} \). During this period very heavy damping is again applied to the tuned circuit and the inductive current rapidly asymptotes to the steady value \( I \).

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 2021 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.

**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, \( v_{\text{BA}} \) maintained by the charge in \( C_0 \), is positive. The switch (Fig. 3) is open. The potential \( v_B \) 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 \( C_0 \), voltage \( v_B \) is elevated as part of a sinusoidal oscillation with a period \( T_2 \) (governed by \( L \) and \( C_2 \)) of 37 \( \mu \text{sec} \).

The switch remains open for 20 \( \mu \text{sec} \), 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 \( \mu \text{sec} \), 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 \( \mu \text{sec} \) of the conduction period.

During the period of the next frame pulse, the switch is opened for 40 \( \mu \text{sec} \). 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 \( \mu \text{sec} \)). In the instant a quarter of this period (20 \( \mu \text{sec} \) later), the current in the inductance will be zero, and the voltage across it, \( v_A - v_{\text{BA}} \), 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*\(^4\) 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.
During a succession of frame pulses, the magnitude of the voltage pulses at B is, of course, 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 \( \sqrt[3]{36} = 6 \). 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, or the more elaborate "train separator," the derived sync-signal is 400 \( \mu \)sec 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 \( \mu \)sec, 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 \( \pm 20\% \) of...
nominal, while the permitted variation in the value of the inductance L (Fig. 2) was even greater, only a minimum value of 100 mH being specified7. 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

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. 5) 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 to be repeated at an instant one period later. This set will then be shown to be substantially independent of the setting of the frame hold adjustment, provided of course that operation was within the synchronous range.

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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

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

where \( t \) is in microseconds from the closing of the switch and \( i \) is in milliamperes. 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

\[
i = \frac{92}{R} \left[ \frac{\sin t}{\sqrt{L/C}} - \frac{1}{4CR^2} \right] \exp \left( -\frac{t}{2CR} \right) - \frac{12}{R} \quad (4)
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\]
maintained by the charge in $C_1$. 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 $T_2 = 37$
$\mu$sec. Thus, if time $t$ is measured in microseconds from
the commencement of the frame pulse

$$v_B = (v_{A,t} + 8) - \cos \frac{2\pi}{T_2} (t - 20) \quad (6)$$

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.,
$$\frac{1}{2} L i^2 + \frac{1}{2} C V^2$$
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

$$I_1 = 8 \sqrt{\frac{L}{C}} = 0.436 \text{ mA, and therefore the current in the}
\text{ inductance is given by}$$

$$i = - I_1 \sin \frac{2\pi}{T_2} (t - 20) \quad (7)$$

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

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

$$v_A = 88 \exp - \frac{t - 40}{T_2} \quad (8)$$

where $T_2$ is the time-constant formed by $R$ and $C_2$ and
has the value of 22 $\mu$s. During this time also

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

$$= 88 \exp - \frac{t - 40}{22} + 8 [1 - \cos \frac{2\pi}{37} (t - 20)] \quad (9)$$

The instant that $v_B = V_{A,t}$, the diode again conducts and
the mode of operation changes. From (9) this instant
occurs at $t = 45$; i.e., 3 $\mu$sec after the start of the conduction
period; while from (7) the corresponding inductive current is
$+0.373 \text{ mA}$. Also at this instant

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

In the 5 $\mu$s 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:

$$i = 5.45 - \frac{70}{14.7} [0.265 \sin 0.716 (t - 45) +$$

$$\cos 0.716 (t - 45)] \exp [-0.0198 (t - 45)]$$

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

$$i = 5.45 - 4.76 [0.265 \sin 0.716 (t - 45) +$$

$$\cos 0.716 (t - 45)] - 0.0794 \quad (11)$$

$$= 1.03 \text{ mA}$$

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 $\mu$A.

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

and

$$v_A = V_{A,t} + 2\pi 1.03 \sin 2\pi \frac{t}{83} (t - 50) \times 10^{-3}$$

where $t$ is once again measured from the beginning of the
previous frame pulse and $L = 100 \mu$H.

At $t = 70$, from (11) $i = 0$ 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 $\mu$A, whereas the corresponding current
immediately before the first frame pulse is of the order of
5.4 $\mu$A. 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 formulae, 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;

The Application of Phase-coherent Detection and
Correlation Methods to Room Acoustics: B.B.C.
Engineering Division Monograph No. 9 by C. L. S.
Describes modifications of the pulsed gliding tone
technique of displaying the transient response of rooms,
while from (7) the inductive
current will be approximately zero.

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

$$v_A = 88 \exp - \frac{t - 40}{T_2} \quad (8)$$

where $T_2$ is the time-constant formed by $R$ and $C_2$ and
has the value of 22 $\mu$s. During this time also

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

$$= 88 \exp - \frac{t - 40}{22} + 8 [1 - \cos \frac{2\pi}{37} (t - 20)] \quad (9)$$

The instant that $v_B = V_{A,t}$, the diode again conducts and

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.

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 function­
ing 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.
Iffle 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
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 S-valve convertor. The power supply is built on the same chassis.

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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 oscillator 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 converter.

The unit shown incorporates the features dis-

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**LIST OF COMPONENTS**

**Capacitors**
- C13, C14, C16: 20 pF trimmer
- C20: 10 pF variable
- C30, C20: 50 pF variable
- C40, C10: 470 pF
- C17, C13, C18: 0.01 pF (Hi-k)
- C48, C50: 1000 pF (Hi-k)
- C9: 10 pF
- C13, C18, C25: 0.01 pF
- C14, C19: 47 pF
- C15: 4.7 µF
- C20: electrolytic.

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

**Resistors**
- R1, R2, R3, R4: 4.7 MΩ 1W
- R5, R6, R14: 270 Ω 1W
- R7: 6.8 kΩ 1W
- R8: 22 kΩ 1W
- R9: 100 kΩ 1W
- R10, R11: 10 kΩ 1W
- R12, R13: 470 kΩ 1W

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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 R18 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 R1 and R4 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 C3 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 40mA at 200V.

The main points to watch when constructing apparatus for the higher frequencies have frequently been stressed; summarized they amount to this: Unless 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 40mA at 200V.

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The coils were wound on 1-in diameter formers, provided with 1-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 C1, C4 and C3), 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 d.c. in L1, L3 and L4 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 capacitances could be mounted on each coil; this was done in the case

<table>
<thead>
<tr>
<th>Range</th>
<th>Coverage</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15-22 Mc/s</td>
<td>2</td>
<td>81</td>
<td>2</td>
<td>81</td>
<td>2</td>
<td>74</td>
</tr>
<tr>
<td>B</td>
<td>21-30 Mc/s</td>
<td>1</td>
<td>54</td>
<td>2</td>
<td>54</td>
<td>2</td>
<td>41</td>
</tr>
<tr>
<td>C</td>
<td>30-53 Mc/s</td>
<td>1</td>
<td>24</td>
<td>2</td>
<td>44</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>40-85 Mc/s</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>34</td>
<td>2</td>
<td>31</td>
</tr>
</tbody>
</table>

Notes

- All are wound with 22 s.w.g. tinned copper wire, on 1-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. L1 and L2, L3 and L4, L5 and L6) are wound on the same former, end to end with about 1/16-in spacing between them.

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of $L_n$ (Range C), where an additional 13 pF was needed. The value of the paddler 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

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 $D_3$ 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 $D_3$, 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 $D_3$ 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 by members of the West Bromwich and District Amateur 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 200 Mc/s 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.: G. 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. Caven), 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 mrose classes. Sec.: F. J. Davies (G3KSS), 39, Pullum Avenue, Eccleshill, Bradford, 2.

**Bury.**—The February meeting of the Bury Radio Society will be held at 8.00 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 (G3KZX) in his lecture to the Leicester Radio Society on February 18th at 7.30 at 91, Swannington Street. Sec.: M. H. Kind, 91, Swannington Street.

**Newbury.**—J. H. Etheridge, of Cinema-Television, will speak at 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 5.00. G. Usher (G2CCD) will give a talk entitled "Antennas for the amateur." Sec.: W. G. Wards (G3JHC), 49, Dulverton Road, 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 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 is shared between it and the dynatron we plot it to an inverted voltage scale, beginning at V0, 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 V0 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 any two voltages 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 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

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*F. A. Toute La Radio, November 1955, p. 391.
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 300 μF 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, milliamps through the device illustrated in Fig. 5 necessarily causes the p.d. across it to be Vp volts, applying Vp volts to it doesn't necessarily drive I, milliamps through it. It might be I,. Or I,,. 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
reduce the voltage available for driving current from emitter to base. So \( I_e \) falls. That immediately causes a bigger fall in \( I_b \), which makes the base less negative; that is, the base potential rises to meet the falling emitter potential, further reducing \( I_b \). So the slightest reduction in \( V_e \) causes \( I_b \) 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—it can be now, by raising \( V_e \) 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 \( V_e \), 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 \( I_b \) and \( I_e \), 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)

**Fig. 6. Diagram of transistor circuit used to experiment with current-controlled negative resistance.**
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 over-
ridden 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 in turn raises the voltage until it is a sufficient level to change the state of flux and doesn't really exist as a static curve.

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,

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.

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

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Fig. 7. A series inductance L makes possible a gap V₁₁—V₁₀ 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.
and we haven't found any explanation for the reversal at each bend.

When I put an oscilloscope across R, 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 of 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 result at the frequency of resonance, for the integration 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 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 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. 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.


2. The normal expression for resistance of a conductor is given by:

\[ R = \frac{\rho \times l}{w} \]

where \( R \) = resistance in ohms, \( \rho \) = resistivity in ohm-cm, \( l \) = length, \( w \) = thickness and \( w \) = width in cm. Resistance of films of constant \( R \) 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. O. Cherry at 5.30 at Savoy Place, W.C.2.

8th. Television Society.—“Scatter propagation and its application to television” by 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 structure of the single-trace high-speed oscillograph” and “The design and performance of a single-trace high-speed 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 photog. etry” 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.—“Nucleonics 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 Stereoscopic 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. Davies (Consort) and D. A. Drew at 5.30 at Savoy Place, 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 Dr. R. W. B. Stephens and P. B. Vanderlyn at 5.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.1.

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

BRISTOL

27th. Institution of Production Engineering.—“The use of transistors in radio and television” by Dr. A. J. Biggs at 6.15 at Kings College.

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

CARDIFF

CHESTER
27th. Society of Instrument Technology.—“Computer-controlled machine tools” by G. S. Kerram (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

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. I.E.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.

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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 today. 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. 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 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.
were actually that what now look like gaps will only take account of stations that are under construction. A possible explanation is that the map showing the locations of European transmitters, for the French authorities are determined to make television a success in their country. A vision 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.*

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.
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. 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 A Bucolic Bugbear.

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 “teleodynamics.” 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.

Destaticizing?

I HAVE previously denounced as mere superstition the dainty little trailing chains which many motorists use 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 auto-suggestion 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 destaticized by the wearing 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 an 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 “disdour of impiety.” There is, in fact, a characteristic odour associated with every motion, 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 an odour of fear which is not necessarily akin to the odour of sanctity—which his dog readily picks up.

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.
The "AVO" Valve Characteristic Meter, Mk. III is typical of the ingenuity of design and high standard of workmanship that exemplify all of the multi-range instruments in the wide "AVO" range.

It is a compact and comprehensive meter that will test quickly any standard receiving valve or small transmitting valve on any of its normal characteristics under conditions corresponding to a wide range of D.C. electrode voltages. The method of measuring mutual conductance ensures that the meter can deal adequately with modern T.V. receiver valves. It does many useful jobs too numerous to mention here, but a completely descriptive pamphlet is available on application.

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Output—R.F. Three position attenuator, 0, —20 and —40 db relative to 100 mV.

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Output—Synchronizing. Additional sync. output from 2Kohms through 8µF 10V peak to peak positive going waveform comprising line and frame synchronizing pulses, interlacing signals (and equalizing pulses on 625 and 525 lines).

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(3) F.M. Signal Generator. (4) T.V. Sweep Oscillator.

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(1) 4 to 7 Mc/s. (2) 8 to 14 Mc/s. (3) 15 to 22 Mc/s.

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(7) 150 to 220 Mc/s.

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Abridged Data for the MY3-275
(Services Type Numbers CV1252 and CV1619)

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<tr>
<td>$g_m$</td>
<td>8.5   mA/V</td>
</tr>
<tr>
<td>$u_a$</td>
<td>16</td>
</tr>
<tr>
<td>$r_a$</td>
<td>1900  $\Omega$</td>
</tr>
</tbody>
</table>

*Measured at $V_a=2000$V, $I_a=160$ mA

Typical operation for two valves in class 'AB2' push-pull

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_a$</td>
<td>3000  V</td>
</tr>
<tr>
<td>$I_s$</td>
<td>2x60  mA</td>
</tr>
<tr>
<td>$I_s$ (max signal)</td>
<td>2x280 mA</td>
</tr>
<tr>
<td>$R_{a-a}$</td>
<td>13,800 $\Omega$</td>
</tr>
<tr>
<td>$P_{out}$</td>
<td>1300  W</td>
</tr>
<tr>
<td>$D_{tot}$</td>
<td>3     %</td>
</tr>
</tbody>
</table>

MULLARD LIMITED, COMMUNICATIONS & INDUSTRIAL VALVE DEPARTMENT
for the closest approach to the original sound

The criterion, as always, is that the reproduced sound shall be the closest approach to the original—that the enjoyment and appreciation of music may be unimpeded. This is reflected throughout the design of the QUAD II. It is reflected, too, in the straightforward and logical system of control, achieved without the sacrifice of a single refinement or adjustment capable of contributing to the final objective.

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End background hiss...

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NEW 

WEARITE 

DE-FLUXER

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

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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.

<table>
<thead>
<tr>
<th>Capacitance (µF)</th>
<th>D.C. Wkg. Voltage</th>
<th>Dimensions</th>
<th>Ripple Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100—200</td>
<td>275—275</td>
<td>4&quot; x 1½&quot;</td>
<td>700—300</td>
</tr>
<tr>
<td>50</td>
<td>280</td>
<td>3&quot; x 1½&quot;</td>
<td>500</td>
</tr>
<tr>
<td>100</td>
<td>280</td>
<td>2½&quot; x 1½&quot;</td>
<td>550</td>
</tr>
<tr>
<td>50—100</td>
<td>350—280</td>
<td>3&quot; x 1½&quot;</td>
<td>500—200</td>
</tr>
<tr>
<td>50—100</td>
<td>280—280</td>
<td>3&quot; x 1½&quot;</td>
<td>450—200</td>
</tr>
<tr>
<td>200—500</td>
<td>350—350</td>
<td>4&quot; x 2&quot;</td>
<td>700</td>
</tr>
<tr>
<td>64—120</td>
<td>350—350</td>
<td>4&quot; x 1½&quot;</td>
<td>500</td>
</tr>
<tr>
<td>100—200</td>
<td>350—280</td>
<td>4&quot; x 1½&quot;</td>
<td>900—300</td>
</tr>
<tr>
<td>100—200</td>
<td>350—280</td>
<td>4&quot; x 1½&quot;</td>
<td>700</td>
</tr>
<tr>
<td>60—100</td>
<td>350—350</td>
<td>4&quot; x 1½&quot;</td>
<td>500—200</td>
</tr>
<tr>
<td>60—250</td>
<td>350—350</td>
<td>4&quot; x 1½&quot;</td>
<td>700—400</td>
</tr>
<tr>
<td>100—100</td>
<td>350—350</td>
<td>4&quot; x 1½&quot;</td>
<td>550—200</td>
</tr>
<tr>
<td>100—200</td>
<td>350—350</td>
<td>4&quot; x 1½&quot;</td>
<td>900—300</td>
</tr>
</tbody>
</table>

DUBILIER

DUBILIER CONDENSER CO. (1925) LTD., DUCON WORKS, VICTORIA ROAD, NORTH ACTON, W.3
Telephone: ACOrn 2241
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This range incorporates not only many new items, but also improvements on established designs; and a continuation of research into basic materials and methods of production has resulted in components of high performance at economic cost. Overseas Design Engineers and Equipment Manufacturers are invited to write for full information.

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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.
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Complete Communication Systems

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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.

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Address
Occupation
Your Signature

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Indoor and outdoor models to suit all conditions and to provide the very best results for VHF/FM equipment. Models for fitting to existing TV masts are available.

BAND III
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HILO
17 models to provide perfect Band I/Band III reception with only one aerial. All incorporate the patented Electronic Coupling exclusive to Antiference.

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Our Export Department will, on request, be pleased to give full details of this specially designed Export Range. Fully detailed literature showing current models and prices available on request.
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**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 4 VA.

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.*

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Telegrams: Magnetic Newmarket.
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THEORETICAL PERFECTION

WHAT IT OFTEN IS –
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CHIPPED OR ROUGH SURFACE

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ACOS Styli have to pass a quality inspection at x 500 magnification. Only in this way can some faults, which may have important effects on reproduction or record or stylus wear, be reliably detected. The standards we set ourselves are high but practical. They are reflected not only in ACOS products but also in the record reproducing equipment in which ACOS pick-ups or cartridges are fitted.
**MODEL HF25**

The amplifier has been critically designed to give living expression to recent improvements in recording and broadcasting techniques. Clear life-like reproductions 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.

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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.
MORGANITE Carbon Resistors and Potentiometers fit into Printed Circuitry!

Over the years MORGANITE Resistors and Potentiometers have attained a unique reputation for reliability and service. Now with the introduction of printed circuitry they have swiftly proved their worth in this new field.

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MORGANITE Carbon Resistors. Type R (1 watt) Type T (¼ watt).

MORGANITE Type A Potentiometer, with D.P. Switch, for vertical mounting. Also available without switch, and for horizontal mounting.

MORGANITE Type A Multi-Unit Potentiometer, with D.P. Switch, for horizontal mounting. Also available without switch.

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Wholesale and retail distributors' enquiries to
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Integral terminations at both ends ensure a wide field of application for these cores in the construction of self-resonant chokes for TV interference suppression. Indeed, this is an outstanding design feature for many types of R/F coils and chokes required in small lightweight equipment. High internal resistance means that the shunting effect on the coil is negligible. The range of materials and terminations is such that most frequencies, particularly Band III, are adequately covered.

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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.

* 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 in.; weight, 31 ozs.; can be used on 2.5 to 6.3 volt supply (4 volt transformer normally supplied) or from a car battery.

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* Simple to operate; ideal for precision work.

* Requires minimum maintenance—at negligible cost; shows lowest operating costs over a period.

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Factories also in Surrey and North Wales
ELMAG High Fidelity Units
Designed to give good quality at domestic volumes. For a power output stage providing more than 4 watts, 2 or more speakers are recommended.

- Flux Density 8,000 gauss (27,500 Maxwells).
- Frequency Response 40-12,000 c.p.s.
- 9 x 5in. Model 59T. Price 38/2 inc. P.T.

All prices are for speakers without transformers.

TRADE TERMS: 33 1/3%
Garrard World's Finest
MODEL 301 transcription turntable

As used by the B.B.C. and many other broadcasting stations throughout the world.

Gentlemen:

January 16, 1956

We have tested the three Garrard Model 301 Turntables which the undersigned selected at random from sealed unopened cartons in your warehouse stock. These three bore the following serial numbers: 867, 937, 3019. We used a standard Model WB-301 mounting base without modification, a Leak tone arm fitted with their LP cartridge, and a complete Leak preamplifier and power amplifier, model TL/10.

Pickup and amplifier system conformed in response to the RIAA-new AES-new NARTB curve within ± 1 db.

Standards referred to below are sections of the latest edition, National Association of Radio & Television Broadcasters Recording and Reproducing Standards.

Our conclusions are as follows:

Turntable Speed
Measurements were made in accordance with NARTB specification 1.05.01, using a stroboscope disc. In every case, speed could be adjusted to be in compliance with section 1.05, i.e. within 0.3%. In fact, it could easily be adjusted to be exactly correct.

Wow
Measurements were made at 33-1/3 rpm in accordance with NARTB specification 1.11, which calls for not over 0.20% deviation.

<table>
<thead>
<tr>
<th>Garrard Serial No.</th>
<th>Wow</th>
</tr>
</thead>
<tbody>
<tr>
<td>867</td>
<td>.17</td>
</tr>
<tr>
<td>937</td>
<td>.13</td>
</tr>
<tr>
<td>3019</td>
<td>.15</td>
</tr>
</tbody>
</table>

These values substantially agreed with those given on Garrard's individual test sheets which are included with each motor.

Rumble
Measurements were made in accordance with sections 1.12 and 1.12.01, using a 10 to 250 cps band pass filter, and a VU meter for indication. Attenuation was the specified 12 db per octave above 500 cps and 6 db per octave below 10 cps. Speed was 33-1/3 rpm.

Mr. C. J. LeBel
President of the Audio Instrument Co., Inc.;
Chairman of one of the groups which prepared the NARTB Standards; Founding member of the Audio Engineering Society, past president; Member of the Acoustical Society of America.
Audio Instrument Co., Inc., makers of special high calibre test equipment for use in laboratory measurements.

Garrard 301 has been designed to provide the professional user and quality enthusiast with a unit supreme in its class—truly the world's finest transcription turntable for home use!
to those seeking finest results in a transcription turntable

*TESTED:* for performance by Audio Instrument Company, Inc., an independent laboratory.

**RESULTS:** Garrard Model 301 tested even better than most professional disc recording turntables...sets a new standard for transcription machines!

Read Mr. LeBel's report below

---

**Signal to Rumble Ratio,**

*Using Reference Velocity of 7 cm/sec at 500 cps*

This reference velocity corresponds to the NARTB value of 1.4 cm/sec at 100 cps.

Garrard Serial No. | DB
---|---
867 | 52
937 | 49
3019 | 49

The results shown are all better than the 35 db broadcast reproducing turntable minimum set by NARTB section 1.12. In fact they are better than most professional disc recording turntables.

**Signal to Rumble Ratio,**

*Using Reference Velocity of 20 cm/sec at 500 cps*

Garrard Serial No. | DB
---|---
867 | 61
937 | 58
3019 | 58

We include this second table to facilitate comparison because some turntable manufacturers have used their own non-standard reference velocity of 20 cm/sec, at an unstated frequency. If this 20 cm/sec were taken at 100 cps instead, we would add an additional 23.1 db to the figures just above. This would then show serial number 867 to be 84.1 db.

It will be seen from the above that no rumble figures are meaningful unless related to the reference velocity and the reference frequency. Furthermore, as stated in NARTB specification 1.12.01, results depend on the equalizer and pickup characteristics, as well as on the turntable itself. Thus, it is further necessary to indicate, as we have done, the components used in making the test. For example, a preamplifier with extremely poor low frequency response would appear to wipe out all rumble and lead to the erroneous conclusion that the turntable is better than it actually is. One other factor to consider is the method by which the turntable is mounted when the test is made. That is why our tests were made on an ordinary mounting base available to the consumer.

Very truly yours,

AUDIO INSTRUMENT COMPANY, INC.

C. J. LeBel

---

Now there's a Garrard for every high fidelity system

MODEL 301  RC 98/4  RC 88/4  RC 121/4  TPA 10

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Miniature Crystal Oven

This miniature oven has been designed specifically for accurate temperature control of Ministry Style "D" (Cathodeon Type 2M) Crystal Units. It is particularly recommended where the requirement is for a frequency stability better than .0002% over a wide range of ambient temperatures.

Centre tapped heater for 6.3 or 12.6 volt supplies.
Current consumption 0.73 amp. at 6.3 volt.
Temperature differential ±2°C within a temperature range 75°C to 85°C.
Temperature control within the ambient range—20°C to +70°C.
Heating time less than 5 minutes from ambient temperature to 85°C.
Precision bi-metallic contacts with provision for On/Off indicating lamp.
Low loss Mycalon base.
Weight 1½ oz. (43 grammes).
Overall Dimensions 1½” x ½” x 2½” long (3.2 x 2.0 x 6.6 cm.).

CATHODEON CRYSTALS LIMITED
LINTON CAMBRIDGESHIRE
TELEPHONE LINTON 223
**G.E.C. Valves for Voltage Stabilisation**

The A2293 is a new low impedance triode particularly suitable as the series valve in stabilised power packs. List price 27/-.

**RATINGS**

- $V_h = 6.3$ V
- $I_h = 0.95$ A
- $V_a = 300$ max. V
- $I_a = 120$ max. mA
- Base = B9A

$g_m^* = 12$ mA/V

$r_a^* = 375$ Ω

$p_a = 0.15$ max. W

*Measured at $V_a = 150$V, $I_a = 100$mA

For further details write to the G.E.C. Valve & Electronics Dept.

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 microwatts 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).
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MAKE UP YOUR ORDER TODAY — DELIVERY EX-STOCK

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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.

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They say we make a perfect pair...

To be exact, this is the 12 pin version of the Multi-Way Plug and Socket range, which covers 4, 8, 12, 20 and 28 ways. The range features unusually low insertion pressures, and embodies considerable experience in meeting humid conditions. Designed to overcome as far as possible the difficulties encountered when using this type of connector in rack mounting applications, they have greater latitude in matching up than any comparable product, and are in use throughout the world in Radio, Television and Telecommunications equipment by such renowned firms as:-


A.I.D. & A.R.B. - APPROVED

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LIMITED

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PHONE: NEW 3181/2/3
LOW-INERTIA MOTORS
- Linear voltage/speed characteristic
- Starting power: 6 microwatts
- Permanent magnet
- Nom voltages: 1.5, 6, 12 and 24 v, d.c.

D.C. TACHO GENERATOR
- Linear voltage/speed characteristic
- Compact design for standard fixing
  - Synchros size 11, grade 2
  - Output voltage: 5.75 per 1000 rpm.
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.

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%

Nett price in U.K. £60.0.0

Full technical details in Folder W38
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"Why don't dealers stock and recommend our Amplifiers and Tuners, etc?"

ANSWER

 "Because they cannot afford to do so as they give us a 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 Dealers 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 will 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.

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32 WIRELESS WORLD

FEBRUARY, 1957

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

<table>
<thead>
<tr>
<th>E.E.V. Type</th>
<th>Function</th>
<th>Centre Frequency (Mc/s)</th>
<th>Maximum Output</th>
<th>Noise Factor (dB)</th>
<th>Gain (dB)</th>
<th>Plate Volts</th>
<th>Collector Current</th>
<th>Focusing Field (Gauss)</th>
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<tr>
<td>N.1001</td>
<td>Power</td>
<td>2000</td>
<td>16W</td>
<td>-</td>
<td>26</td>
<td>2600</td>
<td>40mA</td>
<td>600</td>
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<tr>
<td>N.1002</td>
<td>Low Noise</td>
<td>2000</td>
<td>1mW</td>
<td>10</td>
<td>24</td>
<td>550</td>
<td>200µA</td>
<td>200</td>
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<tr>
<td>N.1004</td>
<td>Power</td>
<td>4000</td>
<td>4W</td>
<td>-</td>
<td>21</td>
<td>2600</td>
<td>20mA</td>
<td>450</td>
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<td>N.1005M</td>
<td>Low Noise</td>
<td>4000</td>
<td>1mW</td>
<td>11</td>
<td>22</td>
<td>360</td>
<td>200µA</td>
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<tr>
<td>N.1013</td>
<td>Amplifier</td>
<td>2000</td>
<td>200mW</td>
<td>20</td>
<td>32</td>
<td>650</td>
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<td>1mW</td>
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<td>700</td>
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<td>N.1018M</td>
<td>Amplifier</td>
<td>4000</td>
<td>100mW</td>
<td>20</td>
<td>30</td>
<td>630</td>
<td>2mA</td>
<td>350</td>
</tr>
</tbody>
</table>
A remarkable new instrument for Physicists

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

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UNIVERSAL BRIDGE
B.221

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K.75: Small Pointer Knob for $\frac{1}{8}$in. spindles.

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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.

The present range of bridge lighting units is as follows:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Description</th>
<th>Lamps</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Mk. G4B Gyro Compass</td>
<td>4</td>
</tr>
<tr>
<td>B</td>
<td>Artificial Horizon</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>Large S.A.E. Case (4BA screws)</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>Small S.A.E. Case (4BA screws)</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>Horizontally mounted Double Desynn</td>
<td>2</td>
</tr>
<tr>
<td>F</td>
<td>Large S.A.E. Case (2BA screws)</td>
<td>2</td>
</tr>
<tr>
<td>G</td>
<td>Small S.A.E. Case (2 BA screws)</td>
<td>2</td>
</tr>
<tr>
<td>H</td>
<td>Large Air Ministry Case</td>
<td>2</td>
</tr>
<tr>
<td>J</td>
<td>Instruments with 3&quot; P.C.D. fixing</td>
<td>2</td>
</tr>
<tr>
<td>K</td>
<td>Double Desynn mounted vertically</td>
<td>2</td>
</tr>
</tbody>
</table>

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.
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<table>
<thead>
<tr>
<th>Way</th>
<th>Connectors</th>
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<tbody>
<tr>
<td>8</td>
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<td>16</td>
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<tr>
<td>24</td>
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<tr>
<td>32</td>
<td></td>
</tr>
<tr>
<td>24 way connector</td>
<td></td>
</tr>
</tbody>
</table>

* Gold plated Contacts
* Nylon loaded P.F. mouldings
* Easy insertion and withdrawal

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Send S.A.E. for details of requirements not listed here.

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<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
<th>Cash</th>
<th>Credit</th>
<th>Hire Purchase</th>
<th>Export Price</th>
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<td>12/3/4</td>
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<td>Editor Super Hi-Fi</td>
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</tbody>
</table>

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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.

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**Features**

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Master VoltOhmyst WV-87B</th>
<th>Senior VoltOhmyst WV-98A</th>
<th>Junior VoltOhmyst WV-77C</th>
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<tbody>
<tr>
<td>DC Voltage</td>
<td>0.02-1500v</td>
<td>0.02-1500v</td>
<td>0.05-1200v</td>
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<tr>
<td>AC (rms) Voltage</td>
<td>0.1-1500v</td>
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<td>0.1-1200v</td>
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<tr>
<td>AC (peak-to-peak) Voltage</td>
<td>0.2-4200v</td>
<td>0.2-4200v</td>
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<td>Resistance Current</td>
<td>0.2-10000meg.</td>
<td>0.2-1000meg.</td>
<td>0.2-10000meg.</td>
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<tr>
<td>Accuracy.§</td>
<td>±3%</td>
<td>±3%</td>
<td>±3%</td>
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<td>—</td>
</tr>
<tr>
<td>AC current</td>
<td>—</td>
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</tr>
<tr>
<td>DC Voltage</td>
<td>±3%</td>
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<tr>
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<td>±3%</td>
<td>±5%</td>
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<tr>
<td><strong>All full scale points</strong></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

SEND THIS COUPON FOR COMPLETE INFORMATION

RCA INTERNATIONAL DIVISION—DEPT. TE-49-A
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**OUTPUT VOLTAGE REGULATION:** 33%.
**NOISE:** 70 dB below 10 kW.
**MAINS SUPPLY:** 350-450 volts 50 c/s 3 phase.

---

<table>
<thead>
<tr>
<th>Power</th>
<th>Type</th>
<th>Frq. Range</th>
</tr>
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<tbody>
<tr>
<td>100 Watts</td>
<td>&quot;VLF&quot;</td>
<td>3 c/s to 6 c/s</td>
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<tr>
<td>1 kW</td>
<td>&quot;VLF&quot;</td>
<td>6 c/s to 2,000 c/s</td>
</tr>
<tr>
<td>1 kW</td>
<td>Mark II Star</td>
<td>50 c/s to 10 kc/s</td>
</tr>
<tr>
<td>1 kW</td>
<td>&quot;LRF&quot;</td>
<td>5 kc/s to 100 kc/s</td>
</tr>
<tr>
<td>10 kW</td>
<td>Type 10</td>
<td>40 c/s to 10 kc/s</td>
</tr>
</tbody>
</table>

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**Y PLATE CONNECTION:** Direct or series capacitor connection. Input resistance—2.5 megohms. Input capacitance—50 pf. approx.

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**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

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TRAFFORD PARK 2141
30 c/s — 20 Mc/s

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Type 830

Y PLATE AMPLIFIER:
Frequency Response:
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Sensitivity:
75 millivolts per cm.
Rise-time:
30 Millimicroseconds.

TIME-BASE:
Ranges:
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Operation:
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Expansion:
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Traverse:
A traverse control enables any portion of the expanded time-base to be viewed.

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NAME ____________________________
ADDRESS ____________________________

It is understood that this places me under no obligation to buy.
a transmitting all communications

<table>
<thead>
<tr>
<th>Valve Output Power in Watts</th>
<th>Type Number</th>
<th>Frequency in Megacycles</th>
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<tbody>
<tr>
<td>10,000</td>
<td>TY7-6000A</td>
<td>20 30 40 50 60 80 100 200 300 400 600 800 1000 2000 3000 4000</td>
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<tr>
<td>10,000</td>
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<td>9,900</td>
<td>TY6-5000A</td>
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<tr>
<td>4,100</td>
<td>QY5-3000A</td>
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<td>4,100</td>
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<td>1,600</td>
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<tr>
<td>0.02</td>
<td>TD05-12</td>
<td></td>
</tr>
</tbody>
</table>
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.

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<tr>
<td>1/4&quot;</td>
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<td>£3 10 0</td>
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<td>W.B. Crossover Unit</td>
<td>£1 10 0</td>
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<td>W.B. Tweeter Unit</td>
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<td>Kelly Ribbon Tweeter</td>
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TEST EQUIPMENT

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<tr>
<td>AVO</td>
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<td>AV 13</td>
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ADVANCE

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<td>H.I. (Sig./Gen.)</td>
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<td>E2 (Sig./Gen.)</td>
<td>£32 10 0</td>
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<td>P.I.</td>
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<td>J.I.</td>
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COSSOR

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<tr>
<td>Oscilloscope</td>
<td>£104 0 0</td>
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MICROPHONES

ACOS

<table>
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LUSTRAFPHEN

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FILM INDUSTRIES

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MICROPHONE STANDS

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LEAK AMPLIFIERS

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<td>Point 1, TL12</td>
<td>£34 7 0</td>
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<td>Point 2, TL25</td>
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QUAD, Mk II | £42 0 0 |

MULLARD

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<tr>
<td>E.A.R. + 4 wst</td>
<td>£10 8 0</td>
</tr>
<tr>
<td>TRX 4 wst</td>
<td>£16 10 0</td>
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Dimensions (inches)

Centre Conductor: 1/0.022 7/0.0076 1/0.029 7/0.010 1/0.044

Over Cellular Telcothene: 0.003 0.003 0.128 0.128 0.200

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Time Base Frequency. 6 to 250,000 c.p.s.
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300. 1.3 mV RMS/mm, 10 to 100,000 c.p.s.
300. 1.3 mV RMS/mm. 10 to 200,000 c.p.s.
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300. 1.3 mV RMS/mm, 10 to 200,000 c.p.s.

Deflector Coils. 2 mm/mA RMS.
Power Supply. 110-250V A.C. 120 watts.

Sensitivity. Y1, Y2. 1 JV D.C. 1.41 RMS
Voltage divider. X and S-bands.

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Spectrum Analyser

Type TSX-4SE

(1 centimetre)

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Aircraft version of BC221.

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Grey Lizard Resin covered

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Overall dimensions 16 x 14 x 9in. Clearance under lid when closed 5in.

Dimensions as above.

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THE ABOVE CABINETS ARE COMPLETE WITH CARRYING HANDLE, PADDERS AND PANEL.

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SP434, 420-0-420, 200 m.A. 6 v. @ 2 a., 6 v. @ 3 a., 6 v. @ 4 a.

£3 30 0

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PREMIER RADIO COMPANY

February, 1957

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CASH PRICE

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<td>Garrard Changeover Type ROSE/IE/ACEC</td>
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<td>Lenco-Transcription Unit Model 910-90 complete with P.F.</td>
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S.R.R. THE Speeded Record Player £4/12/- plus 7/- post and packing.

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PLUS PACKING AND POST 1/-.

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PLESSEY-17” TONED TUBES 1/-2/-

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PLUS 5/- packing and carriage.

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Plus postage and postage 2/-

A LARGE RANGE OF TEST METERS IN STOCK

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CREDIT TERMS

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PREMIER BUREAU DE LUXE

A superb cabinet in finely figured walnut veneer. Interior light sycamore, with res. inine matching lining. Overall dimensions: 33 in. high, 34 in. long, 17 in. deep. Uncut control panel on right hand side approximately 16 in. x 10 in. Uncut baseboard on left hand side 16 in. long, 13 in. deep. Two full size felt-lined storage cupboards in the lower part of the cabinet.

Cash price £16 19s. HP. Terms, deposit £8 19s. 6d. and 9 monthly payments of £2 2s. 6d.

Credit Terms, deposit £1 15s. 6d. and 9 monthly payments of £2 15s. 6d. Packing and Carriage 20/- extra.

THE WOLSEY BAND III CONVERTER

This converter has been designed to receive alternative programmes on Band 3. Channels 6 to 13, selection of Channel being made by rotation of Switch Knob. Mains supply 200/250 v. A.C. only. The high gain of this Converter (minimum 20dB) together with low noise factor ensures good picture quality. A variable gain control makes it possible to balance a Band 1 and Band 3 signal inputs to the receiver. Any single channel Receiver of either T.R.F. or Superhet design may be fed from the Converter. Separate input sockets are provided for Band 1 and Band 3 inputs. Cash price £19 19s. 6d. Credit Terms deposit £8 19s. 9d. and 9 monthly payments of £2 19s.

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The famous Premier Baby Alarm which is a device to enable Baby’s cries, or even breathing, to be heard in any selected room in the house. May be left permanently connected. Extra Microphones In different rooms may be used. The microphone may be positioned up to 100 ft. from the main unit. Suitable flexible lead can be supplied at 5d. per yard extra. Completely wired and tested at £3 9s. and post at 216 post and pkg.

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Announcing the Avantic DL7-35

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 21" 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 20 watts (h.f.).

Please send me illustrated leaflets on the DL7-35 and 'Glyndebourne'; also the name of my nearest Avantic dealer.

NAME
ADDRESS

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.


Hum & noise: — 69 db relative to 20 watts output.

Output impedances: 40, 80 & 1652 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.

S-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.

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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: Parion, Witham
FEBRUARY 1957

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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 300kΩ. 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 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.
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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.
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 planning 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 18/6, 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.


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.

Advertisement of BELLING & LEE LTD. Great Cambridge Rd., Enfield, Middx. Written 20th December, 1956
NEW! THE PRACTICAL WAY
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E.M.I. INSTITUTES
-Part of "His Master's Voice," Marconiphone, etc. etc.

FEBRUARY, 1957

WIRELESS WORLD
A CONFIDENTIAL STAFF LOCATION SYSTEM!

Verbal Orders Quickly and Quietly

It's new and it's unique—the Multitone Staff Location System. There've been loudspeakers, bells, lights and even buzzers, but not a system in which confidential messages can be delivered to individual members of a staff—whether numbered in tens or hundreds. However compact or scattered an organisation may be, this is going to be the biggest business time-saver yet. Originally developed in conjunction with St. Thomas' Hospital, this system is now far in advance of anything yet made and is sold at a highly competitive price!

HOW IT WORKS. A magnetic induction loop is laid round the building from the Coder/Oscillator unit. Anyone needed to be on call carries a receiver (only 5" long, 1" diameter and it only weighs 5 oz. with battery!). On being alerted by his call signal, which is received by him alone, he can hear a direct speech message without anyone else being disturbed.

WHAT IT COSTS. The average cost of an installation with 50 receivers would be under £1,500 including the cost of the loop. The receiver incorporates four transistors and is powered by a single cell. Since the quiescent current is less than 0.5 m.a. it will only cost a few shillings a year to run each receiver—considerably less than any other electronic system.

The London Ambulance Service uses V.H.F. radio-telephones to provide the immediate response essential in emergencies.

For this vital life and death service the London County Council selected equipment manufactured by British Communications Corporation—a wise choice where fine performance and utmost reliability are vital factors.

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- 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 μs to 100 ms (2½ %) direct from meter.

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Instrument Division
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Each Kit, in addition to Printed Circuits and all parts, includes an illustrated comprehensive instruction book describing the step-by-step assembly.

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Telegrams: Cossor, Norphone London  
Cables: Cossor, London
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.

**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

*data sheet available from: Standard Telephones and Cables Limited*
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(We shall not worry you with personal visits)
The amplifier, speaker and case, with detachable lid, measures 8.0in. x 22.2in. x 15.2in. and weighs 30Ib.

**PRICE, complete with WEARITE TAPE DECK** £84 0 0

- 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.

**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**

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Something to be proud of...

There is much more in a tape recorder than just circuitry. Try a TK8 out, and you'll agree that anybody could be proud of it!

Just take a look at the specification...

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption:</td>
<td>Approximately 60 watts (rising to 118 watts when Fast Winding).</td>
</tr>
<tr>
<td>Fuses:</td>
<td>2 amps. (for 105-115 V)</td>
</tr>
<tr>
<td>Valves:</td>
<td>EF86, ECC81, EL-42, EL84, EM8I, 2 metal rectifiers.</td>
</tr>
<tr>
<td>Recording Level Indicator:</td>
<td>Magic Eye.</td>
</tr>
<tr>
<td>Loudspeakers:</td>
<td>Elliptical 6 ins. High Flux permanent ceramic magnet type plus two 2½ in. treble units.</td>
</tr>
<tr>
<td>Amplifier Output:</td>
<td>4 watts approximately.</td>
</tr>
<tr>
<td>Tape Speed:</td>
<td>3½ ins. per second, and 7½ ins. per second.</td>
</tr>
<tr>
<td>Frequency Response:</td>
<td>50-9,000 c.p.s., ±3 db at 3½ ins/sec.</td>
</tr>
<tr>
<td>Recording Sense:</td>
<td>Twin Track, recording on the top track (British and International standard).</td>
</tr>
<tr>
<td>Maximum Tape Length:</td>
<td>1,200 feet.</td>
</tr>
<tr>
<td>Running Time per Tape:</td>
<td>30 minutes each track at 7½ ins/sec. (1 hr. total),</td>
</tr>
<tr>
<td>Fast Forward/Fast Rewind</td>
<td>60 minutes each track at 3½ ins/sec. (2 hrs. total).</td>
</tr>
<tr>
<td>Times:</td>
<td>Approximately 1½ minutes.</td>
</tr>
<tr>
<td>Automatic Stop Switch:</td>
<td>Electro-magnetic.</td>
</tr>
</tbody>
</table>

GRUNDIG TK8-3D — for Price & Performance

GRUNDIG (GREAT BRITAIN) LIMITED

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We shall be pleased to send you full details of

LEAK TL/10 10-watt Amplifier, 17gns.
and "Point One" Pre-amplifier, 10gns.

Harmonic Distortion 0.1%, 0.2%, 2 watts output.

The B.B.C. MONITOR LOUDSPEAKER UNIT uses a LEAK TL/12 AMPLIFIER

Price £28.7.0

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All the parts up to the cigarette box receiver, 2/9/6. Includes Ferrite aerial but not the earpiece, battery or case.

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This overhead heater warms only the area within its radiant rays, and so effects a considerable saving of fuel. Its benefits are felt locally only, there is no warming up period. It is essentially a personal type of heater, having controls within easy reach of the operator. The controls give four variations of heat and "Off." At maximum heat the unit consumes 1.6 kw. The Infra Red Major is of particular use—

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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 2/- each. Post and insurance 2/-.

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**OCCASIONAL SNIP—**we have evolved a new T.R.F. circuit and have bad really good results, equal if not better, than many superhets. You really should try this circuit. All parts (including valves 6K7, 6.17, 6F6 and 6T5) and full circuit, with 100,000 free with parts or available separately £1/6/- post free and insurance.

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FEBRUARY, 1957

WIRELESS WORLD

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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 sus- pended 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.

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 10 x 2 x 3in. Frequency 9.7t Mco/s. 2 EF.92s and 1 EF.91 F.P. amps. EB.91. DET/AGC. EF.91 AGC. Amp. and EF.91 Limiter. Circuit supplied.

PRICE £7/6 p.p.

TRANSMITTER Type T1131-L

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, 4,500-9,000. Selectivity: 2 kc/s at 2.5 db down; 5 kc/s at 35 db down; 150 c/s at 50 db down. Supply required: 6 v. 1.4a; 175/200 v. 65 ma. CIRCUIT: variable mu pentode I.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. £10.0.0 With power supply, plus £1 packing and carriage.

POWER UNIT Type 173

BENDIX TRANSMITTERS

TYPE T.A. 12B Master oscillator type transmitter. 4 channel 40 W. operation provide telephone, CW or M/CW 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 12SK.7. The IPA stage consists of an 807, while the PA is two 607s in parallel. Size 10in. x 6in. x 15in. 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 2in. x 1in. x 4in. Price, with circuit, 10/- each, plus 1/- p.p.

POST OFFICE COUNTERS
500 ohm, 4 figure no reset; size 5 x 11 x 1in. 5/- each, p.p.

BUZZERS
6 volt A.C., with tone adjuster, size 2 x 1 x 2in., 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

All these fine offers are on display at
PROOPS BROS. LTD.

VALVE TESTERS
MODEL 314

This model is of American manufacture and versatile, free-point return valve tester. Its design is such that it enables the user to test any type valves, regardless of its filament voltage or base wiring. Flexibility is attained by using individual lever switches for each valve element. Complete coverage of American Series including Acorns. Instruction manual supplied.

Complete in Carrying case £10 Plus 10/- carriage.

RII15 RECEIVERS

Air Tested, in good secondhand condition. Price £6/5/-, plus 10/- packing and carriage.

A room-to-room telephone . . .

Ideal for two-way conversation, house-to-garage or internal communication.

- No batteries required
- No soldering required
- Just connect it up and it works

The sets consist of 2 high-quality microphone/receivers (new and boxed) and 15 yards of twin wire.

COMPLETE FOR 8/6
plus 1/6 postage

MAINS POWER UNIT Type 234
(For use with Receiver T1392)

Double Smoothed 200-250 v. 50c. input. 240 V. 100 mA. 6.3 at 6 amps. with Volt-Meter reading input and output voltages. Size: 19in. x 10in. x 6in. Standard Rack Mounting. Price £4/10/- each, plus 7/6 carriage.

RECTIFIERS


BATTERY CHARGING LEADS

2 yds. of cab tyre twin cable, and 2 large crocodile clips; new and boxed. 3/4- p.p.

HEATER TRANSFORMERS

6.3 volt, 1 Amp. Brand new, 6/6 each plus 1/- p.p.

NOTE: Carriage prices quoted apply only to England and Wales.

NOTE: Orders and Enquiries to Dept. "W". Shop hours 9 a.m. to 6 p.m.—Thurs.: 9 a.m. to 1 p.m.

OPEN ALL DAY SATURDAY.

Telephone: LANgham 0141

52 TOTTENHAM COURT ROAD, LONDON, W.I
FERN'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 . . .

* A "COMBINED" 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.

PRICE OF COMPLETE RECORDER

INCLUDED MOVING COIL MIKE and 1,200ft.

REEL OF TAPE.

Plus £1 carriage and insurance of which £1 refunded on return of packing case.

CREDIT SALE TERMS.

Deposit £9 and 9 monthly payments of £3/13/5.

HIRE PURCHASE TERMS.

Deposit £21/5/- and 12 monthly payments of £1/13/5.

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.

CREDIT SALE TERMS.

Deposit £9 and 9 monthly payments of £3/13/5.

HIRE PURCHASE TERMS.

Deposit £25 and 12 monthly payments of £1/11/5.

Following is a list of Home Constructors.

If you cannot call and hear this Recorder send a stamped addressed envelope for fully descriptive leaflet.

* High Quality Output Transformer by Gilson

* 3 Speeds, 33 1/2, 78 and 15ips, TWIN TRACK

* Position provided for use as straight amplifier

* Efficient Tone Control arrangement

* High-grade Components throughout

* Two position equaliser for 33 1/2 and 78ips.

* Monitor and Extension Speaker Sockets are provided

* Beautiful styling and cabinet

STERN'S "COMPACT 5" AMPLIFIERS

EXPRESSLY DEVELOPED FOR VERY HIGH QUALITY REPRODUCTION OF GEAR RECORDS AND PARTICULARLY SUITABLE FOR HIGH QUALITY REPRODUCTION OF THE F.M. TRANSMISSIONS:

PRICE £28/7/0.

The "Compact 5-3" - A 2-stage version of the "9-9" model but in this case having an additional stage and incorporating negative feedback. PRICE £25/10/-.

The Amplifiers are compact and very attractively designed having a "Hammond/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) £10/10/-.
FEBRUARY,

**AMPLIFIERS**

**PRE-AMPLIFIERS**

**FOR THE HOME CONSTRUCTOR**

**COMPLETE KITS OF PARTS FOR THE “Hi-Fi” ENTHUSIAST**

**QUALITY OF THIS NATURE HAS NEVER BEFORE BEEN OFFERED AT SUCH LOW COST.**

WE WILL SUPPLY (a) COMPLETE KIT OF PARTS to build THE MULLARD "5-10" MAIN AMPLIFIER and the STERN'S "Fidelity" PRE-AMPLIFIER - TONE.CAMER (Plus 5/- care, and in). TO UNITS at this exceptional price.

We also sell the two separately:

- **10in. and 12in. records of same speed.**
- **10in. and 12in. speeds,** on all three will autochange.
- **£7 19s. 6d. (Plus 5/- care, and in).**

STERN'S NEW "MODERNISE YOUR OLD RADIOGRAM" SPECIAL PRICE REDUCTIONS.

BRIEFLY IT HAS: - An 8 valve line up incorporating the latest MULLARD type valves. Provides complete coverage of the VHF/FM waveband plus the SHORT, MEDIUM and LONG waves.

**STERN'S "Fidelity" PRE-AMPLIFIER TONE CONTROL UNIT**

"A design for the music lover".

Briefly, it has inputs for all types of MICROPHONE, HIGH and LOW GAIN PICK UPS and a RADIO TUNING UNIT. Includes (a) GRAM, EQUALISING CONTROL TROL, (b) STEREOPHIL FILTER, (c) Continuously variable BASS and TREBLE CONTROLS and a variable OUTPUT CONTROL which enables it use with any type of Amplifier.

**PRICE OF COMPLETE KIT OF PARTS**

WE ALSO OFFER IT ASSEMBLED READY FOR USE, ESN- (Plus 5/- care, and in). TO UNITS at this exceptional price.

**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 £19 12s. 6d. and READY FOR USE for £2 12s. 6d. TO UNITS at this exceptional price.

**“MODERNISE YOUR OLD RADIOGRAM”**

THE LATEST DESIGN OF COMBINED AM/FM REPLACEMENT RADIOGRAM CHASSIS STERN'S NEW "Fidelity" COMBINED AM/FM RADIOGRAM CHASSIS

A completely hand-made chassis providing really high quality on both Radio and Gram.

**PRICE**

£26 15s. 0d. (Plus 7½ care, and in). TO TERMS: Credit Deposit £17 15s. and 9 monthly payments of £2 6s. 3d. TO Deposit £21 17s. 6d. and 12 monthly payments of £1 5s. 6d.

**PRICE OF COMPLETE KIT OF PARTS**

WE ALSO OFFER IT ASSEMBLED READY FOR USE, ESN- (Plus 5/- care, and in). TO UNITS at this exceptional price.

**RECORD PLAYERS**

**THE VERY LATEST MODELS ARE OFFERED AT GREATLY REDUCED PRICES**

- **TRANSCRIPTION UNIT.**
- **5- and 6-SPEED AUTOCHANGER.**
- **AUTOCHANGER with MANUAL CONTROL POSITION.**

Send B.A.R. FOR ILLUSTRATED DESCRIPTIVE LEAFLET.

**SPECIAL CASH OFFER !!**

**109-115 FLEET ST., LONDON, E.C.4.**

Phone: FLEET Street 5012-3-4
THE JASON FM TUNER

Based on the booklet by Data Publications Ltd., 92/- post paid. A complete kit, including individually priced Parts List. Highly sensitive free from drift. Incorporates 4 valves 6MM and 2 specially graded D.C. Cystals. The kit supplied includes drilled chassis with tuning condenser, scale calibrated in metres, and attractive bronzed silver enamelled front plate already mounted. Illustration: P: 32 x 61 x 111 cm. Complete with all necessary parts fully assembled, ready for fitting, 22/10/-, plus 6/- P & P. Fringes area kit 27/15/-, plus 2/- P & P.

THE T.S.L. FM TUNER

We can now supply this FM/VPB adapter either in kit form, fully assembled and wired and tested. Our price for the rebuild only, is £15/- 10/-, paid. plus 5/- P. & P. It will take approximately 5 hrs. to build. Additionally priced parts List available at 22/6 post free.

THE T.S.L. AM/FM CHASSIS

Handsome walnut cabinet. Complete with all instructions, diagrams technical data and point-to-point wiring diagrams. £44/- plus 8/- P. & P. Illustrated leaflet at 2/- 6d. post free. Our advantageous H.P. terms are available at 2/- 6d. plus P. & P. or H.P. Lerma. Magic eye tuning indicator, just plug in, 5/- P. & P. or H.P. around.

DULCI F3 RADIOGRAM CHASSIS

We have been very fortunate in being able to obtain a limited quantity of these handsome chassis. AC/DC 200/250 v. for building and Long Line-up. Complete with all necessary parts fully assembled, ready for fitting, 22/14/-, plus 2/- P. & P. Fringes area kit 27/15/-, plus 2/- P & P. E.

DIAMOND FM TRANSISTOR/CRYSTAL RECEIVER KIT

This receiver, completely described in the booklet by Data Publications Ltd., can be obtained at 22/- 6d. post free. The kit contains all necessary parts fully assembled, ready for fitting, 22/- 10/-, plus 6/- P. & P. This pack is extremely small, incorporating valve EF89, EABC80, 6X4 and EM80. Overall size: 10 1/8 in. W. x 5 1/16 in. D. Dial else 11 3/8 x 11 1/16 x 1 3/16 in. Complete with all necessary parts fully assembled, ready for fitting, 22/- 10/-, plus 6/- P. & P. E.

THE JASON FM TUNER

Owing to favourable purchase we can offer strictly limited quantity of these handsome chassis. AC/DC 200/250 v. for building and Long Line-up. Complete with all necessary parts fully assembled, ready for fitting, 22/- 10/-, plus 6/- P. & P. E.

DULCI H4T AM/FM TUNER

This unit has been designed for Quality reproduction and built to the highest technical standards. Contains own power supply. £24/- 6/- cash or M.P. terms. Based on the booklet by Data Publications Ltd., this kit contains all necessary parts fully assembled, ready for fitting, 22/- 10/-, plus 6/- P. & P. E.

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THE "ECONOMY FOUR" T.R.F. SET. Requires only plus metal rectifier receiver, A.M. 200/250 volts. Medium and long waves. Can be supplied all wave signal transformers ready for the last in. and bolt. Valve line-up 6X6, 6X7 and 614. Chassis ready for 12 in. x 8 in. x 5 in. rugged, stylish cabinet. Complete Instruction booklets with practical and theoretical diagrams, explaining component read and new tested to packading. Our price £4.3.0 complete. This set is being demonstrated at our shop presently. We proudly claim that for this type of set complete kits are available at 1½ post free. This is allowed if kit is purchased later. Plus 1/6 packing and carriage for complete kit.

THE "SUPERIOR" FOUR KIT. Our new four-valve receiver. A.M. 200/250 volts. Medium and long waves. Can be supplied all wave signal transformers ready for the last in. and bolt. Valve line-up 2 x 6X8, 6X7 and 614. Chassis ready for 12 in. x 8 in. x 5 in. rugged, stylish cabinet. Complete Instruction booklets with practical and theoretical diagrams are provided. Booklets available at 1½ post free. Our price for complete kit, £21.6.0. Please add 2/6 packing and carriage for complete kit. Instruction booklets with practical and theoretical diagrams are provided. Booklets available at 1½ post free. Our price for complete kit, £21.6.0. Please add 2/6 packing and carriage for complete kit.

HEADPHONES. Low resistance.

30 Ib. Completely smoothed, incorporates 24 VOLT ROTARY CONVERTOR. Input 1.5 a., Output 200 volt at 80 mA. D.C. 200 volt at 80 mA. Incorporates 8 pin Vibrator, heavy-duty transformer, etc. Variable. Output dimensions 10 to 100 volts. Brand new, typical components, exactly as specified, including transformer, 8 pin Vibrator, heavy-duty transformer, etc. Price 4½ post free. A.M. 240 volt at 25 mA. D.C. 200 volt at 100 mA. Incorporates 8 pin Vibrator, heavy-duty transformer, etc. Price 4½ post free. A.M. 240 volt at 25 mA. D.C. 200 volt at 100 mA. Incorporates 8 pin Vibrator, heavy-duty transformer, etc. Price 4½ post free.

FOUR SPEED CHARGERS! The new H.R. Taped-speed changer in attractive case and gold finish new and improved, made from steel at 22/- only, plus 3/6 P. & P. and 10/- P. & P. for complete kit, 30/- only, plus 1½ F. & P. and 15/- F. & P. for complete kit.

TRIMMERS: MOLLARD TYPE O.C.T. Available ex stock at new list price of 1½ post free and each at 2/- only, plus 1/6 C. & P. and 3/6 C. & P. at 30/- post free.


R.S.C. BATTERY CHARGING

ASSEMBLED CHARGERS
6 v., or 12 v. 2 amps.
Fitted Ammeter and selector plug for 6 v. or 12 v. Louved metal case, finished attractive hammer blue. R. & D. Type, with mains output leads. Double fused.

Only 47/9 carr. 3/6.

SELENIUM RECTIFIERS

L.T. Types to 6/12 v. 6 a. 19/9
2/6 v. and 1/9 1/25/9
6/12 v. and 1/9 25/9
6 mfd. 1,500 v.
4 mfd. 1,000 v.
16µF 450 v.
8-8 mfd. 500 v.
8-16 mfd. 500 v.
25µF 630 v.
16µF 450 v.
32µF 350 v.
6/12 v. 90 mfd. 250 v.
6/12 v. 250 mfd. 100 v.
Co-AXIAL CABLE. 75 ohms, jined, 8d. yard.
Two screened feeder, 11d. yard.

5 CORE FLEX. Hensley circular rubber 14, 18, 24, and colour coded. 1/6.

DIAL BULBS. M.E.S., 8 v. 0.6 a., regular, 69/12.
5 v. 0.3 a., 69/12.

VOLTAGE REGULATORS (current production).

NOT Ex Govt.

Tubular Types
Can Types
8 mfd. 350 v.
16 mfd. 350 v.
6 mfd. 350 v.
16 mfd. 350 v.
6 mfd. 350 v.
16 mfd. 350 v.
8-16 mfd. 350 v.
25µF 630 v.
16µF 450 v.
32µF 350 v.
6/12 v. 90 mfd. 250 v.
6/12 v. 250 mfd. 100 v.

EX GOVT. METAL BLOCK PAPER CAPACITORS

4 mfd. 350 v.
16 mfd. 350 v.
6 mfd. 350 v.
16 mfd. 350 v.
6 mfd. 350 v.
16 mfd. 350 v.
8-16 mfd. 350 v.
25µF 630 v.
16µF 450 v.
32µF 350 v.
6/12 v. 90 mfd. 250 v.
6/12 v. 250 mfd. 100 v.

EX GOVT. VALVES, VR17, EASO, E8M, Hill, Spalding, 45SA 1/4, EL32. 25µF 18 v. 22/9.
1/11; KT4 4/9; 65 J5 3/6; 66VG, SUG 5/9; 6KGT1 1/11; 352A, 6X4 9/9; E280, EB90 7/9.

EX GOVT. UNITS, type RPDI in original sealed cartons with 14 valves including 5/40, etc., trans., L.P. choke, Rectifier, etc., etc. We cannot enter into correspondence regarding these units which represent a really exceptional bargain at 29/9.

VIBRATORS. Oak 2 v. 7 pin, synchronous, 7/9.

R.S.C. TRANSFORMERS

FULLY GUARANTEED. INTERLEAVED AND IMPREGNATED

MAIN TRANSFORMERS

Primaries 200-250 v. 0.5-10 amperes.

FULLY SCHRÖDING UPRIGHT MOUNTING

250-250 v. 500 mA., 6.3 v. 3 x, 6.3 v. 3 x.
250-250 v. 1000 mA., 6.3 v. 3 x, 6.3 v. 3 x.
200-1000 mA., 6.3 v. 3 x, 6.3 v. 3 x.

TOP SCHRÖDING MOUNTED TYPE

250-250 v. 500 mA., 6.3 v. 3 x, 6.3 v. 3 x.
250-250 v. 1000 mA., 6.3 v. 3 x, 6.3 v. 3 x.
200-1000 mA., 6.3 v. 3 x, 6.3 v. 3 x.

E.H.T. TRANSFORMERS

250 v. 5 mA., 3 operation 1.1, 2, 2-2v. 11 a., for
VCR97, VCR57.

For Mains Supply 200-250 v., 50 c/s.
Guaranteed 12 months.

All for A.C. MAINS 200-250 v., 50 c/s.
Guaranteed 12 months.

Assembled 6 v.
or 12 v. 4 amps.
Fitted Ammeter and selector plug.
Also selector plug for 6 v. or 12 v. double fused. Charging, Double.

R.F. RECEIVERS

The sky four t.f. r.f. receiver

The design of a 3-valve 200-250 v. midget receiver, with mains L. & M. wave. T.R.F. receiver and mains L. & M. wave rectifier. For its size, it is a remarkably powerful receiver. For its size, it is a remarkably powerful receiver. It employs valves E97, SP61, R6BG, and is fully described for this reason. It has an input static sensitivity of 5 mV, for a maximum of 94/196 including cabinet. Available in brown or cream bakelite or veneered walnut.
R.S.C. A6 ULTRA LINEAR 30 WATT AMPLIFIER

NEW 1956 DESIGN. HIGH FIDELITY PUSH-PULL AMPLIFIER WITH "BUILT-IN" TONE CONTROL, PRE-AMP, STAGES

High sensitivity. Includes 5 valves (0678 outputs), High Quality electronically tuned output transformer, specially designed for Ultra linear operation, and reliable small condensers of current manufacture. IMPEDANCE CONTROL FOR BASS AND TREBLE - Lift and Cut. Frequency response +3 D.B. at 20-20,000 c/s., 12 D.B. "lift" at 12,000 c/s. Hum and noise 0 D.B.

R.S.C. TAI HIGH QUALITY TAPE DECK AMPLIFIER FOR ALL DECKS WITH HIGH IMPEDANCE RECORD/PLAYBACK AND 3-EBRAE HEADS. Same as above, but special balanced socket for all types of pick-ups and practically all makes and types of pick-ups. Where a high level output is required for mixing purposes this can be provided for 131. -

GARRARD 3-5 SPEED AUTOMATIC RECORD CHANGER

Latest Model Mixer Type 110110, fitted with high fidelity turnover crystal pick-up head with dual point wiring diagrams supplied. A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 39/- millivolts input is required for full output as that is suitable for use with the latest high-fidelity pick-up heads in addition to all other types of pick-ups and practically all makes. Separate Bass and Treble controls are provided. These give full long playing record equalisation. Hum level is negligible, being 71 D.B. down at 0.1 D.B. of negative feedback is used. R.F. of 300 x 30 mill. and L.T. of 0.8 mill. is available for the supply of a Radio Feeder Unit or Tape Deck Amplifier. For A.C. mains output of 200-250 v. 50 c/s. Output for 2 ohm speaker. A.C. mains is isolated from chassis finish. Blue hammer finish, and point-to-point wiring diagrams and instructions included at extra cost only 2/6. For easy-to-follow wiring diagrams. SEND S.A.E. for illustrated leaflet.

P.L.E.S.S.Y. DUAL CONCENTRIC 12 IN. SPEAKERS

(15 ohms), consisting of a high quality 12in. speaker, of orthodox design supporting a small elliptical speaker ready wired with chrome and condensers. 50 c/s. Output for 2/3 ohm speaker.

Radio Supply Co. (Leeds) Ltd.

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 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.
1957 RADIOGRAM CHASSIS

THREE WAVEBANDS
FULL MILLARD
E120, E280, E790
W. 100 - 250 m. - 250
W. 300 - 550 m. - 550
W. 700 - 1100 m. - 1100

E210, E281, E791

12 month Guarantee. A.O. 250000 v. x 4-way switch.

Crate, Bilo, Bilo-E, E50, E400, E500, E790, E791.

Metallic finish. 4.5 watts. Chassis 23x6 x 5cm. x 6cm.

2 Pilot Lamps. Foam Knob, Walnut or Ivory, silenced and calibrated for use in Hi-Fi volume.

T.S.L. Twister supplied free.

BRAND NEW £10.10
Carr. 6/-

TERMS: Deposit £2.50 and 6 monthly payments of £1.

AM/FM RADIOGRAM CHASSIS

Measurements 13cm. x 21cm. x 7cm. Depth 7cm.

Middle band only required only 1x21. 5 x 3 valve plus metal rectifier, switch, socket, push any waveband, tone control, tuned, and H.V.P. wavebands. Valve line-up E281, E282, R400, R421, E401.

For A.C.

Priced at 100/-
£16.19.6

Cartilage Autoswitcher R531 for 78 R.P.M. 10in., 12in. and 12in.

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Brand new and fully guaranteed 12 months.

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Designed to play 18, 33, 45, 78 r.p.m. Records 7in., 10in., 12in. Lightweight 31x11x13½ movements. two separate stage styli, for Standard and L.P. each £4.25 250 A.

OUR PRICE £8.15.0
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3-speed Motor and Turntable with selecting switch for 33, 45 and 78 r.p.m. records 100-200-250 A.C. 50/60 cycles. Also B.R. MONARCH Lightweight Pick-up with Acetate Turntable, heavy. Use this when you are short of space for L.P. and standards records. SPECIAL OFFER, THE TWO £412/6. Post free.

Telenet Band III Converter

London, Midland and Northern for all T.V. makes, T.R.F. or Superhet. Ready wound coils, two EP tubes, all components, punched chassis, circuit diagram, wiring plans. COMPLETE KIT for mains operation 250-250-200 A.C. £17.10.0

AS ABOVE less POWER REQUIRE. 200. For 30, M. 7, 13 0.2 L. T. Z.

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T.V. PRE-AMP (M-Michael)

Will amplify output of your Band 3 Converter, Tuner Band I and 3. Midget size. High gain brings out weak signals.

B.A. Valve. B.large knobs.

REady FOR USE. (B. 30/6, £16.6/- . 2 amp. post free. SPECIAL POWER PACK for above, 5/- extra.

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Midget size.

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C. P. W.

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6 AMPS. TOGGLE SWITCHES
6 Amps./250 Volts A.C. or D.C. Double-pole-changeover operation. Bush and Lever chromium plated, or black finish.

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We are now able to offer this wonderful guarantee. 6 months' full replacement and 6 months' progressive. Made possible only by improved high quality of our tubes. Carr. and Ins. 15/6. Remember all our tubes are guaranteed 90 days. Convert your 9in.-10in.-12in. sets to 14min.-15in.-17in. Our pamphlet is FREE, and on many sets it costs only the tube, to give you this giant picture. SPECIA-L OFFER: 14min.-15in.-17in. T.V. Tubes £5. Perfect. See them working in our shops. 12in. T.V. TUBES £5. Shortage may cause delay, enquire first and save petrol. We may have alternative and can tell you delay if any. 15/6 Carr. & Ins. on all tubes.

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Complete chassis by famous manufacturer, R.F. E.H.T. unit included. Drawing FREE with order. Being in three separate units (Power, Sound-Viewing and Time Base) interconnected these chassis can easily be fitted into existing table or console cabinets. THIS CHASSIS IS LESS VALVES AND TUBE. Channels 1-2, 3-5, 7-9, 11-13. 19.5 Mc/s. vision. Easily converted to T.V. channel. Insured carr. 10/6.

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ARMY TYPE 17 MK. II

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Frequency Range: 440 to 61 MHz.
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Calibrated Wave-meter for same 10/- extra.

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Pre-selected to receive the Light and Home Stations. Total cost, as specified, including Transistors,rells, Condensers and Battery, etc., with circuit (less insert).

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SPECIAL OFFER

Set of five Transistors including one R.F. Transistor... £12 6-0.
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Complete Kit with 2 Transistors, Components. "Phooie with Circuit.
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MULLARD "3-3" QUALITY AMPLIFIER

An ideal companion unit to the JASON Tuner. A really Castle-4 valve, 5-watt Amplifier giving Hi-Fi quality at a reasonable cost. Mullard's home town. Valve line up: EP96, EL4, EZH. Extra HT and BT available for Tuner Unit addition.

Variable treble cut and bass boost controls. Sensitivity 100 BV, for 5-watt output. Frequency response + or - 1 dB, 40 to 25,000 Hz.

Complete amplifier wired and tested with a factory selected output transformer to Mullard specification (less speaker) 28/10/-, Carr. and ins. 4/6.

SUGGESTED USE GENERATOR covers 100 kilo to 80 Mels and six continuous ranges on fundaments (not harmonics) either modulated 400 cps or CW. Frequency accuracy 1%. Bases E91D, 94C and 93H with double wound mains transformer. The scale is directly calibrated on all bands with total scale length over 60 inches. Housed in a large solid green metal case with carrying handle with scale engraved Perspex. Size 9 in. x 13½ in. by 4 in. deep. Only 28/10/-, plus 6/- cartons and packing.

JASON Tuner, 7 Valves, V.F.M. Tuner, Size 9 in. x 13½ in. by 4 in. deep. Only 28/10/-, plus 6/- cartons and packing.

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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.H. dial, wound coils and screening cases, 4 BVA miniature valves and all necessary quality components, etc., for only 50/- plus post free. Superior dial calibrated in miles with 2 pitch bands, 120 extra, as illustrated. Power Pack components kit inc. packing and screen main transformers, $2/5 extra. Tested and approved by "Radio Constructor," etc. Illustrated handbook with full details, 25/-, inc.


BRAND NEW & GUARANTEED 6/9.19.6 Carr. and ins. 4/6. 8" and 10" speakers suitable for this chassis available.

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An Ideal companion unit to the JASON Tuner. A really Castle-4 valve, 5-watt Amplifier giving Hi-Fi quality at a reasonable cost. Mullard's home town. Valve line up: EP96, EL4, EZH. Extra HT and BT available for Tuner Unit addition.

Variable treble cut and bass boost controls. Sensitivity 100 BV, for 5-watt output. Frequency response + or - 1 dB, 40 to 25,000 Hz.

Complete amplifier wired and tested with a factory selected output transformer to Mullard specification (less speaker) 28/10/-, Carr. and ins. 4/6.

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Kit of parts to build this modern and highly successful unit complete with drilled chassis and J.H. dial, wound coils and screening cases, 4 BVA miniature valves and all necessary quality components, etc., for only 50/- plus post free. Superior dial calibrated in miles with 2 pitch bands, 120 extra, as illustrated. Power Pack components kit inc. packing and screen main transformers, $2/5 extra. Tested and approved by "Radio Constructor," etc. Illustrated handbook with full details, 25/-, inc.


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EX-GOVERNMENT HEADPHONES BY
S. G. BROWN, ETC.
CLR. Low resistance headphones.
They may be sold.
Complete with strap, lead and plug TR-15.
2,000 pr., 10/- each.
High Resistance Phones, 4,000 ohms, complete, with plug.
3/- each.

TELEPHONE TRANSFORMERS
SMALL TRANSFORMERS
Suitable for TELEPHONE CONVERTERS, ETC.
SPECIFICATION OVERALL SIZE:
Primary: 250 ohm, 200 ohms.
Secondary 2: 6.3, fixing centres 1 1/2 in. 15/- each.

LOUDSPEAKER CABINETS
Attainable without finished cabinets.
Complete with back and front panels.
Metal speaker grid, complete, with back and front.
E.M. type: Measures 8.5 x 8.5 x 6 in. 0.95 cu. ft.
Primary: 60 ohms.
Secondary: 100 ohms.
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T.S.L ELECTROSTATIC LOUD- SPEAKERS
TYPE: L635.
Size: 8 in. x 8 in. x 6 in. 1.106 cu. ft.
D.C. voltage 60 volts. Audio voltage 60 volts.
Efficiency: Test voltage 450 v. 50 c/s.
Price 1/- each.

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TELESCOPE BAND III CONVERTER COIL SET

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Complete with strap, lead and plug TR-15.
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SPECIFICATION OVERALL SIZE:
Primary: 250 ohm, 200 ohms.
Secondary 2: 6.3, fixing centres 1 1/2 in. 15/- each.

LOUDSPEAKER CABINETS
Attainable without finished cabinets.
Complete with back and front panels.
Metal speaker grid, complete, with back and front.
E.M. type: Measures 8.5 x 8.5 x 6 in. 0.95 cu. ft.
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Price: 9/- each.

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Size: 8 in. x 8 in. x 6 in. 1.106 cu. ft.
D.C. voltage 60 volts. Audio voltage 60 volts.
Efficiency: Test voltage 450 v. 50 c/s.
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CLR. Low resistance headphones.
They may be sold.
Complete with strap, lead and plug TR-15.
2,000 pr., 10/- each.
High Resistance Phones, 4,000 ohms, complete, with plug.
3/- each.

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SPECIFICATION OVERALL SIZE:
Primary: 250 ohm, 200 ohms.
Secondary 2: 6.3, fixing centres 1 1/2 in. 15/- each.

LOUDSPEAKER CABINETS
Attainable without finished cabinets.
Complete with back and front panels.
Metal speaker grid, complete, with back and front.
E.M. type: Measures 8.5 x 8.5 x 6 in. 0.95 cu. ft.
Primary: 60 ohms.
Secondary: 100 ohms.
Price: 9/- each.

T.S.L ELECTROSTATIC LOUD- SPEAKERS
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LOUDSPEAKER CABINETS
AIRCRAFT RADIO RECEIVER (BY RCA Model No. CRV 46151). Free. 195 kcs. to 9050 kcs. (33-1500 meters) continuous. For 20 v. D.C. input with built-in dynamotor. This 6-volt receiver with 2 R.F. stages and 2 L.F. stages with B.F.O. and C.W. is in our opinion one of the finest sets so far released by the Air Ministry. With instruction diagram to convert for masts. For the very modest price of £1/10/-, carried, in good working order.

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BC.23/9/B 33CM INDICATOR UNIT. Containing 1-J-2PH1 3in. C.R.T. 6-6SN7S, 2-6H6s, 1-A.451, 1-A.462; 7 valves in all. Ideal for ‘scope conversion. New, in original sealed cartons. 5/-, carr. 5/-

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RE-ENTRANT LOUD HAILERS. Heavy duty 20 watt all-metal. 15 ohms. By Parmeko. £5/10/-, carr. paid.

PARMEKO TWIN BAKELITE LOUD HAILERS (ex-Admiralty), 15 ohms. By Parmeko. £5/10-/-, carr. paid.


AP9 TRANSMITTER. 6-12 volts. Complete with connecting cables and mounting rack, £15, carr. extra.

P.E. 103 H.D. POWER SUPPLY UNIT. New and boxed. £3/10/-, carr. 10/-.

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ROTARY CONVERTERS. 24 v. D.C. input 230 v. A.C. 50 cycles. Fully tested, £20/5/-, carr. 10/-.

SOUND POWERED HEADPHONES. Can be used for speaking or receiving. £3/5/- per pair, p.p. 1/6.

RCA BRAND NEW. 15in. 15ohms 30 watt P.M. speakers. £9/19/6, carr. 12/-.


ACIDILE POWER SUPPLY UNITS. 230 v. A.C. 50 cycles input. 100 v. D.C. at 1 amp. out. housed In metal strong case, ex-G.P.O. New and unused £4/10/-, carr. 7/6.

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SELENIUM METAL RECTIFIERS. FULL BRIDGE

6 or 12 volt. 1 amp. 10/-
12 volt. 2 amp. 15/-
12 volt. 3 amp. 20/-
12 volt. 4 amp. 30/-
12 volt. 6 amp. 40/-
12 volt 10 amp. 60/-

SPEEDY DELIVERY OF L.T. RECTIFIERS TO ORDER.

ELECTRIC LIGHT SLOT METERS. 200/200 v. A.C., 5-10 amps. In slot, 6d. or 7d. per unit. By Measurement Ltd. All Bakelite case, in very good condition, 50/-, p.p. 3/-.

SOUND POWERED HEADPHONES. Can be used for speaking or receiving. 15/- per pair, p.p. 1/6.

JAS VALVES. Brand new (D.C.C.90), £2/6/-, p.p. 9d.

CONDENSERS. 2 mfd. 7.5 kv. £2/6/-, p.p. 9d.

VARIABLE VOLTAGE REGULATOR TRANSFORMERS. Input 230 v. A.C. at 21 amps. Output 57.5 volts in 16 equal steps to 230 v. at 21 amps. Ex-Govt., in perfect condition. £12/10/-, carr. extra.

DON "S" TWIN TELEPHONE CABLE, on 230 v. at 21 amps. Ex-Govt., in perfect condition. £12/10/-, carr. extra.

INPUT IMPEDANCE : 0 - 100 v, RMS F.S.D

RANGE: 0 - 100 v, RMS F.S.D

FREQUENCY RESPONSE: 20 c/s to 10,000 c/s

ACCURACY: ± 2% INPUT IMPEDANCE: 1 MΩ and 50Ω

A NEW VALVE VOLTMETER

£55 0 0
FOR ALL RADIO BARGAINS

TRANSMITTER/RECEIVER No. 19 Mk. II
Equipment comprises 3 separate units built into one chassis and separate power pack.
Specification: A set, Transmitter/receiver, Frequency coverage 0.5-200 mc/s, 1000 microamps. For R.T., C.W. or F.M. Range on B.T. 25 miles. C.W. 50 miles. Receiver, 4000 kc/s. A.R., B.F.O., etc. E. Valve Type-6K7 (6L6 or G12F), 6K6, 12LA, 6K7, 6G6, 6L6, 450 volt, 30 amp. receiver output. E. Valve Type-5L4 (5L8). P.M. phone output. E. Valve Type-150R. Inter. Com. up to 2 miles. Power line-up 6V, 9 or 17 volts. 4 a., 150 watts. Inter. Com. up to 2 miles. Power line-up 6V, 9 or 17 volts. 4 a., 150 watts.

AMERICAN GEARED MACHINES
American 24 volt D.C. motors with built-in precision gearbox giving twin outputs 20 r.p.m. and 6 r.p.m. Will also operate on 12 v. for reduced output. Size 7 xw. Shaft dia. 1 in. Supplied brand new and tested 110/- each.

MORONCI U.H.F. SIGNAL GENERATOR TF.517, MODULATOR GENERATOR TF.617. Complete station comprising TF.517 signal generator, frequency coverage 16-58 mc/s and 170-300 mc/s and TF.673 pulse modulator, repetition speed 5-1000 cycles, pulse width 2-12.4 mc/s. Supplied brand new in original transit case incorporating the trawler band. Frequency coverage 3/7,5 mc/s, 7.5/18 mc/s. Power pack, spare vibrator, headset, connector leads and 100 volt, 100 microamp. S.F. 61/- each.

MODULATOR TYPE 67
These bargain instruments contain a COMPLETE A.C. D.C. 6.3 V. 5 POWER PACK, Input 230 volts 50 cycles. Outut 350 volts 120 ma. and 6.3 volts 5 ams. Stock and condenser smoothed and uses 524 rectifier. (Transformer actually 200 ma). Also included in the unit are 11 other valves, 5 S961. 1 VR116, 2 6B34 and 3 E1250, and many other useful components, parts, resistors, etc. Size of case is 18 x 9 x 7 in., which is finished in grey. Supplied brand new, 49/- each.

RCA A.R.88 L.F. RECEIVERS. Offered in first class condition, re-aligned and thoroughly tested. Continuous coverage from 75 to 550 kc/s and 1.5 to 30 mc/s. Built in A.C. mains power pack, speaker output, variable selectivity, B.F.O. etc., Price £4.50 each.

AMERICAN ROTARY GENERATORS
Input 12 volt D.C. Output 250 volts 80 ma. Fitted with blowout attachment which can be easily removed if desired. Brand new 22/6 each. Ditto with 6 volt input 22/6 each.

50 MICROAMP METERS
23/2 in. Steel flush mounting meter housed in grey instrument case with chrome handle. Brand new and tested, 59/- each.

FIELD TELEPHONES
Type Don Mk. 5. Buzzer calling. Ideal for inter-office or house communication. Supplied complete with two 1.5 volt cells. tested and ready to operate. Price only 39/- each.

WE PURCHASE ALL TYPES OF RECEIVERS AND TEST GEAR

MODEL-MAKERS' MOTORS
Permanent magnet type, reversible. Size only 2 in., long, 1 in., short, 1 in. Operation from 4.5 to 24 volt D.C. Thoroughly recommended for baschines, etc. Supplied brand new only 22/6 each.

EXPLORERS, DYNAMO-CONDENSER SET MK. I. Operation by a hand generator supplying an A.C. voltage which is stepped up through a transformer, rectified by 2,500, and a final 1,800 volts is developed across a 6 mfd. paper condenser. A neon indicates when charged. Ideal also as a Photo Flash unit. Supplied brand new with circuit, 3/-19/6 each.

GEARED MOTORS
Special offer. Garrard 200-250 volt A.C. gram. motors complete with 5 mfd. crystal and spare turning gear. In original transit case, brand new with instructions, 4/-11/6 each.

MORONCI CRISTAL CALIBRATORS.
Frequency coverage 170 to 240 mc/s. Directly calibrated accuracy 0.001%. Operation 200-250 volt A.C. Supplied complete with 5 mfd. crystal and spare turning gear. In original transit case, brand new, 5/- each.

AMERICAN BEACON TRANSMIT-TER/RECEIVER RT 37/FPN-2. Brand new and boxed, complete with instruction book. Equipment comprises transmitter/receiver with 9 valves (5 3A5, 3I55 and 1 185), with built-in 2 volt vibrator power pack, spare vibrator, headset, connector leads and 100 volt, 100 microamp. S.F. 72/- each.

RADIO CONVERTORS.
Input 24 volt D.C. Output 230 volt A.C. 50 cycles, 100 watts Power 92/- each.

6 VOLT VIBRATOR PACKS.
6 volt output. Operation 300 mc/s and 200 mc/s and 500 volts 50 m/amps. 2in. F.M.M.C. 25/- each. Supplied brand new and boxed, 15/- each.

SUB-STANDARD Voltmeters
Six ranges: 7.5, 15, 30, 60 and 300 volts D.C. 6 in. mirror, finish, mains operated with chrome handle. Brand new 110/- each.

460 KC/S B.F.O. UNIT
Supplied brand new and complete with 155 valve, fully screened in aluminium case, size 2x 1 x 4 in. Price 8/6 each.

SMOOTHING CHOKES
G.B. 20 henries 175 ma. 10/-
Parmeko 6 henries 25 ma. 5/-
Parmeko 9 henries 100 volts 60 ma. 9/-
Parmeko C core 4H. 22.5 ma. 4/-
Parmeko Cramer A 4H. 22.5 ma. 4/-
Parmeko 250 volts, 22.5 ma. 10/-
Collins 8 henries 100 ma. 8/-

MORSE BUZZERS.
Brand new and boxed. Operation from 3 volt D.C. Price 2/6 each.

METER BARGAINS
50 m/amps. 2 in. F.M.C. 7/-
150 m/amps. 2 in. F.M.C. 9/-
200 m/amps. 2 in. F.M.C. 11/-
1 amp. R.F. 2 in. F.M.C. 7/-
4 amp. R.F. 2 in. F.M.C. 12/-
30 volt D.C. 2 in. F.M.C. 10/-
300 volt A.C. 2 in. F.M.C. 13/-
500/1000/microamp. 2 in. F.M.C. 25/-
5000/10000 m/amps. 2 in. F.M.C. 5/-
ALL BRAND NEW AND BOXED.

HOURS OF BUSINESS: 9 a.m.-6 p.m. Thursday 1 p.m. Open all day Saturday. Please print name and address clearly. Also include postage on all items.
SAMSON'S SURPLUS STORES

NEVILIN 3,000 WATT AUTO TRANSFORMERS. Input 200-250, Output 110 v. Completely enclosed in grey metal case. With input voltage selector switch and fuses. Supplied brand new at a fraction of makers price. £915, plus carriage.

LT SUPPLY UNIUT. Type 115. A.C. input 200-250 v. Output 24 v. 26 amp. rating continuous for charging 24 v. batteries at a high current. Approximate size 11 ft. 6 in. 6 in. £179/10, plus carriage.

WILLARD AIRCRAFT BATTERIES. 24 v. 11 A.H. Size 8 x 7 x 3 in. G.M.A. MARINE, C.A.M., carr. 7/6. EXIDE 10 volt, 5 A.H. GLASS ACCUMULATORS. Size 7 x 2 x 5 in. Suitable for H.T. unit construction and models, etc. New in maker's cartons. 8/6, P.P. 1/6, MINIATURE. 36 v. 0.2 amp. ACCUMULATORS made by Willard Co. Size 3 x 1 x 3 in., weight 5½ oz.

New and uncharged. 2/6, P.P. 6d.

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FLUORESCENTS - with choke and starter less tube.

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Send for full fluorescent and control gear also cable, accessories and radio lists. Add 1/4 cent on small orders please.


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Type HAX. Selective crystal diode coil for tape and quality amplifiers, MW 35, LW 3/6. Dual wave TRF Coils, matched pairs (as illustrated). 7-pair. Type S.S.O. Superonic Tape Occ. coil, provides 6.3 v. 3 a. RF for pre-amp heater. Eliminates induced noise. 50 c/s hum, 40/100 kc. 15% ex. Transistor coils, etc. Available from leading stockists. Stamp for complete data and circuits.


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Personnel Manager,
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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.

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Vacancies exist in all grades of work on colour television and associated test gear.

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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.

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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 the 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,
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**English Electric Company Limited**

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TELEMETRY ENGINEERS

in the newly formed Test Department of the Company’s Guided Weapons Division.

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Enquiries invited by the Personnel Manager,

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(1) DEVELOPMENT ENGINEER to work on the integration of Automatic Test Equipment with a complex radar. An applicant having a minimum of two years' experience of Radar circuits including data transmission and servo systems would be suitable.

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HOUSE AVAILABLE FOR A SELECTED APPLICANT FOR (1) OR (2).

Reply stating age, qualifications and experience to Personnel Manager (ref. R.G.).

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IN
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Applications are invited from men aged 19 or over who have a fundamental knowledge of radio or radar with some practical experience. Training courses are provided to give familiarity with the types of equipment used.

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for
RADAR & ELECTRONIC WORK

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ELECTRONICS DIVISION

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Posts are pensionable, Sports Club and other recreational facilities are available. Applications should be addressed to:

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- MARCONI TF-144F, older version of model TF-144G; range 85 kcs to 25 mcs, 8 bands. Output 1 mV to 1 V. Direct calibration. Output impedance 10 and 52.5 ohms. Mains operated.
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  PRICE, fully overhauled: £30 0 0
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  PRICE, fully overhauled: £35 0 0
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- MARCONI UM absorption wave-meter TF-443. Frequency range 20 to 300 mcs.
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- AIRCRAFT BONDBING TESTERS, A.M.
  Ref. 5G/2/26, complete with two matched leads, appro. 6ft. and 60ft. long, and shoulder carrying straps.
  PRICE: £8 15 0
  Alkaline Cell for the above: £3 3 0

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  PRICE, fully overhauled and guaranteed, complete with diode probe: £17 0 0
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  PRICE: Second-hand, in perfect operating condition: £25 0 0
  Brand new, complete with access: £32 10 0
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- RECORD MEGGERS 500 volts, in leather cases, fully overhauled and guaranteed, post free: £10 0 0

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  CASSER OR MODEL 339 DOUBLE BEAM OSCILLOSCOPES, fully overhauled and guaranteed.
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- TS-99/91 VOLTAGE DIVIDER, to extend the voltage range of an oscilloscope. Ratios available 100 to 1 and 10 to 1. Maximum voltage 20,000 volts.
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- MARCONI THUNDERBOLT, model TF-428A or Service Equivalent. Range 10 to 150 volts in five ranges. Resonant frequency approx. 400 mcs.
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has a number of vacancies for Assistants in the Cathode Ray Tube Division (Technical Dept.).

The work involves the design and construction of prototype test circuits and equipment for Cathode Ray Tubes. It is thought that these vacancies might have a particular appeal for men who possess a good basic qualification in Electrical Engineering and who may have had suitable circuiting experience in H.M. Forces or elsewhere.

A feature of employment with the Company is generous facilities for further study and the opportunity to participate in the further development of this field of work.

Commencing salaries will be based upon experience, qualifications and age in each individual case, and good salary prospects prevail. Long-service Benefits and Pension Schemes have long been established in the Company.

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HIGH FIDELITY Input Transformer Type P3667. Price 9/6d and 8/6d respectively.

Potted mounted style available for standard item.

Standard open style of mounting.

Standard hermetically sealed "C" core construction.

Mains Transformer for Mullard 5-L0 Amplifier, sub-chassis wiring.

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PARTRIDGE TRANSFORMERS were employed by the Mullard Valve Measurement and Application Laboratories for the prototypes of the 10 & 20 Watts High Quality Amplifiers.

Above is illustrated the Mullard 5-10 Amplifier, Distributed Load Version, fitted with a Partridge "C" core Output Transformer Type P4013 and Mains Transformer Type P4015. Price 9/6d and 8/6d respectively.

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12/6, 20/6, post paid.

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FOR SALE AND WANTED ADVERTISEMENT FORM TURN TO PAGE No. 165
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Dynamotors, 19/24 volt D.C., 500/1,000/2,500 MA or near; price and details.—Radiodex, Ltd., Oxford Place, W.1. [3647]

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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.
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Apply in writing giving details and quoting reference to the Sales Manager. [0661]

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APPLICATION forms and further particulars may be obtained from the Experimental Training Officer, Ministry of Supply, 66-72, Grosvenor St. S.W.1. This closing date for receipt of completed application forms is 15th May, 1957.

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SENIOR Telecommunications Engineers.

POST A.—To be responsible to a Principal Telecommunications Engineer for the direction of 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), and signalling systems on V.H.F. links, telephone equipment and telegraph equipment, or for a large part of the Principal Telecommunications Engineer at Terri- torial Headquarters.

POST B.—To be responsible to a Principal Telecommunications Engineer for the direction of all wireless communications including M.F. and V.H.F. stations, radio link systems, and a major district territory and to plan and carry out major overhaul and installation of V.H.F. transmitters and installation and minor development work.

PENSIONABLE. Salaries with salary of £1,520 p.a. gross or on contract with salary of £1,420 p.a. gross. For the first three months' satisfaction allowance of £77.50 p.a. for each of two children under 16, and of £75 p.a. for each additional child in Nigeria. Refund of up to the cost of two adult fares for each child's passage on completion of their first tour of duty, when the allowance would cease. Quarter, if available, at departure from home. CANDIDATES should be A.M.I.E.E. and have had at least three years' experience in telecommunications (radio engineering experience is necessary for Post A) or alternatively have held the rank of executive engineer for at least 2 years (post held on employ in engineering wireless) 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, B.C.D. 175/4702.

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Radio Engineer—posts and Telegraphs Department, Fiji.

To be responsible for the preparation required by the International Frequency Registration Board and for radio control over all control of either. CANDIDATES must be of good character, and have at least 5 to 10 years of practical experience in radio communication, and have knowledge of standard purchasing regulations and the International Regulations for operation of radio stations. CANDIDATES must have a A.M.I.E.E. and be thoroughly conversant with the installation, operation and maintenance of all low power radio (H.F. and V.H.F.) radio stations and have a sound knowledge of the International Regulations and procedure regarding frequency registration.

WRITE Director of Recruitment, Colonial Office, London, S.W.1, giving age, qualifications and experience, quoting B.C.D. 176/4702.

RADIO Maintenance Technician required by POLICE Department, Government of Northern Rhodesia, for one tour of 5 months in each station: salary; allowance, baggage and experience, in scale £670 to £1,200 a year; free passages to and from all stations, on full pay, candidates preferably aged 25 to 30, must possess academic qualifications in mathematics and physics of measurement standard, together with sound knowledge of mathematics and techniques of modern and medium powered W.H.F. and V.H.F. equipment, and have experience of radio maintenance.

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POST B.—To be responsible to a Principal Telecommunications Engineer for the direction of all wireless communications including M.F. and V.H.F. stations, radio link systems, radio link systems, and a major district territory and to plan and carry out major overhaul and installation of V.H.F. transmitters and installation and minor development work.

PENSIONABLE. Salaries with salary of £1,520 p.a. gross or on contract with salary of £1,420 p.a. gross. For the first three months' satisfaction allowance of £77.50 p.a. for each of two children under 16, and of £75 p.a. for each additional child in Nigeria. Refund of up to the cost of two adult fares for each child's passage on completion of their first tour of duty, when the allowance would cease. Quarter, if available, at departure from home. CANDIDATES should be A.M.I.E.E. and have had at least three years' experience in telecommunications (radio engineering experience is necessary for Post A) or alternatively have held the rank of executive engineer for at least 2 years (post held on employ in engineering wireless) in the British Post Office.

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Radio Engineer—posts and Telegraphs Department, Fiji.

To be responsible for the preparation required by the International Frequency Registration Board and for radio control over all control of the electrical equipment. CANDIDATES must be of good character, and have at least 5 to 10 years of practical experience in radio communication, and have knowledge of standard purchasing regulations and the International Regulations for operation of radio stations. CANDIDATES must have a A.M.I.E.E. and be thoroughly conversant with the installation, operation and maintenance of all low power radio (H.F. and V.H.F.) radio stations and have a sound knowledge of the International Regulations and procedure regarding frequency registration.

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