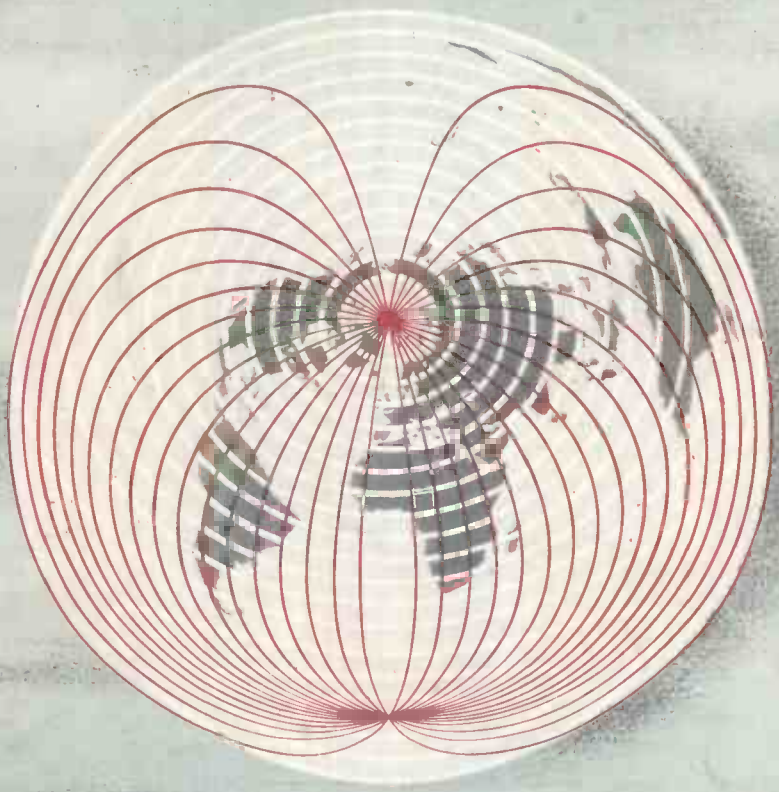
NOVEMBER 1954 · TWO SHILLINGS

Wireless World

Radio · Electronics · Television



FORTY-FOURTH YEAR OF PUBLICATION

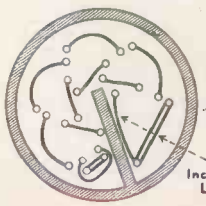
Photo-Electric Multipliers 27M1 and 27M2

for light operated relays, film scanning, facsimile transmission, and many Research and Laboratory investigations involving low light levels.

Now available for prompt delivery

27M1 The 27M1 is a nine stage high vacuum photo cell with high response in the visible region. When operated at 100 volts per stage it is capable of multiplying very small currents produced under weak illumination by an average value of one million times. Under normal operating conditions the resultant output current is a linear function of the exciting illumination. The frequency response is flat up to the frequencies at which transit time of electrons within the valve becomes a limiting factor.

Because of its great sensitivity, low noise level, low dark current and freedom from distortion the 27M1 may be used for light operated relays, film scanning, facsimile transmission and in scientific research involving low light levels. In many applications its small size is an advantage. List Price: £15.



The secondary cathodes, or dynodes, of these multipliers are arranged in cylindrical formation so that they are exceptionally compact.

TYPICAL OPERATION

Voltage between anode and secondary cathode K10	50 volts
Voltage difference per stage	100 volts
Maximum anode dark current (with 100 volts between anode and cathode K10)	0.25μA
Luminous sensitivity (taken on the basis of a lamp colour temperature of 2700°K and a light area of 5 mm x 20 mm)	20A/lumen
Current amplification (ratio of anode sensitivity/cathode sensitivity)	10^6

27M2 The 27M2 is a nine stage high-vacuum photo-cell similar to the 27M1 except that it has wider tolerances on the anode dark current necessitating a lower anode supply voltage with a resultant reduction in the current amplification to approximately one quarter of that obtainable from the 27M1. It is capable of multiplying very small currents produced under weak illumination by an average value of 250,000 times when operated at 80 volts per stage.

The 27M2 is suitable for the same applications as the 27M1 wherever the reduced magnification is acceptable. List Price: £6.

TYPICAL OPERATION

Voltage between anode and secondary cathode K10	50 volts
Voltage difference per stage	80 volts
Maximum anode dark current (with 80 volts between anode and secondary cathode K10)	0.25μA
Luminous sensitivity (taken on the basis of a lamp colour temperature of 2700°K and a light area of 5 mm x 20 mm)	2.5A/lumen
Current amplification (ratio of anode sensitivity/cathode sensitivity)	0.25 x 10^6

Either the 27M1 or the 27M2 may be used as a plug-in replacement for the American type 931A.
A special stabilised power unit providing a highly stable H.T. supply for photo-multipliers is available.
Full details on request.

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RADIO DIVISION

THE EDISON SWAN ELECTRIC COMPANY LIMITED

Member of the A.E.I. Group of Companies SV1

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Wireless World

RADIO, ELECTRONICS, TELEVISION

44th YEAR OF PUBLICATION

Managing Editor: HUGH S. POCOCK, M.I.E.E.
Editor: H. F. SMITH

NOVEMBER 1954

In This Issue

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VALVES, TUBES & CIRCUITS

23. MINIATURE VALVES WITH 25mA FILAMENTS

The Mullard range of low-consumption valves for all-dry battery receivers consists of four types, the DK96, DF96, DAF96, and DL96, mounted on the standard B7G base. The filaments are economically rated at 1.4V, 25mA. The DL96 output pentode has two such filaments which are normally operated in parallel.

The filaments in a receiver using these four types may be fed in three alternative ways: (i) in parallel; (ii) in pairs in a 50mA chain, with the odd filament (say the DAF96) shunted by a 5% tolerance resistor to maintain the correct filament current; (iii) in a 25mA chain. The third method is suitable for ABC receivers with separate h.t. and l.t. batteries; but the variation of cathode current in the output valve, which can occur when the batteries are at different stages of exhaustion, must be limited. For this purpose a special filament chain has been devised, of which full particulars are given in the *Additional Notes*.

For mains operation, supply variations should be allowed for by presetting the filament current (by means of a variable portion of the dropping resistor) to 24mA $\pm$ 2% at nominal mains voltage.

The valves are designed for optimum performance with a 90V supply; but there is no serious loss of sensitivity in the amplifier stages at voltages down to 67.5V, as the recommended screen-grid voltages of the amplifier valves are about 65V. In the output stage, however, the loss of power caused by battery exhaustion is more marked with lower nominal battery voltages.

The Mullard DK96 is a heptode frequency changer in which the first two grids form the oscillator, and the third grid is the signal grid. The optimum conversion conductance is 300μA/V, and the cathode current is 2.4mA at an oscillator voltage of 4.0V r.m.s. The variable-mu characteristic gives good cross-modulation and allows the use of AGC. The screen-grid voltage is about 65V, but in ABC receivers it should be adjusted to give 0.6mA anode current at zero bias.

A tuned-grid oscillator circuit is recommended, with the earthy end of the oscillator grid resistor taken to the positive side of the filament. Feedback should be derived from the oscillator anode, with the feedback winding of the oscillator coil preferably series-fed, especially at the higher frequencies.

The DK96 is not suitable for use above 20Mc/s. Pulling at frequencies above 10Mc/s should be reduced by capacitive neutralisation between the oscillator and signal grids.

The Mullard DF96 is an IF amplifier with a mutual conductance of 750μA/V at a cathode current of 2.2mA. It is suitable for AGC operation, as its grid base has been lined up with that of the DK96. The DF96 and the DK96 can be operated with a common screen-grid dropping resistor; but in ABC receivers this is allowable only if the two filaments are in parallel or if the control-grids are biased to their respective filaments. In all circuits, however, a common screen-grid resistor allows the relatively high screen-grid current of the DF96 to affect the gain of the DK96, and thus to increase the spread in the overall sensitivity of the receiver.

The Mullard DAF96 is a pentode AF amplifier with a detector diode. A voltage gain of 60 is obtainable when the detector presents a source impedance of 500kΩ, and a voltage output of 5.0V r.m.s. is obtained at 3% distortion. If the valve is used as a triode, the gain is about 11 and the voltage output is 5.0V r.m.s. at 2% to 3% distortion.

With a bias resistor of 10MΩ the detector load resistor should be limited to 500kΩ to give minimum attenuation in the control grid input circuit and an adequate a.c. to d.c. load ratio. With a detector load resistor of 1.0MΩ the bias resistor should be 22MΩ.

Anti-microphonic precautions are necessary only when the control grid voltage is less than 20mV for 50mW output.

The Mullard DL96 output pentode is designed for 90V operation; but the grid base at 67.5V is sufficient to allow operation at this lower supply voltage. A single valve, under Class A conditions with a 90V supply, will give a 200mW output at 10% total harmonic distortion for an input signal of 3.4V r.m.s. At 67.5V the output is reduced to 100mW.

Two valves may be used in push-pull, with the grid signal provided by a driver transformer, a centre-tapped choke, or a phase-inverter valve. The total cathode current of the two valves must not exceed 12mA. Class B operation, with all four filaments in parallel, gives, at 2% to 3% distortion, 440mW output at 90V and 235mW at 67.5V. The comparable outputs for Class AB operation, at 3% to 4% distortion, are 420mW and 220mW.

The Mullard DM70 subminiature tuning indicator, which has been described in *Valves, Tubes, and Circuits* Nos. 5 and 6, is suitable for use with these valves.

Reprints of this advertisement, with additional notes on the design of filament supply chains, a circuit for a four-valve battery receiver, and valve data, may be obtained free of charge from the address below.

Mullard

MULLARD LTD., Technical Service Department, Century House, Shaftesbury Avenue, W.C.2

MVM.3C6

Wireless World

NOVEMBER 1954 VOL. 60 No. 11

B.B.C. Report

THE recently published Report* to the Postmaster-General for the year 1953-54 by the B.B.C. Board of Governors loses a little of its interest and value through being a trifle out of date. The document was prepared just before the final passing of the Act setting up the Independent Television Authority, and so, naturally enough, any attempt to consider the position of the Corporation *vis-à-vis* the new competitive body is specifically disclaimed.

Such incidental mention as there is of the possible effects of competition is confined to finance. It is a matter of some concern that, on present estimates, the B.B.C. will receive about £6M less than it expects to need for carrying through development plans during the next three years. Even if the financial stresses of that period can be weathered, the Corporation will, in the words of the Report, "inevitably have to ask for a larger share or even the whole of the proceeds of the £1 and £3 licences thereafter." We imagine that public opinion, and especially opinion in the radio world, will be strongly in favour of allowing the B.B.C. sufficient finance to carry through at least those parts of its development plan that have already been approved in principle by the Government. British broadcasting has been built up on a basis of successful long-term planning and even its harshest critics will not deny that the B.B.C. has in the past shown excellent engineering judgment, not to say foresight.

As might be expected, the bulk of the Report deals with the programme side and also gives detailed accounts of income and expenditure. There is, though, a 10-page section devoted to engineering in which the past year's work is surveyed and plans for the future are set out. In this section there is also a note on present policy in recruitment and training of technical staff. In addition to recruiting ready-trained men, the Corporation is taking in probationary technical assistants. No specific qualifications are expected of these, but they must pass a qualifying examination after an initial 12-week training course.

Colour television is accorded several mentions and it is interesting to read that the main effort of the research department was concentrated on this subject during the latter part of the year. Then there is the rather surprising statement that "the B.B.C. does not expect to introduce regular transmissions in colour within the next two years." This statement, with its inevitable implication that a regular colour service will start shortly after that period has expired, seems rather over-optimistic. In this matter, the Board of Governors appear to be slightly at variance with Sir Ian Jacob, the Director-General, who, in the current number of *The B.B.C. Quarterly*, was (rightly, we think) much more cautious and non-commital. "Nothing," he said, "could be more foolish than a precipitate start with coloured programmes."

* Cmd. 9269 H.M.S.O., 4s. 6d.

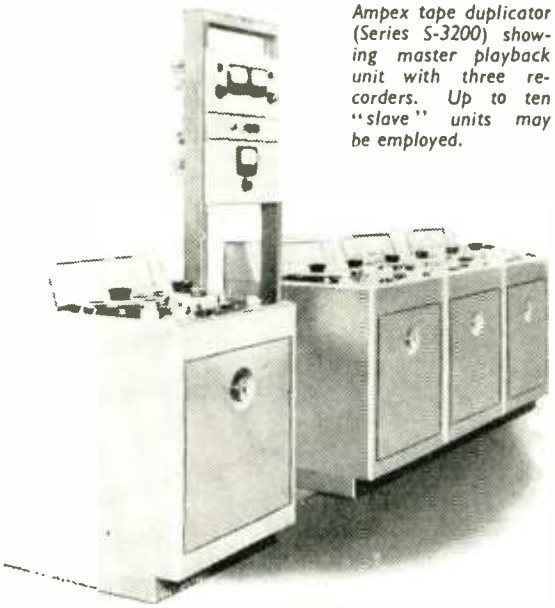
Quality on V.H.F.

AS most of our readers know, the B.B.C.'s plan for reinforcing the present sound broadcasting service with v.h.f. three-programme stations is due to start with Wrotham next May. The remaining eight stations of the first stage of the scheme should be finished within less than two years.

This scheme is described in the Report discussed in the preceding paragraphs, and was also the subject of a talk given recently to the Radio Industries Club by Harold Bishop, B.B.C. Director of Engineering Services. Some disappointment was felt, even among the more realistic, at Mr. Bishop's summary dismissal as "nonsense" of the idea that f.m. broadcasting would automatically bring about a great improvement in quality of reproduction. No doubt, as he said, the idea of giving a bandwidth of 15 kc/s is impracticable for a nation-wide service depending on a long and complicated network of landlines for linking the stations. However, the quieter background and freedom from interference that many f.m. listeners will enjoy will inevitably focus attention on quality of reproduction. It will be a great pity if the B.B.C. does not do all it can, within the bounds of good engineering, to ensure the best possible quality from the new service.

Tape Duplication System

EQUIPMENT for the duplication of recorded magnetic tapes on a commercial basis is now being sold in America. A master playback unit feeding a master amplifier and bias oscillator supplies from one to 10 "slave" recorders. Both tracks of the twin-track



Ampex tape duplicator (Series S-3200) showing master playback unit with three recorders. Up to ten "slave" units may be employed.

master tape are read and re-recorded simultaneously and the tape speed for duplication may be as high as 60 in/sec. This calls for pick-up and recording heads capable of handling frequencies up to 120 kc/s if the original tape carries 15 kc/s at 7½ in/sec. The heads used are designed for supersonic recording and are similar to those which have been developed by Ampex for recording data in flight testing.

No time is wasted in rewinding the master since the machine duplicates in both directions. It has been calculated that, with the full complement of 10 recorders, the output of 3¾-in/sec tape duplicates is increased by a factor of as much as 320 over a pair of standard recorders running at the original speed of the recording. (Speed ×16, twin tracks ×2, recorders ×10.)

Total cost for a 10-unit installation is said to be less than $20,000. The makers are Ampex Corporation, 934, Charter St., Redwood City, California.

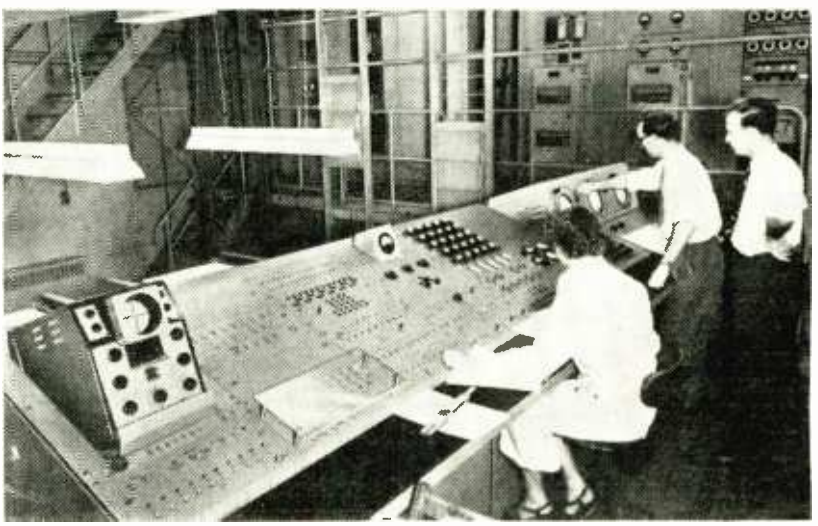
N.B.S. Laboratories

THE new research centre of the American National Bureau of Standards at Boulder, Colorado, was officially opened on September 11th. A series of scientific meetings was held coincident with the opening and included a symposium on propagation. standards and problems of the ionosphere. Among those present at the opening was H. J. Finden, chief engineer of the Electronic Instruments Laboratory of the Plessey Company, to whom we are indebted for the following report.

The Boulder Laboratories, which supplement the N.B.S. facilities in Washington, D.C., include the Bureau's Central Radio Propagation Laboratory transferred from Washington. The C.R.P.L. is the chief American research centre for the study of the troposphere and ionosphere as media for the propagation of radio waves. It also develops and maintains the national primary standards for the complete radio-frequency spectrum. As the nation's central agency for collecting radio propagation data, the C.R.P.L

GUIDED-MISSILE SIMULATOR

The control desk of "Tridac," a large-scale analogue computor built by Elliott Brothers and recently put into operation at the Royal Aircraft Establishment, Farnborough. It calculates the flight behaviour of new types of guided missiles in three dimensions and gives the distance by which they miss the target. Parts of actual missile control systems can be included in the computor, as it behaves as a model of the missile flight and operates in "real" time. The c.r.-tube displays on the right give a representation of the missile approaching its target in three separate dimensions. Computing elements in the machine include large numbers of d.c. amplifiers, and some idea of the techniques used can be gathered from "Electronic Analogue Computing" in our March, 1954, issue.



analyses and disseminates information which is of vital importance for the maintenance of radio services in aviation, shipping and communications.

The Laboratory's studies of frequency allocation and interference affect the establishment and operation of all American broadcasting stations. Data on v.h.f. radio propagation and the development of micro-wave techniques are important to the weather bureau and military aerologists for use in the measurement of upper air temperature, humidity and wind.

Boulder is well situated in that the plains extending hundreds of miles eastwards from the mountains permit many phases in radio propagation research. Use is also made of the nearby mountains and several transmitters are located in the Cheyenne, near Colorado Springs. Frequency utilization research carried out by the N.B.S. is providing valuable data on the effects of noise due to the troposphere as well as the sun and terrain, particularly at frequencies above 50 Mc/s.

"A Guide to Amateur Radio"

THIS book was first published by the Radio Society of Great Britain in 1933; a new edition appeared each year on the opening of the National Radio Exhibition until 1937, when it was superseded by *The Amateur Radio Handbook*. The present publication, styled the sixth edition, follows the tradition of the earlier ones, but is far more comprehensive.

Its aim is to provide the newcomer to amateur radio with up-to-date information on present-day practices and to give expert advice on how to obtain an amateur transmitting licence. There are chapters on learning morse, making simple equipment, abbreviations commonly used in amateur transmission and sundry other subjects not easily found elsewhere.

The publisher's address is New Ruskin House, Little Russell Street, London, W.C.1, and the price is 2s 6d (2s 9d by post).

Fleming's Pre-Valve Work

From Watts to Kilowatts

THE name of Sir Ambrose Fleming is inevitably bound up with the invention of the thermionic diode and this month celebrations are being held to mark the jubilee of the first valve patent (see October issue, p. 474). On such an occasion it is interesting to recall that Fleming had been engaged in radio work for some time before making his great invention, and can be considered as one of the pioneers of the spark transmission era.

Probably his most important pre-valve work was on the design of the famous Poldhu transmitting station, by means of which the Atlantic was first spanned by radio in December, 1901. Here he was acting as scientific adviser to the Marconi Company. Up to this time, radio people had been thinking in terms of the conventional induction-coil spark transmitter, but Fleming realized that a different approach would be needed for a station that would have to radiate kilowatts instead of watts.

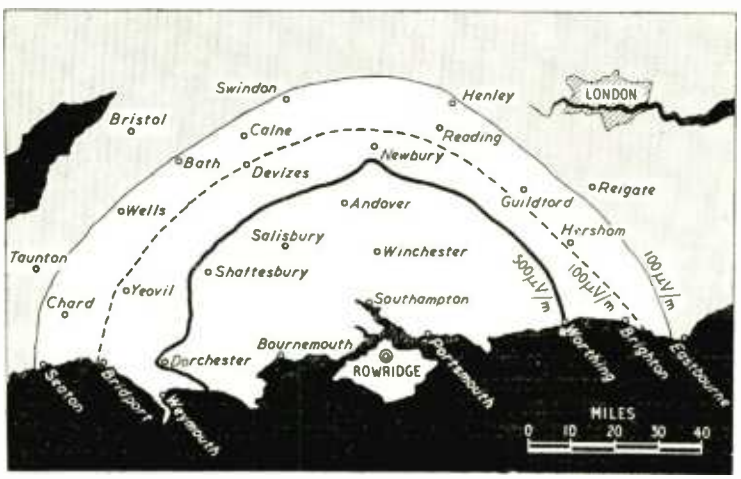
In place of an induction coil he specified an alternator driven by a 25-h.p. engine and working into high tension transformers to give an output voltage of 20kV. This arrangement fed an oscillatory circuit, having the usual spark gap and capacitor, which in turn was coupled by a step-up r.f. transformer to a second similar circuit. Finally came a radio-frequency transformer or "jigger" for coupling to the aerial. Keying the transmitter was achieved by short-circuiting air-core chokes inserted in the leads running from the alternator to the high-tension transformer.

Fleming's contribution to the famous transatlantic experiment is commemorated on the granite column which marks the site of the station on the cliff-top at Poldhu.

SOUTH COAST TV STATION

Coverage of Isle of Wight Transmitter

Provisional field-strength contours of the new Rowridge, Isle of Wight, television station which has been radiating test transmissions for the past fortnight and is scheduled to be brought into service on November 12th. The station, which operates in Channel 3 (56.75 and 53.25 Mc s), will use initially a temporary mast and aerial system and the service area will, therefore, be restricted. The anticipated 100-μV m contour for the temporary aerial is shown dotted on this map. This and the other contours are based on a receiving aerial height of 30ft. The temporary station on Truleigh Hill, near Brighton, which has been serving part of this area of the south coast since May last year, will close down.



WORLD OF WIRELESS

C.C.I.R. Interference Investigation • Receiver Exports • Personal and Industrial Notes and News

I.F. for TV

REALIZING that a nationally protected i.f. band for television does not offer protection against interference from other countries, Italy has asked the International Radio Consultative Committee (C.C.I.R.) to study a number of questions relating to interference with television reception and interference to other services by television receivers.

Among the specific subjects to be studied are: the factors which govern the frequencies and amplitudes of undesired receiver responses and the characteristic values for different types of receiver (sound, television, etc.); the methods which can be adopted to reduce these responses without greatly increasing the cost of receivers (the choice of i.f. falls into this category); the best methods for measuring and evaluating local oscillator and i.f radiation; typical values of the amplitudes of these radiations and the variation of their power as a function of distance; the methods whereby a useful reduction in the amplitudes of these radiations could be achieved without appreciable increase in receiver costs and the extent of this reduction.

Information on these subjects is to be submitted by national representative organizations to the C.C.I.R. and, in the meantime, the European Broadcasting Union Document Tech. 3062 (see our July issue) has been submitted as a contribution to the inquiry.

Amateur Radio Show

AT noon on November 24th, the eighth annual Amateur Radio Exhibition, organized by the Radio Society of Great Britain, will be opened at the Royal Hotel, Woburn Place, London, W.C.1, by H. Faulkner, C.M.G., director of the Telecommunication Engineering and Manufacturing Association. The exhibition will continue until November 27th and be open daily from 11.0 a.m. to 9.0 p.m. Admission is 1s.

Members of the R.S.G.B. will be exhibiting a wide range of home-constructed equipment, and the following manufacturers and organizations are taking space: Air Ministry, Amos, Avo, Cosmocord, English Electric, Enthoven Solders, G.E.C., Grundig, Labgear, Magnetic Devices, Minimitter Co., Philpotts, Pye, S.T.C., *Short Wave Magazine*, Taylor Instruments, War Office, *Wireless World*.

Television Exhibition

THE Television Society's annual exhibition will be held from January 6th to 8th in the gymnasium at University College, Gower Street, London, W.C.1. Admission on the opening evening (6.0-9.0) is limited to members, but tickets will be available to non-members for the following two days, when the show will be open from noon to 9.0 p.m. and 10.0 a.m. to 7.0 p.m. respectively. Tickets will be available from the secretary at 164, Shaftesbury Avenue, London, W.C.2.

About 40 exhibitors will be participating. The majority of exhibits will be laboratory equipment provided by manufacturers, but there will be some members' exhibits. The exhibition is concerned more with research and industrial television than with domestic reception.

Middle East Market

TWELVE receiver manufacturers are sharing the B.R.E.M.A. pavilion at the British Trade Fair which is being held in Baghdad from October 25th to November 8th. The firms participating are: Bush, Cossor, Ekco, E.M.I., English Electric, G.E.C., Kolster-Brandes, Mullard, Murphy, Philco, Pilot and Regentone. Other radio and electronic manufacturers participating in the Fair are B.I. Callenders, Ediswan, Ever Ready, Pye, Redifon, Roberts Radio, S.T.C., and Thorn Electric.

Television programmes for the demonstration of receivers at the Fair are broadcast by a temporary transmitter (using a 60-foot mast) installed by Pye.

The Middle East is regarded as one of the most promising markets for British radio equipment. Figures provided by B.R.E.M.A. show that the value of receivers and radio-gramophones exported to this area in the first eight months of this year almost equalled those for the whole of 1953—£364,906, compared with £412,359.

"No Half-way House"

"NOW that colour has become the obvious next move in the development of television, let us learn from our past mistakes and not again hitch ourselves to a wrong system [as in 1946 when we re-adopted 405 lines]. . . . Let us make our own mistakes if we must, but not a mistake just because the Americans have already made it. . . . The system we start with is the system we shall end with, and in my opinion it rules out any public experiment of a compatible or semi-compatible system in Band III with the hope that later we will be able to move colour television to Bands IV and V." This extract is taken from a speech by C. O. Stanley printed in the annual report of Pye, Ltd., of which he is chairman. He concluded by saying that the radio industry, as a whole, could and should provide the answer to the colour TV question, and not wait for any committe, Government or otherwise, to produce a recommendation.

Servicing Exams

OF the 367 candidates who sat for the Radio Servicing Certificate Examination last May, 143 passed, 96 were put back in the practical test and 128 (35 per cent) failed. The percentage of failures in the television servicing exam was lower—28 per cent. Of the 104 entries 55 passed, 20 were put back in the practical test and 29 failed. The examinations, which are conducted jointly by the Radio Trade's Examination Board and the City and Guilds of London Institute, were held at 24 centres for radio servicing and 7 centres for television servicing.

As mentioned in our last issue the 1955 radio servicing exams will be held on May 3rd and 5th (written) and 14th (practical). Those for television servicing will be on May 9th and 11th (written) and June 18th (practical). Entries for the television servicing exam. (fee 3 gns), must be sent to the R.T.E.B., 9, Bedford Square, London, W.C.1, by January 15th, and those for the radio servicing exam. (fee £2 12s 6d), by February 1st.

PERSONALITIES

Dr. W. H. Penley, B.Eng., Ph.D., A.M.I.E.E., who in 1940 joined the Telecommunications Research Establishment and for the past four years has been superintendent, air defence radar, has been appointed senior superintendent, guided weapons, at the Radar Research Establishment, Malvern, which now incorporates T.R.E.

Group Captain R. C. Richmond has been appointed to the London Office of Marconi's Wireless Telegraph Company (Marconi House, Strand, W.C.2) where he will be concerned with the Company's aeronautical radio business. He joined the R.A.F. in 1929, and took the specialist signals course. During the war he was Chief Signals Officer of various commands and was at one time Chief Signals Officer, Air Defence of Great Britain. Prior to retiring, Group Captain Richmond was Commanding Officer of No. 2 Radio School, Yatesbury.

Grp. Capt. R. C. RICHMOND

S. E. ALLCHURCH

S. E. Allchurch, O.B.E., secretary of the British Radio Equipment Manufacturers' Association since 1946, is at the British Trade Fair in Baghdad to take charge of the composite exhibit of domestic receiving equipment by 12 member-firms. During the war Mr. Allchurch joined a new department of the Ministry of Aircraft Production which dealt with the co-ordination of research, development, production and installation of communication and radar equipment for the R.A.F. He was assistant director when he left to join B.R.E.M.A.

William H. Date, B.Sc.(Eng.), M.I.E.E., has retired from the position of head of the Electrical Engineering Department of the Polytechnic, Regent Street, London, which he has held for seven years. He joined the full-time staff of the department in 1913. During the first world war he was a technical officer (wireless) in the Royal Flying Corps and during the last war was lent to the War Office and was attached to the department concerned with the organization of training schemes for Service men at technical colleges throughout the country.

The new head of the Electrical Engineering Department of the Polytechnic is **Dr. D. O. Bishop,** Ph.D., who received his academic training at the Portsmouth Municipal College and then went to B.T-H. at Rugby. After war service as an education officer in the R.A.F. he returned to the Portsmouth Municipal College and became senior lecturer in 1947. He joined the Regent Street Polytechnic as senior lecturer in the Electrical Engineering Department in 1948.

G. E. Middleton, M.A., the new chairman of the I.E.E. Cambridge Radio Group, went to B.T-H., Rugby, after graduating from Cambridge in 1927. During his 21 years with B.T-H., one of which was spent in the U.S.A. under the company's Fellowship scheme, Mr. Middleton was engaged on the design of small motors. In 1948 he went to Cambridge as university lecturer in engineering—his present position.

Major P. L. Barker, B.Sc., this year's chairman of the Northern Ireland Centre of the I.E.E., has been chief engineer of the N. Ireland Region of the Post Office since 1946. After graduating from Birmingham University in 1923 he entered the Post Office Engineering Department. From 1925 to 1935 he was at the Dollis Hill Research Station working on short-wave propagation and from 1936 until he was commissioned in R.E.M.E. in 1940 he was at the Wembley Laboratories.

Dr. J. H. Mitchell, Ph.D., B.Sc., the new chairman of the East Midland Centre of the I.E.E., has been head of research with Ericsson Telephones, Ltd., Nottingham, since 1947. He studied at Bristol University after which he joined B.T-H. at Rugby as a research engineer. During the war Dr. Mitchell was a member of the Government Scientific Research Pool and undertook research on radar and radio navigational aids and v.h.f. communication.

David H. Thomas, M.Sc.Tech., chairman of the North-Eastern Radio and Measurements Group of the I.E.E. for this session, was for eight years lecturer in telecommunications at the University of Nottingham and is now head of the Electrical Engineering Department of the Rutherford College of Technology, Newcastle-upon-Tyne. Before entering the scholastic field he was a research engineer with Metropolitan Vickers whom he joined as an apprentice.

M. I. Forsyth-Grant, A.M.I.E.E., has resigned from International Aeradio, Ltd., with whom he had been chief engineer since 1952, and has joined the board of Racal Engineering, Ltd. Before joining I.A.L. in 1947 he was with E.M.I. Engineering Development, Ltd. **D. W. Morrell,** B.Sc.(Eng.), A.M.I.E.E., who has been sales manager of Racal for the past 18 months, has also been appointed a director.

A. R. Lash, A.M.I.E.E., recently appointed manager-engineer of the Ongar (Essex) radio station of the Post Office, was previously on the staff of Marconi's W.T. Co. and Cable & Wireless. His duties as a radio communications engineer have taken him as far north as Spitsbergen and as far south as the Falkland Islands.

OUR AUTHORS

W. R. Cass, who, with R. M. Hadfield, contributes the article on "Dip-soldered Chassis Production" in this issue, is in charge of the Methods Development Department of Pye, Ltd., Cambridge. Joining Pye from Telephone Rentals, Ltd., in 1951, he was initially connected with power control and television receiver circuitry development. Mr. Cass obtained the Higher National Diploma in Telecommunications at the Regent Street Polytechnic and was an electronics instructor in R.E.M.E. during the war **R. M. Hadfield** studied at Reading University after serving as a pilot in the R.A.F. In 1952 he joined the Methods Development Department of Pye, Ltd., and is now responsible for operational research and work study development.

Arieh F. Fischmann, author of the article on the design of a tape recording amplifier on page 564, is at present studying at the Polytechnic Institute of Brooklyn, U.S.A. After training at the Deutsche Technische Hochschule, Prague, he emigrated to Palestine in 1938 where he worked on the design of audio amplifiers. From 1948 until going to Brooklyn he was in the Scientific Department of the Israeli Ministry of Defence on development work in the field of pulse techniques.

H. H. Ogilvy, contributor of the article on the measurement of phase and amplitude in this issue, has been employed in the fire-control section at the Admiralty Engineering Laboratory, West Drayton, Middlesex, since 1951. He is concerned with the development of electronic equipment for fire-control systems and the design of equipment for analysing the performance of servo-mechanisms. After war service as h.f. direction-finding

officer in the Navy he took a full-time engineering course at Loughborough College from 1946 to 1950.

IN BRIEF

Broadcast Receiving Licences current in the United Kingdom at the end of September totalled 13,527,864, including 3,677,796 for television and 245,836 for sets fitted in cars. During the month television licences increased by the unprecedented figure of 144,098.

Electronics in Action is the theme of an exhibition of electronic aids to production, design and research being organized by the Scientific Instrument Manufacturers' Association for November 23rd to 25th at the Chamber of Commerce Hall, New Street, Birmingham. Admission to the exhibition is by complimentary ticket, obtainable from S.I.M.A., 20, Queen Anne Street, London, W.1, or the Chamber of Commerce. The exhibition, at which there will be some 20 exhibitors, opens at 2.0 on the first day and 10.0 on subsequent days and closes daily at 8.0.

This combination aerial for television and f.m. sound, exhibited by Belling-Lee at the Radio Exhibition, was by mischance overlooked when our review of the show was compiled for last month's issue

The proposed dates for the second post-war **Northern Radio Show** which the Radio Industry Council plans to hold in the City Hall, Manchester, have been amended; they are now May 4th to 14th, 1955

I.T.A.—The temporary headquarters of the Independent Television Authority, of which Sir Robert Fraser is director-general, are at 12-16, Wood's Mews, Park Lane, London, W.1. (Tel.: Mayfair 6272). The I.T.A. has, so far, been operating from the Post Office headquarters.

The P.M.G. has relaxed one of the regulations included in the recently introduced **Amateur (Television) Licence.** Holders may now transmit messages by telephony or morse without a separate licence provided they are concerned with the technical matter of the visual transmission.

Extending French TV.—The fourth French television station—at Marseilles—was brought into service in September. Operating on 186.55 Mc/s vision and 175.4 Mc/s sound, the 819-line transmitter has an e.r.p. of 50 kW. Initially the station is relying on filmed programmes flown from Paris. On October 15th the fifth television station was brought into service at Lyon-ville which is linked with Paris by radio relay stations. The Lyon-ville 200-watt transmitter operates on 164 Mc/s vision and 175.15 Mc/s sound.

Brit.I.R.E. Awards.—The Clerk Maxwell premium (20 guineas) has been awarded by the British Institution of Radio Engineers to Dr. W. Saraga, D. T. Hadley and F. Moss for their paper "An Aerial Analogue Computer"; the Heinrich Hertz premium (20 guineas) is given to B. E. Kingdon, for his paper "A Circular Waveguide Magic-Tee and Its Applications to High-Power Microwave Transmission"; Dr. D. A. Bell receives the Louis Sterling premium (15 guineas) for "Economy of Bandwidth in Television"; Dr. Paul Eisler the Marconi Premium (10 guineas) for "Printed Circuits—Some General Principles and Applications of the Foil Technique" and J. A. Youngmark the Dr. Norman Partridge Memorial award (5 guineas) for "Loudspeaker Baffles and Cabinets." The first award of the Sir J. C. Bose Premium (250 rupees—approx. 18 guineas) for the most outstanding paper by an Indian engineer has been made to S. K. Chatterjee for "Microwave Cavity Resonators—Some Perturbation Effects and Their Applications."

Cable and Wireless announce the opening of the first direct **Radio-telephone Service** between Aden and India on October 15th. A radio-telephone service between Aden and London and thence to Europe and north America is also provided by the company via its station at Nairobi.

The **Radar Association**, which, although originally formed as a social link between ex-R.A.F. "radar types," is now open to radar engineers and technicians in the other Services and industry and holds regular lecture meetings. The second meeting of the 1954/55 session will be held at 7.30 on November 10th in Theatre No. 1 of the Lime Grove Television Studios, Shepherds Bush, London, W.12, when Group Capt. Philip Dorté and John Elliot (B.B.C.) will deal with the production of the television film "War in the Air." Tickets are necessary.

E.I.B.A. Ball.—The annual ball in aid of the funds of the Electrical Industries' Benevolent Association will be held at Grosvenor House, Park Lane, London, W.1, on November 12th. Tickets, price 2½ guineas, are obtainable from the association at 32, Old Burlington Street, London, W.1.

Two lectures on the design, construction and erection of **Television Aerials** are to be given by P. Jones, of Aerialite, Ltd., at the Gloucester Hotel, Aberdeen, on November 3rd and 4th at 3.0. Admission tickets are obtainable from Aerialite, Ltd., Castle Works, Stalybridge, Cheshire.

The Electrical Engineering Department of the **Oldham Municipal Technical College,** which is now occupying a new building, offers part-time day or evening courses in radio servicing (3 years), television servicing (2 years), telecommunication engineering and for the Higher National Certificate.

A series of eight lectures intended to present an up-to-date account of **Information Theory** and its implications in the field of communication engineering is to be given at the College of Technology, Manchester, on Friday evenings, beginning January 21st. The fee is 30s. Twelve-lecture courses on "Automatic Control in Industry," which began on October 26th, and "Transient Electrical Phenomena" beginning on January 13th (fees 35s) are also provided by the College.

Among the new courses provided at the recently opened engineering block of the **N.E. Essex Technical College** at Colchester is a year's evening course in electronics and measurements for the H.N.C. Part-time day and evening courses in preparation for the radio service work certificate of the City and Guilds of London Institute are also provided by the college which has a well-equipped radio servicing laboratory.

Information additional to that given in our September issue (p. 439) regarding courses provided by the **N.W. Kent College of Technology** (previously the Dartford Technical College) has been received from the head of the Electrical Engineering Department. An evening course in television servicing is provided and as an alternative to the evening course in radio servicing a part-time day course has now been introduced.

Properties of **Glass Reinforced Plastics** and their applications in various industries are dealt with in the 256-page book "Glass Reinforced Plastics," edited by Phillip Morgan and published for *British Plastics* by our Publishers, price 35s. One of the chapters deals with glass fibre laminates in the electrical field.

The second edition of Kenneth W. Gatland's book **"Development of the Guided Missile,"** which has been completely revised and enlarged, includes an appendix giving details of the telemetering equipment used in British missiles. Published for *Flight* by Iliffe and Sons Ltd., this 292-page book costs 15s.

Philips have arranged for the future distribution in this country of their three journals *Philips Technical Review*, *Philips Research Reports* and *Communication News* to be undertaken by Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8.

BUSINESS NOTES

Transmitters for the first three stations of the Independent Television Authority have been ordered from **Marconi's.** The vision transmitters will have a power of 10 kW and the associated sound equipment 2.5 kW. They will, of course, operate in Band III. To expedite the start of transmissions from the London station at Crystal Palace prototypes of the transmitters are being lent to the I.T.A.

International Aeradio, Ltd., of this country, and Adalia, Ltd., of Montreal, Canada, have entered into an agreement to pool their knowledge, experience and staff in order to offer consultancy services to governments and industry throughout the world. Their first joint contract is for the planning of a telecommunications system for the Creole Petroleum Company, of Venezuela.

Claude Lyons, Ltd., the well-known manufacturers of Variac transformers and importers of American laboratory instruments, have acquired a new factory at Valley Works, 4-10, Ware Road, Hoddesdon, Herts. (Tel.: Hoddesdon 3007.) The London office has closed, but the head office and works will remain at 76, Oldhall Street, Liverpool. The new factory houses the research and development staff and provides a repair and recalibration service.

The Service Department of **Baird Television** has been transferred to 308, Battersea Park Road, London, S.W.11 (Tel.: Battersea 7838). All correspondence relating to servicing and replacement parts for television receivers and Baird tape recorders should be sent to this address.

The West Bromwich firm of spring manufacturers, George Salter & Co., Ltd., have built a **"Dry Room"** to Ministry of Supply regulations for the packing of electronic equipment under conditions which ensure that it is not only impervious to outside climatic changes but also that each piece of equipment is thoroughly moisture-free before being packed.

The recently opened factory of **20th Century Electronics** at New Addington, Surrey, has now been extended, doubling the floor space. The manufacturing and research sections of the cathode-ray tube department, formerly at Dunbar Street, London, S.E.27, are now at New Addington, where new plant has been installed for the production of multi-gun tubes. All correspondence should now be addressed to King Henry's Drive, New Addington, Surrey. (Tel.: Springpark 1026.)

Electric Audio Reproducers, Ltd., manufacturers of sound reproducing equipment, of 17, Little St. Leonards, Mortlake, London, S.W.14, have opened a new factory at Worton Road, Isleworth, Middlesex. The development section will occupy part of the factory, but the offices and service department will remain at Mortlake.

A new branch office and depot at 2, St. Nicholas Buildings, Newcastle-upon-Tyne, 1, has been opened by the **Telegraph Construction and Maintenance Company.** The company has also opened a London sales office at Norfolk House, St. James's Square, S.W.1.

Hudson Electronic Devices, Ltd., of Appach Road, London, S.W.2, have appointed Pendry & Kennedy (Electronics) of 6, Coed Celyn Road, Derwen Fawr, Swansea, to handle the land sales and services of their v.h.f. radio-telephone equipment in the south Wales area.

Transvision, Ltd., has been formed by B. J. Martindill, until recently general manager of Wolsey Television, and F. Gould, for the production of television and v.h.f. aerials and accessories. The address is 118, Denmark Hill, London, S.E.5. (Tel.: Brixton 6551.)

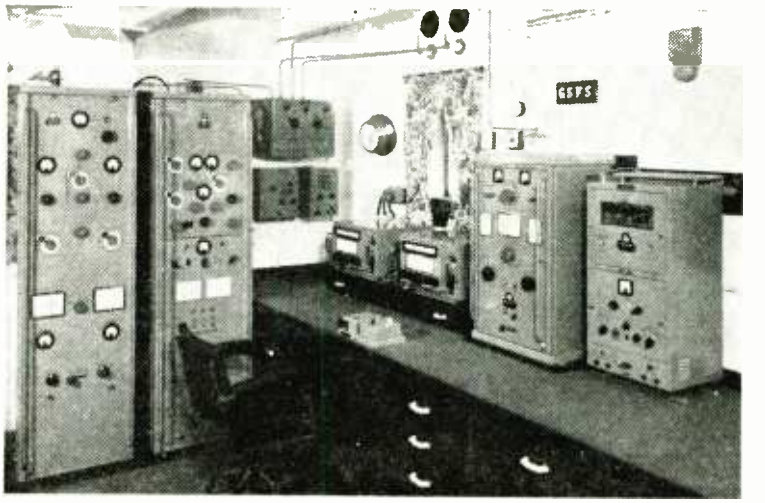
FOREIGN TRADE

Redifon, Ltd., has received a substantial order for marine radio equipment on behalf of the Soviet Fishing Authority. The equipment, comprising transmitters, all-wave receivers, combined medium- and short-wave direction finders and ancillary units, will be installed in twenty deep-sea fishing vessels now under construction for the Soviet Union at Lowestoft, Suffolk.

Haiti.—The British Embassy at Port-au-Prince has received an enquiry from a Government source in Haiti for the supply of robust, cheap battery receivers for use in rural areas. The proposal is to supply about 500 sets for domestic use or for use by small groups, or, alternatively, to equip a smaller number of centres with larger receivers designed for communal use. Manufacturers are invited to send details of their offers direct to H.M. Consul-General, British Embassy, Port-au-Prince, Haiti, W. Indies.

Salvador Agency.—Almacen Liverpool, Calle Ruben Dario-32, San Salvador, are interested in securing an agency for British-made domestic receivers. Transmitters in the western hemisphere operate on medium waves and the mains voltage in Salvador is 110 (50 c/s).

Colombian Agencies for British-made components and accessories are sought by Almacen Radion, Guillermo Ibanez, Calle 36, No. 41-78, Barranquilla, and J. Angers, Apartado Aereo 913, Barranquilla.



WIRELESS ROOM in the 3,300-ton cable ship Recorder, *the latest and fastest vessel in the Cable & Wireless fleet of eight. Marconi's installed the radio-communication equipment and Kelvin & Hughes the radar and echo sounders. An aerial-splitter system permits the use of 35 broadcast receivers in the ship without interference from the transmitters.*

Dip-Soldered Chassis Production

Simplifying the Assembly of Sound and Television Receivers

By W. R. CASS,* H.N.D., Grad.I.E.E., and R. M. HADFIELD,* B.A.

IN the endeavour to reduce the cost of mass-produced electronic assemblies it became apparent that a simpler way of making electrical connections was needed. Conventionally, pliers are used to anchor connecting wires to tags and then solder is applied with an iron to make these mechanical connections into sound electrical joints. In a television receiver there are between 500 and 800 such connections to be made.

After costing several systems it was decided that the most suitable basic technique was one in which all connections are made simultaneously with a single dip in hot solder. For this method it is convenient to bring all points of interconnection into one plane. This is done by laying all the components on an insulated board and inserting their pre-formed wire ends into holes so that all points to be soldered are on the underside. Once such a layout has been adopted it is a short next step to use a printed wiring pattern on the underside of the chassis to replace the wire links which connect one part of the circuit with another.

Superficially it might appear that the addition of printed wiring is of little value, since it obviously costs more than the wires it replaces and only saves a small amount of assembly time. However, this is not so, because the most important function of printed wiring is not, as its name suggests, to eliminate wire links, but to provide a base for dip-soldering. At each component junction a piece of copper foil surrounds the wires, even if there is no circuit line joining this point to another point. This piece of copper picks up solder, which links the adjacent component wires. Besides assisting the soldering of electrical connections, small areas of copper foil left on the board provide points to which the heavier components can be secured in the dip-soldering operation. This saves much mechanical fixing with screws, brackets, etc. A dip-soldering system that does not use a printed wiring base must make use of eyelets at all points where a soldered connection is required. The insertion of these eyelets costs more in material and labour than does a printed wiring board.

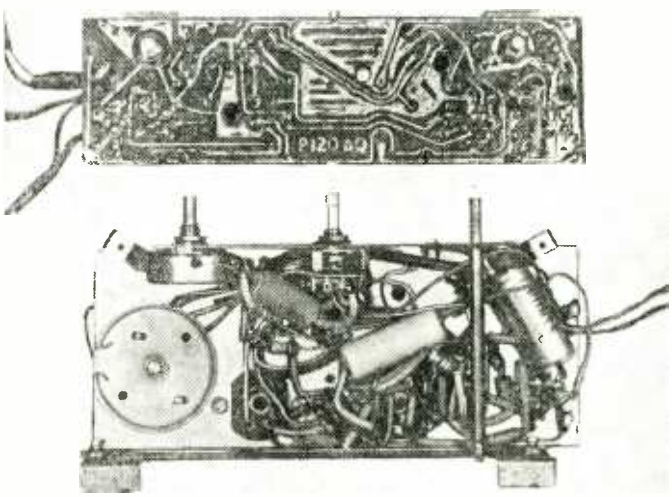
Four times as many sound or television receiver chassis can be made by an assembly line using the dip technique as can be made by one using hand assembly methods. This means not only lower labour costs but reduced overhead costs per unit as well. Savings of the last-mentioned include supervision, factory space, heating, lighting, power and soldering-iron maintenance. It must be emphasized, however, that the assembly cost in mass-produced television and sound receivers is only a small fraction of their total cost. Thus, even the 300 per cent improvement in chassis assembly productivity achieved will only result in overall cost savings of the order of 2-3 per cent.

Material savings result from the elimination of nearly all brackets, tag strips, sleeving, wire, screws, eyelets and rivets. These savings more than offset the extra cost of the copper-faced Bakelite chassis. Some of the savings are possible because the mechanical attachment of many components becomes unnecessary: all forms of screening can be dip-soldered, and trimmers, valveholders, transformers and large capacitors need no additional fixing. Other savings result from the fact that much insulation can be dispensed with when a non-conducting chassis is used. At present this means that neither sleeving nor insulated resistors are necessary in the receivers, and ultimately it will result in cheaper valveholders and transformers as well.

The elimination of the above items plus the use of a laminated Bakelite chassis results in considerable weight saving; this reduces the problem of adequately securing the assembly in a cabinet. The weight saved on the chassis varies from 1lb on a small sound receiver to 4lb on a television set.

Generally, electronic units made by this technique and using conventional components show little reduction in size. It is hoped, though, that with the efforts of the component designers taking advantage of this

* Pye, Ltd.



Underside view of a 4-valve battery receiver made by the "dip-circuit" technique with (below) the same chassis made by conventional methods. The top of the dip-soldered chassis is shown in the picture at the top right of page 538.

new approach to manufacture, drastic reduction in equipment sizes will be achieved.

A description will now be given of the manufacturing methods used to produce a complete "dip-circuit" chassis. First of all the production of the chassis circuit board.

Bakelite faced with copper foil is supplied in 9-in wide strip. This is fed through a piercing and shearing tool which makes some of the larger holes and cuts the material into pieces the size of the chassis blank. Two of the holes made at this stage are for location during printing and during the subsequent major piercing operation.

An acid-resistant ink is next printed on to the copper face of the boards in the pattern of the circuit. The boards are placed, ready for etching, in special acid-proof racks as they leave the printing stage. The printing is done by the silk-screen method. This equipment is cheap and is suitable for work on Bakelite. Output at the rate of 150 circuit boards per hour is maintained with standard equipment, modified to enable the operator to raise the screen frame by a foot pedal. This has reduced fatigue and permits a less complex pattern of hand motions. The operator's hands are not required for lifting the screen frame and so are left free to handle the squeegee and the circuit boards.

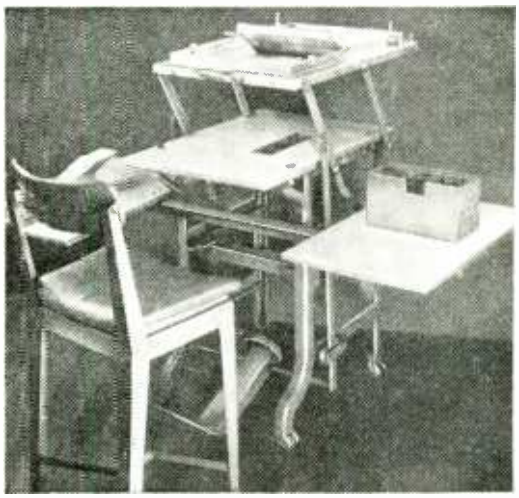
Preparation of the silk-screen master from the photographic plate.

Etching the Circuit

Etching is carried out in tanks containing a solution of nitric acid and copper nitrate. A constant balance is maintained between the acid solution and the weight of copper dissolved in it by calculating the quantity of acid required to etch one chassis and then adding a quantity of acid appropriate to the number of chassis being etched, plus a fixed percentage. The size of this fixed percentage determines the rate at which etching takes place. A 10 per cent excess of acid (which means, in effect, a 10 per cent wastage) gives an etching time of six minutes, using a solution 50 per cent by weight nitric acid in water. This acid wastage varies inversely with the etching time but prolonging the etching time beyond six minutes saves very little acid. Fresh acid is added at the top of the tank and the outflow is taken from the bottom. Turbulence created during etching ensures that the acid is well mixed.

Ferric chloride is sometimes used for etching purposes but we are using nitric acid because it has the following advantages. (a) Four hundred chassis can be etched in six minutes using very simple equipment; no mechanical agitation is needed. To achieve this rate with ferric chloride very expensive equipment is required. (b) Ferric chloride is awkward material to handle and requires heating, stirring and the addition of hydrochloric acid to bring it into solution, whereas nitric acid is readily diluted with the necessary water. Against this must be set the problem of fumes when using acid; this, however, has been solved by using standard extraction equipment. (c) Nitric acid is 30 per cent cheaper to use than ferric chloride.

After etching, the boards are rinsed in water, neutralized in a 2 per cent solution of ammonia and then rinsed again. It was decided to use ammonia in preference to sodium bicarbonate because ammonium salts are volatile, and if traces remain on the board they are dispersed during dip-soldering. Next, the circuits are pierced to take the component wires and the valveholder contacts. Finally, the circuits are

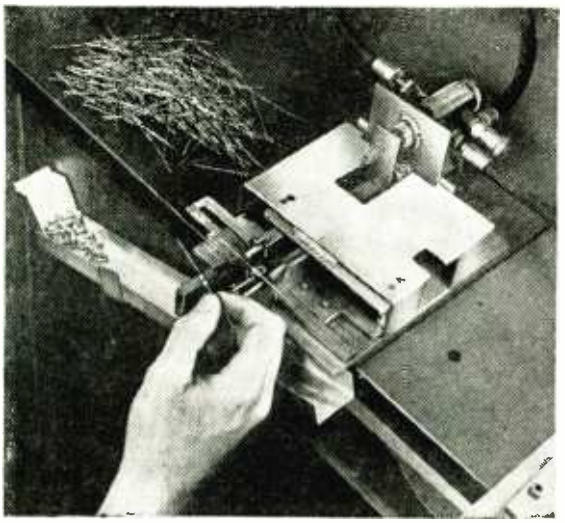


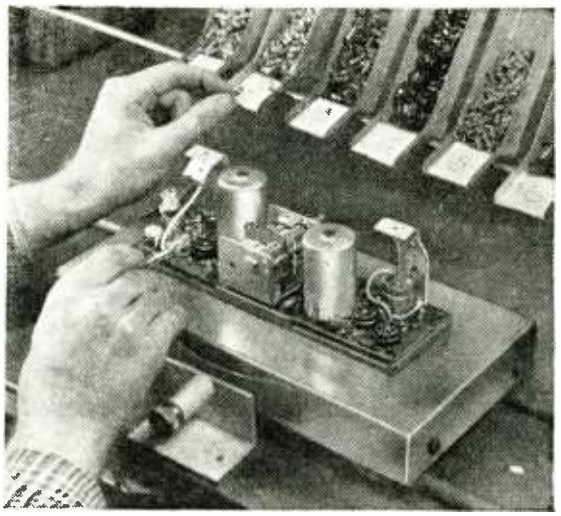
Silk-screen printing machine with foot-operated frame.

placed in a trichlorethylene degreaser to remove the resistant ink.

To make the maximum use of the labour-saving possibilities of "print-dip" technique, the wire ends of the resistors and capacitors are pre-formed suitably for direct insertion into the holes in the chassis. A machine to do this has been made which cuts and bends both wires of the component and which can be hand fed at rates of 1,200 to 1,500 components per hour.

The machine is driven by a compressed air cylinder linked to an air valve in such a way that it operates automatically once the air is turned on. It can be set to any speed to suit the operator and the position of the cutting and forming blades is continuously adjustable to leave any wire length that is desired. When they have been formed the components drop into a container. This container is one of the interchange-





Left: Wire cutting and forming machine for resistors. Right: Part of the assembly line for the 4-valve dip-soldered battery set whose underside is shown in the picture on page 536.

able component storage bins used on the assembly line.

Both the rigid layout imposed by the system and the mechanical pre-forming of the components have tended to standardize assembly operations. This improves assembly efficiency and leaves less to chance in positioning the components—it is virtually impossible to build a short circuit into a printed assembly.

Assembly Trolleys

The fact that only one side of the chassis has components on it has simplified assembly cradles and work on the chassis. Material layout has also been helped because the pre-formed components are more compact and require less bench space. The assembly cradle is a rubber wheeled trolley free to run in a channel on an ordinary wood-topped bench. A shallow rectangular frame is used to locate the chassis on top of the trolley. At each work station there is a spring loaded catch for retaining the trolley while it is being worked on. Trolleys from the end of the line are returned to the beginning on a sloping shelf at the back of the assembly bench.

Component storage bins are of the gravity-delivery type with a protruding lip at the bottom to facilitate the selection of material. The lip of the bin is clear of the bench so that, with the thumb under the lip and the forefinger on top, the resistor or capacitor can be drawn to the edge and held between the thumb and finger as it comes clear of the bin.

For dip-soldering a machine has been devised to do the job because, while it can be done quite simply by hand, the quality of the soldered joints is so important and the factors which can vary are so numerous that to obtain consistent results a mechanical method is necessary.

To use the machine the operator simply hooks the chassis on to a bracket and presses a button. The machine then moves the chassis to a flux spray position, then gives it two dips in the solder. During these dips, and for a short period after each one, the chassis is vibrated. This vibration helps to break down any oxide film on the circuit or on the components and also removes any excess of solder.

Finally, the machine ejects the completed chassis and returns it to the operator for inspection.

There are some benefits accruing from the introduction of "dip-circuits" whose value it is difficult to assess, but which may turn out to be important in the long run:—

1. Storage and material handling will be less for the smaller, non-insulated pre-formed components.

2. Training time will be cut down, as workers will no longer require skill in the use of pliers and soldering irons.

3. Testing, inspection and repair time will all be cut because of the reduction in wiring errors and the ease with which such errors that remain can be detected on the accessible layout that "dip-circuits" provide.

4. The quality of the finished product will be improved and more easily controlled. The rigid layout of the printed wiring assembly will impose a uniformity not obtainable with conventional assembly methods. This uniformity will, of course, mean better quality as closer adherence to the designed performance will be achieved. It must also be emphasized that the mechanization of the soldering operations will greatly improve the reliability of the units.

5. The servicing of a "dip-circuit" chassis will differ only slightly from that of a normal one. Faulty components can be cut away from the top side of the chassis, or, alternatively, the components can be removed by heating the soldered joints on the reverse side with a small-wattage iron and pulling out the components. As there is no mechanical wrapping of the component wires and no wiring mistakes are possible, servicing time will be reduced. In cases where, due to misuse, the printed wiring pattern has been broken, a wire replacement can easily be inserted or the gap can be closed by the use of a soldering iron.

There will be other changes that will be less welcome. For example, in the immediate future purchasing policy will be less flexible because the rigid circuit layout will not permit any change in the middle of a production run to components of a very different shape or size. Later on this may bring benefits by stimulating standardization among the products of different manufacturers.

Another consequence of adopting the printed layout will be an increase in the cost of circuit modifications after tooling. Alterations to the circuit pattern are quite a simple matter, but modifications to the chassis piercing tools are expensive. This does not mean that there need be serious delay in the introduction of modifications, because temporary expedients, such as the use of a drill jig, are available. However, it does mean that adequate pre-production planning will be at an even greater premium than it is at present.

Until a new process has been widely adopted there is usually a period when many firms are developing their own methods more or less in secret. This has certainly been the case with printed circuits. As a result, there has been no agreement yet in this country on standards of quality for the materials used, or on the dimensions and style of components for "dip-circuit" application. Unless the electronics industry, through its consultative bodies, soon agrees on the general direction that component development is to follow, the cost and quality of components is likely to suffer.

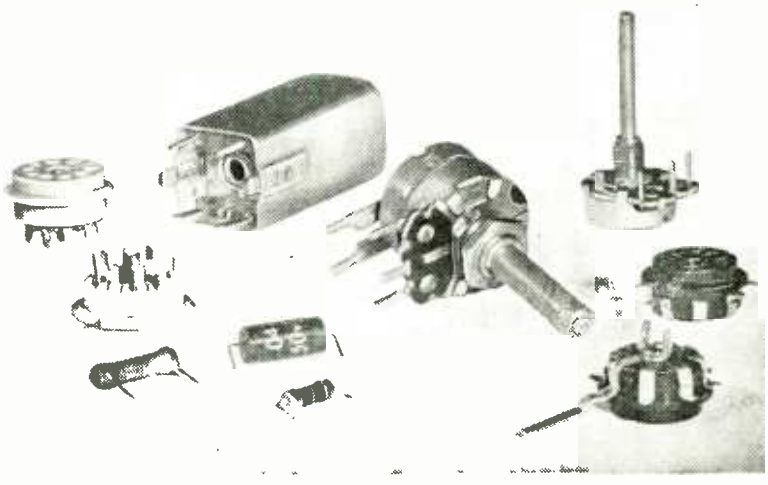
Automatic Component Insertion

With the advent of dip-soldering and printed wiring three-quarters of the possible saving on existing assembly times will have been achieved. If machinery were developed for the automatic insertion of components these times could be reduced by about a further one-tenth. This machinery would be highly specialized and would cost more to develop and install than would the equipment necessary for producing "dip-circuits." In view of this it is not likely that such equipment will repay development in this country, except in cases where production runs are very large or where part of an automatic component manufacturing process can be combined with the automatic insertion process.

A further argument against developing specialized machinery solely for component insertion is that the biggest scope for reducing the cost of electronic equipment lies with the component manufacturers. This may result in the development of components very different in shape and size from those commonly used at present. One such development, called "modular assembly" has already been tried in the U.S.A.* In this system small capacitors and resistors are printed on ceramic wafers and the wafers are assembled in tiers supported by wires; the wires also provide electrical interconnection. This tiered assembly or "module" is surmounted by a valveholder. Several such assemblies go to make a complete circuit and they can be assembled in one unit on a printed wiring base. In the opinion of the authors it has not yet been proved whether such an arrangement is really economical or has a very wide application, but it indicates the possibilities for a radically new approach to the problem of manufacturing electronic components.

Finally, there is the possibility of reducing the costs of component manufacture. In their essentials electronic units consist of four types of elements: capacitors, resistors, inductors and valves. With the possibility of transistors replacing valves there are left for consideration the first three types of elements. Reducing these in turn to their essentials, their costs are made up of: manufacturing labour, conductive and resistive material, some form of casing and terminals for assembly. Of these, the first offers scope for economy but the last two, performing no essential electronic function, are the main targets for material cost reduction. The largest labour savings will result from cheaper methods of producing inductors. In this field printed circuits will have an important part to play. The smaller inductors can be incorporated in the circuit pattern or printed on a separate circuit board which plugs into the base board. This method has been used commercially in the U.S.A. for the coils of a television i.f. strip. This strip was marketed as a separate unit, comprising three valves, five coils and the associated resistors and capacitors assembled on a printed wiring base. Larger inductors such as chokes, transformers and deflection coils need to be printed on a thinner, flexible base material and folded to make them into working units.

The elimination of non-essential material on resistors and capacitors can be achieved by the use of basic components without wires and with simpler insulation. To this end it is sometimes possible to include several electronic elements in one package. The printed circuit "couplet," which consists of a thin, flat, ceramic plate with multiple resistor and capacitor patterns silk-screen printed on one side, has done this and so also has "modular assembly." Multiple capacitor packs and transformers with several voltage tappings use this principle to a lesser extent. However, this trend towards multiple components conflicts with the standardization essential to economic mass production; it also increases the cost of rejects during manufacture. A more flexible system, making use of the physical configuration of either the "couplet" or the "module" but having standard or new-type basic components inserted during the final production process, will perhaps prove to be the best answer.



Components with electrical terminations made suitable for dip-soldering use.

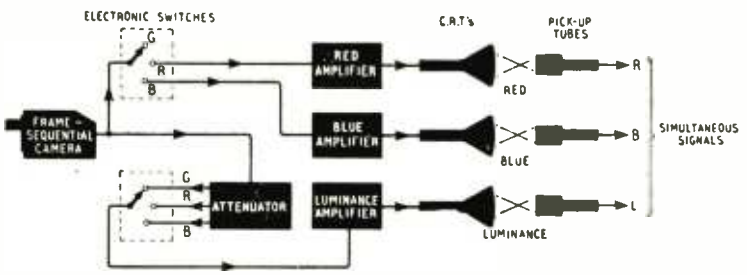
* See *Wireless World*, April, 1954, p. 185

Colour Camera Convertor

Adapting Frame-Sequential Pictures to Simultaneous Transmission System

THE frame-sequential system of colour television has been out of favour lately as a possible means of establishing a public colour service because of its non-compatibility—not to mention the difficulty of the rotating discs at the receivers. Despite this it is known to give very good colour pictures. Moreover, although the system as a whole may be unsuitable, there is a particular part of its equipment—the colour camera—which can offer some very definite advantages if incorporated in a simultaneous compatible system such as the one now operating in America.* This camera is much smaller and lighter than the three-tube type normally used and is simpler and less costly to produce. Having only one pick-up tube, it avoids the necessity for matching and registering the three separate tubes and also the need for three separate amplifiers. Moreover, it avoids the complex optical system which makes turret changes difficult and causes loss of light in the three-tube camera.

To permit the frame-sequential camera to be used in a simultaneous system a device called the "Chromacoder" has been produced. This operates on the three colour-component signals from the camera—red, blue and green—in such a way that they appear not in sequence but simultaneously. The original Chromacoder" was designed in America by the Columbia Broadcasting System and the General Electric Company, but recently a new version of the device has been demonstrated in this country by Emitron Television, a subsidiary of Electric and Musical Industries.



The principle of the Emitron convertor (see block diagram) is to take the sequential red, blue and green signals from the camera and pass them to an electronic switching system which distributes the red signals to one c.r. tube, the blue signals to another and certain proportions of all three signals to a third tube. These three c.r. tubes are then viewed by three pick-up tubes whose outputs give the simultaneous signals. Although the effect on the screens of the c.r. tubes is still sequential, the pick-up tubes store the images on their mosaics until they are scanned off and consequently the outputs become truly simultaneous.

The convertor is arranged in this particular way to make it suitable for the N.T.S.C. type of transmission system, which sends out a luminance signal to provide a monochrome picture for existing black-and-white receivers and two colour-difference signals to provide colour information. In the convertor the luminance information (a mixture of all three colour components) is received in sequential form by the appropriate c.r. tube and the associated pick-up tube integrates it into a complete luminance signal simultaneous with the colour signals. (The green component is recovered later at the receiver by subtracting the red and blue signals from the luminance signal.)

One advantage of this scheme over the three-tube type of "simultaneous" camera is that the three colour components which are added to form the luminance signal all come from the same pick-up tube—the camera tube. They are therefore registered perfectly with each other and no loss of definition occurs through mis-registration. In the three-tube camera, however, the three components come from separate tubes and this difficulty of registration has to be overcome. It is, of course, particularly important for the luminance signal to have good definition because the human eye has great acuity for fine detail in the form of brightness changes, and it is the luminance information which really controls the sharpness of the final picture. On the other hand, the eye is not very sensitive to detail in colour, so that as the red and blue signals from the first two pick-up tubes only provide colour information, not luminance, there is no need for these two tubes to be so accurately registered and give such good definition.

At the demonstration the frame-sequential camera was operating on 405 lines, interlaced 2:1, with 150 frames per second, and the bandwidth was 9 Mc/s. The three pick-up tubes, however, which were C.P.S. Emitrons, were scanned with 625 lines, interlaced 2:1, at 50 frames per second. No doubt the difference of standards helped to avoid the line-beating patterns which might have been caused by the interaction of two similar rasters, but E.M.I. say that there is no reason why two identical standards should not be used.

One inherent drawback of the convertor is that the storage in the pick-up tubes is liable to cause blurring of quickly-moving objects in the picture. This was particularly noticeable at the demonstration when the camera was panning from one subject to another. The colour rendering, however, was very pleasing on all the display systems used, which included an R.C.A. tri-colour tube and a three-tube projection unit.

* See *Wireless World*, November, 1953, p. 524.

Cathode-Follower Probe

For Test and Measurement

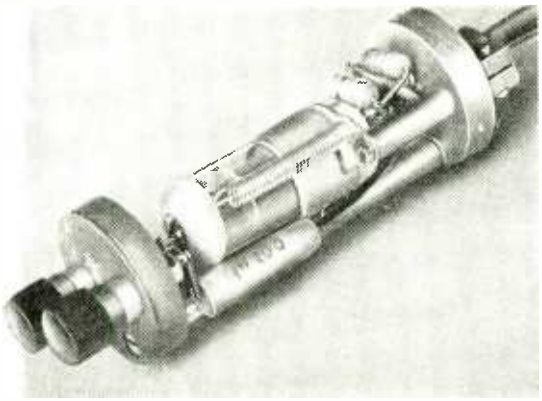
By SYDNEY H. FINN

IT is usually required of an electronic measuring device that its input impedance be high, but the value to which an amplifying-valve grid resistor may be raised is limited, particularly so if potentiometer attenuation is used. Some improvement on a continuously variable input potentiometer is possible by fitting a switch and equalizing each position independently. If a high value of resistance is used then a screening cover will probably be required to reduce hum pick-up. For some purposes the clicking of a switch would be a disadvantage.

In quite a number of instances it is possible, by fitting a probe housing a cathode-follower valve, to more or less completely solve the problem. The attenuator in the main instrument may then be of some conveniently low value, whilst the input impedance to the probe will be very high. By using a probe extremely short leads to the measuring point are possible, although the cable-form to the main instrument can be relatively long.

One such practical arrangement is shown in the circuit diagram and picture. As for some purposes it may be required to use a valve with a high cathode current the load resistor R_L is fitted to the socket on the main instrument, thereby avoiding undue heating of the probe. It also allows some flexibility, in that the same value of load resistance may not be desired for every instrument to which the probe is attached. The six-way socket is so wired that this resistor does not shunt the input circuit after removal of the probe. The cathode follower anode, being at earth potential (to a.c.), acts as a screen around the grid and there is normally no need to use a screened probe. In any case, the outside of the probe should be insulated, otherwise it may be a nuisance when working inside apparatus (particularly if using very short connecting leads) and one wishes to lay the probe down inside the chassis.

The mechanical arrangement is not necessarily the best that could be devised, but is very simple if a lathe is available. The base is made of an aluminium alloy, the outer sleeve of Paxolin tube, and the terminal plate of loaded ebonite (Caramot RM70). A cable clamp is an essential if the probe is to be much used



Construction of the probe with the Paxolin-tube cover removed.

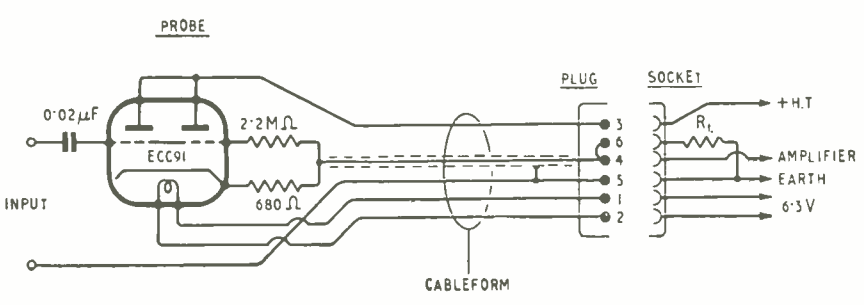
and would ideally be formed as part of the base. Actually it was modified from an already-existing device. A very simple type of clamp can be made using a short piece of angle with one end flanged. This is screwed to the base (by means of the flanges) so that the cable lies inside the included angle. Twine is then bound tightly round the whole, preferably within grooves filed on the edges of the angle. These grooves prevent any subsequent movement of the binding.

Choice of Valve

The particular valve fitted was used only because it was to hand and was adequate for the job. A triode-connected pentode of the Z77-EF91 type would do just as well. If for some reason a valve with a higher cathode current is required, the Osram N78 has a B7G base and a maximum anode dissipation (triode connected) of 12 watts. As screening will, in general, be unnecessary, ventilation can be provided without compromising the design electrically. The valve retainer is a Carr Fastener type 77/264.

Instruments designed to have an input impedance high in relation to, say, 600-Ω lines, are commonly found in the laboratory. This input impedance, which may be around 100kΩ, will often be the limiting factor in an otherwise first-class instrument. The fitting of a probe may greatly increase its scope, and perhaps even save the cost of a new instrument, if for any reason higher impedance networks must be dealt with. The author has found this probe a very useful instrument to use in conjunction with a c.r. oscilloscope.

If absolute measurements are required an initial calibration will have to be carried out, as the voltage output is somewhat less than the input.



Circuit of the probe with plug and socket connections. The load resistor R_L is 22kΩ nominal. For the plug and socket, Painton types 500693 and 500680 were used.

Miniature Bedside

Two-Valve A.C. Mains Circuit With Pre-set Tuning

THIS article describes a receiver recently built by the author for bedside use by a child. It is a very simple a.c. mains-operated receiver employing two valves and giving approximately 1 watt output from a 5-inch diameter loudspeaker. Tuning is pre-set, the local Home Service or Light Programme being selected by a 2-way switch. The receiver is relatively inexpensive to build and all the components, including the tuning coil, are standard commercial products which are readily obtainable. Where local-station reception is all that is required and great volume is unnecessary, the receiver is suitable for general domestic use.

As the receiver was intended for a child, consideration was first given to the use of batteries, but battery-replacement cost can be serious when a receiver is used in this way and mains operation was decided in spite of the additional bulk and first cost of mains transformer, rectifier and smoothing components. An earthed chassis was considered essential and a mains h.t. transformer is used although receivers with a filament transformer or an l.t. dropping resistor are smaller and cheaper. As the receiver is mains-operated it does not greatly matter if it is accidentally left on, but if this occurs the indicator lamp at the front serves as a reminder.

Great volume is not required from such a receiver and 1 watt output is quite adequate. This can be obtained from a miniature valve of the 6AM6 type for approximately 1 volt input, and two valves of this type give all the gain necessary for local-station reception. A second 6AM6 is therefore used as a leaky-grid detector, the two valves being coupled by a "starvation" circuit as shown in Fig. 1. This particular form of coupling has been described elsewhere[1,2] and is adopted because it is economical of components and gives high gain. It is not desirable, however, to carry the process of starvation too far, otherwise the receiver does not function very well on strong signals. V1 is a leaky-grid detector and, on receipt of signals, generates a negative bias on the control grid approximately equal to the carrier amplitude. If the valve has a very low screen-grid potential, the bias produced by a strong signal may cause the valve to operate on a markedly non-linear part of the I_a-V_g characteristic producing unpleasant harmonic distortion. To minimize this effect the screen-grid potential must be kept high to give V1 an adequate grid base; this sets an upper limit on the value of anode load which can be used and prevents full exploitation of the starvation circuit. In the compromise solution adopted by the author, the screen grid is operated at 40 volts and results are satisfactory provided that the input signals are reasonably small. If a long outdoor aerial is used, or in regions of particularly high field strength, it may be desirable to reduce the input to the detector. A convenient way of doing this is described later.

The required screen-grid potential of 40 volts is obtained in the following way. This potential is also that of the cathode of V2 and, for optimum results, V2 should consume approximately 12 mA. This gives the value of R_7 as $40/(12 \times 10^{-3}) = 3.3$ kΩ. The value of R_3 is now chosen to give a screen-grid potential of 40 volts. The value used by the author was 820 kΩ but others may find a slightly different value is required, dependent on the characteristics of the particular valve used as detector.

Gain Control

One of the difficulties of a circuit such as that shown in Fig. 1 is that of controlling gain. It is not possible to use a potentiometer in the coupling between the valves without upsetting operation of the starvation

[1] W. K. Volkers, "Direct-coupled Amplifier Starvation Circuits," *Electronics*, March, 1951.
[2] H. E. Styles, "Sensitive Two-valve Receiver," *Wireless World*, May, 1953.

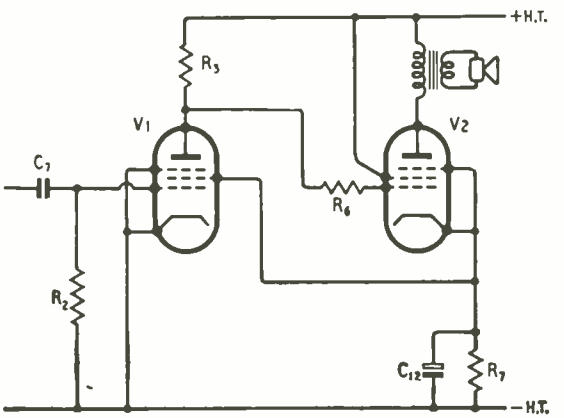


Fig. 1. Basic circuit of the receiver illustrating the starvation technique adopted.

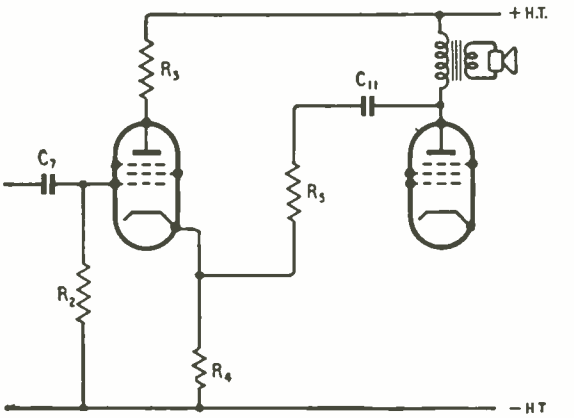
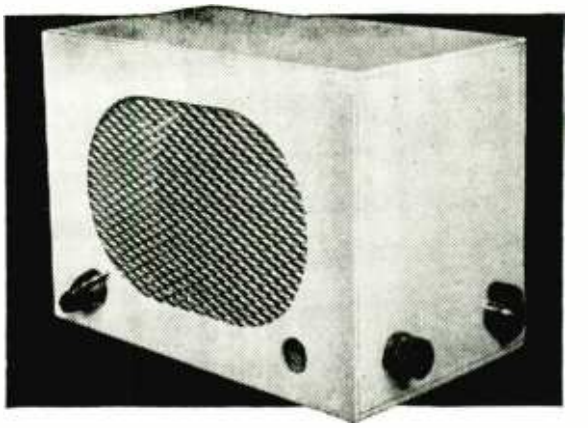


Fig. 2. Method of applying negative feedback without risk of instability.

Receiver

By S. W. AMOS,* B.Sc. (Hons.) A.M.I.E.E.



Translucent Perspex sheet was used for making the cabinet.

circuit. Practically the only form of gain control which can be used is one employing variable negative feedback. Such a method of gain control has the advantage that any gain in excess of that required at any moment is not " thrown away " in an attenuator, but is usefully employed in reducing distortion and improving loudspeaker damping.

Feedback gain controls usually have a number of disadvantages; for example their range is often inadequate, because the maximum degree of feedback is limited to a value which does not cause instability, and output volume cannot be reduced to zero. The circuit used in this receiver is free from these limitations; it was developed from the circuit shown in Fig. 2 in which a feedback potentiometer R_4R_5 is connected between the anode of V2 and the cathode of V1. This arrangement permits a very large degree of negative feedback without instability; in fact R_5 can be reduced to zero without provoking oscillation.

To give control of gain either R_4 or R_5 can be made variable. If R_4 is variable, it must have an inverse logarithmic law to give smooth control of volume; on the other hand if R_5 is variable this must have a logarithmic law to give smooth gain control. Accordingly R_5 is made variable and the circuit takes the form shown in Fig. 3. A further advantage of making R_5 variable is that, at the position of minimum gain, it effectively short-circuits the primary winding of the output transformer to give zero output from the receiver. However, the shunting effect of R_5 on the primary winding is undesirable at settings of R_5 other than near the minimum. This can be minimized by choosing the values of R_4 and R_5 in the following way. For reception of a reasonably strong signal the a.f. gain of the receiver averages approximately 1000. For such values of gain, the gain is determined by the constants of the feedback loop and is given approximately by R_5 R_4. To keep the a.f. loss in R_5 reasonably low, R_5 should preferably not be less than 100 kΩ (5 times the effective loudspeaker impedance at the primary winding). This gives the minimum value of R_4 as 100 Ω and a value of 140 Ω is used.

* B.B.C. Engineering Training Department.

Maximum Gain

There now arises another difficulty. To obtain maximum gain from the receiver there should be no feedback when R_5 is set to its maximum value. This requires that the ratio of R_5 to R_4 should be large compared with the internal gain of the circuit (i.e., the gain in the absence of feedback). The internal gain is approximately 60,000 (150 from V2 and 400 from V1) and thus R_5/R_4 should preferably not be less than say, 300,000. Since R_4 is 140 Ω, R_5 must be 42 MΩ! There is, however, no need for such a large value if the " free " end of R_5 is returned to h.t. negative as shown in Fig. 4. When R_5 is advanced to its maximum setting it now short-circuits R_4 thus removing feedback and giving maximum gain. R_5 can be a standard logarithmic volume control of 1 MΩ.

Finally the value of C_{11} must be determined. This must be fairly large because R_5 may be 10 kΩ or less at low volume settings and, if the reactance of C_{11} is comparable with this at low audio frequencies, an

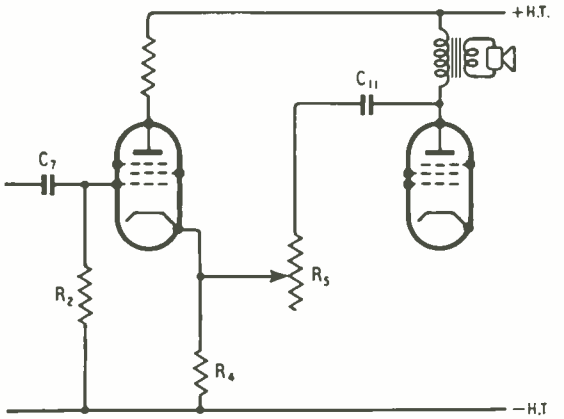


Fig. 3. First stage in the development of the feedback gain control.

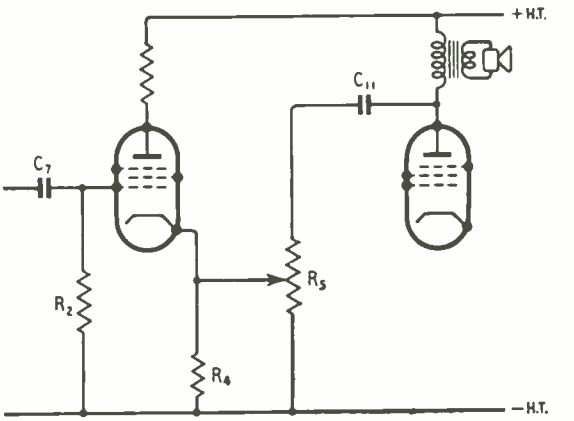


Fig. 4. Final circuit diagram of the feedback gain control giving maximum volume range.

accentuation of the lower audio frequencies results. To restrict any bass lift to less than 1 db at 50 c/s when R_5 is 10 kΩ, C_{11} must be greater than 0.6 μF and a miniature 4-μF electrolytic capacitor is used.

To keep the receiver simple it was decided to use only a single LC circuit for tuning. Such a simple tuning arrangement is, of course, incapable of giving good reception of weak signals when there are strong ones on the same waveband but, with the aid of reaction, it has proved capable of separating the two medium-wave signals in the London area without pressing reaction to the point of oscillation. For ease of operation it was decided to employ pre-set tuning, the Home or Light programmes being selected by a 2-way switch. This decision simplified the problem of coupling the aerial to the tuning circuit, for it is possible to connect the aerial to the " hot " end of the LC circuit *via* a fixed capacitor as shown in Fig. 5. Such simple coupling can be very effective in a circuit operating at fixed frequency but is unsatisfactory in receivers with variable tuning because gain and selectivity are greatly dependent on frequency and vary considerably over the band.

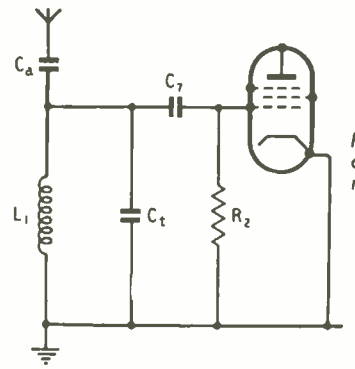


Fig. 5. Method of aerial coupling used in the receiver.

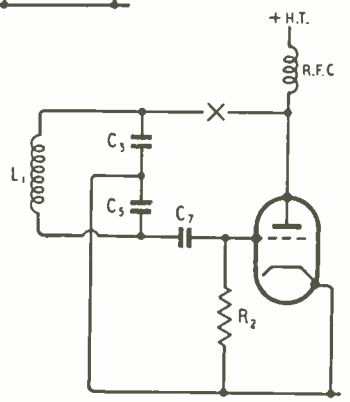


Fig. 6. Colpitts oscillator circuit from which the reaction circuit was derived.

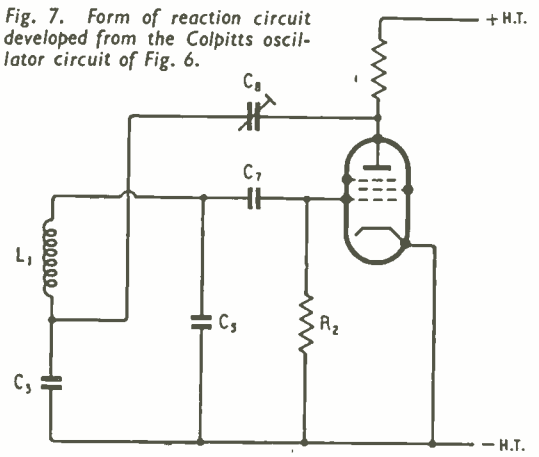


Fig. 7. Form of reaction circuit developed from the Colpitts oscillator circuit of Fig. 6.

As shown in the appendix, the gain of an aerial coupling circuit of this type is given approximately by C_aQ/C_t where C_a is the coupling capacitance, C_t is the tuning capacitance and Q is the reactance/resistance ratio of the inductor L_1. Thus if C_a is an appreciable fraction of C_t, the gain is an appreciable fraction of Q. For example if $C_a = 50$ pF and $C_t = 200$ pF a gain equal to Q/4 is available. This is hardly a practical condition, however, for if C_a is 50 pF, the effective tuning capacitance is greatly affected by variations in aerial capacitance. Thus the calibration of the receiver tuning control is dependent upon the aerial constants and varies from aerial to aerial. It is particularly desirable that the tuning of the receiver should be substantially unaffected by changes in aerial constants, because adjustment of tuning is not so convenient as in a receiver without pre-set tuning. This condition can be achieved by making C_a small compared with the capacitance of the aerial itself; a value such as 10 pF is suitable. To achieve high gain with $C_a = 10$ pF, C_t must also be small, say 30 or 40 pF. To tune the Home Service (1088 kc/s in the Midland area, for which this receiver was destined) with such a small capacitance necessitates an inductor of approximately 700 μH. Such a value was accordingly used. It enables the whole of the medium waveband to be covered with a capacitor of 120 pF maximum capacitance, and also has the advantage that the long-wave Light Programme (200 kc/s) can be tuned with a capacitor of 1000 pF.

Thus the medium-wave Home Service and the long-wave Light Programme are both tuned using the same inductor by simple selection of capacitors. The coil used (Osmor QIF1) is a standard component used in a 465 kc/s i.f. wavetrap and gives an inductance range of 500 to 800 μH by adjustment of the iron core. This inductance adjustment is used for tuning long waves (the 1000-pF capacitor being fixed) and the Home Service is tuned with an adjustable trimmer of 70 pF maximum capacitance. Since C_t is 1000 pF on long waves C_a should be approximately 200 pF to maintain the same gain as on medium waves. This is of the order of the capacitance of an aerial and thus no physical capacitance is necessary for long-wave coupling, the aerial being connected directly to the top of the coil. Variations in aerial capacitance are unlikely to affect the long-wave calibration because they will in general be small compared with the 1000-pF tuning capacitance.

Reaction Circuit

Reaction is usually obtained by use of an additional inductor closely coupled to the tuning inductor, but such a circuit is not suitable for use in this receiver because it requires a coil assembly which would need to be specially wound. It was decided therefore to use a reaction circuit which can be applied to a single untapped inductor such as that chosen for tuning purposes. The circuit adopted is derived from that of the Colpitts oscillator shown in its usual form in Fig. 6. A significant feature of this circuit is that oscillation is most vigorous when C_3 is equal to C_5, the effective tuning capacitance being then $C_3/2$. The amplitude of oscillation can be controlled by a variable capacitor C_8 introduced at the point X and if this capacitance is reduced below a certain value, oscillation ceases,

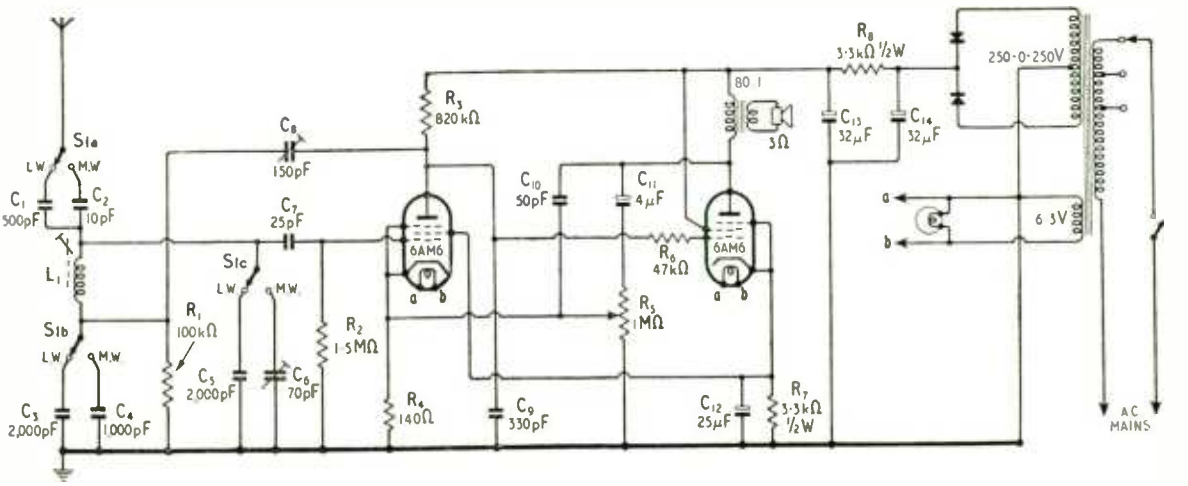


Fig. 8. Complete circuit diagram of the receiver for reception of one medium-wave and one long-wave signal. All resistors can be ¼ W unless otherwise specified.

the circuit then resembling that of a detector in which C_8 acts as a reaction control. This is precisely the circuit used for long-wave reception although in the complete circuit diagram it is drawn in the form shown in Fig. 7. C_3 and C_5 are both 2000 pF, giving the required effective tuning capacitance of 1000 pF. A maximum value of 150 pF is adequate for C_8 and adjustment of its value has no significant effect on tuning. The fact that C_3 and C_5 are both equal implies that only one half the signal developed across L_1 is applied to the detector.

As shown in the complete circuit diagram (Fig. 8), for medium-wave reception C_5 (2000 pF) is replaced by C_6 (70 pF maximum) and C_3 (2000 pF) by C_4 (1000 pF). If C_4 and C_6 were made equal C_8 would need to be very much smaller to control reaction on medium waves than on long waves. In a pre-tuned receiver it is desirable that the reaction control should not require readjustment after each operation of the station-selector switch. The value of C_4 is chosen to satisfy this condition as far as possible but the capacitance of C_8 required to give oscillation on medium waves increases as C_6 is decreased; this differs from the behaviour of the more usual reaction circuits. The large ratio of C_4 to C_6 ensures that nearly all the signal developed across L_1 is applied to the detector and it also enables the whole of the medium waveband to be covered by variation of C_6 alone. To cover the whole of the band C_6 should be 120 pF maximum; a value of 70 pF was used by the author to tune in the Midland Home Service. Medium-wave

TABLE

Maximum wavelength in metres	Minimum frequency in kc/s	Maximum capacitance of trimmer required in pF
250	1200	25
300	1000	35
350	857	50
400	750	65
450	667	80
500	600	100
550	545	120

These values are based on an inductance of 700 μH

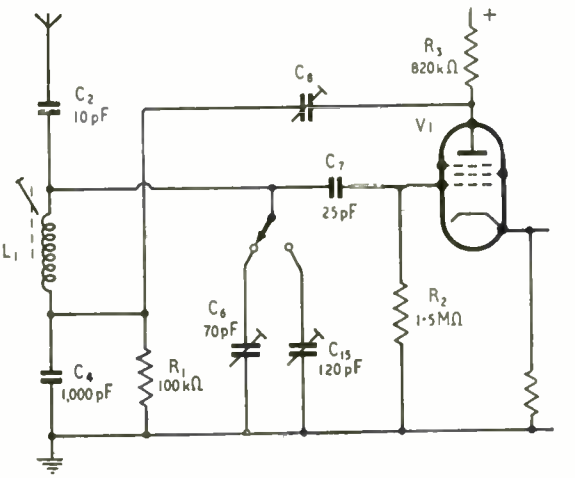


Fig. 9. Input circuit suitable for reception of two medium-wave stations.

tuning is substantially unaffected by operation of the reaction control.

A third section of the station-selector switch connects a 10-pF capacitor (C_9) in the aerial lead for medium-wave reception. If long-wave reception is not required there is no need for the 2000-pF capacitors or to change the series aerial capacitance and C_4 can be retained for both stations as shown in Fig. 9. As suggested in this circuit C_6 could be, say, 70 pF for a station near the high-frequency end of the band and C_{15} could be 120 pF maximum for a station at the other end. If the receiver is pre-tuned to two medium-wave signals of widely different frequencies, say one near 600 kc/s and the other near 1.5 Mc/s it may be desirable to have different values of C_4 for the two signals to give approximately the same degree of regeneration on both. A value of C_4 of 2000 pF is suitable for 600 kc/s and 500 pF for 1.5 Mc/s, a value of 1000 pF being suitable for 1 Mc/s as shown in Fig. 8. Approximate values of C_6 necessary for various frequencies are given in the table.

R_1 and C_1 are included in the circuit to provide some attenuation to 50-c/s signals from the aerial.

Without R_1 the tuning inductor has a high impedance to earth at 50 c s and on long waves, when the aerial is in direct contact with L_1, 50 c/s signals can be of sufficient amplitude to modulate a received signal. This trouble is not present to any extent on medium waves because of the very high reactance at 50 c/s of the series capacitor C_2.

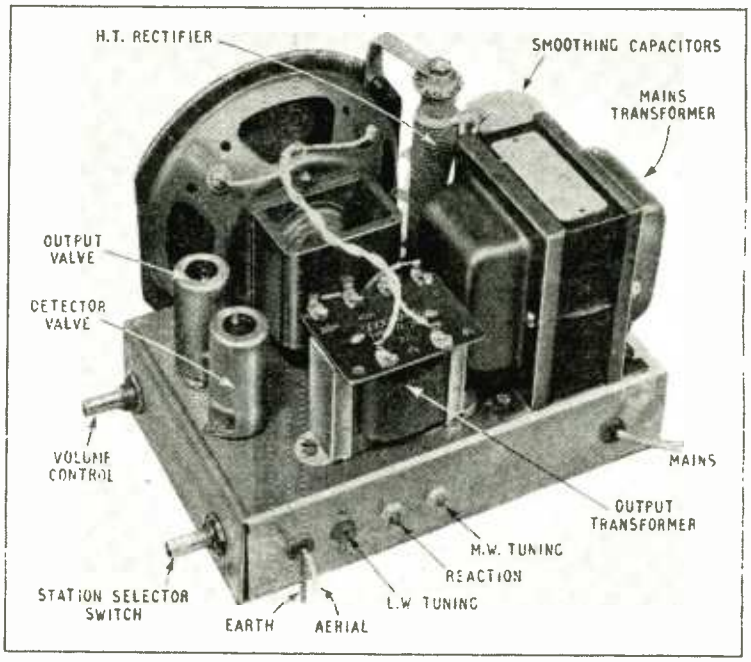
As mentioned earlier, in certain circumstances, results from a particular transmission may be unsatisfactory due to overloading of the detector. If this occurs the input can be reduced by decreasing the appropriate series input capacitor (C_1 or C_2).

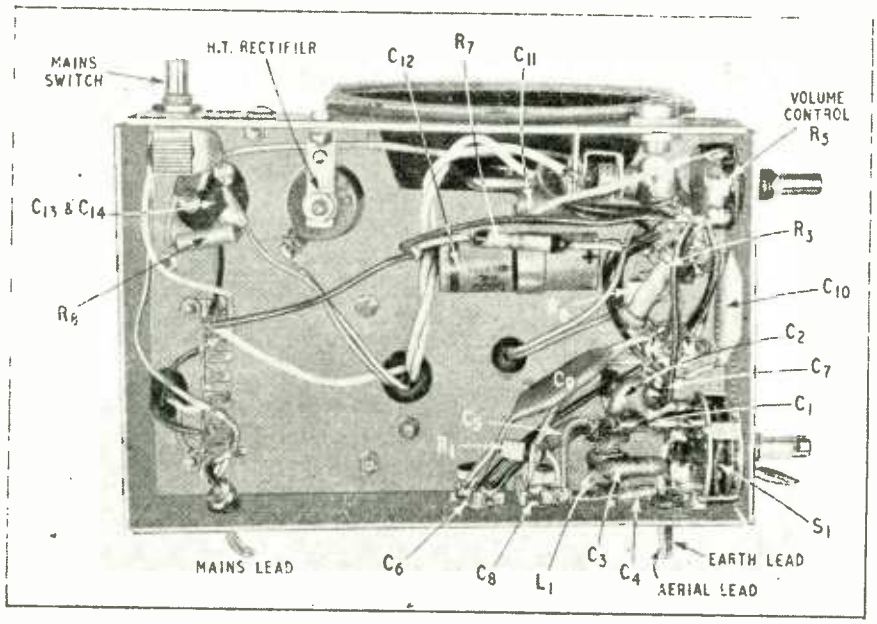
In receivers with pre-set tuning it is advantageous to have equal volume from all stations; the station-selector switch can then be operated without necessity for subsequent volume readjustment. This can be achieved in this circuit by correct choice of values for C_1 and C_2. If both transmissions give good signals, one being stronger than the other, the capacitor corresponding to the stronger of the two signals can be decreased until the volume obtained is equal to that from the other signal.

The only other points of note in the circuit are the capacitors C_9 and C_{10} which are for r.f. decoupling and the resistor R_6 which also provides some r.f. attenuation with the input capacitance of V2 but which is primarily intended as a grid stopper

A full-wave selenium rectifier is used to supply h.t. and the smoothing circuit $R_7C_{13}C_{11}$ supplies 280 volts at 12 mA. Approximately 40 volts are lost across R_7 and the effective h.t. supply for V2 is thus 240 volts.

The construction of the receiver is illustrated in the accompanying photographs. The four-sided chassis measures 7 inches by 4½ inches by 1½ inches and much of it is occupied by the mains transformer which is rated at 250-0-250 volts 60 mA and has a single 6.3-volt l.t. winding. This is an unnecessarily generous rating for such a small receiver but this type of transformer (Electro-Voice Type 104E) is used because it is fairly small and readily obtainable. The selenium rectifier is a 250-volt 60-mA bridge type, a government surplus component type 280 LU997AW used here as a push-pull rectifier after removing the link joining the outermost tags. The current rating is again unnecessarily high and any push-pull rectifier rated for 250 volts and capable of supplying 12 mA will be satisfactory. The output transformer is a Goodmans Type 74/243. The station-selector switch and volume control are mounted on one end wall of the chassis, the on-off switch and





Plan view of chassis is shown above. The mains transformer is somewhat larger than it need be. On the left is the underside of chassis showing positions of most resistors and capacitors.

indicator lamp on the front, tuning and reaction controls being on the rear flange.

In setting up the receiver it is necessary to tune in the long-wave programme first, by adjustment of L_1, and the medium-wave programme afterwards by adjustment of C_t. If possible the 6AM6 used for detection should be specially selected because some valves of this type tend to be microphonic and can set up continuous oscillation by acoustic feedback from the loudspeaker.

The cabinet illustrated was home-made of Perspex, and the internal dimensions are 8½in × 6in × 5in. The length of the chassis is thus 1½ inches less than the corresponding dimension of the cabinet, this margin being necessary when the chassis is inserted in the cabinet to enable the controls on the end wall of the chassis to be fitted into the corresponding holes in the cabinet.

APPENDIX

The essential features of the aerial-coupling circuit are shown in Fig. 10 in which r and c represent the resistance and capacitance respectively of the aerial-earth system. Values of r and c commonly used in medium-wave dummy aerials are 40 ohms and 200 pF. C_a is the coupling capacitor and r_L is the r.f. resistance of the inductor L_1.

Maximum voltage is developed across C_t at the frequency at which the net inductance of L_1, C_t and r_L resonates with the net capacitance C of c and C_a in series.

The impedance Z of the network L_1, C_t and r_L is given by

$$Z = \frac{(j\omega L_1 + r_L)/j\omega C_t}{j\omega L_1 + r_L + 1/j\omega C_t}$$

$$= \frac{j\omega L_1 + r_L}{1 + j\omega C_t r_L - \omega^2 L_1 C_t}$$

By rationalizing this expression we can show that the network is equivalent to a series circuit of inductance given by

$$L = \frac{L_1}{1 - \omega^2 L_1 C_t} \quad .. \quad .. \quad .. \quad .. \quad (1)$$

and resistance given by

$$R = \frac{r_L}{(1 - \omega^2 L_1 C_t)^2} \quad .. \quad .. \quad .. \quad .. \quad (2)$$

Since the inductance (1) resonates with the capacitance C we have

$$\frac{1}{\omega C} = \frac{\omega L_1}{1 - \omega^2 L_1 C_t}$$

from which

$$1 - \omega^2 L_1 C_t = \omega^2 C L_1$$

Substituting for $(1 - \omega^2 L_1 C_t)$ in (2)

$$R = \frac{r_L}{\omega^4 C^2 L_1^2}$$

Thus the circuit is equivalent to the simple series network shown in Fig. 11. The voltage gain of this circuit is equal to the quotient of the reactance (of the inductance or the capacitance) and the resistance, thus

$$\text{Gain} = \frac{1/\omega C}{r + r_L/\omega^4 C^2 L_1^2}$$

If practical values are substituted for the symbols in this expression it is found that r is normally small

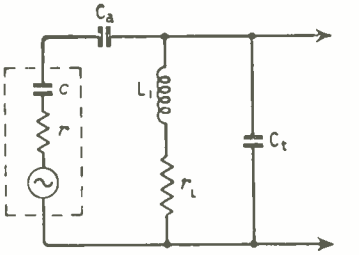


Fig. 10. Aerial-coupling circuit with aerial replaced by equivalent generator.

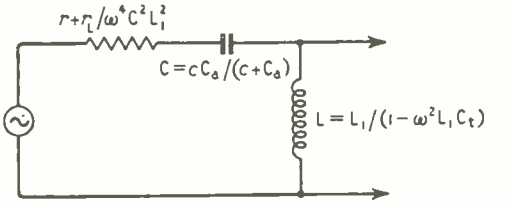


Fig. 11. Simple series circuit equivalent to the network of the previous figure.

in comparison with the other term in the denominator. If r is neglected the gain is given approximately by

$$\text{Gain} = \frac{\omega^3 C L_1^2}{r_L}$$

Now r_L is given by $\omega L_1/Q$ and substituting for r_L we have

$$\text{Gain} = \omega^2 C L_1 Q$$

which shows that the gain is proportional to the square of the frequency. It thus varies in the ratio 9 : 1 over the medium waveband.

C_a is made small compared with c in order to make the calibration of the receiver substantially independent of variations in c. For such values of C_a the frequency of maximum gain is approximately the resonance frequency of L_1 and C_t. Thus $\omega^2 L_1$ may be replaced by $1/C_t$ and we have

$$\text{Gain} = \frac{CQ}{C_t}$$

If C_a is small C is approximately equal to C_a. Hence

$$\text{Gain} = \frac{C_a Q}{C_t}$$

which is the result used in the text.

"DECADE COUNTER"

Correction

An error unfortunately appeared in this article in the May issue. In Fig. 2 the second feedback path should go from the anode of V2 in the fourth stage to the grid of V1 in the third stage. Then, in the right-hand column of page 235 the section beginning 20 lines from the top, "This time, a negative pulse . . ." should be deleted to the end of the paragraph and be replaced by the following: "The third stage remains in this condition (the original state) for only a fraction of a microsecond because this transition causes a reversal of itself. The negative transient produced when the third stage is triggered by the second stage switches stage four through a half-cycle of its operational cycle. A positive pulse is thereby returned to point "C" of the third stage, re-triggering it extremely quickly. So brief was the excursion of the third stage to its original state that insufficient pulse energy is delivered to the second stage via the feedback path to cause any disturbance."

Recording Low Frequencies on Magnetic Tape

By D. W. THOMASSON, A.M.Brit., I.R.E.

The Application of Pulse Code Techniques

NOT many years ago it used to be said that the upper frequency limit of a tape recording system was approximately one kilocycle per inch of tape speed. Today, with responses sensibly flat to 15 kc/s at a speed of 7½ inches per second, this is no longer true. There has been no comparable development at the other end of the frequency range, however, the "hum barrier" at 50 c/s still setting a limit to low frequency response in most cases.

The difficulty arises from the small output given by the playback head at low frequencies, typical figures being 200μV at 50 c/s and 100μV at 25 c/s. Since 1.5μV effective input hum represents good performance in an amplifier with an a.c. heater supply, the signal/hum ratio cannot exceed 40 db, and even when a d.c. heater supply is used hum pick-up imposes a serious limitation. At lower frequencies the problem of obtaining high gain without instability sets the ultimate limit.

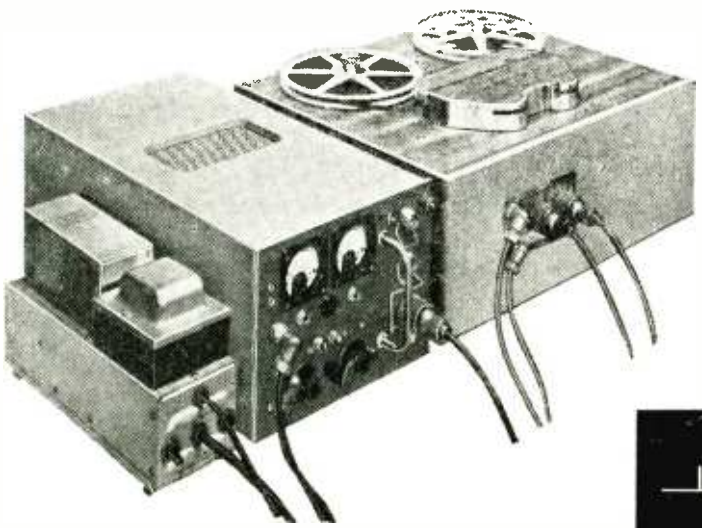
For recording the very low frequencies involved in some types of scientific and industrial measurement, a pulse code method can be used. Two systems are employed in apparatus introduced by Messrs. Rudman, Darlington (Electronics), Ltd., Clyde Works, Lichfield Road, Wednesfield, Wolverhampton, Staffs., one covering the 0-150 c/s range with manual setting of the d.c. level (tape speed 3¾ inches per second) and the other covering the 0-250 c/s range with fully automatic d.c. maintenance (tape speed 7½ inches per second).

The first method uses pulse interval modulation, Fig. 1 (a). The pulses are of uniform length and amplitude, varying only in their separation, and they are converted by a charging circuit into triangular pulses having a mean level that follows the modulation. The coding frequency component is filtered out, leaving the original input signal.

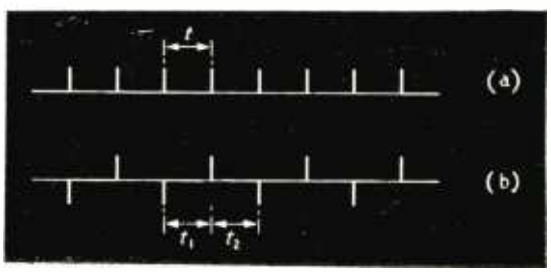
It will be appreciated that, while the system is unaffected by a reasonable degree of hum and noise superimposed on the code signal, any variation in tape speed alters the d.c. level at the output, and provision is therefore made to balance out any spurious d.c. component by manual adjustment. A very good performance in respect of wow and flutter is essential and the tape drive used has a maximum variation of only 0.2 per cent at 3¾ inches per second, giving a negligible disturbance of the output signal. A second recording channel on the same tape deals with higher frequencies up to 6 kc/s using orthodox techniques.

While this method of coding allows maximum tape economy, it was recognized that there is a need for a system in which the d.c. component is maintained without manual adjustment, and the second method meets this need. In this case all low-frequency stages are of balanced d.c.-coupled form, allowing a higher input sensitivity, and the coded signal conveys two information channels, each represented by a set of time intervals, Fig. 1 (b). With zero input voltage all the time intervals are equal and the twin decoders pass equal voltages to the balanced output. With any other input voltage level one interval is increased, the next decreased, and so on, the decoder signals becoming unequal by a corresponding amount. The output is proportional to the difference in the two time intervals divided by their sum, and since all the intervals change in

(*Continued on page* 549)



Twin-cnannel pulse coded strain gauge magnetic recorder, for use in aircraft.



Right: Fig. 1. (a) Simple pulse time system (b) push-pull system giving modulation amplitude independent of tape speed.

the same proportion when the tape speed is altered the recording can be played back at any speed without altering the output voltage levels.

The more complex waveform of the coded signal makes heavier demands on the actual recording process and it is interesting to note that the success of the system largely depends on the improvement in high frequency response which has already been mentioned.

Both methods are of especial interest in strain gauge and vibration testing, but can be applied in many fields where pen recorders are usually employed. Recordings can now be inspected and selected before transfer to paper and the time scale can be changed by alteration of the tape speed if it is necessary to ease the demands made on pen recorder performance.

Another interesting application arises in connection with the flight testing of aircraft. The equipment illustrated is used for flight testing jet engines, and is designed to minimize the effect of the aircraft's movements. If the recorder cannot be mounted in the aircraft the second coding system can be used to provide a telemetering system that is unaffected by the signal fading which is inevitable over air-to-ground paths. The technique is likely to be of even greater interest soon, as current development work is aimed at recorders giving four or eight independent channels on a single tape.

LEIPZIG FAIR

Impressions of Eastern European Radio Products

By V. A. SHERIDAN, A.M.I.E.E.*

COMMENCING with the ordinary domestic radio receivers, these were being exhibited in profusion by most East European countries. In appearance and performance they are not unlike ours. Radio-gramophones, however, were few and far between and certainly had no automatic record changers. Generally, all receivers are of the table type, housed always in wooden cabinets.

Of television receivers, I only saw the East German product being demonstrated. The sets are of the table type and are fitted with an approximately 8-inch tube The brightness is very poor and the picture can only be viewed in complete darkness. Also there is a distinct flicker present obviously due to insufficient persistence of the screen material. The definition is good, as would be expected from the 625-line system. The only other exhibitors of television receivers were the U.S.S.R. who are showing 9-inch table models. These sets were not being demonstrated.

The German radio receivers are priced between 300 and 400 marks. It is difficult to translate this into our currency as the official rate of exchange is 6.20 marks to the pound. I think the West German rate of 12 marks to the pound does give a fair comparison in relation to the people's income. Television sets are priced at 1,300 marks. Needless to say, the popular demand for these sets is negligible.

The valves are much of the same design as ours; that is the all-glass construction with bases similar to our B7G and B9A. The main difference is that the contact wires are fitted with shaped sleeves soldered on to the wires. This results in a rather more positive grip in the valve holder itself and dispenses with valve retainers. Specialized valves such as magnetrons and klystrons, etc., were also exhibited. Crystal diodes and transistors were conspicuous by their absence.

Cathode-ray tubes displayed were of the all-glass design as well as the metal-glass construction. A wide range of oscilloscope tubes of the single and double-beam variety were exhibited.

In the component field a very wide range was shown. The makes known before the war are being produced under new names, as practically all firms have been nationalized, and are called People's Owned Works.

The general range and design is much the same as ours. However, nearly all paper capacitors employ the metallized paper process, resulting in very neat and small units. Carbon resistors are all of Grade I type and are made from 1/20th watt to 2 watts. I have brought back some samples and find they are equal to the best British ones whilst their price is about 1/5th of what we pay here. Furthermore, they supply a precision-type high stability resistor with 0.5 per cent limits. For high resistance values they have a so-called "colloidal" type. I was assured by the chief research engineer of one of the firms concerned that they do not employ a colloidal graphite coating. The standard values are up to 10^{10} ohms, whilst small quantities can be supplied up to 10^{12} ohms. They claim that a maximum voltage of 1,000 volts d.c. can be applied. The resistors are contained in evacuated glass envelopes.

A wide range of rotary switches are available. The makers of one type claim a maximum contact resistance of 20 milliohms. I confirmed this value on a sample. However, by applying a contact oil the value dropped to 5 milliohms. This value was maintained after 3,000 operations.

Components which employ much metal are not of the standard which we are accustomed to. This is due to the acute shortage of all raw materials in Eastern Germany. For instance, brass will be used instead of copper wherever possible, in order to save the copper. It must be borne in mind that the whole economy is working under typical wartime conditions throughout.

Regarding instrumentation, not only did the East Germans show a wide range, but also the Russians, the Czechs and the Hungarians. The equipments cover the entire range from indicating instruments up to equipment for the measurement of centimetre waves.

The general appearance and finish of the East German instruments is very good. In particular they have developed excellent designs of dials, resulting in a very clear indication. The dial rotates according to the multiplier setting, permitting up to eight ranges, thus completely eliminating reading errors.

* British Physical Laboratories.

Some Electrical Theorems

Their Practical Utility

By W. TUSTING

TEXTBOOKS of the more mathematical kind abound in theorems having more or less high-sounding names. The ordinary man is apt to pass over such matters as being difficult and of little practical value. In this, however, he is quite wrong, for some of them are not at all hard to understand or to remember and they are of considerable utility. Apart altogether from their mathematical applications they sometimes help considerably to an understanding of circuits.

Thévenin's Theorem

One of the best-known of such theorems is the one commonly known as Thévenin's theorem. This states that any linear network, no matter how complex, containing any number of sources of e.m.f. is, when regarded from any pair of terminals, equivalent to an impedance in series with an e.m.f.; the impedance is that measured between those terminals with all internal sources of e.m.f. short-circuited and the e.m f. is the open-circuit voltage at those terminals.

This sounds very difficult, but a few simple examples will make it clear. Suppose the network comprises a potential divider R_1 and R_2 connected to a battery E as shown in Fig. 1. The impedance measured between the terminals with E short-circuited (if one were making a real measurement instead of an imaginary one, one would naturally remove the battery and short-circuit the terminals to which it had been connected, just to avoid destroying the battery!) is clearly R_1 and R_2 in parallel. Call it

$$R = \frac{R_1 R_2}{R_1 + R_2}$$

The voltage measured across the terminals on open-circuit (that is, with no current-consuming device connected to them) is plainly

$$V = E \frac{R_2}{R_1 + R_2}$$

The equivalent circuit is thus Fig. 2(b) and it is in every respect identical in performance with the more complex original (a).

A numerical example may help here. Suppose E is 250 V, the h.t. line of a receiver, and R_1 and R_2 form a potential divider to provide a lower voltage supply; suppose R_1 is 100 kΩ and R_2 is 25 kΩ. Then $V = 250 \times 25/125 = 50$ V, and $R = 100 \times 25/125 = 20$ kΩ. The supply obtained in this way is exactly the same as one obtained from a 50-V source through a 20-kΩ resistor.

The theorem holds for a.c. as well as d.c., but the voltage may then become frequency dependent. Consider Fig. 2(a) in which a resistor R and a capacitor C are connected to an a.c. generator *e*. Applying Thévenin's theorem gives (b) the internal impedance being R and C in parallel. The generator voltage is

$$v = e \frac{1/j\omega C}{R + 1/j\omega C}$$

and this varies in magnitude and phase with the frequency.

The theorem is quite valid under this condition but is less useful. In this particular example there is really no point in using the theorem at all, for it tends to complicate matters rather than to simplify them. However, with a circuit like Fig. 3(a) its use is very helpful if it is applied discriminatingly.

The thing to do here is to disregard C for the time being. Then apply the theorem to *e* and the resistors only. This bit of the circuit is the same as Fig. 1(a) and has the equivalent of Fig. 1(b). We now put back

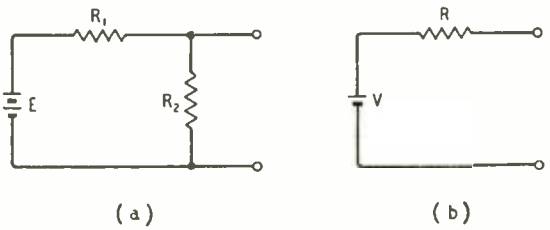


Fig. 1. Simble potential divider and battery (a) and its Thévenin equivalent (b).

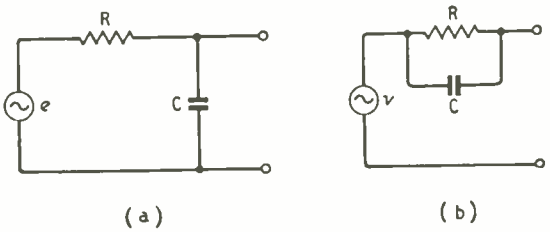


Fig. 2. An a.c. generator with an RC circuit (a) can be transformed to (b) but in this case there is rarely much advantage in doing so.

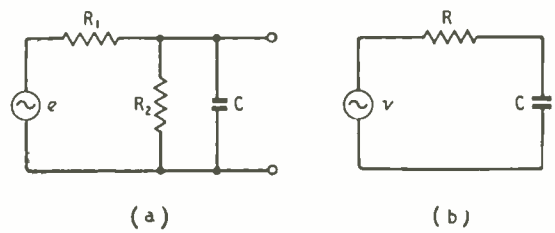


Fig. 3. An RC circuit of form (a) can be advantageously transformed to (b).

the capacitor and get Fig. 2(a) and draw it again as Fig. 3(b) where

$$v = e\,\frac{R_2}{R_1 + R_2} \quad \text{and} \quad R = \frac{R_1R_2}{R_1 + R_2}$$

The theorem can be applied in reverse. In Fig. 4(a) is shown a resistance-coupled stage, which might be the sync separator of a television receiver. The required value of R_a might be 10 kΩ and we might wish to operate the stage from a 20-V supply whereas the h.t. line might be 200 V. The natural thing to do is to make R_a = 10 kΩ and to obtain the 20-V supply by a potential divider R_1R_2 as in Fig. 4(b) and this is necessary if decoupling as provided by C is needed. If it is not, we can leave off C. We can then apply Thévenin's theorem to R_1R_2 and get Fig. 4(c) and we can see that to keep the load on the valve at 10 kΩ we shall have to reduce R_a by the value of R.

It now becomes obvious that there is a redundant resistor, for if R is made 10 kΩ and V is made 20 V, R_a can be dispensed with and the potential divider itself becomes the load. This is shown at (d). For our figures we have

$$20 = 200\,\frac{R_2}{R_1 + R_2} \quad \text{and} \quad 10 = \frac{R_1R_2}{R_1 + R_2}$$

so

$$\frac{R_2}{R_1 + R_2} = \frac{1}{1 + R_1/R_2} = \frac{1}{10} = \frac{10}{R_1}$$

and

$$R_1 = 100\ \text{k}\Omega,$$

$$R_1R_2 = 9, \quad R_2 = 11.1\ \text{k}\Omega$$

This form of circuit, in which the load and voltage-droppers are combined in potential-divider form is sometimes used in television receivers. It is a bit puzzling when first met but is easily unravelled with the aid of Thévenin's theorem.

Norton's Theorem

One could go on quoting examples of the application of Thévenin's theorem indefinitely but enough has been said to show its utility and the time has come to turn to another—Norton's theorem. This is a very similar one and states that any network, containing any number of sources of e.m.f. is, when regarded from any pair of terminals, equivalent to an impedance in shunt with a current generator of infinite internal impedance; the impedance is that measured between those terminals with all internal sources of e.m.f. short-circuited and the current is the current which will flow between the terminals when they are short-circuited.

Let us apply this to the circuit of Fig. 5(a), which is the same as Fig. 1(a). The impedance measured at the terminals is

$$R = \frac{R_1R_2}{R_1 + R_2}$$

as before, and the equivalent circuit is Fig. 5(b) where I is the current generator. The short-circuit current in (a) is E/R_1 and this is the value of I in (b).

Norton's theorem is much less used than Thévenin's in this general sense, but it is very widely used in connection with pentode valves. The ordinary equivalent circuit of a valve is of the form of Figs. 1(b) or 3(b) and is expressed like Fig. 6(a). By the use of Norton's theorem it can be put in the form of Fig. 6(b) which is equally known. The resistance is the same in both. In (a) the short-circuit current is $\mu v_g/r_a = g_m r_a$, which is the current generator of (b). It is only because we commonly write μ/r_a as g_m, the mutual conductance, that we do not always recognize (b) as a transformation by Norton's theorem of (a).

Star-Delta Theorem

Another very useful theorem is that commonly known as the star-delta theorem, but also called the T-delta, T-Δ, or T-π theorem. Any three impedances in the

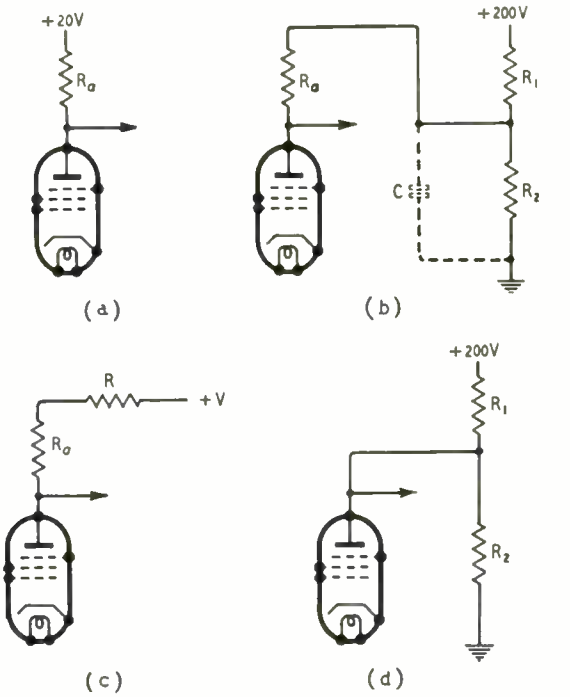


Fig. 4. A valve with a load R_a which requires a low h.t. voltage as in (a) might be used with a potential divider R_1R_2 when the supply is of high voltage. The Thévenin transformation is (c) and shows there is an unnecessary resistance and so the final circuit can be reduced to (d).

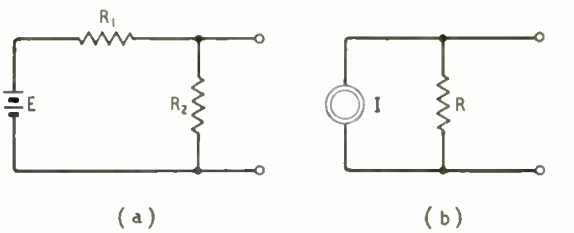


Fig. 5. By Norton's theorem these two circuits are equivalent.

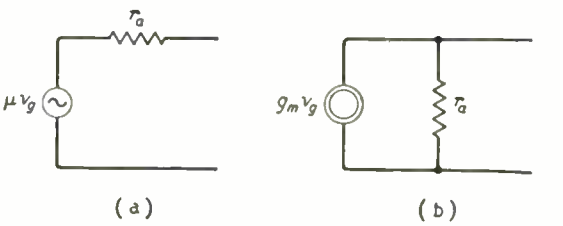
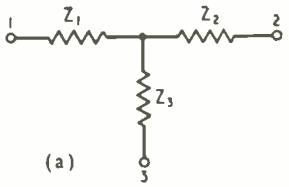
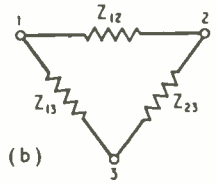


Fig. 6. Norton's theorem in the case of a valve: (a) is the circuit commonly used to represent a triode and (b) that used for a pentode.



$$Z_1 = Z_{12}Z_{13}/(Z_{12}+Z_{13}+Z_{23})$$
$$Z_2 = Z_{12}Z_{23}/(Z_{12}+Z_{13}+Z_{23})$$
$$Z_3 = Z_{13}Z_{23}/(Z_{12}+Z_{13}+Z_{23})$$



$$Z_{12} = Z_1 + Z_2 + Z_1Z_2/Z_3$$
$$Z_{13} = Z_1 + Z_3 + Z_1Z_3/Z_2$$
$$Z_{23} = Z_2 + Z_3 + Z_2Z_3/Z_1$$

Fig. 7. The star and delta networks shown here are identical if the impedances have the relations shown.

star or T form of Fig. 7 (a) can be transformed into three different impedances in delta or π form as shown at (b) or, of course, vice versa. The relations between the impedances are given in the figure. If the network is symmetrical (i.e., $Z_1 = Z_2$ or $Z_{13} = Z_{23}$) the relations simplify considerably.

There are many uses for this equivalence. One simple one is in attenuators, perhaps for a television aerial feeder. In such a case, the values for a star might be $Z_1 = Z_2 = 59\ \Omega$ and $Z_3 = 14.6\ \Omega$, values which would give 20-db attenuation for a feeder impedance of 72 Ω. It might well happen that one had no suitable resistors available and the delta equivalent might be more convenient. From Fig. 7,

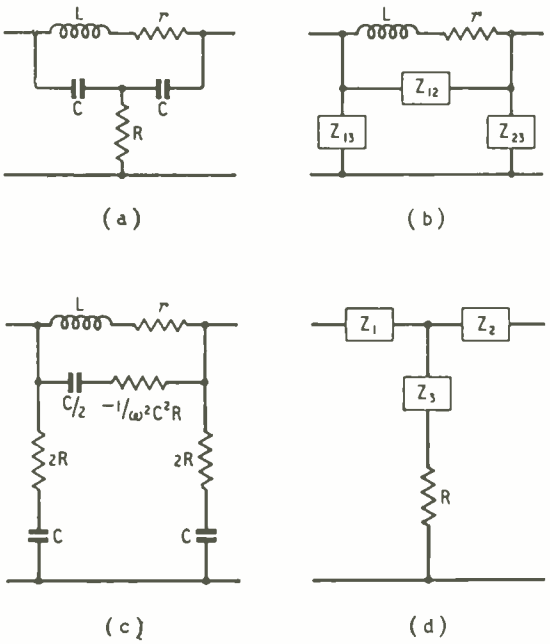


Fig. 8. Application of star-delta theorem to a bridged-T network (a). The star of C and R is transformed to a delta (b) and gives the result (c). Alternatively, the delta of L,r,C can be transformed to a star as in (d).

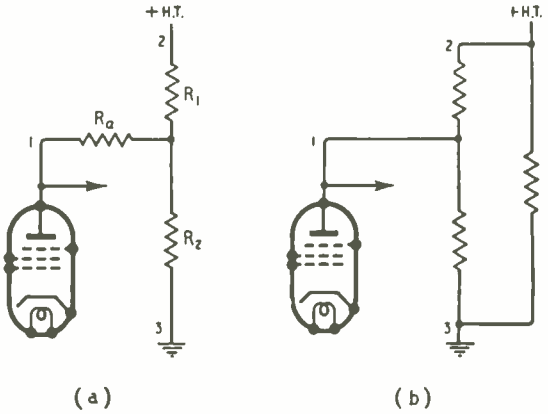


Fig. 9. The application of the star-delta theorem to the problem of Fig. 4. The star of (a) transforms to the delta of (b) and at once shows up the redundant resistance.

Fig. 10. Basic 4-terminal network.

this would call for $Z_{12} = 59 + 59 + 59^2/14.6 = 358\ \Omega$ and $Z_{13} = Z_{23} = 59 + 14.6 + (59 + 14.6)/59 = 88.2\ \Omega$.

The star-delta theorem is often of great use theoretically in simplifying things. This is especially the case in bridged-T networks. The circuit of Fig. 8(a) without the resistance R is a simple parallel resonant circuit which might be used as a rejector. The inductance L has losses which are represented by the series resistance r and it is tuned by the two capacitors C in series having the total value C/2. At resonance the circuit behaves as a high resistance of value $2L/Cr$, the dynamic resistance.

When R is added, it is possible to make it behave as though the dynamic resistance were infinite. Physically, some current passes through L and r and some through the T network C, R, C. By the adjustment of the components, the currents at the output can be made equal and opposite. The conditions are most easily determined by using the star-delta transformation, which can be applied in two different ways. The first is to transform the star of two capacitances and one resistance to a delta (b). We get

$$Z_{12} = 2/j\omega C - 1/\omega^2C^2R$$
$$Z_{13} = Z_{23} = 1/j\omega C + 2R$$

and can re-draw the circuit as Fig. 2(c). This is an exact equivalent of (a) but is not physically realizable in this form because it includes a negative resistance $-1/\omega^2C^2R$. From this, one can write down at once the conditions for resonance and infinite attenuation as

$$\omega^2LC/2 = 1$$

and $$r = 1/\omega^2C^2R$$

or $$R = L/2Cr$$

The alternative way of applying the transformation is to turn the delta of L, r and the capacitors into a star as in Fig. 8(d). In this particular case, this is not such a good transformation as the first, because

the expressions for the star impedances turn out to be more complex than those for the delta impedances of (b).

Wherever such alternatives for transforming a circuit exist, it is quite usual for one to be simpler than another and one naturally chooses this one.

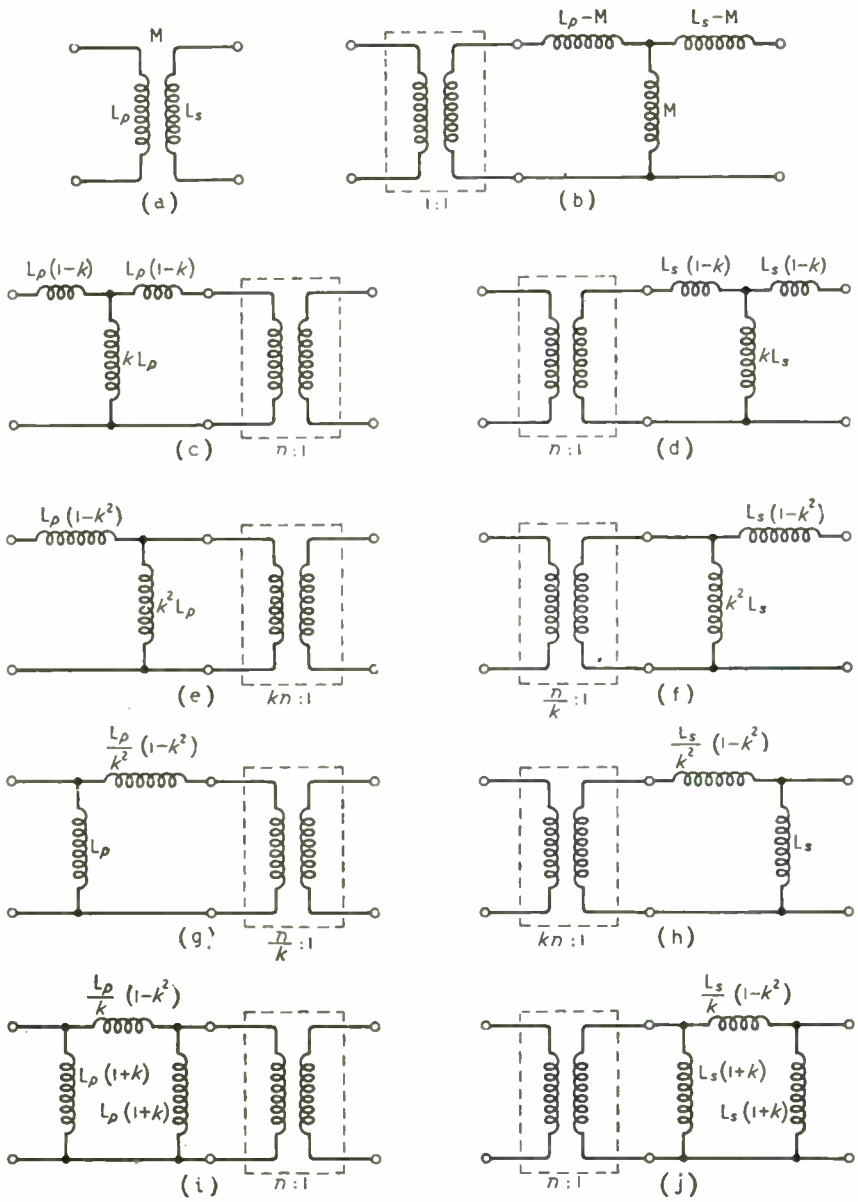
The star-delta theorem can be applied to the valve problem of Fig. 4 and, although it is not so useful as Thévenin's in this instance, it does show up more clearly the redundancy of one of the resistors in Fig. 4(b). The circuit is repeated in Fig. 9(a) and the three resistors form a star which can be replaced by a delta formation as in (b). It is at once obvious that one resistance R_{23} comes straight across the h.t. supply and performs no useful function. We can remove it, therefore, which is the same as making it infinite and the equations of Fig. 7 show that when Z_{23} is infinite Z_1 is zero. In Fig. 9(a), R_a is the Z_1 component and becomes zero. We end up then with the simple potential divider.

In this instance, the star-delta theorem is less useful than Thévenin's because it does not include the supply voltage and so does not permit us to calculate component values for particular conditions.

Equivalent Circuit Theorem

There is a theorem which states that any two circuits are equivalent if their open- and short-circuit impedances are the same. It applies to four-terminal networks, shown diagrammatically in Fig. 10. The open-circuit impedances are the impedances between 1 and 2 when 3 and 4 are open and between 3 and 4 when 1 and 2 are open. The short-circuit impedances are the impedances between 1 and 2 when 3 and 4 are shorted and between 3 and 4 when 1 and 2 are shorted. By the application of this theorem it is possible to prove a whole series of equivalent circuits for the transformer, some of which are of great utility. No less than ten such equivalents are shown in Fig. 11.

These circuits are all exact equivalents and the basic arrangement is shown in Fig. 11(a), a primary coil L_p and a secondary coil L_s having mutual inductance M between them. In the equivalents, the transformer shown in a dotted box is an ideal one which serves to preserve the d.c. isolation and to provide a voltage transformation ratio. It has no other



WHERE n = RATIO $\frac{\text{PRIMARY}}{\text{SECONDARY}}$ TURNS $= \sqrt{\frac{L_p}{L_s}}$

AND k = COUPLING COEFFICIENT $= \frac{M}{\sqrt{L_p L_s}}$

Fig. 11. Ten equivalent circuits for a transformer are shown here. The ideal transformer, surrounded by a dotted box, provides the turns ratio and d.c. isolation but has no other characteristics. The coupling coefficient is $k = M/\sqrt{(L_p L_s)}$ and the ratio of the primary/secondary turns is nominally n; actually $n = \sqrt{(L_p/L_s)}$.

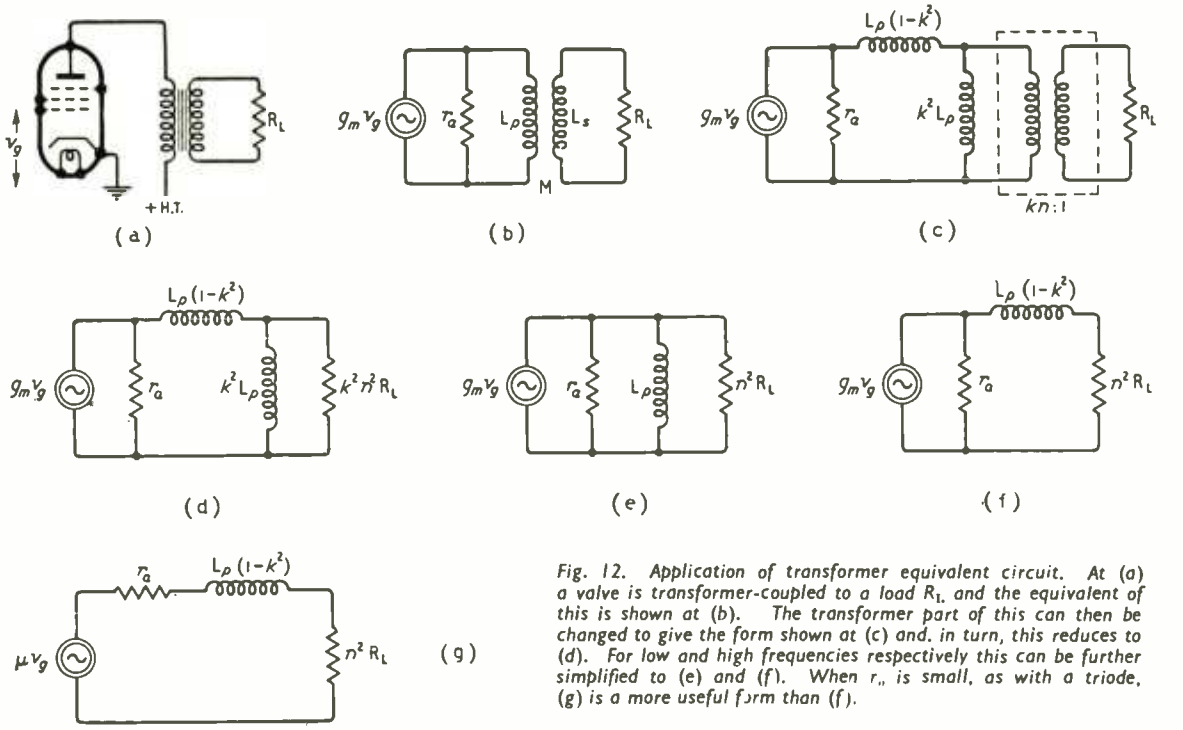


Fig. 12. Application of transformer equivalent circuit. At (a) a valve is transformer-coupled to a load R_L, and the equivalent of this is shown at (b). The transformer part of this can then be changed to give the form shown at (c) and, in turn, this reduces to (d). For low and high frequencies respectively this can be further simplified to (e) and (f). When r_a is small, as with a triode, (g) is a more useful form than (f).

characteristics. The other inductances represent the other characteristics of the real transformer. In these equivalents k is the coupling efficient of the real transformer and equals $M/\sqrt{L_p L_s}$ while n is $\sqrt{L_p/L_s}$ and is usually the turns ratio of the real transformer. The true definition is $\sqrt{L_p/L_s}$, however, and there are cases where the two are not quite the same.

Some writers make great use of the symmetrical forms of circuit (c) and (d) but the others are often simpler and, in particular, (f) is a very convenient one.

These circuits are of considerable help when one wishes to determine transformer characteristics by measurement. From Fig. 5(f), for instance, it is obvious that if one measures inductance at the secondary terminals one measures L_s with the primary open and $L_s(1 - k^2)$ with the primary shorted, and from the two k can be determined. From Fig. 5(e) similar measurements on the primary give L_p and $L_p(1 - k^2)$, from which k can again be determined. Then, knowing L_p and L_s, n can be found.

One great use of these equivalent circuits is the way in which they make important factors almost obvious instead of being determinable only after a lengthy calculation. For example, suppose a valve is coupled to a load resistor R_L as in Fig. 12(a). We replace the valve by its Norton equivalent circuit, and the equivalent circuit becomes (b). We now use the transformer equivalent of Fig. 11(e) and get (c) and then transfer the load R_L from the secondary to the primary of the ideal transformer where it takes the value $k^2n^2R_L$, as in (d).

It is at once obvious that k^2L_p will rob $k^2n^2R_L$ of current, for it comes in shunt with it, while $L_p(1 - k^2)$ will cause a voltage drop, since it comes in series. In practice, in a.f. applications k^2 is very nearly unity and $L_p(1 - k^2)$ is consequently very small compared with k^2L_p. Because of this, the former has a negligible effect at low frequencies and the latter is negligible at high frequencies.

The circuit can thus be further simplified to the equivalents (e) and (f) of Fig. 12, which are valid respectively for low and high frequencies only. If r_a is large compared with n^2R_L it can usually be neglected. If it is not large, the Thévenin equivalent is better than the Norton at high frequencies and (f) can be changed to (g).

It is plain from (e) that the frequency response at low frequencies depends only on the relation of L_p to the value of r_a and n^2R_L in parallel and that at the lowest frequency $f(= \omega/2\pi)$ we must have ωL_p large enough compared with this resistance for it to shunt it negligibly. It is equally clear from (g) that the leakage reactance at the highest frequency must be small compared with $r_a + n^2R_L$; if it is not, it will reduce the current.

If the lowest and highest frequencies are fixed, L_p must be fixed by low-frequency requirements and $L_p(1 - k^2)$ by high frequency, which means that k is fixed by the high-frequency needs. More strictly, k is fixed by the bandwidth required.

The use of the transformations brings out the important factors very simply and clearly without the use of appreciable mathematics. From (e) and (g) it is easily possible to write simple equations expressing the performance from which numerical values can be obtained.

LETTERS TO THE EDITOR

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

Output Stage Performance

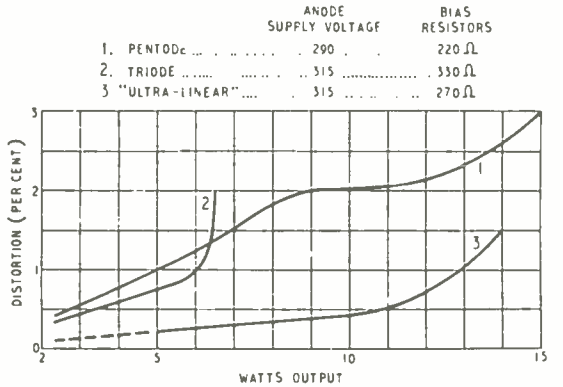
IN a description of the Osram 912 amplifier given in the September issue (page 430), it is stated that the output circuit is a compromise between pentode and triode operation as far as efficiency and harmonic distortion are concerned.

The object of employing the "ultra-linear" circuit in the Osram 912 is to provide virtually the same efficiency and power as pentode-connected valves, but a distortion lower than that of either pentodes or triodes at their respective full outputs.

Some data relevant to the Osram N709 valves specified for this circuit are as follows:

	Pentode	"Ultra-linear"	Triode
Anode input, per pair	33.4	31.5	25.2 watts
Output power	15	14	6.5 watts
Distortion, full output ..	3	1.5	2 per cent
Distortion 6.5 watts approx.	1.5	0.25	2 per cent
Output impedance	38,000	9,000	4,000 ohms
Grid-to-grid input voltage	14	18	18 (r.m.s.)

The accompanying curves enable a comparison to be made at other power levels. These results are for the output stage alone, without external feedback.



Other valves, such as the KT66, also work well in the circuit.

The output transformer is connected to the anodes and screens and not to the cathodes as stated.

GRAHAM WOODVILLE.

The M.O. Valve Co., Ltd.

"*Inexpensive 10-Watt Amplifier*"

WITH reference to the second part of E. F. Good's letter in your October issue concerning "the obstinate refusal to adopt the tertiary feedback-winding system" as used in P. J. Baxendall's amplifier, I would suggest the reason why this ampifier did not become as famous as others such as the Williamson is not connected in any way with the method of obtaining feedback, but because of the use of beam-tetrodes in the output stage.

With the tetrode output and about 40 db negative feedback the Baxendall amplifier has roughly the same distortion as triode output types, such as the Williamson, *on a resistive load.*

With a variable impedance device such as a loudspeaker, the load presented to the output valves rises to a high value at the high audio frequencies, and also at the bass resonant frequency. With a triode-output stage and to a lesser extent with the triode-tetrode connected type, any increase in load above the nominal causes a reduction in distortion; but with the tetrode or pentode a violent increase in third harmonic results. Negative feedback only reduces distortion by a given factor ($\times 100$ for 40 db) and does not eliminate the cause.

Mr. Baxendall states that when his amplifier was tested on a loudspeaker load, "a several times increase in distortion of the output voltage occurred due to the non-linearity distortion in the current drawn by the loudspeaker" (*W.W.*, Jan., '48). I am not so sure that all the blame for this can be attributed to the speaker.

I will admit that the RC network across the primary of the output transformer in the Baxendall amplifier keeps the load reasonably constant with increase of frequency, but this does not alter the situation at the l.f. end. I am also surprised that the new Mullard amplifier circuit contains no such load correctors.

From the above reasoning it seems that to get equivalent performance to a triode from a tetrode or pentode output stage on loudspeaker load, considerably more feedback is required than is apparently necessary from comparative tests on resistive loads. This, of course, is not practicable with a single-loop feedback circuit. A multiple-loop feedback arrangement, including one loop in the output stage, by triode-tetrode connection, seems to be the best answer to the problems of size, weight, and heat developed.

A further advantage of the multiple feedback loop system is that those unpleasant peaks outside the audio band can be avoided. The rise in response below 10 c/s with the Williamson circuit is the main reason why the complication of an additional mains transformer and smoothing system is necessary for the h.t. supply to auxiliary apparatus.

Aldeburgh, Suffolk. JOHN BRIGHTON.

"*Why Lines?*"

AS one who has long been interested in Lissajous scanning and who recently has spent considerable time observing television pictures produced in this way, you may imagine my surprise at seeing this article in your August issue. Why lines, indeed?

As I read further through the author's list of supposed advantages, and the Editor's list of probable difficulties, I noted that he, too (as I) had failed to anticipate a major objection to the scheme. Here is a short account of the work which brought this to light.

The possibility of producing television signals with essentially no geometrical distortion is very attractive for various industrial applications. The simplicity of the equipment (which appealed so much to Mr. Hughes) had made the idea appear very promising. Hence we constructed four sine-wave amplifiers to drive the horizontal and vertical deflection coils of a flying-spot scanner and monitor kinescope and used separate audio oscillators, set at approximately 11,350 c/s and 15,250 c/s. It at once became evident that the phasing was very critical, in order to avoid a double image due to mis-register between the forward and reverse scans. It also turned out that the frequencies must be held very nearly correct to prevent the pattern from degenerating into a lower-order coarse pattern or, worse still, a very badly flickering one, if reasonable brightness were used. We then built a synchronizing generator to produce locked signals, and while this never did work perfectly, we were nevertheless convinced that no insuperable obstacles stood in the way of a satisfactory solution of the scanning problem.

All observers remarked favourably on the geometry of the picture and noted with genuine surprise the fact that there was no need to make any brightness correction due to non-linear scanning. Even on a blank raster (no video

signal) the pattern appeared uniformly bright except at the very edge, and when a picture was present even this effect was practically invisible.

You might reasonably ask, in view of the above favourable results, what is wrong with the system? It is this: Each point in the picture is scanned twice. At the centre, for example, the first scansion occurs as the beam is moving down to the right and the second as the beam moves up to the right. Nearby points may be scanned to the left. Now if the picture detail at this point happens to be a straight narrow line, those segments reproduced by the first scansion are shifted slightly down to the right, and alternate segments reproduced by the second scansion are shifted up to the right, due to the finite bandwidth of the system. The line is reproduced as a zig-zag, and the entire scheme is shifted into uselessness. This effect is most noticeable on a test chart, such as the RMA Resolution Chart, 1946. On low-detail subjects such as close-up portraits, the effect is not serious and merely gives a "soft" rendering.

In passing, it is worth noting that sinusoidal scanning, rather than being entirely novel, was analyzed in the report of the first N.T.S.C., "Television Standards and Practice," McGraw Hill, 1943, p. 33, and was rejected at that time for reasons similar to the Editor's list of probable difficulties.

W. F. SCHREIBER.

Technicolor Motion Picture Corp.,
Hollywood, U.S.A.

"*Filters Without Fears*"

I HAVE read with great interest the article by Thomas Roddam in your September issue, in which the application of Chebyshev polynomials to filter theory is clearly and explicitly given. The purpose of my letter is to point out that the above spelling of this distinguished mathematician's name has nothing to do either with the "post-revolutionary alphabet" or with "foreign politics." A slight acquaintance with the Cyrillic alphabet will show that only minor changes were made at the time of the revolution, none affecting the name in question, and all made with the laudable object of removing redundant letters. Transliteration from non-Roman alphabets is always a matter of some difficulty and should aim at rendering, letter by letter, words printed in one alphabet into another. It is desirable in this process to obtain a result which will also enable the reader of the transliterated material to pronounce it as nearly as possible in the original way. It is unfortunate that many of the Russian proper names with which we are familiar came into Western literature *via* German transliteration, Tchebycheff being a case in point. Librarians and linguists in English-speaking countries have devised consistent systems of transliteration based upon English phonetics and conforming to the above criteria. These are widely used—as reference to *Science Abstracts* will confirm—and the spelling Chebyshev is the recognized English transliteration, which should be universally used in place of the German monstrosity given by Mr. Roddam.

The further point that the polynomials are denoted by T_n (a) is irrelevant. After all, the Bessel functions are J(x) and Y(x), in no way suggesting their discoverer; and the elliptic functions have a notation far removed from the names of Jacobi or Weierstrass.

Glasgow University. B. HAGUE.

Television Interference

G. O. THACKER'S letter in the October issue of the *Wireless World* concerning the radiation of interference from television receivers raises a further point.

If it were possible to comply with Condition 4 of the broadcast television licence, which states that "the apparatus shall be so maintained and used that it does not cause interference . . ." the television pirate detector vans described and depicted on p. 476 of the same issue would need to be rather more complicated and probably less effective.

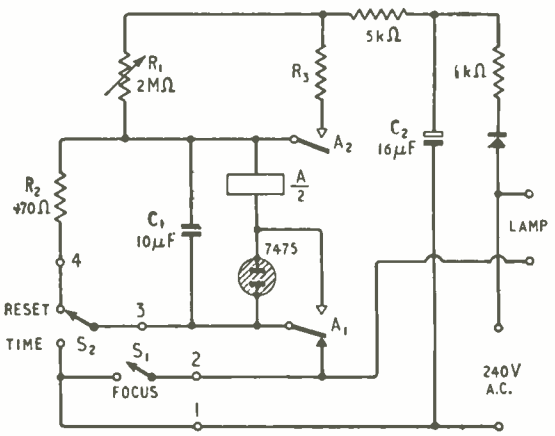
I wonder if this is why the G.P.O. has limited powers in preventing television generated interference?

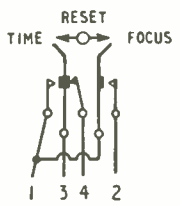
Further, it would seem ironical that, as the law stands at the moment, following the detection of a pirate television receiver by the existing means, a summons could be issued on two counts (a) the use of a television receiver without a licence, and (b) failing to comply with Condition No. 4 governing the use of a television receiver.

Stoke-on-Trent, Staffs. G. E. KING.

"*Neon Timers*"

WITH reference to the circuit in Fig. 3 of the article by B. T. Gilling (your September issue, p. 460), this could be made much simpler and still perform the same





Circuit of the simplified photographic timer. The key on the left could be used in place of S_1 and S_2 and would be connected to the numbered points on the circuit.

functions by using the arrangement shown in the accompanying diagram.

Resistor R_3 would depend on the resistance of relay A, and is adjusted to allow a current greater than its holding current to flow to hold the relay after C_1 has discharged. The resistance of the relay is not critical. The voltage regulator has been dispensed with as any inaccuracies in the time lag would be due to the firing potential of the 7475 tube and the c.r. time constant of C_1R_1. Also, I do not think the mains supply voltage varies sufficiently to justify its use for the order of accuracy needed for photographic purposes.

The operation is as follows. When S_2 is thrown to the TIME position, C_1 charges via R_1 until the 7475 tube fires, when the relay operates and locks via S_2, A_1, the relay coil, A_2 and R_3. On throwing S_2 to the RESET position, the relay releases and C_1 discharges via R_2. S_1 is used leaving S_2 in the RESET position for focusing without timing. S_2 could be a change-over toggle switch and S_1 a make-break switch, or a single-lever key could be used.

Norwich. J. R. BARNARD.

Flywheel Synchronizing

2.—*Principles of Automatic Frequency Control*

By W. T. COCKING, M.I.E.E.

IN practice, flywheel synchronizing is normally obtained through the use of an automatic frequency control (a.f.c.) system. In this, the sync pulses are compared in a phase discriminator with a locally-generated voltage which is usually obtained from the line timebase. As a result of the comparison, an error signal is developed which depends upon any difference of frequency or phase between the sync and the local waveforms. This error signal is passed through a filter, which provides the flywheel effect, and is then applied to the timebase as a control voltage which operates to bring any frequency error to zero.

The system is not, however, the same as the one which is used to control the frequency of the local oscillator of some superheterodyne receivers, in spite of the fact that that is also called an automatic frequency control system. In that, a control voltage is developed which depends upon the difference of the frequency generated from its proper value and the circuit cannot reduce an error to zero, for some error must exist for there to be a control voltage at all. This kind of circuit acts only to reduce the magnitude of an error but it cannot bring it to zero.

In the case of a timebase, it is essential that the frequency be exactly that of the sync pulse recurrence. The frequency error must be zero. Frequency and phase change together and it is not possible for one to change without the other changing also. It is, however, possible to have two frequencies which are exactly the same but which have any desired constant-phase relation. It is the relative phase of the local waveform and the sync pulses which is used, therefore, in order to develop a control voltage. Because of this, the system is sometimes known as one of automatic phase control, although it is not phase which is controlled, it is phase which is the controlling quantity.

In general form, all a.f.c. systems can be represented by the block diagram of Fig. 1, but sometimes an amplifier is included between the low-pass filter and the timebase. It can be seen from this that the circuit includes a closed loop, for the output of the phase detector depends on both its inputs and one of them is derived from the timebase which is under the control of the output via the low-pass filter. It is, therefore, a feedback system and, as in all such systems, the problem of obtaining stability is important.

There are many forms of a.f.c. circuit and it is not practicable to discuss all of them here. So far as possible the discussion will be in general terms and we shall endeavour to find the most suitable type before coming to the particular.

For correct synchronism, the start of flyback in the timebase must occur nearly in coincidence with the leading edge of the sync pulse. It need not coincide exactly but, in general, it must not occur more than 1 μsec earlier nor more than 4 μsec later. Any difference greater than this is likely to result in a noticeable displacement of the picture on the raster and, possibly, to fold over or cut off. The total difference of timing can thus vary over a range of about 5 μsec at most. When the two frequencies are the same, the phase detector produces an output which is dependent on the relative timing (that is, the relative phase) of two particular parts of the waveforms. This is illustrated in Fig. 2, in which the sync pulse waveform is shown at (a) and the saw-tooth wave of the timebase in (b), (c) and (d). In (b) the relative timing, or phase, is such that the start of flyback coincides with the leading edge of the sync pulse, which is the normal condition with direct locking. In (c) the flyback is shown starting about 1 μsec earlier and in (d) about 4 μsec later.

Let us now consider a timebase which has no synchronizing system at all, but a manual hold control which is capable of very fine adjustment. As this control is turned, slowly, the frequency of the timebase comes nearer and nearer to the correct value and at length equals it. The timebase is then in synchronism with the signal and the frequency error is zero.

The saw-tooth and the sync signals are not necessarily in their right relative phase, however, and the sync pulses may well appear somewhere remote from the flybacks. The picture will then appear divided into two parts separated by a vertical black bar which corresponds to the blacker than black of the sync pulses and the black of the back and front porches. What should be the left-hand part of the picture will appear to the right of the bar and what should be the right-hand part will be on the left. The picture will be quite coherent, however.

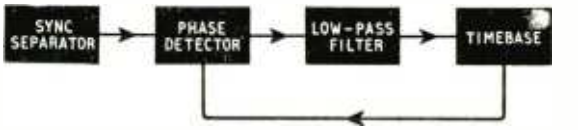


Fig. 1. Basic form of an a.f.c. system for flywheel sync.

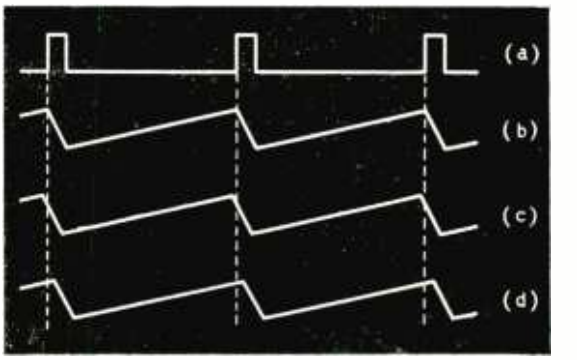


Fig. 2 Sync pulses are shown at (a) with a saw-tooth in correct phase relation at (b). The limits of permissible phase error are indicated in (c) and (d).

To obtain the correct picture it is necessary to bring the sync pulses and flybacks into approximate phase coincidence, as in Fig. 2. In order to do this, the timebase frequency must be slightly altered by the hold control and then brought back again to its correct value by returning the control to its previous setting. Synchronism is then established again but with a different phase condition.

The attainment of the correct frequency demands the provision, by the hold control, of a certain steady voltage, the precise value of which depends on many factors. such as supply voltage, temperature, stability of components, etc. If any of these change the "steady" voltage must change in a compensating manner.

Correct phasing can be secured only by a momentary change of frequency. If the black bar occurs in the centre of the picture, for instance, it is theoretically possible to bring it to its proper place at the edge by making one individual scanning line of one-half its normal duration. The change of "frequency" can occur and be over all in less than one line, which implies a momentary change to double the normal value. Alternatively, the change can be minute and persist for many lines, so that the black bar gradually creeps to the edge.

In practice it is not easy to observe these effects, but they can be seen if the timebase is a very stable one and the hold control permits sufficiently fine adjustment to be made.

An a.f.c. system performs the equivalent action to adjusting a manual control by providing automatically the voltage which would otherwise be provided by the manual control. When there is no frequency error, a voltage is developed by the discriminator which has a constant value depending only on the phase difference between the sync pulses and the saw-tooth waveforms. The system then settles down in synchronism, but with a phase error which depends upon the voltage needed by the timebase for it to run at the correct frequency. If anything changes to make the timebase need a different voltage, the relative phase must change so that this new voltage can be provided. While the change is actually occurring there is, of course, a change of frequency also.

Noise Reduction

It is necessary that synchronism should be obtainable only when the flyback is in approximate coincidence with a sync pulse and that the range of possible phase errors should be small. This is easily arranged by using the sync pulses on the one hand and a waveform derived from the flyback on the other as the signals on the phase discriminator. for a steady output can then be obtained only when at least some parts of them occur together.

If the manual hold control is adjusted while the a.f.c. system is in operation it is found that the visible picture moves as a whole sideways on the raster by a small amount. This is a characteristic of all a.f.c. systems and results from the change of phase needed to maintain the frequency at its correct value.

At this stage it will probably not be at all evident how an a.f.c. system reduces the effects of noise and interference. It does so in reality in substantially the same way as with the tuned-circuit system of Part 1. The sync pulses, together with the noise and interference, are mixed in some way with the local waveform in the phase discriminator and the output is usually some form of pulse having some characteristic dependent on the relative phase of the signals, but it is also accompanied by noise and interference. The control voltage for the timebase is the mean value of the discriminator output and it is virtually d.c. It is the filter which changes the pulse output to d.c. and it does this by smoothing the wave. On a frequency basis it attenuates all the varying components to leave the d.c. and, in doing so, it naturally removes the noise and interference.

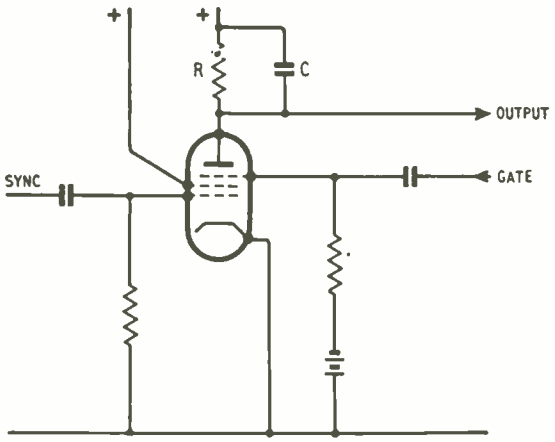


Fig. 3. Simple form of phase detector. Sync and gating pulses are applied to the control and screen grids of a pentode.

An analogy is helpful here. In a sound broadcast receiver a heterodyne whistle results if two stations are too near together in frequency. This whistle can be eliminated by making the r.f. circuits so selective that one r.f. carrier is sufficiently attenuated relative to the other, or it can be removed by using an a.f. filter after the detector. The first is analogous to the tuned-circuit flywheel system described in Part 1 and the second to the a.f.c. type of flywheel circuit. Both operate by frequency selectivity, but in different places. It is much easier to obtain the necessary selectivity in an a.f.c. system, however, and a simple RC network suffices.

There are a great many different a.f.c. circuits and the differences are chiefly in the form of the phase discriminator. The two most important divisions are between balanced and unbalanced discriminators; within these, most of the different kinds fall into the unbalanced category but the balanced type is probably the more widely used.

It will appear later that the balanced discriminator has important advantages over the unbalanced and we shall deal mainly with this kind. It is not. however, the simplest to understand and it is helpful first to consider a particular form of unbalanced circuit.

The basic circuit of this is shown in Fig. 3. The sync pulses are applied to the control grid of a pentode; they are not differentiated and so the pulses are substantially rectangular. The pulses are negative-going and the cathode current is cut off whenever a pulse is present, but at all other times the grid is at about cathode potential.

The timebase waveform comprises positive-going pulses which are preferably, but not essentially, of rectangular form. This gating-pulse waveform is applied to the suppressor grid of the pentode which is so biased that anode current is cut off except when a pulse exists on the suppressor.

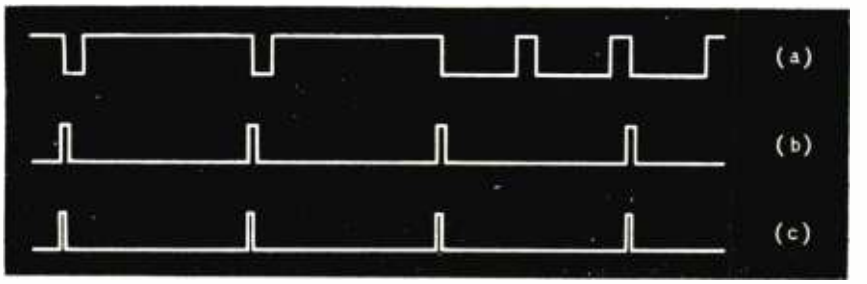


Fig. 4. Waveforms for the circuit of Fig. 3. are shown here. The sync pulses are at (a) and the gating pulses at (b). The anode-current waveform of the phase detector is shown at (c); the pulse width depends on the overlap of (a) and (b).

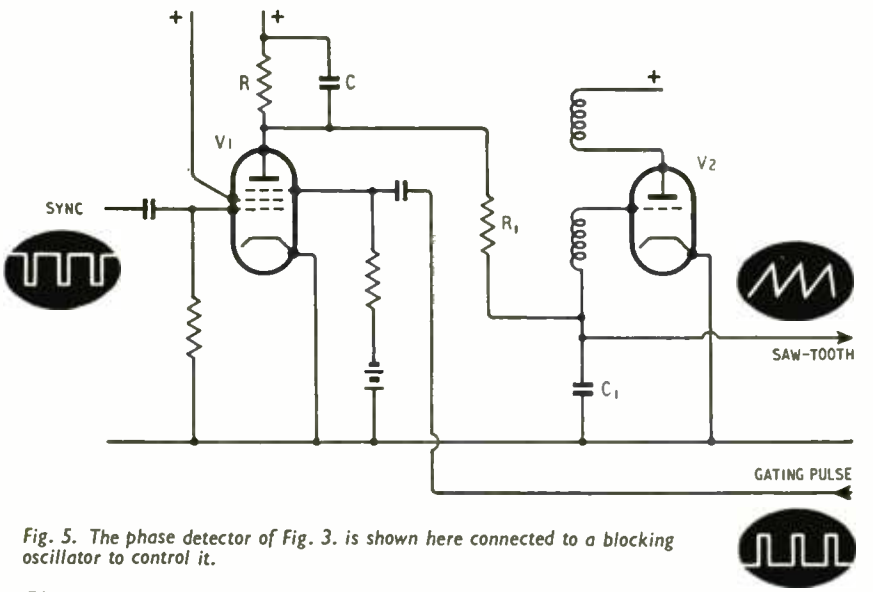


Fig. 5. The phase detector of Fig. 3. is shown here connected to a blocking oscillator to control it.

If sync pulses are absent, the valve passes anode current for the duration of every gating pulse and a mean voltage drop appears across R corresponding to the mean current through it. When sync pulses are present and overlap the gating pulses anode current is cut off during the sync pulses and so current flows only during that part of a gating pulse which is not overlapped by a sync pulse. Since the pulses are all of constant amplitude the magnitude of the anode current is always the same whenever it flows. The time for which it flows, however, depends on the overlap of the pulses and therefore, also, the quantity of electricity passed by the valve and carried into C. The resulting mean voltage developed across RC, which forms the output voltage, therefore, depends upon the degree of overlap of the pulses; that is, upon the relative phase of the sync and time-base waveforms.

Phase Discriminator Operation

One condition of operation is shown in Fig. 4. The sync pulses are shown in (a) with some of the frame pulses as well as the line. The gate-pulse waveform is shown at (b); it is generated by the timebase and is here rectangular and the pulses are assumed to have a duration of 4 μsec, compared with the 10 μsec of the line sync pulses. The phase relation shown is with the gate pulses centred on the leading edges of the line sync pulses.

The anode *current* waveform is shown at (c) and comprises pulses of 2-μsec duration. Current flows for the first 2 μsec of the gate pulse because the sync pulse has not then started; the control grid is at about cathode potential and the current starts when the gate pulse brings the suppressor grid to cathode potential. No current flows for the last 2 μsec of the gating pulse for, after the first 2 μsec, the sync pulse comes along and cuts off the current.

No change of current waveform occurs during the frame-pulse period, for the gating is accomplished on the leading edges of the pulses and these recur regularly during the frame-pulse period. The half-line pulses have no effect because there is no gate pulse when they occur. Generally, noise or interference can have no effect at all except when it occurs during the time for which the gate pulse exists. This alone can result in a considerable reduction in the frequency with which noise and interference can affect the synchronizing, although it does not alter the magnitude of its effect when it actually does occur.

If a phase change occurs between the sync pulses and the gating waveform, the effect is of a relative displacement of (a) and (b) in Fig. 3. If (b) is moved to the left, for instance, the pulse overlap is reduced and the current pulses are longer. If it is moved to the right, the overlap is greater and the current pulses are shorter. The maximum permissible movement is the width of the gating pulse—4 μsec in this instance. It can move to 2 μsec later than the position shown, when anode current is just cut off completely, or to 2 μsec earlier when the anode current flows for twice the time shown in (c) and so has twice the *mean* value.

The resistor R in Fig. 3 might have a value of 100 kΩ and the peak anode of this valve might be 5 mA. The mean voltage across R for 100-μsec line period would be $500 \times 2/100 = 10$ V for the mean condition and would vary from 0 to 20 V as the phase varied from 2 μsec late to 2 μsec early.

If the timebase is normally running so that condition (c) is obtained and some change occurs, so that the gate pulses start arriving later, it means that the interval between them is increasing and the timebase is tending to run at a lower frequency. The resulting decrease of voltage across R, which is a rise of anode potential with respect to the positive h.t line, must be applied to the timebase so as to increase its frequency.

One way of doing this is to return the charging resistor of the timebase to the anode of the valve in

Fig. 3. The increase of voltage then increases the charging current and the capacitor of this circuit charges more rapidly. This means, of course, that the frequency of the timebase tends to rise.

If the initial charge is the other way round, everything happens inversely.

The interconnection of the circuit of Fig. 3 with a blocking oscillator saw-tooth generator is shown in Fig. 5, in which R is the charging resistor and would normally be in part variable as a manual hold control. The circuit is not a very practical one for it is difficult to generate a suitable gating pulse.

Normally with direct locking the flyback is initiated by the leading edge of the sync pulse and may start almost immediately or after a small delay. The picture ceases 0.5–1 μsec before the leading edge. It is usually impracticable to make the leading edge of the gate pulse occur prior to the start of flyback and it is not easy to make it even coincide with it. The easy thing is usually for it to occur several microseconds after the start of the flyback.

When the leading edge of the sync pulse is gated and the start of the gating pulse coincides with the start of the flyback, then the flyback must start earlier than the sync pulse by up to the duration of the gating pulse. In the example quoted, flyback must start from 0 to 4 μsec before the sync pulse. As a result, from 3–3.5 μsec of the right-hand side of the visible part of the picture may be cut off or folded over. This can be avoided only by narrowing the gating pulse and it should not exceed 1 μsec in duration and, preferably, be still less. The output of the phase detector is proportionally reduced and will quite likely not be enough for adequate control.

It would, of course, be possible to obtain the same result by delaying the sync pulses and this would be preferable if it could be done easily enough. At present, however, it seems to be economically impracticable.

Another difficulty arises over the generation of a 1-μsec undelayed pulse by the timebase. The gating waveform is usually taken from the output stage of the timebase, for a large voltage exists there and it is buffered from the saw-tooth generator by the output stage. The pulse has considerable delay over the start of the flyback, however. If a voltage from the saw-tooth oscillator itself is used, there is a grave risk of the oscillator being triggered by the pulses in the phase detector, for the smoothing by RC of Fig. 2 is often far from perfect and appreciable amplitude of pulse does exist here. The circuit would then merely degenerate to an expensive and unsatisfactory way of obtaining direct locking. Because of these practical difficulties the circuit is not much used.

Effect of Noise

It will be remembered from Part 1 that the effect of noise and interference is partially or completely to fill a sync pulse or, by cancelling the signal just prior to a sync pulse, to make the pulse in effect start earlier than it should do. In the gating circuit the effect is, therefore, to make the anode current pulses somewhat variable in width. Noise and interference do affect the mean output voltage and hence the operation of the time base, but not to the same degree. Because of the integrating effect of CR, Fig. 2, any effect is very slow and spread over many scanning lines. The effect can be, in fact, no more than a slow and small sideways movement of the picture as a whole. If the time constant is smaller, so that the integration is over a period corresponding to a dozen lines or so only, then there may be a displacement of these lines relative to the others, but it is not an abrupt and erratic displacement like that which occurs with direct locking. It is a gradual displacement and the visible effect may be more than the appearance of a slight bend in vertical lines.

If, on the average, the effect of interference is to cause sync pulses to be as much early as they are late, then because CR gives an averaging effect, the effect of the interference is zero. In practice this is not likely to occur, but some reduction in its effects may well occur because of the two different ways in which noise and interference can affect the pulses.

(To be concluded)

Headquarters for Scottish Electronics

ON October 11 the Duke of Edinburgh opened a new laboratory building adjacent to the Ferranti works at Crewe Toll, Edinburgh. It has been built by the Government, and as well as housing Ferranti's own research staff it will provide a centre for the Scottish Council scheme of developing the electronics industry in Scotland. As reported in our February, 1952, issue, this scheme is based on the fact that the Scottish Council have induced the Government to place a fair share of research contracts in Scotland, from which firms will be able to build up their technical knowledge and facilities. Once the firms have established themselves with this kind of work they will be in a position to go into the commercial applications of electronics.

Ferranti's are acting as a "parent" organization for the scheme and their main function is to accept large design contracts from the Government and sub-divide them amongst the firms participating. They also provide technical liaison in the progress of these contracts and assist the participating firms with administrative matters.

The importance of the new laboratory block to the scheme is that it will provide a place where engineers from these firms can work alongside Ferranti engineers and so gain experience of electronic techniques which they would not otherwise obtain. The scheme is, in fact, mainly intended for existing firms who wish to establish their own electronics departments. One engineering firm, for example, which started by appointing one man to work in the Ferranti laboratories, now has a team of about 30, including six graduates, at work in its own factory.

Sunspot Minimum

SUNSPOT activity has, on the average, been decreasing since the maximum in May, 1947, and by the beginning of this year had reached a very low level.

Although it is not possible to predict future sunspot activity with any certainty it had been generally expected that it would reach a minimum value sometime during 1954. According to information received from the Zurich Observatory the activity is now increasing again, and it is thought probable that the minimum occurred in June. It is too early yet to be certain about this, and it is also improbable that sunspot activity will increase sufficiently to have any very significant effect upon the usable radio frequencies for several months to come.

The significance of sunspot activity to radio men is, of course, that it is one of the observable phenomena indicative of the general solar activity, upon which depends the degree of ionization of the reflecting layers of the ionosphere. When the solar activity is high the ionization of the layers is greatest, and the higher frequencies become usable for long-distance communication, when solar activity is low the m.u.fs. are lower. T. W. B.

Filters Without Fears

3.—*Some Practical Design Calculations*

By THOMAS RODDAM

IN the two previous parts of this article which appeared in the August and September issues, some attempt has been made to show how low-pass filter networks can be designed from first principles. The first article, which contained two stupid slips at the beginning, was intended to lay a foundation for its successors and in this article the idea of the Butterworth, maximal flatness, response was introduced. The second article dealt with the more complicated Tchebycheff response, the closest approximation type of characteristic. The *Wireless World* "standard reader," who serves much the same purpose as the canary in the coal mine or the leech in the jam jar, has been heard muttering that all this mathematics would never have done for *The Signal*. Can I introduce a new non-symbolic algebra, to serve as a counterpart to that study now so popular among electronic engineers, symbolic logic? Dare I press on with the mathematics and tell those of you who find it too heavy going that I can do "nothing but sympathize?"

Let us at least see where we have reached. The basic circuit which we are considering is made up of a generator of impedance R_1 and a load, R_2. Across the load there appears a voltage V_2, produced by the generator voltage V_1. Quite obviously,

$$(V_1/V_2)' = (R_1 + R_2)/R_2$$

(So obviously indeed that I wrote it incorrectly in Part I).

This is the scene before we put in the filter, which consists of a chain of shunt capacitances and series inductances making a total of n reactive elements. which we call an nth order filter. For this filter we find a new expression (V_1/V_2) = some expression containing the frequency. The insertion loss of the filter is defined as

$$20 \log (V_1/V_2) - 20 \log (V_1/V_2)' \text{ decibels.}$$

If we were not being too strict about the exact meaning of the decibel, we could say that this meant simply the loss from generator to load with filter minus the corresponding loss without filter. Just at this time, however, the definition of the decibel is under scrutiny, so we must be careful with our words. For algebraic convenience, we can rewrite the expression above as

$20 \log [(V_1/V_2)/(V_1/V_2)']$ (In Part I, I'm afraid, the prime was in the wrong place).

Now the expression $(V_1/V_2)/(V_1/V_2)'$, which we call N for short, is a complex quantity which contains terms in j, j^2, and so on. Of course $j^2 = -1$ and $j^3 = j \cdot j^2 = -j$ but after getting rid of the j^2's we finish up with $N = A + jB$, where A and B are expressions containing ω. The physical meaning of this is that N contains information about both the insertion loss and the insertion phase shift, and it is all mixed up together. We want to know the insertion loss, so we take $|N| \angle \theta = \sqrt{A^2 + B^2}$ arc tan B/A and the insertion loss is $20 \log |N| = 10 \log |N|^2 = 10 \log (A^2 + B^2)$. If for any reason we want to work with the insertion phase shift, we have tan θ = B/A.

For the second-order filter we derived the two equations

$$V_1/V_2 = (R_1 + R_2)/R_2 + j\omega(CR_1 + L/R_2) - \omega^2 LC$$
$$(V_1/V_2)' = (R_1 + R_2)/R_2$$

and dividing one by the other,

$$N = 1 + j\omega[CR_1R_2/(R_1+R_2) + L/(R_1+R_2)] - \omega^2 LC\, R_2/(R_1 + R_2)$$

Therefore $|N|^2 = 1 + \alpha\omega^2 + \beta\omega^4$, where the actual expressions for α and β were given in Part I. By putting $\alpha = 0$, the expression for $|N|^2$ is simplified to $1 + \beta\omega^4$, which is what we call a Butterworth response. The equation $\alpha = 0$ fixes a relationship between the inductance L and the capacitance C, and this relationship was given at the beginning of page 369 (August issue). It depends on the ratio of the two resistances R_1 and R_2, and some special cases were considered.

It is fairly certain that $\alpha = 0$ leads to the simplest solution, but is it the best? Bitter experience suggests that because it is the simplest it will not be the best. A more complicated solution is obtained by using the Tchebycheff polynomials, which are expressions giving a response oscillating between limits in the pass band, and offering us a choice of those limits. In Part II I used the limits of ± 0.625 db mainly in order to make the mathematics simple. This gave us two equations, $\alpha = -1$ and $\beta = +1$ and these in turn led to a new relationship between the inductance and the capacitance, a relationship which depends on the ratio of the two resistances.

Butterworth or Tchebycheff?

Have we wasted our time with the extra complication, and was the whole exercise worth while, anyway? The results which were derived in Part II showed us that the Tchebycheff filter has a much narrower transition region than the Butterworth filter. We can perform a different sort of calculation to compare the two types of filter and to give an idea of the sort of problem we may want to tackle. Suppose that we are dealing with the input to a video amplifier and we have a source with an impedance of 1,000 ohms. which is to be connected to the input grid, with a capacitance of 10 pF. In this particular example matching will be regarded as unimportant: what we shall look for is bandwidth. Common sense tells us that we should not put any resistance into the circuit, because that will reduce the available signal, so that in all the results derived in the previous articles we can take $R_2 = \infty$.

Let us consider what we will get. The simplest solution is just to connect the source directly to the input grid, giving us a first-order filter. It will be 3 db down when $2\pi f CR_1 = 1$ or $f = 1.6$ Mc/s. What is

more, and more disturbing, it gives us a very gentle cut-off, and the response will be 1.25 db down when 10 log $[1 + (2\pi fCR_1)^2] = 1.25$ or $f = 0.92$ Mc/s.

We can do better than this by adding a series inductance to convert the network into a second-order filter. With a Butterworth filter we find that the response is 3 db down at $2\pi fCR_1 = \sqrt{2}$ or $f = 2.26$ Mc/s. It is a rather sharper cut-off, too, and at the 1.25 db. point we have $f = 1.72$ Mc/s. Another capacitance, across the input end of the network, would give us a third-order filter, with $f_{3db} = 2.4$ Mc/s and $f_{1\cdot25db} = 1.95$ Mc/s.

For the Tchebycheff response, we have a tolerance of ± 0.625 db, and this gives us a response of the form $1 - x^2 + x^4$ with a 1.25-db bump at $x = 0.7$. The edge of the pass band is at $2\pi fCR_1 = 1$ or 1.6 Mc/s.

For this tolerance, therefore, Butterworth seems to give a higher limiting frequency than Tchebycheff. Against this we must set the fact that the Tchebycheff response is always above the zero frequency level, while the Butterworth response is below it: the reduction in bandwidth is paid for by a small increase in gain.

When we consider very much closer tolerances on frequency response, in which there is no gain difference worth worrying about, we find that the Tchebycheff responses do offer some advantage in terms of bandwidth for a given capacitance-resistance situation. The arithmetic is complicated, and I don't propose to do more than assure you that it is so, and that facts and figures are given in "Amplitude-Frequency Characteristics of Ladder Networks" by E. Green, published by Marconi's Wireless Telegraph Company.

Tolerance Calculations

We can use all this algebra for interstage coupling networks, too, if we stick to third-order filters. One reader wrote to me and complained that R_1 was never really infinite, even with a pentode, and of course R_2 cannot really be infinite, what with grid leaks, transit-time damping, dirty valve bases and anything else you choose to mention. The point which the reader made was that you need to get the volts on to the anode, so you must put in a physical resistor. Partly, of course, it all turns on tolerances: the tolerance on valve capacitance may be $\pm$ 15%, and in such a problem the effect of an anode supply resistance of 10 times the value of R_2 would not be too serious compared with the inherent inaccuracy of the analysis. In the example we have just considered we could make R_2 something like 100,000 ohms and never notice the slightest difference: after all, the components have some losses which are not included in the calculation. Anyway, in a second-order network which we meet very often, L is the leakage inductance of a transformer and we get a path for bias through the secondary, although we can neglect the actual shunt inductances for purposes of calculation.

There is, I think, sometimes a lack of understanding of the reasons why network theorists consider rather artificial networks. It is not that they want to analyse problems which are outside the experience of the practical man, but rather that they are rehearsing situations which illustrate fairly clearly some particular feature. Then when the practical man turns up with his problem, the theorist can say that, stripped of irrelevancies, the system is a network of such-and-such type, and you design it so and so. In these articles we have done a moderate amount of algebra, and we now have this material as background. Let us take a rather different sort of problem, and use our old algebra again.

We shall take a second order filter, and for simplicity we shall take $R_2 = \infty$. That makes $k = 1$, and the response will be given by

$$|N|^2 = 1 + \omega^2(C^2R_1^2 - 2LC) + \omega^4L^2C^2$$

We know that if $C^2R_1^2 = 2LC$ we have a Butterworth response. But suppose we make a practical filter, with some small errors in the component values: what will happen to the response?

Let us take $C' = C + \delta C$ and $L' = L + \delta L$

In this pair of equations, δC and δL are perhaps about 1/10th of the values of C and L respectively.

First, let us assume that the method we use for adjusting the filter is one which makes $\omega_0^2L'C' = \omega_0^2LC$ where ω_0 is the design cut-off frequency. We shall have $LC + C\delta L + L\delta C = LC$ (neglecting $\delta L.\delta C$ which is very small) so that $\delta L/L = -\delta C/C$. The two tolerances are equal but in opposite directions. The response is now expressed by

$$|N|^2 = 1+\omega^2[(C+\delta C)^2R_1^2 - 2LC] + \omega^4L^2C^2$$
$$= 1+\omega^2[2C\delta CR_1^2 + C^2R_1^2 - 2LC] + \omega^4L^2C^2$$

(dropping terms in δC^2)

The response was to be a Butterworth one, so $CR_1^2 - 2LC = 0$ and we have

$$|N|^2 = 1 + \omega^2\,2C\delta CR_1^2 + \omega^4L^2C^2$$

Now we know that $C^2R_1^2 = 2LC$ so that we can write

$$|N|^2 = 1 + 2\sqrt{2}.\omega^2\sqrt{LC}.\delta CR_1 + \omega^4L^2C^2$$

If the cut-off frequency is ω_0, with $\omega_0^2LC = 1$, we have

$$|N|^2 = 1 + 2\sqrt{2}\,\frac{\omega^2}{\omega_0}.\delta CR_1 + \omega^4L^2C^2$$

From this, since $CR_1 = \sqrt{2}/\omega_0$ (see Part 1), we reach

$$|N|^2 = 1 + 4\delta C/C.\omega^2/\omega_0^2 + \omega^4/\omega_0^4$$

We could now calculate the shape of the insertion loss characteristics for any particular value of $\delta C/C$. It is quite useful, however, just to look at this expression and to examine what happens if we have $\omega = \omega_0$. Then $|N|^2 = 1 + 4\delta C/C + 1 = 2 + 4\delta C/C$.

Suppose we take $\delta C/C = \pm 0.25$. For $\delta C/C = +0.25$ we have $|N|^2 = 3$ and the response is 4.77db down where it should be 3db down. If $\delta C/C = -0.25$ the response is not down at all at the ideal 3db point, and looking back we see that it has the form

$$|N|^2 = 1 - \omega^2/\omega_0^2 + \omega^4/\omega_0^4$$

This is just the expression we found for the ± 0.625db Tchebycheff case. As we know that Tchebycheff responses are in general more profitable than Butterworth ones, we can aim our design so that it falls between the two by making C' rather below than above the design value, and L' on the high side. The simple calculation above has given us a guide as to the way in which we must make provision for the errors of the practical solution.

Suppose, however, that you insist on a Butterworth response at all cost. We have $CR_1^2 = 2L$ so that in the practical case $C'R_1^2 = 2L'$

and therefore $\delta CR_1^2 = 2\delta L$

giving $\delta C/C = \delta L/L$

This time both reactances are in error in the same direction, and again the percentage error is equal. Now the insertion loss characteristic is given by

$$|N|^2 = 1 + \omega^4(L'C')^2$$
$$= 1 + \omega^4(L + \delta L)^2\,(C + \delta C)^2$$
$$= 1 + \omega^4(L^2C^2 + 2L^2C\delta C + 2LC^2\delta L +$$

terms in the products of the errors, which we can neglect).

From this $|N|^2 = 1 + \omega^4L^2C^2\left(1 + 2\frac{\delta C}{C} + 2\frac{\delta L}{L}\right)$

$= 1 + \omega^4L^2C^2(1 + 4\delta C/C).$

It is not very hard to get from this to the result that if $\omega_0^2LC = 1$, the response will be 3db down at $\omega_0(1 - \delta C/C)$. While we quite cheerfully accepted a value of $\delta C/C = -0.25$ before, giving us a response change from $\pm$1.5db to $\pm$1.25db, this capacitance tolerance allied with the insistence on a Butterworth characteristic has cost us a 25% change in bandwidth. If we took $\delta C/C = +0.25$ the response would be narrowed by 25%, and would be 6.2db down at the design cut-off, instead of 4.77 db.

We really have collected quite a lot of information from the second-order equation, and now, you notice, it is really practical stuff, which gives us guidance when we are designing a network to be made. We want to lean our design towards the region between a Tchebycheff response and a Butterworth response, and we must adjust the components to give the correct resonant frequencies, rather than just try to get the individual values right.

Let us now look at yet another way in which we can make use of some of our results. The simple filter networks are often used for connecting one valve to another: the circuit used may not look exactly like one of those shown in Table I (page 445, September issue), but it reduces to the filter form if you twist it round suitably. When we have two filter circuits separated by a valve, the overall response characteristic is given by the equation $|N|^2 = |N_1|^2.|N_2|^2$ where N_1 and N_2 relate to the two filter networks. To save labour I shall confine myself to first- and second-order filters, for which

$|N_1|^2 = 1 + x^2$ (first order)

$|N_2|^2 = 1 + ax^2 + x^4$ (second order)

If then we have two first-order filters connected through a valve:

$$|N|^2 = (1 + x^2)(1 + x^2)$$

This is a very dull solution, 6 db down at $x = 1$. If we have a first-order filter and a second-order filter in tandem the most general form we can find for this is:

$$|N|^2 = (1 + x^2)(1 + ax^2 + bx^4)$$
$$= 1 + (1 + a)x^2 + (a + b)x^4 + bx^6$$

I'm not sure if this can be made into a Tchebycheff response: I rather think it cannot. But if we put $b = 1$ and $a = -1$ it reduces to $|N|^2 = 1 + x^6$, a Butterworth response. We have, in fact, obtained a Butterworth response of the third order by combining a first-order characteristic with a second-order Tchebycheff response.

Two second-order filters in tandem will give us, in the most general case:

$$|N|^2 = (1 + ax^2 + x^4)(1 + bx^2 + cx^4)$$

There is an extensive field for study here, but let us put $c = 1$, so that

$$|N|^2 = 1 + (a + b)x^2 + (ab + 2)x^4 + (a+b)x^6 + x^8$$

Here we can take $a = -b = \sqrt{2}$, and we are left with

$$|N|^2 = 1 + x^8$$

This particular result is one which happens to crop up in the design of feedback pairs, and we might also find it in the design of a system consisting only of an input circuit, a valve and an output circuit. One valve or four, low-pass or band-pass, its all part of the same family, and one lot of plodding suffices. In this case we should have to go back from

$$|N|^2 = 1 \pm \sqrt{2}\,x^2 + x^4$$

to

$$|N|^2 = 1 + [(CR_p + L R_s)^2 - 2LC]\omega^2 + \omega^4L^2C^2k^2$$ (September issue)

and the corresponding equation with k'. We would, perhaps, take k and $k' = 1$, which you can find to be what happens if a pentode is used with an unloaded grid. Then $|N|^2 = 1 + (CR^2 - 2LC)\omega^2 + \omega^4L^2C^2$ and therefore $CR^2 - 2LC = \pm\sqrt{2}\,LC$

$$\frac{CR^2}{L} = 2 \pm \sqrt{2}$$

In this composite equation R is the source impedance for the input filter, and the load impedance for the output filter. C is the valve capacitance, input or output. It doesn't really matter to us which filter we use at the input and which at the output, even though one is a characteristic with a hump in it, while the other is a rounded one. We should check both forms against the valve characteristic in practice, because one presents a much higher load resistance to the valve than the other.

We could, of course, go on to consider what happens if third-order filters are included, but the algebra becomes involved, and is, indeed, sufficiently involved to justify a slightly different approach, based on the distribution of the characteristic frequencies of the networks. I do not propose to discuss this matter at all, because the algebra really does get rather beyond the permitted limit.

Nothing in this article, of course, will enable you to design a filter wihtout thought. None of the equations should be taken on trust, because they are only introduced as examples of how to set about the job, and I usually work them out from first principles every time I need them. But if you can work out what happens in a simple RC circuit, you can calculate a second-order filter, too. If you can do that, you can try the third-order filter: better still, you can try the problems of variations, like the effects of component tolerances we have been considering above, or problems connected with the phase characteristic, which I haven't discussed at all. Then there's quite a different set of response characteristics, of the general form $N = (1 + j\omega/\omega_0)^n$. These are thoroughly well damped, and give no overshoot at all when a step wave is applied to them. Some of this work, perhaps, is just shadow boxing, just a light paddle between the locks, a chess problem by the fireside; but it is all part of the process of building up a solid foundation on which further development can take place.

NEW EPOXIDE RESIN

IMPROVED strength and toughness is claimed for a new epoxide resin ("Epophen" M-777) made by Leicester Lovell and Company, North Baddesley, Southampton. It is used as a contact adhesive for bonding metals, glass and plastics, as well as wood and other materials which are normally glued. In addition it can be used as a casting resin, and one application is in the production of press tools for sheet metal working Castings up to ½-ton in weight are possible, one reason being that there is no appreciable evolution of heat during the setting process.

For test purposes, a kit containing resin, catalyst and filter, with means of measuring and mixing and full instructions, is obtainable from the manufacturers, price 7s. 6d.

High-Quality Tape Recording

Circuit Design for a Recorder Using High-impedance Heads

By A. F. FISCHMANN*, A.M.Brit.I.R.E.

THE design described in this article is simple and may be adopted easily to different tapes and high impedance recording heads. Frequency-selective feedback is used throughout the system in order to modify the frequency response.

The author's equipment consists of the Model 5 Tape Desk built by Bradmatic Ltd., Station Road, Aston, Birmingham 6. It is equipped with erasing, recording and reproducing heads, all of the high-impedance type. Its performance using MC1-111 tape of the Minnesota Mining and Manufacturing Company Ltd. at a speed of 7.5in/sec. was found to be as follows:

Response within ±3db between 40-10,000 c/s.
Signal-to-noise ratio 45 db.

The distortion was not measured but the reproduction of high-quality discs through the recorder proved to be indistinguishable from the original. An extension of the frequency range could have been readily obtained, using additional equalization.

The system consists of a recording amplifier, playback amplifier and supersonic bias oscillator and may be used in connection with any high-quality pre-amplifier as a front-end control unit for a power amplifier. Obviously all the equalization necessary for the truthful reproduction of records or any other programme must be provided within the pre-amplifier, and the system itself is designed for flat response within the above-stated limits between its input and output. The main amplifier should provide the conventional tone control circuits (treble and bass lift and cut). A block diagram of the complete system is shown in Fig. 1 together with the selector switch. Switch S_1 is provided in order to compare the performance of the unit with direct transmission and is especially useful for the adjustment of its frequency response in the absence of accurate measuring gear.

The diagram of the record amplifier is shown in Fig. 2. To suit the special requirements of a tape recorder, it should provide a constant current through the recording head at all transmitted frequencies, thus ensuring equal magnetization of the tape over the whole transmission band. In addition, treble lift may be necessary to compensate for losses due to the tape and the airgap of the recording head, whose width sets a definite limit to the highest transmitted frequency. The constant-current characteristic is frequently achieved by providing a frequency response rising by 6db per octave. The signal is then applied to the recording head which represents a mainly inductive load and a substantially constant-current characteristic is thus obtained. Different arrangements use a resistance of about 50kΩ through which the recording head is connected to a conventional amplifier. The latter has to provide a considerable output voltage at all frequencies due to the losses in that resistance and may give rise to distortion if not properly designed.

In this amplifier a different way was chosen. The output stage, Fig. 3(a), will be considered separately and its equivalent circuit diagram is shown in Fig. 3(b), where

$$R'_i = R_i + R_k(\mu+1) \qquad (1)$$

(R_i = internal resistance of V2).

The voltage across the load

$$E_L = -\frac{\mu E_{in} Z_a}{R_i' + Z_a} \qquad (2)$$

where $Z_a = \dfrac{R_a Z_L}{R_a + Z_L}$

$$g'_{m2} = \frac{\mu}{R_i' + Z_a} \qquad (3)$$

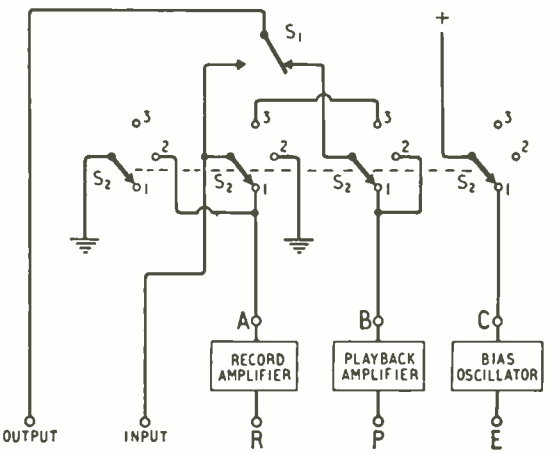


Fig. 1. Block diagram of the system. Switch positions are: 1, recording: 2, reproducing: 3, direct.

* Israeli Ministry of Defence, Scientific Department.

Symbols

R_{in}	=	Internal resistance of valve *n*.
R_k	=	Cathode resistance.
R_{an}	=	Anode resistance of valve *n*.
μ	=	Amplification factor.
g_{mn}	=	Mutual conductance of valve *n*.
g_{pn}	=	$\frac{1}{R_{in}}$
G_k	=	$\frac{1}{R_k}$
G_a	=	$\frac{1}{R_a}$
Z_{out}	=	Output impedance of recording amplifier.
i_r	=	Recording current, C_{92} connected.
i'_r	=	Recording current, C_{92} disconnected.
L_R	=	Inductance of recording head.
r_R	=	Equivalent series resistance of recording head.

System

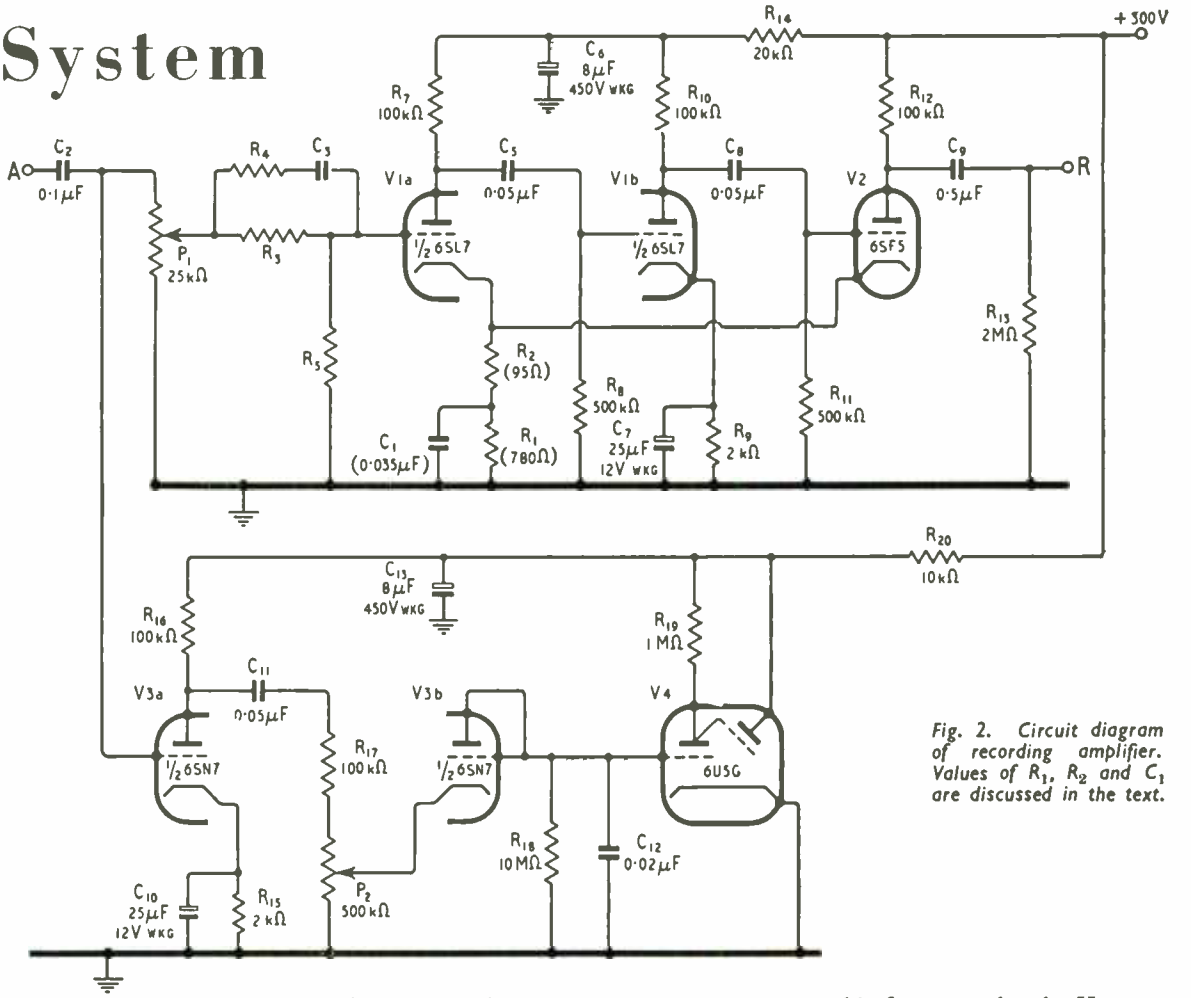


Fig. 2. Circuit diagram of recording amplifier. Values of R_1, R_2 and C_1 are discussed in the text.

may be considered as the effective transconductance of the valve V2 due to the current feedback from the cathode. As $R_i' \gg Z_a$ within the transmitted frequency spectrum, $g'_{m2} \approx \frac{\mu}{R_i'}$ and V2 is working as a constant current generator.

R_k may be designed as to make R_i' sufficiently high in order to drive a recording head with a constant current over a reasonable frequency band. However, in that case V2 would need a driving voltage of approximately 20 volts, which can hardly be provided by any of the pre-amplifiers generally in use. Therefore a double triode is added and the feedback is extended over two additional stages. Using the simplified diagram shown in Fig. 4 and putting $G_{a1}=G_{a2}=G_{a3}=0$, the output admittance of that circuit is

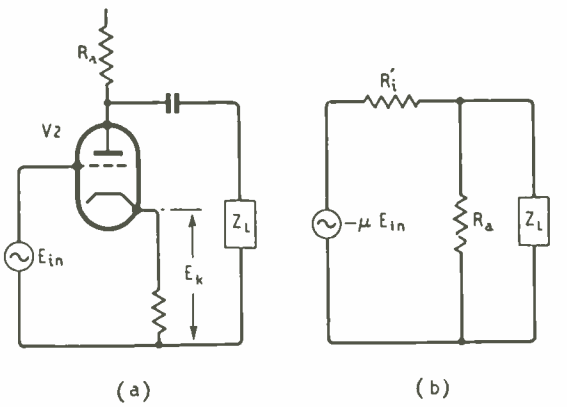


Fig. 3. (a) Output stage of recording amplifier and (b) its equivalent circuit.

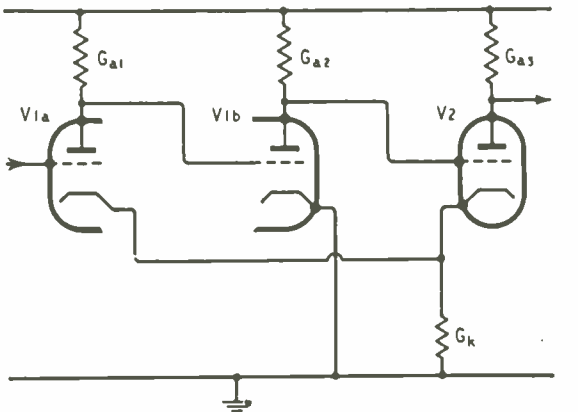


Fig. 4. Simplified diagram of feedback in the recording amplifier.

$$Y_{out} = g_{p2}\left(1 - \frac{1}{1+\beta G_k}\right) \quad .. \quad .. \quad .. \quad (4)$$

where $\beta = \dfrac{1}{g_{m2} + g_{p2} + \dfrac{(g_{m1}+g_{p1})g_{m2}g_{p2}}{(g_{p1})^2}}$

and g_{m1}, g_{m2}, g_{p1}, g_{p2} are the respective mutual conductances and plate conductances of V1 and V2.

As $\beta G_k \ll 1$, therefore $1 - \dfrac{1}{1+\beta G_k} \approx \beta G_k$ and $\dfrac{1}{Y_{out}} = Z_{out} \approx \dfrac{1}{g_{p2}\beta G_k} = \dfrac{14.4\times10^6}{g_{p2}G_k}$ MΩ for practical values of g_m and g_p.

Z_{out} may therefore be neglected in comparison with R_a and the latter determines solely the output impedance of the complete amplifier. Its current amplification will be inversely proportional to R_k and may be made to rise over a certain frequency range by introducing an R−C network (R_3, R_4, R_5, C_3, in Fig. 2). It should be designed to compensate for the loss of high frequencies as already mentioned, and may extend the flat frequency range by one octave. It should be noted that the high-frequency response of the amplifier may be controlled by extremely low impedances, avoiding the conventional high-impedance type networks which are most liable to capacitive pick-up if not properly screened. The recording amplifier response may also be easily adapted to different kinds of tape speed by changing C_1, which will move both the low and the high frequency turnover point by an equal amount. The value of these components should be determined experimentally according to the characteristic of the individual tape and recording head. Their design procedure will be outlined later in this article.

A magic eye V4 is connected to the input of the recording amplifier through V3. It should close for full modulation of the tape and its sensitivity may be adjusted by P_2 (Fig. 2).

The playback amplifier (Fig. 5) is designed along conventional lines. A signal recorded with a constant current characteristic will provide an output rising by 6db per octave at the terminal of the playback head. In this particular case the response was measured as shown in Fig. 6, using MC1-111 tape at a speed of 7½in/sec. It rises by 6db per octave up to a frequency of 1,600c/s, then flattens out gradually and drops considerably above 6,000c/s. This is caused by losses due to self-demagnetization, penetration and the gap effect[1].

The response of the playback amplifier should be inverse to the curve shown in Fig. 6 and should therefore fall by 6db per octave from 40c/s per second (the lowest transmitted frequency) up to 2,500c/s. This is controlled by the frequency-selective feedback network between the anodes of V5 and V6 consisting of $R_{53}+R_{54}$, R_{56}, C_{52}, R_{55}. The value of $R_{53}+R_{54}$ will determine the high-frequency turnover point, but leave the low-frequency turnover point unchanged as long as the other values of the network are retained. The playback amplifier characteristic may therefore be easily adapted to different tape speeds by changing the value of $R_{53}+R_{54}$.

C_{51} belongs to the de-emphasis network and will be mentioned later. The respective values of these components are not specified and the reader is referred to the alignment procedure as outlined at the end of this article.

As the output voltage at the playback head is extremely low, especially at low frequencies, the amplifier should be designed for minimum noise level. A triode-connected 12SJ7, with the heater d.c. fed, preferably from the main amplifier anode current, is used in the first stage, with an equivalent noise resistance due to shot effect of approximately $\dfrac{2.5}{g_m}$ ohms at the input[3]. To this is added the flicker effect which increases with the square of the emission current, but decreases with the inverse square of the frequency[4]. Because of this frequency dependence, the flicker effect becomes appreciable at low frequencies where the amplification of the playback amplifier is just at its maximum value. The noise due to the flicker effect may however be held sufficiently low reducing the anode current of V5 by making R_{57} 0.3MΩ.

Finally we come to the erase and bias oscillator (Fig. 7). Greatest possible freedom of harmonics is desired to ensure low noise level and low distortion of the recorded signal. It consists of a cathode follower type oscillator, the principle of which was described elsewhere[2]. The variable feedback resistor P_3 provides a method of controlling the negative resistance injected into the tuned circuit with great accuracy. It may be adjusted to provide an amplitude of 8 volts at the cathode of V7. Under those conditions the grid-cathode voltage of that valve is small enough to ensure its linear operation, and such an oscillator will therefore provide an output containing less har-

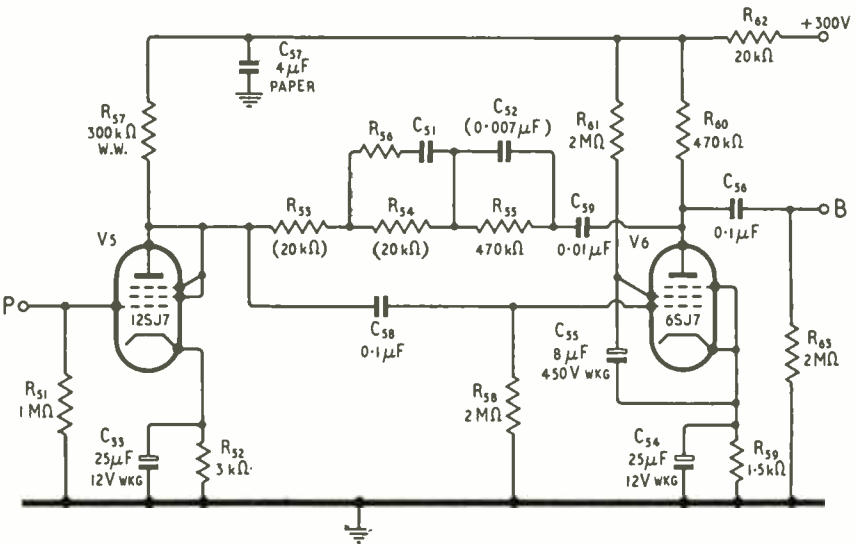


Fig. 5. Circuit diagram of playback amplifier. Values of R_{53}, R_{54} and C_{52} are discussed in the text. The heater of the first valve should be fed with d.c., preferably from main amplifier anode current.

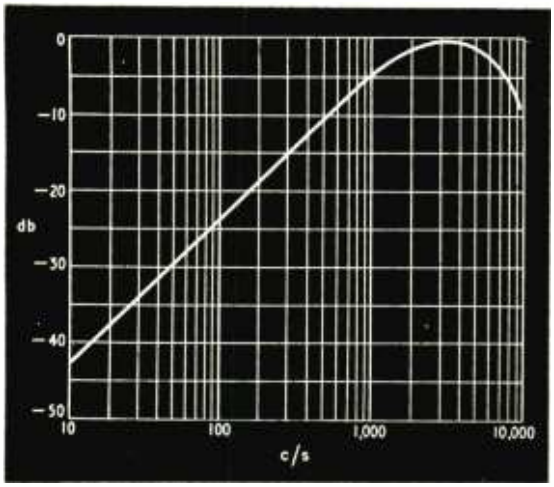


Fig. 6. Measured response at playback head, with constant-current recording.

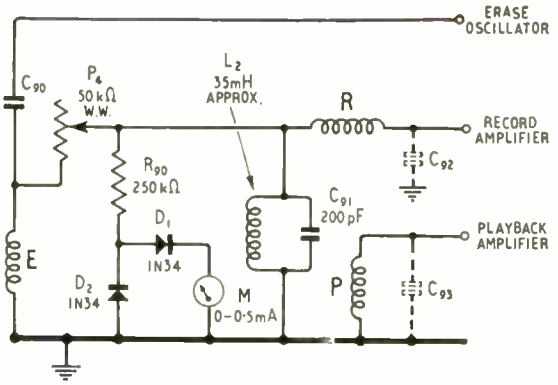


Fig. 8. Connections of magnetic heads and bias level meter. R, recording head: P, playback head: E, erase head. C_{92} and C_{93} are the capacitances of the connecting leads. C_{90} is adjusted to resonate with E at 60 kc/s.

monic distortion than a conventional one. However, its amplitude is not absolutely constant over a considerable time and therefore P_1 and M (Fig. 8) provide a means of adjusting the bias amplitude accurately during recording. The erasing head in the author's equipment was found to have an inductance of 29mH and an equivalent series resistance of 4,700 ohms at 60kc/s. It is brought to series resonance with C_{90} (Fig. 8) thus providing the necessary load of 5,000 ohms for V8. In addition, the output voltage is stepped up, the Q of the circuit being about 2. This selectivity will also provide some attenuation of harmonics generated in the output valve.

It is important that C_{90} should be connected directly to the erasing head thus leaving the capacitance of the connecting cable in parallel with the tuned anode load of V8, which should resonate at the oscillator frequency of 60 kc/s.

The anode of the oscillator valve V7 is bypassed to earth with 8μF and consequently its anode voltage will decrease only gradually after interruption of the supply voltage by S_2, which ensures slow damping out of the oscillations. This is important in order not to leave any magnetism in the erase and recording head after the oscillator is switched off. The relay L_3, S_3 serves to short the erasing head to earth when the oscillator is inoperative. It should close only after the oscillations are completely damped out. This is accomplished by removing the copper rivet generally used in conventional relays. This rivet serves to prevent sticking of the relay due to remanent magnetism, after the current is interrupted. With this small alteration the relay will open with a certain delay and thus provide the necessary characteristic.

The recording bias is taken from the erasing head and is adjustable by P_1 (Fig. 8). The parallel tuned circuit L_2C_{91} resonates at 60 kc/s, thus forcing the bias current mainly through R and C_{92} (the capacitance of the connecting cable), the voltage drop across the latter being negligible. The filter formed by P_1 L_2 C_{91} will also provide additional attenuation of harmonics of the bias frequency.

The situation is different at recorded frequencies: L_2 provides then a short circuit and C_{92} will resonate with the recording head R somewhere above the highest transmitted frequency. This method of coupling was chosen in order to prevent the bias from entering the record amplifier and at the same time to maintain the high input impedance of R as seen by the record amplifier. Any capacitive load of the latter would considerably impair the response at the highest audio frequencies due to its high output impedance.

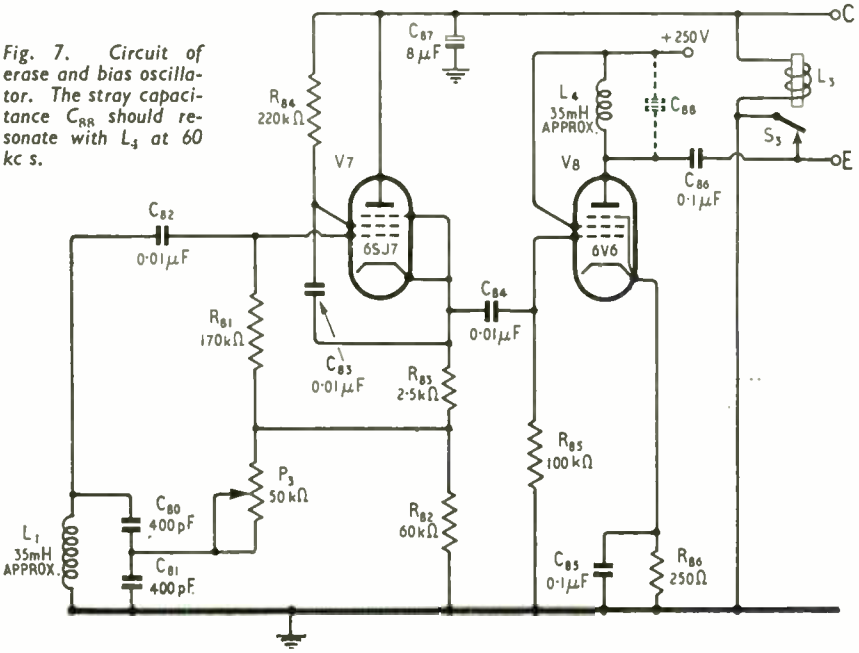


Fig. 7. Circuit of erase and bias oscillator. The stray capacitance C_{88} should resonate with L_4 at 60 kc/s.

A value of 200pF was chosen for C_{92} to resonate with the recording head used in the writer's equipment at 14,000 c/s. The voltage drop across that capacitance due to the bias will be fed into the record amplifier and, although small, it may give rise to beats with the recorded frequencies. It will, due to the feedback action of the amplifier, appear in antiphase at the grid of V2 with an amplitude determined by the voltage divider consisting of the cathode resistor and the internal resistance of V2. In order to keep this amplitude low a valve with a high internal impedance should be chosen for V2 and a 6SF5 having an internal resistance of about 60 kΩ was found to be adequate. However a pentode with an internal resistance of the order of a megohm may be chosen in extreme cases.

Circuit Adjustments

The values of the various components determining the frequency response should be found by trial and error. A signal generator providing frequencies between 40-15,000 c/s and a valve voltmeter calibrated in db are highly desirable. First the amplifier will be operated with C_1, C_3, C_{51} and C_{52} disconnected. The optimum bias may now be adjusted by means of P_4 using a signal of about 3,000 c/s. When increasing the h.f. bias from zero, the volume will rise and distortion will decrease considerably, until a maximum of volume is reached. A further increase of the bias will cause additional reduction of distortion but also of the volume. The optimum setting of P_4 for minimum distortion will therefore slightly increase the signal-to-noise ratio, but minimizing the distortion is considered to be of primary importance. In the writer's equipment a bias of 135 volts across the recording head was found to correspond to minimum distortion.

After adjusting the bias, the amplification of the record amplifier may be adjusted by means of the feedback resistor $R_1 + R_2$ (see Fig. 2) to deliver at the recording head a signal as specified by the makers of the tape desk. The response of the playback amplifier should now be plotted, yielding a curve similar to the one shown in Fig. 6. Then, taking the flat response between 2,500-4,000 c/s as the reference level, the value of C_{52}, $R_{53} + R_{54}$ may be found for flat response down to 40 c/s. $R_{56}C_{52}$ determines the low-frequency turnover and $R_{53} + R_{54}$, C_{52} the high frequency turnover. Now the treble boost provided by C_1, R_1, R_2 in the record amplifier may be adjusted to extend the frequency response at the high-frequency end. The time constant R_1C_1 determines the low-frequency turnover point and R_2C_1 the high-frequency turnover point.

In addition the response of the record amplifier at the high frequencies depends on the value of C_{92}, which works out as follows:

$$i_r \propto \frac{1}{R_{a2}(1-\omega^2 L_R.C_{92})+r_R+j\omega L_R\left(1+R_{a2}\frac{C_{92}.r_R}{L_R}\right)} \quad (5)$$

and the ratio of the response with C_{92} connected to the response without C_{92}

$$\frac{i_r}{i_r'} = \frac{R_{a2}+r_R+j\omega L_R}{R_{a2}(1-\omega^2 L_R.C_{92})+r_R+j\omega L_R\left(1+R_{a2}\frac{C_{92}.r_R}{L_R}\right)} \quad (5a)$$

Consequently the response of the playback amplifier may be lifted at the high frequencies by a ratio indicated in equation 5a.

Additional treble equalization may be obtained by tuning the playback head to resonance at the high end of the transmitted frequency band. The capacities C_{92}, C_{93} may be fully or partly realized by the capacity of the connecting cables. An effective means of improving the signal-to-noise ratio is to use pre-emphasis for frequencies above 1000 c/s similar to the characteristic used for records. This may be introduced by the conventional network R_3, R_4, R_5, C_3 connected to the input of the recording amplifier†. The loss of amplification due to this network may be compensated by decreasing the feedback from R_1, R_2.

As R_1, R_2, C_1 have been determined previously, the time constant R_1C_1 and R_2C_1 should remain unchanged in order not to affect this adjustment, The de-emphasis is incorporated in the feedback network of the playback amplifier and consists of R_{53}, R_{54}, R_{56}, C_{51}.

If records are played with a magnetic pickup (giving constant output from constant velocity recording), they may be recorded on the tape without any correction of the frequency band above 1000 c/s, which will provide directly the wanted pre-emphasis characteristic.

The only correction applied in that case will then be the de-emphasis, incorporated in the playback amplifier.

† See, for example, "Radio Designers Handbook," by E. Langford Smith, p. 653.

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1 "Frequency Response of Magnetic Recording," by Otto Corner in "Electronics Manual for Radio Engineers," p.107. (McGraw Hill).

2 "Simplified Q Multiplier," by H. E. Harris, in "Electronics for Communication Engineers," p. 29. (McGraw Hill).

3 "Vacuum Tube Circuits," by L. B. Arguimbau, Chap. 3, 15. (Chapman and Hall).

4 "Vacuum Tube Amplifiers," M.I.T. Radiation Laboratory Series, Vol. 18, Sec. 12, 5. (McGraw Hill).

Commercial Literature

F.M. Car Radio covering 87-109 Mc/s with a.f.c. for locking on to signal and 2μV sensitivity. The aerial is embedded in a strip of plastic for sticking to inside of windscreen. Descriptive leaflet from Hastings Products, 171 Newbury Street, Boston 16, Mass., U.S.A.

Prefabricated Cabinets and telescopic mountings; a new illustrated catalogue including additions and improvements to the Widney-Dorlec range of parts. From Hallam, Sleigh and Cheston, Bagot Street, Birmingham 4.

Tape Table made by Lane with two speeds and frequency response of 40 c/s-10 kc/s. Tape reels are locked when machine is off to avoid tape spilling. Leaflet from Verdik Sales, 8 Rupert Court, Wardour Street, London, W.1.

Flexible Shafts; a detailed and well-illustrated handbook describing their construction and characteristics, with graphical and tabular data, and explaining their application to various remote control problems. From The S. S. White Co. of Great Britain, 126 Great Portland Street, London, W.1.

Audio-frequency Amplifiers; leaflet describing the "Astronic" 12-watt range, for various inputs, from N. Miers and Co., 115 Gower St., London, W.C.1.

Flux-cored Solder Wires, using pure rosin, activated rosin and acid compound; also solder preforms, solid solders, solder paints and other products. Described in a booklet from Enthoven Solders, 89 Upper Thames Street, London, E.C.4.

Plastics Used in Cables; their history and general characteristics described in a booklet "The Application of Plastics in the Cable Industry" from The Telegraph Construction and Maintenance Company, Telcon Works, Greenwich, London, S.E.10.

More Rectification

By "CATHODE RAY"

Far-reaching Effects of a Reservoir Capacitor

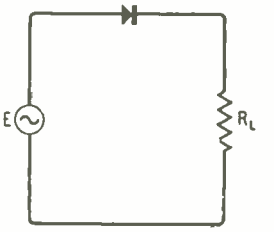
LAST month we considered Fig. 1, the simplest possible rectifier circuit, reduced to its simplest possible terms, namely a resistanceless generator of pure sine waves feeding a pure resistance load through a perfect rectifier, i.e., one having no resistance at all to current in one direction and infinite resistance to current in the opposite direction. We considered the readings of perfect voltmeters of various types connected to read the three possible voltages in the circuit—across generator, load, and rectifier—and perfect ammeters to read the one possible current. And in spite of taking a long time over this apparently simple and straightforward job, we didn't even finish it. We drew up a table of readings given by three types of voltmeter: (1) the ordinary moving-coil type used for d.c., which responds to mean values; (2) the same with a full-wave rectifier to adapt it for a.c., which responds to mean values of rectified voltages, but is scaled to read r.m.s. values, which are 11% higher; and (3) the electrostatic or moving iron or any other type that actually responds to r.m.s. values as well as being scaled in them. Most valve voltmeters are outside all these categories because, although usually scaled to read r.m.s. values, they respond to peak values. Our first job now is to complete the table by filling in the entries for this type of meter.

Again let us assume that the instrument is perfect, so that the rather complicated matter of its errors doesn't arise. Now we know that the r.m.s. value of a sine wave is equal to its peak value divided by $\sqrt{2}$; in the usual symbols, $E = E_{max}/\sqrt{2} = 0.707E_{max}$. So to make the peak voltmeter read r.m.s. values directly, it is arranged so that it indicates 0.707 times the peak value. Consequently when connected across the generator in Fig. 1, where it sees waveform 2(a), it reads E, the r.m.s. value—like the other types of a.c. voltmeter.

Next, connect it across the rectifier or the load. In either of these positions it sees waveform 2(b). If the voltmeter has no blocking capacitor or transformer coupling it responds to the peak voltage from the zero line. Connected one way round, this peak voltage is E_{max}, and as the instrument is scaled to read 0.707 times this it reads E as before. If connected the other way round it receives only the half-cycle that has been removed by rectification, so the reading is nil.

But most valve voltmeters have a series capacitor,

Right: Fig. 1. The simplest possible rectifier circuit again.



Below: Fig. 2. Waveforms associated with Fig. 1: (a) across the generator; (b) across rectifier or load resistance; (c) after using a blocking capacitor on (b) to exculde the d.c. part.

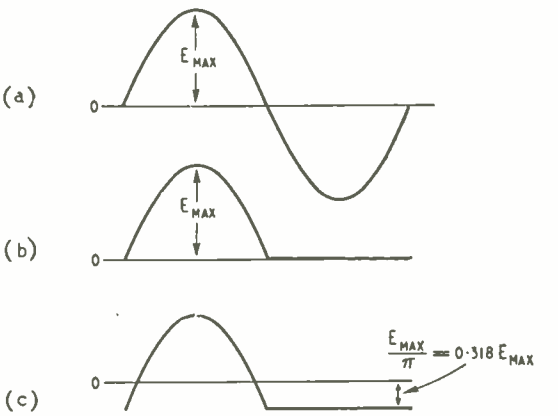


TABLE I

Type of voltmeter	Across generator (with or without blocking capacitor)	Across R_L or rectifier (without blocking capacitor)	Across R_L or rectifier (with blocking capacitor)
Mean (moving-coil)	0	0.450E *or* —0.450E	0
Rectifier .. (calibrated to read r.m.s. values of sine wave)	E	0.500E	0.551E
Square-law .. (calibrated to read r.m.s. values of sine wave)	E	0.707E	0.545E
Peak .. .. (calibrated to read r.m.s. values of sine wave)	E	E *or* 0	0.682E *or* 0.318E

which blocks the d.c. component, and after the surge caused by the charging of this capacitor at the moment of connection has died away the voltmeter sees waveform 2(c). We have already found that the d.c. component is equal to the peak value divided by π, and the voltages are in the same proportion. So if connected one way the peak value is $(1-0.318)\ E_{max}$, and the other way $0.318E_{max}$; and the readings, being 0.707 times these, are 0.682E and 0.318E respectively.

So except across the generator, where the waveform is symmetrical, the reading of the peak voltmeter depends on which way it is connected; hence the two pairs of entries in Table I for this type. The only other reading that is affected by direction is the mean value, and that is not with regard to the actual value of the reading but only its polarity.

We must remember once more that if the generator provided some other waveform than sinusoidal, most of the figures in the table would be different. We noted before that if a rectifier meter were connected across a source of square waves (whose mean, r.m.s. and peak values are all equal) it would read 11% high —because it is designed to do this in order to allow for the inequality of the mean and r.m.s. value of sine waves. The inequality between *peak* and r.m.s. values is the other way around and greater; our compensated peak voltmeter would read square waves nearly 30% low.

Now for Current

No type of ammeter that I know reads in proportion to peak values. The only way would be to put a very low resistance in circuit, amplify the voltage across it, and measure that with a peak voltmeter. A cathode-ray oscillograph would do as the amplifier and voltmeter. Any such arrangement would hardly be calibrated in either r.m.s. or mean values, so would not be comparable with other types of current meter. But while we are at it we might as well tabulate last month's findings for these other types (Table II).

Fig. 1 being a purely series circuit, there is only one current throughout, the waveform of which is as Fig. 2(b). But in the current table there are two columns of readings, because some meters receive the current directly, while others are coupled by a transformer, which eliminates the d.c. component. The moving-coil d.c. meter is always directly connected, for obvious reasons. But the rectifier meter can be connected either way, as in Fig. 3, and when it is used in a rectifier circuit the reading depends on which. In practice it is almost always transformer-coupled (b), because this allows the range to be varied by varying the number of primary turns in circuit. Fig. 3(a) only provides one range, up to the maximum rating of rectifiers and meter, because owing to the varying resistance of the rectifiers the range cannot be varied in the usual way by shunts. Lastly the square-law type, which is usually a heat operated instrument, because that can be accurately calibrated on d.c. The point to remember is that the true r.m.s. reading which it indicates (regardless of waveform) is, with a sinusoidal input to this simple circuit, 1.57 times the mean current, as read on a d.c. meter, so its heating power is $1.57^2 = 2.46$ times as much.

Having claimed so much of your valuable time on this absurdly simple(?) circuit, I may be running a grave risk of assault if I now calmly announce that it is of theoretical interest only, being rarely used in practice. But I hope that the effort may be seen to have been worth while, as a convincing warning against tackling even the simplest rectifier circuits and calculations without due care and attention. They are thoroughly deceptive things. That being understood, however, perhaps I can deal with the practical types more sketchily.

The reason why Fig. 1 is rarely used in that simple form is that d.c. in the Fig. 2(b) form is rarely desired. But the smoothing circuits needed to reduce it to pure d.c. have the incidental effect of radically altering the rectifier circuit. So let us now look into rectifier circuits modified by smoothing.

The simplest is Fig. 1 with a capacitor connected across R_L, as in Fig. 4(a). A closely related variety is Fig. 4(b). These come in for a great deal of attention, because they are so much used; nearly all detectors, nearly all valve voltmeters, and nearly all the rectifier circuits in a.c./d.c. sets are essentially one or other of these types. Quite recently they were discussed at some length from the valve voltmeter point of view.* Pages and pages of data appear on them in the *Radio Designer's Handbook* and indeed in most books on radio. So all I am going to do now is to outline how C in Fig. 4(a) affects the currents and voltages.

If we were to continue on our hitherto ideal lines, we would assume that C was infinitely large, so as to provide perfect smoothing. But these assumptions would lead to the generator being required to supply an infinitely great current for an infinitesimally small time during each cycle; and to avoid such arrant

* M. G. Scroggie, *Wireless World*, June, p. 284, and July, p. 339, 1954.

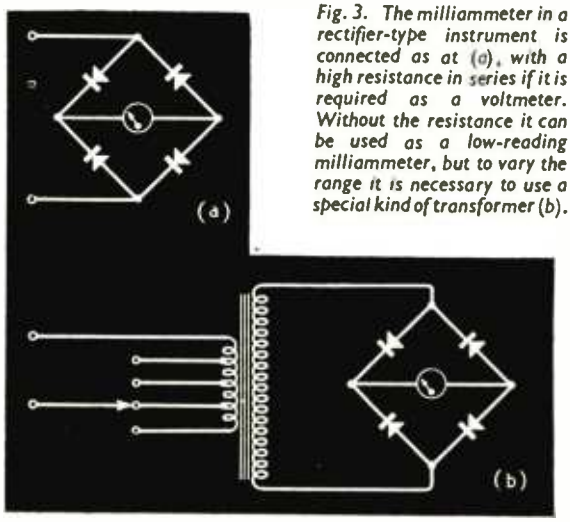


Fig. 3. The milliammeter in a rectifier-type instrument is connected as at (a), with a high resistance in series if it is required as a voltmeter. Without the resistance it can be used as a low-reading milliammeter, but to vary the range it is necessary to use a special kind of transformer (b).

TABLE II

Type of ammeter		Directly in circuit	Transformer coupled
Mean (moving-coil)		I_{av}	0
Rectifier	Calibrated to read r.m.s. values of sine wave	1.11 I_{av}	1.22 I_{av}
Square-law		1.57 I_{av}	1.21 I_{av}

Peak value = πI_{av}

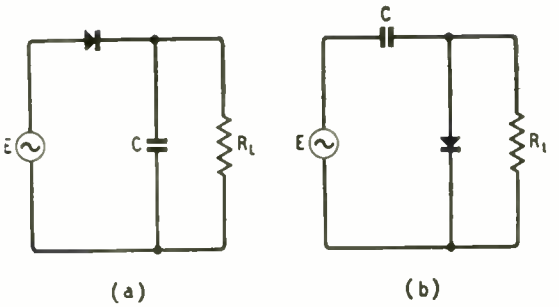


Fig. 4. Two varieties of the reservoir type of half-wave rectifier. (a) is used for power supply, and either (but usually (b)) for valve voltmeters.

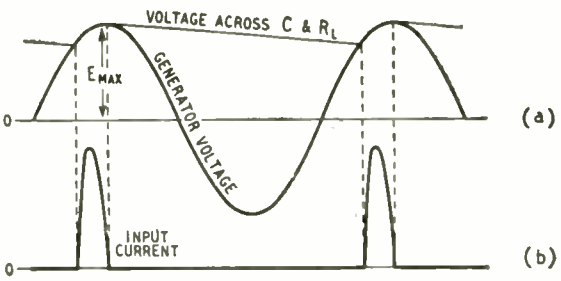


Fig. 5. Voltage and current waveforms for the Fig. 4 type of rectifier circuit.

nonsense we have to acknowledge the existence of resistance in the generator and rectifier (conducting phase). And this leads to all the complicated data and calculations referred to. However, the general picture is that when the rectifier conducts C charges up to nearly E_{max}; and, provided its capacitance is large enough to keep current flowing steadily through R_L during the rest of the cycle, its voltage remains not far short of E_{max} (Fig. 5(a)). Consequently it is only close to the peak that the generator voltage is great enough to overcome the capacitor voltage and make current flow through the rectifier. During this small fraction of the cycle, the generator has to supply enough current to C (Fig. 5(b)) to keep current going through R_L all the time. The larger C is the less its voltage drops below E_{max}, the shorter the time during which current enters it from the rectifier, and the heavier that current must be. It is quite usual for it to be five or even ten or more times the load current. In fact, in power circuits, having to supply a lot of load current, it is necessary to limit C, or to insert extra series resistance, or both, if the rectifier is to be preserved from an early death.

What about the meter readings and the actual currents and voltages? In valve voltmeters and detectors, where it is output voltage rather than current that counts, the resistance R_L can be made very high, and the load current consequently very low; so the output voltage is nearly steady at only a very little below E_{max}. (This is very different from Fig. 1, where the output voltage (Fig. 2(b)) is very unsteady and only momentarily reaches E_{max}, its average value being less than one third as much.) In these circumstances the output current is of course also steady at nearly E_{max}/R_L. But the generator current through the rectifier, although it is bound to have the same average value (as would be shown by a moving-coil milliammeter), consists of a series of brief pulses. If these pulses were square-cut, then if they lasted one *n*th of each cycle they would be *n* times the load current. But being peaky their peak value is even greater than this. Almost the only practical way to measure it is by means of the c.r. oscilloscope across a low series resistance.

As you may have guessed from our experience with the Fig. 2(b) waveform, the true r.m.s. value of this current is much greater than its mean value. Suppose we take as an example a circuit in which the mean output voltage is 95% of E_{max}. Fig. 30.5 in *Radio Designer's Handbook* shows that if the series resistance (generator, rectifier, and any added) is 0.0005 R_L, the value of ωCR_L (time constant of the load multiplied by 2π times the frequency) is about 37. Fig. 30.8 in the same book then shows that (assuming constant rectifier forward resistance) the peak input current is nearly 20 times the mean output current, and the r.m.s. input current is about $3\frac{1}{2}$ times the output. So although a d.c. milliammeter in series with the rectifier would indicate the same current as in R_L, its heating effect in a given resistance would be about $3\frac{1}{2}^2$ or 12 times as great! If one chose the gauge of wire for the transformer secondary (acting as the generator) on the basis of the d.c. meter reading, one would probably be able to burn one's fingers on the transformer after it had been running some time. That is if the rectifier, chosen on the same basis, was still rectifying, which would be unlikely. For power units it is uneconomic to attempt a 95% voltage yield; it is more usual practice for the output voltage, after allowing for the drop in further smoothing if any, to be equal to about E, say 70% of E_{max}. The peak current is then of the order of five times the output, and the r.m.s. value a little over twice. Even so, its heating value is some five times that of the same current after smoothing.

Readings to Take

The measurement procedure with this type of rectifier circuit, then, is to use an ordinary d.c. milliammeter for the output current. Multiplying this by R_L gives the mean output voltage. Comparing this with the peak input voltage (which is $\sqrt{2}$ times its measured r.m.s. value if sinusoidal waveform can be assumed) and knowing the component values, we can look up data sheets to find the r.m.s. and peak input currents, which are needed to design the transformer and choose the rectifier. If the data sheets are lacking, or we want to check them, it is necessary to have a true r.m.s. current meter (preferably a thermojunction type; but keep it shorted except when taking a reading, or it will almost certainly burn out when switching on!) and the low resistance and oscilloscope or sensitive peak voltmeter. A rectifier type of a.c. milliammeter is really more than useless almost anywhere in a rectifier circuit, because the readings it gives are quite different from what they purport to be. A rectifier voltmeter can be used to measure the generator voltage, provided pure waveform can be guaranteed; but even quite small generator impedance is enough to upset this guarantee, because of the very peaky current waveform.

Usually there are some additional smoothing components between C and R_L, and these affect the situation in rather a complicated way. But provided that C is relatively large, the basic action of the circuit as already described is not altered out of all

recognition. Apart from the actual smoothing effect, which I discussed in the October and November 1949 issues, the main practical point to reckon with is the voltage drop in the series smoothing components, and that is easy enough.

Although Fig. 4(a) is very widely used for power supplies, that is because it is almost the only choice in a.c./d.c. sets, and not because it is a good circuit for power supplies. Because the rectifier passes current only once per cycle, the current it does pass has to be so large that a high-rated rectifier must be used. And for the same reason the voltage drop between current pulses is apt to be large, and the output needs a lot of smoothing. When the source is definitely a.c., so that a transformer can be used, it nearly always is used, in order to take advantage of certain benefits obtainable therewith. One of the benefits is the ability to use both half-cycles of the source, replenishing the reservoir C twice per cycle. Another is the ability to step up the voltage, not only in the transformer itself but also by the arrangement of rectifiers. There is the centre-tapped transformer full-wave circuit, the rectifier-bridge full-wave circuit, two sorts of voltage doubler, and a voltage quadrupler, besides some rarer varieties. The first of these is the commonest, and the only one I am going to take for the present.

Fig. 6 is the basic circuit. I have drawn it that way, because it is how it usually appears in circuit diagrams; but obviously it would look simpler and clearer if C and R_L were drawn straight across between the transformer centre tap and the junction between the rectifiers. That would help to bring out the fact that it is really the same as Fig. 4(a) supplemented by a second rectifier fed by a source in opposite phase, to double the number of current input pulses per second. But except for the reduction in output voltage fall during the cycle, there is no increase in voltage obtained by the doubling of the end-to-end secondary voltage. For this reason it is not the circuit one would choose for high-voltage low-current output. Even an ordinary receiver requiring, say, 350 V., necessitates a considerably higher transformer voltage. Using our rough rule that in power units the output voltage is about equal to the r.m.s. input voltage, we see that the peak voltage of each half of the secondary is $\sqrt{2} \times 350 = 495$ V., so the total peak secondary voltage is practically 1,000—much too high for one's health if one gets it between the hands!

Assuming that the circuit is balanced—rectifiers and secondary half-windings identical—it is obvious that if we connect our moving-coil milliammeter in series with either rectifier it should read half the load current. In practice there is usually an appreciable unbalance, but it ought not to be more than 10 or 15 %. As with the half-wave circuit, the number of times the r.m.s. and peak values are greater than the mean depends on the component values and frequency. Approximately the same ratios—and output-voltage ripple—as in the half-wave circuit will be obtained in a full-wave circuit having everything the same, except for rectifier, etc., resistance being doubled on each side (because each carries only half the current) and C halved (because the ripple frequency is doubled).

Note that, although the voltage of the whole secondary coil in the full-wave circuit is in the same direction from end to end, so that the a.c. is likewise, the d.c. flows in opposite directions in the two halves.

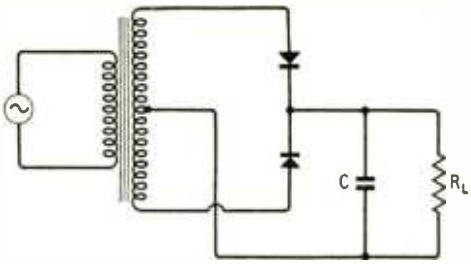


Fig. 6. Modification of Fig. 4(a) for full-wave rectification. This is the commonest type for supplying h.t. in a.c. receivers.

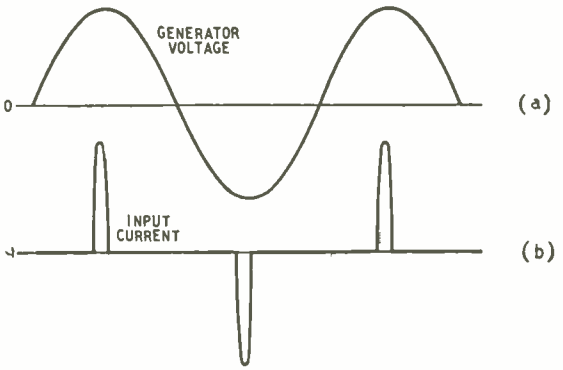


Fig. 7. Voltage and current waveforms in Fig. 6.

Consequently the core of the transformer is not magnetically polarized by d.c., as it is in the half-wave system, and this is a point in favour of the full-wave system. If it were not for the reservoir C, which distorts the current waveform into sharp peaks, the current would be sinusoidal, and the transformer would be working under the most comfortable conditions possible. As it is, however, the current is distorted, as in Fig. 7. Now here is a question. The r.m.s. value (E) of the transformer voltage is known, and for a given set of rectifier conditions and hence waveform the r.m.s. value (I) of the transformer current can be calculated. The question is, what is the power supplied by the transformer? Is it EI? In ordinary a.c. theory it would be, provided that E and I were in phase. Well, here they do seem to be, as near as makes no matter. But if you start calculating the power used up in the load, and add in the power lost in the rectifiers and transformer wire, you soon find that the power delivered by the transformer can't be accounted for on this basis. So, as there is no possibility of deceiving Nature's auditor with regard to the power balance sheet, the basis must be wrong.

Watch the Waveform

Well, it is just another example of how theory limited to sine waveform lets one down if applied to other waveforms regardless. As I mentioned some years ago while discussing phase,† it is not really allowable to compare the phases of dissimilar waveforms. It is true that the fundamental component of the Fig. 7(b) current is practically in phase with the

† *Wireless World*, May and June, 1948.

voltage, but the current is certainly not all fundamental. The peakier its waveform, the greater is the proportion in the form of harmonics. And while some half-cycles of these harmonics are admittedly flowing in the same direction as the generator voltage, others flow against it so represent negative power (i.e., power flowing back into the generator), and tend to cancel out the positive power. Just what the net result is necessitates a not-so-easy integration; but without knowing any integral calculus at all we can make sure that when the current is very peaky the power is *not* equal to EI. Suppose that the current is I_{max} for one-tenth of each half-cycle, from 81° to 99°, and zero elsewhere. During this time the voltage varies from 0.988 E_{max} to E_{max} and back again. Its average is clearly above 99% of E_{max}, so we shall be near enough if we say it is E_{max}. The power during this period is therefore practically $E_{max}I_{max}$, and for the rest of the half-cycle is zero. The average power is therefore one-tenth of this—0.1 $E_{max}I_{max}$. Now compare this with EI. E is $E_{max}/\sqrt{2}$. While it is flowing, the current is I_{max}; the current-squared is I^2_{max}; the mean current-squared is $I^2_{max}/10$; the root mean current-squared or r.m.s. value is $I_{max}/\sqrt{10}$. So EI is $E_{max}I_{max}/\sqrt{20} = 0.223\ E_{max}I_{max}$. In other words, the actual power is not EI but

$$\frac{0.1\ EI}{0.223} = 0.447EI \quad —$$

less than half what it would have been with a sine current waveform having the same r.m.s. value.

But although the r.m.s. value of the current, such as would be indicated by an accurate thermojunction milliammeter, doesn't necessarily count in reckoning power delivered, it counts only too well in reckoning heating of any resistance it passes through, so again it is the value that must be used for choosing the gauge of wire for the transformer secondary.

Summary

Let us sum up the voltage and current lore concerning the full-wave reservoir rectifier circuit. Voltages present little difficulty in practice: the "generator" (i.e. transformer secondary) usually supplies something reasonably sinusoidal, which can therefore be measured with any reasonably accurate voltmeter having an appropriate a.c. range. The significant voltage at the output is the mean value, measured with a moving-coil voltmeter. So far, the ordinary multi-range test meter is sufficient. The actual peak inverse voltage across either rectifier is important, but one doesn't usually bother to measure it, because the most it can be is a trifle less than twice the *peak* half-secondary voltage (or, if you prefer, a trifle less than the peak voltage across the whole secondary). The reason is pretty obvious: the greatest instantaneous voltage the generator can apply in the "wrong" direction is E_{max}, and at that moment C is also applying a voltage in the same direction, which at no-load would be very nearly E_{max}. So to be on the safe side the peak inverse voltage with this circuit is always taken as $2E_{max}$, or $2\sqrt{2}E = 2.8E$.

If one is interested in ripple voltage, then certainly complications do arise, because it has a decidedly non-sinusoidal waveform. But usually there is no need to distinguish very clearly between the several possible values—a rough idea will do. The peak value can be read by means of a peak valve voltmeter with blocking capacitor, or alternatively an oscilloscope.

Currents are trickier. There are:

(1) The mean value of the output current, measured by a moving-coil meter in series with R_L. This should equal the sum of the readings on the same meter connected to measure each rectifier current in turn.

(2) The peak value of the current through each rectifier. This is important for voltage rating. Use about 5Ω of resistance and a sensitive peak voltmeter or oscilloscope.

(3) The r.m.s. value of current through each rectifier. This is measurable with a thermal meter and is the one that must be used for calculating watts loss.

(4) The equivalent r.m.s. value of sinusoidal current in phase with the voltage. Presumably this could be measured by means of a suitable wattmeter, by dividing the watts supplied from the whole secondary by the r.m.s. voltage of the same. Lacking the suitable wattmeter (as most people do), one would have to reckon up the wattage bit by bit: chiefly the load power (load current × load voltage), plus twice the square of the r.m.s. current through either rectifier multiplied by the effective resistance of either rectifier and any limiting resistance in series with it.

(5) The ripple current through C. This is necessary for checking that the rating for the capacitor is not being exceeded. If a r.m.s. current meter is available, it can be read directly by connecting the meter in series with C. Because the ripple voltage waveform is far from sinusoidal—and the current waveform still farther from it, because the reduced reactance of C at higher frequencies favours the harmonics—the reading on a rectifier-type meter is likely to be somewhat out, but perhaps good enough for the purpose.

A disadvantage of the reservoir type of rectifier circuit, half-wave or full-wave, is that if the load is absent—as happens if the rectifiers come into action before the valves in the set have warmed up—the output voltage rises to nearly E_{max}. So if the smoothing capacitors have been chosen on a $E_{max}/\sqrt{2}$ basis they are not likely to be very happy during these periods. For this and other reasons (such as avoiding high rectifier peak current) use is sometimes made of the "choke input" circuit, in which a so-called swinging choke is connected between the rectifiers and C. This type of circuit works quite differently from any we have discussed, and would demand several pages to itself, moreover it is practically never used in domestic equipment, so I am only just mentioning it to show that when you have explored all the voltage-doubling etc. types there are still more worlds to conquer!

Receiving Valve Manual

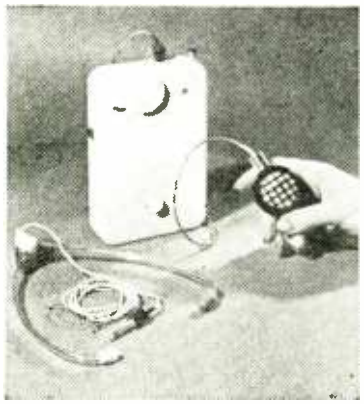
VALVES for colour television are included in the latest edition (RC-17) of the well-known RCA "Receiving Tube Manual" which is now available in this country. The book has been revised, expanded and brought up to date, and contains technical data on more than 500 valves and c.r. tubes. There are also sections on basic theory, interpretation of data, applications, installation and testing which contain a good deal of new matter. The section on circuits now includes several new circuits for use in high-quality audio amplifiers. Among these are a low-distortion input amplifier stage, a two-stage input amplifier using cathode-follower output, a bass and treble tone-control amplifier stage and a complete 10-watt high-quality amplifier.

Priced at sixty cents in the U.S.A., the manual is available in this country from RCA Photophone, Ltd., 36, Woodstock Grove, Shepherds Bush, London, W.12, at 8s.

Pocket Wire Recorder

PLAYING times of up to 2½ hours are provided in the German-designed "Minifon 54" recorder which is to be distributed in this country by the "Emidicta" Division of E.M.I. Sales and Service, Ltd., 363, Oxford Street, London.

Measuring $6\frac{5}{8} \times 4\frac{3}{8} \times 1\frac{3}{8}$ in and weighing only 2½ lb with batteries, the "Minifon" is a remarkable example of



"Minifon 54" wire recorder with lapel microphone and stethophone earpiece.

miniaturization, particularly in the mechanical drive mechanism and controls, which are of watch-like precision. A 12-V layer-built battery costing 5s 6d gives a running time of 10 to 15 hours. The motor, which is governed, drives a large diameter take-up spool which ensures a virtually constant winding speed of 11.8 in (30 cm)/sec: re-winding is at 2½ times this speed. The wire diameter is 0.002 in.

A three-stage amplifier using hearing-aid type valves is used for recording and playback, and runs from separate 1.5-V and 30-V batteries. The recorded frequency range claimed is 200-4,000 c/s and the quality of reproduction with saturation bias (a permanent magnet is used for erasure) is more than adequate for speech.

The basic price of the "Minifon 54" is £85 with batteries, 1-hour duration spool, lapel microphone, stethophone earpiece, and leather case. Numerous accessories are available including a wrist microphone, typists' foot-control unit, mains power supply unit for the motor, and a pick-up coil for recording two-way telephone conversations.

News from the Clubs

Birkenhead.—The Wirral Amateur Radio Society continues to meet at 7.30 on the first and third Wednesdays of each month at the Y.M.C.A., Whetstone Lane, Birkenhead. Sec.: A. C. Wattleworth, 17, Iris Avenue, Claughton, Birkenhead, Cheshire.

Birmingham.—"Television Aerials" is the subject of the talk to be given by A. P. Hale, of Belling & Lee, to members of the Slade Radio Society at their meeting on November 12th at 7.45 at the Church House, High Street, Erdington. The annual general meeting will be held on November 26th. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Portsmouth.—The Portsmouth & District Radio Society now has its own club room, open every evening, at the British Legion Club, Queen's Crescent, Southsea. Meetings are held each Tuesday at 7.30. The November programme includes films (2nd), a lecture on televison (9th) and a discussion on television interference (23rd). The club operates a QRP transmitter, G3DIT. Sec.: L. B. Rooms (G8BU), 51, Locksway Road, Milton, Portsmouth, Hants.

Cleckheaton.—At the November 3rd meeting of the Spen Valley & District Radio & Television Society D. Skirrow (G3GFD) will speak on "Radio Valves and their Uses." The subject for the meeting on November 17th is "Oscilloscopes" by G. F. Craven, of Craven Electronic Instruments. Meetings are held at 7.30 at the Temperance Hall, Cleckheaton. Sec.: N. Pride, 100, Raikes Lane, Birstall, Leeds, Yorks.

Newark.—Technical films will be shown at the meeting of the Newark & District Amateur Radio Society at 7.0 on November 7th at the Northern Hotel, Newark. At the mid-monthly meeting at Northgate House at 7.0 on November 18th a commercial trans-receiver will be demonstrated. Sec.: J. R. Clayton, 160, Wolsey Road, Newark, Notts.

Romford.—Meetings of the Romford & District Amateur Radio Society are held each Tuesday at 8.15 at R.A.F.A. House, 18, Carlton Road, Romford. Details of the winter programme, which includes lectures, discussions and films, are available from the secretary, N. Miller, 18, Mascalls Gardens, Brentwood, Essex.

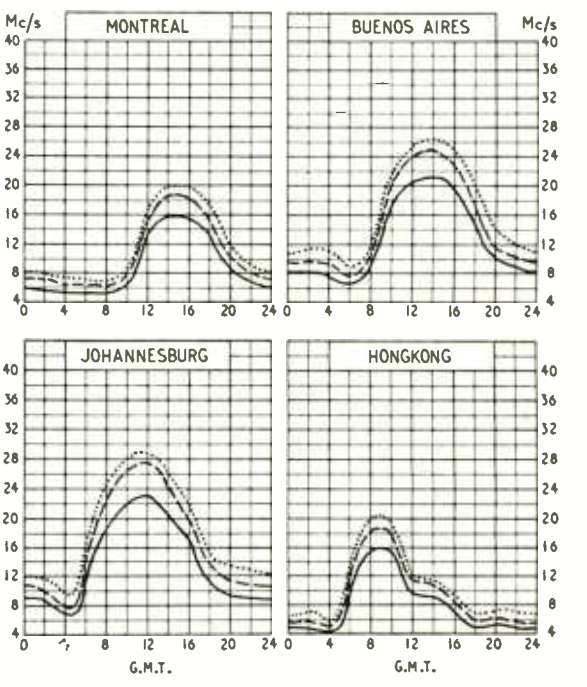
Southend.—Meetings of the Southend & District Radio Society are temporarily being held at the Ekco Works, Southend-on-Sea, on alternate Fridays at 7.45, the November meetings being on the 12th and 26th. Sec.: J. H. Barrance, M.B.E. (G3BUJ), 49, Swanage Road, Southend-on-Sea, Essex.

Short-wave Conditions

Predictions for November

THE full-line 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 November.

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



Measurement of Phase and Amplitude

Simple Method for Use with Feedback Amplifiers

By H. H. OGILVY, D.L.C.(Eng.), A.M.I.E.E.

IT is well known that high-gain negative feedback amplifiers tend to become, in fact, positive feedback amplifiers at extreme frequencies and may, unless special phase shifting and attenuating circuits are introduced, actually oscillate and become useless for the purpose intended. Feedback amplifiers, such as those used for computing are especially likely to be troublesome, since the feedback is usually about 100%. It is very desirable to be able to measure the characteristics of a prototype amplifier so that the tendency to oscillate, or rather, the stability margin, may be determined and, if insufficient, the necessary steps taken to improve this margin. The data required to assess the performance is usually presented in the form of a Nyquist diagram, and the preparation of this diagram requires the measurement of relative phase and amplitude of output with respect to input under open loop conditions over a wide range of frequencies. In particular, the measurement of phase presents some difficulty.

The conventional method is to use a cathode-ray oscilloscope and estimate phase from a Lissajous figure. This is rather clumsy and uncertain since the characteristics of the C.R.O. amplifier cause phase shift, particularly at the lower and upper frequencies. Commercial equipment is available for the measurement of phase, but is usually rather costly and complex. The method to be described is simple and economical.

If two sine waves of the same amplitude and frequency but differing in phase by an angle ϕ are added together, the resultant is also a sine wave, i.e., the resultant,

$$v = V \sin \omega t + V \sin(\omega t + \phi)$$
$$= V \sin \omega t + V \sin \omega t \cdot \cos \phi + V \cos \omega t \sin \phi$$
$$= V(1 + \cos \phi) \sin \omega t + V \sin \phi \cos \omega t$$
$$= V\sqrt{(1 + \cos \phi)^2 + \sin^2 \phi}\, \sin(\omega t + \alpha)$$

where $\alpha = \tan^{-1} \dfrac{\sin \phi}{1 + \cos \phi}$

$$= V\sqrt{\cos^2\phi + \sin^2\phi + 1 + 2\cos \phi}\, \sin(\omega t + \alpha)$$
$$= \sqrt{2}V\sqrt{1 + \cos \phi}\, \sin(\omega t + \alpha)$$

Hence the amplitude of the resultant is proportional to $\sqrt{1 + \cos \phi}$ where ϕ is the phase angle. The deflection of a C.R.O. or a moving coil rectifier instrument would therefore be dependent on this function. The maximum value of $\sqrt{1 + \cos \phi}$ occurs when $\phi = 0$ and if full-scale deflection (D = 1) on the indicating instrument occurs when $\phi = 0$ then $D = K\sqrt{1+\cos\phi}$, where K is a constant. Hence $1 = K\sqrt{1 + 1}$ and $K = 1/\sqrt{2}$ and therefore $D = \dfrac{1}{\sqrt{2}}\sqrt{1 + \cos \phi}$ or $\cos \phi = 2D^2 - 1$ and $\phi = \cos^{-1}(2D^2 - 1)$.

Fig. 1 shows the curve relating phase angle to relative deflection (full line). Phase angles between 80° and 180° are easily determined from the deflection, but below 80° the rate of change of phase with deflection becomes too great for reasonable accuracy of

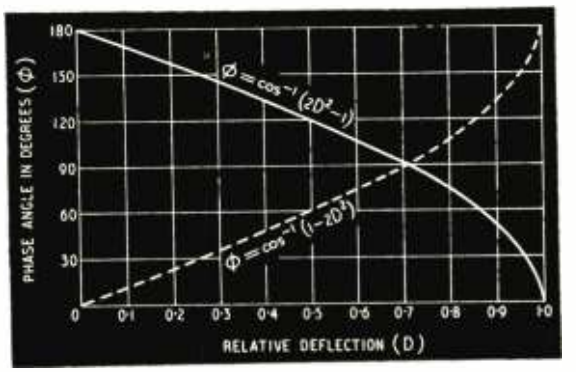


Fig. 1. Relative amplitudes resulting from the addition of two sine waves of equal amplitude and frequency, but with different phases.

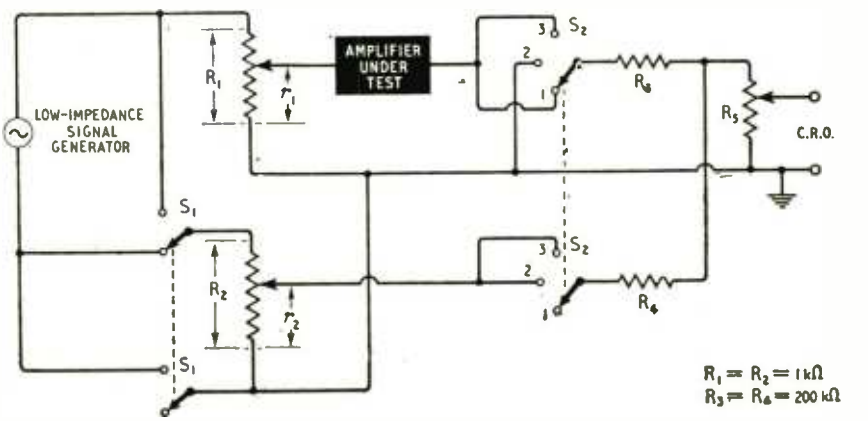


Fig. 2. Schematic diagram of phase measuring apparatus.

observation. However, if the reference signal, $V \sin \omega t$ is reversed in phase the resultant wave is now

$$v = -V \sin \omega t + V \sin (\omega t + \phi)$$

and this gives a resultant amplitude of $\sqrt{2}V\sqrt{1-\cos\phi}$. The relative deflection (D) is now 0 when $\phi = 0$ and 1 when $\phi = 180°$, if the constant of proportionality is obtained as before. Hence the expression $\phi = \cos^{-1}(1 - 2D^2)$ is obtained and this is also plotted in Fig. 1 (broken line) showing that phase angles between 0° and 100° may be accurately determined. It should be understood, of course, that this method does not differentiate between leading and lagging angles, but where there is a doubt the sense can be easily determined. In general, the condition required, i.e., that both signals to be compared must be of equal amplitude, will not apply but the method to be described shows how this may be achieved quite simply.

The basic scheme for measurement of phase and amplitude is shown in Fig. 2. It is assumed that a low-impedance signal generator is fed into two potentiometers of equal and relatively low resistance (about 1,000 ohms). With the switch, S_1, in the position shown, equal antiphase voltages are available at the wipers of R_1 and R_2 with respect to earth. This condition is therefore suitable for the measurement of phase angles between 0° and 100°. The amplifier under examination is fed from the wiper of R_1 which is set to some convenient value ($= r_1$) sufficiently small to avoid saturation of the amplifier. With S_2 in position 1 the deflection of the C.R.O. is adjusted, using R_5, to 50% of a predetermined arbitrary magnitude. S_2 is then placed in position 2 and R_2 adjusted for the same deflection ($= r_2$). The condition of equality of amplitudes has thus been achieved and the ratio r_2/r_1 is obviously the gain of the amplifier at the particular frequency.

If S_2 is now placed in position 3, the output of the amplifier $= V \sin (\omega t + \phi)$ is now added to the reference $= -V \sin \omega t$ in the network R_3, R_4 and R_5. The arbitrary full scale deflection will occur when $\phi = 180°$. The relative deflection obtained will be according to the law $\phi = \cos^{-1}(1 - 2D^2)$ and ϕ may be determined from the curve in Fig. 1.

For phase angles greater than 100°, S_1 should be placed in the upper position and then $\phi = \cos^{-1}(2D^2 - 1)$. In the majority of cases, the sense of the phase angle will not be in doubt. Where there is uncertainty, however, the sense may be determined by making the output of the amplifier lag, using a simple RC circuit and repeating the above procedure. If the angle obtained has increased, then the original angle must have been negative or lagging. The facilitate measurements, the C.R.O. time base should be switched off, except when checking the amplifier output for saturation.

Although the scheme shown in Fig. 2 will be satisfactory for many purposes, there may be errors in measurement at the higher frequencies due to unequal impedances to earth at the terminals of the signal generator. Also, in some applications, it may be undesirable to load the device under test, even though the load (R_3) is several hundred thousand ohms. To overcome these difficulties, the circuit shown in Fig. 3 is suggested. This presents a very high impedance to the amplifier. Phase splitting is obtained electronically by V1a which is one-half of a double triode (12AT7). The measurement procedure is the same as before. The potentiometer R_5, may be fed into an amplifier of low output impedance and used to drive a moving coil rectifier meter. For convenience this meter may be scaled according to the law relating phase angle (ϕ) to relative deflection (D) (Fig. 1) and phase read off directly.

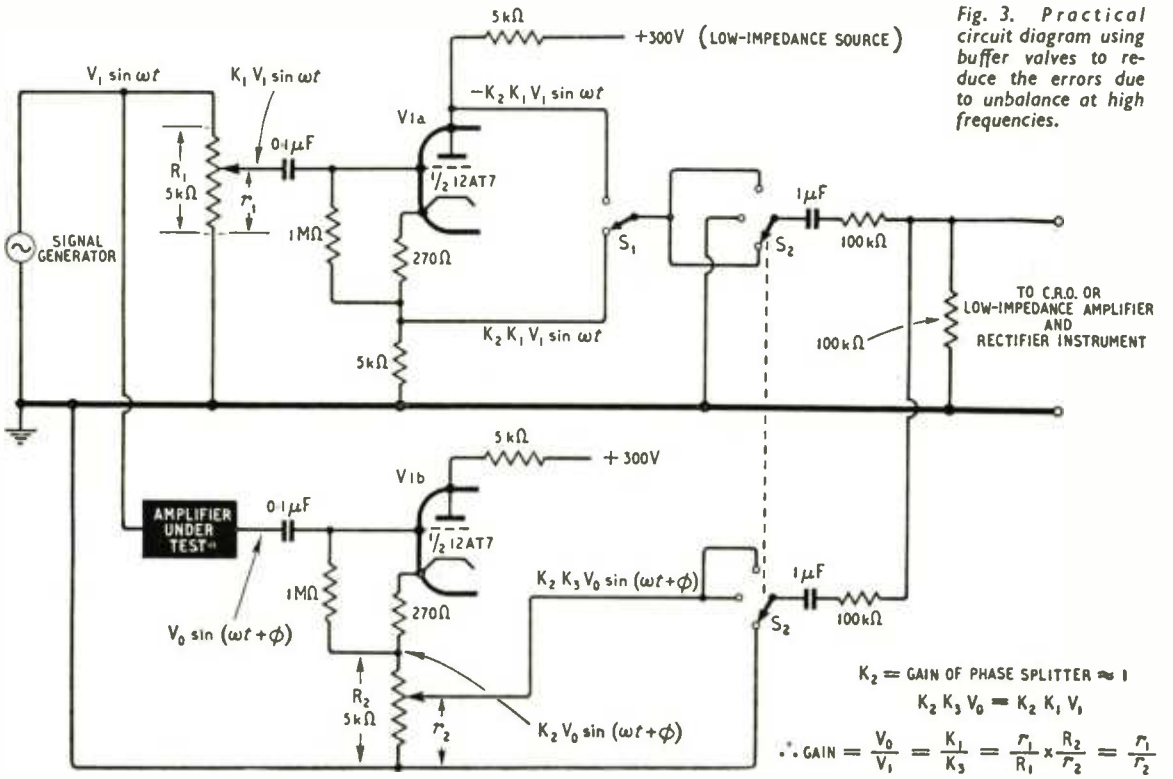


Fig. 3. Practical circuit diagram using buffer valves to reduce the errors due to unbalance at high frequencies.

NOVEMBER MEETINGS

Institution of Electrical Engineers

London.—November 8th. Discussion on "Methods of Teaching Technical Writing" opened by G. Parr at 6.0.

November 10th. "Standard Frequency Transmissions" by L. Essen, D.Sc., Ph.D., at 5.30, followed by "The Standard Frequency Monitor at the National Physical Laboratory" by J. McA. Steele, B.Sc.(Eng.), and "Standard Frequency Transmission Equipment at Rugby Radio Station" by H. B. Law, B.Sc.Tech.

November 16th. Celebration of the Jubilee of the Thermionic Valve commencing at 2.30 with the address of the Lord President of the Council, the Marquess of Salisbury, followed by "The Genesis of the Thermionic Valve" by Professor G. W. O. Howe, D.Sc., LL.D. At 3.30 "Thermionic Devices from the Development of the Triode up to 1939" by Sir Edward Appleton, D.Sc., LL.D., F.R.S., and at 5.30 "Developments in Thermionic Devices since 1939" by J. Thomson, M.A., Ph.D., D.Sc.

November 22nd. "Plastics for the Radio Engineer" by Maldwyn Jones at 5.30.

November 23rd. "The Application of the Hall Effect in a Semi-Conductor to the Measurement of Power in an Electromagnetic Field" by Professor H. E. M. Barlow, Ph.D., B.Sc.(Eng.), at 5.30 followed by "Audio-Frequency Power Measurements by Dynamometer Wattmeters" by A. H. M. Arnold, Ph.D., D.Eng.

November 30th. Discussion on "The Servicing of Electronic Measuring Instruments and its Effect on their Design" opened by Denis Taylor, M.Sc., Ph.D., at 5.30.

All the above meetings will be held at Savoy Place, London, W.C.2.

East Midland Centre.—November 9th. "Properties and Application of High Permeability Magnetic Alloys" by G. A. V. Sowter, Ph.D., B.Sc., at 6.30 at Loughborough College.

November 23rd. "Telemetering for System Operation" by R. H. Dunn. B.Sc., and C. H. Chambers, at 6.30 at the Gas Dept., Demonstration Theatre, Nottingham.

November 26th. "A Radio Position Fixing System for Ships and Aircraft" by C. Powell at 6.30 at the College of Technology, Leicester.

North Midland Centre.—November 9th. Discussion on "The New I.E.E. Examination Regulations" opened by E. C. Walton, B.Eng., Ph.D., at 6.30 at 1, Whitehall Road, Leeds.

North-Western Radio Group.—November 24th. "The Manchester-Kirk o'Shotts Television Radio-Relay System" by G. Dawson, B.Sc., L. L. Hall, K. G. Hodgson, B.A., R. A. Meers, and J. H. H Merriman, M.Sc., at 6.45 at the Telephone House, Chapel Street, Salford.

South Midland Centre.—November 22nd. "Loudspeaker Systems—Recent Trends in Design" by Major A. E. Falkus, B.Sc.(Eng.), at 6.0 at the James Watt Memorial Institute, Great Charles Street, Birmingham.

November 25th. "Colour Television" by C. J. Hirsch at 7.15 at the Winter Gardens Restaurant, Gt. Malvern.

Reading District.—November 29th. "Television Interference" by K. R. Seamans at 7.15 at the George Hotel, Reading.

British Institution of Radio Engineers

London Section.—November 24th. "The Development and Design of Direct-Coupled Oscilloscopes for Industry and Research" by M. J. Goddard at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

Scottish Section.—November 4th. "The Latest Developments in TV Cameras" by H. McGhee at 7.0 at the Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow.

Merseyside Section.—November 4th. "Radio Receiving Valve Manufacture" by G. P. Thwaites, B.Sc., at 7.15 at the College of Technology, Byrom Street, Liverpool, 3.

North-Western Section.—November 4th. "Electronic Servo Mechanisms" by J. L. Russell at 7.0.

November 30th. "Electronics and the Wind Tunnel" by G. J. Scoles, B.Sc., at 7.0.

Both meetings will take place at the Reynolds Hall, College of Technology, Sackville Street, Manchester.

North-Eastern Section.—November 10th. "Stereophonic Sound" by R. A. Bull, B.Sc.(Eng.), at 6.0 at Neville Hall, Westgate Road, Newcastle-upon-Tyne.

South Wales Section.—November 17th. "The Techniques of Power Measurements from D.C. to 5 Mc/s" by G. F. Lawrence at 6.30 at the College of Technology, Cathays Park, Cardiff.

British Sound Recording Association

London.—November 19th. "Balance and Control" by G. Elliott at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.

Manchester Centre.—November 22nd. "Transformers and Chokes" by J. S. Holiday at 7.30 at the Engineers' Club, Albert Square, Manchester.

South-Western Centre.—November 24th. "Hi-Fi Can Be Music" by N. C. Mordaunt (Tannoy) at 7.30 at Callard's Café, Torquay, Devon. (Joint meeting with Incorporated Practical Radio Engineers).

Physical Society

November 5th. Duddell Lecture, "The Development and use of Large Radio Telescopes," by Professor A. C. B. Lovell at 5.0 at Burlington House, London, W.1.

Television Society

London.—November 12th. "Faulty Interlacing" by G. N. Patchett, Ph D., B.Sc., at 7.0 at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, W.C.2.

November 18th. Conversazione to mark the Jubilee of the Invention of the Thermionic Valve at 7.0 at University College, Gower Street, W.C.2.

November 25th. "European Television Programme Exchanges" by M. J. L. Pulling, O.B.E., M.A., (B.B.C.) at 7.0 at the C.E.A., 164, Shaftesbury Avenue, W.C.2.

British Kinematograph Society

London.—November 24th. "Factors Affecting Quality in Colour Television" by I. J. P. James, B.Sc., at 7.15 at the Gaumont-British Theatre, Film House, Wardour Street, W.1.

Radio Society of Great Britain

November 19th. Technical films at 6.30 at the I.E.E., Savoy Place, London, W.C.2.

RANDOM RADIATIONS

By "DIALLIST"

TV Interference with Radio

THERE IS perhaps far more interference radiated by television receivers, to which J. Platts and G. O. Thacker refer in last month's *Wireless World,* than is generally realized. Many owners of broadcast receivers have come to regard any unwanted noise from the loudspeaker as just one of those things and don't know that, if they will only report it, the P.O. engineers will do their best to help. No one should be allowed to operate a television receiver which spreads alarm and despondency among his listening and viewing neighbours. But the P.O. anti-interference people either don't realize the existence of clause No. 4 of the television licence schedule or have been instructed not to enforce it—or to prohibit the use of the offending set (under clause 7) until it has been rendered innocuous.

A Bit Much?

The people really to blame, of course, when television interference is broadcast, are not the users but the manufacturers. It never occurs to the ordinary completely non-technical buyer of a TV receiver that the set of his choice may possibly cause various unpleasant things to happen to his neighbours' receivers whenever he switches it on. The advertisements assure him that it is the best of the lot; his wife likes the cabinet; the 17-inch tube will take the wind out of the sails of the Robinson's 15-inch next door. He puts down his money, or signs a "never-never" agreement, and feels that a good job has been well done. Can't you imagine his indignation and his "Pygmalion" retort when the P.O. engineers diffidently suggest that he should have something done to his beautiful set and pay for it? A warning to manufacturers by the P.M.G. that after a certain not-too-far ahead date a ban on the use of interfering receivers would be enforced might work wonders. The new B.R.E.M.A. standards for manufacturers should bring about a great improvement; but not all makers of television receivers are members of the association.

Anti-Flutter

WITH the rapid expansion of both civil and military aviation each year sees more and more planes in the air. Unless we live in remote places they now pass over or near our homes at all hours of the day and night. Aeroplane flutter is already one of the commonest kinds of interference with television, particularly in places near aerodromes, or on regular flying routes. No form of a.g.c. seems able to cope adequately with flutter, for the time constants of the circuits are too long. Here's an opportunity for someone to develop an effective system of "automatic flutter suppression." It's sure to be done some day. As a dweller within a couple of miles of a big and busy aerodrome, I hope fervently that it may come soon.

All-Dry Sets

THE "ALL-DRY" receiver has many attractive points; and there is still more to be said for the kind that can be worked from the mains or from its own batteries. The "pros" for both sorts are that they are light, genuinely portable and of small size. But there is one serious "con" and that is the comparatively short life of the rather expensive combined h.t. and l.t. battery. Actually, it's the filament part of this battery which passes out, as a rule, and leads to distortion and, eventually, to a signal too weak to be of any use. When the filament section has packed up the h.t. cells would usually be good for many more hours of useful service. Would it not be a great improvement if the h.t. and l.t. dry batteries were separate units? I haven't a doubt that it would; nor should there be any difficulty about it for set makers or battery manufacturers.

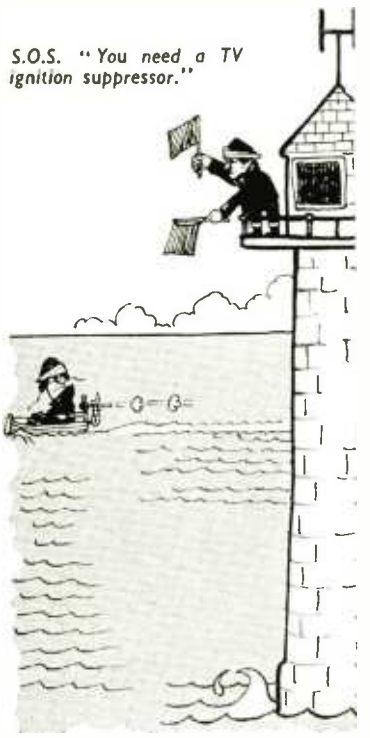
Time by the Forelock

DURING a recent visit to East Anglia I noticed over one house the familiar vertical H television aerial and a very much smaller horizontal array. The orientation appeared to be about right for Wrotham; but could this moderately powered f.m. transmitter possibly be receivable at so great a distance? The answer came a day or two later when I happened to meet the owner of the house. "Do you find Wrotham any good here?" I asked. "Wrotham," he said; "What's that?" "Why, the B.B.C. experimental f.m. station. Isn't that what your horizontal array's for?" He laughed: "Oh no," he said, "that's for Norwich, when it gets going." Nothing like being in good time! The temporary Norwich TV station, using, I believe, the present channel 3 Brighton "booster" as its transmitter, isn't due to make a start for 5 or 6 months yet.

Modern Mains Receivers

THE thing that I like least about our mains receivers of to-day is that the

great majority are built on a.c./d.c. lines with no transformer between them and the supply mains. On d.c. there's nothing much amiss, for neither sound nor television receivers will work unless the mains plug is put the right way round into its socket. But on a.c. both will function whichever way it's inserted. According to the law of averages this means that at any time half the mains sets operated on a.c.—say 5,000,000 "sound" and 1,500,000 television—are working with their chassis directly connected to the phase wire and with nothing earthed. The thought of all those acres of chassis swinging through 500-700 volts peak-to-peak 50 times each second must be a rather solemn one to any electrical engineer brought up on the old sound principles. Ours is, I believe, the only civilized country in which this sort of thing is permitted and I can't help feeling sorry that the I.E.E. regulation about the use of an isolating transformer between a.c. mains and apparatus was ever relaxed. But there it is, and we've got to make the best of it. As a safeguard, my suggestion is that all mains leads should be fitted with sockets which can be connected in one way only to the plugs in the receiver and that at the other end there should be a 3-pin plug. Those who install receivers should be required to see that the a.c. power supply is from a correctly connected 3-pin socket.



UNBIASED

By FREE GRID

Stars or Sunspots?

FORECASTING the future by means of the calculated positions of the heavenly bodies at certain given times is known as astrology when carried out by Madame Estelle or by those journals which cater for the unlettered masses, and astronomy when employed by the Astronomer Royal to give us the dates and times of tides and eclipses.

Now, astrologers usually confine their prophecies to things like love, marriage and other disasters which depend on the whimsy of women and it is not very surprising therefore, that their percentage of success is so low. The Astronomer Royal on the other hand, eschewing women and their ways, bases his forecasts on the solid rock of science and so obtains 100% success.

I draw attention to these facts because something quite new in the realm of these stellar forecasts has made its appearance and this something concerns we radio men very much indeed. A super-modern star-gazer hailing from the U.S.A. claims to be able to forecast ionospheric conditions for radio transmissions at certain times by studying the stars instead of sunspots.

This celestial observer has secured the backing of one of the largest radio organizations in America, which has published figures showing that his successful forecasts represent 92% of the whole. However, in the opinion of some British ionospherists, this rather startling figure is obtained by a method of relating forecasts to ionospheric disturbances which, technically speaking, is open to question.

I am inclined to agree with this opinion, although I think we ought to give this planetary pundit more rope with which to hang either himself or us. Any good racecourse tipster can produce first-class results over a limited period but he cannot keep it up. Indeed, we had a remarkable instance of this sort of thing in the middle of the war when the editor published a letter under the heading of "What the Sunspots Foretell."* The writer of this letter pointed out a striking correlation between the sunspot cycle and the career of Hitler and then proceeded to use this correlation to prophesy the end of the war with some degree of accuracy.

"History is Bunk"

WHY is it that the Radio Industry Council took such pains to stress that this year's radio show was the 21st when actually it was the 25th? I believe that the official explanation is that the shows of the 1922-25 period were not "National" shows, and yet in a potted "Radio Show History" which the R.I.C. issued to the Press at the time of the show we are told that one of them was promoted by the *National* Association of Radio Manufacturers and Traders (NARMAT). What the R.I.C. means, I suppose, is that the pre-1926 shows were not organized by its progenitor —the Radio Manufacturers' Association—because it was not until that year that this new name—and a new constitution too—was adopted. It is as though the B.B.C. issued a history of British broadcasting and ignored the pre-1927 years because the service was then conducted by the British Broadcasting *Company* and not the British Broadcasting *Corporation*.

The "historian" picks out home-construction as the one thing worthy of mention at the 1924 show and completely ignores the fact that a valve with the then unheard-of amplification factor of 20 was shown. This was also the first show at which the superhet was seen; two very prominent firms exhibiting it.

This official "history" describes the superhet as one of the novelties of the 1927 show, whereas in actual fact it was rather in eclipse then. It did not start to stage a real comeback until over three years later, as I myself mentioned in *W.W.* for September 17th, 1930. The real novelty about which everyone was talking in 1927 was the screen-grid valve. And so I could go on.

Sackcloth and Ashes

I CERTAINLY put my foot in it when I said in the October issue that the smallest tape recorder available weighed 12 lb and was far from pocketable. I have had several letters pointing out to me that there is one on the market weighing only 2½ lb which is really pocket-size. As it is described elsewhere in this issue, I will say no more about it except to plead in my defence that at the time I wrote I don't think this instrument was available in this country; I won't split hairs by claiming that I said tape recorder, whereas this instrument uses wire.

Electronic Pulse Taking

LAST JUNE I suggested that the present method of pulse-taking in hospitals was out of date, likely to be very misleading and a gross waste of the nurses' time. I pointed out that this could be done electronically and automatically. By means of a miniaturized v.h.f. transmitter strapped to each patient's wrist and a receiver with a battery of c.r. tubes in the ward-sister's room, heartbeats could be read at any moment and, if desired, recordings could be made on film or magnetic tape.

The Palpatron

Now I learn from the leading journal of the nursing profession (*Nursing Mirror*, August 27th) that an electronic device called the Palpatron is in use for this purpose at the Boston City Hospital, Massachusetts, U.S.A., and that its great sensitivity enables a pulse reading to be detected when nothing can be discerned by the normal manual method.

Τηλεόρασις

THROUGH the courtesy of a reader I learn that the terrible word τηλεβιστου is not used in modern Athens for television. No doubt some of you noticed that there was an unfortunate typographical error in my note last month, the omicron being omitted. The modern Greek word is τηλεόρασις but I don't think we should have taken kindly to teleorasis instead of television. The same reader tells me of an excellent and up-to-date telecommunications dictionary of English and Modern Greek, published by the Sivitanideos Institution in Athens, with funds provided by the American Mission (European Co-operation Administration) in Greece.

* The letter mentioned by Free Grid was published in our March 1942 issue.—ED.

AVO

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0.150—0.385 Mc/s } in 6 bands
0.510—30.0 Mc/s }

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Better than 1.0 μV for 1.5 watts output, over the whole band.

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0.150—1.3 Mc/s	< 10.0 μV

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Six switched bandwidths:—

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Output constant within 3 db for 100 db change in signal input.

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At 2.5 or 15 ohms	2.5 watts
At 120 ohms	0.05 watts
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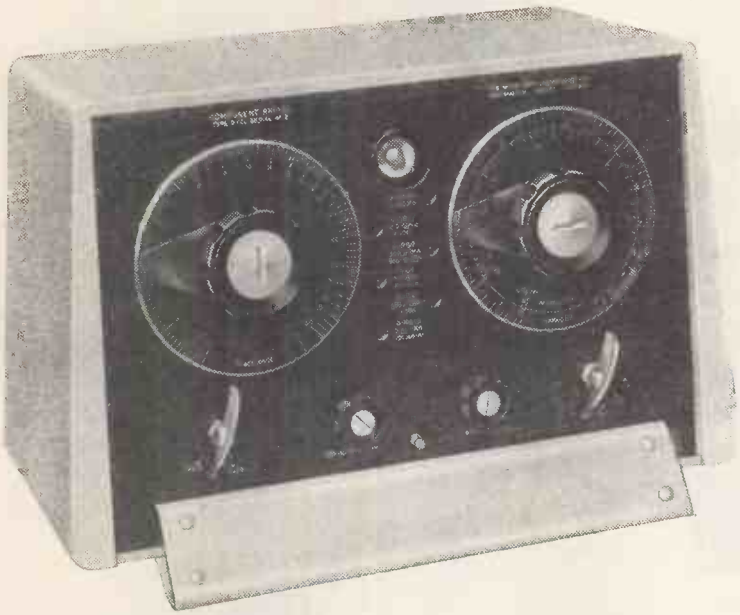

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THE WAYNE KERR MODEL B.121

A MODERATELY PRICED self-contained instrument, capable of a wide range of accurate measurements.

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ACCURACY: *2% on all ranges over the major part of the scale. If higher accuracy is required, the instrument can be supplied hand-calibrated.*

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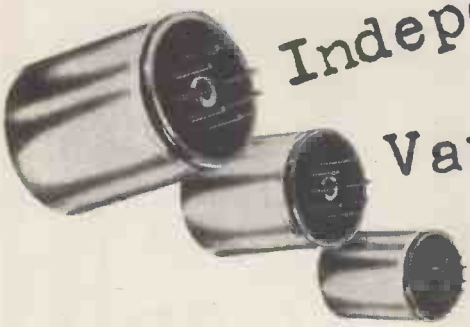
ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER, 17

/E 203

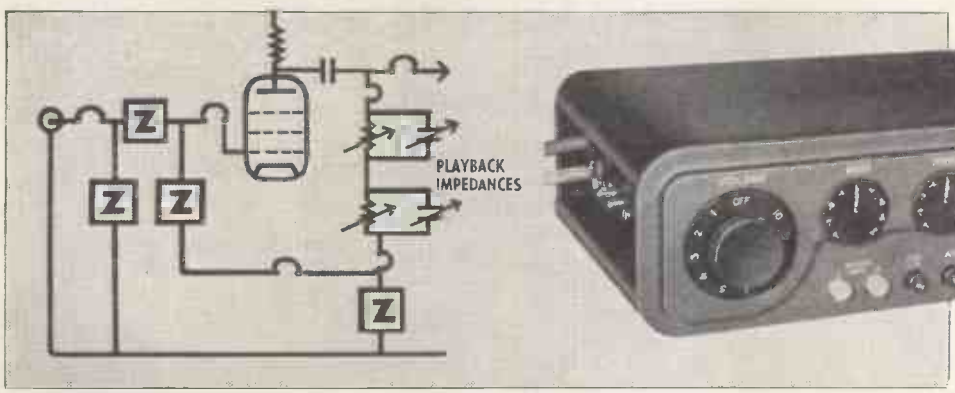


Independently Variable Z Impedances

When a designer contemplates the input stage from a gramophone pickup he can (a) amplify and then compensate, (b) compensate before amplification, (c) compensate over the first stage by feedback.

No single method is acceptable over a wide range of impedances if the requirement is low distortion and low noise. His choice and the circuit impedances used will depend upon the output level of the pickup, its source impedance, its load impedance and its characteristic.

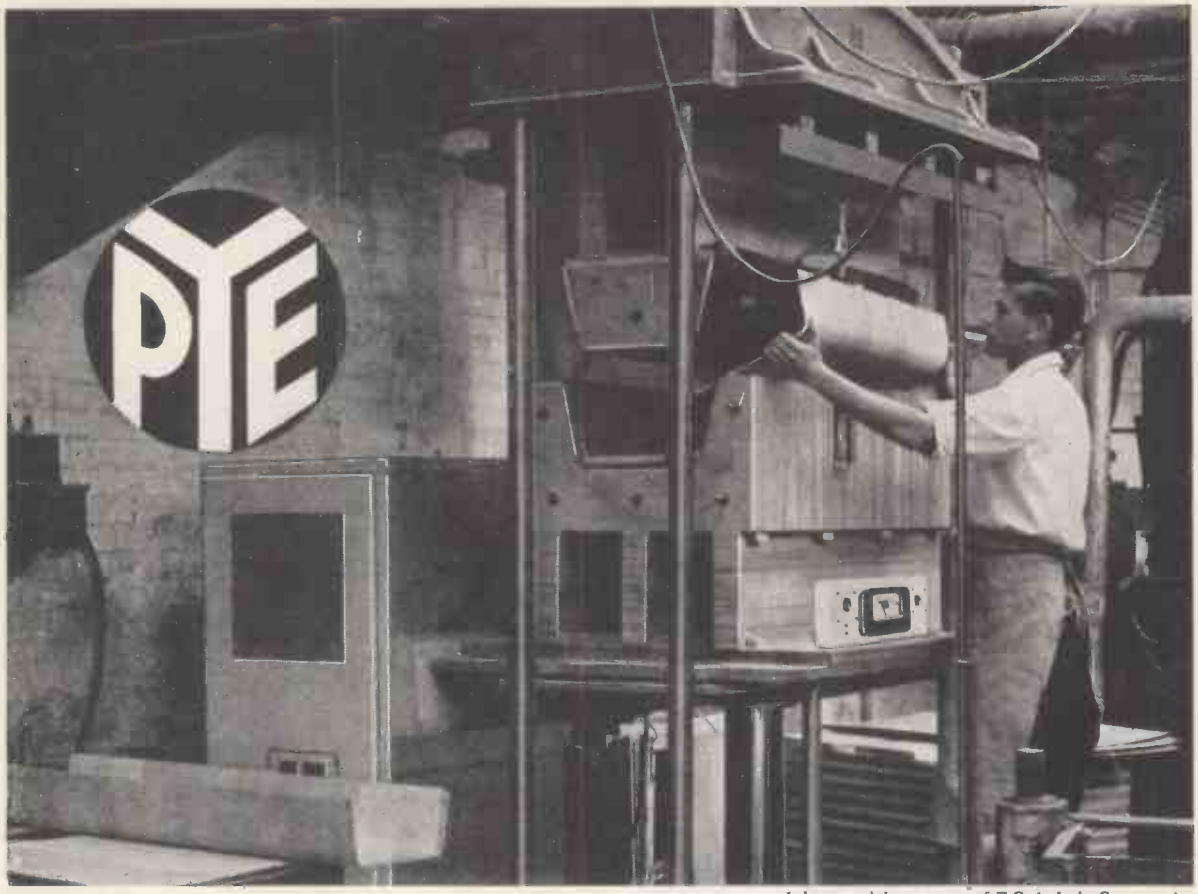
In the QUAD 11, the first stage circuit connections and their impedances are contained within a detachable plug unit. A range of units covers optimum design requirements for all types of pickups.



ONLY THE QUAD 11 GIVES PERFECT MATCHING AND OPTIMUM INPUT CIRCUIT ARRANGEMENTS. ONE OF THE REASONS WHY THE QUAD 11 GIVES THE CLOSEST APPROACH TO THE ORIGINAL SOUND.

ACOUSTICAL MANUFACTURING CO LTD

The Acoustical Manufacturing Co. Ltd Huntingdon, England



(photograph by courtesy of E.S.A. Ltd., Stevenage)

This is a typical application of R.F. Heating as used in the Woodworking Industry, showing how shapes are manufactured with veneers. The jig is of laminated wood, in the form of the final shape, and is lined with aluminium sheets which are connected to the terminals of the R.F. Heater.

The pressure, which should be about 50 lbs. per square inch, is applied on the centre ram by means of a hydraulic pump. With this method the R.F. is fed to the two plates which cause the wood mass to become hot and the resin to cure in a few minutes.

Thus only one jig is required to give a large daily output and the cost of the job is thereby reduced. Less floor space is required than for any other method.

The main advantage of R.F. Heating over other methods, however, is that heating can be localised and heat will only be applied where it is needed.

Agent for London & Southern England

Messrs. H. F. Industrial Services Ltd., Fairfax Road, London, N.8. Telephone: Fitzroy 0045

Agent for Scotland

Messrs. Pye Scottish Telecommunications Ltd., 74 York Street, Glasgow. Telephone: Glasgow Central 7637.

Agents are required for other areas of the United Kingdom and countries abroad

ALL COMMUNICATIONS TO BE ADDRESSED TO:-

MESSRS. PYE LIMITED

R. F. HEATING DIVISION • RADIO WORKS • CAMBRIDGE • ENGLAND

Telephone: Cambridge 57590

This low frequency oscillator costs only £75

(Bench stands 1 gn. extra)

This reasonably-priced low frequency oscillator is extensively used in the aircraft industry and elsewhere as a convenient source of signals down to 1.15 c.p.s. for the testing and calibration of vibration recorders, servo systems etc. It is also widely used in medical research and clinical work for the calibration of biological amplifiers and recorders, and low frequency wave analysers.

Brief Specification:

TYPE	FREQUENCY RANGE	OUTPUT	INPUT	CONSTRUCTION
Resistance capacity, with automatic amplitude control effective over the whole frequency range.	1.15 c.p.s. to 5,500 c.p.s.	Sine wave 50 volts peak to peak, push-pull, with built-in attenuator.	200-250 volts, 40-60 c.p.s.	Standard 19" rack mounting, but also suitable for bench use. Bench stands available.

NOTES. An incremental switch is fitted. Provision is made for mixing other signals with the output.

Immediate delivery from

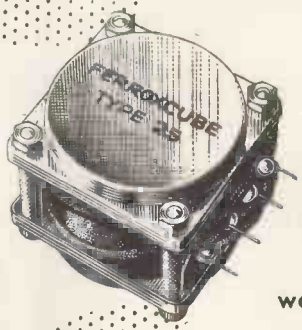
EDISWAN

RADIO DIVISION · THE EDISON SWAN ELECTRIC COMPANY LIMITED

Member of the A.E.I. Group of Companies

155 Charing Cross Road, London, W.C.2. *Telephone:* Gerrard 8660. *Telegrams:* Ediswan, Wescent, London

SP 130



High Q inductance coils

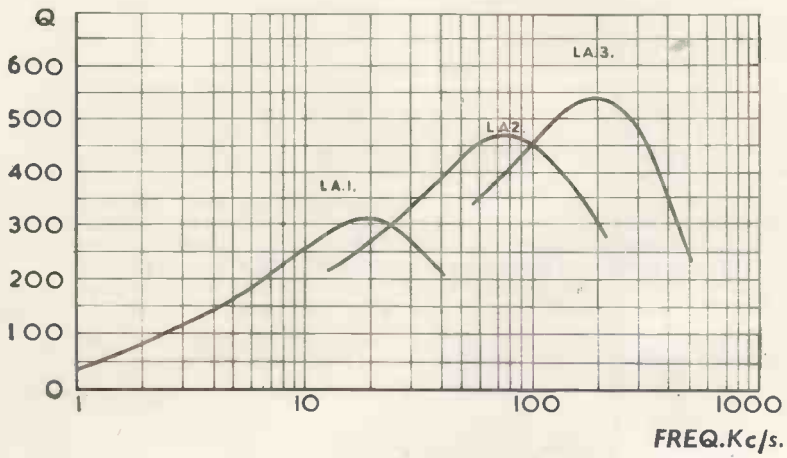
wound on Ferroxcube cores

DESIGNERS of compact and efficient tuned circuits and wave filters are making ever-increasing use of Mullard high Q inductance coils.

Based on Ferroxcube, the world's most advanced magnetic core material, these coils combine small size with an inductance of up to 30 henries over a wide frequency range. Furthermore, their convenient shape and self screening properties facilitate either individual mounting or stacking.

Full details of these and other high grade components now available from Mullard will be gladly supplied on request.

TYPICAL Q VALUES



Special Features

Small size

Low hysteresis loss factor

High value of inductance

Low self capacitance

Controllable air gap facilitating inductance adjustment

Self screening

Controlled temperature coefficient

Operation over a wide frequency range

Easily mounted

Mullard

'Ticonal' permanent magnets, 'Magnadur' ceramic magnets, Ferroxcube magnetic cores.

MULLARD LIMITED · COMPONENT DIVISION · CENTURY HOUSE · SHAFTESBURY AVENUE · LONDON · W.C.2
(MM450)

And NOW—a range of 'CERAMICAPS' for your LAB Storage Unit!

The LAB Continuous Storage Unit is widely acknowledged as the most efficient and convenient method of storing and selecting resistors. Now its usefulness is still further extended with the introduction of LAB pak'd 'Ceramicaps'. With the LAB Unit, research and experimental laboratories and small production groups have to hand immediately, a complete range of resistors and 'Ceramicaps', easily selected with card index simplicity from some 700 sorted and carded components. Empty cards are merely replaced with full ones from stock.

The LAB unit is supplied FREE with initial purchase to your specification. Standard assortments available. Each LAB Unit can be used to store one type of component exclusively, or quantities of the complete range of resistors and 'Ceramicaps'. Full details and illustrated list will be sent on application.

Ref.	Type	Loading	Max. Volts	Range	Dimensions
RESISTORS					
T	½ watt	½ watt	250	10 ohms to 10 megohms	⅜" x ⅛"
R	½ watt	1 watt	500		¾" x ¼"
Tolerance available ± 20%, 10%, 5%					
HIGH STABILITY RESISTORS					
HS3	½ watt	½ watt	750	1 ohm to 500 megohms	1.1" x 0.1"
Tolerance available ±5%, 2%, 1%					
WIREWOUND RESISTORS 5 ohms to 100K ohms — 5 - 10 watts					
'CERAMICAPS' Tubulars 3 - 470 pf 500 - 5000 pf Tolerances ±2%, 10% Hi-K					

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

THE LAB TESTED CONTINUOUS **STORAGE UNIT**

★ **Continuous Storage for Resistors and 'Ceramicaps'**

★ **Values separately carded**

★ **Finger-tip Selection**

THE RADIO RESISTOR COMPANY LTD

50 ABBEY GARDENS · LONDON · N.W.8 · Telephone: Maida Vale 5522

9 Octave realism... from a single unit

The G.E.C. metal cone loudspeaker gives lifelike reproduction of any type of sound over a range of 9 octaves. This includes the entire musical fundamental range together with overtones which give tonal quality and character to the performance of each musical instrument.

The sound engineer will appreciate the simplification and improvement in performance which has been achieved by combining the following attributes in a single unit.

- **Smooth response over a range of nine octaves with extremely good low frequency response**
- **Negligible inter-modulation**
- **Unequalled transient response due to special coil and cone construction**

£8.15.0
TAX PAID

For the Home Constructor

This is a professional instrument and must be used under the correct conditions to obtain the optimum results. Cabinets have been specially designed for use with this loudspeaker, details of which will be available shortly.

G.E.C.

Metal Cone Loudspeaker

THE GENERAL ELECTRIC COMPANY LTD., MAGNET HOUSE, KINGSWAY, W.C.2

INTRODUCING THE NEW E.M.I. MAGNETIC RECORDING TAPE

EMITAPE TYPE '77' AND '88'

E.M.I. with a small select team of scientists and research chemists pioneered the manufacture of Magnetic Recording Tape in this country, and due to the ever increasing demands for this tape by the famous studios of His Master's Voice, Columbia and Parlophone, etc., the British Broadcasting Corporation and leading Broadcasting Studios at home and abroad, the E.M.I. plant today is the largest and most up-to-date production unit in this country.

Unremitting research with this new development in electronics has produced: *The magnetic recording tape by which all other tapes are judged.*

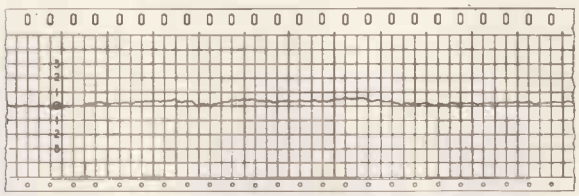
EMITAPE is the universal tape, suitable for all types of Tape Recorders, whether they are single or twin track recording. The tape is readily joined and edited with the E.M.I. jointing accessories.

EMITAPE '88' SPECIAL FEATURES

- High Sensitivity
- Anti-static-P.V.C. Base
- High Tension Strength
- Freedom from Curl
- Editing leader and trailer Strip
- Metallic Contact Strip on 5" spools for auto-stop
- New domestic plastic spool

EMITAPE is available wound on a range of five spools covering all professional and domestic hub machines. Spare empty reels are available in all sizes.

EMITAPE '77'
"Pen Tested" for Special Applications



Although manufactured under the same conditions as Type '88' and having all the special features, Type '77' undergoes an individual "Pen Test" examination for accuracy of sensitivity. Each reel is "Pen Tested" throughout its entire length to ensure a level of sensitivity not exceeding $\pm\frac{1}{2}$ dB, and an overall variation from reel to reel not greater than ± 1 dB. A typical example of a "Pen Tested" chart is given above.

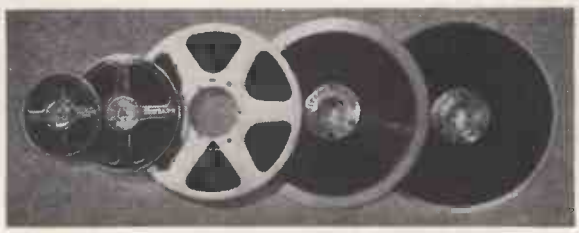


Illustration of range of tape available in Type '77' and '88'

EMITAPE SPECIFICATION

Magnetic Properties:—
Coercive Force 270 Oersteds
Remanence 0.6 flux lines per $\frac{1}{4}$" width

Sensitivity Uniformity for Type '77'
1 Kc at optimum bias at 15"/sec.
(a) Slow variation within one reel not greater than $\pm\frac{1}{2}$ dB on mean sensitivity
(b) overall variation from reel to reel not greater than ± 1 dB on mean sensitivity
(c) Instantaneous variation in sensitivity not greater than $\frac{1}{2}$ dB

Sensitivity:—
The sensitivity for a given recording current is 8 dB above H50 tape.
Sensitivity of tape at 15"/sec.
1 Kc $\pm$ 1 dB
10 Kc $\pm$ 2 dB on sensitivity at 1 Kc.
15 Kc $\pm$ 3 dB on sensitivity at 1 Kc.

Bias Ratio:—
Optimum bias is 80% of that required for H50 tape

Print:—
At least 60 dB below test signal after close contact for 5 minutes at 70°F.

Modulation Noise:—
At least 50 dB below peak mod. (2% total harmonics)

Basic Unweighted Noise:—
At least 65 dB below peak recording level

Tensile Strength:—
7$\frac{1}{2}$ lbs. per $\frac{1}{4}$" width

Elastic Elongation:—
At 1 lb. load — less than 0.5% (15 secs. application)

Yield Point:—
4$\frac{1}{2}$ lbs. per $\frac{1}{4}$" width

Recommended Operational Tension:—
3 ozs.

Longitudinal Temp. Coeff:—
4 x 10^{-5} per degree F.

Humidity Expansion:—
Negligible

PRICE LIST

	REEL	LENGTH	TYPE 88		TYPE 77	
5"	DOUBLE SIDED PLASTIC SPOOL	600 ft.	88/6	1. 1.0	77/6	1.10.0
7"	DOUBLE SIDED PLASTIC SPOOL	1,200 ft.	88/12	1.15.0	77/12	2. 8.0
10½"	NAB DOUBLE SIDED ALUMINIUM SPOOL	2,400 ft.	88/24N	4. 3.0	77/24N	5.17.6
11"	EUROPEAN SINGLE SIDED ALUMINIUM SPOOL	2,400 ft.	88/24E	3.13.6	77/24E	5. 8.0
11"	EUROPEAN SINGLE SIDED ALUMINIUM SPOOL	3,250 ft.	88/325	4.11.0	77/325	6. 0.0

Send for illustrated brochure of Emitape Tape Accessories & Magnetic Tape Recording equipment to:—

E.M.I. SALES & SERVICE LTD., RECORDING EQUIPMENT DIVISION, HAYES, MIDDLESEX. Telephone: SOUTHALL 2468

ES55

ADVANCE COMPONENTS LTD., MARLOWE ROAD, WALTHAMSTOW, LONDON, E.17 Telephone: LARkswood 4366/7/8

7·5 to 250 Mc/s
ON FUNDAMENTALS
IN FIVE RANGES
SINE AND SQUARE WAVE MODULATION
R.F. OUTPUT 1 μV to 100 mV

Advance

MODEL Q1

V.H.F. SIGNAL GENERATOR

£45
(List price in U.K.)

Again Advance lead the way—this time with a V.H.F. Signal Generator covering 7.5 to 250 Mc/s, a range that embraces Bands 1 and 2 *and also the impending Very High Frequency Television Transmissions on Band* 3. Moreover, this instrument is available at a price well within the reach of every service man. In the traditional Advance manner, this instrument is designed for simple operation and with a versatility that not only fulfils present needs, but anticipates the even more exacting requirements to deal with the television test problems of tomorrow.

Below ore some outstanding features:-

- WIDE RANGE—7.5 to 250 Mc/s
- SINE AND SQUARE WAVE MODULATION
- RELIABLE ATTENUATION
- LOW LEAKAGE—*less than 3 microvolts*
- TRULY PORTABLE—*weighs only 17 lbs*
- COMPETITIVE PRICE

The Q1 provides the ideal complement to the Model E2. These together give complete coverage from 100 kc/s to 250 Mc/s.

Full technical details available in Folder W23 on request.

Photograph by courtesy of Handley Page Ltd.

with GOODMANS VIBRATORS

The flight characteristics of a newly designed aeroplane are the subject of lengthy calculations before the first prototype is built. Whilst the mathematical calculations are themselve accurate, they are based, as in all design work, on several assumptions which have to be verified by a series of pre-flight tests.

One of these essential investigations is the Ground Resonance test, the purpose of which is to determine the various complex modes of vibration of the airframe structure. The frequency of the mode and the dynamic response at remote parts of the aircraft must be accurately determined. The information obtained together with the aerodynamic derivatives is used in predicting the critical ' flutter ' speed of the aircraft. The illustration shows one of the two Goodmans Model 8/600 Vibration Generators which were used to excite the Handley Page " Victor" for this very important test.

For wide frequency range vibration testing and dynamic response investigations, Goodmans Vibration Generators are an obvious choice. These units require no field excitation and provide a faithful reproduction of the input wave form. Industrial applications of controlled vibration are continually increasing; maybe it can serve you—in which case our unique experience is at your service.

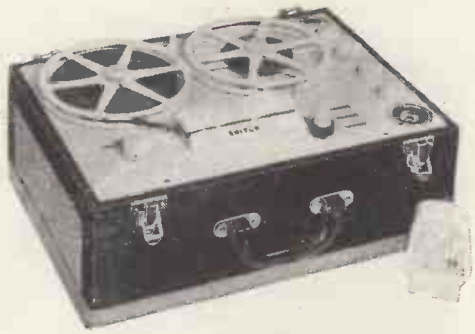
The range includes models from the 8/600 shown, developing a force of ± 300 lb., to the midget model, with a force of ± 2 lb., for optical cell research and hairspring torque testing, etc.

Just another of the wide applications of Goodmans Vibration Generators. Full technical data available from Vibration Division "W"

GOODMANS INDUSTRIES LIMITED, Axiom Works · Wembley · Middx · Wembley 1200 (8 lines)
GD

THE POPULAR RECORDER at the POPULAR PRICE

THE **Editor** SUITCASE TAPE RECORDER



TWO SPEED TAPE RECORDER

45 GNS.

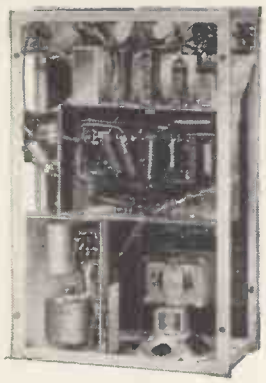
Complete with Ronette Crystal Desk Microphone, 1,200ft. spool high coercivity tape, and take up spool.

THE Tape Recorder for the Connoisseur who wants the best in Tape Recording. At 45 Gns. there is no better value. Now available with two speeds giving 2 HOURS' PLAYING TIME, the "EDITOR" combines the latest recording techniques with the advanced technical achievements of our research engineers.

Suitable for use with pre-recorded tapes, this wonderfully compact unit is amazingly simple to use for a hundred and one different recording purposes. Superb true balanced recording and listening can be obtained. **The "EDITOR" is the smallest mains-operated Tape Recorder giving 2 HOURS' FULL PLAYING TIME.**

TECHNICAL DATA

- **INDEPENDENT BASS AND TREBLE CONTROLS FOR RECORDING AND PLAYBACK.**
- **Two speeds 3¾in. and 7½in. per sec.**
- **High quality Amplifier can be used quite independently for PA or gramophone record reproduction.**
- **Overall negative feedback.**
- **High flux speaker together with amplifier giving superb and brilliant reproduction.**
- **Instantaneous and positive braking.**
- **High fidelity recording heads (twin tracks), automatic erasure.**
- **Powered by three high grade recording motors.**
- **Fast forward and rewind without unlacing tape.**
- **Precision engineering giving negligible wow and flutter.**
- **Magic eye recording level control.**
- **Speaker muting switch and provision for external speaker.**
- **Radio/Gram and microphone inputs.**
- **Size only 16½in. x 12in. x 5in. (without lid). Weight 33 lbs.**
- **MULLARD Miniature Valves.**
- **Attractive 2-tone leathercloth case with detachable lid with handsome gilt fittings.**
- **For use on AC mains 200/250 v.**



THE HEART OF THE "EDITOR"
The Precision Engineered Chassis

Custom-built and modern in styling, the "EDITOR'S" ingenious planned circuitry is built on a quickly removable, all steel frame —a remarkable development in chassis design construction. This skilful method of assembly facilitates ease of inspection. The chassis can be withdrawn from the case in 30 seconds by removing only 4 screws.

EASY H.P. TERMS *Send only 20% deposit with order, balance over any period up to 18 months. Add 15/- for carriage and packing.*

TWO YEARS' GUARANTEE with every

Burgoyne 8 VALVE Radiogram Chassis

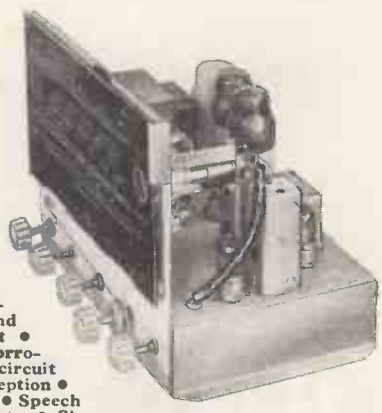
22 GNS.

(carriage and packing 7/6)

EASY H.P. TERMS

Send 20% deposit with balance spread over any period up to 18 months.

With a push-pull output giving 8 watts of undistorted quality reproduction and using negative feedback, this fine chassis is supplied for those connoisseurs wanting only the best, at a price within their means.



TECHNICAL DATA

• Illuminated full vision coloured tuning scale 11½in. x 6½in. • Negative feedback • 8 valves—6C9, 6F15, 6LD20, 6L1 (2), 6P25, UU7 and 6MI • Separate bass and treble controls for cut and lift • Wavebands 16-50; 190-550; 1,000-2,000 metres • Magic eye tuning indicator and precision flywheel tuning • 8 watts push-pull output • Heavy gauge steel chassis, specially treated against corrosion • Special mains transformer with smoothing circuit reduces hum to a minimum • Clear long distance reception • Recommended for use with 10in. or 12in. P.M. speaker • Speech coil impedance 3 or 15 ohms • Extension speaker sockets • Size 9½in. high x 13in. wide x 8in. deep—chassis height 2½in.

M·O·S

E. & G. **MAIL ORDER**

Telephone: MUSeum 6667. *THE RADIO CENTRE*

Track Assembly

Moulded with

'Araldite'

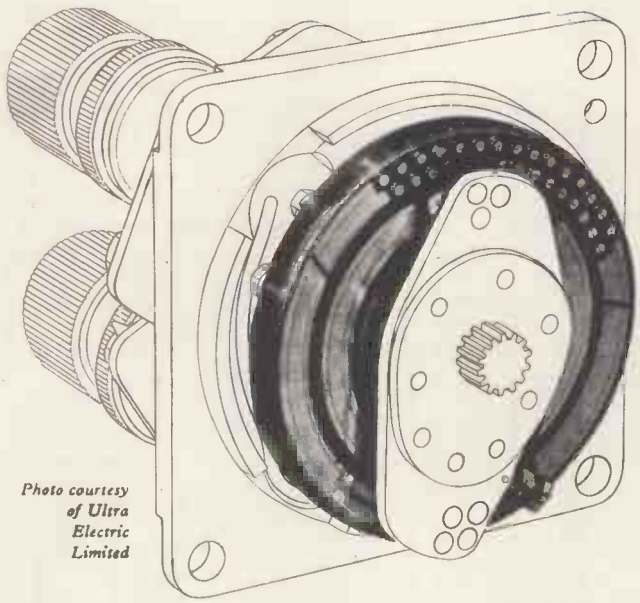


Photo courtesy of Ultra Electric Limited

This selector unit (part of the Ultra Jet Pipe Temperature Control System) controls the temperature of the exhaust gases of a turbo-jet aero-engine.

The resistance elements and track segments are moulded in 'Araldite' Casting Resin B, simplifying assembly and sealing the elements against climatic changes and ensuring mechanical stability.

This is another example of the versatility of 'Araldite' epoxy casting resins which combine exceptionally low shrinkage on setting with resistance to high temperatures, humidity and corrosive agents. 'Araldite' epoxies are facilitating production in many industries—most notably in the potting and sealing of components for radio, electronics and electrical engineering generally.

THESE ARE THE NEW EPOXIES!

'Araldite' (regd.) epoxy resins are obtainable in the following forms :—

- *Hot and cold setting adhesives for metals and most other materials in common use*
- *Casting resins for the electrical, mechanical and chemical engineering industries*
- *Surface coating resins for the paint industry and for the protection of metal surfaces*

Full details will be sent gladly on request.

'Araldite' *epoxy casting resins*

Aero Research Limited

DUXFORD, CAMBRIDGE. Telephone: Sawston 187 A Ciba Company

264-75 A

THE

SCALAMP

ELECTROSTATIC VOLTMETER

For high voltage measurements at zero current drain the "SCALAMP" ELECTROSTATIC VOLTMETER is the ideal instrument.* With a three-second period and hairline-spot indicator on a clear open scale, measurements can be taken with great rapidity and ease. The instrument is completely self-contained, all components being enclosed in a robust dust-proof plastic case mounted on resilient feet. Lamp illumination is effected from the mains-supply through a built-in transformer or from an external 4V battery. Please write for descriptive leaflet.

RANGES

Cat. No. W.W. 11308 *1 to 5 kV (a.c. or d.c.)*
W.W. 11309 *3 to 10 kV (a.c. or d.c.)*
W.W. 11310 *5 to 18 kV (d.c.) and 5 to 12 kV (r.m.s. on a.c.)*

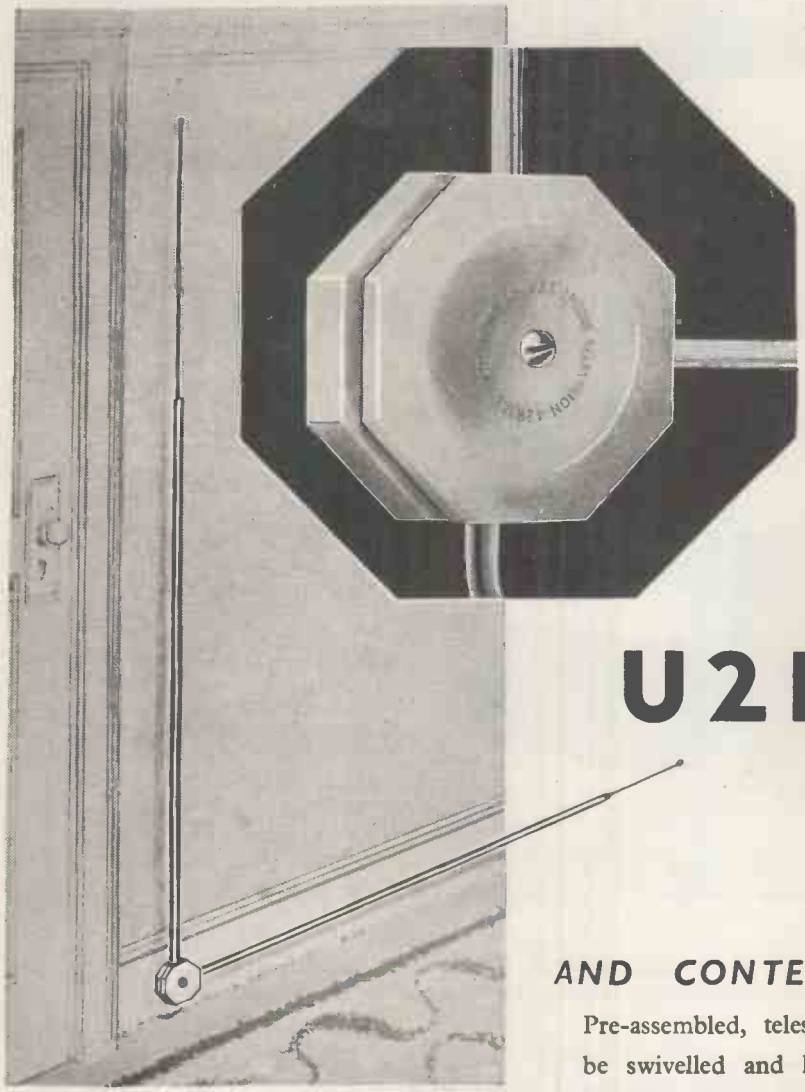
Heavy demand, leading to increased and more economical production has enabled us to reduce the price of this outstanding instrument to only £25.0.0.

*vide page 100 of Television Engineers' Pocket Book—a Newnes Publication.

SCIENTIFIC PYE INSTRUMENTS

W. G. PYE & CO. LTD., GRANTA WORKS, CAMBRIDGE, ENGLAND

WG.62



The illustration shows how unobtrusive the U2RC is and how, with its attractive cream insulator and cream sleeved rods, it so readily fits in with any form of room decoration.

U2RC-ing perfect pictures

AND CONTENTED CUSTOMERS

Pre-assembled, telescopic tuneable rods, which can be swivelled and locked in any angular position, are the exclusive features of the Antiference De Luxe room aerial for multi-channel use.

Model U2RC complete and ready for immediate use with 15ft. of cream plastic covered cable.

LIST PRICE 21/-

Model U2R as U2RC but without cable

LIST PRICE 15/-

ANTIFERENCE
LIMITED

The design of these aerials is fully covered by Antiference patents.

BICESTER ROAD, AYLESBURY, BUCKS. Telephone : Aylesbury 1467/8.

DRB/A/B

S.I.M.A
An Exhibition
ELECTRONICS AT WORK
22nd-25th November 1954
BIRMINGHAM
Chamber of Commerce Hall

Q and tan δ

bridge or resonance methods

1 kc/s or 50 Mc/s

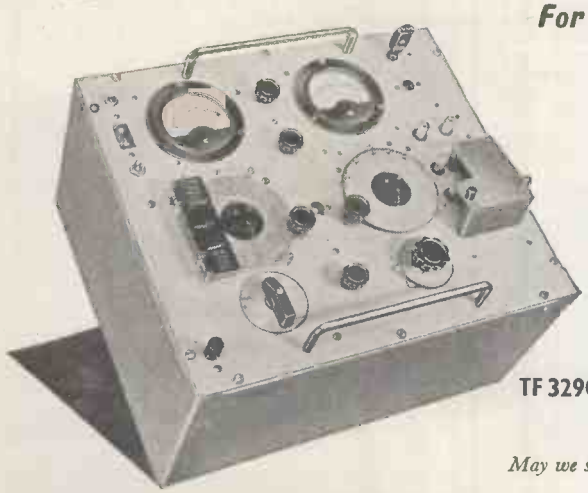
For the measurement of the magnification factor of inductors or the phase defect of capacitors at 1 or 10 kc/s UNIVERSAL BRIDGE Type TF868/1.

TF 868/1

OPERATING FREQUENCY: 1 or 10 kc/s
DIRECT MEASUREMENT RANGES

Q: 0.1 to 10 at 1 kc/s; 1 to 100 at 10 kc/s
Tan δ: 0.001 to 0.1 at 1 kc/s; 0.01 to 1 at 10 kc/s
Capacitance: 1μμF to 100μF
Inductance: 1μH to 100H
Resistance: 0.1Ω to 10MΩ (d.c.)

For measurements up to 50 megacycles —CIRCUIT MAGNIFICATION METER Type TF 329G.



TF 329G

OPERATING FREQUENCIES
50 kc/s to 50 Mc/s

DIRECT MEASUREMENT RANGES

Q: 10 to 500
Tan δ: 0 to 0.1
Capacitance: 0 to 416μμF

Inductance and resistance may be determined indirectly: for measurements at frequencies up to 170 Mc/s, use H.F. Circuit Magnification Meter Type TF 886A.

May we send you our booklet "Measurement by Q Meter"?

MARCONI INSTRUMENTS

SIGNAL GENERATORS · VALVE VOLTMETERS · FREQUENCY STANDARDS
OUTPUT METERS · WAVEMETERS · WAVE ANALYSERS · BEAT FREQUENCY OSCILLATORS

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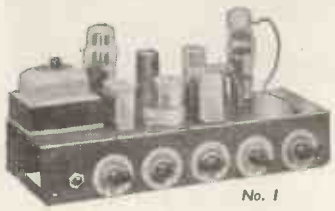
Export Office: Marconi House, Strand, London, W.C.2

TC26

REAL HIGH FIDELITY *at modest cost . . .*

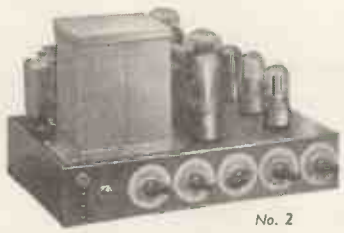
•*Manufacturer-to-Consumer policy saves you at least one-third cost!*

We are now specialising in the supply of units for making up high-fidelity Radio and Record-reproducing Equipments for use in the Home, small Halls, Schools and Gramophone Societies and single items for replacing in existing equipments and radiograms.
Our Chief Engineer, who is operating a Technical Guidance Service, is available daily, including Saturdays, from 10 a.m. to 6 p.m., or will deal with enquiries by return of post. Our new illustrated Catalogue and Supplement will be a great boon to those desiring high quality equipment for modest expenditure. Send two 2½d. stamps for your copy now. It may well save you pounds.



No. 1

No. 1 "SYMPHONY" AMPLIFIER is a 3-channel 5-watt Gram/Radio Amplifier with astonishingly flexible tone control. You can lift the treble, the bass, or—and here is the unique feature—the middle frequencies to suit your own ear characteristics and the record or radio programme being heard. It is thus possible to arrange the frequency-response of the amplifier to a curve equal and opposite to the resultant curve of the other items in the chain so that what finally registers in the brain is as per original. This flexibility of control is far more important than mere nominal linear response of the amplifier, as the pick-up, speaker, etc., are not linear. Independent Scratch-Cut is also fitted and special negative-feedback circuit employed. The Amplifier can accommodate a wide variety of records from old 78's to new L.P.s. Input is for all types of pick-up of 0.2v. output or more and there is full provision (and power) for Radio Tuner. It is available. to match 2/3 or 15 ohms speakers. Price: 10 gns. (carriage 5/-). Fitted in Portable Steel Cabinets, 35/- extra.



No. 2

No. 2 "SYMPHONY" AMPLIFIER as No. 1 but with 10-watt Push-pull triode output and triodes throughout. Woden mains and output transformers and choke. Full provision and power for Tuner. Output tapped 3, 7.5 and 15 ohms. Competes with the most expensive amplifiers on the market yet costs only 15 gns. (carriage 5/-). Fitted in portable Steel Cabinet 2 gns. extra.

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

"STUDIO SYMPHONY" AMPLIFIERS, Models 1 and 2, new models specially designed to get the maximum out of the revolutionary new Collaro Studio pick-ups and heads type "P." Specification as per our Standard Symphony models but with high-gain, low-noise, built-in Pre-amplifier stage with separate switched correctors for Std. and L.P. Third position on switch provides input matching for Acos and similar output pick-ups. These remarkable new models thus provide all the facilities and matching of our Standard Symphony Amplifiers PLUS the specialised Collaro matchings. Send for copy of "The Gramophone" review of these instruments. Price: No. 1, 12 gns.; No. 2, 17 gns. Carriage 5/-.

CURRENT GARRARD PRODUCTS AVAILABLE FOR IMMEDIATE DELIVERY FROM STOCK AT PRESENT.

3-SPEED GRAM UNIT MODEL "T" with new type turnover pickup head, £10/12/8, post 2/6.
MODEL TA as above, but with plug-in turnover head, £10/16/-, or with two separate high fidelity Acos HGP35 heads, £12/15/6. Unit less heads, £8/11/-, post 2/6. Heads, 42/3 each, post 1/-.
MODEL TB as above, but with long pickup arm. Less heads, £8/11/-, post 2/6.
Heads to fit this unit: Decca XMS, 55/-, Decca Crystal, 35/-, Garrard Standard Magnetic, 25/-, miniature magnetic low impedance, 25/-, miniature magnetic high impedance, 35/-. Post on heads 1/-. Unit can be supplied with any combination of above heads and is carefully adjusted for stylus pressure on despatch.
RC110 NEW MODEL AUTO-CHANGER with new type turnover head, £13/19/6, carriage 5/-.
MODEL RC80M, less heads, £15/4/6, with new turnover head, £17/9/6, with two separate Acos HGP35 heads, £19/9/-, carriage 5/-.
COLLARO latest model **AC3/554 Unit** with fixed head ("O" or "P" cartridge) £8/18/4. Post 2/6.
COLLARO model **3RC531 AUTO-CHANGER.** We are pleased to say that after most careful and rigorous trial, we can highly recommend these improved Auto-Changers by Collaro. The standard of engineering is of the highest and in addition to being very easy and quick and foolproof in operation, they are fitted with the revolutionary high-fidelity plug-in **"STUDIO"** Pickup heads of which the Type "O" is matched to radio sets and medium-gain amplifiers and the Type "P" is designed for high-gain amplifiers. The Type "P" is exactly matched to our new model Studio Symphony Amplifiers. The price complete with either type pickup head is £15/3/-. The **3RC532** as above, but mixes 10-inch and 12-inch records, costs £17/10/-, carriage 5/-. Delivery from stock.
COLLARO NEW MODEL RC54 MIXER/AUTO-CHANGER with Studio "O" or "P" Pick-up Cartridge in head, £13/4/2, carriage 5/-.

TRANSCRIPTION MOTORS IN STOCK.
COLLARO MODEL 2000, less pickup, £13/9/6.
COLLARO 2010 with pickup complete on unit plate, £18/4/9.
Illustrated leaflet on Collaro Products on request.
CONNOISSEUR, 3-speed motor, £23/8/11.

GOODMANS CORNER CABINETS (left) for the AXIOM 150 Mark 2 manufactured by us to Messrs. Goodmans' measurements. Height, 44in. Price: complete kit in plain board with 1-in. thick felt, 8 gns. Price ready built, 10 gns. Finished in figured walnut, 16 gns. Other veneers to order. Carriage extra according to area.
"SYMPHONY" BASS REFLEX CABINET KITS. 30in. high, consist of fully-cut ¾in. thick, heavy, inert, non-resonant patent acoustic board, deflector plate, felt, all screws, etc., and full instructions. 8in. speaker model, 85/-; 10in. speaker model, 97/6; 12in. speaker model, £5/7/6. The design is the final result of extensive research in our own laboratory and is your safeguard of optimum acoustic results. Carriage 7/6. Ready built, 10/6 extra.

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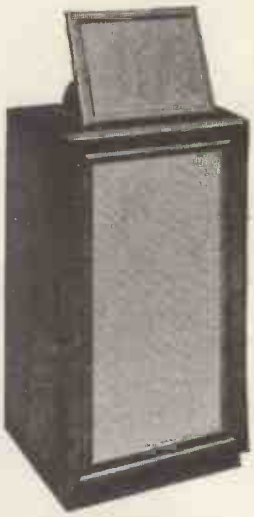
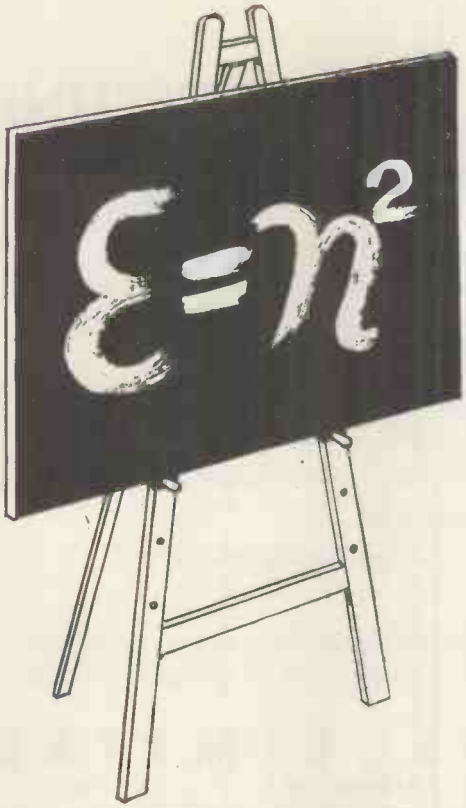
Tubes: Swiss Cottage and Chalk Farm.
Buses: 2, 13, 31, 113, 187.



"SYMPHONY" BASS REFLEX CABINETS, fully finished in figured walnut, oak or mahogany to our own design and to match our Console Amplifier Cabinet, enabling the housing of a whole equipment in a two piece suite, cost: 12in. speaker model, £11/10/-; 10in., £11; 8in., £10/10/-. Carriage according to area. The 10in. model is ideal for the WB HF 1012 (see "The Gramophone" review March).

W.B. BASS REFLEX CABINET in Kit Form (veneered) to house HF1012 and Tweeter, 10 gns. Carr. by Road, 10/-.

CONSOLE AMPLIFIER CABINETS (above), 33in. high, lift-up lid with piano hinge, take Tape Deck, Gram Unit or Auto-changer, Amplifier, Pre-amplifier, and Radio Feeder Unit, finished medium walnut veneer. De Luxe version, 10 gns. carriage according to area. Other veneers 10/- extra.



IN 1881 J. C. MAXWELL

derived this relationship between dielectric constant and refractive index.

That this holds true for Polystyrene implies that polarization is almost entirely due to elastic displacement of electrons only.

This means LOW DIELECTRIC LOSS and dielectric constant independent of temperature, frequency and voltage.

SUFLEX POLYSTYRENE CAPACITORS

because of their LOW DIELECTRIC LOSS and SMALL SIZE are admirably suited for use in I.F. transformers and padded circuits. Their uniquely high insulation resistance and low dielectric absorption make them indispensable in computors, nucleonic and medical equipment.

* The capacitors shown here are actual size.

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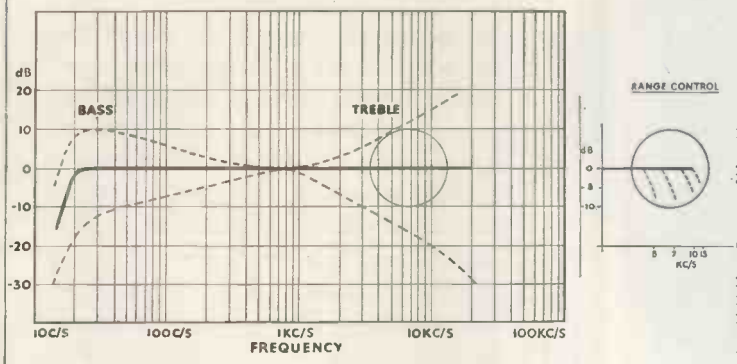
LONDON

CAPACITIES :	5 pf. to 0.5 mfd.
TOLERANCE :	20% to 1%.
VOLTAGES :	250v. to 750v. D.C.
HS Type :	for general use.
HSA Type :	with additional sealing for use in exceptional humidity conditions.

35, BAKER STREET, LONDON, W.1. *Telephone:* WELbeck 0791.

DESIGN FEATURES OF HIGH FIDELITY REPRODUCERS



Frequency response of "H.M.V." Model 3001. Response of the main amplifier is shown by the full line; maximum variations given by the bass and treble controls are shown dotted. The inset shows the cut-off positions of the frequency range selector.

Two alternatives usually confront the designer of high fidelity record reproducing equipment. He can specify separate units for loudspeakers, pre-amplifier, power amplifier and turntable assembly; or he can incorporate all the units in one self-contained cabinet. Both systems have obvious merits, and both have their drawbacks, but when normal domestic conditions have to be taken into account, the latter course is usually the more acceptable, providing the cabinet is kept down to reasonable proportions.

The design of a self-contained reproducer of high fidelity standards raises problems not encountered when the separate unit method is adopted. Since a relatively large acoustic output and freedom from acoustic feedback and noise are basic requirements of high fidelity reproduction the principal problems the designer has to overcome concern the loudspeaker enclosure and the turntable and pick-up assembly. The way in which "His Master's Voice" engineers have overcome these problems is evidenced in the design of the new high fidelity reproducer, Model 3001, and the techniques and principles enumerated in this article have been tried and proven by the results achieved by that equipment.

Model 3001 uses two special 13½" elliptical cone units, each covering its natural frequency range and mounted at an angle of 5°–7°. Consequently a greatly improved propagation of the high frequencies has been achieved.

Both these units have a high flux density and both are fitted with aluminium cone centres for increased output in the upper register. One of them has a specially designed speech coil, which sustains the upper response of the unit well into the normally accepted "high fidelity range", and the other has an improved low resonance cone and coil assembly which provides a clean bass response down to 30 c.p.s. The loudspeaker enclosure provides the maximum volume compatible with a cabinet of reasonable size and is fully lined with sound absorbing material and acoustically curtained to avoid standing waves and reflections. Throughout, the enclosure is constructed of heavy cored timber to reduce vibrations and resonances to negligible proportions.

The net result of these features is a loudspeaker system having a good damping factor, wide angled distribution of the higher frequencies, a frequency range of 30–18,000 c.p.s. and a good mean spherical response.

Of necessity, the turntable and pick-up are mounted in close proximity to the loudspeakers. The dangers of sound coupling and mechanical coupling will be apparent. In Model 3001 the turntable and pick-up are mounted in a separate compartment that is completely insulated from the loudspeaker enclosure. This is achieved by mounting the entire assembly on a two stage mechanical filter, which comprises a special metal framework, spring mounted and mechanically loaded to bring its natural resonance down to the order of 10 c.p.s. or lower. In this way, both sound coupling and mechanical coupling are virtually eliminated.

Having dealt with some of the special problems of a self-contained reproducer, the general problems of high fidelity reproduction still remain. The requirements and features mentioned here are again all realised in Model 3001. Taking the amplifier system first: the main amplifier must be capable of a large output with no more distortion than 0.1% total, and the frequency response should be flat from 20 to at least 20,000 c.p.s. if realism and good transient response are to be attained. This standard of performance is best achieved by using a balanced drive and push-pull output arrangement, preferably with triode or triode-connected valves, and a large multi-sectioned output transformer having high primary inductance and very low leakage reactance. A generous measure of negative feedback is of course essential.

The pre-amplifier, which will normally incorporate the tone controls, should be characterised by high sensitivity, low noise and hum, and negligible distortion. Special low noise valves are desirable, and so is a balanced input to reduce the effect of stray magnetic fields. Tone controls must be flexible and simple to operate. There should be separate bass and treble controls giving maximum variations of about 30db at 50 and 10,000 c.p.s. respectively. An additional and extremely useful refinement is a frequency range selector comprising bridged "T" filters with cut-off frequencies at considered points, thus allowing optimum results to be obtained from all records whatever their age or condition (see graph).

The motor unit must be free from rumble and wow and be capable of providing an absolutely constant speed. Fine speed adjustment is best achieved by an eddy-current device. Needless to say, the motor unit must be resiliently mounted.

The pick-up should be an electro-magnetic component of good basic design, the chief requirements being low playing weight, wide frequency response with resonances well controlled and outside the audio range, and preferably, an efficient hum-bucking arrangement. The stylus should be diamond for L.P. reproduction; sapphire is suitable for 78 r.p.m. records.

A high fidelity equipment whose design takes into account all the features and requirements outlined here will be capable of extracting full value from modern recordings.

A recommended GOODMANS crossover system

. . . means a choice of

★ **20-Watt System**

Bass Unit. Audiom 70 (Bass) £13 15 0
Treble Unit. Axiom 102 £9 18 2 (incl. Tax)

Both these units are equipped with extremely powerful magnet systems; providing 17,500 gauss and 16,000 gauss respectively. Frequency coverage 25–15,000 c/s.

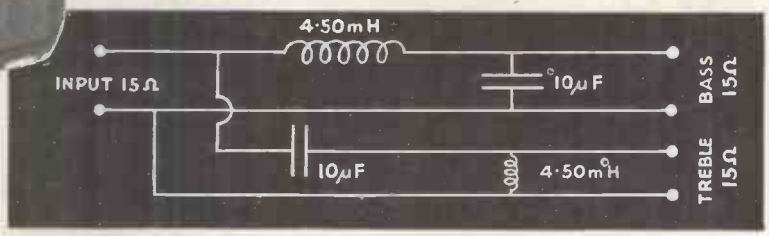
★ **15-Watt System**

Bass Unit. Audiom 60 (Bass) £8 12 6
Treble Unit. Axiom 101 £6 12 1 (incl. Tax)

Similar diaphragms to the 20-Watt system are employed; high flux magnet systems produce 14,000 gauss and 13,500 gauss respectively. Frequency coverage 25–15,000 c/s.

The Audiom 60 and 70 can be supplied with a fundamental resonance of 75 c/s, 55 c/s, or 35 c/s. For both systems it is recommended that the 35 c/s resonance be used.

The frequency of crossover between the two units may lie between 400 c/s and 1,000 c/s. A very satisfactory arrangement for 750 c/s is shown:—



4.50 mH chokes will be available shortly.

There are many paths by which realism of sound reproduction can be approached. Where the loudspeaker is concerned, the number of possibilities is very great and conflicting claims for various systems only add to the confusion.

However, it is now generally accepted that it is preferable to employ separate radiating sources for the various registers comprising the audio spectrum. The primary reason for the preference of a multiple system of this type is that extremely low distortion can be obtained, combined with a very wide frequency coverage. Since each of the sound sources is a specialist in its own part of the range, the combination can give a performance which is unattainable with a single source.

Any number of sources may be employed, but in the interests of simplicity and economy the number is usually restricted to two or three at the most.

In a "Twin" system, both radiators may be incorporated in a single unit (as in the well-known Goodman's Axiom 150 Mk. II and Axiom 22 Mk. II), or they may comprise two separate units.

REMEMBER POPPY DAY

An example of the twin unit system was recently demonstrated to the public at the 1954 Radio Exhibition at Earls Court. It received such praise that we are making public the full details of the system.

The Bass Unit should be mounted in an enclosure which will ensure adequate loading down to the lower end of the range and we shall be pleased to forward details of a specially designed cabinet, on application.

The Treble Unit should be mounted on a small open baffle, which need not be more than two feet square. Bass and Treble Units should be positioned as close together as possible.

A TRADITION OF EXCELLENCE FIDELITY EFFICIENCY

GOODMANS

GOODMANS INDUSTRIES LTD., AXIOM WORKS, WEMBLEY, MIDDX. WEMbley 1200

PREMIER RADIO COMPANY

Limited supplies of C.R. TUBES

VCR517C
6½in. picture. This tube is a replacement for the VCR97 and VCR517. Guaranteed full size picture.
Price 35/-. Plus 2/6 pkg., carr., ins

VCR516
9in. blue picture. Heater volts 4 anode 4 kV. In manufacturer's original carton. £3/19/6. plus 5/- pkg., carr., ins.

ALL BRAND NEW

CABINETS—PORTABLE

Model PC/1
Brown Rexine covered 22/6
Overall dimensions 15in. × 13½in. × 5in.
Clearance under lid when closed 2½in.

Model PC/2
Grey Lizard Rexine covered.....45/-
Overall dimensions 15in. × 13in. × 6in.
Clearance under lid when closed 2½in.

Model PC/3
Rexine type covering in various cols..... 69/6
Overall dimensions 16½ in. × 14½in. × 10½in.
Clearance under lid when closed 6½in.

All the above Cabinets are supplied with Panel, Carrying Handle and Clips.
Packing and Postage 2/6.

PREMIER MAINS TRANSFORMERS

All primaries are tapped for 200-230-250 v. mains 40-100 cycles. All primaries are screened.

SP175B, 175-0-175, 50 mA., 4 v. @ 1 a., 4 v. @ 2-3 a.	15/-
SP350A, 350-0-350, 100 mA., 5 v. @ 2-3 a., 6.3 v. @ 2-3 a.	21/-
SP501, 500-0-500, 150 mA., 4 v. @ 2-3 a., 4 v. @ 2-3 a., 4 v. @ 2-2 a., 4 v. @ 3-5 a.	37/-
SP501A, 500-0-500, 150 mA., 5 v. @ 2-3 a., 6.3 v. @ 2-3 a., 6.3 v. @ 2-3 a.	40/-
SP425A, 425-0-425, 200 mA., 6.3 v. @ 2-3 a., 6.3 v. @ 3-5 a., 5 v. @ 2-5 a.	52/6
250-0-250, 80 mA., 6.3 v. @ 4 a., 5 v. @ 2 a.	19/6
350-0-350, 80 mA., 6.3 v. @ 4 a., 5 v. @ 2 a.	19/6
200-230-250 output 3 v.-30 v., @ 2 a.	17/6

RECTIFIERS

E.H.T. Pencil Type S.T.C.

Type K3/25	650 v.	1 mA.	4/7
,, K3/40	3.2 kV.	1 mA.	6/-
,, K3/45	3.6 kV.	1 mA.	8/2
,, K3/50	4 kV.	1 mA.	8/8
,, K8/100	8 kV.	3 mA.	14/8
,, N3/160	12 kV.	1 mA.	21/6
,, K3/180	14.4 kV.	1 mA.	24/6

H.T. Type S.T.C.

Type RM1	125 v.	60 mA.	4/-
,, RM2	125 v.	100 mA.	4/6
,, RM3	125 v.	125 mA.	5/6
,, RM4	250 v.	250 mA.	18/-

L.T. Type Full Wave

6 v. 1 amp.	4/-
12 v. 1 amp.	8/-
12 v. 2 amp.	10/9
12 v. 4 amp.	15/-

BATTERY CHARGERS

200-250 v. A.C. Will charge 2 v., 6 v. and 12 v. Car Battery at 1 amp. Housed in strong metal casing. Finished in Green hammered enamel. Size 6in. long, 3½in. wide, 3½in. high. Guaranteed 12 mths. The above unit is manufactured by PREMIER and does not contain Ex-Govt. components. Plus 2/6 post and pkg. **39/6**

BATTERY CHARGER KITS

All incorporate metal rectifiers. Transformers are suitable for 200/250 v. A.C. cycle mains.

Cat. No.
2002 Charge 6 volt accumulator at 1 amp. Resistance, supplied to charge 2 v. Accumulator 19/6
2004 Charges 2, 6 and 12 v. accumulators at 1 amp. 22/6

ALUMINIUM CHASSIS 18 s.w.g.

Substantially made from Bright Aluminium, with four sides:

7 × 5½ × 2in.	4/-	10 × 9 × 3in.	7/-
7 × 3½ × 2in.	3/9	12 × 10 × 3in.	7/9
9½ × 4½ × 2in.	4/3	14 × 10 × 3in.	7/11
10 × 8 × 2½in.	5/6	16 × 10 × 3in.	8/3
12 × 9 × 2½in.	7/-	16 × 8 × 2½in.	8/-
14 × 9 × 2½in.	7/6		

ALUMINIUM PANELS 18 s.w.g.

7 × 6in.	1/3	7 × 4in.	1/-
9½ × 6in.	1/8	9½ × 4in.	1/5
10 × 9in.	2/2	10 × 7in.	1/11
12 × 9in.	2/8	12 × 7in.	2/5
14 × 9in.	3/2	14 × 7in.	2/11
16 × 9in.	3/8	16 × 7in.	3/5
20 × 9in.	4/8	20 × 7in	4/5
22 × 9in.	5/2	22 × 7in	4/11

SPECIAL OFFER ! !

SAVAGE AUTO-TRANSFORMERS. INPUTS 110 v., 130 v., 200 v., 230 v., 250 v. Stud switch control. OUTPUTS 110 v. and 230 v. at 1,200 w. nominal, tested 2.4 KVA. 15A. 3 pin sockets and fuses on panel in handsome grey cabinet. Brand new, £7/15/-. De Luxe model by Neverlin, £8/15/-., P. & P. 10/-.

A.C.R.I. C.R. TUBES

5½in. screen. 4 volt Heater. This Electrostatic Tube is recommended as eminently suitable for Television. 15/- plus 2/6 Pkg., carr. and ins. Data sheets supplied.

GRAMOPHONE PRE-AMPLIFIER

Power requirements 200/250 v., 2 mA., and 6.3 v. .3 a., this may be taken off existing radio.
All the components to build the above unit, 22/6, plus 1/6 pkg. and postage.

Famous Manufacturer's Surplus of

ANTI-INTERFERENCE AERIALS

offered at a fraction of original cost

The aerial is designed for reception of long, medium and short waves, with any ordinary or communications receiver, having an input impedance greater than 1,000 ohms long/medium waves and 150 ohms short waves. The installation discriminates against locally generated electrical interference, especially on the short wavebands. The equipment enables the installation of an 8.3 Mc/s flatly-tuned dipole which operates as a "T" aerial on medium and long waves. The aerial and receiver transformers are intended to be interconnected with a 70 ohms co-axial cable.

COMPONENT PARTS

Aluminium Aerial Transformer Assembly. Comprising one each: Aluminium transformer, Transformer clip rubber sucker, ¼in. × ¼in. brass screw, 4AB × ¼in. brass bolt, 4BA nut.
Receiver Transformer. Complete with insulators, clips, etc.; porcelain insulators, 2 each, 60ft. insulated aerial wire, 60ft. screened co-axial down lead.
Installation instruction leaflet included.
LESS CO-AXIAL CABLE & AERIAL WIRE, 15/-, plus 1/6 pkg. and carr.
COMPLETE, 35/-. plus 1/6 pkg. and carr.

★ **QUALITY CRYSTAL PICK-UP ROTHERMEL TYPE U48 26/-**
Plus 1/6 Pkg. and Carr.

The New

"PREMIER PORTABLE"

TAPE RECORDER

USING THE NEW LANE 2 SPEED TAPE UNIT MARK 6

COMPLETE 39 GNS CASH

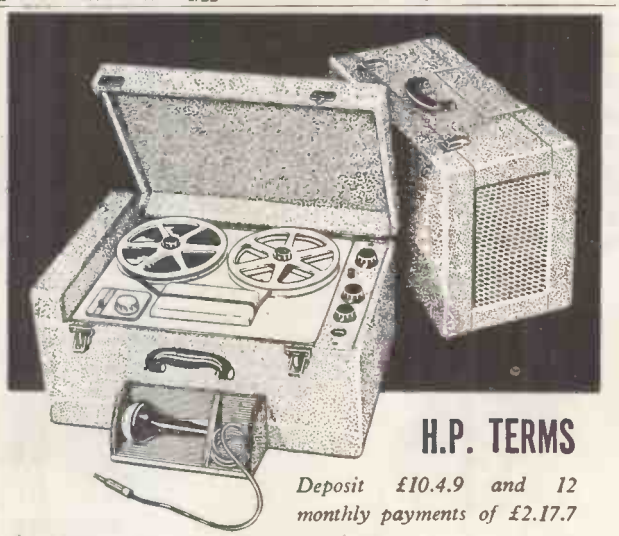
Packing & Carriage 1 gn.

(Including Reel of Scotch Boy Tape and Microphone)

or **Complete Kit** Including All Parts, Valves, Speaker Cabinet, Tape Unit, Reel of Scotch Boy Tape, Rewind Spool and Microphone at **£37.4.0** plus pkg. & carr. 15/-.

SPECIFICATION

- ★ TWO SPEEDS 7½in. AND 3¾in. PER SECOND.
- ★ THREE SPECIALLY DESIGNED RECORDING MOTORS.
- ★ 1,200ft. TAPE REELS PROVIDING PLAYING TIMES OF 1 HR. AND 2 HRS.
- ★ DROP IN TAPE LOADING.
- ★ EASY FORWARD OR REWIND WITHOUT REMOVING TAPE.
- ★ ONE KNOB DECK OPERATION.
- ★ 7 VALVE HIGH QUALITY AMPLIFIER.
- ★ INDEPENDENT TREBLE AND BASS CONTROLS.
- ★ MAGIC EYE RECORD LEVEL INDICATOR.
- ★ AMPLIFIER MAY BE USED FOR RECORD REPRODUCTION OF HIGH QUALITY.
- ★ COMPARTMENT FOR HOUSING MICROPHONE.
- ★ SPECIALLY DESIGNED MICROPHONE BY A LEADING MANUFACTURER.



H.P. TERMS

Deposit £10.4.9 and 12 monthly payments of £2.17.7

SEPARATE UNITS CAN BE SUPPLIED AS LISTED BELOW:—

Amplifier (built, wired and tested with Speaker). £14/15/-, plus postage and carriage 7/6.
Hire purchase terms, Deposit £3/13/9 and 12 monthly payments of £1/0/9.
Amplifier Kit (including Speaker). £11/-/- plus packing and carriage 5/-.
Hire purchase terms, Deposit £2/15/- and 12 monthly payments of 15/6.
New Lane 2-speed Tape Unit Mark 6, £18/10/- plus packing and carriage 7/6.
Hire purchase terms, Deposit £4/12/6 and 12 monthly payments of £1/6/-.
Portable Cabinet (rexine covered). £4/19/6, plus postage and carriage 5/-.
Microphone, £2/19/6, plus postage and carriage 1/-.
Reel Scotch Boy Tape MC2-111 (1,200ft.), £1/15/-, plus packing and carriage 1/-.
Instruction Booklet, 2/6. Post free.

PREMIER RADIO COMPANY

WILLIAMSON AMPLIFIER KIT 15 gns.
plus 7/6 p. & p.

H.P. Terms Dep.£5.5.0 &12 m'thly p'ym'nts of19/9

This Kit is absolutely complete and all components are guaranteed exactly to author's specification.

WILLIAMSON OUTPUT TRANSFORMER
Author's Specification 3.6 ohms secondaries **£4.4.0**

MAINS TRANSFORMER SP425A
(Completely Shrouded)

This Transformer has an additional 6.3v. 3A and is capable of supplying an extra 50 mA. for Pre-amp or Feeder unit **£2.12.6**

WILLIAMSON CHOKES

12H 150 mA. Fully shrouded **19/6**
30H 20 mA. Fully shrouded **11/9**

METERS

Full Scale Deflection	External Dimensions in.	Movement	
25 A.	2½ round	R.F. Thermo ..	7/6
3.5 A.	2½ × 2½	R.F. Thermo ..	7/6
4 A.	2½ × 2½	R.F. Thermo ..	7/6
20 A.	2½ round	M/C	8/6
40 A.	2½ round	M/C	8/6
5 mA.....	3½ round	.....	7/6
6 mA.....	3½ round	.....	16/9
50 mA.....	2½ × 2½	M/C	7/6
20 V.	2½ × 2½	M/C	6/6
40 V.	2½ × 2½	M/C	8/6
1 mA.....	2 × 2	M/C	17/6
1 mA.....	2½ round	M/C	22/6
1 mA.....	2½ round	Desk type M/C	25/-

H.T. ELIMINATOR AND TRICKLE CHARGER KIT

All parts to construct an eliminator to give an output of 120 volts at 29 mA., and 2 volts to charge an accumulator. Uses metal rectifier, 37/6.

GARRARD GRAMOPHONE UNITS

£4 · 19 · 6
plus 5/- p.c.

Induction motor 100-250 volt, 50 cycles A.C. only. 78 r.p.m. The GARRARD Induction motor is totally enclosed. Entirely free from radio frequency disturbance, magnetic hum and electrostatic Variable speed. With 12in. Turntable. BRAND NEW!

CORRECT ASPECT WHITE
Rubber Mask—Round or Flat

6in. ..... 8/3 15in. 22/6
12in. 12/11

T.V. PRE-AMPLIFIER

Amplifier Unit Type 208A using 2-VR91 valves suitable for operation on London frequency. Brand New. Plus 1/6 pkg. and carr. **19/6**

Build these NEW PREMIER DESIGNS

3-BAND SUPERHET RECEIVER

MAY BE BUILT FOR **£7.19.6** Plus 2/6 Pk. & Carr.

Latest type Superhet Circuit using 4 valves and metal rectifiers for operation on 200/250 volts A.C. mains. Waveband coverage—short 16-50 metres, medium 180-550 metres, and long 900-2000 metrs. Valve line-up 6K8 freq. changer, 6K7 IF, 6Q7 Detector AVC and first AF, 6V6 output. The attractive cabinet to house the Receiver size 12in. long, 6½in. high, 5½in. deep can be supplied in either WALNUT or IVORY BAKELITE or WOOD. Instruction Book 1/- post free, which includes assembly and wiring diagrams, also a detailed stock list of priced components.

TRF RECEIVER

MAY BE BUILT FOR **£5.15.0** Plus 2/6 Pkg. & Carr.

The circuit is the latest type TRF using 3 valves and Metal Rectifiers for operation on 200/250 A.C. mains. Wave band coverage is 180/550 metres on medium wave and 800/2,000 metres on long wave. The dial is illuminated and the Valve line-up is 6K7 H.F. Pentode 6J7 Detector and 6V6—Output. The attractive Cabinets to house the Receiver size 12in. long, 6½in. high, 5½in. deep, can be supplied in either WALNUT or IVORY BAKELITE or WOOD

INSTRUCTION BOOK 1/- (post free) which includes Assembly and wiring diagrams, also a detailed Stock List of priced components.

4-WATT AMPLIFIER

MAY BE BUILT FOR **£4.10.0** Plus 2/6 Pk. & Carr.

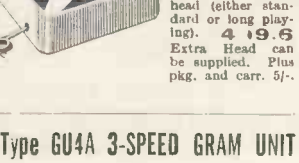
Valve line-up 6SL7, 6V6 and 6 × 5, FOR A.C. MAINS 200/250 VOLTS. The twin triode 6SL7 is used for preamplification and also for a comprehensive tone control circuit, which includes two very wide range and continuously variable tone controls for bass and treble. The output Valve is of the beam type and feeds 4 watts into a specially designed output Transformer which is suitable for either 3 ohm or 15 ohm Speakers. Negative feed-back is applied from the secondary of the output Transformer over the whole Amplifier to the input stage giving an excellent frequency response. Due to the high gain and wide range tone controls any type of pick-up may be used. Overall size 9 × 7 × 5in. Price of Amplifier complete, tested and ready for use, £5/5/-, plus 3/6 pkg. and carr.

INSTRUCTION BOOK, 1/- (Post Free) which includes Assembly and wiring diagram, also a detailed Stock List of priced components.

DECCA MODEL 33A
DUAL SPEED RECORD PLAYER

Includes crystal pick-up with sapphire stylus and a light-weight plastic spring balanced arm. Heavy gauge pressed steel case with brown enamel finish in good quality for operation on A.C. mains 200/250 v. 50 c.p.s. Supplied complete with single head (either standard or long playing). **4 19.6** Extra Head can be supplied. Plus pkg. and carr. 5/-.

B.S.R. Type GU4A 3-SPEED GRAM UNIT
Fitted with Decca Heads



Single Record Player, 3-speeds 33½, 45 and 78 r.p.m. for operation on 100-120 volts or 200-230 volts A.C. Mains. Complete with one standard and one long playing head, crystal or magnetic (please state choice), £7/19/6. pp. & carr., 5/-. Suitable cabinet for above Player type PC/2 at 45/-. See advertisement on previous page.

MINIATURE TUNING CONDENSERS

2-gang .0005 mfd. with trimmers 6/9

PREMIER VARIABLE IMPEDANCE "MATCHMAKER" M.O.15 OUTPUT TRANSFORMER

Designed to meet the demand for an efficient variable ratio Output Transformer 11 ratios from 13 : 1 to 80 : 1 all centre tapped and can be used to match any output valves either single or push-pull Class "A" "AB1" "AB2" or "B" to any low impedance speech coil or combination thereof. Primary Inductance 50 henries 15 watts audio 100 mA. Price 45/-.

LOUDSPEAKERS

ELAC—2½in. dia., Moving Coil, 15 ohm Imp. .. 15/-
PLESSEY—3in. dia., Moving Coil, 3 ohms Imp... 9/11
ELAC—3½in. dia., Moving Coil, 3 ohms Imp. .. 15/-
ELAC—8in. dia., Moving Coil, 3 ohms Imp..... 19/6
PLESSEY—8in. dia., Mains Energised, 3 ohms Imp. (600 ohms field) with Pentode Transformer 22/6
PLESSEY—8in. dia., Mains Energised, 3 ohms Imp. (600 ohms field) 19/6
PLESSEY—10in. dia. Moving Coil, 3 ohms Imp... 23/6
GOODMANS—12in. dia., Moving Coil, 15 ohms. Plus 5/- packing and carriage £8/8
VITAVOX—K12/20 12in. dia., Moving Coil, 15 ohms. Imp. £11/11
Plus 5/- packing and carriage.

CRYSTAL MICROPHONE INSERTS

Ideal for tape recording and amplifiers. No Matching transformer required. 8/6 post free.

ACCUMULATORS

2 volt 10 amp. (by famous maker) 4/11
2 volt 16 amp. 5/11

MOVING COIL METER

A super quality Moving Coil Meter basic movement 2 mA. and 4 mA. Scale dimensions 2½in. Overall dimensions 2½in. dia. 1½in. deep. Bakelite Case projecting type. At present scaled 1 amp. R.F. By removing thermo couple, reversing scale and recalibrating the meter, a high grade test instrument with any range above the basic F.S.D. may be built up. Price 2 mA., 5/9, 4 mA., 4/9.

MICROPHONES

LUSTRAPHONE: Moving Coil; High Impedance, Stand Type: £5/15/6—Hand Mike £6/6/-.
RONETTE—Crystal Mike Incorp. the Filter Cell Insert: High Impd. Ball Type, £2/10/0.
CRYSTAL MICROPHONE—Rothermel 2AD56. Especially recommended. £2/19/6. Table stands for all the above 10/6 and 17/6.
ACOS. High Impedance Crystal Microphone, type 35-1, 25/-.
ACOS. High Impedance Crystal Microphone, type 33-1, £3/10/-.
ACOS. "MIC 30" impedance Crystal Microphone £2/10/-. (This Microphone can be used as either Hand or Desk type.)

CRYSTAL MICROPHONE

An entirely insulated crystal microphone which can be safely used on A.C./D.C. amplifiers. High impedance. No background noise, really natural tone. The ideal Mike for tape, wire and sound projectors, price 22/6.

MAINS NOISE ELIMINATOR KIT

Two specially designed chokes with three smoothing condensers with circuit diagrams. Cuts out all mains noise. Can be assembled inside existing receiver, 4/11, plus 6d. pkg. and carr.

Germanium Crystal Diodes. G.E.C. wire ended, 2/6, 24/- doz.

Wireless World

RADIO, ELECTRONICS, TELEVISION

44th YEAR OF PUBLICATION

Managing Editor: HUGH S. POCOCK, M.I.E.E.
Editor: H. F. SMITH

NOVEMBER 1954

In This Issue

PUBLISHED MONTHLY (last Monday of preceding month) by ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1. *Telephone:* Waterloo 3333 (60 lines). *Telegrams:* "Ethaworld, Sedist, London." *Annual Subscription:* Home and Overseas, £1 7s. 0d. U.S.A. $4.50. Canada $4.00. BRANCH OFFICES: *Birmingham:* King Edward House, New Street, 2. *Coventry:* 8-10, Corporation Street. *Glasgow:* 26B, Renfield Street, C.2. *Manchester:* 260, Deansgate, 3.

VALVES, TUBES & CIRCUITS

23. MINIATURE VALVES WITH 25mA FILAMENTS

The Mullard range of low-consumption valves for all-dry battery receivers consists of four types, the DK96, DF96, DAF96, and DL96, mounted on the standard B7G base. The filaments are economically rated at 1.4V, 25mA. The DL96 output pentode has two such filaments which are normally operated in parallel.

The filaments in a receiver using these four types may be fed in three alternative ways: (i) in parallel; (ii) in pairs in a 50mA chain, with the odd filament (say the DAF96) shunted by a 5% tolerance resistor to maintain the correct filament current; (iii) in a 25mA chain. The third method is suitable for ABC receivers with separate h.t. and l.t. batteries; but the variation of cathode current in the output valve, which can occur when the batteries are at different stages of exhaustion, must be limited. For this purpose a special filament chain has been devised, of which full particulars are given in the *Additional Notes*.

For mains operation, supply variations should be allowed for by presetting the filament current (by means of a variable portion of the dropping resistor) to 24mA $\pm$ 2% at nominal mains voltage.

The valves are designed for optimum performance with a 90V supply; but there is no serious loss of sensitivity in the amplifier stages at voltages down to 67.5V, as the recommended screen-grid voltages of the amplifier valves are about 65V. In the output stage, however, the loss of power caused by battery exhaustion is more marked with lower nominal battery voltages.

The Mullard DK96 is a heptode frequency changer in which the first two grids form the oscillator, and the third grid is the signal grid. The optimum conversion conductance is 300μA/V, and the cathode current is 2.4mA at an oscillator voltage of 4.0V r.m.s. The variable-mu characteristic gives good cross-modulation and allows the use of AGC. The screen-grid voltage is about 65V, but in ABC receivers it should be adjusted to give 0.6mA anode current at zero bias.

A tuned-grid oscillator circuit is recommended, with the earthy end of the oscillator grid resistor taken to the positive side of the filament. Feedback should be derived from the oscillator anode, with the feedback winding of the oscillator coil preferably series-fed, especially at the higher frequencies.

The DK96 is not suitable for use above 20Mc/s. Pulling at frequencies above 10Mc/s should be reduced by capacitive neutralisation between the oscillator and signal grids.

The Mullard DF96 is an IF amplifier with a mutual conductance of 750μA/V at a cathode current of 2.2mA. It is suitable for AGC operation, as its grid base has been lined up with that of the DK96. The DF96 and the DK96 can be operated with a common screen-grid dropping resistor; but in ABC receivers this is allowable only if the two filaments are in parallel or if the control-grids are biased to their respective filaments. In all circuits, however, a common screen-grid resistor allows the relatively high screen-grid current of the DF96 to affect the gain of the DK96, and thus to increase the spread in the overall sensitivity of the receiver.

The Mullard DAF96 is a pentode AF amplifier with a detector diode. A voltage gain of 60 is obtainable when the detector presents a source impedance of 500kΩ, and a voltage output of 5.0V r.m.s. is obtained at 3% distortion. If the valve is used as a triode, the gain is about 11 and the voltage output is 5.0V r.m.s. at 2% to 3% distortion.

With a bias resistor of 10MΩ the detector load resistor should be limited to 500kΩ to give minimum attenuation in the control grid input circuit and an adequate a.c. to d.c. load ratio. With a detector load resistor of 1.0MΩ the bias resistor should be 22MΩ.

Anti-microphonic precautions are necessary only when the control grid voltage is less than 20mV for 50mW output.

The Mullard DL96 output pentode is designed for 90V operation; but the grid base at 67.5V is sufficient to allow operation at this lower supply voltage. A single valve, under Class A conditions with a 90V supply, will give a 200mW output at 10% total harmonic distortion for an input signal of 3.4V r.m.s. At 67.5V the output is reduced to 100mW.

Two valves may be used in push-pull, with the grid signal provided by a driver transformer, a centre-tapped choke, or a phase-inverter valve. The total cathode current of the two valves must not exceed 12mA. Class B operation, with all four filaments in parallel, gives, at 2% to 3% distortion, 440mW output at 90V and 235mW at 67.5V. The comparable outputs for Class AB operation, at 3% to 4% distortion, are 420mW and 220mW.

The Mullard DM70 subminiature tuning indicator, which has been described in *Valves, Tubes, and Circuits* Nos. 5 and 6, is suitable for use with these valves.

Reprints of this advertisement, with additional notes on the design of filament supply chains, a circuit for a four-valve battery receiver, and valve data, may be obtained free of charge from the address below.

Mullard

MULLARD LTD., Technical Service Department, Century House, Shaftesbury Avenue, W.C.2

MVM.3C6

"BELLING-LEE" NOTES

THREE-YEAR GUARANTEE AND INSURANCE

When we announced that we had increased our insurance cover on aerials from one to three years, dozens of letters came in from dealers asking for particulars, as they did not know of the existence of any insurance cover. This was most surprising in view of the fact that particulars have appeared on every piece of aerial literature issued by us for many years, and certainly on every instruction sheet. So that there need be no misunderstanding, we reprint the details of the cover below:—

INSURANCE COVER ON "BELLING-LEE" AERIALS

£1,000 against third party claims arising from personal injury or damage to property during the installation of "Belling-Lee" aerials by any dealer.

£1,000 against claims for damage to property arising from defective aerial material or faulty aerial workmanship for a period of three years.

£100 against claims for damage by lightning to the aerial system or receiver for a period of three years.

This insurance operates within the United Kingdom of Great Britain and Northern Ireland, from the date of purchase by the ultimate user, no matter where purchased.

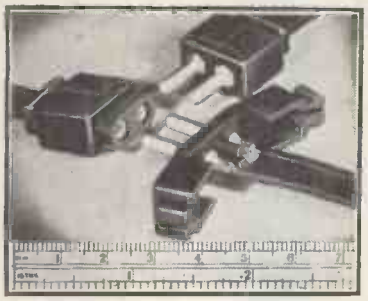
The insurance cover applies only when the whole aerial, including mast, lashings and brackets, is manufactured by Belling & Lee, Ltd., and where there is no collateral insurance or after any existing cover has been exhausted.

MANUFACTURERS' THREE-YEAR GUARANTEE WITH "BELLING-LEE" AERIALS

If a "Belling-Lee" aerial (or part) is proved to be defective in workmanship or material within three years from date of purchase, the aerial (or part) will be replaced free of charge by the manufacturer.

CONNECTORS FOR 300 OHM FEEDERS

We understand that a large number of radio amateurs are changing over to 300 ohm feeders and we feel that the "Belling-Lee" plug and socket (L677/P and /J respectively),



specially designed to snap onto ribbon feeder, is not as well known as it deserves to be. This was brought to our notice by several visitors to our stand at the Radio Show.

Provision is made to crimp the conductors into the spills.

Pins and sockets nominal ⅛in. diameter spaced 0.312in.

SOCIETY OF BRITISH AIRCRAFT CONSTRUCTORS' EXHIBITION AT FARNBOROUGH

For the first time, we exhibited here, and quite shamelessly, we were fascinated by seeing so many "Belling-Lee" components on so much equipment designed to do such a wide variety of jobs. It was a very wonderful exhibition, but

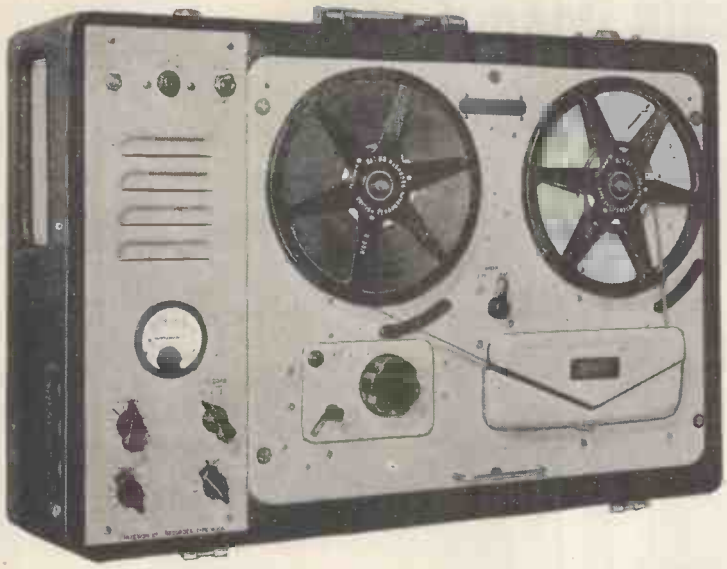
we were far too busy ourselves to take full advantage of the opportunity to examine such an exhibition of instrumentation.

The organizers must be very gratified by the number of overseas visitors who came to the Display.

At the official dinner the writer sat between a gentleman from Malaya and another from South Africa. Both were readers of this page.

Advertisement of
BELLING & LEE LTD.
Great Cambridge Rd., Enfield, Middx.
Written 21st September 1954.

VORTEXION TAPE RECORDER



The amplifier, speaker and case, with detachable lid, measures 8¼in. x 22½in. x 15¾in. and weighs 30 lb.

PRICE, complete with WEARITE TAPE DECK £84 0 0

★ The noise level is extremely low and audibly the hum level and Johnson noise of the amplifier and deck are approximately equal. Only 25% of this small amount of hum is given by the amplifier alone.

★ Extremely low distortion and background noise, with a frequency response of 50 c/s.—10 Kc/s., plus or minus 1.5 db. A meter is fitted for the measurement of signal level and bias level.

★ Sufficient power is available for recording on disc, either direct or from the tape, without additional amplifiers.

★ 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.

★ The .5 megohm input is fully loaded by 18 millivolts and is suitable for crystal P.U.s, microphone or radio inputs.

★ A power plug is provided for a radio feeder unit, etc. Variable bass and treble controls are fitted for control of the play back signal.

★ The power output is 3.5 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

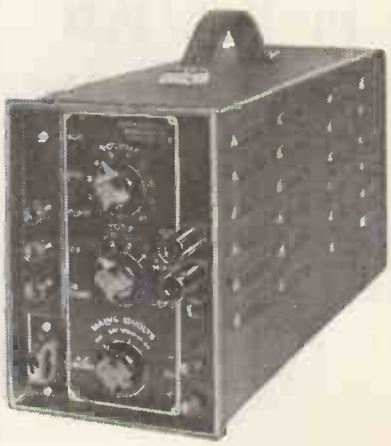
★ Facilities are provided for using the amplifier alone and using power output or headphones while recording or to drive additional amplifiers.

★ The unit may be left running on record or play back even with 1,750 ft. reels with the lid closed.

POWER SUPPLY UNIT to work from 12 volt. Battery with an output of 230 v., 120 watts, 50 cycles within 1%. Suppressed for use with Tape Recorder. **PRICE £18 0 0.**

TYPE C.P.20A AMPLIFIER

For A.C. Mains and 12 volt working giving 15 watts output, has switch change-over from A.C. to D.C. and "Stand-by" positions. Consumes only 5½ amperes from 12 volt battery. Fitted with mu-metal shielded microphone transformer for 15 ohm microphone, provision for crystal or moving iron pick-up with tone control for bass and top. Outputs for 7.5 and 15 ohms. Complete in steel case with valves. **PRICE £30 16 0.**



Manufactured by

VORTEXION LIMITED, 257-263, The Broadway, Wimbledon, London, S.W.19

Telephones: LIBerty 2814 and 6242-3 Telegrams: "Vortexion, Wimble, London."

COSSOR presents Model 1052 double beam oscillograph

Two similar amplifier channels with an approximate gain of 2000 and an upper frequency response of 5 megacycles (—6DB) are features of this new Cossor Double Beam general purpose oscillograph. The repetitive or triggered time base has a sweep duration from 200 milliseconds to 5 microseconds.

The instrument will operate from power supplies of any of the various frequencies and voltages encountered in the Armed Services or from standard civil supply mains.

and Model 1433 voltage calibrator

Primarily designed to be used with the Model 1052 oscillograph the Cossor Voltage Calibrator Model 1433 provides an accurate means of calibration of input voltages to the plates or amplifiers of any oscillograph. Calibrating voltages are read directly from a wide scale meter without any computation being necessary. Measurements can be made to an accuracy of ± 5% and the instrument can be used in any application where a source of accurately-known voltage is required.

Watch for the
NEW TELE-CHECK AND CRYSTAL MONITORED MARKER GENERATOR
for Bands I and III

COSSOR ELECTRONIC INSTRUMENTS

Write for illustrated leaflets about both of these instruments

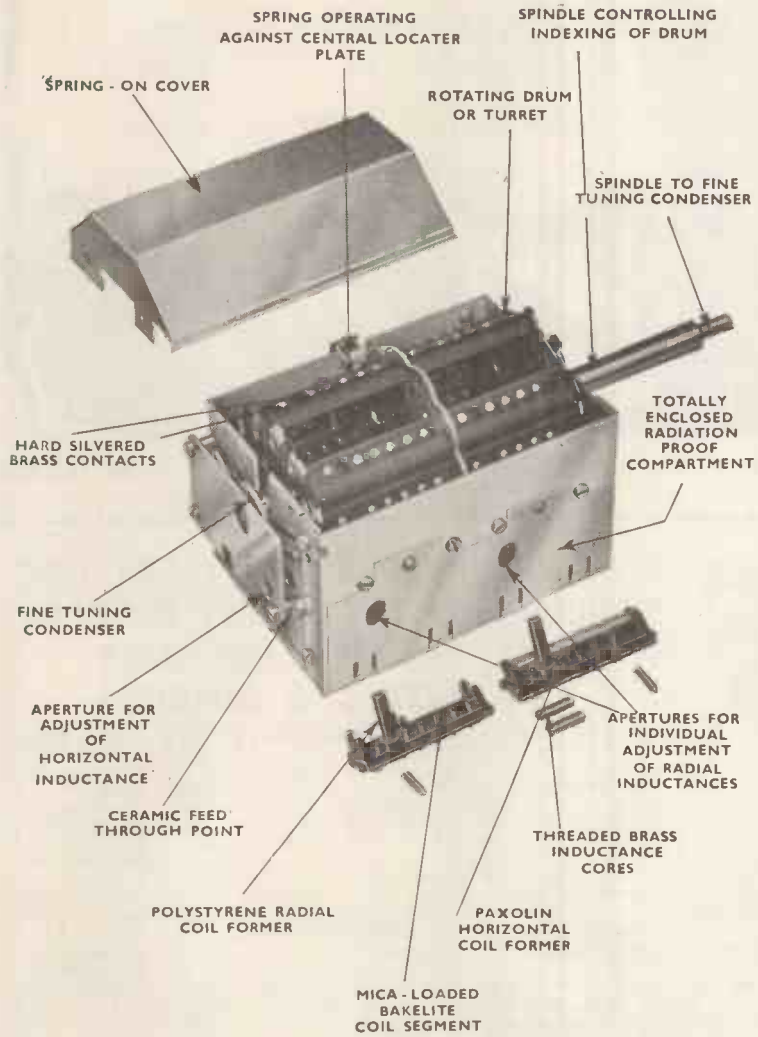
A. C. COSSOR LTD., INSTRUMENT DIVISION, DEPT. 1, HIGHBURY GROVE, N.5

Telephone: CANonbury 1234 (33 lines). Telegrams: Cossor, Norphone, London. Cables: Cossor, London

C.I.56

ALWAYS USE COSSOR TUBES & VALVES

Five Advantages of the Clix TELEVISION TURRET TUNER



1 *Accurate switching*

The rotating drum of the Ediswan Clix Television Turret Tuner indexes accurately to any of twelve positions and re-sets precisely in these positions after switching. No question of mistuning after switching.

2 *All circuits are adjustable with the unit in position in a Television receiver.*

Adjustable cores to all inductances are easily accessible with the tuner in position in a Television receiver.
The tuner can, therefore, be set up or re-adjusted in its actual operating position.

3 *Additional tuned circuits may be added at any time without removing the Tuner from the receiver.*

The Ediswan Clix Tuner is designed so that additional coil segments can be added at any time while the tuner is in position in a receiver.
To tune to another channel the serviceman merely clips into position additional coil segments, carrying correctly wound coils, and trims them by the adjustable cores provided.
There is no need to dismantle the tuner or return it to the Factory for any part of this operation.

4 *Wiring reduced to an absolute minimum thereby eliminating stray capacities.*

Stray capacities between wiring can lead to serious mistuning on the very high frequencies of Television Band 3. The Ediswan Clix Tuner is designed so that wiring is reduced to an absolute minimum and materials are specially selected to overcome the problems of drift and instability encountered on these frequencies.

5 *Suitable for mounting in deep or shallow chassis.*

Four 4BA tapped holes are provided for mounting the Ediswan Clix Turret Tuner. If required, suitable mounting brackets can be provided for use in shallow chassis.

Full technical information and prices on request.

EDISWAN

CLIX

THE EDISON SWAN ELECTRIC CO. LTD.

Member of the A.E.I. Group of Companies

155 Charing Cross Road, London, W.C.2. Radio Components Sales Office: 21 Bruton Street, London, W.1. *Tel: Mayfair 5543*

The NEW LEAK

TL/10 AMPLIFIER & "POINT ONE" PRE-AMPLIFIER

27 GNS COMPLETE

A price made possible only by world-wide sales.

★ *Make this*

THE HEART of your HI-FI EQUIPMENT!

TL/10 POWER AMPLIFIER

This 10 watt amplifier maintains, in every respect, the world renowned Leak reputation for precision engineering, fine appearance and fastidious wiring.

SPECIFICATION

Circuitry
A triple loop feedback circuit based on the famous TL/12. The output transformer is the same size as in the TL/12.

Maximum power output: 10 watts.

Frequency Response: ± 1db 20 c/s to 20,000 c/s.

Harmonic Distortion: 0.1%, 1,000 c/s, 7.5 watts output.

Feedback Magnitude: 26 db, main loop.

Damping Factor: 25.

Hum: —80 db referred to 10 watts.

Loudspeaker Impedances: 15 ohms, 8 ohms, and 4 ohms.

"POINT ONE" PRE-AMPLIFIER

The handsome gold escutcheon plate contributes to the elegant appearance, and blends with all woods.

★ **Pickup**
The pre-amplifier will operate from any pickup generally available in the world. A continuously variable input attenuator at the rear of the pre-amplifier permits the instantaneous use of crystal, moving-iron and moving-coil pickups.

★ **Radio**
The radio input sockets at the rear permit the connection of the LEAK V.S. tuner unit. An input attenuator is fitted. H.T. and filament supplies are available from the pre-amplifier.

★ **Distortion**
Of the order of 0.1%.

★ **Hum**
Negligible, due to the use of recently developed valves and special techniques.

★ **Input selector**
Radio, tape, records; any and all record can be accurately equalised.

★ **Treble**
Continuously variable, + 9 db to — 15 db at 10,000 c/s.

★ **Bass**
Continuously variable, + 12 db to — 13 db at 40 c/s.

★ **Volume Control and switch**
The switch controls the power supply to the TL/10 power amplifier.

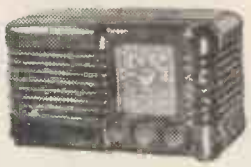
★ **Tape Recording Jacks**
An exclusive feature. Readily accessible jacks are provided on the front panel for instantaneous use with Tape Recorders which have built-in (low level) amplifiers.

★ *Write for leaflet W* ★

H. J. LEAK & CO. LTD., BRUNEL ROAD, WESTWAY FACTORY ESTATE, ACTON, W.3

'Phone: SHEpherds Bush 1173/4 *Telegrams: Sinusoidal, Ealux, London* *Cables: Sinusoidal, London*

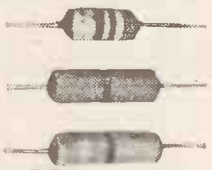
OCCASIONAL RADIO



You will find that the building of our all-mains radio receivers is simplicity itself, and the more you make the less time each takes, everything down to the last nut and bolt is supplied, and everything fits together in a professional manner. The one illustrated above we call the "Occasional," in a choice of colours, Ivory or Walnut and the T.R.F. costs £5/15/- to make, H.P. terms being £2 deposit.

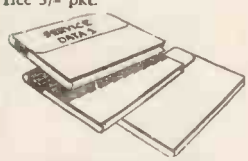
CONSTRUCTORS BARGAIN

Excellent rexine-covered cabinet —over production by one of our very famous makers. Complete with three-colour scale and metal chassis. Suitable for battery or mains receiver. Size approx. 13in. × 9¼in. × 6in. Limited quantity: price 17/6, postage 2/6.



RESISTORS

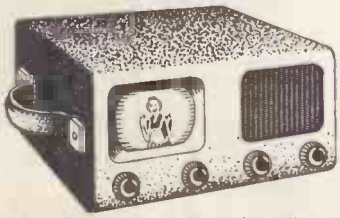
50 assorted ¼ and ½ watt resistors, Ranging between 10 ohm and 10 meg. ohm. (Our selection.) Price 5/- pkt.



SERVICE DATA

100 service sheets, covering British receivers which have been sold in big quantities, and which every service engineer is ultimately bound to meet. The following makes are included: Aerodyne, Alba, Bush, Cossor, Ekco, Ever-Ready, Ferguson, Ferranti, G.E.C., H.M.V., Kolster-Brandes, Lissen, McMichael, Marconi, Mullard, Murphy, Philco, Philips, Pye, Ultra. Undoubtedly a mine of information invaluable to all who earn their living from radio servicing. Price £1 for the complete folder. Our folder No. 2 consists of 100 data sheets covering most of the popular American T.R.F. and superhet receivers "all dry" etc., which have been imported into this country. Names include Sparton, Emmerson Admiral, Crossley, R.C.A., Victor, etc. Each sheet gives circuit diagrams and component values, alignment procedure, etc. etc. Price for the folder of 100 sheets is £1. Post free.

MINIATURE PORTABLE T.V.



The Elpreq Miniature Telvisor uses standard conventional circuitry, employing a total of 13 valves and 2 crystal diodes. The cathode ray tube used is a 2½in. Service type V.C.R. 139A, which has a standard equivalent and will therefore always be obtainable. The layout is extremely clean, straightforward, and professional. The wiring, whilst naturally being a little more intricate due to miniaturisation, is nevertheless completely accessible, and very good results have been obtained.

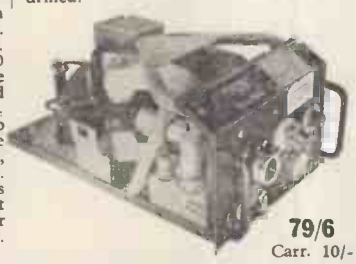
The total cost, if you have to buy every part, would come to £16-£17, but you may have many of the components already in stock as only standard conventional components are used. A carrying case, similar to the artist's illustration above, will be available shortly. Its size will be approximately 9½in. × 8in. × 6in. (internally).
Full construction data, layouts, diagrams, templates, etc., running into some 50 sheets, is available, price 5/-, post free.

ALSO CONTAINING DATA FOR CONVERSION TO THE PICNIC PLAYER

SEND 2/6 *to-day for constructional booklet entitled "STROLLER."*

A FEW REMAIN

This cabinet is offered below cost. It is suitable for a televisor using tube sizes varying from 12in. to 17in., its overall dimensions being 3ft. 5in. high, 1ft. 4in. deep, 1ft. 10in. wide. It is complete with plywood back and "Bowler Hat." Originally made for a very expensive televisor and really good quality. Unrepeatable. Offered at £7/5/- or £2/8/4 dep., carriage, packing, etc., 12/6. Note: These are cut for 12in. tubes, but the holes for the controls are not drilled.



79/6
Carr. 10/-

CENTIMETRE RADAR TRANSMITTER RECEIVER

—new and complete—contains magnetron, rhumbatron, spark gaps, wave guides, pre-amp., etc. etc., costs the Government over £100 each to make.

RESISTORS

50 assorted 1 watt resistors. Ranging between 10 ohm to 5 meg. ohm. (Our selection.) Price 7/6 pkt. Post 6d.

L.T. RECTIFIERS

All recently manufactured and guaranteed. All full Wave Bridge type. CIRCUIT DIAGRAM INCLUDED.

6-12 volt—1 amp.	7/6
6-12 volt—2 amp.	11/6
6-12 volt—4 amp.	17/6
6-12 volt—6 amp.	27/6

COIL PACK

Long, medium, short wavebands. With connecting diagram. Price 19/6. Post 6d.

H.T. RECTIFIERS

FAMOUS SELENIUM "SENTERCEL."
All are this year's stock—for higher voltages join two or more in series.

R.M. 1.	125V.	60Ma.	3/9
R.M. 2.	125V.	100Ma.	4/2
R.M. 3.	125V.	120Ma.	5/9
R.M. 4	250V.	250Ma.	16/-

PORCELAIN STAND OFF INSULATORS

threaded each end. Price 6/- doz.

HEATER TRANSFORMERS

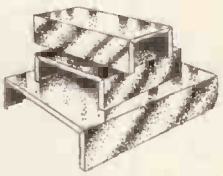
All 200-240 Volt working.

6.3V 1½ amp.	5/9
6.3V 3 amp.	9/6
2V 3 amp.	7/6
4 and 6V 2 amp.	7/6

Special Type over wound to give normal H.T. and with primary tapping 6.3V. and 2.3 amp.—9/6.

CONNECTING WIRE SNIP

P.V.C. insulated 23 s.w.g. copper wire in 100 ft. coils, 2/9 each. Colours available: Black, Brown, Red, Orange, Pink, Yellow, White, Transparent. 4 coils for 10/-



BLANK CHASSIS

18 S.W.G. Aluminium

7 × 3½ × 2	3/9
9½ × 4½ × 2½	5/-
10 × 8 × 2½	5/6
10 × 5½ × 2½	5/-
10 × 9 × 3	7/-
12 × 9 × 2½	7/-
14 × 9 × 2½	7/6
14 × 10 × 3	7/9
16 × 10 × 3	8/3
16 × 12 × 3	8/8
19½ × 9 × 2½	8/3
20 × 10 × 3	10/-

E.P.E. LTD.

SEE OVER →

INSTANT HEAT CONVECTOR

The heater with the lowest possible thermal capacity, 4ft. long; made from heavy gauge sheet steel (galvanised), 1 kw., suitable A.C. or D.C. Price only £2 or with thermostat £3/15/-. Note: The thermostat mounts separately and will control up to three heaters.

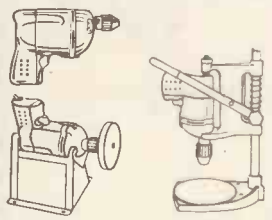
EX-ROYAL NAVY SOUND POWERED TELEPHONE

These require no batteries, and will go for long periods without attention. Complete with generator and sounder which gives a high pitched note, easily heard above any other noise. Also fitted with an indicator lamp which in quiet situations can be used instead of the sounder, or where several h'phones are used together will indicate which one is being called. Size 7¾in. × 9in. × 74in., wall mounting, designed for ships' use, but equally suitable for home, office, warehouse, factory, garage, etc. Price 57/6 each, plus 4/6 carriage.

MULTIMETER KIT

All the essential parts, including 2in. moving - coil meter, selected resistors, wire for shunts, 8-point range selector, calibrated scale, stick-on range indicator and full instructions for making are available as a kit, price 15/-, plus 9d. post and packing.

SENT FOR £1 ONLY
BLACK AND DECKER ELECTRIC TOOLS



¼in. drill, £5/19/6 or £1 deposit—Bench stand for drill £3/7/6—Lathe stand for drill, £5/5/- or £1 deposit. The three items supplied for £14/12/- or 43/- deposit.

THE INFRAY LAMP

Means real comfort in bed or in workroom or other place where air temperature is low as it emits Infra-Red Rays which not only warm you but relieve pain, if you have any, and keep you healthy.

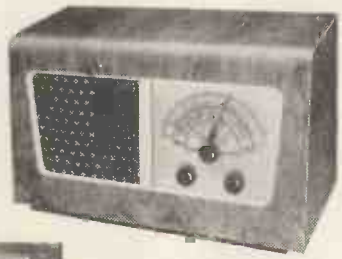
- Economical because its rays warm you and not the room.
- Costs only ¼d. per hour to run (electricity at 1d. per unit).
- Works off lighting circuit (full instructions supplied).
- Absolutely safe for continuous burning, no health or fire risk.
- Ideal for many other uses: over pet's basket—rearing pup, chicks—over desk—work bench, etc.
- Completely and unconditionally guaranteed for five years.
- All complete and ready to work. Price 36/-, post and pkg. 2/-. Money refunded in full if after seven days' trial you are not completely satisfied.

Please state mains voltage.

SUPERHET RADIO BY BEETHOVEN

NOW AVAILABLE FOR LONG, MEDIUM and SHORT WAVES

Extremely well built on chassis size approx. 9½ × 7½ × 8½ using only first-class components, fully aligned and tested, 110-240 volt A.C. mains operation. Large clear edge-lit dial. Three wave bands covering Long, Medium and Short waves. Complete with five Mullard valves, frequency changer, double diode triode, pentode output and full wave rectifier. Complete with Rola loudspeaker ready to operate. Special cash-with-order price this month, £8/17/6, carriage and insurance 7/6. Hire purchase terms £3 deposit, balance over 12 months.



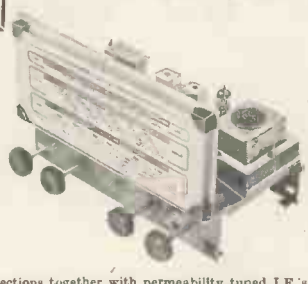
Really beautiful walnut veneered and polished cabinet for only 39/6 if purchased at the same time as the Beethoven 5 valve superhet chassis (illustrated above). Bought separately the price of the cabinet is 49/6. H.P. deposit on cabinet and chassis is 32/- only.

CONSTRUCTOR'S PARCEL
Contains cabinet as Wolsey 54, drilled metal chassis—dial—pointer, etc., 29/6. All other components available total cost £5. Data 1/6 (free with component).

THE WOLSEY 54

A really fine ready built modern Superhet at the remarkable price of £8/19/6 or £3 deposit, balance over twelve months.
The Wolsey 54 is an A.C. mains superhet employing latest circuitry covering long and medium wave bands in an ultra modern case with illuminated dial—overall size approximately 11½ × 7 × 8—complete ready to work—twelve months' guarantee.

THE CLEVELAND "ORGANTONE"



The Cleveland "ORGANTONE" is a 5-valve 3-wave band superhet covering long wave (1 020-1,875 metres), medium wave (187.5-545.5 metres) and short wave (16-50 metres). Built to a very stringent specification, it attains a high level of performance both with regard to sensitivity and fidelity.
Osram all-glass miniature valves are employed throughout and low loss iron cored coils in both aerial and oscillator sections together with permeability tuned I.F.'s account for an excellent signal to noise ratio. Full A.V.C. is applied to both frequency changer and I.F. stages, and particular care has been taken to ensure freedom from frequency drift.
The output stage utilises variable negative feedback for tone control, and, but for standard pentode correction, no cut in the ordinary sense is applied. A gram. position is provided on the wave change switch and reproduction of records is particularly good. An amply proportioned power transformer with a primary tapped for 110-280 volts gives complete isolation from the mains.
Chassis size is 12in. × 7in. × 7in.—Scale size is 10½in. × 4½in.
This receiver has been tested in particularly difficult areas and its stability and noise rejection have produced exceptional results. It is an instrument which could fairly be described as a custom-built chassis.
Price £11/10/- or £3/16/8 deposit—carriage, etc., 7/6.
A circuit diagram and photograph available price 2/- post free.

VARIABLE POWER RESISTORS

Mounted on substantial framework, overall dimensions approximately 11 × 3½ × 6in. high, 25 amps. .4 ohms. Quite suitable for rewinding for other values, power rating exceeds 250 watts. Adjustment is by twisting protruding knob which is the only part that needs to show in front of panel. Price 17/6, carriage and packing. 2/- extra.

HEAVY DUTY MAINS TRANSFORMERS

400-0-400 at 200 m/a. with two 4-volt L.T. windings, both rated at 6 amps. A really massive job made for services equipment—limited quantity 19/6 each.

TRANSFORMER LAMINATIONS

Ideal for making up experimental and special purpose jobs. Price 1/6 per lb. or 1/6 per dozen pairs (approximately 48 required for 1in. stack), size 4½in. × 4in. (approx.). Small size, suitable for output transformers, etc. price 6d. per dozen pairs.

BREAKDOWN UNIT

Unit for breaking down, offered at little over the price of the ⅜in. Aladdin Coil Formers. Note: all parts can easily be removed as they nut and bolt together. The unit contains:—
6 Aladdin ⅜in. coil formers with dust cores.
6 metal cans for above coil formers.
1 4-position 12-pole switch.
6 miniature R.F. chokes.
2 25 mfd. 25 v. electrolitic.
30 paper tubular condensers .002 to .1 mostly for 450 v.
56 carbon resistors value from ¼-watt to 2-watt.
2 medium size R.F. chokes.
7 moulded octal valve holders.
1 moulded diode valve holder.
20 mica condensers (moulded, silver and ceramic).
7 insulated top caps for valves.
4 components strips (1 40-way, 1 11-way, 1 5-way, and 1 3-way).
1 very useful chassis size 18 × 5 × 3½in. Plus dozens of nuts, bolts, screws, washers and other useful items such as ¼in. spindle extender, etc., etc.
Price 7/6, post and packing 2/6.

MAKING A CONVECTOR HEATER?

250-watt elements ideal for use with home built convectors, towel rails, airers, etc. Price only 2/6 each, post and pkg. 6d.

METERS FOR BATTERY CHARGERS

2in. square Bakelite cased meter reading 0-5 amps. Price 9/6, post and packing 9d.

CHANGER TRANSFORMERS

9 v. 6 15 v. secondaries, suitable for 6 v. and 12 v. batteries. Charging rate up to 6 amps. Amply rated, price 21/6, post and packing 2/6.

UNIVERSAL METER

2-milliamps moving coil movement. Complete with sheet of printed scales, covering most ranges of volts, milliamps, amps. Price 9/6 post and packing 9d.

VALVES FOR V.H.F.

Type C.V. 64 and C.V. 186 Magnetrons unused and guaranteed. Price £2/10/-, post and insurance 10/-.

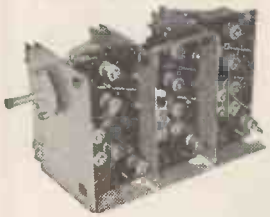
HEAVY DUTY CHOKE

300 milliamps, 7 henrys, 50 ohms. D.C. Size approximately 4½ × 4½ × 3in. New, not Government surplus, price 10/-, plus 2/- post and packing.

SEE PREVIOUS PAGES

ORDERS TO →

5-WAVE BAND ASSEMBLY



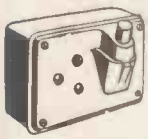
5-wave coil pack for up to 11 mtrs., with R.F. stage, three-gang tuning condenser, slow motion drive, I.F. transformers and numerous other parts, make a really fine receiver. Price £6, plus 10/- post and insurance. **Note:** The above are new, but removed from chassis.

ELECTRICAL BARGAINS

In addition to our large range of radio accessories we also carry a good stock of electrical wiring accessories; details of a few of these can be found below:—

T.R.S. CABLES, 250 v. CLASS	
1/.044 Twin flat	9d.
3/.029 Twin flat	1/-
3/.029 Twin with earth ..	1/3
3/.020 3 Core flat	1/6
3/.036 Twin flat	1/4
3/.036 Twin with earth ..	1/7
3/.036 3 Core flat	2/-
7/.029 Twin flat	1/6
7/.029 Twin with earth ..	1/11
7/.036 Twin flat	2/9
7/.036 Twin with earth ..	3/3
7/.064 Twin flat	4/9

LEAD-COVERED CABLES 250 v. CLASS	yard
3/.029 3 Core	2/3
3/.036 3 Core	2/8
7/.044 Twin	3/3
3/.036 Twin	2/-
7/.029 Twin	2/9
7/.064 Twin	3/-



CLIX 15 AMP. FOOT PLUG

MadetoB.S.S. specification, shuttered in moulded Bakelite case, 8/6 each.

SOCKETS HICRAFT

Flush type for skirting, 5 amp. 3-pin shuttered, 1/3 each; ditto with switch, 2/3 each.

LAMP HOLDERS

Bakelite, 1/- each or 10/6 doz. Bakelite skirted Batten holder, 1/6 or 15/- doz.
Bakelite type threaded, for ⅝in. with HO. skirt, 1/6.

5 AMP. SURFACE SWITCHES —HICRAFT

OblongBrown Plastic 1-way 1/3 each.
Oblong White Plastic 1-way, 1/3 each.

Oblong Brown 2-way ..	1/6 each
Oblong White 2-way ..	1/6 „
Round Brown 1-way ..	1/3 „
Round White 1-way ..	1/3 „
Round Brown 2-way ..	1/6 „
Round White 2-way ..	1/6 „

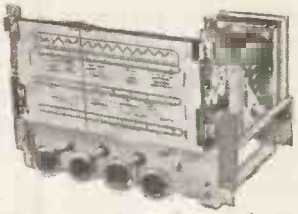
15 per cent. discount if bought in dozens.

Price this monta 15 gns., carr. etc. 12/6—also available by H.P. terms, deposit being 15%.

DULCI RADIO CHASSIS

Complete range of these famous receivers now available at all our branches—cash or Hire Purchase —demonstrations gladly given.

3-wave (L. M. & S.) 5-valve £12 12 0 Ref B3
Pushpull 6-valve 3-wave..... £15 15 0 Ref. B3PP



	£	s.	d.	Ref.
Pushpull with R.F. stage 3-wave 7-valve ..	15	18	0	B3PP/RF
6-wave L.M. and 4 short waves (band spread)	15	15	0	B6
6-wave with pushpull	18	18	0	B6PP
6-wave with pushpull and R.F. stage	23	2	0	B6PPRF

All available on H.P.—deposit 15 per cent, balance over 12 months.

MULLARD AMPLIFIER

A High Quality Amplifier designed by Mullard engineers. Robust high fidelity, with a power output exceeding 10 watts and a harmonic distortion less than .4% at 10 watts. Its frequency response is extremely wide and level being almost flat from 10 to 20,000 C.P.S.—three controls are provided and the whole unit is very suitable for use with the Collaro Studio and most other good pickups. The total cost of the amplifier is around £11. For 30/- extra a unit completely made up and tested can be supplied. Carriage in either case is 10/- extra. Data will be provided with all orders for components. Send for the " Mullard Amplifier Shopping List."

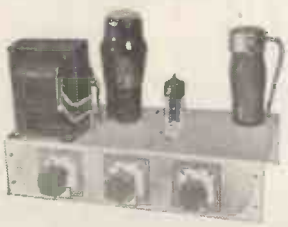
CHASSIS BARGAIN

7-valve pushpull radio chassis with approximately 7 watts output—designed for high quality gramophone reproduction but equally good on radio—covers long, medium and short wave bands—uses latest midget B.V.A. valves and most up-to-date circuitry—price only £12/15/-, or in fine walnut veneered cabinet, £14/14/—carriage and insurance 10/- extra.

GRAMOPHONE AUTO CHANGER COLLARO 3/521

The latest three-speed type with the famous " Studio " turn-over pick-up. Price **£11/10/0,** carriage etc. 7/6.

THE ELPREQ " SELECTIVE FEED-BACK " AMPLIFIER



The amplifier is fitted with independent bass and treble control, both connected through different feed-back loops so that no " cut " at all in the ordinary sense is applied. The variation which can be achieved, by applying various degrees of negative feed back in the higher and lower ranges of the sound strata will accommodate all individual tastes.
We strongly recommend a 12in. speaker in order to make the fullest use of the instrument's potentialities. Booklet and set of components available at once at **£3/19/6,** post, etc., 2/6. Booklet separate 1/6. 12in. speaker to suit **£3,** post free if bought with amplifier. **Now available, ready to work, 20/- extra.**

EMPRESS CONSOLE

ALSO AVAILABLE AS BUREAU TYPE

This cabinet is undoubtedly a beautiful piece of furniture. It is elegantly veneered externally in figured walnut, internally in white sycamore. The radio section is raised to convenient level but is not drilled or cut. The lower deck acts as the motor-board again, is uncut, it measures 16 × 14 and has a clearance of 5in. from the lid. There is a compartment for the storage of recordings. Overall dimensions of this essentially modern cabinet are 3ft. wide, 2ft. 8in. high, and 1ft. 4½in. deep.

LIGHT WEIGHT REFLECTORS

Ideally suitable for all purposes where the intensification of electric illumination or infra red is required, The material used is light-weight aluminium, highly polished. All are pierced for Standard Lampholder.

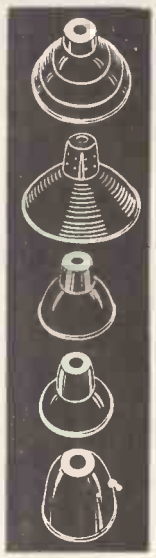
STAR
7½" diameter by 6" deep Price **7/6** ea. Post etc. 1/3.

SENIOR
11½" diameter by 4" deep. Price 13/6 each. Post etc. 1/9.

JUNIOR
6½" diameter by 3½" deep. Price 7/3 each. Post etc. 1/3.

BIJOU
5½" diameter by 2" deep. For 40/60 watt lamps. Price 6/6 each. Post etc. 1/3.

BELL
5½" diameter by 5" deep. Price 6/3 each. Post etc. 1/3.



1" MICROMETER

Exceptional purchase enables us to offer a 1in. precison micrometer at the very low price of **10/-.** A micrometer is an essential part of an engineer's equipment. You will have found the need for one on many occasions in the past for measuring wire gauge, etc. Price **10/-** post free.
NOTE: We now have a waiting list for this, orders in rotation.

12" TELE-CABINET

Veneered & polished — less glass, makes ideal extension speaker cabinet for 12in. Price 19/6. plus 3/6 carr.

SOMWEAVE

This really lovely loud-speaker fabric we offer at approximately a third of today's cost. It is 42in. wide and Our Price is **12/-** per yard or panels 12in. × 12in., 1/9 each. This is also very suitable for covering plain wooden cases, for portable radio amplifiers, etc.

CLEVELAND CAR BATTERY CHARGER

gives 1½-amp. charge—uses everlasting metal rectifier and robust double wound mains transformer—in metal carrying case with leads and croc. clips. Price, 6 volt 29/6. 6 and 12 volts, 39/6, post 2/6.

ELECTRONIC PRECISION EQUIPMENT LTD.

249, Kilburn High Road, Kilburn.
(Opening shortly.)

42-46 Windmill Hill, Ruislip Middlesex.
Phone: RUISLIP 5780
Half-day Wednesday.

152-153 Fleet Street, E.C.4.
Phone: CENTRAL 2833
Half-day Saturday.

29, Stroud Green Road, Finsbury Park, N.4.
Phone: ARCHWAY 1049
Half-day Thursday.

Post orders should be marked " Dept. 2" and addressed to our Ruislip dept.

Out of this world.....

The "Hi-Fi" enthusiast wants reproduction that is a pure re-creation of the original performance. And that is what we at Classic always try to provide—a quality that one of our customers recently described as "Out of this world."

Bass reflex cabinet in straight grained or burr walnut veneer, or oak veneer. Dimensions 20in. × 21in. × 42in. high. Cabinet only £20.

A selection of typical "Hi-Fi" equipment

LOUDSPEAKER UNITS

	Cash Price	Credit Sale Terms £1 Deposit & 9 P'mts. of	HIRE PURCHASE TERMS Deposit	12 P'mts.	18 P'mts.
W.B. H.F.1012	£3 13 6	—	—	—	—
W.B. Duo Concentric	£22 10 0	54/9	£4 10 0	34/6	24/-
Goodmans Axiom 22	£14 14 0	34/9	£2 14 0	23/-	16/-
Goodmans Axiom 150 Mk. II	£10 5 6	23/7	£2 5 6	16/8	11/1
Goodmans Audiom 60	£8 12 6	19/3	£1 12 6	13/7	9/4
Tannoy 12in. Dual Concentric	£27 10 0	67/6	£5 10 0	42/2	28/4
Wharfedale Loudspeaker Super 5	£6 13 3	14/3	£1 13 3	10/-	6/8
Wharfedale Super 8/CS/AL	£8 13 3	14/3	£1 13 3	10/-	6/8
Wharfedale W.10CSB	£12 6 6	28/10	£2 6 6	20/-	13/4
Wharfedale W.15CS	£17 10 0	44/-	£3 10 0	27/-	18/8
Wharfedale Super 12 CS/AL	£17 10 0	44/-	£3 10 0	27/-	18/8
Lowther P.M.2	£35 0 0	86/10	£7 0 0	53/8	37/4

AMPLIFIERS AND PRE-AMPLIFIERS

Leak T.L.10	£17 17 0	43/2	£3 11 6	27/5	19/-
Leak Point-One Pre-amplifier	£10 10 0	22/-	£2 2 0	17/6	11/8
Quad Mark II Amplifier	£22 1 0	53/9	£4 8 0	33/8	23/5
Quad Mark II Pre-amplifier	£19 19 0	48/1	£4 0 0	30/7	21/3
Goodsell G.18 Williamson	£33 15 0	83/5	£6 15 0	51/8	36/-
Goodsell G.W.12 Williamson	£27 10 0	67/6	£5 10 0	42/2	29/4
Goodsell C.R.500 "C" Core	£23 8 0	57/1	£4 8 0	36/5	25/4
Goodsell F.U./P.C. Pre-amp	£14 14 0	34/9	£2 14 0	23/-	16/-
Goodsell P./F./A. Pre-amp	£20 0 0	48/7	£4 0 0	30/8	21/4
Rogers Mark II Baby de Luxe	£14 0 0	33/3	£2 16 0	21/5	14/10
Rogers Mark II Junior Pre-amp	£9 0 0	20/5	£1 16 0	15/4	10/3
Pye P.F.91	£29 8 0	72/5	£5 18 0	35/4	24/7
Pye P.F.91A	£12 12 0	29/5	£2 12 0	19/2	13/4
Pamphonic 25-watt Ultra lin	£45 0 0	112/5	£9 0 0	69/-	46/11
G.E.C.	Details on application. Complete kits available from stock.				
Mullard					

Radiogram cabinet to match. Dimensions 20in. × 21in. × 36in. high. Cabinet only (inc. tax) £36.

Equipment cabinet to match for Tape Recorder or record storage. Dimensions 20in. × 21in. × 36in. high. Cabinet only £27.

MOTORS AND PICKUPS

Connoisseur 3-speed motor	£23 8 11	57/2	£4 8 11	36/5	25/4
Connoisseur 3-speed motor with pick-up and 2 heads	£32 14 5	80/10	£6 14 5	49/10	34/8
Garrard Model R.C.80	£19 6 7	46/9	£3 6 7	30/8	21/4
Garrard R.C.90	£22 9 0	54/8	£4 9 0	34/6	24/-
Garrard T/A	£10 16 0	25/-	£2 2 8	16/2	11/3
Collaro Transcription Motor 2000	£13 9 6	31/8	£2 9 0	21/1	14/8
Collaro Transcription Motor 2010 with studio pick-up	£18 5 3	44/-	£3 15 3	27/9	19/8
Monarch auto-changer	£16 10 0	39/5	£3 6 0	25/3	17/7

TUNER AND F.M. UNITS

Goodsell S.P.1	£9 17 6	22/5	£1 17 6	15/4	10/8
Goodsell F.M. Unit	£24 17 6	61/-	£4 17 6	38/4	26/8
Chapman 84	£16 0 0	38/4	£3 0 0	24/11	17/4
Chapman F.M. Unit	£21 0 0	51/1	£4 0 0	32/7	22/8
Chapman 86B8	£44 0 0	109/10	£9 0 0	67/1	46/8
Lowther D.T.4	£33 0 0	81/9	£6 12 0	50/6	35/1
Lowther D.T.5	£45 0 0	112/5	£9 0 0	69/-	46/11
Lowther F.M. Unit	£27 18 6	68/8	£5 18 6	42/2	29/4

Corner reflex cabinet to match Radiogram cabinet and equipment cabinet. Dimensions 30in. × 15in. × 36in. high. Cabinet only £17/10/-.

Wherever you are, at home or overseas, we can ship your order or answer your queries. The quality is truly "out of this world" . . .

. . . . but we've got it at Croydon

CLASSIC ELECTRICAL CO LTD

352-364 LOWER ADDISCOMBE ROAD · CROYDON · SURREY TEL · ADDISCOMBE 6061-2

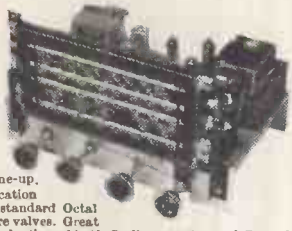
G

RECEIVER CHASSIS — *Modernise your old Radiogram* — RECORD PLAYERS

COMPLETE RADIOGRAM EQUIPMENT—QUALITY AT LOW COST

STERN'S DESIGN FOR HOME CONSTRUCTORS
The "SUPER-SIX"

A compact and highly efficient superhet Radio-Radiogram chassis of outstanding quality.



YOU CAN BUILD IT FOR £10/7/6 Including the OCTAL VALVE LINE-UP.
(£12/7/6 with the miniature valves)

We will supply it assembled and READY FOR USE for **£13/13/0** (Plus 7/6 Carr. & Ins.)

H.P. Terms £3.10.6. deposit and 12 months at 19/-.

Incorporating the new B.V.A. Miniature Valve Line-up.

This receiver is designed to the very latest specification and provision is made to incorporate either the standard Octal Valve Line-up or the new B.V.A. range of miniature valves. Great attention has been paid to the quality of the reproduction of both Radio reception and Record playings, and excellent clarity of speech and music is obtained.

A few brief details.

- Covers 3 wavebands 18-50 metres, 190-550, and 800-2,000 metres.
- Employs 6 valves having PUSH-PULL for 5-6 watts output.
- Incorporates delayed A.V.C. on all wavebands and pre-selective feedback.
- A 4 position Tone Control operates on both Radio and Gram.
- Has independent mains supply socket for a Record Player.
- Size of Assembled Chassis 12in. × 8in. × 8in. Dial aperture 8¼in. × 4¼in.
- For operation on A.C. mains 200-250 volts 50 cycles.

THE INSTRUCTION and ASSEMBLY MANUAL is available for 2/-, it contains very detailed practical drawings and circuit diagrams and a complete Component Price List.

THREE COMPLETELY ASSEMBLED ALL-WAVE SUPERHET CHASSIS

- Model B.3. A 5-valve 3-waveband Receiver.
- Model B.3.P.P. A 6-valve 3-waveband Receiver with PUSH-PULL OUTPUT.
- Model B.3.P.P./R.F. A 7-valve 3-waveband Receiver incorporating an R.F. stage with PUSH-PULL OUTPUT.

The three Receivers are for operation on A.C. mains 100/110 volts and 200/250 volts, and employ the very latest miniature valves. They wre designed to the most modern specification, great attention having been given to the quality of reproduction which gives excellent clarity of speech and music on both gram. and radio, making them the ideal replacement chassis for that "old Radiogram," etc.

Brief specifications: Model B.3.—Valve line-up, 6BE6, 6BA6, 6AT6, 6BW6, 6X4—waveband coverage short 16-50, medium 187-550, long 900-2,000 metres. Controls: (1) volume with on/off; (2) tuning (flywheel type); (3) wavechange and gram; (4) Tone Control (operative on gram. and radio). Negative feedback is employed over the entire audio stages. Chassis size: 11 × 7½ × 8¼in. high. Dial size 8¼ × 4¼in. Price complete and READY FOR USE, excluding speaker £12/12/- (carr. and ins. 7/6 extra).

H.P. Terms: £3/4/- deposit, 12 months at 17/8.

Model B.3.P.P. This model is the B.3 Receiver but incorporates two 6BW6 VALVES in PUSH-PULL, resulting in really excellent quality reproduction up to approximately 6 watts. Price £15/15/- (plus 7/6 carr. and ins.) or £3/19/- deposit, 12 months at £1/2/2.

Model B.3. P.P./R.F. This model is similar in appearance and has same waveband coverage as the Model B.3, but in addition it incorporates an R.F. STAGE together with PUSH-PULL OUTPUT, employing a total of 7 valves with two type 6BW6 in Push-Pull. This makes for a really sensitive receiver with genuine quality reproduction. Price £18/18/- (plus 7/6 carr. and ins.) or £4/13/- deposit, 12 months at £1/6/9.

AN OUTSTANDING OFFER

A BULK PURCHASE ENABLES US TO OFFER THIS "PUSH-PULL" 7 VALVE SUPERHET RECEIVER

For only **£12/19/6** (Carr. and Ins. 7/6 extra.).

H.P. Terms £3/4/6 Dep. 12 months at 18/4.

These receivers Model AW3-7 are made by a well-known set manufacturer and incorporate the latest Osram Valve Line-up of X79—W77—DH77—H77—U78 and two N78's in Push-Pull for approx. 7 watts output.

They cover 3 wavebands 18-50 metres, 190-550 and 800-2,000 metres, and are for operation on A.C. mains 200-250 volts. A Gram position is on the Wavechange Switch.

They make an excellent replacement Radiogram Chassis having a P.U. connection on the chassis. Extension speaker connection is also provided. Overall size of chassis: 12in. long × 7¼in. × 6¼in. high, dial aperture 8¼in. × 4¼in. (Dial Escutcheon available for 4/9).

THESE RECEIVERS ARE BRAND NEW AND FULLY GUARANTEED.

This AUTOCHANGE UNIT by a famous Manufacturer is offered for £11/10/0 (Plus 7/6 Carr. & Ins.)

Hire Purchase Terms £2/17/6 Dep. and 12 months at 16/4.

(Normal price is £16/10/-).

- These units will autochange on all three speeds, 7in., 10in. and 12in.
- They play MIXED 7in. 10in. and 12in. records.
- They have separate sapphires for L.P. and 78 r.p.m., which are moved into position by a simple switch.
- Minimum baseboard size required 14in. × 12¼in., with height above 5¼in. and height below baseboard 2¼in. A bulk purchase enables us to offer these BRAND NEW UNITS at this exceptional price.

The COLLARO 3RC/521 3-SPEED AUTO CHANGE UNIT

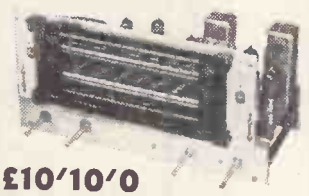
£9/19/6 (Plus 7/6 Carr. & Ins.) H.P. Terms £2/10/0 Deposit and 11 months at 15/9

Normal price £18/10/-.

- Complete which High Fidelity Crystal "Turnover" Head which incorporates separate stylus for L.P. and 78 r.p.m. Records.
- Will autochange on 7in. 10in. and 12in. records not intermixed.
- Minimum Baseplate size 15in. × 12¼in., with height above 4¼in. and below baseplate 3in.
- Brand new in Maker's Cartons, complete with Mounting instructions.

We have the NEW ARMSTRONG CHASSIS—see over

A Replacement RADIO-RADIOGRAM CHASSIS



- MODEL AW3-5. A 5-Valve Superhet Receiver covering the standard 3 wavebands, 16-50 190-550, 900-2,000 metres. PRICE COMPLETELY ASSEMBLED AND READY FOR USE (plus 7/6 carr. and ins.). **£10/10/0**

H.P. Terms £2/12/6 Deposit and 12 Months at 15/-. This receiver is for operation on A.C. Mains 200-250 volts. It contains the latest MULLARD VALVE LINE-UP, being ECH42 (Freq. Ch.), EF41 (I.F.), EBC41 (Det. 1st Audio), EL41 (Output) and EZ41 (Rect.). The four controls being (1) Tuning. (2) Wavechange and Gram. Switch. (3) TONE. (4) VOLUME-OFF. It provides really good reproduction on both Gram. and Radio and gives an exceptionally good range of station selection. Overall size 13¾in. x 7in. high × 6in. deep. Dial aperture 10in. × 4¼in.

SPECIAL REDUCTIONS FOR COMPLETE EQUIPMENT

SUMMARY

Select a RECORD PLAYER and CHASSIS and we will supply it TOGETHER WITH AN 8-inch or 10-inch P.M. SPEAKER as follows:—

THE £11.10.0 AUTOCHANGER WITH A SPEAKER AND:—

	Cash Price	Deposit	Monthly
(a) With Model B3 chassis	£24 15 0	£6 4 0	12 of £1 14 10
(b) ,, ,, B3PP	£23 0 0	£7 0 0	12 of £1 19 5
(c) ,, ,, B3PP/RF	£31 2 0	£7 15 0	12 of £2 3 9
(d) ,, ,, Super six (assem. chassis only)	£25 15 0	£6 9 0	12 of £1 16 2
(e) ,, ,, AW3-5	£22 15 0	£5 10 0	12 of £1 12 4
(f) ,, ,, AW3-7	£25 5 0	£6 7 0	12 of £1 15 5

THE COLLARO AUTOCHANGER MODEL 3RC/521 WITH A SPEAKER AND:—

(a) With Model B3 chassis	£23 6 0	£5 16 0	12 of £1 12 10
(b) ,, ,, B3PP	£26 9 0	£6 11 0	12 of £1 17 4
(c) ,, ,, B3PP/RF	£29 12 0	£7 9 0	12 of £2 1 6
(d) ,, ,, Super six (assem. chassis only)	£24 8 0	£6 0 6	12 of £1 14 5
(e) ,, ,, AW3-5	£21 4 0	£5 6 0	12 of £1 9 10
(f) ,, ,, AW3-7	£23 14 0	£6 0 0	12 of £1 13 2

An additional charge of 10/- is made in each case to cover Carriage and Insurance.

109 and 115 FLEET ST., London, E.C.4. 'Phone: CENtral 5812/3/4

CONSTRUCTORS say "IT'S STILL THE BEST MAINS or BATTERY PORTABLE SET"

A Midget 4-valve Superhet Portable covering medium and long wavebands. Designed to operate on A.C. mains 200/240 volts or by an "Alldry" battery. The set is designed so that the main section can be supplied as a separate unit, and can be added at any time. The set supplied as an "Alldry" battery Superhet can be accommodated in the attache case illustrated (size 9½in. × 4½in. × 7in.). This is attractively finished in lizard, maroon, dark green or blue rexine. As a combined Mains/Battery Superhet Portable a polished cabinet is available to accommodate both Mains Unit and Batteries. Circuit incorporates delayed A.V.C. and pre-selective Audio Feedback. The Set is complete in every detail and includes ready-wound frame aerials, fully aligned I.F. transf. and drilled chassis etc. Overall size of assembled chassis 8in. × 4in. × 2½in. This receiver as illustrated, can be completely built for £8/16/3 (plus Mains Unit if required). Send 1/3 for the fully descriptive Assembly Book which includes Practical Layouts and complete Price list of Components. Attache case available separately, 37/6.

BATTERY PORTABLE

THE "MINI TWO-THREE"

An "Alldry" Battery Portable of midget size, 6½in × 4½in. × 3½in. designed to cover medium waveband 190-559 metres, with use of short trailer aerial.

The simple design of this Receiver is so arranged that either a 3-valve set or a 2-valve (afterwards easily converted to the 3-valve) can be made.

Consists of a T.R.F. circuit using a regenerative detector with H.F. stage and a high gain output pentode. Valve line up 1T4—1T4—DL94.

The 2-valve set can be completely built for £4/3/6 (less case) and the 3-valve for £5/3/- (less case). Each price includes valves, speaker and drilled chassis.

Send 2/- for the assembly instructions: they include simple and complete practical component layouts and diagrams which enable the most inexperienced constructor to successfully build either set. All components are available for separate sale, a price list being supplied with assembly instructions.

"PERSONAL SET" BATTERY ELIMINATOR

A complete Kit of parts to build a Midget "Alldry" Battery Eliminator, giving approx. 69 volts and 1.4 volts. This eliminator is for use on A.C. mains and is suitable for any 4-valve Superhet Receiver requiring H.T. and L.T. voltage as above, or approx. to 69 volts.

The Kit is quite easily and quickly assembled and is housed in a light-aluminium case size 4½in. × 1½in. × 3½in. Price of complete Kit with easy-to-follow assembly instructions, 42/6.

In addition we can offer a similar COMPLETE KIT to provide approx. 90 volts and 1.4 volts. Size of assembled unit 7in. × 2½in. × 1½in. Price 47/6.

A COMPLETE "CAR RADIO" FOR THE HOME CONSTRUCTOR

11½in. × 4½in. × 3½in.

A design of a complete 5-VALVE SUPERHET RECEIVER employing an R.F. Stage, and incorporating a separate VIBRATOR PACK size 4½ × 2½ × 6½in. for use on 6 or 12 volt D.C. supplies.

We can supply all components to build this complete Receiver and Vibrator Pack including a Metal Case, Valves, Drilled Chassis and 5in. P.M. Speaker for £13/9/6. (Carr. and Ins. 5/6 extra.) Or the Receiver Components for £9/19/6 and the Vibrator Components for £3/10/-.

This is NOT an EX-GOVT. Receiver, it is a new design employing new Components. Send 2/8 for the complete set of ASSEMBLY INSTRUCTIONS, CIRCUITS and PRACTICAL LAYOUTS, including a complete individual Component Price List.

THE NEW ARMSTRONG F.C.48

OUTSTANDING FEATURES INCLUDE:—

- 8 Valves including 2 double Triodes.
- 8 Watts output from push-pull tetrodes. Heavy negative feed back is used resulting in negligible distortion and high damping factor.
- Provision for using F.M. adaptor to receive the present high quality transmissions from Wrotham and the new B.B.C. V.H.F. stations.
- An accessible socket at rear provides the power supply for this unit.
- Independent controls give BASS and TREBLE lift and cut with unique Thermometer visual indicator.
- Gram position on wavechange switch.
- 4 wavebands Coverage 16-51, 50-120, 190-550, 1000-2000 metres.
- Large four-colour illuminated dial.

CASH PRICE COMPLETE and READY FOR USE £23/18/0

(Plus 7/6 Carriage and Insurance).

H.P. Terms. Deposit £5/18/- and 12 months at £1/13/9.

"MINI-TWIN" 1-VALVE BATTERY SET

A design of a simple 1-valve 2-stage Battery Receiver, giving excellent results on medium and long wavebands and having exceptionally low battery consumption. Drilled chassis and practical diagrams make it the ideal set for the beginner to build.

The complete chassis, including valve, can be built for 37/6, plus 8/11 P/Tax, the attractive plastic case is 9/6. and suitable headphones, 14/9.

The complete assembly instructions, layouts and a component price list are available for 1/6.

This Receiver also performs excellently, without modification, as a tuning unit, and, in addition, with simple modifications for which a complete diagram is provided, makes a first-class pre-amplifier for pick-up or microphone.

109 and 115 FLEET ST.

LONDON, E.C.4 Phone: CENTRAL 5812-3-4

!!!CONSTRUCTORS!!!

A NEW SUPERHET TRANSPORTABLE

THE "SUPER THREE"

Designed for local station reception without the use of an external aerial. This design provides for a 3 valve (plus Metal Rectifier) Superhet Receiver incorporating a Frame Aerial for "room to room" use, provision is also made for a short external aerial, if required, for the reception of Continental Stations.

Briefly the features are as follows:—

- For use on A.C. Mains 200-250 volts.
- This set includes a Mains Transformer and Chassis is NOT live to mains (as many other sets of this type are) and consequently the Receiver can safely be used in the Kitchen, etc.
- Valve line up 6K8—6J7—KT61, plus Metal Rectifier.
- The I.F. Transformer is supplied "pre-aligned" and thereby ensures extreme simplicity of Tuning—in fact, more simple than most T.R.F. Receivers.
- Compact and easy to build simple "point to point" practical diagrams are supplied with a completely drilled chassis.

The complete Receiver Chassis can be built to cover the Medium Waveband only for **£6 . 6 . 6**

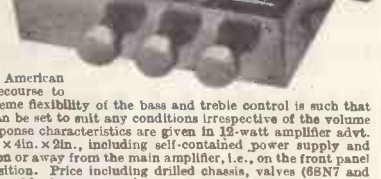
Or to cover both Long and Medium Waves for **£6 . 16 . 3**

If the Receiver is first built to cover the Medium Waveband, Long Waves can be added at any time, separate diagrams are provided for this purpose.

The attractive Polished Wood Cabinet 11½ inches wide, 8½ inches high and 6 inches deep illustrated above is **£1 . 1 . 0**

The CONSTRUCTOR'S MANUAL is available for 1/-, this shows the component prices, which are all available for separate purchase.

DUAL-CHANNEL PRE-AMPLIFIER and TONE CONTROL UNIT



This comprehensive PRE-AMPLIFIER and TONE CONTROL UNIT provides a full control of bass and treble in conjunction with a main Volume/Mixer Control.

It can be used with any amplifier and with any pick-up, the range of frequency control provided by the unit affording ample compensation for all types of pick-up and all natures of recordings, i.e., English, American and long-playing, without recourse to pick-up correction. The extreme flexibility of the bass and treble control is such that the level of bass and treble can be set to suit any conditions irrespective of the volume output of the amplifier. Response characteristics are given in 12-watt amplifier advt. The unit measures only 7in. × 4in. × 2in., including self-contained power supply and can be accommodated either on or away from the main amplifier, i.e., on the front panel of a cabinet or any other position. Price including drilled chassis, valves (6BN7 and 6J5), £3/16/9. Complete assembly data are available separately for 1/-. Completely assembled and ready for use, £5/5/-.

AN AMAZING OFFER!

A COMPLETELY ASSEMBLED

4 VALVE T.R.F. CHASSIS

Including a 5in. P.M. SPEAKER and VALVES FOR ONLY

£6/9/6

(Plus 7/6 carr. and Ins.)

This receiver is of the very latest design and is for use on A.C. or D.C. Mains. It covers both Long and Medium Wavebands, and includes the modern BVA miniature valves The line up being 12 BA6—12AT6—12A6—35W4. It incorporates Permeability Tuned Coils, thus ensuring excellent selectivity and sensitivity. The overall size of the complete chassis including speaker is 10½in. × 4½in. × 6½in. An attractive Bakelite Ivory-finished Cabinet size 11½in. × 5½in. × 6½in. is available for 16/6 (plus 2/6 carriage and insurance).

THE TELE KING

5 CHANNEL 16 or 17 INCH SUPERHET RECEIVER

WIDE ANGLE — LARGE SCREEN

Do you know . . . this famous and well tried home constructor set can now be built for **£29/10/-** including valves. Only tube and cabinet extra.

LASKY'S RADIO

A MULTI CHANNEL TUNER FOR THE TELE KING WILL BE AVAILABLE SHORTLY.

EVERY COMPONENT CAN BE SUPPLIED SEPARATELY.

Full constructional data, wiring diagrams and circuits.

Price 6/- POST FREE

WRITE NOW FOR OUR NEW TELE KING PRICE LIST.
WE CAN SAVE YOU MONEY.

CHOKES

40 m/a. . .	3/3	120 m/a.	7/3
60 m/a. . .	3/11	200 m/a.	12/6
80 m/a. . .	4/11	250 m/a.	14/-

SPECIAL TRANSFORMER
Secondary tapped as follows: 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24 and 30 volts at 2 amps. **PRICE 17/6.**

TELEVISION SELENIUM RECTIFIERS
The very latest "Sentercell" S.T.C. range.

K3/40, 3.2 kV	6/-
K3/45, 3.6 kV	8/2
K3/50, 4.0 kV	8/8
K3/100, 8.0 kV	14/8
K3/160, 12.8 kV	21/6
K3/200, 16 kV	26/-

MANUFACTURER'S SURPLUS R.F. E.H.T. OSCILLATOR COILS
Doubler type, 6-9 kV. Uses 1 or 2 EY51's. **LASKY'S PRICE 12/6.**

HEARING AIDS
By well known manufacturer. In metal case 2½ × 4½ × 1in. Complete with batteries and 3 subminiature valves. Fitted with internal crystal microphone. Used and soiled condition. **LASKY'S PRICE 39/6.** Post 2/6.
Earpiece and Cord. For use with hearing aid. **LASKY'S PRICE 17/6.**

INTERCOM. UNITS
4-station operation. For use on A.C./D.C. mains 200-250 volts. Complete, with 3 valves. Fitted in attractive plastic cabinet. **MASTER UNIT £5/19/6.** Carr. 5/- extra.
Extension Units, Price 21/- each complete. Carriage 2/- each extra.

P.M. LOUDSPEAKERS
All with 3 ohm speech coil.
3½in., 14/6. 5in., 14/6. 8in., 19/11. 4in., 12/6. 6½in., 15/-. 10in., 19/6.

ENERGISED SPEAKERS
8in. with O/T 600 ohm field, 15/6
8in. less O/T 600 ohm field, 12/6
8in. less O/T 1,200 ohm field, 12/6. 6½in. with O/T 600 ohm field, 14/-.

SPECIAL OFFER. 12 INCH CATHODE RAY TUBES. Standard types, suitable for T.V. LIMITED QUANTITY. **LASKY'S PRICE £12/19/6.** Carriage and insurance 15/- extra.

ION TRAPS. All types, 3/-.

ARMOUR PLATE GLASS

16in. Actual size 17½in. × 15½in. × ¼in.	7/11
15in. Actual size 16⅝in. × 13in. × ¼in.	6/11
12in. Actual size 13in. × 10¼in. × ¼in.	4/-
9in. Actual size 9in. × 8in. × ¼in.	3/-

TRIPLEX DARK SCREEN FILTERS

14 × 12½ × 3/16in.	7/6
15⅛ × 13¼ × 3/16in.	9/6

Postage and packing 5/- per piece extra. (This charge is necessary owing to extra packing required).

PERSPEX IMPLOSION GUARDS, incorporating escutcheon and filter plate.

12in.	12/6
12in. de Luxe	15/-
16in. de Luxe	17/6

C.R.T. MASKS. Brand New LATEST ASPECT RATIO

9in.	7/-
10in.	7/6
12in.	15/-
12in. Old Ratio	9/6
12in. Escutcheon mask, with Perspex filter	12/6
14in. Rectangular	12/6
15in. Cream rubber	17/6
16in. Plastic, white	12/6
17in. Rectangular	15/-

TELESCOPIC AERIAL MASTS
As previously advertised Complete. **LASKY'S PRICE 25/-** Carriage 2/6 extra.

MANUFACTURERS' SURPLUS T.V. COMPONENT BARGAINS

WIDE ANGLE 38mm.

Line E.H.T. trans., ferroxcube core. 9-16 kV.	25/-
Scanning Coils, low imp. line and frame	25/-
Frame Output Transformer	10/6
Scanning Coils low imp. line and frame	17/6
Frame blocking osc. transformer	4/6
Line Blocking osc. transformer, caslam cored	4/6
Focus Magnets Ferroxdure	25/-
P.M. Focus Magnets. Iron Cored	19/6
Duomag Focalisers	29/6
300 m/a. Smoothing chokes	15/-
Electromagnetic focus coil, with combined scan coils	25/-

STANDARD 35mm.

Line Output Transformers. No. E.H.T.	12/6
Line Output Transformers. 6-9 kV. E.H.T. and 6.3 v. winding Ferroxcube	19/6
Scanning coils. Low imp. line and frame	12/6
Scanning Coils. Low imp. line and frame, by Igranic	14/6
Line blocking oscillator transformer	4/6
Frame blocking oscillator transformer	4/6
Frame output transformer	7/6
Focus Magnets: Without Vernier	12/6
With Vernier	17/6
Focus Coils. Electromagnetic	12/6
200 m/a. Smoothing chokes	10/6

AERIAL ROD SECTIONS
Steel, heavily copper plated. 12in. long, ¼in. diameter. Any number may fitted together. **PRICE 2/6** per doz. POST FREE.

MAINS TRANSFORMERS
All 200-250 v. 50 c.p.s. primary Finest quality, fully guaranteed.
MBA/3. 350-0-350 v. 80 mA. 6.3 v. 4 a., 5 v. 2 a. Both filaments tapped at 4 volts. An ideal replacement trans. **18/-.**

MBA/6. 325-0-325 v. 100 mA. 6.3 v. 3 a., 5 v. 2 a. With mains tapping board. Price **22/6.**

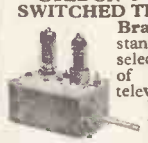
MBA/7. 250-0-250 v. 80 mA. 6.3 v. 3 a., 5 v. 2 a. Both filaments tapped at 4 volts. **18/-.**

MBA/8. SPECIAL OFFER Drop through type. 235-0-235 v. 60 mA. 6.3 v. 3 a., **12/6.**

MBA/9. 400-0-400 v. 60 mA. 6.3 v. 1 a., 4 v. 2.5 a. Price **12/6.**
AT/3. Auto transformer. 0-10-120, 200-230-240 volts 100 watts Price **17/6.**

CLOSED FIELD SPEAKERS
6½in. **18/6**
8in. round and 6½in. Eliptical. **19/11.**

CYLDON 5-CHANNEL SWITCHED TELETUNERS



Brand new. Instant and positive selection of any one of the 5 B.B.C. television channels, by a single control knob. Uses **EF.80** or 6BW7 RF pentode and ECC81 or 12AT7 Double Diode Triode as frequency changer. Tuning is obtained by switching incremental inductances. Size 4½ × 2¾ × 2½in. Spindle 2½in. long ¼in. diameter. I.F. Output 9.5-14 Mc/s., noise figure on all channels better than 10.5dB. I.F. rejection better than 45dB. on all channels. Power gain 24dB. **LASKY'S PRICE,** less valves, **12/6.** POST FREE. Complete with valves. **37/6.** POST FREE.

TAPE RECORDER AMPLIFIERS. Complete with 5 valves: 2 6SN7, 2 6V6, 1 5Z4. Twin inputs, also volume control and record level. On aluminium chassis, size 11½ × 2½ × 9in. Complete with valves and 8in. speaker. Totally enclosed in case. **LASKY;S PRICE £9/19/6.**
Less cover **£8/15/-.**
Less cover and head lift transformer **£7/15/-.** Carriage 5/- per unit extra.

LASKY'S RADIO

LASKY'S (Harrow Road) Ltd.,

370 HARROW RD., PADDINGTON, LONDON, W.9

(Opposite Paddington Hospital)

Telephone, all departments: CUNningham 1979/7214.

Please Add a Reasonable Amount For Postage.

The R.C. RAMBLER ALL-DRY PORTABLE KIT

Full assembly details with practical and theoretical diagrams can be supplied at 1/6 post free. This is a truly professional 4-valve superhet—all dry—for medium and long waves. A cream plastic top panel, with dial engraved in red and green, adds to the very imposing appearance of this model which is housed in an attractive cream and grey leatherette covered attache-case type cabinet, measuring only 9in. × 7in. × 5¼in. Weight (less batteries) 4¼ lb. with batteries 6¼lb. This set really has everything! Built - in frame aerial, high quality, extremely sensitive, and very adequate volume from the 5in. speaker. Valve line-up: 3V4, 1R5, 1S5, 1T4. All the required components, exactly as specified, including cabinet, can be supplied from stock at the special inclusive price of £7/7/- plus 2/6 P. & P. (less batteries). Uses Ever Ready 90 v. H.T. type B126 at 9/3. Also L.T. 1.5 v. AD.35 at 1/4. N.B. When batteries are removed there is adequate space for mains unit which will shortly be made available.

THE "SUPERIOR FOUR" KIT. Our new four-valve receiver. A.C. mains, 200/250 v. M. and Long Waves. As with our very successful "Economy Four" all required components are supplied. Valve line-up: 2 6SG7, 6X5GT and 6V6GT. Chassis ready drilled. Cabinet size, 10¼in. × 10in. wide. Maximum depth at base, 5in., tapering to 3¼in. at top. Sloping front. Very attractively finished in light walnut and peach. Each component brand new and tested prior to packing. Complete Instruction booklet with practical and theoretical diagrams is provided. Booklet available at 1/6, post free. Our price for complete kit, £6/9/6!!! Please add 2/6 packing and carriage. If preferred, we can supply Cabinet, Assembly only, comprising Cabinet and bracket wavechange switch, dial, pointer, drum pulleys, drive spindle, drive spring and knobs, at 45/- plus 2/6 packing and carriage.

N.B.—Our Kits are even supplied with sufficient solder for the job!

THE R.C. GRAM REPLACEMENT CHASSIS KIT

To meet the very great demand for this type of receiver, we have produced this unit. For Long, Medium, and Short Waves. Valve line-up: 6K8 Frequency changer, 6K7, I.F. Amplifier, 6Q7, 1st Audio, Detector and A.V.C., 6V6 Output, 6X5 Full-wave rectifier.

For A.C. mains 200/250 volts. 4 watts output. Excellent quality. High sensitivity. Provision for gram. Attractive illuminated black, red, green and gold dial, for horizontal tuning. Four controls are: Tuning, L/M/S/Gram. Vol./on/off, Tone (variable). Chassis size: 13¼in. × 5¼in. × 2¼in. Dial size: 10in. × 4¼in. Assembly is simplified by the use of a 3-waveband coil pack, and pre-aligned 465 Kc/s. I.F. transformers—high-grade drop-through half-shrouded Mains Transformer, with voltage adjuster panel. This chassis can easily be assembled in one evening. Illustrated pamphlet with full assembly instructions, practical and theoretical wiring diagrams and itemised price list, 1/6, post free.

The main items for this receiver can be supplied separately, as under.

Drilled chassis, complete with valve-holders, A/D panel, P/U panel, tuning condenser and ready-assembled dial and drive at 39/6. 3 waveband coil pack with gram position, 39/6, tax paid. Pair of 465 Kc/s. I.F. Transformers, 9/6 pair. Half-shrouded drop-through Mains Transformer, 22/6. The total cost of ALL items purchased separately is nearly £10, but we shall be pleased to supply all the required components right down to the last nut and bolt, at a special inclusive price of £8/8/-, plus 2/6 packing and postage. A set of four small brown or cream engraved knobs to suit is available at 1/2 each knob. This chassis is a professional job in every respect and can be seen and heard at our premises. This chassis can also be supplied, ready assembled, in very limited quantities, at £9/19/6 plus 5/- carriage and packing.

THE "ECONOMY FOUR" T.R.F KIT

A three valve plus metal rectifier receiver. A.C. mains 200/250 v. Medium and Long waves. We can supply all required components right down to the last nut and bolt. Valve line-up, 6K7, 6J7, and 6V6. Chassis ready drilled—Cabinet size 12in. long by 6in. high by 5in. deep—Choice of ivory or brown bakelite, or wooden, walnut finish cabinet. Complete instruction booklet with practical and theoretical diagram. Each component brand new and tested prior to packing. Our price £5/10/- complete—Remember this set is being demonstrated at our shop premises! We proudly claim that our fully illustrated instruction booklet is the most comprehensive available for this type of receiver—Booklet available at 1/6 post free—this is allowed if kit is purchased later—Please, 2/6 packing and carriage for complete kit.

THE R.E.P. ONE-VALVE BATTERY RECEIVER KIT. Simple one-valve all-dry battery receiver for headphones, easily built in one evening. All required components including headphones, can be supplied at inclusive cost of 42/- plus 2/- p. & p. Operated by Ever Ready B114 type battery available at 7/9. Full assembly details available separately at 9d. plus 3d. post.

TELESCOPIC AERIAL MAST. Ex-R.A.F. dinghy transmitter mast. Total length when extended, 17ft. Collapses into two sections each approx. 24in. Complete with dies and lashings, lightweight duralumin construction, diameter at thickest point, 1¼in. approx. tapering to ¼in. New condition. 32/6. Plus 2/- post and packing.

CO-AXIAL CABLE. Standard 80 ohms. brown, stranded centre conductor, 6d. per yard only! Not Govt. surplus. Min. 12 yds. We stock MICROPHONES by Lustraphone, Rouette, etc., and have available, ex-stock, the New ACOS Crystal Microphone Type MIC 35-1 at 25/- and MIC 33-1 at 50/-.

BRANDENBURG E.H.T. UNITS. 6-9 kV., 6 gns.; 13-16 kV., 9 gns.; 6-9 kV. coil, 39/-; 10-15 kV. coil, 55/-. Wiring diagram supplied.

SPECIAL !!!

DECCA LIGHTWEIGHT PICKUPS. Complete with either Standard or L.P. Crystal Cartridge insets. Complete with Rest and Tracking Instructions. 32/6 plus 2/6 P. & P. Also their very latest type, as above, but with turn-over head, 47/6 only!

TWO GANG .0005 mfd. Absolutely standard, with feet by Wingrove & Rogers. Long spindle, 6/6 each.

THREE GANG DITTO, less mounting feet, 6/6 only.

22 SET POWER UNIT NO. 4MK1 ZA10478—Complete with 4 metal rectifiers each 250 v. 60 mA. 2·12 v. 4 pin Mallery Vibrators, transformers, condensers, resistors, signal 1 amp. indicator, etc. etc., in good condition. Complete in metal box size 10¼in. × 6in. × 8in. Weight 19lb., 27/6, plus 5/- P. & P.

VALVES. We have a very comprehensive stock of special purpose surplus valves at competitive prices. A stamp will bring Valve Price List.

L.T. RECTIFIERS TYPE R.K. A newly manufactured range, guaranteed 12 months.

6 or 12 v. 1 a. F.W. bridge type.....	7/6
6 or 12 v. 1.5 a.	9/6
6 or 12 v. 2 a. F.W. bridge type	11/3
6 or 12 v. 4 a. F.W. bridge type	15/-
6 or 12 v. 6 a. F.W. bridge type	23/6

CHARGER TRANSFORMERS. Input 230 v.

6/12 v. 2 a.	11/9
6/12 v. 4 a.	17/6
6/12 v. 6 a.	25/-

COIL PACKS. MANUFACTURERS' SURPLUS. Few only, iron-cored, 7 waveband (2 medium, 5 short waves), comprising 14 coils, trimmers, wave-change switch, etc. etc., complete with copy of manufacturers' original circuit, 50/- only, tax paid. Completely assembled. Suitable Glass Dial, 3/6.

"CONTEMPORARY." A well made Cabinet in light wood, made especially to blend with this type of furniture. The motor board is uncut, and will accommodate most Radio Chassis and Auto-change units. Size: 30in. × 15in. × 29in. high. Price £9/15/-, plus 10/- post and packing.

THE NEW R.C. HIGH-FIDELITY AMPLIFER. P.P. 6V6 output. Freq. 25—18,000 cps.—60db at 6½ watts. Treble boost and cut—Bass boost—L.P. correction. Provision for Feeder Unit Max. UNDISTORTED OUTPUT 8½ watts. Price 14 gns., plus 7/6. NOW AVAILABLE. Kit of Parts, complete with fully illustrated instructions £11/19/6, plus 5/- carriage. Illustrated booklet available separately at 2/6. Attractive metal cover, now available. With built-in carrying bandle, 19/6.

24 VOLT ROTARY CONVERTER. Input 24 v. D.C. Output 200/250 v. A.C. 100 watts. Complete in black steel box 18¼in. × 11¼in. × 8½in. Weight approx. 30 lb. Completely smoothed, incorporates Sodium Lamp transformer. Brand new. 92/6.

I.F. TRANSFORMERS. SPECIAL OFFER. All iron-cored 465 Kc/s. Plessey—Iron-cored 2¼in. × 1¼in. × 1in., 7/6 pr. Philips, size 2¾in. × 1¼in. diameter (cylindrical), 7/6 pair. By Invicta—Cylindrical, 2¼in. × 1¼in. diameter, 8/6 pr. Also our own special ultra midget, size 1¼in. × 13/16in. × 13/16in. Only 9/9 per pair. By Wearite, Type 501 and 502. 12/6 per pair.

SPECIAL OFFER.—Garrard AC/DC model U5A centre drive motor for 78 r.p.m.—Speed regulator—Few only at £7/19/6, plus 2/6 packing and carriage. We also have in stock—Connoisseur 3-speed motors, pick-ups. Pick-ups and heads, by Garrard, Decca, Collaro, Acos, Chancery, etc. etc., at current prices.

ELPICO 4-WATT AMPLIFIER. AC/34. A small 3-valve 3-stage audio amplifier. AC 200/250 v. Output 4 watts. 2/3 ohm. Suitable for Radio, Microphone or Gramophone input. Volume and Tone Controls—Valve line up. 6SL7, 6V6, 573—Engraved front panel. Size of chassis only—7in. × 5in. × 2in. Overall height—5½in. Price £7/10/-. We have in stock the very latest "Elpico" Feeder Unit type RF/720. Superhet for L., M., Short and Trawler Bands. Very attractive illuminated black and gold dial, for immediate use with any amplifier. 15 gns., tax paid.

PORTABLE CABINETS. Manufacturers' surplus. Well made brown rexine covered. Will take any standard single player with bottom clearance of 3in. Total size closed 15in. × 13½in. × 5½in., fitted with snap catches and carrying handle. 22/6 only, plus 2/6 P. and P.

CABINETS. We can supply a cabinet for every requirement, Table Model, Extension Speaker, Portable Player, Console, even for Projection T/V! Why not call and see us?

4-WATT 2-STAGE AMPLIFIER. Valve line-up: 6L6, EF37 and GZ32, complete with 10in. Mains Energised Speaker, £6/19/6, plus 5/- packing and carriage.

STUPENDOUS HALF-PRICE OFFER!! DECCA SINGLE SPEED RECORD PLAYING DESKS 33A. Easily converted to either Standard or L.P. Price with one crystal cartridge of either type, £4/19/6; or with both cartridges, £5/19/6. Plus 5/- P. & P.

WHIP AERIALS. All copper, 3 sections each of 4ft. Screw in, 7/6 complete. Ditto, but two bottom sections only at 4/6. Both plus P. & P. 1/6.

8 MFD. 1,200 v. PAPER BLOCK CONDENSERS. Size: 5in. × 4¼in. × 3¼in., 15/- each. Many others in stock.

CLYNE RADIO LTD.

18, Tottenham Court Road, London, W.1.

SELENIUM RECTIFIERS

L.T. Types		H.T. Type H.W.	
2/6 v. ½ a.h.w....	1/9	120 v. 40 mA....	3/11
6/12 v. ½ a.h.w....	2/9	250 v. 50 mA....	5/9
		250 v. 80 mA....	7/9
F.W. Bridge Types		RM2 125 v. 100 mA	3/11
6/12 v. 1 a.....	5/9		
6/12 v. 1½a.....	7/9	RM3 125 v. 120 mA	5/9
6/12 v. 2 a.....	9/9		
6/12 v. 4 a.....	14/9	RM4 250 v. 250 mA	11/9
6/12 v. 6 a.....	19/9		
6/12 v. 10 a.....	29/9	300 v. 275 mA.	12/11

CO-AXIAL CABLE. 75 ohms ¼in., 7d yard. Or in 20yd. lengths, 6d. yd. Twin screened feeder, 9d. yd.

RHEOSTATS (VARIABLE RESISTORS) 2 ohms 5 amps, 6/9; 0.4 ohm 25 a., 8/9; 10 ohm 3 amps., 8/9; 60 ohms 1.5 amps, 14/9.

SILVER MICA CONDENSERS. 5, 10, 15, 20, 25, 30, 35, 50, 100, 120, 150, 180, 200, 230, 300, 330, 400, 470, 500, 1,000 pfd. (.001μF), .002 mfd. (2,000 pfd.). All at 5d. each, 3/9 dozen one type.

DIAL BULBS, M.E.S., 8 v. 0.15 a., 6/9 doz.; 6.5 v. 0.15 a., 6/9 doz. 4.5 v. 0.3 a., 6/9 doz.

ELECTROLYTICS (Current production) NOT ex Govt.

Tubular Types		Can Types	
8μF 450 v.....	1/11	16 mfd. 350 v....	1/11
8 mfd. 500 v....	2/6	16μF 450 v.....	2/9
16μF 350 v.....	2/3	24μF 350 v.....	2/11
16μF 450 v.....	2/9	32μF 350 v.....	2/11
16μF 500 v.....	3/9	32 mfd. 450 v....	4/9
24μF 350 v.....	3/3	64 mfd. 450 v....	4/9
32μF 350 v.....	3/9	8-8μF 350 v....	3/9
32 mfd. 500 v....	5/9	8-8μF 450 v....	3/11
8-16μF 500 v.	4/11	8-8 mfd. 500 v.	4/9
25μF 25 v.....	1/3	8-16μF 450 v....	2/11
50μF 12 v.....	1/3	16-16μF 450 v.	4/11
50μF 50 v.....	2/3	16-32μF 350 v.	4/9
Can Types		16-32 mfd. 450 v.	4/9
8 mfd. 350 v....	1/3	32-32μF 350 v.	4/9
8 mfd. 450 v....	2/3	32-32μF 450 v.	5/11
8 mfd. 500 v....	2/9		

AMPLIFIER OR CHARGER CASES. Size 14¾×5⅝×7¼in. high. Strongly made in perforated steel. Grey enamel finish. Only 9/6.

VOLUME CONTROLS with long spindles, all values less switch, 2/9; with S.P. switch, 3/9.

WIRE WOUND POTS: 20 ohms, 500 ohms, 5K, 20K, 50K, 100K (medium length spindles), 2/9. 220 ohms, 2K, 10K, 20K, 50K, Preset type, 1/9 ea.

AMMETERS. Moving coil. G.E.C. 0—5 amps., 2in. scale, 11/9.

EX-GOVT. E.H.T. SMOOTHING CONDENSERS

.25 mfd. 4,000 v. Blocks.....	4/9
.5 mfd. 2,500 v. Blocks.....	3/9
.5 mfd. 3,500 v. Cans.....	3/3
.1 mfd. plus 1 mfd. 8,000 v., large blocks (common negative isolated).....	9/6
1.5 mfd. 4,000 v. blocks.....	5/9

EX-GOVT. ACCUMULATORS with non-spill vents. Unused and guaranteed. 2 v. 16 A.H., 5/9 each. or 3 in wood carrying case 9×7×5in., 14/9, plus 3/6 Carr.

EX-GOVT. BLOCK PAPER CONDENSERS

2 mfd. 800 v.	1/9	4 mfd. 2,000 v.	6/9
4 mfd. 500 v.	2/9	6-6 mfd. 500 v....	5/9
4 mfd. 730 v.	3/9	8 mfd. 500 v.....	5/9
4 mfd. 1,500 v. ...	4/9	8-8 mfd. 500 v....	6/11
		15 mfd. 500 v....	7/9

4 mfd. 400 v. plus 2 mfd. 250 v. 1/11.

EX-GOVT. AUTO TRANSFORMERS 50 c/s.

Double Wound 0-230 v. to 15-10-5-0-195-215-235 v., 1,000 watts..... 27/9

Double Wound 220/240 v. input. Output 57.5 v. to 230 v. 21 amps in steps of 11 v. £6/15

Double Wound 10-0-200-220-240 v. to 10-0-275-295-315 v. 1,000 watts..... 69/6

For 110-115 v. input or output primaries and secs., can be connected in series.

0-110-190-230 v. 1,400 watts 49/6

M.E. SPEAKERS. All 2-3 ohms, 6½in. Rola-field 700 ohms, 11/9. 10in. R.A. field, 1,500 ohms, 23/9. 10in. R.A. field 1,000 ohms, 23/9. **SPECIAL OFFER.** Mains Trans. 200-250 v. 50 c/s. Primary. Secs. 300-0-300 v. 150 mA. 6.3 v. 4 a., 5 v. 3 a., Half shrouded drop through, 21/9.

R.S.C. TRANSFORMERS

FULLY GUARANTEED, INTERLEAVED AND IMPREGNATED

MAINS TRANSFORMERS
Primaries 200-230-250 v. 50 c/s.

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250 v. 60 mA., 6.3 v. 2 a., 5 v. 2 a., Midget type, 2½-3-3in..... 16/9
350-0-350 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.... 18/9
250-0-250 v. 100 mA., 6.3 v.-4 v. 4 a., c.t., 0-4-5 v. 3 a..... 23/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a... 22/9
250-0-250 v. 100 mA., 6.3 v. 6 a., 5 v. 3 a., for R1355 conversion..... 29/6
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.... 22/9
300-0-300 v. 100 mA., 6.3 v.-4 v. 4 a. c.t., 0-4-5 v. 3 a..... 23/9
350-0-350 v. 100 mA. 6.3 v. 4 a., 5 v. 3 a. 22/9
350-0-350 v. 100 mA., 6.3 v.-4 v., 4 a. c.t., 0-4-5 v. 3 a..... 23/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a. 31/6
350-0-350 v. 150 mA., 6.3 v. 2 a., 6.3 v. 2 a., 5 v. 3 a..... 33/9
350-0-350 v. 250 mA., 6.3 v. 6 a., 4 v. 8 a., 0-2-6 v. 2 a., 4 v. 3 a., for Electronic Eng. Televisor 69/6
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t., 6.3 v. 4 a., c.t., 5 v. 3 a., suitable Williamson Amplifier, etc..... 47/9
425-0-425 v. 250 mA., 6.3 v. 6 a., 6.3 v. 6 a., 5 v. 3 a..... 69/6

TOP SHROUDED DROP THROUGH TYPE

250-0-250 v. 70 mA., 6.3 v. 2.5 a..... 12/11
260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.... 15/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.... 17/6
275-0-275 v. 80 mA., 6.3 v. 3 a., 4 v. 2.5 a. 14/11
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a. 21/9
300-0-300 v. 100 mA., 6.3 v.-4 v. 4 a., c.t., 0-4-5 v. 3 a..... 21/9
350-0-350 v. 100 mA., 6.3 v. 4 a., c.t., 5 v. 3 a. 21/9
350-0-350 v. 150 mA., 6.3 v. 2 a., 6.3 v. 2 a., 5 v. 3 a..... 29/11
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a. 26/9

E.H.T. TRANSFORMERS. 2,500 v. 5 mA., 2-0-2 v. 1.1 a., 2-0-2 v. 1.1 a., for VCR97, VCR517 or ACR2X..... 36/6

FILAMENT TRANSFORMERS
Primaries 200-250 v. 50 c/s.

6.3 v. 1.5 a.....	5/9	0-4-6.3 v. 2 a....	7/9
6.3 v. 3 a.	8/11	6.3 v. 6 a.	17/6
12 v. 1 a.	7/11		
0-2-4-5-6.3 v. 4 a.	16/9	12 v. 3 a. or 24 v. 1.5 a.	17/6
6.3 v. 2 a.	7/6		

CHARGER TRANSFORMERS
All with 200-230-250 v. 50 c/s Primaries: 0-9-15 v. 1.5 a., 12/9; 0-9-15 v. 3 a., 16/9; 0-9-15 v. 6 a., 22/9; 0-4-9-15-24 v. 3 a., 22/9.

ELIMINATOR TRANSFORMERS
Primaries 200-250 v. 50 c/s. 120 v. 40 mA. 7/11
120 v. 40 mA. 5-0-5 v. 1 a..... 14/9

OUTPUT TRANSFORMERS

Midget Battery Pentode 66 : 1 for 3S4, etc. 3/6
Small Pentode, 5,000Ω to 3Ω..... 3/9
Standard Pentode 5,000Ω to 3Ω..... 4/9
Standard Pentode, 8,000Ω to 3Ω..... 4/9
Standard Pentode, 10,000 ohms to 3 ohms 4/9
Multi-ratio 40 mA. 30 : 1, 45 : 1, 60 : 1, 90 : 1, Class B Push-Pull..... 5/6
Push-Pull 8 Watts 6V6 to 3 ohms..... 8/9
Push-Pull 10-12 Watts 6V6 to 3Ω or 15Ω... 15/9
Push-Pull 10-12 Watts to match 6V6 to 3-5-8 or 15Ω..... 16/9
Push-Pull 15 Watts 6L6s, KT66s, etc. to 3 or 15 ohms..... 19/9
Push-Pull 20 Watts high-quality sectionally wound 6L6, KT66, etc., to 3 or 15Ω..... 47/9
Williamson type, exact to author's spec. 85/-

SMOOTHING CHOKES

250 mA., 3 H. 50 ohms..... 11/9
150 mA., 7-10 H. 250 ohms..... 11/9
100 mA., 10 H. 200 ohms..... 8/9
80 mA., 10 H. 350 ohms 5/6
60 mA., 10 H. 400 ohms..... 4/11
50 mA., 40 H. 1,000 ohms. Potted 10/9
20 mA., 30 H. 1,000 ohms..... 4/9

MICROPHONE TRANSFORMERS
100:1 ..... 5/9

THE SKY CHIEF T.R.F. RECEIVER

A design of a 4-stage, 3 valve 200-250 v. A.C. Mains receiver with selenium rectifier. For inclusion in any of cabinets illustrated above. It consists of a variable Mu high gain H.F. stage followed by a low distortion grid detector triode. The next stage is a further triode amplifier with tone correction by negative feedback. Finally comes the output stage consisting of a parallel connected double triode giving ample output at an extraordinary low level of distortion. Point to point, wiring diagrams instructions, and parts list, 2/6. This receiver can be built for a maximum of £4/16/- including cabinet.

P.M. SPEAKERS. All 2-3 ohms. 3½in. Goodmans (Ex New Units), 10/9. 5in. Goodmans, 15/9. 6½in. Plessey, 16/9. 8in. Plessey, 15/9. 10in. R.A., 26/9. 10in. Plessey, 18/6. 10in. Rola with Trans., 29/6.

R.S.C. BATTERY CHARGER KITS. For mains input 200-250 v. 50 c/s. To charge 6 v. accumulator at 2 amps., 25/9. To charge 6 v. or 12 v. battery at 2 a., 31/6. To charge 6 v. or 12 v. battery at 4 a., 49/9. ABOVE KITS CONSIST OF BLACK CRACKLE LOUVRED STEEL CASE, MAINS TRANSFORMER, FULL WAVE METAL RECTIFIER, FUSES, FUSE-HOLDERS AND CIRCUIT. Any type assembled and tested for 6/9 extra.

H.T. ELIMINATOR AND TRICKLE CHARGER KIT with case, Mains input 200-250 v. Output 120 v. 40 mA. and 2 v. ½ a. Price with circuit 29/6. Or in working order, 37/6.

EX. GOVT. MAINS TRANSFORMERS
All 230 v. 50 c/s. input

250-0-250 v. 40 mA., 6.3 v. 2 a., 5 v. 2 a..... 9/11
8.8 v. 4 a..... 9/9
48 v. 1 a..... 9/6
0-11-22 v. 15 a..... 35/9
0-11-22 v. 30 a..... 72/6
16-18-20 v. 35 a..... 79/6
7.7 v. C.T. 7 amps 4 times..... 25/9
460 v. 200 mA., 6.3 v. 5 a..... 27/9
365-0-365 v. 150 mA 8/9
300-0-300 v. 80 mA. 5 v. 3 a..... 8/11
278-0-278 v. 100 mA..... 8/9
300-0-300 v. 150 mA., 610-0-610 v. 150 mA., 1,220 v. 350 mA..... 29/9
400 v. C.T. 150 mA. 4 v. 6 a., 6.3 v. 6 a., 6.3 v. 0-6 a., 4 v. 6 a., 4 v. 3 a., 4 v. 3 a., 4 v. 3 a., 5 v. 2 a..... 22/9

EX-GOVT. SMOOTHING CHOKES

250 mA., 10 H. 50 ohms..... 14/9
250 mA. 10 H. 100 ohms..... 14/9
250 mA. 3 H. 50 ohms..... 8/9
150 mA. 10 H. 50 ohms..... 10/11
100 mA. 10 H. 100 ohms, Tropicalised..... 6/9
100 mA. 5 H. 100 ohms. Tropicalised..... 3/11
50 mA. 50 H. 1,000 ohms. Potted 8/11
90/100 mA. 10 H. 100 ohms. Potted..... 8/9
50 mA. 5-10 H..... 2/9
L.T. type 1 amp..... 2/9

EX-GOVT. TRANSMITTER-RECEIVER TYPE TR9D, complete with all valves, only 47/9, plus carr. 5/-.

CHASSIS

18 s.w.g. undrilled aluminium amplifier type (4-sided).

12in.×9in.×2½in.	6/11
14in.×9in.×2½in.	6/11
14in.×10in.×3in.	7/11
16in.×10in.×3in.	8/3

18 s.w.g. aluminium receiver type.

6in.×3⅛in.×1½in.	1/11
7½in.×4⅜in.×2in.	2/9
10in.×5½in.×2in.	3/3
11in.×6in.×2½in.	3/11

16 s.w.g. aluminium, receiver type.

12in.×8in.×2½in.	5/3
16in.×8in.×2½in.	7/6
20in.×8in.×2½in.	8/11

16 s.w.g. aluminium, amplifier type, 4-sided.

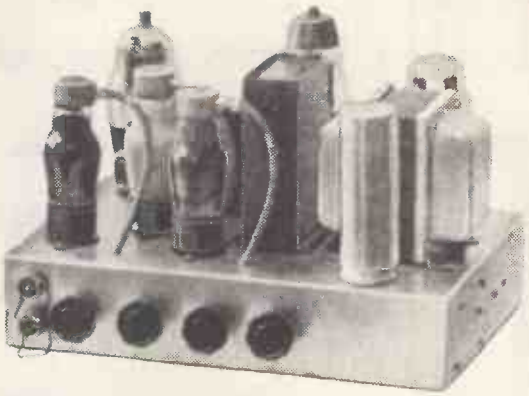
12in.×8in.×2½in.	7/11
16in.×8in.×2½in.	10/11
20in.×8in.×2½in.	13/6
14in.×10in.×3in.	13/6

R.S.C. 25 WATT "PUSH-PULL" AMPLIFIER

Now firmly established and proving extremely popular, our A11 Quality Amplifier we consider to be the best value in amplifiers offered to-day. The volume of its high fidelity reproduction is completely controllable, from the sound of a quiet intimate conversation to the full glorious volume of a great orchestra. Its sensitivity is so high that in areas of fair signal strength it can be operated straight from a crystal receiver. Entirely suitable for standard or long-playing records in small homes or in large auditoriums. For electronic organ or guitar or for garden parties or dance bands.

The kit is complete to the last detail, and includes easy to follow point-to-point wiring diagrams.

Twin volume controls with twin input sockets allow SIMULTANEOUS INPUTS for BOTH MICROPHONE and GRAM, or TAPE and RADIO. SEPARATE BASS and TREBLE CONTROLS giving both LIFT and CUT. FOUR NEGATIVE FEEDBACK LOOPS with 15 db in the main loop from output transformer to voltage amplifier. Frequency response ± 3 db 50-20,000 c.p.s. Hum and distortion LESS THAN 0.5 per cent. measured at 10 watts. This is comparable with some of the highest priced amplifiers. Six B.V.A. valves, Marconi-Osram KT series output valves. A.C. only, 200-230-250 v. 50 c/s. input 420 v. H.T. LINE. Paper reservoir condenser. Compact chassis. Matched components. OVERALL SIZE 12 × 10 × 9in. approx. Output impedances for 3 and 15 ohms speakers.



Available in kit form at the amazingly low price of **9 gns.** Plus carriage 5/- Or ready for use 50/- extra.

W.B. "STENTORIAN" High fidelity P.M. Speaker, HF1012, 10 watts. 15 ohm (or 3 ohm) speech coil. Where a really good quality speaker at a low price is required we highly recommend this unit with an amazing performance. **£3/13/6.**

MICROPHONES. Crystal, hand type, good quality, **£2/19/6.** Stand type with base and adjustable stand, **£5/19/6.** Both suitable for use with our amplifiers.

CONNOISSEUR HIGH FIDELITY LIGHTWEIGHT MAGNETIC PICK-UP COMPLETE WITH MATCHING TRANSFORMER. A fortunate purchase enables us to offer limited supplies. Brand New, Boxed and Perfect at a fraction of normal price. Buy Now at only **26/6.**

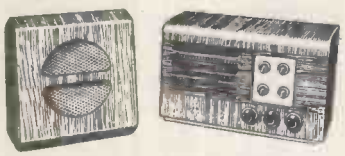
PLESSEY 3-SPEED MIXER AUTOCHANGERS with high impedance magnetic pick-up with duo point alloy stylus for long playing or standard records. (Will play 2,000 records before replacement stylus required.) Brand new, cartoned, guaranteed. Limited stocks at only **10 gns.**, plus 5/- carr.

COLLARO TAPE DESK MOTORS. Shaded pole type. Clockwise or anti-clockwise. Mains input 110-200-250 v., **31/6.**

H.M.V. LONG PLAYING RECORD TURNTABLE COMPLETE WITH CRYSTAL PICK-UP (SAPPHIRE STYLUS). Speed 33⅓ r.p.m. BRAND NEW, CARTONED. Only **£3/19/6** (approx. half price). Carr. 5/-. (For 200-250 v. A.C. Mains.)

A PUSH-PULL 3-4 WATT HIGH-GAIN AMPLIFIER FOR £3/12/6

For mains input 200-250 v. 50 c/s. Complete kit of parts including point-to-point wiring diagrams and instructions. Amplifier can be used with any type of feeder unit or pick up. This is not A.C./D.C. with "live" chassis but A.C. only with 400-0-400 v. Trans. Output is for 2-3 ohm speaker. (We can supply a very suitable 10in. unit by Rola at **27/9.**) The amplifier can be supplied ready for use for **25/-** extra. Full descriptive leaflet, **7d.**



R.S.C. MASTER INTERCOMM. UNIT, with provision for up to 4 "Listen-Talk Back Units" individually switched. A high gain amplifier enables speech and other sounds emanating from the rooms containing remote control units to be heard at the master control. The unit is in kit form and point-to-point wiring diagrams are supplied. A walnut veneered wood or Brown Bakelite cabinet is included. Mains input is 200-250 v. 50 c/s H.T. line 300 v. CHASSIS IS NOT "ALIVE" Ideal also for use as "Baby Alarm." Sound amplification 4 watts. Price only **£5/19/6.** "Listen—Talk Back Unit" in bakelite or walnut veneered cabinet, can be supplied at **30/-** each. Full descriptive leaflet 10d.

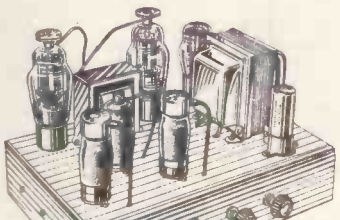
The Master Unit can be supplied assembled and tested for **30/-** extra.

PERSONAL SET BATTERY SUPERSEDER KIT.

All parts for an "All Dry" Battery Eliminator. Complete with case. Supplies 90 v. 10 mA. and 1.4 v. 250 mA. fully smoothed, from normal. 200-250 v. 50 c/s mains. For 4-valve superhet receivers. Price with circuit, **35/9.** Or ready for use, **42/6.** Size of unit 5½-4-1½in

BATTERY SET CONVERTER KITS. All parts for converting any type of battery receiver to all mains. A.C. 200-250 v. 50 c/s. Kit will supply fully smoothed H.T. of 120 v. 90 v. or 60 v. at up to 40 mA., and fully smoothed L.T. of 2 v. at 0.4 a. to 1 a. Price complete with circuit and instructions only **48/9.** Supplied ready for use for **8/9** extra.

R.S.C. 10-watt "Push-Pull" HIGH-FIDELITY AMPLIFIER A3



Complete with integral pre-amp. Tone control stage (as AII amplifier), using negative feedback, giving humproof individual bass and treble lift and cut tone control. **Six Negative Feedback Loops.** Completely negligible hum and distortion. Frequency response ± 3 db. 30-20,000 c.p.s. Two independently controlled inputs. Six B.V.A. valves. A.C. mains 200-230-250 v. input only. Outputs for 3 or 15 ohms speakers. Kit of parts complete in every detail, **£7/19/6,** plus 5/- carriage, or ready for use, **45/-** extra. Descriptive leaflet **1/-.**

FOUR STAGE RADIO FEEDER UNIT. Design of a HIGH FIDELITY, L. and M. wave T.R.F. Unit with self-contained heater supply and thorough H.T. decoupling. Only 250-400 v. 15-20 mA. H.T. required from main amplifier. Three valves and Low Distortion Germanium Diode Detector. Flat topped response characteristic. Loaded H.F. coils. Two variable Mu controlled H.F. stages, 3 gang condenser tuning. Cathode follower output stage. Switch position for Gram. and Gram. input and output sockets. Performance comparable with the best in Feeder Units. For A.C. mains 200-230-250 v. operation. Size 11-6-7½in. Illustration, full set of easy-to-follow wiring diagrams and instructions and individually priced parts list 2/6. This unit can be built for only **£3/15/-,** including Dial and Drive Knobs and every item required.

R.S.C. TONE CONTROL-PRE-AMP. UNIT. A complete set of parts for the construction of a very efficient but simple pre-amplifier and tone control unit. For use with any amplifier and pick-up. Fil. supply self-contained. Size 7½-5-5½in. approx. Descriptive leaflet **9d.** Price, inc. wiring diagrams, **37/6.** Ready for use, **15/-** extra.

Radio Supply Co. (LEEDS) LTD.

32 THE CALLS. — LEEDS, 2.

Terms C.W.O. or C.O.D. No C.O.D. under £1. Postage 1/- extra under 10/-, 1/6 extra under £2, 1/11 extra under £3. Full Price List 6d. Trade List 5d.
Open to Callers: 9 a.m. to 5-30 p.m. Saturdays until 1 p.m.

MAINS TRANSFORMERS

Primary, 200-250 v. P. & P. 2/-.

300-0-300, 100 mA., 6 v. 3 amp., 5 v. 2 amp., 23/6.

Drop thro' 350-0-350 v. 70 mA., 6 v. 2.5 amp., 5 v. 2 amp., 14/6.

Drop thro' 250-0-250 v. 80 mA., 6 v. 3 amp., 5 v. 2 amp., 14/6.

280-0-280, drop through, 80 mA., 6 v. 3 amp., 5 v. 2 amp., 14/6.

250-0-250 80 mA., 6 v. 4 amp., 14/-.

Drop thro' 280-0-280, 200 mA., 6 v. 5 amp., 5 v. 3 amp., 27/6.

Drop thro' 270-0-270, 80 mA., 6 v. 3 amp., 4 v. 1.5 amp., 13/6.

Drop thro' 270-0-270 60 mA., 6 v. 3 amp., 11/6.

250 v. 350 mA., 6.3 v. 4 a., twice 2 v. 2 a., 19/6.

Auto-trans. Input 200/250, H.T. 500 v., 250 mA., 6 v. 4 a., twice, 2 v. 2 a., 19/6. 250-0-250, 60 mA., 6.3 v. 1.5 a., 0-5-6.3 v. 1.5 a., 10/6.

Auto Trans. Input 200/250. H.T. 350 v. 350 mA. Separate L.T. 6.3 v. 7 a., 6.3 v. 1½ amp., 5 v. 3 amp., 25/-. P. & P. 3/-.

Heater Transformer. Pri. 230/250 v. 6 v. 1½ amp., 6/-; 2 v. 2½ amp., 5/-. Pri. 200/250. Secondary 9 v. 3.5 amp., 9 v. 3.5 amp., 12/6.

Pri. 200-250. Secondary 9 v. 3.5 amp., 6.3 v. 3 amp., 12/6.

Pri. 230 v. Sec. 500-0-500 and 500-0-500 250 mA. both windings. 4 v. 3 amp., 4 v. 3 amp. 39/6. P. & P. 5/-.

Mains Transformer, fully impregnated, input 210, 220, 230 and 240. Sec' 600-0-600, 275 mA., and 200 v. at 30 mA., complete with separate heater transformer. Input 210, 220, 230, 240. Sec. 6.3 v. 2 amp. three times, 0, 4, 6.3 v. at 3 amp. and 5 v. 3 amp., 45/-. P. & P. 5/-.

Mains Transformer, fully impregnated. Input 210, 220, 230, 240. Sec. 350-0-350 100 mA., with separate heater transformer. Pri. 210, 220, 230, 240. Sec. 6.3 v. 2 amp., 6.3 v. 3 amp., 4 v. 6 amp., and 5 v. 2 amp., 30/-. P. & P. 5/-.

MAINS TRANSFORMERS, chassis, mounting, feet and voltage panel. Primaries 200/250.

350-0-350 75 mA. 6.3 v. 3 a. tap 4 v. 6.3 v. 1 a., 13/6.

350-0-350 70 mA. 4 v. 4 a., 4 v. 2.5 a. C.T., 18/6.

500-0-500 125 mA. 4 v. C.T. 4 a., 4 v. C.T. 4 a., 4 v. C.T. 2.5 a., 27/6.

500-0-500 250 mA. 4 v. C.T. 5 a. 4 v. C.T. 5 a. 4 v. C.T. 4 a., 39/6.

9in. T.V. Cabinet, front in contrasting walnut veneers, size 16½in. long, 11½in. high, by 12½in. wide. Complete with two pieces expanded aluminium in gold, 12 × 9in. and 5in. speaker baffle and chassis, 20/-, post paid.

P.M. SPEAKERS	with trans.	less trans.
2½in.	—	18/-
3½in.	—	16/-
5in.	19/-	15/-
6½in.	19/-	15/-
8in.	21/-	17/6
10in.	—	22/-

6½in. M.E. Speaker, 1,000 ohm field, 15/-.

R. & A. T.V. energised 6½in. speaker with O.P. trans., field coil 175 ohms, 9/6. P. & P. 2/6.

R. & A. 6½in. M.E. speaker with O.P. trans., field 440 ohms 10/6. P. & P. 2/6. Volume Controls. Long spindle less switch, 50K, 500K, 1 meg., 2/6 each. P. & P. 3d. each.

Volume Controls. Long spindle and switch, ¼, ½, 1 and 2 meg., 4/- each; 10K and 50K, 3/6 each. ¼ and 1 meg., long spindle double pole switch, miniature, 5/-. P. & P. 3d. each.

Trimmers, 5-40 pf., 5d. 10-110, 10-250, 10-450 pf., 10d.

Twin-gang .0005 Tuning Condenser, 5/-. With trimmers, 7/6.

Line Cord, 2-way 0.3 amp., 60 ohms per foot, 1/3 per yard.

Twin-Gang .0005, with feet, size 3¼ × 3 × 1⅝in., 6/6.

3-gang .0005, with feet, size 4¼ × 3 × 1⅝in., 7/6.

T.V. Coils, moulded former, iron-cored, wound for re-winding purposes only. All-can 1¼ × 1¼in., 1/- each, 2 iron-core all-can 2¼ × 1¼in., 1/6 each.

Used Metal Rectifier, 250 v. 150 mA., 6/6.

Metal Rectifier, 230 v. 45 mA., 6/-.

Metal Rectifier, RM2, 125 v., 100 mA., 3/6.

D. COHEN

RADIO AND TELEVISION COMPONENTS

Terms of Business: Cash with order. Despatch of goods within 3 days from receipt of order. Where post and packing charge is not stated please add 1/6 up to 10/-, 2/- up to £1, and 2/6 up to £2. All enquiries, S.A.E., lists 5d. each.

SPECIAL NOTE: NO GOODS SENT WHERE CUSTOMS DECLARATION IS APPLICABLE

23 HIGH STREET (Uxbridge Road) ACTON, W.3. Telephone: ACOrn 5901.

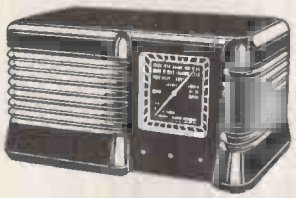
Hours of Business:

Saturday 9—5 p.m. Wednesday 9—1 p.m. Other days 9—4.30 p.m.

T.V. CONVERTER for the new commercial stations complete with 2 valves. Frequency:—can be set to any channel within the 186-196 Mc/s. band. I.F.:—will work into any existing T.V. receiver designed to work between 42-68 Mc/s. Sensitivity:—10 Mu/v with any normal T.V. set. Input:—arranged for 300 ohm feeder. 80 ohm feeder can be used with slight reduction in R.F. gain. Circuit EF80 as local oscillator. ECC81 as R.F. amplifier and mixer. The gain of the first stage, grounded grid R.F. AMPLIFIER 10 db. Required power supply of 200 v. D.C. at 25 mA. 6.3 v. A.C. at 0.6 amp. Input filter ensuring complete freedom from unwanted signals. 2 simple adjustments only. £2/10/-. P. & P. 2/6.

HIGH-IMPEDANCE PLASTIC RECORDING TAPE, by famous manufacturer. 600ft. on aluminium spool, 8/-, 1,200ft. on aluminium spool, 17/6 post paid.

PLASTIC CABINET, as illustrated, 11½ × 6½ × 5½in., in Walnut, Cream and Green, also in polished Walnut complete with T.R.F. chassis, 2 wave-band scale, station names, new wave-band, back-plate, drum, pointer, spring, drive spindle, 3 knobs and back, 22/6. P. & P. 3/6.



AS ABOVE, with superhet chassis, 23/6. P. & P. 3/6.

AS ABOVE, complete with new 5in. speaker to fit and O.P. trans., 37/6. P. & P. 3/6. With superhet chassis, 38/6. P. & P. 3/6.

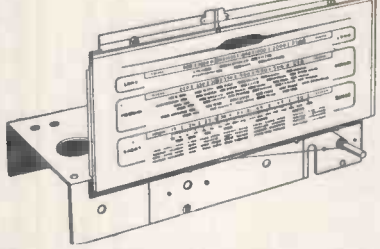
Used metal rectifier, 230 v. 50 mA., 3/6. gang with trimmers, 6/6; M. & L. T.R.F. coils, 5/-; 3 obsolete ex-Govt. valves, 3 v/h and circuit, 4/6; heater trans., 6/-; volume control with switch, 3/6; wave-change switch, 2/-; 32 × 32 mfd., 4/-; bias condenser, 1/-; resistor kit, 2/-; condenser kit, 4/-; M. & L. Superhet Coils with circuits, 6/6; iron-cored 465 I.F.s, 7/6; min. gang, 5/6; volume control with switch, 4/-; wave-change switch, 2/6; heater trans., 7/6; 4 v/h, 1/6; 4 obsolete ex-Govt. valves, metal rectifier and Xtal diode with circuit, 14/6; 25 × 25 mfd., 1/-; 16 × 16 mfd., 3/3; condenser kit (17), 7/6; resistor kit (14), 3/6.

Cylden 5 channel T.V. Tuner, uses EF80 and 12AT7, less valves, 12/6, post paid.

Radiogram Chassis, 5 va ve A.C./D.C. 3 wave-band superhet 195-255 v., 19-49, 200-550 and 1,000-2,000 metres, I.F. 470 Kc. size of chassis 13 × 6½ × 2½in., size of scale 7½ × 3½in. valve line-up 10C1, 10F9, 10LD11, U404 and 10P14. Twin mains filter input, 2 dial lights and 8in. P.M. £8/17/6. P. & P. 5/-

CR100 Coil packs, 10-2,000 metres, in soiled condition complete with 4-gang tuning condenser. 19/6. P. & P. 3/6.
CR100 Coil packs in first class condition less oscillator section, complete with 4-gang tuning condenser. 19/6. P. & P. 3/6.
CR100 465 Kc. I.F.s, types 3, 4 and 5 and B.F.O., new condition, 7/6 each.
465 Kc Xtal for CR100, 12/6.
4-gang tuning condenser for CR100, 9/6.

CONSTRUCTOR'S PARCEL comprising chassis 12½ × 8 × 2½in., cad. plated, 18 gauge, v/h., I.F. and trans. cut-outs, back-plate, 2 supporting brackets, 3 wave-band scale, new wavelength stations names. Size of scale 11½ × 4½in., drive sp., drum, 3 pulleys, pointer, 3 bulb holders, 5 par. I.O. v/h., 4 knobs and pair of 465 I.F.s, twin gang, 16 × 16 mfd. 350 wkg., mains trans. 250-0-250 60 mA., 6.3 v., 2 amp. 5 v. 2 amp. and 6½in. M.E. speaker with O.P. trans. 39/6. P. & P. 3/6.



Battery charger, input 230/250 v. output 6 and 12 volt 1 amp. Black crackle finished case size 10 × 6 × 4in. 21/-. P. & P. 3/-.

OUTPUT TRANSFORMERS. Standard type 5,000 ohms imp., 4/9; 42-1 with extra feed-back windings, 4/3. Miniature 42-1, 3/3. Multi-ratio 3,500, 7 000 and 14,000, 5/6. 10-watt push-pull, 6V6 matching, 7/-. 90-1 3 ohm speech coil, 6/6.

PUSH-BACK CONNECTING WIRE. Doz. yds., 1/6. Post paid.

STANDARD WAVE-CHANGE SWITCHES 4-pole 3-way, 1/9; 5-pole 3-way, 1/9; 3-pole 3-way, 1/9; 9-pole 2-way, 3/6; Miniature type, long spindle 3-pole 4-way, 4-pole 3-way and 4-pole 2-way, 2/6 each. 2-pole 11-way twin wafer 5/-; 1-pole 12-way single wafer 5/-. P. & P. 3d.

POTATO AND VEGETABLE PEELER

By famous manufacturer, capacity 4½ lbs., complete with water pump. All aluminium construction, white stove-enamel finish. Originally intended for adaption on an electric food-mixer, can be easily converted for hand operation. 39/6. P. & P. 3/-.

PERSONAL SHOPPERS ONLY. 9in. Enlarger, 17/6; 12in., 27/6.

Germanium Crystal Diode, 1/6, post paid.

Used 9in. Tube, with ion burn, 17/6, post paid.

Line O.P. Transformer in aluminium can mounted in rubber, 12/6.

Crystal Set, medium and long wave, in plastic cabinet, 16/-.

Headphones, per pair 8/-.

Speaker Matching Unit on aluminium chassis, 3-15 ohms, reversible, 12/6.

Line and E.H.T. Transformer, 14 kV., using ferrocart core, complete with line and width control, and corona shields, U37 rectifier winding, 35/-.

Line and E.H.T. Transformer, 9 Kv., using ferrocart core, complete with built-in line and width control. Mounted on small all-chassis. Overall size 4½ × 1½in. EY51 rec. winding, 27/6.

Line and E.H.T. Transformer, 9 Kv., ferrocart core, EY51 heater winding, complete with scan coils and frame output transformer, and line and width control, £2/5/-. P. & P. 3/-.

Scan Coils, low line low impedance frame, complete with frame transformer, to match above, 27/6. P. & P. 2/-.

Valve Holders, moulded octal Mazda and loctal, 7d. each. Paxolin, octal Mazda and loctal, 4d. each. Moulded B7G, B8A and B9A, 7d. each. B7G moulded with screening can, 1/6 each.

32 mfd., 350 wkg.	2/-
16 × 24, 350 wkg.	4/-
4 mfd., 200 wkg.	1/3
40 mfd., 400 wkg.	3/6
16 × 8 mfd., 500 wkg.	4/6
16 × 16 mfd., 500 wkg.	5/9
16 × 16 mfd., 450 wkg.	3/9
32 × 32 mfd., 350 wkg.	4/-
32 × 32 mfd., 350 wkg., and 25 mfd., 25 wkg.	6/6
25 mfd., 25 wkg.	11d.
250 mfd., 12 v. wkg.	1/-
16 mfd., 500 wkg., wire ends	3/3
8 mfd., 500 v. wkg., wire ends	2/6
8 mfd., 350 v. wkg., tag ends	1/6
50 mfd., 25 v. wkg., wire ends	1/9
100 mfd., 350 wkg.	4/-
100 mfd., 450 v. wkg., 280 mA., A.C. ripple	3/11
150 mfd., 350 v. wkg., 280 mA. A.C. ripple	4/6
100+200 mfd., 350 wkg.	9/6
16+16 mfd., 350 wkg.	3/3
50 mfd., 180 wkg.	1/9
65 mfd., 220 wkg.	1/6
8 mfd., 150 wkg.	1/6
60+100 mfd., 280 wkg.	7/6
50 mfd., 12 wkg.	11d.
32+32 mfd. min 275 wkg.	4/-
50 mfd., 50 wkg.	1/9

Miniature wire ends moulded, 100 pf., 500 pf., and .001, ea... 7d.

T.V. Filter in lightly tinted Perspex, size 13½ × 11 × 3/16in., 4/6.

Combined 12in. mask and escutcheon in lightly tinted Perspex. New aspect, edged in brown. Fits on front of cabinet, 12/6. As above for 15in. tube, 17/6.

Frame Oscillator Blocking Trans., 4/6.

Line Osc. Blocking Trans., 4/6.

Tube Mounting Bracket, size 9½ × 4½in. 12in. tube clamps, 2/-.

CHOKES:
2-20 Hen, 150 mA., 15/-. P. & P. 3/-. 6 Hen., 275 mA., 15/-. P. & P. 3/-. 100 Hen., 40 mA., 15/-. P. & P. 3/-. 2 henry 150 mA., 3/6; 250 mA. 10 henry 10/6; 5 henry 250 mA., 60 ohms, 8/6.

P.M. Focus Unit for any 9 or 12in. tube except Mazda 12in., with Vernier adjustment, 15/-.

P.M. Focus Unit for Mazda, 12in., with vernier adjustment, 17/6.

Wide Angle P.M. Focus Units, Vernier adj., state tube, 25/-.

Energised Focus Coil, low resistance mounting bracket, 17/6.

Ion Traps for Mullard or English Electric tubes, 5/-, post paid.

465 Kc. I.F.s, size 2½ × 1½in. Q.110, removed from American equipment 5/- per pair. Standard 465 Kc. iron-cored I.F.s, 4 × 1½ × 1½in., per pr. 7/6. Wearite standard, iron-cored, 465 Kc. I.F.s 3½ × 1⅝ × 1⅝in., per pr. 9/6.

Iron-cored 465 Kc. Whistle Filter, 2/6.

465 KC. MIDGET I.F.s. Q.120 size 1½in. long, 1in. wide, ¾in. deep by very famous manufacturer. Pre-aligned adjustable iron-dust cores, per pair 12/6.

Mains Droppers. 0.3 amp., 460 ohms, tapped 280 and 410, 1/6; 0.2 amp., 717 ohms, tapped at 100 ohms, vitreous, 1/6; 0.3 amps, 950 ohms, tapped 700 and 825, 2/6; 0.2 amp., 1,000 ohms, vitreous, tapped, 2/6; vitreous, 0.3 amp., 700, tapped 680, 640, 600, 3/6. P. & P. on each 3d.

T.V. Width Controls, 3/6.

ANOTHER DELIVERY OF INFRA-RED RECEIVERS, TYPE 5C/2801. This unit is an Infra-Red Detecting Device, as used by the R.A.F. for tail warning system. The unit consists of two parts, viz.: (1) an image converter tube of the type described in "Electronic Engineering" (Sept., 1948), is used in conjunction with a lens system. The Lenses, which are covered with an infra-red filter to admit infra-red radiation only, focus to object to be viewed on the photo cathode of the image converter. (2) A canister consisting of a number of high-voltage batteries connected to give a voltage of 4 kV. (These batteries are known as Zun Band Piles, and are described in "Electronic Engineering," Oct., 1948.) A high voltage from this canister is applied to the tube and an image is formed on a fluorescent screen. This image is viewed by means of another lens, forming an eye-piece. These receivers have many uses in their original form, or their parts used in various work. The lenses are well mounted and the converter tube housed in an insulated case. This unit is ideal where high voltage with negligible current drain is required in a small space, and is useful for many other uses in laboratories, viz., electrostatic experiments with electroscopes of all types. Supplied in wooden transit case (size 20in. × 7½in. × 9in.). An absolute bargain at 55/-.
HAND GENERATOR POWER SUPPLY UNIT No. 7 (ZA17571). With hand generator and cut-out, but less accumulator. Can be used as a wind generator or as ordinary hand operated charger for 6-volt batteries. Will give sufficient current to a "flat" battery to start a car. Complete in case (17in. × 10in. × 7½in.) with full working instructions. Brand new in original cartons 19/6 plus 3/6 carriage.
INDICATOR UNIT TYPE 157. Has same line-up as **INDICATOR TYPE 62**: viz.: VCR97 C.R. Tube, mask, and mu screen, 16-SP61, 2-EB34, 4-EA50 valves, 15 potentiometers, resistors, condensers, Muirhead S.M. dial, etc. Brand new in transit case. Price £3/7/6. Plus 7/6 carr.
INDICATOR UNIT TYPE 233. Complete with VCR97 C.R.T. 3-VR91, (EF50), 3-VR65 (SP61), 3-VR54 (EB34), 2-VR92 (EA50) valves, resistors, condensers (including .1 mfd. 2.5 kV.), pots, etc. Price 49/6. Plus 5/- carr.
R.F. UNITS, TYPE 26. Covering 50 to 65 mc/s. Complete with all valves. Brand new in cartons. Price 35/-. Plus 2/6 post. Also **R.F. UNITS. TYPE 24.** Complete with valves. Slightly soiled on outside. Price 14/6. Plus 2/6 post.
R.F. MONITOR. TYPE 114. With 2-EF50 valves and EA50 diode, mounted on neat chassis, 4in. × 4½in. Price 12/6. Plus 1/6 post.
CONDENSERS. .1 mfd. 2.5 kV wkg. at 4/6 each, 5 for £1. .03 mfd. 2.5 kV at 2/6 each. .1 mfd. 1,200 v. wkg. at 1/9 each. .25 mfd. 1,500 v. wkg. at 3/6 each. Also **ELECTROLYTIC CONDENSERS.** Brand new current stock 20 mfd. 500 v. wkg. 2/6 each, 5 for 10/-. 100 mfd. 450v. wkg. 2/6 each, 5 for 10/-. Please add 1/3 postage.
MANSBRIDGE BLOCK CONDENSERS. 4 mfd. 1,000 v. wkg., 3/9 each. Plus 1/- post.
CERAMICONS. 3.3 pf., 1.5 pf., at 3/- doz. 30/- gross.
MAINS TRANSFORMERS. 425-0-425 v. 200 mA. at 32/6 each, plus 2/6 post., 320-0-320 v. 80mA., 6.3 v. 3A, 5 v. 2A. at 13/6 each, plus 1/6 post.
SMOOTHING CHOKES. 16 henries 60mA. Size 3in. × 2in. × 1¾in. Ideal for small receivers, power packs, etc. 4/6 each, plus 1/- post. 6 henries 70mA. (140 Ω) at 6/6 each, plus 1/- post.
OCTAL PLUGS (with covers). Fits into int. octal holder to make a useful 8 way plug and socket, 9d. each, 8/6 doz.
12 PIN PLUG AND SOCKETS. At 9d. per pair, 8/6 doz. pairs.
LONDEX RELAY UNIT. Containing 2,000 Ω relay (1 break, 1 change-over) with heavy duty contacts, and slight delay chain of 50 Ω wire wound resistor, 1,500 Ω slider resistor, and a 250 mfd., 12 v. condenser. Mounted on Bakelite base. Will operate on 24-30 v. D.C. Brand new in original cartons. Price 8/6 each, plus 1/- post.
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VALVES. VR65 at 2/6 each, 24/- doz. VR92 at 2/6 each, 24/- doz. VS70 at 3/6 each.
GERMANIUM CRYSTAL DIODES. Wire-ended. 1/6 each. 13/6 doz.
BULBS. 2.5 v. .15 amp. American manufacture. Brand new and boxed in sets of 10. Price 1/9 per box. Plus 3d. post.
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CUT-OUTS. 6 volt and 12 volt. Available at 2/- each. Post free.
SPECIAL OFFER OF TRIMMERS. One dozen assorted (fair quantities of each) of the following:—Double postage stamp 100/50 pf. Paxolin, 100/100 pf. Paxolin, 100/100 pf. Ceramic, single air-spaced 25 pf., 50 pf. and 100 pf. at 4/6 per doz. (minimum quantity 1 dozen).
TUNING CONDENSERS. .0003 mfd. (300 pf.) 3 gang. At 3/6. Post free.
AMPLIFIER UNIT. TYPE 1271. Containing EF36 valve, 400 Ω relay (4 makes, 2 breaks), 10,000 Ω pot., resistors, condensers, etc., in black metal case 5in. × 5in. × 5in. Brand new at 7/6 each. Plus 1/6 post.
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0-2.5 amps. R.F. 2in. square panel mounting. Mounted in neat wooden box 5½in. × 3in. × 3in. Brand new at 7/6 each. Plus 1/6 post.
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METERS. 2½in. Flush mounting M.C. 100 mA., 0-10 mA., 0-30 mA., 12/6 ea.; 2in. Flush square 0-5 mA., 10/-; 0-15 A., proj. thermo. 2½in., 7/6; 0-9 A. hot-wire, 5/-; 0-1 mA. 2in. Flush, 20/-.
TEST METER. 7 ranges as follows: 1.5 v., 3 v., 150 v. 6 mA., 60 mA., 5,000 ohms, 25,000 ohms 2½in. dia. scale M.C. meter. Rotary selector switch. Black bakelite case, 6 x 4½ x 4½ fitted with removable lid, also provision for internal batts., ranges can be easily extended. Bargain price 30/-, plus 1/6 post.

SPECIAL OFFER, AR88 SPARES. Cabinets, complete with base, feet and side strips, £4/15/- each. Pkg. and Carr. 5/-. Set of 14 valves for "D" or "LF" model receivers, £5/10/-. Panel escutcheons, 22/6 each. "D" type I.F.S., 12/6 each. Good selection of Spare Coils available for "D" Model, 7/6 each. Matching Speakers by R.C.A., fitted rubber feet and 6ft. lead, 65/-. Output Transformers to Govt. specification, 37/6 each.

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STREAMLINED BUG KEYS. By famous manufacturer. List over £4. Our price 45/-. **AIR SPACED COAXIAL CABLE,** 150 ohm (normal price 3/11 per ft.), 20yd. coils only. £1 per coil, post free.
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TINNED COPPER WIRE—All 4 oz. Reels.

16 S.W.G.	2/-
18 S.W.G.	2/2
20 S.W.G.	2/4
22 S.W.G.	2/6
24 S.W.G.	2/8
26 S.W.G.	2/10

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S.W.G.	Price	S.W.G.	Price
16	1/11	30	3/1
18	2/1	32	3/3
20	2/3	34	3/5
22	2/5	36	3/7
24	2/7	38	3/11
26	2/9	40	4/2
28	2/11		

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12in. × 8in. × 2½in.	8/6 ea.
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All are four sided—ideal for radio receivers—amplifiers—power packs, etc.

SET OF VALVES. Ten VR91 (EF50) valves. Ex-Brand new units, 6/- each, 45/- set.

GRAMOPHONE MOTORS, etc. Collaro AC37 Gramophone motor suitable for 100/120 v. 200/250 v. A.C. variable speed, complete with 10in. E.M.I. type turntable felt covered. Price, 46/- each, plus 2/- post.

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THE "EKE" QUALITY 3 WATT AMPLIFIER

COMPARE THIS PRICE!

This is not a kit of parts but a well-built unit—read this specification.

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- ★ A.C. mains fully isolated.
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Price 79/6. Packing & Post 2/6.

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To strip cable of diameters ¼in., ⅜in., ½in., ideal for coaxial cable ..... 5/- ea.

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45Ω Impedance with leads No. AZ0545 ..... 1/9 ea.

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9002	5/6	VU120A	3/-	VR92	2/-	VR66	3/9
9006	6/-	1A5GT	6/6	VR116	4/-	VR105/30	9/-
956	3/6	6G6G	6/6	VR137	6/3	VR119	4/-
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"Regent" Hand Microphone. Crystal insert, nickel chrome plated head, complete with lead and Jack plug, listed at 2 Gns. Our price	21/- ea.
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230 v. Input 2 volt 3.0 amp.	7/9
230 v. Input 4 volt 1.5 amp.	5/-
230 v. Input 4 volt 3.0 amp.	10/-
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Multi Ratio suitable for all ordinary receivers giving six single ratios..... 6/6 ea.

CONTROL KNOBS in MODERN STYLING

Tastefully and clearly engraved in gold.
Size A. Diameter 1⅛in. Depth ⅜in.
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These Mouldings are available in two colours: Walnut and Ivory.
They are suitable for use with ¼in. spindles, and are simply and firmly held by means of a grub screw and locking nut.
Prices:
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Plain Knobs can be supplied in either size or colour: Price 1/- each and 8d. each respectively.
Inscriptions available:—
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This well-known cabinet of which thousands have been sold is ideal for every constructer. Complete with chassis, dial, backplate, cord drive, pointer and dial drum. Price 27/6 each.

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20H, 250Ω, 60 mA. Clamp construction	6/- ea.
10H, 200Ω, 90 mA. Clamp Construction	9/3 ea.
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230 v. Input Tapped 6-12 v. 1 amp. ..... 13/6 ea.
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(Both with tap on Primary for 2.5 v. Pilot light)

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This attractive walnut finished cabinet is available for 6½in. or 8in. speaker units. Metal speaker fret, complete with back and rubber feet.
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Tolerance + − 10%.
Ratings 5 watt, 1/- each. 10 watt 1/3 each. 15 watt 1/9 each.

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Primary 200/250 v. Secondary 6.3 volt 1.5 amps, tapped at 4V. and 2V. 7/6 ea.

MALLORY .1mfd. 600V CONDENSERS. 1/- each.

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Vibrator Clips 4d. each.
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Ex Govt. Hand Microphones. Bakelite case, switch in handle, complete with lead, 7/6 each.
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PLESSEY 3in. Round type for personal portables 2 to 3 ohm	12/9
ELAC 4in. Square type 4/02, 2 to 3 ohm	13/9
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R. & A. 10" unit	21/6 ea.

PENCIL RECTIFIERS

K3/25, 5/8; K3/40, 7/6; K3/45, 8/2; K3/50, 8/8; K3/60, 9/8; K3/100, 14/8.

SENTERCEL RECTIFIERS

RM1, 3/9 ea.; RM2, 4/2 ea.; RM3, 5/- ea.; RM4, 16/- ea.

METAL RECTIFIERS

12 v. ½ amp., 1/6 ea.; 12 v. 1 amp. 4/6 ea.; 2 v. 1 amp., 3/- ea.; 250 v. 45 mA., 6/3 ea.; 250 v. 75 mA., 7/6 ea.; 300 v. 60 mA., 7/6 ea.

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12 v. 1 amp., 4/9 ea.; 12 v. 2 amp., 8/- ea.; 12 v. 3 amp., 13/- ea.; 12 v. 5 amp., 18/- ea.

SPECIAL OFFER
Co-axial Cable
Best quality grade "A" cable solid 1/022 70 ohms, 7½d. yd. Best quality Grade "A" cable stranded 7/0076, 8½d. yd. Best quality Grade "A" cable air spaced 1/036, 1/- yd.

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½, 1, 1½, 2, 3, 5 amp. 1¼in. Standard Cartridge Fuses 3d. ea.
Panel Mounting Press Switch 1/3 ea.

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Complete with mounting bracket and including 2 space heating units 230 v. 230 w. ..... 35/- set

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Suitable for use as a projector or recording case, size 15in. × 9½in. × 13in. Internal dimensions: 14in. long, 11½in. deep, 5½in. front H.T. 8½in. rear H.T. With a black rexine finish. Weight 8½ lb. ..... 13/6 ea.
Post and packing 2/6.

TERMS: Cash with order or C.O.D. Postage and Packing charges extra, as follows: Orders value 10/- add 9d.; 20/- add 1/-; 40/- add 1/6; £5 add 2/- unless otherwise stated. Minimum C.O.D. fee and postage 2/3.

MAIL ORDER ONLY

ALPHA RADIO SUPPLY CO.

5/6 VINCES CHAMBERS, VICTORIA SQUARE, LEEDS 1.

WHEN ORDERING PLEASE QUOTE "DEPT. W.W."

Best Buy at Britain's

MODULATOR TYPE 67. This unit is a pulse modulator with pulse width of 1, 2 and 5 micro-seconds. The pulse amplitude is also variable. It is a particularly useful instrument as it contains a heavy duty power pack suitable for 230 volt 50 cps. mains supply. The mains transformer outputs are 6.3 volts twice, 5 volts. for the rectifier and the H.T. winding is 345-0-345 volts. Also included are 5 SP61, one VR116, 2 EB34, and 3 EA50. Size of case 18 × 9 × 7 inches. These units are brand new in original packing cases. Price 67/6 plus 7/6 carriage.

POWER PACK TYPE 301. This was the mains power pack used for the complete TR.1196 contained in a neat black case size 8¼in. × 4½in. × 6½in. high. For 200/250 volts A.C. 50 cps. Output 250-0-250 v. 6.3 at 2.8 amps. 6.3 v. at .6 amps. for 6X5G rectifier. 31 volts at .3 amps. supplies metal rectifier for bias. The transformer is a massive job. Price only 27/6 plus 2/6 post. Should be O.K. for R.1155, etc.

METER BARGAINS, ALL BRAND NEW

15 v. (50 ~) mov. Iron 2½in. pnl. mtg....	8/6
20 volt moving coil 2in. sq. pnl. mtg. ...	7/6
3,500 volts moving coil 3½in. projection	10/-
150 milli-amp. 2in. sq. pnl. mtg.....	7/6
5 milli-amp. moving coil 2in. sq. pnl. mtg.	7/6
20 amp. moving coil 2½in. dia.	7/6
1mA. 2½in. barrel flush pnl. mtg.	22/6
1 milli-amp. 2½in. barrel desk type	25/-
100 micro-amps. 2½in. barrel pnl. mtg. scaled 0-1,500 in 15 clear divisions. Only	42/6
500mA. Thermo Couple 2in. sq. pnl. mtg.	5/-

METER RECTIFIERS. 1 mA. Salford instruments, 8/9. 5mA. Salford Instruments, 6/9. 2mA. S.T.C. as used in E.M.I. Output Meter, 5/6. All are full wave bridge and brand new.

METAL RECTIFIERS. Heavy duty Selenium 10½in. long with 3½in. square plates. Two are required for a full wave bridge giving 48 volts at 10 amps. Brand new and ridiculously cheap at only 57/6 per pair plus 2/6 post. R.M.4 250 volts 250-mA. Only 12/6. R.M.2, 4/3 each or 2 for 8/-. Selenium 300 volts 100 mA. Brand new, ex-W.D., 6/9 each.

X'TALS

465 kc/s S.T.C. ½in. pins suitable for crystal gates, IF checking, etc. Brand new, boxed, 10/- each.
200 kc/s American G.E.C. ½in. pins suitable for crystal calibrators, etc. Brand new, boxed, 10/- each.

6 VOLT H.R.O. VIBRATOR PACK. Gives 165 volts at 80 mA. smoothed D.C. Uses Mallory Vibrator 6X5G, heavy duty smoothing choke, etc. In black crackle cabinet size 7in. × 7in. × 6in. Brand new, only 29/6.

POWER UNIT TYPE 285. A.C. mains input 230 v. 50 cps. Outputs E.H.T. 2 kV. @ 5 mA., H.T. 450 volts @ 200 mA., L.T. 6.3 v. @ 17 amps., fully smoothed, 2 chokes, paper condensers, etc., complete with valves 5U4G, VU 120 and EF 50. This was the ground power unit for the "Gee" equipment and should be very useful for T.V., etc. A REAL BARGAIN AT ONLY 69/6.

TRANSFORMER BARGAINS. Brand new ex-manufacturer's surplus drop through. Primary 200/250 volts 50 cps. Secondary 310-0-310 v. 70 mA., 6.3 @ 3 a., 4 v. @ 2 a. Can be used with either 4 v. or 6.3 v. rectifier. Only 9/6 plus 1/6 post. A similar type transformer 325-0-325 100 mA., 6.3 v. 4 a., etc., can be supplied to callers only at 14/6.
Filament transformers, standard tapped primary, 12 v. 1½ a. and 4 v. 1½ a. secondary. Only 7/6.

GRAYSHAW INSTRUMENTS

We are London stockists of these fine instruments which represent superlative value. We can thoroughly recommend these and have no hestitation in stating that they compare very favourably with much more expensive equipment.
Now available—**SIGNAL GENERATOR SG50** covering 100 Kc/s to 80 Mc/s on FUNDAMENTALS in 6 bands. Priced at £7/19/6, its handsome appearance does not belie its excellent performance.
RESISTANCE CAPACITY BRIDGES priced at £6/19/6. An accurate and compact companion instrument also available.

COMMUNICATIONS RECEIVER ADMIRALTY TYPE B.28 (MARCONI CR.100). Valve line up 2 RF, F.C. separate local Osc., 3 I.F.'s, 2nd Det., Output, B.F.O., and rectifier. Self contained power supply 200/250 volts A.C. 50 cps. Variable Selectivity (crystal filter), 6,000, 3,000, 1,200, 300 and 100 cycles. Frequency coverage 60 kc/s to 30 Mc/s in six ranges, continuous except for gap between 420 to 500 kc/s. Size 16in. × 13½in. × 12in. Weight 82lb. The set for the serious operator. Thoroughly overhauled and in good condition, complete with new valves and air tested prior to desptach. A real bargain at only £27/10/- plus £1 carriage.

RECEIVER 25/7 (TR.1196). This is a six-valve superhet receiver with 465 kc/s I.F.s. Complete with all valves—2 EF39, 1 EK32, 2 EF36, 1 EBC33. In good condition with full conversion data. Price 27/6 plus 2/6 carriage.

COMMUNICATIONS RECEIVER TYPE R.1155. For world-wide reception. We ARE ONCE AGAIN ABLE TO OFFER THESE FINE RECEIVERS ABSOLUTELY BRAND NEW IN ORIGINAL TRANSIT CASE AT £11/19/6 plus 10/6 carriage. This delivery is in really fine condition. If you are contemplating the purchase of one of these receivers in the near future, we advise you not to delay in order to secure a really "MINT" receiver.

SLIGHTLY USED MODELS STILL AVAILABLE. Price £7/19/6 plus 10/6 carriage. All receivers gladly demonstrated to callers and air tested prior to despatch. Send 1/3 for full details and circuit, which is supplied free with each receiver.

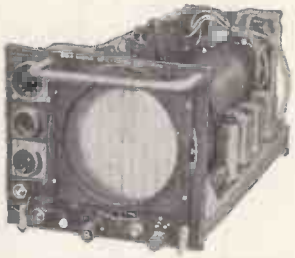
A.C. MAINS POWER PACK OUTPUT STAGE. Enable the R.1155 to be used to operate speaker from 200/250 volts A.C. without ANY MODIFICATION WHATEVER. All our power packs have heavy duty transformers, are complete with leads and Jones plugs and are guaranteed for 6 months.
Type A. In smart black metal case, size 8½in. × 4½in. × 6½in., less speaker, price £4/10/- plus 3/6 carriage.
Type B. With built In. 5in. speaker in black metal case size 13½in. × 5½in. × 7½in. Price £5/5/- plus 3/6 carriage.
Type C. With an 8in. speaker in specially designed beautiful black crackle cabinet speaker to match receiver, size 11½in. × 10½in. × 6 In. A de Luxe job. Price £6/10/- plus 3/6 carriage.

NOTE: 10/- REDUCTION WHEN PURCHASING ANY OF THE ABOVE POWER PACKS WITH RECEIVER.

TRANSMITTER TYPE 12. Frequency coverage 1.2 to 17.5 Mc/s in four bands. M.O., Buffer, P.A., 2 stage Modulator, built in stabilised A.C. mains power pack, P.A. Anode current meter M.C.W., C.W., and R.T. operation. Can be crystal controlled. Super "Table Topper" size 24in. × 12½in. × 17½in. weight 134lb. Complete with all valves ready for operation. In first-class condition and tested before despatch, with circuit and full instructions. Only £16/16/- plus 14/- carriage. Can be demonstrated to callers.

ROTARY POWER UNIT TYPE 104. Input 12 v., Output 230 volt 60 mA. and 6.3 v. at 2.5 amp. Fully filtered and smoothed and noise suppressed. Ideal for car radio, etc. Only 15/- each.

HEAVY DUTY SLIDING RESISTORS. 250 watts rated to carry 25 amps., resistance 0.4 ohms, suitable for physics labs, charging board, etc. Laboratory type with worm drive, on metal stand, size 9in. × 4in. × 6in. high. Price 7/6 each. BRAND NEW.



INDICATOR TYPE 182A

Indicator contains 3 EF50, 1 5U4G, 4 SP61 and a 6½in. C.R.T. Type VCR 517, complete with Mu Metal-screen, 9 wire wound pots, with large assortment of resistors and condensers. Can be converted to Oscilloscope (as described in "Radio Constructor"). Circuit supplied. Tubes have no "Cut Off" and can be demonstrated to callers. BRAND NEW (less relays). In original transit case, 67/6 plus 7/6 carriage.

INDICATOR UNIT TYPE 95. Exactly the same as the 62 indicator unit but is 50 cycle version. Double decker chassis, containing loads of components, 16 SP61, 2 EB34, 4 EA50, etc., etc. Brand new condition (less VCR97). Only 45/- plus 7/6 carriage.

U.S.A. DYNAMOTOR

12 volts D.C. Input, 250 volts 60 mA. output, weight 2¾lb., size 4½in. × 3in. diameter. Ideal for car radio, mobile amplifiers, small transmitters, etc. All tested prior to despatch. Only 22/6 post paid.

45 Mc/s PYE STRIP. Vision unit for London frequency complete with 6 EF50 and EA50. Circuit provided. Ex-brand new units. Price £3/10/-.

E.H.T. TRANSFORMER. For VCR97, etc. Mains input, output 2,500 volts, 4 volts at 2 amps. and 2-0-2 volts at 2 amps. Fully guaranteed at 35/- plus 1/- post.

NITROGOL CONDENSERS. With ceramic insulating terminals. 8 mfd. 2 kV. wkg size 5 in. × 3½in. × 4½in., at 12/6 each. 4 mf. 2 kV wkg. size 3½in. × 2½in. × 4½in. at 7/6 each. 4 mf. 1.25 kV. wkg. size 3½in. × 2½in. × 4½in. at 5/6 each.
BLOCK CONDENSERS. 40 mfd. 450 v. wkg. metal cased, paper insulation, size 4½ × 5½ × 4½in. Weight 5½lbs. For power factor correction, etc. Brand New Price 15/- plus 2/- post. 8 mfd. 600 v. D.C. wkg. at 71° C. size 4 × 2 × 4½in. high. Very suitable for all good quality amplifiers, etc. Brand new Price 5/- each.

U.S.A. BLOWER MOTOR for 105 volts A.C. operation. Outlet 2½in. diameter, extremely powerful. Snip for only 22/6 plus 2/- post.

CABLE. Heavy duty twin polythene weather-proof, suitable for extension mains, lead, etc. SPECIAL CLEARANCE OFFER, 39/6 per 100 yd. coil, plus 3/6 carriage. S.A.E. for sample.

3 CENTIMETRE TEST SET. Type 205A. In brand new condition. £17/10/-.

R.1355 RECEIVER. Complete with all valves. Good condition. SUPER BARGAIN AT ONLY 22/6 plus 7/6 carriage.

RACKS. 6ft. "U" channel P.O. type for 19in. panels, heavy angle base. Price 79/6, plus carriage at cost.

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Readers are warned that Government surplus components and valves which may be offered for sale through our columns carry no manufacturers' guarantee : Many of these items will have been designed for special purposes making them unsuitable for civilian use, or may have deteriorated as a result of the conditions under which they have been stored. We cannot undertake to deal with any complaints regarding any such items purchased.

NEW RECEIVERS AND AMPLIFIERS

C.J.R. ELECTRICAL & ELECTRONIC DEVELOPMENT, Ltd., Bickford Rd., Witton, Birmingham, 6 (Eas. 0435), the Midlands specialist manufacturers of high fidelity sound reproduction equipment for the world-famous Williamson amplifier and associated accessories, including tone control stages, loudspeaker crossover units, distortionless contrast expenders and radio feeders; send for details and prices. [0105

R.C.A. speech amplifiers, type MI-11220, immediately available in quantity. McELROY-ADAMS MANUFACTURING GROUP, Ltd., 46, Greyhound Rd., London, W.6. [0195

SHIRLEY LABORATORIES, Ltd., 125, Tarring Road, Worthing, Sussex, announce the superb "Jupiter" amplifier with pre-amplifier incorporated, 15 watts output, response 15 c/s to 60,000 c/s; bass lift 18 db, cut 18 db, treble lift 14 db, cut 20 db, hum and distortion level almost immeasurable; 230v @ 20 m.a., 6.3v @ 1 a at octal socket; beautifully constructed to instrument standards; B.V.A. valves; price complete with engraved panel £18/18; also the "Jupiter" reproducer, comprises above amplifier with 12in speaker in hand-made cabinet at 32gns., or with Audiom 50 at 34gns., or with Axiom 150 Mk. II, at 40gns.—Write for full details. [3579

VHF-FM; a new combination receiver, the CB4 long-range FM, and sensitive MW reception; obtainable as feeder, or with push-pull output stage and mains driven; superhet 5v chassis (plus diodes) with JB tuning scale; designed for best fidelity on both systems; will suit any amplifier, tested at 60 miles range; all on a 6X11n chassis; obsolete feeders are easily convertible to a radio set with our 90/- power unit/output stage chassis; the WW FM unit; complete kits, using latest valves and vhf-type components, elegant stoved chassis, wound and pre-aligned coils, circuits, layout; this design is ultimate with zero background, unique am rejector, and oscillator; many have been built by beginners, and we align the completed set; kit, £7/5; we are pioneers and have quite a range of FM products; trade supplied; sets of literature 1/-
BEL SOUND PRODUCTS Co., Marlborough Yard, London, N.19. Day and evening demonstrations, ring Arc. 5078 [0184

RECEIVERS, AMPLIFIERS—SURPLUS AND SECONDHAND

HARTLEY tone control pre-amp 3, valves perfect; £4.—Waterworth, 5, Rennie St., Burnley, Lancs. [3597

TELEVISION projector, 1954 model, 30in picture, with screen; £85 cash; seen by appointment.—Davies, 32, Clovelly Ave., Hendon, N.W.9. [3562

7 VORTEXION 50w amplifiers, complete with valves, good working order; £10 each.—Retford Radio Relay Service, 89, Carolgate, Retford, Notts. [3457

HRO Rx's and coils in stock, also AR88, BC348R, CR100, etc.—Requirements please to R. T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0053

R.F. units, types 26 @ 32/6, 25 @ 16/6, 24 @ 12/6, brand new in original cartons, with valves; postage 2/6.—E.W.S. Co., 69, Church Rd., Moseley, Birmingham. [3393

R.C.A. receivers, type AR.88D, immediately available in quantity, fully reconditioned. McELROY-ADAMS MANUFACTURING GROUP, Ltd., 46, Greyhound Rd., London, W.6. [0194

TV RECEIVERS AND AMPLIFIERS—SURPLUS AND SECOND-HAND

BUSH T91 TV, 9in, just overhauled, 7 new valves, bargain; £25 or near.—Hardyman, 7, College Lane, Faringdon, Berks. Tel. 2230. [3627

TV RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

TELEMECHANIC projection television, as new with 4ft×3ft screen, oak cabinet, Birmingham frequency, bargain; £50 or nearest offer.—Clark, 114, High St., Rushden, Northants. Tel. 2906. [3515

NEW LOUDSPEAKERS

GOODMANS Axiom 150 Mk II, £8/15 Taylor circuit analyser 20B, £13/5; Remington 60 electric shaver, £8; new, unopened, maker's guarantee; carr. paid.—Armstrong, Witchampton, Wimborne. [3595

LOUDSPEAKERS—SURPLUS AND SECONDHAND

HARTLEY Turner 215; £7.—Ruddock, 10, The Meads, Bricket Wood, Herts. [3589

WHARFEDALE 3-speaker units, as new, W 15/CS, super 8/CS, super 5/CS/AL, 1/2 section 3-way crossover; £25; must sell.—20, Mark Ave., Chingford, E.4. [3596

TEST EQUIPMENT—SURPLUS AND SECONDHAND

ADVANCE H1 A.F. signal generator, A.F. amplifier, Celestion type 74 12in speaker.—Fibre Form, Ltd., Wimbledon 3946. [3549

COSSOR 339A double beam oscilloscope; £28; overhauled, all new electrolytics, tubulars, etc.—Browne, 114, Park Lane, South Harrow. [3595

RECOND. Cossor 339A D.B. Oscpe, as new; offers over £30.—Robinson, 16, River Bank, Hampton Court. [3609

TV pattern gen., 40-75mc/s, full mod. atten., 80ohms imped., as new, only £6, guar. make; s.a.e details.—Box 8315. [3612

MODEL 3339 Cossor double-beam oscillograph, recond.; £25 offer; evening.—Stent, 18, Montserrat Ave., Woodford Green, Essex. [3499

SIGNAL generators, oscilloscopes, output meters, valve voltmeters, frequency meters, multi-range meters in stock; your enquiries are invited.—Requirements to R.T. & I. Service, 254, Grove Green Rd., London, E.11. Ley 4986 [0056

AUDIO gen., 10c/s-200kc/s 1%, attenr., perfect, £7/10; R.F sig. gen., 0.1-35mc/s within ½%, atten., range sw., etc., £6/15; tape recr. ampfr., complete with oscr. and power, unused, only £8; all above guar. makes, as new; s.a.e. details.—Box 8316. [3613

NEW DYNAMOS, MOTORS, ETC.

WARD rotary converters for radio, television, amplifiers, etc.
ALSO, rotary transformers, alternators, D.C. generators, etc.
WARD, 75, South St., Bishop's Stortford, Herts. Tel. Bishop's Stortford 1694. [0039

BATTERY chargers 4 models, 2-6-12v, 1-2-4 amp D.C., any mains voltage; also larger types special transformers, chokes, test gear, interior car heaters, etc.—The Banner Electric Co., Ltd., Hoddesdon, Herts. [0112

SPECIAL television rotary converters, guaranteed interference free, fitted radio and television filters, wt. 60lb, d.c. input 12v 200va, out. 24v, 32v, 50v, 110v, 230v d.c., to 230v out. 250va, £28/10 del., also converters for radiogram and general use, inputs, outputs and prices as above; the above also supplied without smoothing, £25 del. immediate despatch; trade supplied.
AT a purchaser's home 60 mls. S.W. of Sutton Coldfield a 24v
TELEVISION converter was tested on Ekco television, 12in tube, stated consumption 135 watts d.c. current from battery only 9½ amps, picture and sound were perfect and completely free of interference or flutter.
THE above is the latest product of British manufacture, and is guaranteed for one year. J.A.P. No. 2A 1.2hp petrol engine, air-cooled, 4-stroke, starting rope, tools; £17/10 delivered. T. W. PEARCE, 66, Great Percy St., W.C.1 (near Angel). [0013

DYNAMOS, MOTORS, ETC.—SURPLUS AND SECONDHAND

FOR sale, double-wound rotary converter, 110 volts D.C. input, 230 volts A.C., 300 watts output, complete with filter and soundproof cabinet, suitable for use with radio or television receiver or amplifier.—Box 7698. [3468

NEW GRAMOPHONE AND SOUND EQUIPMENT

FERROGRAPH magnetic tape recorder, 76gns.
WEARITE tape decks and component parts.
DISC recording machines and blank discs.
LEAK amplifiers, 10w £17/17; preamp £10/10.
GOODSELL, 5w £13/10, preamp £10/10.
RESLO ribbon microphones and stands.
EVERYTHING for the professional recording studio and quality dealers.
SOUND DISCS (SUPPLIES), Ltd., 178, Bispham Rd., Southport, Lancs. Tel. 88153. [3169

GRUNDIG tape recorder, as new, with tape and microphone.—Arnold 6360 daytime. Mill Hill 4033 evenings. [3584

NEW GRAMOPHONE AND SOUND EQUIPMENT

TRUVOX Decks.—Amplifier to suit, 8min. Valves, 10w P.P., Latest design, Sep. Power Unit; Treble lift choke; Var. Bias. Mic. and Radio inputs, Mixer control, M. Eye indicator, 30-10Kc/s response; 19gns.
RECORDING Amplifiers with Meter, Treble lift choke, P. Pack, etc., 18gns; trade supplied; Pre-amp., £3/15.
HARDING ELECTRONICS, 120a, Mora Rd., London, N.W.2. [0032

TAPE recorders for sale, exchange, or hire in Greater London, good quality tape recorders wanted for cash, all types of repairs, mechanical and electronic, carried out by specialists, all accessories available, we deal exclusively in magnetic recording equipment.
THE MAGNEGRAPH RECORDING Co., Ltd., 1, Hanway Place, London, W.1. Tel. Langham 2156. [3396

GRAMOPHONE AND SOUND EQUIPMENT —SURPLUS AND SECONDHAND

FERROGRAPH 2A tape recorder, absolutely as new, £60 or near offer, available London.—Box 8009. [3524

CONNOISSEUR 2-speed varigroove recorder with 3-channel mixer amplifier in case; £130.—Full details from Box 8256. [3594

M.S.S. portable disc recorder, £60; leak, TL/10 and pre-amp. £22; Ferrograph tape recorder, £65, as new (Lancashire).—Box 7622. [3427

TAPE recorder, "Ferrograph" professional, photo, details supplied, perfect condition, 60gns; auxiliary radio unit, £6.—Wood, 90, Grestone Ave., Birmingham, 20. [3525

UNUSED "Editor" tape recorder, in original carton, cost £47/5 three weeks ago, will accept £35; owner going abroad.—Box 7931. [3512

7½/3¾ i.p.s. tape equipment comprising Bradmatic Deck, C.J.R. Amplifier assembly. Includes monitor head and channel, peak programme meter, 2 stage bias oscillator, other professional refinements. For quick sale at £60, or nearest offer.
ARIEL SOUND, 57, Lancaster Mews, London, W.2. Tel: Paddington 5092. [3629

NEW TRANSMITTING EQUIPMENT

WILCOX-GAY V.F.O. and crystal multiplier units; small quantities.
McELROY-ADAMS MANUFACTURING GROUP, Ltd., 46, Greyhound Rd., London, W.6. Cables: Hallicraft, London. Tel. Fulham 1138-9. [0203

TRANSMITTING EQUIPMENT—SURPLUS & SECONDHAND

COMPLETE Pye 80 Mcs. radiotelephone, master station, 3 mobiles with P.A. equipment, guaranteed; £280.
McELROY-ADAMS MANUFACTURING GROUP, Ltd., 46, Greyhound Rd., London, W.6. Cables: Hallicraft, London. Tel. Fulham 1138-9. [0197

R.C.A. transmitters, type ET.4332 and ET.4336, fully reconditioned to maker's spec., complete with V.F.O. crystal multiplier, etc.
McELROY-ADAMS MANUFACTURING GROUP, Ltd., 46, Greyhound Rd., London, W.6. Cables: Hallicraft, London. Tel. Fulham 1138-9. [0196

NEW COMPONENTS

FREE list; sensational prices; valve, components.—Jack Porter, Ltd., College St., Worcester. [3296

SOUTHERN RADIO SUPPLY, Ltd., 11, Little Newport Street, London, W.C.2. See our displayed advertisement, page 158. [0016

FLUORESCENT 80w chokes 16/6, glow starter lamps 2/-; transformers, 10,000v 25mA 230v a.c., 32/6; metal rectifiers, 6/12v 2amp 8/6, 4amp 12/6, 6amp 18/6; battery chargers, 6/12v 1amp, 39/6; complete 5ft 80w fluorescent fittings, 75/-; heavy duty battery chargers, 24v 50amp, £16; car batteries, 6v £3, 12v £5/10. 2 years' guarantee.—Malden Transformer Supplies, 2a, Cambridge Rd., & 134, London Rd., Kingston-on-Thames. Kingston 7534. [0038

COMPONENTS—SURPLUS AND SECONDHAND

SUPREME RADIO, 746B, Romford Rd., Manor Park, London, E.12. Tel. Ilf. 1260. Est. 19 years.
SUPREME for good quality radio and TV component bargains at the right price.
70 ohm co-axial cable, 7d per yd or 6/6 per doz. yds.
JUST arrived! Drylitic condensers, chassis fitting can type 32+8+8mfd 275v, 3/3 ea.; also 32mfd 350v clip fitting, small, our price 1/9 ea.
TUBULAR card/w/end cond. 8mfd 450v, our price 1/11 ea.
LOOK! 3meg carbon V/controls, 6d ea.; limited quantity.
STEEL chassis, grey finish, ready punched for s/het layout, 14in×6in×3in, 2/6 ea.
2-POLE 2-way w/change switches, 1/- ea., 11/- per doz.
WALNUT control knobs, 1¼in dia, with grub screws and nuts, engraved in gold colour as follows: Tone, vol/on-off, gram, L, M, S and tuning, 1/- ea.
SPRAGUE condensers, tub/metal, w/end. 0.1mfd 350v, 8d ea. or 7/6 per doz.
A REAL winner, bargain, mains trans.: Shrouded, upright mounting with base connections, 290-0-290v 60m/a, 6.3v 1.5amp and 4v 2amp, with screen; primary, tapped on panel. 0-200v-220v-240v size. H 3¾in×3¼in× 2¾in D. our price, 12/6 + 1/- pack/post.
ELLIPTICAL P.M. speakers, 7in×4in, 2 to 3 ohms v/coil, our price, 15/11 ea.
TERMS: c.w.o., no c.o.d.
SEND 9d extra for postage orders under £5. 2½d s.a.e. all enquiries and list. [0021

COMPONENTS—SURPLUS AND SECONDHAND

RADIO CLEARANCE, Ltd., 27, Tottenham Court Rd., London, W.1. Tel. Museum 9188. ELECTROLYTICS, capacity, voltage, size, type of mounting, price post paid: 400, 6v, 1×2in, lug, 1/9; 250+250, 6v, 1×2in, lug, 2/-; 40+40, 150v, 1⅛×2, clip, 2/9; 40, 150v, 1×2, clip, 2/6; 20+20, 275v, 1×2, lug, 3/3; 16+32, 275v, 1×2, lug, 3/3; 16+16, 275v, 1×2, clip, 3/3; 100, 275 350v, 1⅛×?, clip, 3/6; 32+12, 350v, 1⅜×2, clip, 4/-; 16+16+16, 350v, 1⅜×2, clip, 1¾×2, 4/9; 16, 350v, ¾×2, lug, 1/9; 40+40, 300v, 1×3, lug, 3/6; 10, 450v, ¾×2, lug, 1/6; 16, 450v, ⅞×2, tag, 2/9; 20, 450v, 1×2, 2/3; 32, 450/525v, 1⅜×2, clip, 3/9; 15+15, 450v+20mf 25v, 1⅛×3, lug, 4/6; 200, 6v, ⅜×1¾, clip, 1/6; 100, 12v, ⅜×1¾, clip, 1/9; 8, 450v, 1×2 clip, 2/-; 50, 12v, ¾×1⅝, tag, 1/6; 150, 25v, ¾×1¾, clip, 2/-; 250, 12v, ¾×1¾, wire 2/3; 16+16 450v, 1¼×2, clip, 4/-; 40+40, 275v, 1⅜×2, clip, 3/3; 24+24+16, 350/425v, 1⅜×2, clip, 4/9; 60+200, 275/350v, 1¾×4½, clip, 6/6; 4, 150v, ⅜×1¾, clip, 1/1; 500, 12v, 1⅜×2¾, clip, 2/-; 8, 350v, ¾×2, clip, 1/9; 32+32, 350/425v, 1¾×2, clip 5/-; 8+16, 450/525v, 1×2, clip, 4/-; 2, 450/525v, ¾×1⅝, tag, 1/6; 2, 350v, ¾×1¾, tag, 1/3; 8, 450v, ¾×2, clip 1/9; 32+32, 450/525v, 1⅛inx3in, wire ended, 5/6; 64+120, 275v, 1¾×4½, clip, 5/6; all all cans, some with sleeves, all voltages, WKG, surge where marked, new stock guaranteed.

TELEVISION! Set of 3 components, comprising line output trans., with E.H.T. winding to give 7kV, using EY51 (heater winding for EY51 also included), and fitted with width control scanning coils, low impedance line and frame, focus coil (res. 10,000Ω), current approx. 20 mA); the set of 3 for 42/-, plus 2/- post, diagram of line trans. supplied.

UNIVERSAL amplifiers, 8-valve 20watt A.C./D.C., black crackle chassis, and black and chrome cover, overall size 15½inx7½inx7in. First-class components (Partridge O.P.T., and driver, Gardner choke, A.E.E. Mu-Metal input trans. for mike) Valves, 2×EF37, 4×CL33, 2×UR3C. Switched input for high or low imp., top cut and bass cut switches. V.C. mains switch, mains plug and socket, 220-250v, isolated chassis, 15Ω output. Wired and tested, ready for use, with valves, brand new, £10/19/6, carr paid.

5mA meters, moving coil, bakelite case, 2in square, flush mounting, new, boxed: 7/- post paid.

MAINS trans., 250-0-250v, 80ma, 6.3v, 2.5A, 6.3v, 0.6A, Pri. 0-210-230-250v. 12/- post paid.

MAINS trans., Pri. 200/250v, sec., 305-0-305v, 80mA, 800v 5mA, 6.3v 4.2A 6.9v 0.4A, 2v 2A. 4v 1.1A, 5v 2.3A; these trans. have been taken from ex-Govt. equip.; some may have tag panels broken, but guaranteed O.K.; 13/- post paid; ideal for scopes.

RADIO CLEARANCE, Ltd., 27, Tottenham Court Rd., London, W.1. Tel. Museum 9188. [0015

EXP., radio and elec. surplus, plenty of real bargains; send stamp for list.—Illingworth, 90, High St., Bridlington, Yorks. [3537

ONCE-A-YEAR bargain list free, Telefunken valve stockists.—Jackson Electrical Co., 3, Terminus Place, Eastbourne. [3514

HAYNES scanning coil S914, focus coil F912H, line transformer TW6126.—Box 8271. [3607

COMPONENTS—RADAR

1.—723AB Klystrons; available in quantity.

2.—Magnetrons type CV.292, complete with cavities.

3.—Large quantity long length 3cm wave guides, junctions, cavities, projectors, radiators, spinners, etc.; immediately available.

ALSO 3cm echo boxes and oscilloscopes.

MCELROY-ADAMS MANUFACTURING GROUP, Ltd., 46, Greyhound Rd., London, W.6. Cables: Hallicraft, London. Tel. Fulham 1138-9. [0202

WANTED, EXCHANGE, ETC.

VHF test equipment.

TS47AP, TS174, TS175/U, TS148 or TSX-4SE; analysers; BC221 freq meters, TS69, and any U.S.A. test gear; Klysrons type 723/AB, 2K33 2K39 2K41; receiver, APR4 and units TN16 17-18-19; RCA AR88D, S27 and SX28s and S27CA; microwave equipment; highest offers given by return.—Ger. 8410. Universal Electronics, 27, Lisle St., Leicester Square, London, W.C.2. [0229

WANTED, U.S. mine detector, type SCR.625. —Box 7944. [3513

ALL cables and flexes bought.—B.D.C., 591, Green Lanes, London, N.8. [5152

WANTED receivers A.P.R.4, also T.N. 16, 17, 18, 19, etc., and any radio test gear. LESLIE DIXON & Co., 214, Queenstown Rd., Battersea, S.W.8. Macaulay 2159. [0176

WANTED, Tuning units, TN17, TN18, TN19, for R54/APR4; £50 each offered.—Box 4963. [0261

WANTED, HRO coils, Rxs, etc., A.R.88s, BS348s, S27s, etc.—Details to R.T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0163

WANTED, set manufacturers' or ex-Government radio equipment, large or small quantities of valves, electrolytics, speakers, meters, also components.

LOWE BROS., 5, Fitzroy St., London, W.1. Tel. Museum 4389. [2703

WANTED, EXCHANGE, ETC.

WANTED RCA speech amplifiers, type MI-11220, J, or K, and aerial tuning units BC939a; offers stating quantity and price to—P.C.A. Radio, Beavor Lane, Hammersmith, W.6. [0080

WANTED, BC610 Hallicrafters, ET4336 transmitters, AR88 Ds and LFs, receivers and spare parts for above, also BC221 frequency meters; best prices.—P.C.A. Radio, Beavor Lane, Hammersmith, W.6. [0079

URGENTLY wanted, manuals or instruction books, data, etc., on American or British Army, Navy or Air Force radio and electrical equipment.—Harris, 93, Wardour St., W.1. Tel. Gerrard 2504. [3331

COMPASS indicators I.81-A, I.82-A; inverter supply units MG.149; cryptograph converters M.209; top prices paid.—R. Gilfillan & Co., Ltd., 7, High St., Worthing, Sussex. Tel. Worthing 8719. [3497

WANTED, signal generators types TF146, TF390G, TF762A, frequency meters BC221, TS174, TS175; also receivers types AR88, etc., APR4 or similar; send price and details to—Hatfield Instruments, Ltd., 175, Uxbridge Rd., Hanwell, W.7. Tel. Ealing 0779/9857. [0037

WANTED, good quality communication RYS tape recorders, test equipment, domestic radios, record players, amplifiers, valves, components, etc., estb. 18 years.—Call, send or 'phone Ger. 4638, Miller's Radio, 38a, Newport Court, Leicester Sq., W.C.2. [3416

WANTED, good quality communication rxs., domestic radios, test equipment, etc.; top prices paid, established since 1937.—Miller's Radio, 38a, Newport Court, 1 min. from Leicester Sq. Tube. Tel. Ger. 4638. Call, write or send. Hours of business 10-6 p.m. Open all day Saturday. [0195

VALVES WANTED

ALL types of valves required for cash; state quantity and condition.—Radio Facilities, Ltd., 38, Chalcot Rd., N.W.1. Primrose 9090. [3614

45s paid for 813; also wanted 723, A/B, 805, 803, 2J32, 2K33, TZ40, 808, etc., any quantity.—Write, Pype Hayes Radio, 606, Kingsbury Rd., Birmingham, 24. Erdington 4942. [3575

CABINETS

LEWIS RADIO have the best selection and finest finish.—See page 165. [0224

WALNUT radiogram and television cabinets, soundly constructed; stamp for details.—R. Shaw, 69, Fairlop Rd., Leytonstone, E.11. [3193

GRAMOPHONE record cabinets, from £5/10: write for details, easy payments.—Stamford (Dept. D.5), 20, College Parade, Salusbury Rd., London, N.W.6. [3519

HAND-MADE polished speaker cabinets, G.E.C. design, £12/10; metal cone units, £8/15; custom-built audio furniture to individual requirements.—Jones, 205, Lynmouth Ave., Morden, Surrey. [3605

CABINETS made to order; bass reflex speaker cabinets, all types and finishes, see display advertisement; open till 5.30 Saturdays.—A. Davies & Co. (Cabinet Makers), 3, Parkhill Place, off Parkhill Rd., Hampstead, N.W.3. Gulliver 5775. [3530

REPAIRS AND SERVICE

MAINS transformers rewound, new transformers to any specifications.

MOTOR rewinds and complete overhauls; first-class workmanship; fully guaranteed.

F.M. ELECTRIC Co., Ltd., Potters Bldgs., Warser Gate, Nottingham. Est. 1917. Tel. 47898. [0113

LOUDSPEAKERS repaired promptly.—Model Loudspeaker Service, Bullingdon Rd., Oxford. [3192

MAINS transformers, E.H.T. line outputs, chokes and field coils, etc., promptly and efficiently rewound or manufactured to any specification; 12 months' guarantee.

LADBROKE REWIND SERVICE, Ltd., 820a Harrow Rd., Kensal Rise, N.W.10. Lad. 0914. [0222

TRANSFORMER rewind service, mains, E.H.T. transformers and chokes, prompt delivery, range of replacement types ex-stock or manufactured to your specification.

METROPOLITAN RADIO SERVICE Co., 75, Kilburn Lane, London, W.10. Ladbroke 2296. [0200

SERVICE sheets for hire or sale over 2,000 models, radio and television; list 1/-; s.a.e. enquiries.—W. Gilbert, 24, Frithville Gardens, London, W.12. Tel. She. 3052. [3315

WAVE winding, specialists rewinds of every description including E.H.T. line outputs, mains armatures, etc.—Northern Coil Winding Co., 1, Hollings Mount, Bradford, 8, Yorks. [3478

VAC. armatures rewound, 15/- each, fully guaranteed; good delivery; drills, F.H.P. motors, etc., rewound; competitive prices.—K. R., 6, Mitchells Crescent, Penydarren, Merthyr Tydfil [3611

ELECTRICAL test instruments repaired and standardized, all types British or American, ammeters, voltmeters, ohmmeters DC/AC multi-range meters, etc.; meters converted to specification.

THE ELECTRICAL INSTRUMENT REPAIR SERVICE, 329, Kilburn Lane, London, W.9. Tel. Lad. 4168. [2821

REPAIRS AND SERVICE

REWINDS and conversions to mains and output trans, pick-ups, fields, clock coils, etc., from 4/6; PP equipment a specialty; all work guaranteed.—N.L. Rewinds, 173, High Rd., Willesden Green, N.W.10. Tel. Wordsworth 7791. [3563

24-HOUR service, 6 months' guarantee, any transformer; rewind, mains outputs and t.f.s., etc.; all types of new trans., etc., supplied to specification; business heading or service card for trade prices.—Majestic Winding Co., 180, Windham Rd., Bournemouth. [2526

AS professional sound recordists and members of the Association of Professional Recording Studios, we are particularly well qualified to give advice and service on all aspects of sound recording and reproduction. Design of tape equipment a speciality. Circuits designed, repairs and modifications carried out quickly. Advice freely given. See also below:—COMPREHENSIVE service to trade and amateur; design, manufacture and repair of electronic equipment carried out by specialists; equal attention given to small or large orders. See also below:—Autochangers, 48-hour service, cleaning and adjusting at fixed price of 45/-, plus carriage; also all repairs carried out; trade enquiries invited; callers by appointment only please.—Ariel Sound, 57, Lancaster Mews, London, W.2. Tel. Paddington 5092 (2 lines). [0026

ARMATURE rewinding service to the trade. vacuums, drills, grinders, hood dryers, dental motors, vacuum cleaner armatures replaced from stock, 24 hours service; every job guaranteed; we also specialise in complete overhauls and rebuilds of vacuum cleaners; all vacuum cleaner parts, hoses, bearings, fans, brushes, for any make in stock.—Regam Electric, 95, Park Lane, Leeds 1 [0028

PAINTS, CELLULOSE, ETC.

PAINT spraying handbook, 3/6 post free, cellulose and synthetic paints and all spraying requisites supplied; catalogues free.—Leonard Brooks, 53, Harold Wood, Romford. [0207

MACHINERY FOR SALE

UNUSED and as new, 5kW G.E.C. high frequency induction heating and melting set, complete with various accessories, owner selling due to reorganisation at one-third cost; can be inspected working at—Davidsons Eng. (M/cr.), Ltd., Garratt St., Manchester, 10. Tel. Collyhurst 1610. Price £350. [3223

BUSINESS OPPORTUNITIES

OLD-ESTABLISHED firm of exporters in the electronic field, invite manufacturerr seeking overseas sales to communicate Box 0239 [0252

WORK WANTED

ASSEMBLY, wiring of all types of electronic eqpt., control panels, switchboards, etc.—R.A.E., 377, High Rd., London, N.2. [0219

ARMATURE, stator and general coilwinding, excellent production and test facilities, express rewind service.—Coilwinding Services, 26, Lower Richmond Rd., London, S.W.15. Putney 2667. [3438

WORK wanted; versatile AID approved winding, assembly machining capacity available; Toroidal to close accuracy, and distrene machining specialists.—Bel, Marlborough Yard, N.19. Arc 5078. [C0183

CAPACITY AVAILABLE

PRODUCTION WINDING COMPANY, 117, High St., Brentwood, Essex. Tel. Brentwood 3353.

HAVE capacity available for coil, armature and stator winding. Also wiring and sub-assembly of electronic equipment. [3610

MISCELLANEOUS

COIL winding machines; from £15.—Hawkins, 170, Witton Rd., Birmingham, 6. [2879

RUN your 3-phase motor on single phase; send 2/6 for instructions.—Holderness, Wantage, Berks. [3353

HOME-MADE, regulated power supplies, oscilloscope, etc., plus many unused components; total £25 or offers.—Gul 6300 evenings. [3536

METALWORK, all types cabinets, chassis, racks, etc., to your own specifications; capacity available for small milling and capstan work up to 1in bar.
PHILPOTT'S METAL WORKS, Ltd. (G4B1), Chapman St., Loughborough. [0208

MOTORISTS! Avoid all battery troubles and ensure easy starting this winter; the very latest in battery chargers and trickle chargers, fully guaranteed.
6 OR 12 volt at 1 amp, 35/-, postage 2/-.
6 OR 12 volt at 2 amp, 39/6, postage 2/-.
6 VOLT, 4 amp, 62/6, postage 2/-.
12 VOLT, 4 amp, 62/6, postage 2/-.
SOLE Midland stockists:—
WALTON'S WIRELESS STORES, 48, Stafford St., Wolverhampton. [0145

GR photographic electronic timer, 1-60 seconds, instant push button re-set, construction kit; 70/-; p. & p. 2/6; 7 days' approval; s.a.e. details.
G.R. PRODUCTS, 22, Runnymead Avenue, Bristol, 4. [3561

ENGRAVING, quantities large or small, front panels, components, etc., let us quote price and deliveries.—Plastic & Metal Engraving, 26, Lower Richmond Rd., Put. 8930. [3484

MISCELLANEOUS

YOUR own tape recording transferred to disc.—Write, call or 'phone Queensway Private Recording Studios, 123, Queensway, W.2. Tel. Bay. 4992. Studio recordings, tape recording service. [3297

COPPER wires enamelled, tinned, Litz, cotton, silk covered, all gauges; B.A. screws, nuts, washers, soldering tags, eyelets, ebonite and laminated bakelite panels, tubes, coil formers; Tufnol rod, headphones, flexes, etc.; latest radio publications, full range available; list, s.a.e.; trade supplied.—Post Radio Supplies, 33, Bourne Gardens, London, E.4. [0138

SNP. members Assoc. Professional Rec., would service your equipment, supply tested recording materials; quick, reliable tape to disc service; D.s. 10in records 15/6, 12in 18/6, including trailers; also LP-s (12in LP dur. 45 min); trade enquiries from equipment dealers invited; avoid Xmas rush.—Sound News Productions, 3, Clover Mews, London, S.W.3. Flaxman 3706. [3615

YOUR tapes to tape, L.P., E.P. and 78 discs, best materials used only; tape recorders, microphones, E.M.I. 88 tape, etc.; complete recording service backed by years of professional broadcasting and recording experience.—"Eroica" Recording Services, Peel St., Eccles, Manchester. Eccles 1624. Musical Director, Thurlow Smith, A.R.M.C.M. Consult us before you buy. [0121

NOTICES

BRITISH SOUND RECORDING ASSOCIATION. Details of membership, open to the professional sound recording engineer and all others interested in recording high quality reproduction and other branches of audio engineering, together with details of the London lecture programme and the Manchester, Portsmouth and Cardiff Centres, may be obtained from the Hon. Membership Secretary, H. J. Houlgate, A.M.I.E.E., 12, Strongbow Rd., Eltham, S.E.9. [0031

SITUATIONS VACANT

The engagement of persons answering these advertisements must be made through the local office of the Ministry of Labour and National Service, etc., if the applicant is a man aged 18-64 or a woman aged 18-59 inclusive, unless he or she or the employer is excepted from the provisions of The Notification of Vacancies Order 1952.

ENGINEERS

URGENTLY required for the design and development of commercial radio and television for mass production; applicants should have necessary qualifications and experience in this field; the appointments carry excellent opportunities for progressive advancement, and of continuity on a long-term basis; salary up to £1,000 per annum for suitable applicants.—Write in the first instance, giving full details of qualifications and experience, to Box 7678. [3455

DRAUGHTSMEN.

ATTRACTIVE, permanent positions are offered to Draughtsmen, due to expansion of our Electronics Division. Applicants should be experienced in development and design for production of high-grade communications equipment to service requirements.
GOOD salary and staff conditions. Company superannuation and insurance scheme in operation. Applications, which will be treated in confidence, should be addressed to:
THE PLESSEY COMPANY, Ltd., Vicarage Lane, Ilford. Essex. [3619

ULTRA ELECTRIC, Ltd.,

WESTERN Ave., Acton, London, W.3.
RADIO & television development engineers.
(a) APPLICATIONS are invited from senior development engineers with experience and academic qualifications for important work on new development projects.
THE posts are permanent and pensionable and offer scope for the right men to work in ideal conditions, in modern, well-equipped laboratories.
PLEASE write in strict confidence to the Personnel Manager for an interview appointment.
(b) JUNIOR engineers (aged 21/29) are also required, and applicants for these posts should have some technical training and preferably previous experience. Please write as above. [3572

RADIO Officers required by the

EAST Africa High Commission Directorate of Civil Aviation for one tour of 30 to 48 months in the first instance with prospect of permanency. Salary scale (including present temporary allowance of 35% of salary) £742 rising to £965 a year. Gratuity of 13½% of total basic salary drawn during contract for those not taken on permanent establishment. Free passages. Liberal leave on full salary. Outfit allowance £30. Candidates must be capable of operating at 25 w.p.m. and should preferably hold M.C.A. 1st Class Certificate in Radio Telegraphy. Knowledge of touch typing for teleprinter, the operation of modern radio or radar aids, or experience in radio maintenance would be an advantage.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/30606/WF. [3487

SITUATIONS VACANT

ULTRA ELECTRIC Ltd., WESTERN Ave., Acton, London, W.3.
ELECTRONIC development engineers are required in all grades for work on: (a) subminiaturisation of VHF, radio and audio circuitry; (b) transistor applications; (c) VHF communication; (d) pulse techniques; (e) radar and radio navigation.
APPLICATIONS are invited from:—
(a) SENIOR development engineers with degree or equivalent qualifications, and more than five years' experience in one or more of the above fields.
(b) JUNIOR engineers with degree or HNC with or without experience for work in the above fields.
(c) TEST equipment development engineers with experience of design of test equipment to meet production requirements.
THE posts are permanent and pensionable, and offer scope for the right men to work in ideal conditions, in modern, well-equipped laboratories.
PLEASE write, in strict confidence, to the Personnel Manager for an interview appointment. [3573

ELECTRICAL engineer required by MINISTRY OF SUPPLY, at Armament Design Establishment, near Sevenoaks, Kent, for instrumentation, technical organisation and supervision of trials. Work includes development and maintenance of V.H.F. radio and other electronic equipment, and recording and analysis of trials results. Minimum qualification required is Higher School Certificate (Science) or equivalent but possession of a degree or Higher National Certificate in Electrical Engineering may be an advantage. Experience appropriate to above duties is desirable. Salary within scale: Experimental Officer (male) (min. age 26) £690-£850.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1. quoting D.467/54 A. Closing date 13 November, 1954. [3500

ROTHAMSTED Experimental Station, HARPENDEN, Herts.
REQUIRE for (a) Chemistry Department, and (b) Pedology Department, Laboratory Assistants with knowledge of electronics and aptitude for electrical and mechanical construction. Salary according to age and qualifications on Assistant or Senior Assistant Scientific scales; e.g., £360 maximum on entry to Assistant scale (age 25): £520 on entry to Senior scale rising to £715. A man who has completed his National Service would be preferred.
APPLY in writing to the Secretary giving details of age, education, qualifications and experience. [3486

VACANCIES with Housing Accommodation.
ENGINEERS of Higher National Certificate or degree standard and Students of Ordinary National standard are required at our Hemel Hempstead factory for development work on servo-mechanisms and magnetic amplifiers.
PREVIOUS experience is desirable but not essential, applicants with suitable background and interested in this work should apply. Vacancies also available for Mechanical Designers acquainted with this type of work. Prospects of promotion are excellent in this new and expanding laboratory.
SUITABLE applicants will have the opportunity of renting a modern house or flat in the New Town.
WRITE, as fully as possible, stating your age, experience, to: Dept. B, Box 8269. [3600

TECHNICIANS, Grade I (Radio), required by EAST AFRICAN POSTS & TELECOMMUNICATIONS ADMINISTRATION on probation for pensionable employment. Salary scale (including present temporary allowance of 35 per cent of salary) £742 rising to £1,134 a year. Outfit allowance £30. Free passages. Liberal leave on full salary. Normal tour 4 years. Candidates should possess a thorough practical knowledge of the working and maintenance of modern HF radio telegraph equipment and VHF multi-channel radio-telephone equipment. G.P.O. staff should apply through departmental channels.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M2C/32424/WF. [3582

THE ENGLISH ELECTRIC VALVE Co., Ltd., Chelmsford, have vacancies for YOUNG engineers to work on radio valve design and development; applicants should be of degree standard, whilst experience of this type of work is desirable, it is not essential and otherwise suitable candidates will be considered.—Write, giving full details, quoting Ref. 497H, to Dept. C.P.S., 336-7, Strand, W.C.2. [3494

TESTERS required for television and radio manufacturers: good rates for experienced men; N.W. London area.—Write for full particulars to Box 7628. [0032

TELEVISION and radio engineer is required for the design and development of components including small power transformers, ability to engineer these components for mass production essential; the post carries a salary of £600/£800 p.a. and is pensionable.—Please apply, stating age, experience, etc., to Box 2 J J 9849, A.K. Advg., 212a, Shaftesbury Ave., London, W.C.2. [3540

SITUATIONS VACANT

A. V. ROE & Co., Ltd.,
WOODFORD Aerodrome, Cheshire.
HAVE vacancies in their newly formed WEAPONS Research Division.
AERODYNAMICISTS.
WITH Honours Degree in Physics, Mathematics or Engineering and at least two years experience are required to work on an aerodynamics group on aerodynamic theory and analysis of new weapon projects. Candidates should be familiar with supersonics.
MATHEMATICIANS.
WITH Honours degree to work on flight dynamics and studies of control systems, a knowledge of numerical mathematics would be an advantage.
ELECTRONIC Engineer.
A graduate with research and development experience in electronics or with electro-mechanical devices.
GOOD salaries and prospects.
PENSION and life assurance scheme.
APPLY giving full particulars of academic training and experience to:—
A. V. ROE & Co., Ltd.,
WEAPONS Research Division,
WOODFORD, Cheshire. [3539

WIRELESS Station Superintendents required by the NIGERIA Posts and Telegraphs Department for one tour of 18 to 24 months in the first instance. Option of appointment (a) on temporary terms with salary scale (including Expatriation pay) £864 rising to £1,392 a year. Gratuity at the rate of £100/£150 a year, or (b) with prospect of pensionable employment with salary scale (including Expatriation pay) £750 rising to £1,175 a year. Outfit allowance £60. Free passages for officer and wife. Assistance towards cost of children's passages or grant up to £150 annually for maintenance in U.K. Liberal leave on full salary. Candidates must have had wide practical experience of modern radio techniques and equipment, in particular V.H.F. equipment, and preferably also V.H.F. multi-channel equipment.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/30086/WF [3623

WIRELESS station superintendent required by the GOLD COAST GOVERNMENT POSTS & TELECOMMUNICATIONS DEPARTMENT for two tours of 18 to 24 months in the first instance. Consolidated salary scale £990 rising to £1,230 a year. Gratuity at the rate of £100/£150 a year. Outfit allowance £60. Liberal leave on full salary. Free passages. Candidates should possess C. of Gds. Final Certificate in Telecommunicattions (Radio) or C. and Gds. Certificates Radio III and IV equivalent, and have had three years' experience in two or more of the following fields:—V.H.F. link systems; H.F. communications systems; frequency shift keying and teleprinter maintenance; V.H.F. and H.F. cathode ray direction finding system; aeronautical navigation aids (ground); manufacture of light engineering equipment; candidates from the British Post Office should apply through departmental channels.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/29100/WF. [3581

RADIO (Meteorological) Mechanics required by METEOROLOGICAL Office. Qualifications: Basic knowledge of radio and radar and experience in maintenance/operation of radar equipment, including oscilloscopes. Successful applicants serve in United Kingdom and overseas. Commencing London salary £445 at age 25 or over rising annually to £540 subject to deductions for each year below age 25. Provincial salary £20 to £30 lower. Overtime, night duty allowance, etc.—Apply at any Employment Exchange quoting Borough 881. [3602

ST. CRISPIN HOSPITAL, Duston, Northampton.
ELECTRO-Encephalography Recordist, Grade 1, required at the above hospital for Mental and nervous disorders, for a new E.E.G. department to be opened in the near future. The hospital has 1,250 beds and is situated three miles from Northampton. Whitley Council Scales and conditions. Excellent social amenities.
APPLICATIONS giving full details and names of two referees to the Physician Superintendent within fourteen days of the appearance of this advertisement. [3238

A. H. HUNT (CAPACITORS), Ltd., require the following technical staff:
SENIOR assistants with qualifications in Chemistry or Physics.
ALSO
JUNIOR laboratory assistants for development and process control work on paper, ceramic and electrolytic capacitors.—Apply in writing to:
THE Personnel Manager, A. H. Hunt (Capacitors), Ltd., Bendon Valley, Garratt Lane, S.W.18. [3506

RADIO and television engineer for general service work required by old-established dealer holding all main agencies; only applicants quick at fault finding and fully experienced can be considered; suitable house for living accommodation will be provided; state experience and salary required, with fullest particulars.
A. E. HUGHES & SONS, 28, Clarence Place, Newport, Mon. [3574

SITUATIONS VACANT

HIGHLY qualified glass technician required by:—
THE ENGLISH ELECTRIC VALVE Co., Ltd., Chelmsford, for small laboratory production of specia. glasses; some years' experience in actual manufacture of glass as well as academic qualifications.—Apply, quoting Ref. 497J, to Dept. C.P.S., 336-7, Strand, W.C.2. [3493

FULHAM and Kensington Hospital Management Committee.
METROPOLITAN Ear, Nose and Throat Hospital at St. Mary Abbots Hospital, Marloes Rd., Kensington, W.8.
HEARING Aid technician required.
NATIONAL salary scales and conditions.
APPLICATIONS giving full particulars should be made to the Hospital Secretary (W.W.32), immediately. [3504

MINISTRY of Supply, Radar Research Establishment, Malvern, Worcs, requires ELECTRICAL Engineers and Physicists for research and development work on radio and electronic equipment. Work ranges from fundamental research on circuitry and physics of the solid state, to devising and developing, in collaboration with Industry, electronic devices for the Army, R.A.F. and Naval Aviation. There is ample scope for initiative and originality over a very wide field concerned mainly with electronics Qualifications: 1st or 2nd class honours degree or equivalent in Physics or light Electrical Engineering. Salary within Scientific Officer range £445-£815. Women somewhat less. F.S.S.U. benefits may be available.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting A 267/54A. Closing date 15 November, 1954. [3601

MITCHAM WORKS, Ltd., have vacancies for:
TECHNICAL ASSISTANTS able to carry out without close supervision, measurements on Radio and/or Television receivers and associated components. These posts offer excellent opportunities for young men to enter the Factory Laboratory of a leading receiver manufacturer.
COMMENCING salaries in accordance with age, experience and qualifications. Candidates, who should have academic qualifications to the standard of H.N.C., should apply in writing to the Personnel Officer, Mitcham Works, Ltd., New Rd., Mitcham Junction, Surrey, quoting reference G.1. [3503

A commencing salary of up to £1,000 per annum is offered to
ENGINEERS and designers with suitable qualifications for highly specialised design and development work in the design of mass produced electronic equipment; the unique aspect of these positions is that a long term future is assured regardless of the international political situation; please reply, giving full details of qualifications and experience to—Box 7696. [3458

FERRANTI, Ltd., of Wythenshawe, have a number of vacancies for technical assistants in the following fields of investigation:—
HYDRAULIC control mechanisms and Servos.
GYROS.
RELAYS and electro-mechanical instruments.
EXPERIMENTAL vibration testing.
MICRO-WAVE systems.
R.F. circuits.
PULSE circuits.
APPLICANTS should hold a degree or Higher National Certificate in electrical or mechanical engineering.
THE work would be of particular interest to men completing National Service in technical brancnes of the Services.
The appointments would be to the permanent staff of the company and offer the prospect of interesting work in modern well-equipped laboratories opened in South Manchester within easy reach of residential districts.
THE company operates a staff pension scheme.
APPLICATION forms from Mr. T. J. Lunt, Staff Manager, Ferranti, Ltd., Hollinwood, Lancs.
PLEASE quote reference WTA. [3403

WANTED by a large garage in Midlands, wireless mechanic; experienced men only need apply stating wages required.—Box 8140. [3571

TV service manager required, must be first-class engineer, used to visual alignment and good organizer; salary £750 p.a. plus expenses.—Tel. for interview. Rav. 9603. [3568

FULLY exp. T/V engineers reqd., must drive, very progressive post; top rates.—Apply E. Coyne, 120, Ladbroke Grove, W.10. Bay. 1947. [3546

LEADING Brighton dealers require competent television/radio service engineer with at least 5 years' experience in retail trade; superannuation/pension scheme.
LYON & HALL, Ltd., 92, Western Rd., Brighton, 1, Sussex. [3535

ELECTRONIC instrument draughtsmen wanted for expanding old-established business, experience V.H.F. and R.F. test equipment desirable, age 23-40, salary according to experience and qualifications.—Apply Box 8126. [3554

REPRESENTATIVE required for two associated small companies covering electro-mechanical engineering as applied to electronic equipment and transformers; S.W. London area. —Write, stating previous experience and suggested manner of remuneration, to Box 8047. [3531

SITUATIONS VACANT

RADIO/Television Engineer wanted. Accommodation available.—Write, with particulars of experience, to Hallahans, Ltd., Kingsbury Square, Aylesbury. [3482

TELEVISION/radio service engineers required; workshop experience and driving essential; apply in writing.—Service Manager, Moons, 1, Queen Anne Terrace, Plymouth. [3466

SALES engineer, qualified in public address equipment, prepared to travel, car owner, good salary and expenses.—Write Magneta Time Co., Ltd., Export Division, Leatherhead, Surrey. [3584

RADIO and/or television engineer required for bench and outside repairs, driver; references, age, experience, salary expected.—Field's Radio, Ltd., 52, Hall Gate, Doncaster. [3542

BRITISH INSULATED CALLENDER'S CABLES, Ltd., invite applications for the undermentioned vacancies with their Telecommunications Engineering Department at Prescot.
TECHNICAL assistant for the preparation of technical recommendations and the evaluation of tenders, etc. A capacity for clear exposition is essential and the successful candidate must become familiar with a wide technical field which will require Higher National or degree standard in Electrical Engineering.
TECHNICAL assistant to undergo training in telephone cable design and allied work which will involve considerable responsibility and judgment. Minimum qualifications, National Certificate or equivalent in Electrical Engineering.
APPLICATIONS quoting reference No. P/50/54 should be submitted in writing to:
THE Staff Officer, Prescot, Lancs. [3423

SENIOR Test Equipment Development Engineers are invited to apply for positions arising in expanding electronic section of the General Electric Co., Ltd., in the south.
APPLICANTS should have a good technical electronic background and previous experience in the development of production test equipment for complete equipments.
THE salary paid will be in accordance with experience and ability Assistance with housing given and superannuation scheme exists.—Full details of experience should be submitted, quoting reference WJS/TE, to the Employment Manager, The General Electric Co., Ltd., Brown's Lane, Allesley, Coventry. [3620

A VACANCY exists for an engineer to take charge of an expanding department engaged on the testing of a wide range of electronic equipment. applicants should have the following qualifications:—
(a) ABILITY to organize and control staff.
(b) A sound technical background with, preferably, a H.N.C.
(c) EXPERIENCE of V.H.F. and pulse technique.
(d) EXPERIENCE of A.I.D. and I.E.M.E. procedure an advantage.
SITUATED within 30 miles London.—Apply Box 8128. [3558

FULLY qualified TV engineer required; top makes held; good wages paid; accommodation can be arranged if necessary.—Apply, giving particulars of salary required. to Victor Freed, Ltd., Aberdare. [3435

ELECTRICAL SERVICE (EDGWARE), Ltd., have a vacancy for a service engineer familiar all types radio and TV; good position, conditions and wages; references.—117, Edgware Rd., W.2. Pad. 2342. [3510

TELEVISION Field Service Engineers. Basic salary £12/10 per week. Only competent, fully experienced men should apply.—Leytonia Radio, Ltd., 828, High Rd., Leyton, E.10. Ley. 1396. [3502

TECHNICIANS required for maintenance and repair of radar, predictors and anti-aircraft artillery in various locations in Lancashire, Cheshire, the Midlands, South and Mid-Wales.
TWO grades of appointment are available:—
(a) TECHNICAL assistants Grade III; salary £510 rising to £640 per annum.
(b) TELECOMMUNICATION mechanics and electricians; weekly wage £7/7 plus up to £1/10 according to ability.
FOR posts (a) O.N.C. City and Guilds or equivalent qualification is desirable; for posts (b) several years' service or civilian experience of electronic equipment repair is required; in the Liverpool area there is a vacancy for technical assistant Grade III with specialist knowledge of CI and IC engine maintenance and a technical assistant Grade III with experience of heavy anti-aircraft or naval armament.
APPLY A.D.M.E. H.Q. 4 A.A. Group, Peninsula Barracks, Warrington, Lancs. [3580

TELEVISION cathode ray tube repairing company requires technician fully conversant with all branches of tube gun assembly. Good salary and commission; also 2 men able to assist.—Box 7749. [3479

TRANSFORMER designer, male, for small transformers. etc., of all types up to 5 kVA; experience of AID and Govt. specs. and estimating an advantage; old-established manufacturers on south coast.—Apply Box 7740. [3472

DESIGNER-DRAUGHTSMAN, age 25-35, with experience modern instrumentation, post offers advancements in expanding organization handling electronic and neucleonic equipment, salary according to qualifications.—Apply Box 8125. [3553

SITUATIONS VACANT

SEMI-CONDUCTORS.—The following personnel are required for development of new types of transistors and other semi-conducting devices; improvements of existing types and development of methods of manufacture:—
DEVELOPMENT engineers, for work on development and engineering control of production of semi-conducting devices; qualifications: science or engineering degree, preferably with factory experience.
EQUIPMENT engineers, for development of equipment for assembly and testing; qualification: engineering degree or H.N. certificate, preferably with factory experience.
DRAUGHTSMEN, for jig and tool design and machine layout work.
RADIO mechanics, for building, calibration, and servicing of test equipment including V.H.F.
APPLICATIONS stating age, qualifications and previous experience to—The Superintendent, British Thomson-Houston Co., Ltd., Lutterworth. [3459

APPLICATIONS are invited from persons with production experience in the Radio Components Industry for a supervisory position in a large and expanding company in south London.
THE position requires a person with good technical background and a practical outlook; able to deal with varied production problems in co-operation with existing staff.
THE post is pensionable and offers excellent prospects to the right man.
WRITE, giving full particulars and salary required, to Box 7914. [3505

RADIO service mechanics required by Smiths (Radiomobile), Ltd., for many parts of the country.—Write details of experience and qualifications to Personnel Officer, Goodwood Works, North Circular Rd., London, N.W.2. [0342

SHORT BROTHERS & HARLAND LIMITED have vacancies in their Research Department for the following additional staff to work on guided missiles and other interesting military and commercial projects:—
MECHANICAL Section.—Senior engineers, engineers and technical assistants to develop hydraulic and pneumatic servos, precision mechanical devices, etc.
ELECTRONICS Section.—Senior engineers, engineers and technical assistants to work on computing, navigational and servo systems.
ELECTRO-Mechanical Section.—Engineers and technical assistants to develop small electromagnetic devices, navigational instruments, etc.
QUALIFICATIONS.—Senior engineers, Honours Degree plus at least five years' good engineering development experience; engineers, University Degree or equivalent, with several years' experience of development work; technical assistants, H.N.C. or equivalent, with good practical experience in appropriate field.
THESE are permanent positions in an expanding organization; good salaries and prospects for men with initiative; pension scheme, assistance with housing.—Send full particulars of age, qualifications and experience, with salary required, to Short Brothers and Harland, Ltd., Castlereagh Factory, Belfast, quoting Ref. No. E9. [3267

DRAUGHTSMAN required for interesting work on mechanical layout of electronic equipment; small progressive firm near Southampton; write, stating age, experience and salary required.—Box 8204. [0251

RADIO engineer required, experienced in design and development of mobile radio equipment; small, progressive firm near Southampton; state qualifications, experience and salary expected.—Box 8205. [0263

PYE, Ltd., require experienced development engineers for radio receiver development in Cambridge, salary according to qualifications.—Apply Personnel Department, Pye, Ltd., St. Andrew's Rd., Cambridge. [3521

THE GENERAL ELECTRIC Co., Ltd., have a vacancy for an Assistant Chief Inspector (mechanical) in their new factory in southern England to produce high grade precision light engineering components.
APPLICATIONS are invited from men under 45 who possess considerable initiative, administrative ability and experience of the machining and assembly of precision work.
EXPERIENCE of the control of inspection staff is essential; salary will be paid according to experience and ability; arrangements for superannuation and housing exist.
WRITE full details of experience and age, quoting ref. WJS/AOI Mech., The Employment Manager, The General Electric Co., Ltd., Brown's Lane, Allesley, Coventry. [3621

PILOT RADIO, Ltd., require senior design engineers for radio and television development, preferably those able to work on own initiative, with knowledge of modern production methods.—Apply Park Royal Rd., N.W.10. [3522

OLD-ESTABLISHED dealers of high repute, holding every leading agency, require additional radio and television engineers; top salary and permanency offered to first-class applicants.—E. P. Fox, Ltd., East Molesey, Surrey. [3598

PRODUCTION Engineer required with experience of press tooling and assembly line fixtures connected with radio industry, injection moulding experience an advantage; permanent position; pension scheme; apply with full particulars to—Personnel Manager, Vidor-Burndept, Ltd. Erith, Kent. [3591

SITUATIONS VACANT

EXPERIENCED radio and television service engineers required for bench work; congenial conditions; good rate of pay.—Northern Lights, Ltd., 370, Cricklewood Lane, N.W.2. Tel. Speedwell 4262. [3603

ELECTRONIC engineers.—E. K. Cole, Ltd., Southend, have vacancies in their electronics department for development engineers. —Apply, stating age, qualifications and experience, to Personnel Manager. [3518

TELEVISION service engineer for London retail business of good standing; driving experience essential; good position for capable man with high standards of service; state age and details of experience.—Box 8255. [3593

TELEVISION engineer, able to drive, reqd. by leading dealer holding all main agencies; must be first-class engineer, salary £625 per annum; accommodation will be available if required.—Apply, giving experience, to Box 7582. [3433

ENGINEER or science graduate to take full responsibility for a production unit combining physical and chemical processes; also to work on improvement of process.—Please apply Painton & Co., Ltd., Kingsthorpe, Northampton. [3510

AN outstanding opportunity exists for an Assistant Chief Inspector (Electrical) of a large established company in a new factory situated near the south coast. This will be concerned with the production of modern electronic equipment.
MEN under 45, possessing experience of radar techniques administrative ability, and considerable experience in the control of test department please apply.
THE salary paid will be commensurate with ability and past experience in a similar position.
HOUSING and superannuation arrangements exist.
REF. "WJS/ACI/Elec." The Employment Manager, The General Electric Co., Ltd., Brown's Lane, Allesley, Coventry. [3630

VACANCIES exist in the Liverpool and Wirral area for technicians with experience of radar, predictors, or similar electronic equipment. Wages commencing £7/7 per week.—Apply 4 MURA, Bluebell Lane, Huyton, Liverpool. Tel. Huyton 3261. [3489

ASSISTANT Buyer, Electronic Instruments, Ltd., Richmond. Experience in electronic equipment essential; duties will include production, planning and progressing; age 25-30; written applications giving qualifications, experience and salary. [3586

LABORATORY assistant required for making up prototype test equipment, applicants must have a keen interest in radio and electronics.—Apply: Hatfield Instruments, Ltd., 175, Uxbridge Rd., Hanwell, London, W.7. Tel. Ealing 0779/9857. [3570

EXPERIENCED engineers required for design of electronic instruments for aircraft, marine and industrial applications, salary £600 to £1,000, housing assistance.—Apply Simmonds Aerocessories, Ltd., Treforest, Pontypridd, Glamorgan. [3516

TRAINEE television service engineer required by old-established London retail radio and electrical business; good opportunity for keen man with aptitude for this work; driving experience essential; state age and details of career.—Box 8254. [3592

SENIOR designer, capable handling all aspects design/development sound amplification equipment for industrial or Service requirements; substantial salary and position in expanding organisation.—Full details career to Box 8201. [3578

A SENIOR Engineer is required by a firm of electronic instrument manufacturers in Surrey; applicants must have had wide practical experience together with first class knowledge of theory; this job will suit the right man.—Box 8340. [3624

SERVICE Engineer required with a knowledge of radio and electricity, must be able to drive; this position is suitable for a young man who has completed his National Service, preferably with technical training.—Radio Heaters, Ltd., 46, Gray's Inn Rd., London, W.C.1. [3622

SENIOR electronic engineer with sound technical knowledge and experience required for development of domestic television and F.M. receivers and components; state age, experience and salary, to—Raymond Electric, Ltd., Brent Crescent, North Circular Rd., N.W.10. [3461

DRAUGHTSMEN, aged 22-25 years, required for mechanical and electronic work, must be neat and accurate and capable of making production drawings from original sketches and ideas, experience in the drawing of circuit diagrams would be an advantage.
EXCELLENT working conditions, bus services to Kingston, London, Guildford, pass the premises.
CANTEEN, pension scheme, sports and social club, with recreational facilities.
APPLICANTS must be of British nationality. Full details of experience and salary required should be addressed to:—
THE Joint Secretary, Cottage Laboratories, Ltd., Portsmouth Rd., Cobham, Surrey. [3480

SITUATIONS VACANT

INSTRUMENT Mechanics who have served or recognised relevant apprenticeships required as Research and Experimental Mechanics at United Kingdom Atomic Energy Authority, Industrial Group, Windscale Works, Sellafield, Cumb.
ELECTRONICS.—Good theoretical knowledge of electronics (Ordinary National Certificate standard desirable) with practical knowledge of wiring, assembly and testing of electronic apparatus. Experience of general instrument calibration an advantage.
PHYSICAL.—Experience of industrial instruments used in measurements or control of temperature, specific gravity, pH and flow; knowledge of vacuum techniques and measurement of gaseous properties an advantage.
GENERAL.—Experience of relay circuits and automatic telephone exchange maintenance.
RATES of pay for 44-hour 5-day week: 160/1 on entry with early assessment for merit pay. Opportunities for advancement to 186/1 with a ceiling for a specialised few of 202/1. Apply giving details of apprenticeship, training (including Forces training), qualifications and experience, to Senior Labour Manager, Windscale Works, Sellafield, Calderbridge, Cumberland. [3374

EXPERIENCED radio testers and inspectors required for production of communication and radio apparatus, also instrument makers, wirers and assemblers, for factory test apparatus.—Apply Personnel Manager, E. K. Cole, Ltd., Ekco Works, Malmesbury, Wilts. [0238

ENGINEERS—radio/TV service—for appointments within the salary range £400-£750 in areas West End, Acton, Lewisham, Croydon, Chatham, High Wycombe, Aldershot, Reading.—Apply Broadmead Wireless Co., Ltd., 123, The Broadway, Wimbledon, S.W.19. Lib. 2435. [3556

ENGINEERS required for research and development work on servo-mechanisms; hydraulic, pneumatic and electrical servos are involved in this work covering such devices as guided missiles, radar scanners, motor control gear and turbo-alternators; vacancies as follows:—
(A) THEORETICAL engineers accustomed to carry out mathematical analysis of servo-systems. (Ref. 60.)
(B) PRACTICAL systems engineers capable of directing original work in all above fields. (Ref. 61.)
(C) ASSISTANT grades to work under direction of systems engineers on development work. (Ref. 62.)
CANDIDATES for (A) and (B) should possess honours degree with some practical experience or have had some previous practical experience in similar work. Candidates for (C) should be mechanical engineering or electrical engineering graduates or students. Knowledge of electronics of great value in this work.
WRITE in detail, quoting reference number of position sought, to: The Personnel Manager (Technical Employment), de Havilland Propellers, Ltd., Hatfield, Herts. [3477

ASSISTANT chemist required for factory producing electrical resistors of all types, some industrial experience desirable but recent graduates considered; starting salary range, £475 to £650 p.a., according to qualifications. PAINTON & Co., Ltd., Bembridge Drive, Kingsthorpe, Northampton. [3511

MECHANICAL engineer or designer required as assistant chief engineer; experience of radio and electronic components desirable, administrative experience essential; pension scheme in operation.—Apply in writing to Carr Fastener Company, Ltd., Stapleford, Nottingham. [3617

TRANSFORMER Designer required for development projects involving audio-frequency power transformers, pulse transformers, oil-filled units, etc.—Apply stating age, qualifications and experience, to The Personnel Manager (Ref. R.G.), The General Electric Co., Ltd., Brown's Lane, Allesley, Coventry. [0260

RADIO and radar testers.—First-class men required for work on V.H.F. communication gear and Government contracts for radio and radar equipment by Midland manufacturers.—Men with wide experience of faults finding in any of the fields mentioned should write, giving full details, to Box 7700. [3470

SENIOR Development Engineers (two) required for work on electronic test gear, varied, interesting work, one vacancy calls for experience in pulse work, permanent well-paid positions; write details of academic qualifications and practical experience to—General Manager, Taylor Electrical Instruments, Montrose Ave., Slough. [3397

TELEVISION engineer required by South Wales dealers, fully experienced; all leading agencies held; permanency to single or married man, and accommodation arranged if required; excellent salary.—Apply, giving particulars of experience and salary required, and appointment can be arranged immediately (all letters answered), Box 7583 [3434

MICROWAVE Engineers reqd. for research and development laboratory at Feltham, Middx. Applicants should have a good academic background with previous experience of microwave problems and design of microwave components. Two vacancies exist, one requiring qualities of leadership.—Applicants should write with full details to Personnel Dept. (ED/201), E.M.I. Eng. Dev., Ltd., Hayes, Middx. [3483

SITUATIONS VACANT

SENIOR transformer designer required with experience of all types of transformers up to 3,000 kVA; excellent prospects for an energetic man capable of supervising junior engineers, excellent working conditions, pension scheme, canteen, etc.; West London area.—Applications to Box 8135. [3565

RADIO and television engineer.—Applications from experienced men in the London area invited by Selfridges, Ltd.; excellent working conditions; good wages; staff canteen; discount on most personal shopping.—Apply Staff Manager, Provisions Building, Somerset St., W.1. [3462

TECHNICIAN required with knowledge electronics for cm radar and to assist in research lab., salary according to age and qualifications in range £315-£450 plus London Weighting £20-£30, good conditions of service.—Apply, own handwriting, to Meteorology Dept., Imperial College London, S.W.7. [3559

RADIO and electronic Laboratory engineer required by North London manufacturers, experience in receiver design and/or transistor technique advantageous; applicants should give fullest details of technical training, qualifications, experience and minimum salary required to—Box 8099. [3550

JUNIOR designers required to deal with small transformers, power, audio, pulse, etc.; specialised training will be given to engineers with suitable basic training and experience.—Applications to Technical Director, Graham Transformers, Ltd., Twickenham Rd., Hanworth, Middx. [3569

SIEMENS BROS. & Co., Ltd., Woolwich, London, S.E.18, have vacancies for qualified engineers in the carrier telephone transmission field; must be capable of controlling staff engaged in research work on new developments; salary according to capabilities and experience.—Quote Ref. 744. [3474

EXPERIENCED fault-finders wanted by Midland manufacturers of radio equipment; permanent posts located in the Midlands are offered to men with experience of radar, radio control, V.H.F. equipment.—Write, stating full experience and salary required, to The Personnel Manager, Box 7701. [3471

DESIGNER draughtsman, preferably with experience on electro-mechanical instruments and components; H.N.C. (Mech.) standard with workshop training desirable, good prospects and conditions.—Full particulars of age, experience and salary required, to Muirhead & Co., Ltd., Elmers End, Beckenham. [3495

ELECTRICAL/electronic engineer required to take charge of small laboratory; applicant must have some years' experience in laboratory of manufacturers or large scale user of any of the following: Cables, capacitors or insulation materials; maximum age 35; address, London, E.11; write with fullest particulars.—Box 8136. [3566

ELECTRONIC engineer with sound knowledge of chemistry required immediately for work on production processes of semi-conductor devices, applicants should preferably be age 22-26 with H.N.C. (El. Eng.) and prepared to work in the Newmarket area.—Details of experience, salary expected, etc., to Box 8127. [3557

ASSISTANT engineers required for radio communication development work, good prospects for men with H.N.C. and up to 5 years' industrial experience; commencing salary according to age and experience; South-East London area.—Apply in writing, stating age, education and salary required, to Box 8011. [3527

LABORATORY engineers required for work on all aspects of television and sound wire broadcasting; excellent opportunities for advancement in expanding organization.—Write, stating age, qualifications, experience and present salary, to The Chief Engineer, British Relay Wireless, Ltd., Giltspur House, Giltspur St., London, E.C.1 [3604

HOUSE provided for suitable applicant, leading retailer (Manchester area) requires first-class television service engineer capable of working on own initiative, excellent prospects in expanding organisation, driving licence essential, superannuation scheme, canteen facilities.—State full details of previous experience, etc., to Box 7822. [3498

DECCA RADAR, Ltd., have vacancies for men with a sound knowledge of radio and radar as installation engineers and airfield radar engineers; the work is interesting and varied and in all cases specialist training is given.—Write or tel. for application form to the Manager, Decca Radar, Ltd., 50, Southwark Bridge Rd., London, S.E.1. Wat. 6944. [3585

INDUSTRIAL television a vacancy exists for a television engineer in the age group 23-35 within a team working on the design of industrial television equipment.—Applications, giving full details of age, experience and qualifications should be addressed to the Chief Television Engineer, Pye Radio Works, St. Andrew's Rd., Cambridge. [3555

GRADUATES with an honours degree in physics or in electrical engineering are required by the British Thomson-Houston Co., Ltd., Rugby, for research in the field of high-power ultra high-frequency valves; applicants should write to the Director of Research giving their age, qualifications and college, quoting reference DR. [3529

SITUATIONS VACANT

TELEVISION engineer required, must be experienced with leading makes and quick fault finder, able to drive, permanent progressive position to right applicant; wages £600 per annum, single or married; flat supplied if necessary.—Apply, giving full particulars, to Box 6637. [3210

THE English Electric Co., Ltd., Stevenage, require personnel for the testing of components, sub-assemblies, systems and flight preparation of guided missiles. The work demands a keen sense of responsibility and offers excellent prospects of advancement. Applications are invited from men who have:
(a) SERVED apprenticeships with technical qualifications of O.N.C. or equivalent City & Guilds;
OR
(b) GOOD practical experience with technical background, e.g., wiremen, fitters or inspectors.
APPLICATIONS from ex-Service technicians, with experience of radio, radar, electronic and mechanical maintenance units, also invited. Housing available to men on demob. or from the Greater London Area.—Apply stating age, experience and salary required to Dept. C.P.S., 336/7, Strand, W.C.2, quoting Ref. 1356A. [3490

TECHNICAL Assistants required for investigational work in connection with radio valve manufacture. Applicants should possess at least Higher National Certificate. Five-day week, modern welfare facilities, staff pension scheme.—Write, giving full personal details, including age, qualifications and experience, Box 8091. [3545

SENIOR development engineer reqd. for interesting work in small section engaged on the development and design of sound recording equipment, qualifications. degree or equivalent, superannuation scheme.—Initial applications by letter, giving fullest details of age, experience, qualifications, etc., to the Personnel Dept. (RD/1), E.M.I., Ltd., Hayes, Middx. [3551

TECHNICAL Salesman required London area with experience in industrial engineering field to handle in U.K. the sale of oscillograph equipment and other electronic instrumentation lines; technical qualifications, particularly general physics, chief consideration; state salary required and mark envelope Attention of Managing Director.—Box 8341. [3626

A WELL-KNOWN large radio component manufacturer has a vacancy for a senior development engineer, with prospects of advancement to an executive and eventually a directorial position; consideration will be given only to applicants with technical and administrative experience in the radio or allied trades; honours degree; age 35-45.—Box 8048. [3534

TELEVISION engineers required by old-established company holding every one of the well-known agencies; applicants must be fully experienced and preferably able to drive; top rates and permanent progressive positions to the right men.—Apply to A. S. White & Sons, Ltd., 130/2. High Rd., S. Tottenham, London, N.15. Sta. 7861-2. [3178

DESIGNER-draughtsmen and detail draughtsmen are required by British Telecommunications Research, Ltd., in connection with development work on V.H.F. radio, line and television transmission projects. Applicants for the designer-draughtsmen posts should have had previous experience of communication, radar or allied light current equipment.
THE company operates a superannuation scheme and offers attractive working conditions with good social and recreational facilities.
APPLICATIONS will be dealt with in confidence and should be addressed to the Executive Director, British Telecommunications Research, Ltd., Taplow Court, Taplow, Bucks. [3293

ELECTRONICS engineer required for practical work in electronics laboratory of research department with experience in wiring circuits and installation; must be capable of building electronics from wiring diagrams; staff conditions, good pay and prospects.—Applications, giving full particulars, to Personnel Officer, Davy and United Engineering Co., Ltd., Park Iron Works, Sheffield, 4. [3532

CRAFTSMEN for radio and television service required in Shrewsbury and Ludlow districts, applicants should be fully experienced in the repair and maintenance of all types of radio and television receivers; rate of pay at present 3/9 per hour. N.J.I.C. conditions.—Apply in writing to Mr. W. Winwood, Sub-Area Manager, Midlands Electricity Board, Spring Gardens, Ditherington, Shrewsbury. [3523

CRAFTSMEN for radio and television service required at Wellington; applicants should be fully experienced in the repair and maintenance of all types of radio and television receivers; rate of pay at present 3/9 per hour; N.J.I.C. conditions.—Apply, in writing, to Mr. W. Winwood, Sub-Area Manager, Midlands Electricity Board, Spring Gdns., Ditherington, Shrewsbury. [3616

ENGINEERS required for maintenance and design of electronic test equipment, quality control and investigational work on thermionic valves; Inter B.Sc. or Higher National Certificate standard; apply giving full particulars of age, qualifications and experience to—Personnel Superintendent, The Edison Swan Electric Co., Ltd., Cosmos Works, Brimsdown, Enfield, Middlesex. [3480

SITUATIONS VACANT

PLANNING engineer required with electrical qualifications dealing with amplifier units and similar apparatus, modern factory Crawley New Town, housing available for successful applicant after probationary period.—Please write, giving full details, to Personnel Officer, Redifon, Ltd., Kelvin Way, Manor Royal, Crawley. [3520

CHIEF engineer required by Beethoven for their London laboratory; applicant to have sound technical knowledge and administrative experience to supervise and organize laboratory for television and F.M. developments.—Apply by letter, stating experience, age and salary, to Beethoven Electric Equipment, Ltd., 89, Reddish Lane, Manchester, 18. [3467

AN opportunity occurs in progressive manufacturing concern in London area for engineer, aged 25/35, with electrical or physicist degree, on development and research work on high frequency telecommunication cable and associated testing equipment; salary will be commensurate with qualifications and experience.—Apply giving full particulars to Box 7677. [3456

ENGINEERS required for maintenance and design of electronic test equipment, quality control and investigational work on thermionic valves; Inter. B.Sc., or Higher National Certificate standard.—Apply, giving full particulars of age, qualifications and experience to Personnel Superintendent, The Edison Swan Electric Co., Ltd., Cosmos Works, Brimsdown, Enfield, Middlesex. [3628

ELECTRONIC Engineer for research and development post with well-known Birmingham company. Applicants should possess University degree and have had experience in pulse techniques and digital computer principles. The appointment offers good prospects and conditions in a substantial organization. Pension scheme.—Apply, stating age and qualifications, to Box 8090. [3544

THE UNIVERSITY OF LEEDS.—Laboratory technician required in the Department of Electrical Engineering; knowledge of electronics essential; wages scale 120/- to 174/-; starting figure depending on age and qualifications.—Applications, giving full details of experience, education and age, to Professor G. W. Carter, Department of Electrical Engineering, The University, Leeds, 2. [3488

ENGINEER or Physicist required by large company of world-wide renown in Birmingham. Applicants should be well qualified academically and have experience in experimental physics or instrumentation. The appointment offers good prospects and conditions in a substantial organization. Pension scheme.—Apply, giving details of age and qualifications, to Box 8089. [3543

ELECTRONIC engineer required to join laboratory of new works—Harold Wood, Essex, for research on high frequency line transmission systems and allied equipment this country and abroad, excellent prospects.—Apply giving details of experience, qualifications and salary to Telefusion (Engineering), Ltd., Church Rd., Harold Wood, Essex. Ingrebourne 2901. [3577

EX-SERVICE radio-radar mechanics.—A leading company in the electronic field has vacancies for men interested in manufacture and maintenance of radar equipment; opportunities occur in the factory and in the outside maintenance field for men who have had service training and some theoretical knowledge.—Applicants should write, giving full details of their experience, etc., to Box 7699. [3469

ELECTRONIC Engineer to work within our Trials Division at Edinburgh. The nature of the work involves conducting trials and evaluating the performance of electronic and radar equipment. Applicants should have recent technical and operational experience in industry or the services. Staff Pension Scheme.—Apply in writing, quoting Ref. EE/TID, to the Personnel Officer, Ferranti Ltd., Ferry Rd., Edinburgh, 5. [3366

ELECTRICAL Engineer with University degree or equivalent qualification, required for development work on rubber and plastic insulated cables, with particular emphasis on telecommunications and radio frequency applications; experience in cable manufacture desirable but not essential; salary in accordance with experience and qualifications.—Apply to the Secretary, W. T. Glover & Co., Ltd., Trafford Park, Manchester. [3501

QUALIFIED Electrical Engineer required at Scientific Research Station near Cambridge to undertake semi-experimental work in Laboratory Workshops. Must be willing to be engaged on ordinary electrical plant maintenance and installation work temporarily. Salary range £550—£750 per annum according to age, qualifications and experience.—Write stating age, fullest particulars and salary required to Box 8355. [3631

TECHNICAL assistants (electronic).—Men required of Final Certificate City & Guilds Telecommunications standard and with experience in V.H.F. and U.H.F.; men with compensating experience in these frequencies can be considered; opportunity to broaden experience and avoid restrictive specialization; Saturday interview if required.—Apply Marconi Instruments, Ltd., Longacres, Hatfield Rd., St. Albans. [3464

SITUATIONS VACANT

RADIO technicians required by International Aeradio, Ltd., for overseas service; permanent and pensionable positions, inclusive salary from £894 per annum to £1,373 per annum, tax free according to marital status; free accommodation; kit allowance; free air fares; generous U.K. leave.—Qualified candidates to whom replies only will be sent please write quoting RT to Personnel Officer, 40, Park St., W.1. [0262

SERVICE Engineer required, chiefly for maintenance of high power amplifiers and construction of special equipment from theoretical circuit diagrams. Excellent opportunity for a keen junior willing to learn and transfer later to television side. Must live in S.W. London. Commencing salary about £400 p.a. Superannuation and life assurance scheme.—Development Manager, Metropolitan Relays, Ltd., 69, Lavender Hill, S.W.11. [3548

RADIO.—Junior laboratory engineer required by North London manufacturers, of good education and technical training, preferably holding or studying for recognised qualifications.—Apply stating fullest details of education, experience and minimum salary required (which latter will be considered in selecting applicants for interview but not to determine the amount offered to successful applicant), to Box 7402. [3383

PRACTICAL electronic engineer required for work on test equipment; should be able to diagnose faults using diagram and technical write-up, calibrate to close tolerances, and work on his own initiative with the minimum of supervision; salary £600 p.a. and above, according to qualifications.—Write, quoting reference 33/EN, to the Personnel Manager, Smiths Aircraft Instruments, Ltd., Bishops Cleeve, near Cheltenham, Glos. [3589

HAVE you a flair for writing? A London advertising agency needs a man with a good electronic background to help compile and write service manuals and sales literature on a variety of electronic equipment and associated components; the appointment is permanent, and carries with it pension and life assurance benefits.—Write fully, stating age, experience and salary required, to Box 8317. [3618

MICROWAVE inspection; engineer required to take charge of microwave inspection department; must have both electrical and mechanical knowledge of testing aerials, waveguide sections attenuators, wave-meters, oscillators, mixers, etc; opportunity for advancement with progressive company in S.W. London area.—Application in writing, stating experience and salary required, to Box 5879, 15, Hill St., London, W.1. [3262

TELEVISION engineers with outside service or workshop experience required by large rental organization, real opportunities exist for advancement in developing company; salaries are graded in accordance with experience and ability; pension scheme in operation.—Applicants should write in first instance stating details of past experience and knowledge, to Birmet Television Manufacturing Co., Ltd., 69, Lavender Hill, S.W.11. [3533

SENIOR engineer required for long term basic development of new types of radio communication equipment; attractive position for engineer of degree standard with interest in radio circuitry and components; the position is permanent and will carry a salary commensurate with the applicant's knowledge and experience; location in South London.—Apply in writing, stating age, education and salary required, to Box 8010. [3526

DRAUGHTSMEN required; excellent opportunity to broaden experience with well-established company, whose wide range of products avoids restrictive specialization; there are vacancies for seniors and juniors with at least Ordinary National Certificate; on well served transport routes; near city centre and amenities; Saturday interview if required.—Apply Marconi Instruments, Ltd., Longacres, Hatfield Rd., St. Albans. [3463

THE electronics department of a large manufacturing company requires enthusiastic and experienced senior and junior electronic and electro-mechanical engineers for new developments in internal and commercial instrumentation work; the company is situated in pleasant countryside on the outskirts of Wolverhampton; a superannuation scheme is in operation; initial salaries will be commensurate with ability, and there are good opportunities for advancement.—Box 7177. [3323

HOUSING assistance will be offered to electrical foreman with wide production experience in radio industry of small and medium electrical control gear manufacture, test and installation, required by manufacturers of materials handling vehicles in pleasant country district, 1 hour London. Good prospects of advancement; canteen and social facilities.—Please write, giving details of past experience, present salary, salary required, married/single, to Box 8092. [3547

McMICHAEL RADIO, Ltd., require senior and junior engineers in their equipment division laboratory at Slough; training and experience in the field of applied electronics (including communications) and experience of working with Government Departments are the chief qualifications required.—Write, stating age and full details of training, qualifications and experience, to the Chief Engineer, Equipment Division, McMichael Radio, Ltd., Slough, Bucks. [0196

SITUATIONS VACANT

TECHNICAL Assistant required by large firm of cable manufacturers for the testing of high-frequency and land communication cables; previous experience in cable testing essential; O.N.C. standard in electrical engineering would be an advantage; salary in accordance with qualifications and experience; five-day week and pension scheme.—Details, quoting reference CD/1, to: Staff Officer, The Telegraph Construction & Maintenance Co., Ltd., Telcon Works, Greenwich, S.E.10 [3528

RADIO and electrical department of British company operating in Central Africa require experienced man; qualifications include expert radio knowledge, practical repair and maintenance of refrigerators domestic appliances, etc., and salesmanship; four years' contract with passages, housing, paid leave, etc., etc.; commencing salary according to experience; pension scheme; low income tax; healthy climate.—Write 2492, Wm. Porteous & Co., Glasgow. [3567

ELECTRONIC engineers required; excellent opportunity for men of degree standard to broaden experience in a field of great interest and variety and involving latest techniques; restrictive specialization can be avoided by joining Marconi Instruments, Ltd., who produce light current communications, measuring and test apparatus for a wide range of requirements; Saturday interview if required.—Apply Marconi Instruments, Ltd., Longacres, Hatfield Rd., St. Albans. [3465

DRAUGHTSMAN required for detailing mechanical and electrical assemblies; must be capable of reading electronic circuits; applicants with any previous experience on sheet metal cubicles, H.V. power supply units, induction heaters or radio and television layouts should write stating age and full details of previous experience and technical training; housing facilities available near factory area.—The Edison Swan Electric Co., Ltd., Eastern Industrial Area, Harlow New Town, Essex. [3588

OLD-ESTABLISHED British company in Far East requires the services of a technical sales assistant; candidates should preferably be between the ages of 23-27, of good education and have a general knowledge of some of the following: (a) Broadcast and telecommunications equipment; (b) Television; (c) Cinema equipment; (d) Light electrical engineering; sales experience an advantage.—Write in confidence to Box "SE/28." c/o 95, Bishopsgate, E.C.2. [3475

THE GENERAL ELECTRIC Co., Ltd., Brown's Lane, Coventry, requires senior and junior electronic development engineers for work on guided weapons and like projects, particularly in the field of microwave and pulse applications; mechanical development engineers, designer draughtsmen and draughtsmen, preferably with experience of radar-type equipments, also required for the above projects; salary according to age, qualifications and experience —Apply by letter, stating age and experience, to the Personnel Manager (ref. R.G.). [0259

ELECTRONIC engineer is required for work in the research laboratory of a progressive East Midlands firm on the design and development of electronic measuring instruments and of circuits for automatic control systems, etc., the post should prove most attractive to a man aged 25-30, who has obtained a good degree and has had some experience in servo systems, electronic motor control and/or magnetic amplifiers; a salary up to £700 depending on qualifications is offered; the post is pensionable.—Please write, stating age, experience, etc., Box 2J J 9847, A.K. Advg., 212a, Shaftesbury Ave., London, W.C.2. [3541

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BRITISH TELECOMMUNICATIONS RESEARCH, Ltd., require draughtsmen accustomed to preparing production drawings from component layouts or engineers circuit information; applicants must have had several years' experience in the electronics drawing office of a manufacturing organisation preferably engaged upon carrier or V.H.F. communication equipment; they should have practical experience and a echnical education up to O.N.C. standard; salaries in excess of current A.E.S.D. rates will be paid to suitable applicants.—Write to Director of Research, Taplow Court, Taplow, Bucks. [3509

MINISTRY OF TRANSPORT AND CIVIL AVIATION.—Radio technicians (men only) required at aerodromes and radio stations in U.K. Special training courses for keen technicians with basic quals. Interesting work in progress providing electronic aids to navigation. Prospect of permanent pensionable posts. Rates of pay (London) from £330 p.a. at age 19, to £4[illegible]; at 25 rising subject to qualifying test to £540. Rates slightly lower for provinces. Candidates aged 19 or over with practical experience in maintenance of radio or radar equipment should apply to any Employment Exchange, quoting Westminster 6627. [3508

SITUATIONS VACANT

ELECTRONICS technician for electro-physiological research wanted by University Department in Medical School; duties to operate and maintain multi-channel amplifying and recording equipment, and to assist with development of new research apparatus; wide knowledge of electronics techniques desirable, EEG/EMG/CRO—photography; salary in range £470-£545, according to experience, with superannuation.—Apply, in writing, to the Secretary, Department of Physiology, Middlesex Hospital Medical School, London, W.1. [3496

YOUNG men with good knowledge of A.C. theory and/or experience in radio, high frequency communications or similar fields, required for limited number of vacancies in inspection department of electrical communications engineering organisation in Liverpool; permanent employment offered with good prospects of advancement; applicants, who should have completed their military service, should write giving full details of age and experience, to Box No. 154, Dorland Advertising, Ltd., 18-20, Regent St., London, S.W.1. [3517

ELECTRONIC engineers with sound basic knowledge of low frequency techniques required for work on design and development of electronic units for servo control work. Candidates should have some practical experience and qualifications in shape of degree; H.N.C. or City & Guilds Cert. desirable but by no means essential. (Ref. 59.)—Write in detail, quoting reference number of position sought, to: The Personnel Manager (Technichal Employment), de Havilland Propellers, Ltd., Hatfield, Herts. [3476

A DEVELOPMENT establishment, associated with a large group of companies and situated west of London, requires draughtsmen with experience in the design of electronic apparatus and preferably with a knowledge of radio or line communication equipment. Salary offered will be commensurate with experience and qualifications. Details of conditions of service which include schemes to assist further technical education will be available during interview. Good social facilities provided. Apply Box No. 962, Dorland Advertising, Ltd., 18/20, Regent St., S.W.1. [3292

MINISTRY OF SUPPLY requires electronics technicians at Aberporth, S. Wales, for novel duties of considerable technical interest in connection with flight testing of guided weapons; quals., British of British parents, recognised engineering apprenticeship or equivalent in electronics, wide experience in electronics field, theoretical knowledge advantageous; O.N.C. City & Guilds or equivalent qual. desirable. Salary, with £510 (at age 26)—£640. Prospect of promotion; housing later if married; opportunities to compete for establishment may arise.—Apply any Employment Exchange, quoting Westminster 5561. [3492

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EXPERIENCED engineers are invited to apply for a position where energy, skill and initiative will be well rewarded; the work relates to the development of television components and circuits and the design of components for large-scale production; previous experience of television receivers is required, preferably in respect to means of scanning and focussing; the position is a permanent one which offers scope for advancement to a senior position; the commencing salary will be in accordance with previous experience, based on a generous and progressive scale.—Write, giving full personal particulars to the Personnel Manager, The Plessey Co., Ltd., Ilford, Essex. [3401

ADMIRALTY—ROYAL NAVAL SCIENTIFIC SERVICE.—Experimental Officers and Assistant Experimental Officers required in Experimental Establishments in London, Portsmouth, Weymouth areas, Gloucestershire and Scotland. The majority of posts are for Engineers and Physicists (particularly with Electronics). Candidates must be British subjects. Qualifications —minimum of H.S.C. (Pass degree, H.N.C. or near equivalent an advantage). London salary (men) £720—£890; A.E.O. (according to age) £290—£645. All appointments are unestablished, but with some opportunities to compete for established posts.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King St., London, S.W.1, quoting A247/52A. [3507

RADIO mechanic required for the Bermuda Police Force in the rank of Constable for a tour of 5½ years with possibility of permanency; salary scale (including present temporary allowance of 10% of salary) £715 rising to £825 a year; free passages and uniform; no income tax; candidates must be unmarried, between 21 and 28 years of age, of sound physique and good education; they must be familiar with signal generator, valve tester, anometer and battery charger equipment and also VHF equipment similar to Pye Series PTC 704 (Fixed Unit) and Pye Series PTC 115 (Mobile Units).—Write to the Crown Agents, 4, Millbank, London, S.W.1; state age, name in block letters, full qualifications and experience and quote M1/36551/WF. [3473

SITUATIONS VACANT

MINISTRY OF TRANSPORT AND CIVIL AVIATION.—Radio technicians (men only) required at aerodromes and radio stations in U.K., special training courses for keen technicians with basic quals., interesting work in progress providing electronic aids to navigation, opportunities for advancement and prospect of permanent pensionable posts; rates of pay (London) from £330 p.a. at age 19, to £445 at 25, rising, subject to qualifying test to £540, rates lower for provinces, candidates aged 19 or over with practical experience in maintenance of radio or radar equipment should apply to any Employment Exchange quoting Westminster 6627. [3625

SENIOR and Junior Electronic Engineers are required for interesting and varied work in the Nelson Research Laboratories, The English Electric Co., Ltd., Stafford. Applicants should have a sound workshop experience, some knowledge of drawing office procedure, and minimum qualifications of Higher National Certificate. Duties involve responsibility for the engineering design of prototype electronic equipment and the preparation of manufacturing information. These posts offer scope for advancement to men with initiative and ability. Salary, according to qualifications and experience, comparable with present-day levels.—Write with full details to Ref. 305J, to Dept. O.P.S., 336/7, Strand, W.C.2. [3485

AIR Ministry requires Scientific Officers (male) at R.A.F. Station near High Wycombe, Bucks, and in Norfolk, for operational research duties, and theoretical studies in field of communications and general electronics. Qualifications: First or Second Class Honours degree in physics or electrical engineering. Salary: Within range £445-£815. Post unestablished with possibilities of establishment through Civil Service Commission for successful candidate whilst remaining under age 31. Opportunities for promotion to higher grade posts on staff of Scientific Adviser to Air Ministry.—Application forms, quoting A109/54A from M.L.N.S., Technical and Scientific Register (K), 26, King St., London, S.W.1. Closing date 13 November, 1954. [3481

ELECTRICAL engineer or physicist required by Ministry of Supply, London Headquarters to maintain technical and standardisation records and supervise a small library and information service. Qualifications—Higher School Certificate (Science) or equivalent but possession of a degree or Higher National Certificate in Electrical Engineering or Physics may be an advantage. A good knowledge of electronics, particularly radar and radio and experience in writing and editing technical reports required. Salary within Experimental Officer range (minimum age 26 years), £720-£890. Women somewhat less. Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting D.485/54-A. Closing date 13 November, 1954. [3538

SITUATIONS VACANT

TECHNICAL supervisor required by Nigeria for one tour of 15-24 months with option of appointment either (a) on agreement with prospect of permanent and pensionable employment in salary scale (including expatriation pay) £1,210, rising to £1,315 a year, or (b) on contract in a temporary capacity with salary (including expatriation pay), £1,307 rising to £1,453 a year; gratuity at rate of £150 a year; outfit allowance of up to £60; free passages for officer and wife; assistance towards cost of children's passages or grant up to £150 annually for maintenance in U.K.; liberal leave on full salary. Candidates must hold C. and G. Intermediate Certificate in Telecommunications Engineering and have passed the final paper in (1) Line Transmission II, or (2) Telegraphy II, or (3) Radio IV, and should have had considerable experience in the maintenance of V.H.F. multi-channel equipment and associated carrier and V.F. telegraph equipment at major V.H.F. terminals.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications, and quote M2C/30626/WF. Candidates at present employed by the G.P.O. should submit their applications through their Establishment Division. [3491

SITUATIONS WANTED

EXECUTIVE engineer, with extensive knowledge and experience in development and engineering electronic and light electrical systems into production processes and in the associated mechanical handling problems, seeks senior post where personality, initiative and drive are required; experienced complete control production unit and technical directorship; present post, 5 years, similar to above, but does not allow full use of abilities; age 40; A.M.Brit.I.R.E.; salary range £1,500-£2,000 p.a. —Box 8270. [3606

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3	0·05μF	500V	CP37S	2/1
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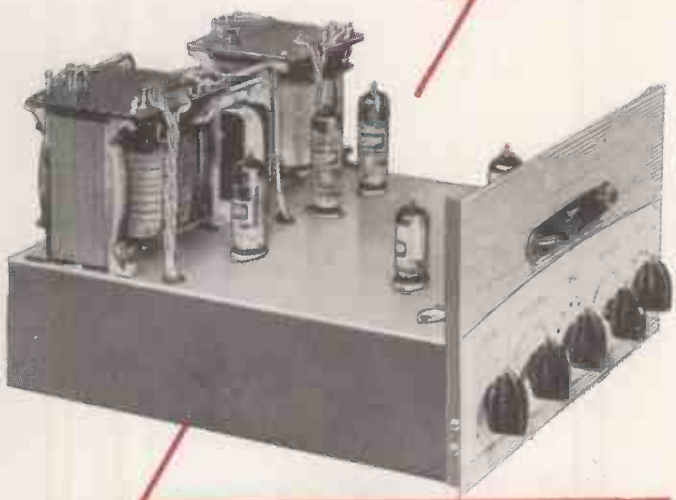

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