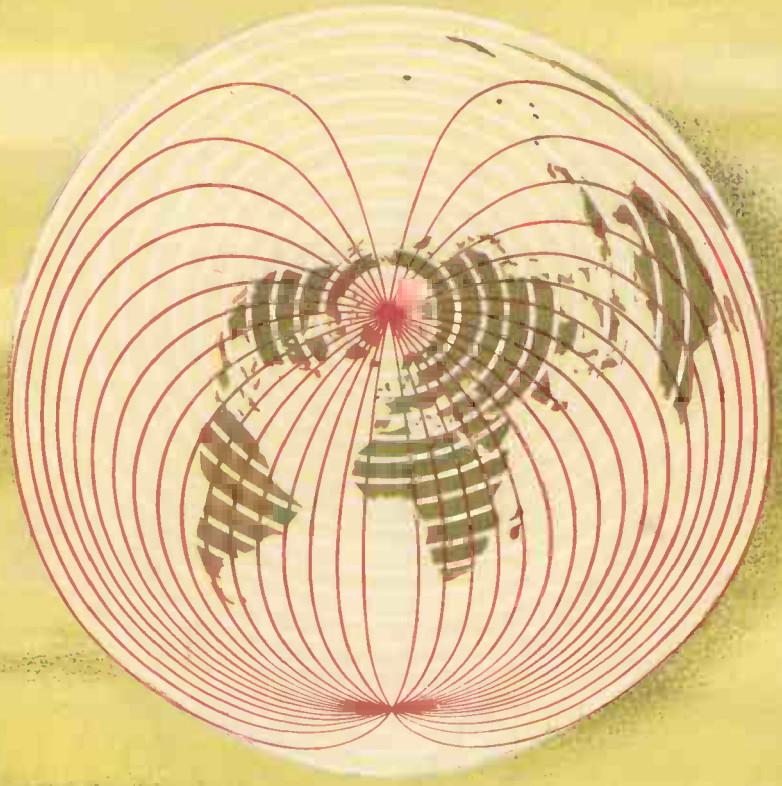
MAY 1955

TWO SHILLINGS

Wireless World

Radio · Electronics · Television



FORTY-FIFTH YEAR OF PUBLICATION

Wireless World

RADIO, ELECTRONICS, TELEVISION

Managing Editor:
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Editor:
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MAY 1955

In This Issue

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OF PUBLICATION

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VALVES, TUBES & CIRCUITS

29. EF89 & UF89: IMPROVEMENTS IN I.F. AMPLIFIERS FOR F.M./A.M. RECEIVERS

I.F. amplifiers for f.m. reception are normally 'neutralised' in order (i) to achieve satisfactory stability and (ii) to minimise the effects of capacitive feedback from anode to signal grid in producing phase distortion and distortion of the bandpass curve. An i.f. voltage is led back on to the screen grid through a neutralising capacitor, and passes through the interelectrode capacity $c_{g1\text{-}g2}$ to the signal grid; there it cancels out the voltage passed through the capacity $c_{a\text{-}g1}$, the two voltages being of equal magnitude and opposite phase. The neutralising capacitor forms the fourth arm of a bridge network, and its value is chosen to balauce the bridge. Unfortunately a bridge which has been balanced for f.m. reception may not remain balanced during a.m. operation.

The Mullard EF89 is a medium slope variable-mu pentode whose introduction will tend to make neutralising requirements less critical. Unneutralised r.f. and i.f. circuits can be considered under some conditions where previously neutralising would have been required.

The maximum amplification realised with the EF89 is higher than that obtained with previously available valves such as the EF41. An indication of the maximum amplification obtainable from an r.f. and i.f. pentode is given by a quality factor defined as the ratio of slope to anode-to-grid capacitance. When designing the EF89, the small anode-to-grid capacitance of the EF41 ($c_{a\text{-}g1} < 0.002$pF) was used as a starting point, and the design of the EF41 modified to produce the highest practicable slope without increasing the capacitance.

Under normal operating conditions, with a 9mA anode current, the slope is 3.5mA/V for a grid bias of -2.0V.

For f.m. reception the first stage of i.f. amplification is provided by the heptode section of the ECH81 (which during a.m. reception functions as a conventional triode heptode frequency changer). The second i.f. amplifier will be the EF89, feeding into the ratio detector (diodes a''_d and a'''_d of the EABC80).

The EF89 has been so designed that when it follows the ECH81 connected as the a.m. frequency changer, the a.g.c. voltage can be applied to both valves if desired. (Normally of course a.g.c. is not necessary for f.m. reception.) At high input signals overcontrolling does not occur, that is, an increase in signal strength does not lead to a decrease in output, and the distortion associated with overcontrolling is avoided. The cut-off characteristics of the EF89 and ECH81 mixer heptode are so matched that, when the grid voltage is changed from -2V to -16.5V, the slope of the EF89 falls to one-tenth of its original value whilst the slope of the ECH81 heptode falls to one-twentyfourth. The cross-modulation curve is better than for the EF41, and the a.g.c. voltage therefore can be allowed to take the slope down to a small value without appreciable distortion.

The EF89 may be used also as a variable-mu r.f. amplifier. The screen grid is brought out to its own pin connection (No. 8), and the internal screening is connected to two separate pins (Nos. 1 and 6). These connections are very helpful in the design of r.f. (and, for that matter, i.f.) amplifiers, in that no additional damping is introduced by earthing the suppressor grid and screening. The suppressor grid connection to the chassis should have the lowest possible resistance (R_{g3} max = 10kΩ).

The UF89 is rated at 12.6V, 100mA and is intended for d.c./a.c. mains receivers. In all other respects it is identical with the EF89 (6.3V, 200mA), and the same operating conditions apply to the E- and U-versions.

PRELIMINARY DATA: EF89

HEATER		
V_h	6.3	V
I_h	200	mA
CAPACITANCES		
c_{in}	5.5	pF
c_{out}	5.1	pF
c_{a-g1}	<0.002	pF
c_{g1-h}	0.05	pF
CHARACTERISTICS		
V_a	250	V
V_{g3}	0	V
V_{g2}	100	V
V_{g1}	−2.0	V
I_a	9.0	mA
I_{g2}	3.0	mA
g_m	3.6	mA/V
r_a	1.0	MΩ
TYPICAL OPERATING CONDITIONS		
$V_a = V_b$	250	V
V_{g3}	0	V
R_{g2}	51	kΩ
R_k	160	Ω
I_a	9.0	mA
I_{g2}	3.0	mA
g_m	3.5	mA/V
r_a	1.0	MΩ
R_{eq}	4.2	kΩ
g_m ($V_{g1} = -20$V)	240	μA/V
LIMITING VALUES		
$V_{a(b)}$ max.	550	V
V_a max.	300	V
p_a max.	2.25	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	300	V
p_{g2} max.	0.45	W
I_k max.	16.5	mA
R_{g1-k} max.	3.0	MΩ
V_{h-k} max.	100	V
BASE	B9A	

Pin:—	1	2	3	4	5	6	7	8	9
	s	g_1	k	h	h	s	a	g_2	g_3

Wireless World

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Ineffective Regulation

ACCORDING to the summary given on p. 207 of this issue the G.P.O. has found that electric motors are now responsible for just about as much interference with broadcast reception as all other devices put together.

This being so, it is to be regretted that the Postmaster General's recently assumed powers to control interference from electric motors are unlikely to have the fullest possible effect in abating the trouble. The issue of the Regulation giving these powers, which comes into force on September 1st, was reported on p. 155 of our April issue. Briefly, all users of motors will be required to keep radiated and conducted interference within specified limits on the bands of frequencies used for television Band I and for medium- and long-wave sound broadcasting.

It must be admitted that, on the face of it, this new Regulation might be considered likely to have the desired effect. But its launching was followed by a Press statement (to which publicity was unfortunately given in the newspapers) which, we fear, will weaken the Regulation. "The new powers," said the statement, "will be used only where it is necessary for the Post Office to insist on an appliance being put right because it causes interference and the owner will not voluntarily have a suppressor fitted." That will be taken by the public to mean, "Don't go to the trouble and expense of fitting a suppressor to your motor-driven device until your neighbours complain to the Post Office."

Cloak of Security

IN drawing attention to the unsatisfactory system for controlling and administering radio matters in this country, we believe this journal is expressing opinions that are widely held among wireless people. It is encouraging to find our views are now given support by two members of Parliament. In the last issue there was a letter from Capt. L. P. S. Orr on the problems of frequency allocation and this month C. I. Orr-Ewing writes an "Open Letter to the Postmaster General," sketching in the framework for a new kind of communications commission which he proposes for regulating our affairs.

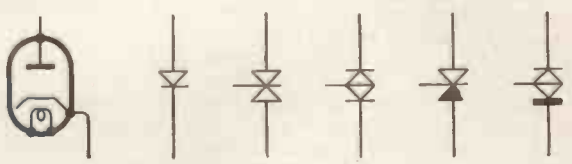
Both these legislators refer to the Defence Services in relation to frequency allocation. Possibly they feel as we do that the Services tend to get more than their necessary and proper share of the cake. Capt. Orr specifically refuses to accept the proposition that "security considerations" can automatically be accepted as a valid reason for making other than the most economical use of communication channels.

"Security" is a sadly abused word, and we would hazard a guess that its excessive use is responsible for many of the difficulties that arise in adjudicating between conflicting demands for channels between civil and military interests. Security-consciousness is infectious, too, and the word is used in relation to matters that in fact might be disclosed to anybody. Not long ago *Wireless World* was refused a list of the frequencies used for the v.h.f. section of the British Forces broadcasting network in Germany!

Transistor Symbols

IT is regretted that the diagram in the Editorial Comment of our April issue was incomplete; section (f) was cut off in making the printing block.

The full diagram is reproduced here. At (a) is shown the normal valve rectifier symbol and at (b) the conventional semi-conductor rectifier on which *Wireless World* suggests that transistor symbols may rationally and usefully be based. Diagrams (c) and (d) represent, respectively, the *p-n-p* and *n-p-n* transistor according to this system, and are similar to those



originally suggested by the Canadian Defence Research Establishment.

Finally, the modified symbols (e) and (f) for *p-n-p* and *n-p-n* junction transistors are suggested by *Wireless World* to simplify the reading of circuit diagrams by facilitating identification of the emitter element, which is thickened or blacked-in.

Twin-Channel Tape Records

H.M.V. Demonstrate "Stereosonic" System

IN addition to the single-channel high-quality tape records which were introduced by the Gramophone Company last year, twin-channel tape records are to be issued in the early autumn. Complementary recordings will be made simultaneously on parallel tracks at a speed of 7½in/sec on a ¼-in wide tape. Separate amplifiers and loudspeakers will be necessary to reproduce the two magnetic records and to establish a sound field in which it is possible to distinguish individual sources of sound when the originals were separated in space.

The system is termed "Stereosonic," which implies a difference from the conventional method of stereophonic recording and reproduction, in which omni-directional pressure microphones are spaced some distance apart in the recording studio and more-or-less omni-directional loudspeakers are sited in similar relative positions in the auditorium. In the H.M.V. system the sound is analysed at a single point by a twin-ribbon microphone, the directional axes of which are fixed at right angles. Since there is no appreciable phase difference at the pick-up point, the outputs from the two channels differ primarily in amplitude and also in the ratio of direct to reverberant sound. The spacing of the twin reproducing loudspeakers is not important, but they should be arranged with their axes more or less at right-angles (60° to 90° is recommended). These conditions can be met in a living room of any size with the reproducers in adjacent corners.

Best results are obtained at the junction of the loudspeaker axes, where the "wall-eyed outlook" of the special microphone is exactly compensated by the "squint" of the loudspeakers, but the "Stereosonic" effect covers a much wider area, as was evident at the inaugural demonstration given at the Abbey Road studios of the Gramophone Company. Most effective items in a varied programme were excerpts from operas in which orchestras, soloists and chorus were well spaced. But it was noticeable also, that piano reproduction had a subtle "live" quality which is not often present in single channel reproduction. The demonstrations also supported the claim that, with this method of partitioning the sound field, directional effects are sustained at much lower frequencies than in the spaced pressure microphone technique.

A "Stereosonic" reproducer for use with these tape records will be available in the autumn and will consist of two cabinets, each with elliptical moving coil units for medium and low frequencies, and electrostatic "tweeters" for 6kc/s and above. Ten-watt power amplifiers will be housed in each cabinet and one cabinet will carry the tape mechanism and two pre-amplifiers, while the other will be fitted with a three-speed automatic disc record changer. A three-position switch will give the choice of "Stereosonic" reproduction, or single-channel through one or both loudspeakers. In addition to volume, bass and treble tone controls there will also be a balance control to give a shift of the virtual sound image between the speakers and to compensate where necessary for the acoustic characteristics of the listening room.

BOOKS RECEIVED

Department of Scientific and Industrial Research. Report for the Year 1953-54. Includes a summary of the work of the Radio Research Organisation which has covered investigations into the phase changes in low-frequency waves at a coastline, propagation at h.f., v.h.f. and u.h.f., the nature and distribution of atmospheric noise, and the use of the noise spectra of semi-conductor junctions to provide information about the physical processes involved. Pp. 326. Price 9s. Her Majesty's Stationery Office.

Schaltungstheorie und Messtechnik des Dezimeter-und Zentimeter-wellengebietes, by Albert Weissfloch. Textbook of circuit theory and measurement technique in the decimetre and centimetre ranges. Pp. 308; Figs. 282. Price 33.50 Swiss francs. Verlag Birkhäuser, Basle, Switzerland.

Electric Transmission and Distribution. Edited by B. G. A. Skrotzki. Theory and practice of power supply and the equipment used in distribution systems; contributed by leading American professional engineers. Pp. 448; Figs. 292. Price 56s 6d. McGraw Hill Publishing Co., Ltd., 95, Farringdon Street, London, E.C.4.

Electric System Operation. Edited by G. B. A. Skrotzki. Symposium on fault protective device, load control and dispatching, and power supply economics. Pp. 370; Figs. 277. Price 49s. McGraw Hill Publishing Co., Ltd., 95, Farringdon Street, London, E.C.4.

Single Sideband for the Radio Amateur. Digest of articles from *QST* covering design of transmitters and receivers. Pp. 208; Figs. 166. Published by the American Radio Relay League. Obtainable from The Modern Book Company, 19-23, Praed Street, London, W.2. Price 14s 6d by post.

Remote Control by Radio, by A. H. Briunsma. Description of an amplitude-modulation system with two independent channels, and an eight-channel pulse-modulation system, as used in the Philips radio-controlled model ships. The text includes complete circuit diagrams with component values. Pp. 97+VIII; Figs. 74. Price 8s 6d. Cleaver Hume Press, Ltd., 31, Wrights Lane, London, W.8.

Television Principles and Practice, by F. J. Camm. Description in simple terms of the technical basis of television transmission and reception, including hints on choosing a receiver, a summary of the Beveridge report and a dictionary of television terms. Pp. 215; Figs. 144. Price 25s. George Newnes, Ltd., Southampton Street, London, W.C.2.

Licence Manual for Radio Operators, by J. Richard Johnson. Model answers to questions likely to be asked in the Federal Communications Commission examinations for American commercial radio operators. Appendices give source references for questions relating to law, common communications abbreviations (including the Q code) and a bibliography. Pp. 430; Figs. 140. Price $5.00. Rinehart & Company, 232, Madison Avenue, New York, 16.

Mobile Radio

P.M.G. Accepts Plan for Clearing Band III

A YEAR ago the Postmaster General appointed a committee to examine the problems (so far as mobile radio is concerned) arising from the decision to clear Band III (174-216 Mc/s) for television. This Mobile Radio Committee—which includes representatives of the Post Office, Ministry of Transport and Civil Aviation, Mobile Radio Users' Association and the Marine Radio Advisory Service, under the chairmanship of R. J. P. Harvey (G.P.O.)—was unable to make firm recommendations by the end of the year as requested. The committee was reconstituted in January and given a further three months in which to complete the enquiry. With the reconstitution the P.M.G. added three independent members to the committee: Dr. R. L. Smith-Rose (D.S.I.R.), F. Jervis Smith (I.E.E.) and H. S. Vian-Smith (Association of British Chambers of Commerce).

The Committee's report has now been published* and was accepted in full by Earl De La Warr the day before retiring from the Government.† He pointed out, however, that it is in some ways an interim report —concentrating on the immediate problems of relieving Band III—and he has, therefore, asked the Committee to continue to advise the P.M.G. on future developments of the mobile radio service.

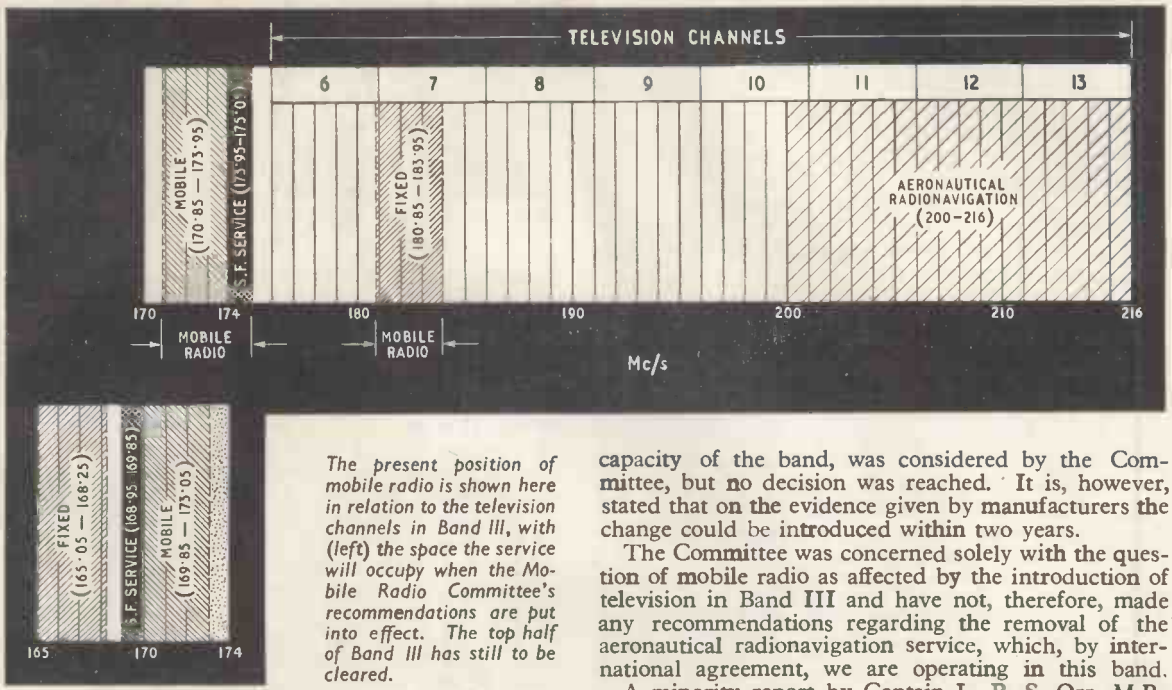
As will be seen from the diagram the recommended changes involve all the fixed stations, those mobile stations operating between 173.05 and 173.95 Mc/s and the single-frequency services. All private mobile radio users will, in future, be accommodated in the band 165-173 Mc/s. They will occupy all but 0.7 Mc/s of the band which is required for other services.

The re-arrangement provides for a guard band of 3 Mc/s between the new mobile radio band and the lower limit of television channel 6. It is, however, pointed out that it may be found possible to reduce this to 2 Mc/s so that those operators at present working between 173.05 and 173.95 Mc/s (shown dot stippled in the diagram) may not have to move.

The possibility of reducing the width of channels from 100 kc/s to 50 kc/s, thereby doubling the capacity of the band, was considered by the Committee, but no decision was reached. It is, however, stated that on the evidence given by manufacturers the change could be introduced within two years.

The Committee was concerned solely with the question of mobile radio as affected by the introduction of television in Band III and have not, therefore, made any recommendations regarding the removal of the aeronautical radionavigation service, which, by international agreement, we are operating in this band.

A minority report by Captain L. P. S. Orr, M.P., representing the Mobile Radio Users' Association, is appended to the Committee's report. The views expressed, which are endorsed by the M.R.U.A., are concerned mainly with compensation for the expense involved in modifying equipment, security of tenure and the P.M.G.'s "refusal to ensure that the loss of frequencies was borne equitably and not exclusively by land mobile radio services."



The present position of mobile radio is shown here in relation to the television channels in Band III, with (left) the space the service will occupy when the Mobile Radio Committee's recommendations are put into effect. The top half of Band III has still to be cleared.

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* "Report of the Mobile Radio Committee," H.M.S.O., price 9d.
† The new P.M.G. is Dr. Charles Hill.

PUBLICATION DELAYS

WE offer apologies to readers who have been inconvenienced by the unavoidable delay, caused by difficulties in our printing works, in the publication of recent issues of *Wireless World*. These difficulties have now been overcome and it is hoped that this and future issues will be available on the correct day of publication—the fourth Tuesday of each month.

WORLD OF WIRELESS

Wrotham Opens this Month ✦ B.S.R.A. Exhibition ✦ International Standards for Colour TV?

V.H.F. Service

PREPARATORY to the opening on May 2nd of the f.m. service from the Wrotham v.h.f. transmitter, test transmissions were radiated daily on one frequency from April 7th to 20th. Since then all three transmitters have daily been testing, radiating the Light Programme (89.1 Mc/s), Third Programme (91.3 Mc/s) and Home Service (93.5 Mc/s). Each transmitter will eventually have an e.r.p. of 120 kW, but during the tests and for the first few weeks of the regular service they will operate with reduced power.

The low-power transmissions from Alexandra Palace during the temporary close-down of Wrotham were discontinued on April 7th.

A further v.h.f. station—making eleven so far approved—has been sanctioned by the P.M.G. It will be at Penmon in Anglesey and, because it will be on the site of the medium-wave station, it is expected that one of the transmitters will be in use by the end of the year. The frequencies for the three-programme service are 89.6 (Light), 91.8 (Third) and 94 Mc/s (Home). Its effective radiated power permitted by the Stockholm Convention is 100 kW but initially it will operate on low power when only the Home Service transmitter will be used.

Sound Recording Show

AS already announced the seventh annual exhibition organized by the British Sound Recording Association will be held at the Waldorf Hotel, Aldwych, London, W.C.2, on May 21st and 22nd. Admission to the exhibition, which opens at 10.0 each day and closes at 6.45 on Saturday and 6.0 on Sunday, is by catalogue obtainable at the door (price 1s 6d), or by post (1s 8d) from the honorary librarian, 3, Coombe Gardens, New Malden, Surrey, after May 10th.

This year's exhibitors are: Acoustical Manufacturing Co., British Ferrograph, C. T. Chapman (Reproducers), Cosmocord, E.M.I. Factories, G.E.C., Garrard Engineering, Goodmans Industries, Grundig, H. J. Leak & Co., Leevers Rich Equipment, Lowther Manufacturing Co., M.S.S. Recording Co., Minnesota Mining & Manufacturing Co., Mullard, Reslosound, Rogers Developments Co., Simon Sound Service, Sugden, Thermionic Products, Truchord, Vitavox, Wharfedale, *Wireless World*.

Colour Television Standardization

A STUDY GROUP of the C.C.I.R. (International Radio Consultative Committee), which met recently in Brussels, agreed that common standards for colour television should be adopted throughout Europe and urged that countries should not make any separate decisions before such standards could be worked out.

Most delegates also agreed that Bands IV and V would have to be utilized for European colour television, though the British group said that this did not exclude the possibility of colour in Bands I and III as well. In these last-mentioned bands, it was suggested by the Belgians, colour ought to be compatible whereas in Bands IV and V non-compatible systems might be introduced.

The French delegation mentioned the difficulty of standards conversion for shared programmes in colour if common standards were not adopted and also stressed the need for a colour system which would not demand expensive receivers. Existing American colour standards, said the U.S.A. group, would not be modified to conform to any C.C.I.R. standards that might be adopted in Europe.

Component Production

SOMETHING in the neighbourhood of 1,000 million parts, valued at £50M, are now produced annually by the components side of the radio industry. This is more than five times the pre-war production figure. The broad summary of the "end-uses" to which components are applied given in the twenty-second annual report of the Radio and Electronic Component Manufacturers' Federation, gives some indication of the ever-widening industrial field this side of the radio industry now serves. Whereas before the war over 90 per cent of the total component production was used in domestic sound and television receivers, the present figure is under 50 per cent. Nearly 25 per cent is now absorbed by what is generally called the "heavy" side of the radio industry—transmitters, communications equipment and navigational aids—and direct exports account for some 16 per cent.

TECHNICAL WRITERS. Some of the recipients of the Radio Industry Council's premiums recently awarded for technical writing in 1954. In the back row are (left to right) D. H. Towns (British Electricity Authority), W. R. Cass and R. M. Hadfield (Pye) and H. S. Jewitt (Decca Radar). Those in the foreground are G. R. Gibbs, E. J. Kaye, Dr. J. M. M. Pinkerton and E. H. Lenaerts, all concerned with LEO (Lyons Electronic Office)

PERSONALITIES

T. P. Douglas, M.B.E., has been appointed engineer-in-charge of the Sutton Coldfield television station in succession to R. C. Harman (see below). Mr. Douglas joined the B.B.C. in 1938 as a junior maintenance engineer at the Daventry transmitting station, to which he returned in 1946 after war service. He was transferred to Kirk o'Shotts television station in 1951 and in 1953 became assistant e.-in-c. of the Sutton Coldfield transmitter.

R. C. Harman, A.M.I.E.E., who has been engineer-in-charge of the Sutton Coldfield television station since January, 1952, has left the B.B.C. and joined I.T.A. as superintendent engineer (operations and maintenance). He joined the B.B.C. in 1935 at the Daventry short-wave station, transferring to television at Alexandra Palace late in 1937, where, after the war, he became senior engineer (transmitters). In 1949 he was transferred to Sutton Coldfield as assistant engineer-in-charge.

The I.T.A. also announces the appointment of two other ex-B.B.C. television engineers—**A. M. Beresford-Cooke,** as senior planning engineer, and **W. N. Anderson,** A.M.I.E.E., as senior lines engineer. Mr. Beresford-Cooke joined the B.B.C. at Alexandra Palace in 1938, having been for two years in the E.M.I. Research Laboratories. During the war he served in A.A. Command on radar, becoming chief R.E.M.E. Radar Officer. Since 1946 he has been a senior member of the television section of the B.B.C.'s Planning and Installation Department. Mr. Anderson, who received his early technical training in the E.M.I. Research Laboratories where he was employed for eight years, joined the B.B.C. Designs Department in 1948 and worked on the design of test equipment for television transmission circuits. He later transferred to the Planning and Installation Department where he was responsible for the development of radio O.B. links.

H. T. Greatorex, B.Sc.(Eng.), A.M.I.E.E., has been appointed assistant head of the Engineering Information Department of the B.B.C. He joined the engineering staff of the Corporation in 1932 and after three months' service in the London Control Room transferred to Brookmans Park and later to the Daventry transmitting station as assistant maintenance engineer. Mr. Greatorex became a member of the Engineering Information Department in 1935

Dr. A. C. B. Lovell, O.B.E., B.Sc., Ph.D., professor of radio astronomy at the University of Manchester since 1951, has been elected a Fellow of the Royal Society. Professor Lovell, whose work on the planning of the giant radio telescope, being built at the Jodrell Bank Establishment of the University, has received a good deal of publicity, was, from 1939 to 1945, at the Telecommunications Research Establishment, Malvern. Before going to T.R.E. he was for three years assistant lecturer in physics at the University, to which he returned as lecturer in 1945.

G. A. Whitfield, B.Sc., at present head of the controlled weapons division in the armament department at the Royal Aircraft Establishment, Farnborough, is to be head of the new department of aircraft electrical engineering at the College of Aeronautics, Cranfield, Beds. He takes up his appointment to the Chair of Aircraft Electrical Engineering on June 1st. It will be recalled that last year Mr. Whitfield was granted an award by the Royal Commission on Awards to Inventors for work on the development of the proximity fuze.

Sir Robert Renwick, K.B.E., has accepted the invitation of the Radar Association to become its president in succession to Air Vice-Marshal D. C. T. Bennett, C.B., C.B.E. Sir Robert, who was president of the Television Society from 1947-1954 and has been president of the R.E.C.M.F. since 1947, was controller of communications in the Air Ministry and of communication equipment in the Ministry of Aircraft Production during the war.

C. M. Benham, B.Sc., M.Brit.I.R.E., A.M.I.E.E., the new chairman of the Radio and Electronic Component Manufacturers' Federation, is chairman and managing director of Painton & Company, of Kingsthorpe, Northampton, which he joined in 1937. He was for eleven years with Standard Telephones & Cables, where he ultimately took charge of the radio engineering department at the New Southgate Works. He studied at the City & Guilds College.

The Insignia Award in Technology (C.G.I.A.) has been conferred by the City and Guilds of London Institute upon two telecommunication engineers for theses submitted. **Arthur H. Watkins,** who receives it for his thesis "The Setting-up and Testing of a Wideband Co-axial Telephony Line Link", joined the Post Office in 1936 and is now executive engineer-in-charge engaged on the installation and testing of wideband co-axial telephony lines. From 1943 to 1946 he was assistant engineer at the G.P.O. Central Training School. **Thomas A. Lewis,** B.Sc., A.M.I.E.E., receives the award for his paper "The Measurement of Radio Interference with Particular Reference to Very High Frequencies and Television." He, too, is in the Post Office, which he joined in 1937. Since 1947 he has been in the Radio Experimental Development Branch at the Backwell laboratory, working on the investigation of radio interference problems, and the design of measuring equipment and receivers for the 30-200-Mc/s frequency range. The Institute has also conferred the award on **J. A. Mason,** M.I.E.E., manager of the Automatic Telephone and Electric Company, which he joined on leaving school in 1911. After military service during the first world war he went into the Engineering Department, where he subsequently became assistant chief engineer.

Cable & Wireless, Ltd., announce the appointment of **Ronald L. Saunders** and **Donald Scott** as assistant engineers-in-chief in succession to **W. J. Knight, M.B.E.,** who becomes deputy engineer-in-chief on the retirement of **E. B. Dillow.** Mr. Saunders joined the Pacific Cable Board in 1926 and transferred to Cable & Wireless on its formation in 1929. During recent years, as engineer-in-charge of the laboratories and workshops at Radio House, Wilson Street, London, E.C.2, he has been responsible for the company's development work. He is a B.Sc.(Eng.) of London University. Mr. Scott, after serving at twelve stations overseas, was transferred to the company's engineer-in-chief's department in 1948, where he has been responsible for the day-to-day operation of the wireless services. He was for four years seconded to the Hong Kong Government as wireless adviser.

OUR AUTHORS

Charles Ian Orr-Ewing, O.B.E., M.I.E.E., M.A., M.P., whose open letter to the Postmaster General is published in this issue, is Member of Parliament for North Hendon and parliamentary private secretary to the Minister of Labour and National Service. After obtaining an honours degree in physics at Oxford he was for three years a graduate apprentice with E.M.I. For some eighteen months before joining the R.A.F.V.R. in 1939 he was in the Television O.B. Department of the B.B.C. to which he returned in 1946 to take charge of the department. He left the B.B.C. in 1949 to join Cossor's, of which he is now a director.

J. A. Lane, joint author with **Dr. J. A. Saxton** of the paper in this issue on the effect of obstacles on high-frequency reception, joined in 1940 the Department of

MEMBERS of the team that designed, built, and installed the Belling-Lee television transmitter (G9AED) at Croydon for experimental transmissions in Channel 9. On the right is F. R. W. Strafford (Technical Manager). A test pattern is radiated daily from 10 a.m. to noon on 194.75 Mc/s with an e.r.p. of 1 kW and a tone (approx. 600 c/s) on 191.27 Mc/s. There is also to be an afternoon transmission from 2.0 to 4.0.

Scientific and Industrial Research where he is now a senior scientific officer in the Radio Research Organization. He is mainly concerned with investigations on various aspects of short-wave propagation and in particular with measurements of dielectric properties and power at centimetre wavelengths. Dr. Saxton, who last year contributed an article on assessing the service areas of v.h.f. and u.h.f. transmitters, needs no introduction to *Wireless World* readers.

IN BRIEF

Broadcast Receiving Licences current in the United Kingdom at the end of February totalled 13,916,246, including 4,407,393 for television and 265,468 for car sets. Television licences increased by 99,621 during the month.

Comparative Recordings (made at the same time and place with a medium-wave receiver and a v.h.f. receiver) will be used by the B.B.C. at the Manchester exhibition, which opens on May 4th, to demonstrate that interference from foreign transmitters is absent on v.h.f. and that electrical interference too is greatly reduced by the use of frequency modulation. Several examples will be given of simultaneous recordings of the same programme transmitted in both bands and the point will be made that there is no difference in the quality as transmitted but that the improved reception on v.h.f. is due to the advantages of frequency modulation.

The annual **International Contest** for radio-controlled model boats will be held at Saltwell Park, Gateshead-on-Tyne, on July 30th and 31st. The contest for radio-controlled model aircraft will be on August 1st at Croft Aerodrome, near Darlington. Details of the contests, which are organized by the International Radio Controlled Models Society, are obtainable from D. W. Aldridge, 1, Fowberry Crescent, Fenham, Newcastle-upon-Tyne, 4.

Four premiums, each valued at £5, have been awarded by the **Television Society** to the following authors for papers read at London meetings during 1954 (titles of the papers are given in parentheses): Dr. G. N. Patchett ("Problems of Interlacing"); G. B. Townsend, E. Ribchester and D. Bauer ("An Investigation of the 625-line C.C.I.R. System"); R. J. Boddy and C. D. Gardner ("An Industrial Television Channel"); and G. G. Gouriet ("Colour Television").

A three-day conference is being held at High Leigh, Hoddesdon, Herts, from May 13th to 15th by the **National Federation of Gramophone Societies**. Details of the fees and the programme, which will include technical and music lectures and demonstrations of high-quality reproducing equipment, are obtainable from G. E. Palmer, 106, Streatfield Road, Kenton, Harrow, Middx.

R.E.C.M.F. Council.—At the annual general meeting of the Radio and Electronic Component Manufacturers' Federation, which now has a membership of 164, the following firms were elected to form the council (the names of the companies' representatives are in parentheses): Automatic Coil Winder (R. E. Hill); British Moulded Plastics (G. F. Carnell); Garrard Engineering (H. V. Slade); A. H. Hunt (S. H. Brewell); Morganite Resistors (E. T. Treganza); Multicore Solders (R. Arbib); N.S.F. (K. G. Smith); Painton (C. M. Benham); Plessey (P. D. Canning); Standard Telephones & Cables (E. E. Bivand); Telegraph Construction & Maintenance Co., (W. F. Randall); Truvox (K. Short). The new chairman and vice-chairman are C. M. Benham and S. H. Brewell, respectively.

Club secretaries may like to know that the latest edition of the 16-mm colour sound film "**Mechanical Handling**" includes sequences on some of the applications of electronics in the handling of goods. One of the sequences covers a combined conveyor and elevator system which is electronically controlled for both flow and sorting of boxes according to colour or size. Applications for the loan of the film, which lasts approximately 40 minutes, should be made to H. A. Collman, *Mechanical Handling*, Dorset House, Stamford Street, London, S.E.1.

Isotope Instrumentation.—Radioactive isotopes are finding increasing uses in industry, medicine and research, and to facilitate the correct choice of detecting and measuring instruments, a comprehensive catalogue has been produced by the Scientific Instrument Manufacturers' Association of Great Britain, Ltd., Queen Anne Street, London, W.1. In addition to details of the products of the member firms there is a useful technical introduction and bibliography on the principles underlying radioactive isotope instrumentation. The brochure is produced under the joint editorship of Dr. Denis Taylor (A. E. R. E., Harwell) and A. G. Peacock (Mervyn Instruments).

Correction.—We tender our apologies to R. F. Gilson, the author of the article "Output Transformer Design," whose name was misspelt on p. 195 of the April issue.

BUSINESS NOTES

Wolsey Television has been acquired by the Gas Purification and Chemical Company who control, among other companies, Grundig (Great Britain), Ltd., and Grundig International, Ltd. H. S. Melly remains on the board and is joined by A. E. Johnson, G. S. Taylor and D. D. Mathieson of Grundig.

An office has been opened at 86, Holly Road, Uttoxeter, Staffs, by the **Narda Corporation**, of Mineola, New York, for the sale of its microwave test equipment in this country.

Demonstrations of Pye industrial and underwater television equipment will be given at the Kongresshaus in Zurich from May 11th to 13th. Examples of the company's television broadcasting equipment will also be on show.

The radio communication equipment and electronic aids to navigation on board the 20,000-ton passenger liner *Southern Cross*, which is now on her maiden voyage round the world, were installed by **Marconi Marine**. The sound reproducing and order system feeds a network of 200 loudspeakers and incorporates a tape recorder for recording news and other broadcast programmes received at times inconvenient for immediate diffusion over the loudspeaker system.

The B.B.C. has ordered from **British Acoustic Films, Ltd.**, twelve combined sound and picture film cameras. Built to a B.B.C. specification, they will produce either a 35-mm picture film with a separate 35-mm magnetic sound track, or a 16-mm picture film with a separate 16-mm sound track.

V.H.F. radio-telephone equipment supplied by **Hudson Electronic Devices, Ltd.**, has been installed by the Automobile Association on the cross-channel car ferries *Hallidale*, *Lord Warden and Dinard*. The A.A. staff on board are thus able to 'phone details to the Association's headquarters in Dover, so facilitating the rapid transit of motorists through the customs.

Sydney S. Bird & Sons, manufacturers of Cyldon capacitors, have moved their works from Enfield to Fleets Lane, Poole, Dorset (Tel.: Poole 1640). A London sales and technical liaison office has been opened at 3, Palace Mansions, Palace Gardens, Enfield, Middx (Tel.: Enfield 2071), under the direction of G. B. Francis.

Aero Research, Ltd., of Duxford, Cambridge, manufacturers of synthetic resins, have moved their northern area office to 409, Royal Exchange, Manchester, 2. (Tel.: Blackfriars 9445.)

The **Plessey Company**, of Ilford, Essex, announce the appointment of Thomas P. Collier, of 120, South La Salle St., Chicago, as their sole representative in the U.S.A.

A London office and show room, at 53, Victoria Street, S.W.1 (Tel.: Abbey 4704), has been opened by **Atkins, Robertson & Whiteford, Ltd.**, of 92-100, Torrisdale Street, Glasgow, S.2, manufacturers of electronic instruments.

The telephone number of **A. F. Bulgin & Co.**, of Bye Pass Road, Barking, Essex, has been changed to Ripleway 5588.

OVERSEAS TRADE

Equipment for the two-way u.h.f. radio-telephone service recently introduced between Algeciras, Spain, and Ceuta, Morocco (a distance of some 20 miles) has been supplied by **Standard Telephones & Cables**. The installation provides for 24 simultaneous two-way conversations.

With the opening of the new Sarawak broadcasting service, the government distributed 2,600 receivers amongst the population. The **General Electric Company** supplied the 4-valve all-dry superhet receivers which cover both the medium-wave and short-wave bands.

Two radio manufacturers were among the 60 or more British firms who exhibited at the **Lyons International Trade Fair** which closed on April 25th. The two firms are Erie Resistor, Ltd., and Standard Telephones and Cables, Ltd., who were showing respectively, capacitors and valves.

Two 485-ft mast radiators, complete with r.f. transmission line of the 5-wire unbalanced type, aerial matching equipment and an earth system, are to be erected by **Marconi's** for the Greek broadcasting authorities on the site of a 50-kW station on the island of Corfu. The order was secured by Marconi's agents P. C. Lycourezos, Ltd., in the face of severe German competition.

Bayerische Rundfunk, the Bavarian broadcasting organization, has secured from **Pye** a television O.B. van which has provision for three camera chains.

Kelvin & Hughes have supplied a modified version of their "Kingfisher" echo sounder for the *Sea Diver* being used by the American expedition seeking the remains of Columbus' *Santa Maria*. The leader of the expedition is Edwin A. Link, the inventor of the Link aircraft trainer, who is concentrating his search off the north coast of Haiti.

Jamaican Agency.—Masterton, Ltd., P.O. Box 73, 23-25, Hanover Street, Kingston, have advised the U.K. Trade Commissioner in Kingston that they would like to act as agents for a British manufacturer of broadcast receivers not already represented in Jamaica. Full particulars should be sent direct to the company, but manufacturers are asked to notify the Trade Commissioner (Royal Mail Building, P.O. Box 393, Kingston, Jamaica, B.W.I.).

SOURCES OF INTERFERENCE

IN view of the recent publication of the regulations covering interference from small motors and refrigerators (see page 155, April issue), a summary of the 140,000 complaints investigated by the Post Office last year is of particular interest.

Sources of interference	Number of complaints	
	Sound	Television
Bedwarmers	578	1183
Calculating machines	342	818
Drills	1177	2492
External cross modulation	280	45
Faulty electrical wiring of premises	2194	494
Hair driers	598	6954
Ignition systems of petrol engines	49	1313
Industrial and medical r.f. equipmt.	196	887
Lighting, filament type lamps	66	2569
Lighting, fluorescent tubes	1676	233
Lighting, street	712	113
Neon signs	416	1444
Power lines	814	3789
Radiation from TV time base circuits	6805	3
Radiation from superhet, local oscillators	62	1604
Refrigerators (compressor, fan, or thermostat)	1228	1587
Transmitters, amateurs	125	303
Transmitters, others in U.K.	142	476
Transmitters, foreign	533	146
Sewing machines	1577	8956
Smoothing irons	399	198
Vacuum cleaners	1043	3269
All other identified sources: contacts type	1978	3356
All other identified sources: commutator type	2930	7056
All other identified sources: miscellaneous types	1468	1692
Unknown	12206	21877

By far the largest individual source of interference with television was electric sewing machines (8,956) with hair driers (6,954) next. The table excludes the 11,495 complaints which were found to be due to defective conditions in the receiving installation. All together, 83,514 complaints of television interference were investigated.

Of the 57,324 cases of interference with sound broadcasting investigated the largest source of trouble, excluding the 19,020 complaints found to be due to "a condition or function" of the receiving installations, was radiation from television time-base circuits (6,805).

It will be seen from the table that there were large numbers of complaints investigated which are classified as "source unknown." These include those in which the interference ceased before or during the investigations, or where the interference was of such infrequent occurrence that it did not justify continual investigation "to the exclusion of more deserving complaints."

Ignition interference is generally so transient that the number of complaints in the table bears no relation to its prevalence.

To give a complete list of sources of interference is impracticable and many of the identified sources are grouped under contacts, commutator and miscellaneous types.

At the end of the year there was a backlog of 9,961 (sound) and 15,417 (television) complaints.

By P. J. WALKER*

Wide Range Electrostatic

1.—*Principles of Design for Operation at Low as well as High Frequencies*

A closer examination of underlying principles leads to the conclusion that the electrostatic loudspeaker may well supersede the moving coil for high-quality sound reproduction. Designs recently developed have proved to be capable of reproducing the full audio-frequency range, with harmonic distortions no higher than those of the associated amplifier.

EVERY loudspeaker designer must, at some time or other, have looked longingly at the electrostatic principal of drive as a solution to his problems of improving quality of reproduction. The movement of a diaphragm driven all over its surface is entirely predictable. The diaphragm can be as light as required. The impedances influencing performance can be predominantly acoustic and—since there are no shape restrictions—entirely under the control of the designer.

What has held it back? First, the fact that *in its generally known form* it is intrinsically non-linear and even in a push-pull construction linearity can only be approached for small amplitudes. Secondly, in order to obtain adequate sensitivity the available gap is small; the diaphragm movement limited and largely stiffness controlled, both factors restricting its use to high frequencies. Thirdly, that being essentially a capacitive electrical load, it is difficult to match to an amplifier.

The first of these objections, that of non-linearity, can be removed completely by an expedient which is spectacular in its effectiveness and simplicity. The second and third difficulties will resolve themselves, as we shall see later, when the designer makes his choice of the interdependent mechanical, acoustical and electrical variables.

Fig. 1 (a) shows diagrammatically the connection of a conventional electrostatic loudspeaker in which the polarizing voltage is applied to the centre diaphragm and the signal in push-pull to the outer perforated fixed plates. Under conditions of no signal, Fig. 1 (b), and assuming the diaphragm to be central, there will be equal and opposite attractive forces on the diaphragm. If one fixed plate is now made positive and the other negative so that the diaphragm will be deflected to the right, the effective capacitance will increase, and to satisfy the relationship $Q=CE$ the charge Q will also increase and will be supplied by a current i during the movement. The force acting on the diaphragm per unit area will, however, be proportional to $\left(\frac{E+e/2}{d_2}\right)^2 - \left(\frac{E-e/2}{d_1}\right)^2$. The relationship will be non-linear. Note that the charge Q, although varying, does not enter directly into the relation.

Suppose that after having charged the diaphragm electrode the source of polarizing potential is disconnected (Fig. 1(d)). The diaphragm now carries a constant charge Q which experiences a force proporional to the product of the field intensity and the charge. This force will be independent of the position of the diaphragm between the plates since both Q and the distance between plates are constants; the only variable is the applied voltage e. Note that the difference between d_1 and d_2, although varying, does not enter into the relation.

The above is perhaps an over-simplification, but it shows that distortion is not necessarily inherent in the electrostatic principle.

The "constant Q" method of operation has another very important advantage in that it reduces the risk of collapse, which occurs at large amplitudes with the conventional method of connection, when the negative stiffness resulting from electrical attraction exceeds the positive mechanical stiffness of the diaphragm. As the diaphragm approaches one of the fixed plates the capacitance is increased, but as the charge Q has been assumed constant, E must fall since $E=Q/C$.

Professor F. V. Hunt of Harvard University has shown† that the criterion for dynamic stability under large excursions is that the time constant R_oC_o of the charging circuit (Fig. 1(e)) should be large compared with 1/2f, the half-period of the applied frequency. This also supplies the condition for low distortion and Professor Hunt gives the results of measurements (Fig. 6.14, p. 212, *loc. cit.*) showing the dependence of second harmonic distortion on both the degree of unbalance due to displacement of the central electrode (in terms of $\Delta C/C$) and of the ratio of time constant to half period $2fR_oC_o$. Even when this latter parameter was reduced to unity, and the diaphragm displaced by a distance equivalent to a capacity unbalance of 25 per cent, the second harmonic did not exceed 0.5 per cent, when driven at 150 c/s by 780 V r.m.s. (plate-to-plate) with a polarizing voltage of 500. Third and higher harmonics were always less than the second.

So much for the driving mechanism; it now remains to see how it fares when coupled to the air and to an amplifier.

It will help in understanding the broad principles involved if we start by considering a loudspeaker whose diaphragm is large compared with the longest wavelength of sound to be reproduced. Under these conditions the mass reactance of the air load on both sides of the diaphragm can be neglected and the impedance per unit area $2\rho c$ offered to the motion of the diaphragm is predominantly resistive ($\rho c = 42$ mechanical ohms per cm^2). With constant voltage driving the diaphragm the force will be proportional to the applied signal voltage and independent of frequency. If the load is resistive the velocity, and also the acoustic power output, will be independent of frequency.

At very high frequencies the mass reactance of the diaphragm can exceed the radiation resistance and will cause a falling off in velocity when the force remains constant; the acoustic output will then decline by

* Acoustical Manufacturing Co., Ltd.

† "Electroacoustics" by F. V. Hunt, chapter 6. Published by John Wiley & Sons (Chapman & Hall).

Loudspeakers

with Negligible Distortion

6 db/octave, but, with suitable choice of diaphragm material, not until a frequency of 20 to 25 kc/s is reached. (How different from the average moving coil in which the cut-off starts at about 1,000 c/s and must be sustained by focusing of high frequencies along the axis or by juggling with cone "break-up.")

Similarly at low frequencies a 6 db/octave falling off with reducing frequency will result when the reactance due to the stiffness (reciprocal of compliance) of the diaphragm exceeds the resistance air load. This state of affairs is shown graphically in Fig. 2. Unfortunately, it is not so easy to put the frequency at which the stiffness begins to exercise control outside the audible range. The choice of stiffness will be dictated by the necessity of constraining the diaphragm against the forces associated with the polarizing voltage. Under "static" conditions ($2fR_0C_0$ less than unity) these forces can increase as the diaphragm approaches the fixed plates and must be limited by a suitable choice of stiffness, polarizing voltage and plate spacing. The plate spacing also determines the electrical capacitance of the loudspeaker, and the impedance offered to the amplifier at the frequency chosen for "matching."

Thus the bandwidth available for constant output, under the acoustic conditions postulated, is limited at low frequencies by the diaphragm stiffness required for stability and at high frequencies by the conditions of matching to the amplifier. (The inertia cut-off will always be well above the matching frequency and can be ignored.)

The true efficiency of an electrostatic loudspeaker is very high indeed, but it is difficult to realize because of the large wattless current which has to be provided due to the electrical capacity of the loudspeaker unit. Thus it is necessary to waste watts in the amplifier or in resistances associated with crossover networks of which the loudspeaker may be part. For purposes of simplification, therefore, it is convenient to use the term "apparent efficiency" the meaning of which is the ratio of the acoustic power output of the loudspeaker to the amplifier volt-ampere output necessary to provide the required voltage across the loudspeaker capacity.

The way in which the designer can trade bandwidth for "apparent efficiency" is illustrated by Figs. 3 and 4. In both cases we assume the maximum output will be available at the high-frequency matching limit, and that constant voltage will be available at this and lower frequencies.

In Fig. 3 let curve (a) represent the response with a given electrode spacing D=1. If we double the spacing the diaphragm stiffness required for stability

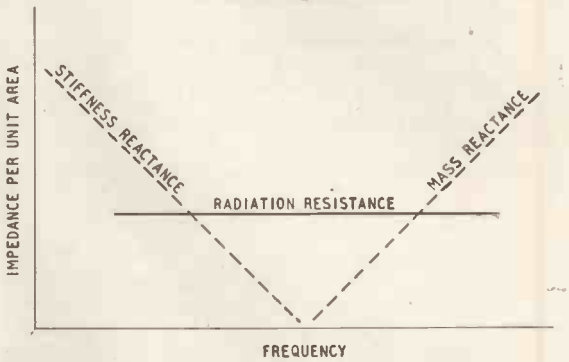


Fig. 2. Variation of acoustical and mechanical impedances with frequency in a diaphragm which is large compared with wavelength.

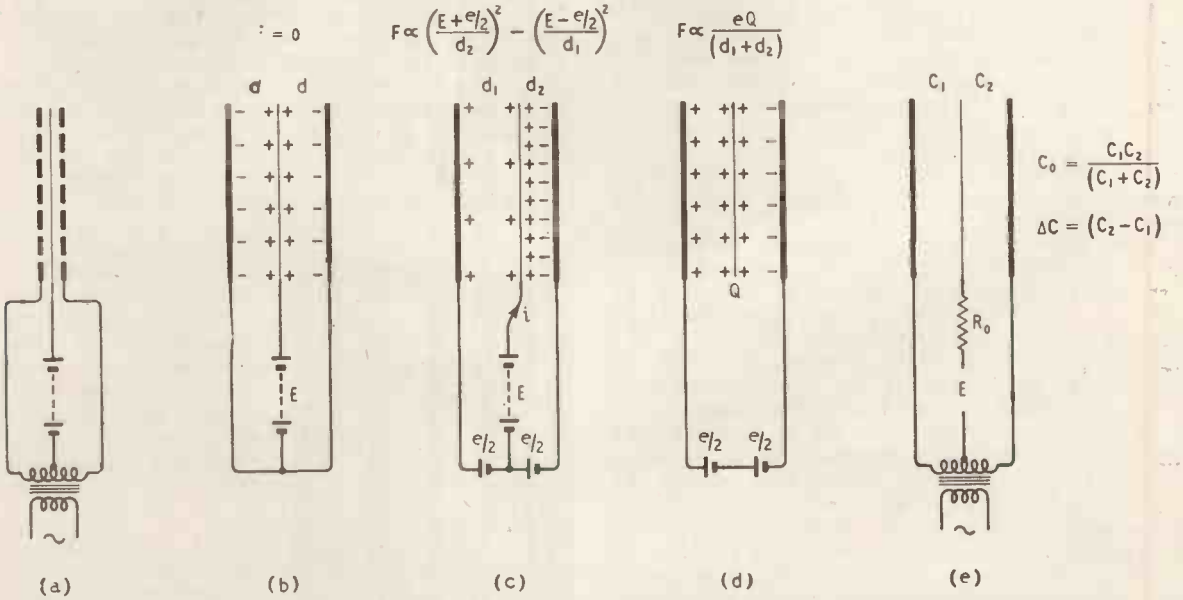
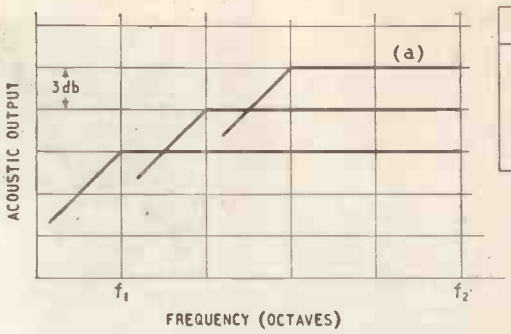


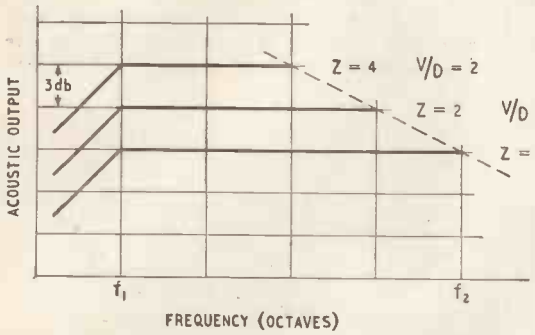
Fig. 1. Essential differences in the operation of electrostatic loudspeakers with "constant voltage" and "constant charge" on the centre diaphragm.



D	C	Z	V	V/D
1	1	1	1	1
2	1/2	2	$\sqrt{2}$	$\sqrt{2}/2$
4	1/4	4	2	1/2

$P = V^2/Z$ } CONSTANT f_2

Right: Fig. 3. Low-frequency response can be extended, at the expense of "apparent efficiency," by increasing the plate spacing and re-matching to the amplifier at f_2, the upper frequency limit.



$P = V^2/Z$ } CONSTANT
D = 1
C = 1
f_2

Left: Fig. 4. Alternatively, with constant spacing and a fixed low-frequency limit the high-frequency response can be extended, again at the expense of "apparent efficiency," by varying the frequency f_2 at which the capacitive impedance is matched to the amplifier.

can be halved and the low-frequency cut-off goes down an octave. At D=2 the capacitance is halved and the impedance doubled, but because the power is limited the volts rise by only $\sqrt{2}$ when the amplifier is re-matched. Thus the field strength V/D available to drive the diaphragm is reduced to $\sqrt{2}/2$ and the response falls by 3 db. We have thus gained an octave for a drop of 3 db in output, and, of course, the necessity of finding twice the polarizing voltage.

We can, if required, regain the lost efficiency by re-matching an octave lower at the top end, as shown in Fig. 4. We now keep D (and C) fixed, and with it the low-frequency cut-off. The field strength available for driving the diaphragm will be proportional only to the voltage available from the amplifier. If we re-match an octave lower Z will be doubled and V will increase to $\sqrt{2}$, so there will be a 3-db rise in acoustic power for the loss of an octave at the high-frequency end.

Since very high efficiencies are not a pre-requisite of high-quality reproduction, it is convenient to arrange the apparent efficiency to be similar to the efficiency obtained from present-day commercial moving-coil speakers. Setting the efficiency at this level and applying polarizing voltages permissible in the given air gap, we find that the available bandwidth for level response is about four to five octaves.

Below the low-frequency cut-off we have the stiffness of the diaphragm controlling response, a large proportion of it under conditions where the "apparent efficiency" is high and wasted. (At low frequencies the impedance is high, and less power is required to maintain constant voltage.) Thus, by a progressive change of "matching" in this area, one can compensate to extend the level response below the mechanical cut-off. The effect of this mechanical stiffness is best considered when we deal with possible forms of loading, since it can be lumped in with the acoustical circuit loading the loudspeaker.

A high polarizing voltage is desirable in order to place a high value of charge Q on the diaphragm. Each small unit area of the diaphragm can be fed with a high voltage at very high impedance, thus charging up that part of the diaphragm in relation to the fixed plates. In this arrangement of the loudspeaker, where the signal is applied to the fixed plates only, there are no signal currents due to the wanted signal in the diaphragm itself, so that this arrangement of high-impedance charging of each unit area of the diaphragm is permissible, and is essential for linearity in any practical construction. Any tendency for the air to conduct between the diaphragm and the fixed plate at any point in the loudspeaker merely causes a slight drop in the voltage at that area on the diaphragm, so that in this way high voltages can be applied without any danger of sparking.

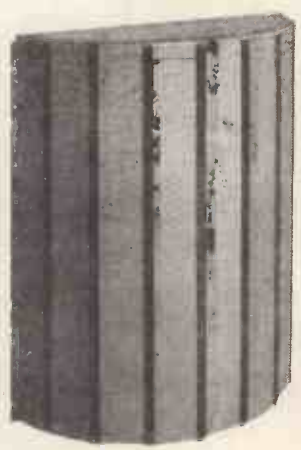


Fig. 5. High-frequency unit with dimensions large compared with wavelength designed to cover frequencies from 1,000 c/s to the upper limit of audibility.

Since the charge on the diaphragm is unvarying, it follows that the force on the diaphragm is completely independent of the position of the diaphragm in the space between these electrodes and the system in linear. With this arrangement, then, it is no longer

necessary to restrict the allowable motion of the diaphragm to a small percentage of the available gap. Again, there is no restriction to the ratio of signal voltage to polarizing voltage. The only non-linear element entering the system at all is that due to the compliance of the diaphragm, and since in most designs this is not a controlling factor in the motion of the diaphragm its importance is small. There is no difficulty in producing units on this principle, the distortion content of which is even lower than that of present-day amplifiers, and many times better than a moving-coil loudspeaker of normal efficiency.

We have seen, then, that it is now possible to design loudspeakers on the electrostatic principle for a given bandwidth, over which the forces are acting directly on to the air. We have seen that this bandwidth can be placed anywhere in the audio range and that linearity represents considerable improvement on anything hitherto produced. The design of a loudspeaker unit on such principles is therefore purely one of applying it to its acoustical load to give any required performance.

We have so far assumed the simple case of $2\rho c$ loading on the diaphragm. Ignoring for the moment horn loading, this can only be achieved in practice at high frequencies, or for cases where the diaphragm is very large indeed.

A simple single unit construction for high frequencies is shown in Fig. 5. This loudspeaker covers the range from 1,000 c/s to the upper limits of audibility. Such a unit could, of course, be used with conventional moving-coil speakers for low frequencies, but the assumption that moving-coil units operate like distortion-less pistons at low frequencies is very far from the truth. It is obviously desirable to introduce the benefits of the electrostatic principle throughout the whole frequency range.

By way of showing what can be done, Fig. 6 shows a more complex design of electrostatic loudspeaker which, when properly loaded, covers the whole frequency range from 40 c/s up to the limits of audibility. In a future article it is proposed to discuss the operation of such loudspeakers, i.e., when size is no longer large compared to wavelength, and to show the basis of design approach for the whole frequency range.

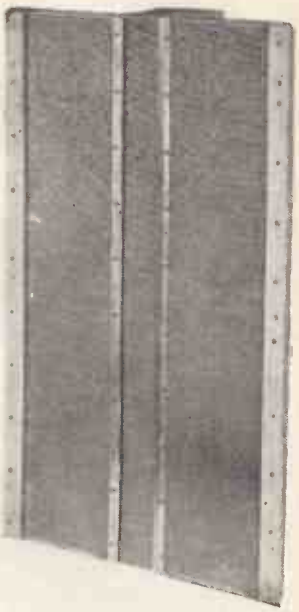


Fig. 6. Unit of more complex design which, with proper acoustic loading, covers the range from 40 c/s to the upper limit of audibility. Measurements on this and the unit of Fig. 5 indicate total harmonic distortions of less than 1 per cent.

Distortion measurements on these units gave figures well below 1%. Measurements were made out of doors, and noise, wind, and other restrictions due to imperfect conditions made it difficult to get reliable figures below 1%. Inspection of the residual waveform indicates that the distortion due to the units is considerably lower than this figure.

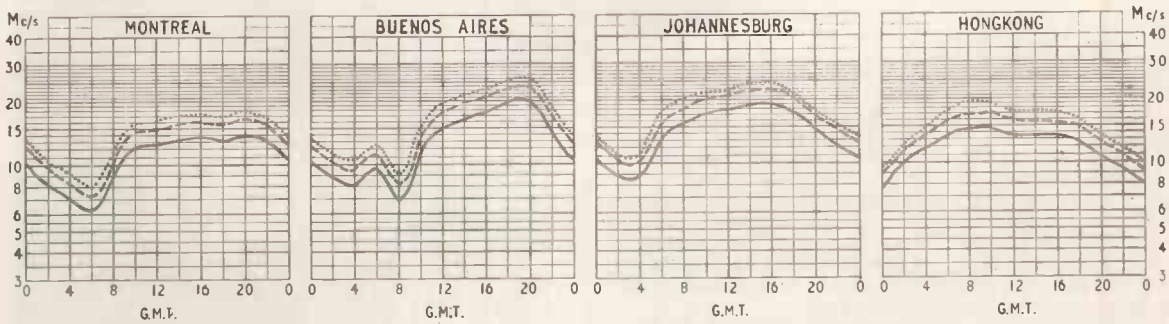
Similar remarks apply to frequency response, due to the fact that it is virtually impossible to achieve perfect loading conditions. Measurements produce responses which are within 2 db of the predicted curves, but the major part of these small discrepancies may be attributed to the approximations assumed in the structures used for loading.

Since 1953, electrostatic loudspeakers have been the subject of joint development between Ferranti, Ltd., of Edinburgh, and The Acoustical Manufacturing Co., Ltd., of Huntingdon. Some of the techniques involved in the design of these loudspeakers are the subject of joint patent applications by P. J. Walker and D. T. N. Williamson.

(To be continued)

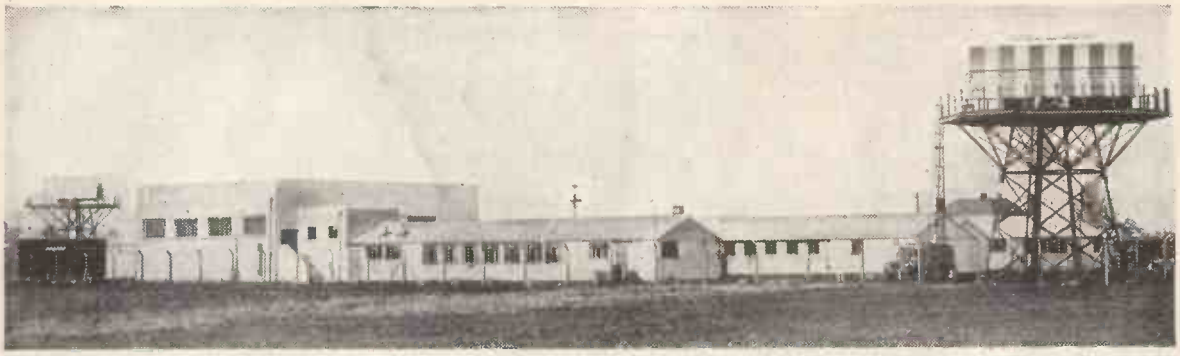
SHORT-WAVE CONDITIONS

Predictions for May



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 May.

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



Air Traffic Control at London Airport

TWO new buildings were recently brought into use at London Airport for the purpose of effecting closer integration of the radio and radar aids to flying now in daily use there. One of the buildings, located on the northern boundary of the aerodrome, is the new air traffic control centre for the whole of southern England and was until recently located at Uxbridge. The main purpose of the move was to bring together in one room the radio and radar controllers who were hitherto widely separated.

No real significance attaches to London Airport as the site of this control centre since the controllers are not concerned with air traffic in and out of the airport, but it is a good radar site and the display information can be made available to the airport's control tower to reinforce data obtained from alternative aids.

The multi-channel v.h.f. area coverage radio-telephone system described in *Wireless World* of March, 1951, is operated from this building. The installation has been expanded a little since it was last described here and now provides 10 v.h.f. channels in the 118-to-132-Mc/s band.

Since both radio and radar controllers occupy the same room a major problem arose in regard to the lighting. Full daylight viewing of c.r. tubes is not yet accomplished, but it is said to be within sight. For the present purpose the lighting is provided by red, blue and green fluorescent tubes giving a mixed light having the appearance of white light, but lacking those shades responsible for strong reflections from the face of c.r. tubes. When used in conjunction with suitable amber c.r.t. filters perfect viewing is possible with an amount of light adequate for the radio personnel in the same room.

The other new building of interest at the airport is the control tower. It is located in the central terminal area and is approached by a 680-yd underground road tunnel. This building is the nerve-centre of the airport and contains the radio and radar controllers concerned with the safe and expeditious movement of aircraft into and out of the airport.

Very comprehensive radio and radar facilities are provided. There are eight radio-telephone channels, seven in the 118-to-132-Mc/s band and one in the 3-Mc/s; an interesting feature of the v.h.f. system is the provision for sharing a common aerial. Cavity resonators enable up to four transmitters (or receivers) to use the same aerial at the same time with a frequency spacing of some 400 kc/s only. Transmitting and receiving stations are widely separated and remotely controlled, but the latter is within the airport boundary.

A Marconi v.h.f. fully automatic direction finder is installed in the tower with its aerial located about half a mile away. The only aerials on the tower are those concerned with the movement of all surface vehicles which are controlled by v.h.f. radio telephones and a scanner for a Decca 8-mm (or Q-Band) radar; Airfield Surface Movement Indicator.

Movements of aircraft within 60 miles of the airport are tracked, and when within tower control marshalled with the aid of the Cossor Airfield Control Radar Mark VI. In bad weather landing is assisted by a modified early model G.C.A. and the latest Pye Instrument Landing System.

A special feature of the new buildings is that only equipment essential for the controllers' needs is accommodated in the control rooms with the main items located in an equipment room immediately below. Here maintenance, repair and routine testing can be carried out and the whole station kept at top efficiency without in any way hindering the work of the controllers.

The need for some aid to location and movement of surface vehicles other than human vision will be appreciated when it is realized that the airport covers some six square miles of country, and some of the runways exceed two miles in length. A pool of walkie-talkie sets is maintained for communication with the control tower by personnel not normally using vehicles.

It is perhaps not surprising that London Airport has a reputation as being one of the safest in the world and the newest aids should materially strengthen this well-merited reputation.

Flying controller operating flight progress boards in control room.

LETTERS TO THE EDITOR

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

Transistor Letter Symbol

I READ with interest E. A. W. Spreadbury's letter in your March issue regarding the evolution of a suitable letter to denote the transistor.

It appears to me preferable to have a single letter symbol for what is, after all, a major element in its associated circuit. Hence I would suggest the use of the letter S to denote a transistor, on the grounds that it is a Solid-state device whereas a valve is a Vacuum device.

The existing use of the letter S to denote a switch may well be replaced by Sw, which letters are already in some use for this purpose.

South Harrow, Middlesex. D. NAPPIN.

I LEAN towards the argument put forward by E. A. W. Spreadbury (your March issue) that some distinctive letter symbol should be adopted for a transistor in order that its different mode of operation from the thermionic valve shall be readily apparent.

Personally, I do not look with favour on the letter V to indicate a transistor; the letter is hackneyed to the extent that it denotes (a) thermionic valve, (b) voltage, (c) velocity, (d) volume, to mention a few. I also feel that Mr. Spreadbury's double-letter symbols can be improved upon, and would suggest the letter Y. This letter is not so widely used as V, and to my mind it bears some resemblance to the graphical symbol that now seems to be fairly well established. In addition, it is not unlike V in appearance, so can impart some indication of the function of the circuit element.

St. Leonards-on-Sea, Sussex. W. E. THOMPSON.

Feedback I.F. Amplifiers

WITH reference to the very interesting articles by H. S. Jewitt (February and December, 1954), we can mention that work on such amplifiers has been going on for some time at the Radio Receiver Research Laboratory of the Danish Academy of Technical Sciences and has led to the following experience.

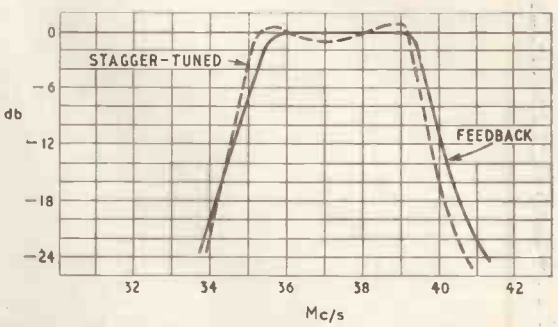
It has been found possible to avoid the difficulties mentioned by Mr. Jewitt in obtaining the wanted selectivity curve in feedback i.f. amplifiers for television when using values for the damping and feedback resistors calculated from the measured capacitances and loss factors of the coils and circuitry.

In i.f. amplifiers for television the valve and circuit losses are not negligible, and therefore the calculations should start from the formulæ for the π-network. The resistances of this network are formed partly by the loss resistances of the coils and valves and partly by extra damping resistances, and it is the network formed by the latter that should be converted to the T-network used in the actual amplifier. Furthermore, it should be taken into account that the capacitances of the different stages are unequal, and that especially the capacitance in the last tuned circuit is low because this circuit is coupled to the detector. Also the loss factor of the last circuit is high because of the damping from the detector. and it may be necessary to connect the detector to a tap on the coil. On account of this, the feedback T network in the last feedback pair of an i.f. amplifier should be unsymmetrical. This fact is apparently not taken into account in the amplifier described in the later of Mr. Jewitt's two articles.

Owing to the small values of the capacitances of the circuits it is not possible to tune all circuits of the amplifier to the centre frequency by short circuiting the cross resistor in the feedback T network, as described in the articles. This is due to the mistuning developed by the self-capacitances of the resistors. The mistuning can, however, be avoided if one circuit of a pair is damped by a suitable shunting resistor when the other circuit is being tuned.

The accompanying Figure shows a selectivity curve obtained from a feedback i.f. amplifier containing five valves arranged in two feedback pairs and one single stage, calculated to give maximum flatness. It is mounted with feedback T networks calculated for a bandwidth of 4.7Mc/s and a centre frequency of 37.12Mc/s from the measured circuit capacitances and the measured coil and valve losses. It should be mentioned that after the calculation and the tuning of all circuits to the centre frequency, no empirical change of the amplifier has been made apart from adjusting the distance of the feedback T network to the chassis in such a way that the stray capacitance gives the correct tilt of the selectivity curve. In this way it was not necessary to connect any extra capacitor across the cross resistor of the T network to give the correct tilt.

For comparison the figure shows also the selectivity curve of a stagger-tuned amplifier designed as a quintuple for same centre frequency and bandwidth and built with the calculated values of the damping resistors, the resonating



circuits being separately tuned to the calculated frequencies. It will be seen that the selectivity curve is very similar to that of the amplifier with feedback pairs, and that both curves are close to the desired curve. The curves shown are measured on an amplifier without sound-traps. The insertion of these did not present any difficulties.

JENS RASMUSSEN, P. V. IVERSEN.
Radio Receiver Research Laboratory,
Danish Academy of Technical Sciences
Copenhagen.

"As She Is Spoke"

I AM afraid I cannot agree with Mr. Briggs that the manufacture of loudspeakers should be prohibited. "But," Mr. Briggs may protest, "I never said it should!" Quite. Neither did I say, or even imply, that use of the word "recording" as a noun was wrong. On the contrary, the use I advocated was as a noun, namely, the process of making a record. I would agree with Mr. Briggs in including within that term the quality of the process, as distinct from the mechanical quality of the individual record produced, just as a photographic *print* may be said to show evidence of faulty *printing*. But he goes on to say that a record on tape must be referred to as a recording. Why? If, as may well happen, it becomes customary to print photographs on plastic materials, will Mr. Briggs insist on their being called "printings"?

It is true that, as Mr. Arnot says, the public are accustomed to records in the form of discs. But if they will now have to get used to them in the form of tapes, what of it? For many centuries they associated the word

"ship" with a wooden structure surmounted by sails, but seem to have experienced no insuperable difficulty in subsequently admitting metal structures, with no sails. The word "record" implies nothing about the material basis, and is equally valid for all. A cheque is usually drawn on a slip of paper, but, as Sir Alan Herbert has pointed out, there is no legal reason why it should not be on the back of a live cow.

A perfectly logical terminology is too much to expect, but please, gentlemen, do not let us go out of our way to introduce false associations.

Bromley, Kent. M. G. SCROGGIE.

Television-To-Sound Interference

WHEN "In Town Tonight" the other evening was broadcast on both the Home and Television Services, I was amused to hear, quite distinctly, vision-channel interference in the background of the sound signal on the Home Service.

This must be very heartening to anyone who has at any time had difficulty in excluding vision interference from the sound channel of a domestic television receiver—and who has not?

London, N.10. IAN LESLIE.

Television Quality

MAY I add my support to the points made by G. T. Clack in the January issue of *Wireless World* concerning the poor quality of television transmissions during the News and Newsreel programme. Obviously there are reasons for this deplorable state of affairs and I suspect that they are not solely concerned with technical considerations. It is, however, most regrettable that the B.B.C.—who are soon going to face strong competition—should have allowed their normally superior standards to fall to such a low level at this crucial time. I would earnestly implore the authority responsible for the nightly perpetration of this return to the magic-lantern era to think again. Even if we ignore the poor technical standards surely very few viewers prefer the present presentation of the News to the previous and more polished style of a few years ago. Mr. Bernard Hollowood has quite adequately summarized the position in a recent article in *Punch*. He suggests that the troubles of News and Newsreel are caused by misplaced enthusiasm and a misconceived notion of the function of the service.

CHARLES A. MARSHALL.

Carshalton,
Surrey.

"*Telepathy by V.H.F.*"

I HAVE just seen "Free Grid's" reference to Maskelyne and his radio experiments in your January issue. This is of great interest to me because the Maskelyne he refers to was my father, the late Nevil Maskelyne, and there can be no doubt as to the seriousness of the work he did. It may be of interest to recall that he was a director of The Amalgamated Wireless Telegraph Co., Ltd., and one of his co-directors was Lee de Forest, whom I was privileged to meet many years later.

I remember, as a small boy, living at Seasalter, near Whitstable, and being invited to look across the Thames estuary on fine days to "see father's wireless mast," at or near Shoeburyness. About the same time he had erected other wireless stations in the country and among them was one near Porthcurno, Cornwall, and another, I think, at Cleethorpes.

I remember well hearing of the incident in which my father proved to an audience at the Royal Institute that there certainly were weaknesses in the tuning devices then in use, though my memory does not connect with it the name of Sir Ambrose Fleming. At or about this time he visited the then St. Petersburg and was instrumental in introducing wireless to the Russian Government, who carried out experiments with a view to equipping the Russian navy.

There can be no doubt that some of his most useful work was carried out in conjunction with the Rev. J. M. Bacon's balloons. Of the two men, the one was interested in balloons as such and the other as a means of carrying wireless equipment. My father was a long-sighted man and foresaw that success in the air would come with heavier-than-air machines, and I have no doubt that he foresaw also that here lay a field for the utilization of wireless.

It may be of interest to record here that I have before me as I write a few leaves from his experimental notebook. The notes are dated July 9th, 1906, and they record, with diagrams, experiments he was then making with "diodes" connected up to produce continuous oscillation. They also show that he wasn't having a very happy time with it. Using a circuit in which there were two diodes connected, he failed to get continuous oscillation. However, he recorded that "Cossor sent in a third valve," and he repeated the experiment using all three, without success. His reasoning shows clearly that it was not more valves that he wanted, but the third electrode. But he just didn't think of it. However, a page or so later he records that he got his oscillations, but could not induce any current in his aerial. In the end he did get a current in his aerial and says that his previous failure to do so was because "The tuning proved to be so sharp that, on passing to the next turn of the helix in either direction, there was no aerial current."

I place a high value on these few pages of a great man's notebook, because they stand for me as a reminder that, but for a certain legal dispute that went against him in the House of Lords, my father might have died one of the greatest personalities of his time.

In the days immediately following my leaving college I tried to follow in his footsteps with the Mullard Radio Valve Co., Ltd., but the attempt proved only that my father was a much greater man than I.

Lurgashall, NOEL MASKELYNE.
Sussex.

Musical Feedback

AS a Scot who used to play the bagpipes before he came to live among the unmusical English, I would like to add to the analogy which "Cathode Ray" uses in his admirable article on rectifier circuits (March issue).

Whereas a capacitor depends to a large extent on dryness for low leakage, the bag of the bagpipes depends on moisture—a minor discrepancy—and the moisture is supplied by pouring into the bag a special liquid which is distilled in the Scottish Highlands.

Also the analogy could have been extended to say that the conductor from G to C is the pipe through which the piper blows. The pipe includes a valve which, in common with other one-way devices, hasn't got infinite resistance in one direction, but "let's by."

What it lets by is the vapour from the liquid in the bag and it is the subtle aroma from the vapour entering the respiratory organs of the "intermittently breathing Scot" that inspires and stimulates him to produce the stirring music which one associates with the bagpipes. It acts, in fact, as a sort of musical positive feed-back!

Leafield, Oxford. A. CAMPBELL.

Electronics on the Farm

I HAVE read with interest letters in your recent issues from H. G. P. Taylor and D. A. Bond on the subject of electric fencers, and your readers may be interested to have a few comments from a manufacturer.

The "hoary old stager" referred to by Mr. Taylor (the inductive discharge type with a balance wheel) has many advantages from the farmer's point of view and is still very much the most popular, both here and (more impressively, perhaps) in the United States, which is the pioneer country in electric fencing and where every conceivable idea has been tried out from time to time. This balance wheel type is robust, efficient from the input-output point of view and, moreover, the audible click at each impulse provides an easy way of ensuring that the unit is working. Also, a great many farmers prefer the rechargeable accumulator to purchasing dry batteries.

I would add the following comments to the various points raised in the two letters referred to above:

(1) A neon tube will not discharge the condenser to sufficiently low voltage due to high extinguishing voltage.

(2) A neon tube will not carry the high peak current required.

(3) Grid-triggered neon tubes such as those used in stroboscopes, while they are capable of passing heavy peak currents, will not work at the voltage of a standard high-tension battery.

(4) Glass-enveloped tubes would not, in my view, be suitable for use under the trying practical conditions experienced on a farm.

(5) The method suggested by Mr. Taylor of permanently connecting a neon in series with a high resistance across the line and earth does not give an indication of a good line, since even with the line fouled so badly that there is only 180 volts (peak) available the neon will still give a flash, but the line at this voltage will be practically useless.

Testing with a blade of grass, as suggested by Mr. Bond, is probably more effective though again extremely inaccurate. We now manufacture a tester incorporating a variable spark gap in series with a neon light, which gives a far more accurate indication.

I think your correspondents may not have heard that there is a British Standard Specification controlling the output and frequencies of electric fencers. This does not allow an interval of less than 0.75 second between impulses.

R. S. DRAKE.
The Wolseley Sheep Shearing Machine Company,
Witton, Birmingham.

OPEN LETTER TO THE POSTMASTER GENERAL

Allocation of Frequencies: A British Communications Commission

DEAR P.M.G.,

During the last twenty years there have been a number of proposals to revise the system under which frequencies are allocated. I suggest that the time has now come when this problem needs tackling. Some of the basic arguments were well covered in the leading article of *Wireless World* for [illegible]ember, 1954.

I suggest it is highly desirable to have a body outside the control of the Postmaster-General responsible for allocating frequencies. It is obviously essential, however, that the Government should maintain overall control in view of the vital part played by radio and radar in the defence of this country.

In the absence of alternative proposals, may I submit the outline of a scheme which might replace that used during the last fifty years?

Need for an Early Change.—The rapid expansion of radio and radar equipments makes the allocation of suitable frequencies increasingly important and difficult. Blocks of frequencies are becoming ever more precious, and it is important that no user, be he civilian or military, should occupy more frequencies than are strictly necessary.

Possible Alternative Method.—As long as the Defence Services are large-scale users of frequencies, the Government must retain overall control. In my submission, this should be exercised, not by the P.M.G., who is himself a user, nor by the Ministry of Defence, which is the largest user; but by some authority under a Minister who is not himself an interested party. I suggest the Lord President of the Council, who controls the Government's scientific policy and therefore has suitable advisers.

I suggest he should control a British Communications Commission and that this Commission should consist of two panels:

(a) The Civilian Radio Panel, on which the radio industry, the Board of Trade and other interested Ministries would be represented.

(b) The Defence Radio Panel, on which the Service Departments, including the Home Office, and the Ministry of Supply would be represented.

It is important that there should be a connection between the work of these two panels. I suggest that the Secretariat should be common to both, and that the Chairman of each Panel should be a member of the sister Panel.

Proof of Occupancy.—The operational needs and radio techniques of the Defence Services are constantly changing. The same applies to the civilian radio services. It is important, therefore, that the frequency bands allocated by the British Communications Commission should be monitored to make sure that unnecessary interference is not being caused, and that the channels are being adequately used.

The responsibility for this monitoring service is a matter which could be discussed later. The G.P.O. have an obvious claim, as they have suitable equipment and personnel. The monitoring service should furnish reports direct to the British Communications Commission.

I don't pretend that this is the ideal set-up, but I would like to see some constructive alternative put forward which would ensure an independent and balanced control of the radio spectrum.

Yours sincerely,

House of Commons. C. I. ORR-EWING.

Design for an F.M. Tuner

(Concluded from p. 163 of the April issue)

2—*Circuit and Constructional Details*

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

THE basic principles governing the design of an f.m. receiver were described in last month's issue and this article gives full details of an f.m. tuner based on these principles. The circuit comprises a pentode r.f. amplifier, a frequency-changer consisting of a pentode mixer and separate triode oscillator, followed by an i.f. amplifier employing two pentodes in cascade, the second acting as a high-level limiter. The next stage is a ratio detector with two crystal diodes feeding a triode cathode-follower output stage. The oscillator and cathode follower are the two halves of a double-triode valve and this, together with a magic-eye tuning indicator and h.t. rectifier bring the total of valves to seven (excluding crystals). There is considerable latitude in the choice of valves. The four pentodes are of the same type; the authors have successfully used B7G-pentodes of the EF91 type and B9A-pentodes of the EF80 type. The double-triode is a 12AT7 or equivalent and the rectifier can be any type delivering 40 mA at 250 V which can be operated from the general l.t. winding.

The complete circuit diagram of the tuner is given in Fig. 1. V_1 is the r.f. stage and the grid-circuit tuning is pre-set to approximately 94 Mc/s, the centre of the 12.5-Mc/s range it is intended to receive.

* Engineering Training Department, British Broadcasting Corporation.

To keep the loss in sensitivity at the ends of the band to less than 3 db, the effective Q of the grid circuit must be less than 94/12.5, or approximately 7.5. The input transformer L_1L_2 is designed to match an 80-Ω unbalanced feeder to a resistive load consisting of the input resistance of V_1 in parallel with the dynamic resistance of the secondary circuit. The dynamic resistance is approximately 2,500 Ω and the valve input resistance may be between 2,000 Ω for an EF91 and 4,000 Ω for an EF80. The effective secondary load may thus be between 1,100 Ω and 1,500 Ω depending on the valve type; the average may be taken as 1,300 Ω, which is reduced to 650 Ω by the addition of the connection to the feeder. To obtain a Q of 7.5 from an L-C circuit of effective dynamic resistance of 650 Ω requires a reactance of 650/7.5, or approximately 90 Ω. At 94 Mc/s this implies a capacitance of 19 pF. Of this 14 pF is contributed by the valve and stray capacitance and remaining 5 pF is added in the form of a physical component.

The anode circuit of V_1 is tuned by L_3C_{15}, C_{15} being one section of the two-gang tuning capacitor. Each section of this capacitor has a capacitance range of about 7 pF and this must have in parallel a fixed capacitor to give the desired frequency range of 87.5 to 100 Mc/s. For a given inductor the reson-

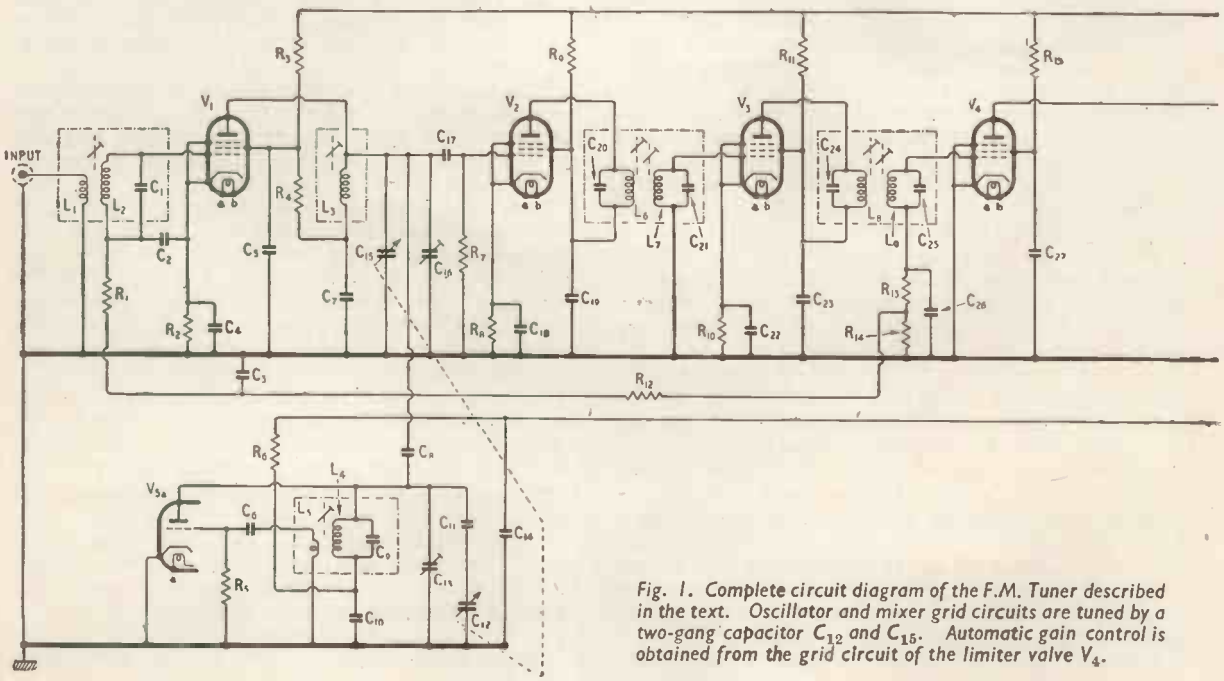


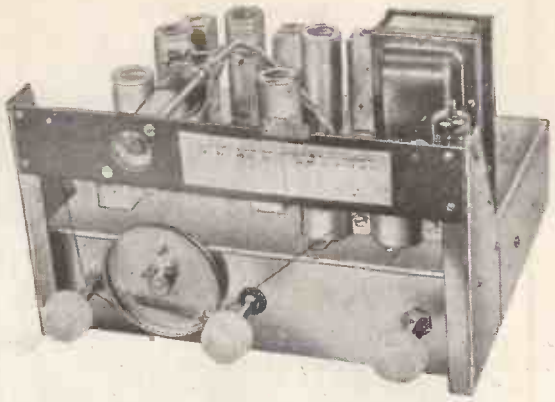
Fig. 1. Complete circuit diagram of the F.M. Tuner described in the text. Oscillator and mixer grid circuits are tuned by a two-gang capacitor C_{12} and C_{15}. Automatic gain control is obtained from the grid circuit of the limiter valve V_4.

ance frequency depends on the square root of the capacitance and thus we have

$$\frac{C + \Delta C}{C} = \left(\frac{100}{87.5}\right)^2$$

where ΔC is 7 pF and C is the fixed capacitance. This gives C as 22 pF. This is approximately the value of capacitance present in the circuit and is made up of the output capacitance of V_1 (4 pF), the input capacitance of V_2 (11 pF), the minimum capacitance of the tuning capacitor (3 pF), strays and the capacitor C_8 in the oscillator circuit. For alignment of the circuit it is necessary to have a trimmer in parallel with L_3 and, because the minimum capacitance of this component necessarily adds further fixed capacitance, the contribution from V_2 is reduced by using a 50-pF coupling capacitor C_{17}. By adjustment of the trimmer C_{16} the correct ratio of maximum to minimum frequency can be obtained and by adjustment of the inductance of L_3 operation can be secured in the correct frequency band.

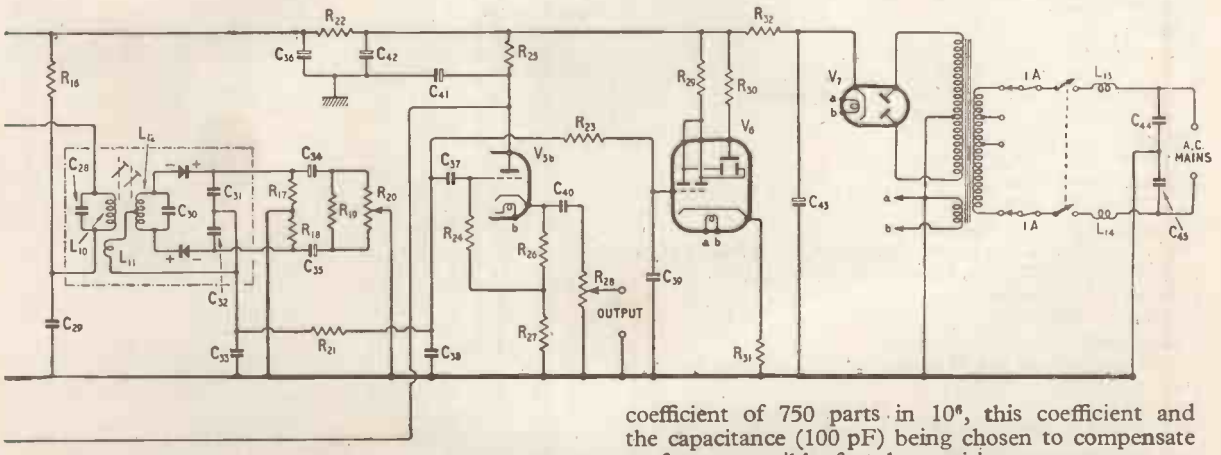
The oscillator is a triode (V_{5a}) operating on the high side of the signal frequency. The intermediate frequency is 10.7 Mc/s and the oscillator frequency limits are therefore 98.2 and 110.7 Mc/s. This is achieved with the second section of the tuning capacitor C_{12}, the capacitance swing being limited to 6 pF by a series fixed capacitor. The fixed shunt capacitance required to give the correct ratio of maximum to minimum frequency is also 22 pF as for the inter-valve r.f. circuit. Of this approximately 4 pF is contributed to V_{5a}, 3 pF by the tuning capacitor, 1 pF by the coupling to the mixer grid and 2 pF by stray capacitance, leaving 12 pF to be included as a physical component. This is made up of a capacitor C_9 and a trimmer C_{13} which is adjusted, as explained in the alignment procedure, to give the desired ratio of maximum to minimum frequency.



General layout of the front of the tuner.

being connected across a small coupling coil, has little effect on frequency of oscillation. Variations in grid-cathode capacitance can cause significant fluctuations in frequency if the resonant circuit is connected between grid and cathode. In the circuit adopted the resonant circuit is shunted by the anode-cathode and anode-grid capacitances which are more stable than the grid-cathode capacitance. It is this latter capacitance which principally controls the frequency drift in the first few minutes after switching on, the total change in this period being of the order of 25 per cent. With the particular form of oscillator circuit adopted, this warming-up shift is reduced to negligible proportions.

The components used in the oscillator circuit are chosen to minimize long-term frequency drift. For example C_{11} in series with the tuning capacitor is an N750 type, i.e. has a negative temperature



The particular oscillator circuit employed was chosen because it enables the cathode of the valve and the moving vanes of the tuning capacitor to be earthed. In this form of oscillator the resonant circuit can be included in the anode or the grid circuit but the former arrangement was considered better because it presents the valve with a higher value of anode load and thus gives a larger output. Moreover the grid-cathode capacitance of the valve, coefficient of 750 parts in 10^6, this coefficient and the capacitance (100 pF) being chosen to compensate as far as possible for the positive temperature coefficient of the tuning capacitor. Similarly the capacitance and coefficient of C_9 are chosen to compensate for variations with temperature of the inductance of L_4; this capacitor is included in the screening can so as to have the same temperature as the inductor. Unless components of similar specification are used in this part of the circuit there may be an undesirable drift in tuning; the complete specification for these and all components in the tuner is given in the list

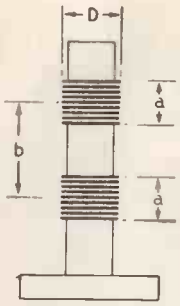


Fig. 2. The i.f. transformers used in the set take this form. As explained in the text the coupling coefficient and hence bandwidth is calculated from the dimensions a and b.

of parts. Provided the correct components are used the long-term frequency drift is very small.

The oscillator output is connected to the mixer V_2 by a small fixed capacitor C_8, the value of which is chosen to give the correct value of oscillator drive at the mixer grid. At the oscillator frequency the mixer circuit behaves as a capacitance the value of which is given approximately by $2Cf_1/f_2$ where C is the physical capacitance present, f_1 is the intermediate frequency and f_2 the oscillator frequency. Substituting C=25 pF, f_1=10.7 Mc/s and f_2=105 Mc/s (values applying when the tuning capacitor is at its mid-setting) gives the effective capacitance as 5 pF. The oscillator output at V_{5a} anode is approximately 20 V peak and the drive required at V_2 grid for optimum conversion conductance is 3 V peak; thus the optimum value of C_8 is less than 1 pF. In practice a 1-pF capacitor is used and the drive is about 4 V in peak value, varying slightly as the tuning setting is changed.

V_2 is an additive mixer and is biased partly by conventional cathode resistor and capacitor and partly by grid current flowing in the 1-MΩ grid leak R_7 as a result of the oscillator drive. The i.f. transformer connected in its anode circuit is of the usual double-wound type and has two similar windings on a former of 0.3 in diameter. To minimize any capacitance coupling between the windings (which might affect the shape of the response curve) the adjacent ends of the windings are arranged to be earthy. The position of the dust-iron cores can affect the mutual inductance significantly and to minimize these effects the design is such that at resonance the cores are only approximately half-embedded in the outer ends of the windings. The spacing between the windings is very critical and an error of as little as 1/16 in can alter the coupling factor (kQ) from 1.2 to 2.0! A formula which has proved very useful in calculating the required spacing (giving coupling factors within a few per cent of the measured values) is the following derived by one of the authors† some years ago:—

$$b = 0.44D\left[\left(\frac{1+2.3a/D}{k}\right)^{\frac{1}{3}}-1\right]$$

where b = distance between coil centres
D = overall diameter of windings
a = length of each winding

† S. W. Amos, Calculating Coupling Coefficients; *Wireless World*, September, 1943. p.p. 272, 273.

LIST OF PARTS

Coils:
Aerial. Allen type FMC102; Osmor type QAFM.
R.F. inter-valve: Allen type FMC103; Osmor type QRFM.
Oscillator: Allen type FMC104; Osmor type QOFM.
I.F. transformer: Allen type FMC101; Osmor type QIFM; Denco type IFT11.
Ratio-detector transformer: Allen type FMC151; Osmor type QICD.

Valves:
Pentodes: EF91, Z77 or equivalent.
EF80, Z719 or equivalent.
Double-triode: 12AT7, B309 or equivalent.
Rectifier: EZ80, U709 or equivalent.
Magic eye: EM34.
Crystals: GEX34 or OA72.

Mains transformer:
Electro-Voice type 104E.

Tuning-drive Components:
Spindle, drum, flywheel, universal coupler, pulleys, pivots, pointer, cord, spring etc. Jackson Bros.

Mains R.F. Chokes:
Dubilier 1-amp type.

Resistors:
All resistors can be ½ W rating and ±20 per cent tolerance unless otherwise specified.

R_1	10 kΩ	R_{10}	270Ω±10% for EF80 or 180Ω ± 10% for EF91
R_2	270 Ω ± 10% for EF80 or 180 Ω ± 10% for EF91	R_{11}	1 kΩ
R_3	1 kΩ	R_{12}	1 MΩ
R_4	1 kΩ	R_{13}	100 kΩ
R_5	47 kΩ	R_{14}	100 kΩ
R_6	1 kΩ	R_{15}	100 kΩ
R_7	1 MΩ	R_{16}	1 kΩ
R_8	270Ω±10% for EF80 or 180Ω±10% for EF91	R_{17}	8.2 kΩ ± 1%
		R_{18}	8.2 kΩ ± 1%
		R_{19}	6.8 kΩ
R_9	1 kΩ	R_{20}	10 kΩ potentiometer

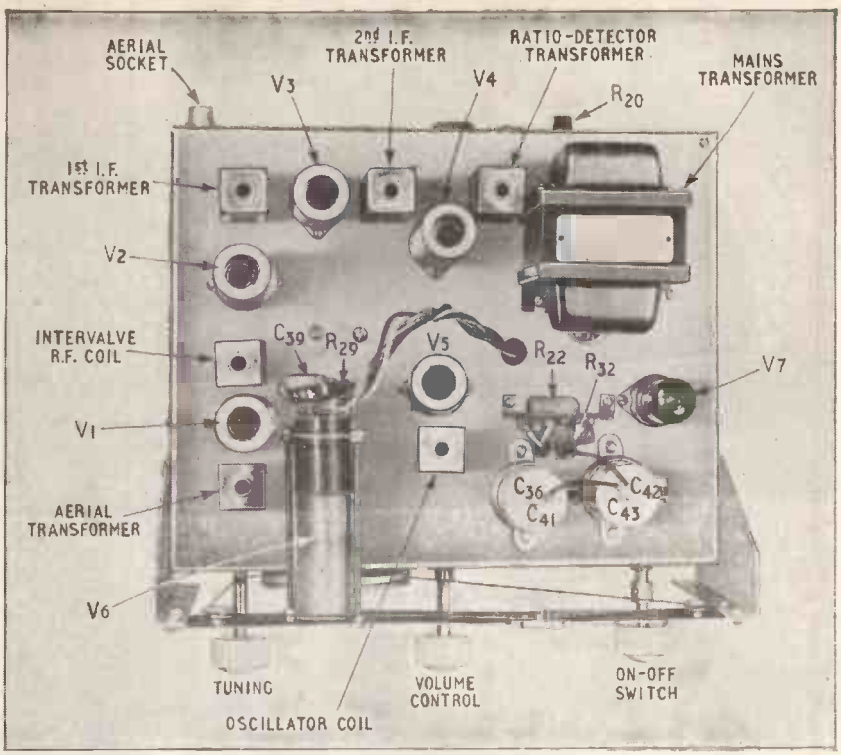
Resistors (*continued*)

R_{21}	100 kΩ	R_{27}	47 kΩ
R_{22}	1.5 kΩ 3W	R_{28}	50 kΩ potentiometer
R_{23}	1 MΩ	R_{29}	to be selected
R_{24}	1 MΩ	R_{30}	200 kΩ
R_{25}	10 kΩ ½W	R_{31}	1.5 kΩ
R_{26}	470 Ω±10%	R_{32}	1 kΩ 3 W

Capacitors:
Where a capacitor is specified as a particular type, or with a particular value of temperature coefficient, it is essential to use this type.

C_1	5 pF	C_{24}	50 pF silver mica ±5%
C_2	0.005 μF ceramic	C_{25}	50 pF silver mica ±5%
C_3	0.1 μF 150V	C_{26}	20 pF
C_4	0.005 μF ceramic	C_{27}	0.005 μF ceramic
C_5	0.005 μF ceramic	C_{28}	10 pF Erie type N750
C_6	20 pF Erie NPOK	C_{29}	0.005 μF ceramic
C_7	0.005 μF ceramic	C_{30}	39 pF Erie type N330
C_8	1 pF Erie NPOK	C_{31}	300 pF
C_9	8.2 pF Erie N750K	C_{32}	300 pF
C_{10}	0.001 μF silver mica	C_{33}	300 pF
C_{11}	100 pF Erie NPOK	C_{34}	25 μF 25 V electrolytic
C_{12}	3-10 pF tuning capacitor, Jackson Bros. type U102	C_{35}	25 μF 25 V electrolytic
		C_{36}	16 μF 350 V electrolytic
C_{13}	1.5-7 pF trimmer Erie type NPO557A	C_{37}	0.01 μF
C_{14}	0.005 μF ceramic	C_{38}	500p F
C_{15}	Same as C_{12}	C_{39}	0.1 μF 150 V
C_{16}	1.5-7 pF trimmer Erie type NPO557A	C_{40}	0.25 μF 150 V
		C_{41}	16 μF 350 V electrolytic
C_{17}	50 pF	C_{42}	16 μF 350 V electrolytic
C_{18}	0.005 μF ceramic	C_{43}	16 μF 350 V electrolytic
C_{19}	0.005 μF ceramic	C_{44}	470 pF Erie type CD9P/101
C_{20}	50 pF silver mica ±5%	C_{45}	470 pF Erie type CD9P/101
C_{21}	50 pF silver mica ±5%		
C_{22}	0.005 μF ceramic		
C_{23}	0.005 μF ceramic		

These dimensions are illustrated in Fig. 2. As an example of the use of this formula suppose $a = 0.35$ in and D = 0.32 in. If the working Q value is 70, and the coupling factor is required to be 1.2, the coupling coefficient must be 1.2/70 = 0.017. Substituting in the above expression gives b as 0.68 in. The spacing between the adjacent ends of the coils must hence be 0.68 − 0.35 = 0.33 in.



The relative position of the larger components, valves and coils is shown by this view.

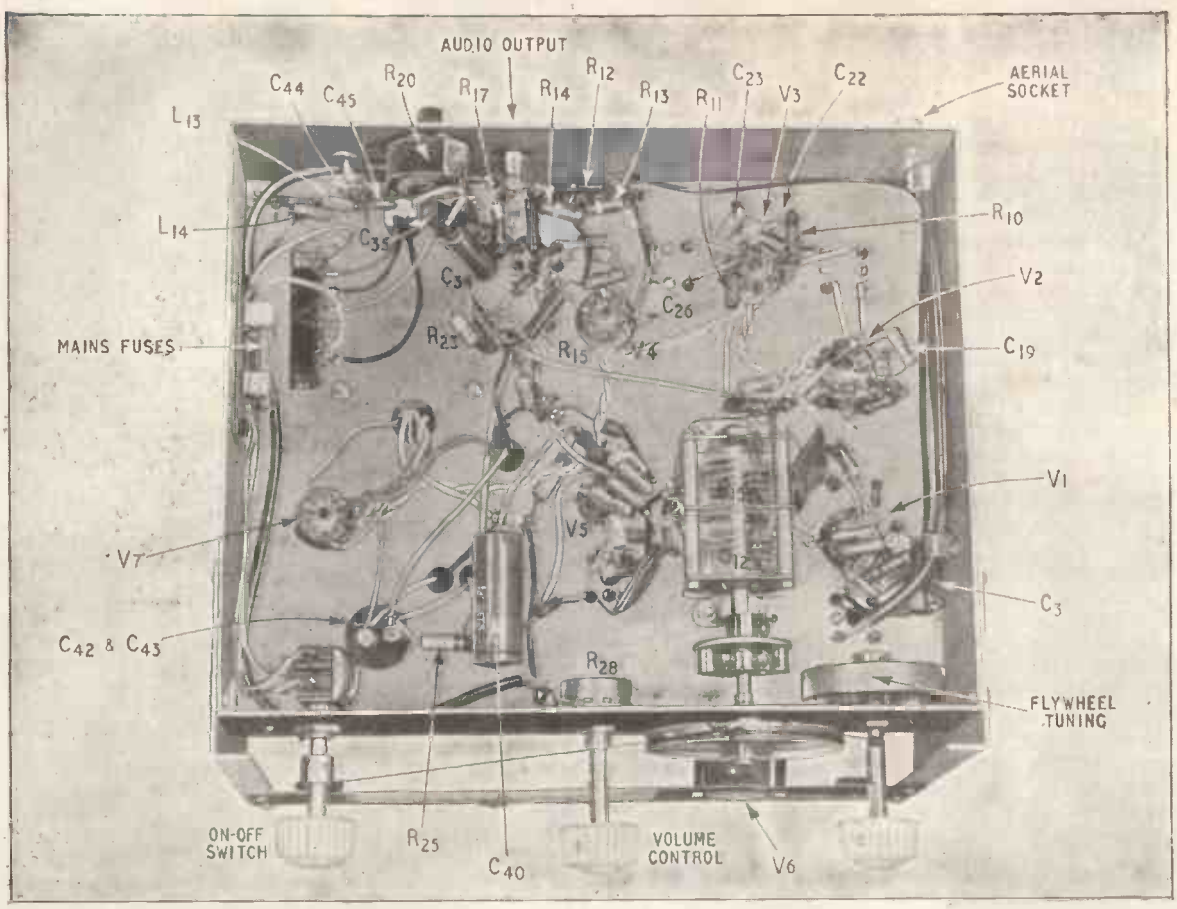
V_3 is the first i.f. stage and operates at full gain. V_4, the second i.f. stage, is designed to work as a high-level limiter and operates with a screen-grid voltage of approximately 100. There is no cathode bias and on receipt of an input signal the valve takes grid current, developing a voltage across R_{13} and R_{14} equal to the peak value of the signal. The voltage across R_{14} is fed back to the grid of V_1 as a.g.c. V_4 acts as a leaky-grid detector and any amplitude modulation present on the input signal (due to ignition interference for example) appears across R_{14}. R_{12} and C_3 are included in the a.g.c. line to prevent such signals from reaching V_1. The grid base of V_1 is approximately 5 V and the a.g.c. line cannot therefore exceed 5 V no matter how strong the received signal. To give 5 V across R_{14} the input to the limiter must be 10 V peak; this is approximately 3 times the grid base of V_4 and thus ensures reasonably good limiting at high signal levels.

The decoupling used in the i.f. amplifier must be satisfactory at 10.7 Mc/s and at very much higher frequencies in order to prevent parasitic oscillation and i.f. harmonic feedback to the r.f. stages. Satisfactory operation was obtained by using 0.005-μF ceramic capacitors for decoupling throughout the tuner. The heater current of all valves is supplied through tightly twisted twin flex. Decoupling was necessary only at the heaters of V_1 and V_5 where a 0.005-μF capacitor is joined between each heater socket in the valve holder and chassis in order to cure a slight modulation hum.

The discriminator transformer L_{10}, L_{11}, L_{12} was wound by the authors to a specification by the General Electric Company but it is also obtainable commercially (see the list of parts). It employs two crystals which are included with the capacitors C_{31}, C_{32} in the screening can. With a ratio detector of the conventional type, such as that used in the F.M. Feeder Unit (*Wireless World*, September 1952) amplitude limitation is adjusted to a maximum by variation of the resistance in series with the electrolytic capacitors. Such adjustments upset the d.c. balance of the circuit with the result that there may be a d.c. output when the applied signal is accurately in tune. This was of no significance in the F.M. Feeder Unit but in this tuner the d.c. output is used to operate a magic-eye tuning indicator, and for this to be successful, it is essential that adjustment of the series resistance should not affect the d.c. balance. The circuit used meets these requirements provided the resistors R_{17} and R_{18} are equal; 1 per cent tolerance components are recommended.

The output of the discriminator passes through the de-emphasis network (of 50 μsec time constant) R_{21}, C_{38} and then feeds the magic-eye through the network R_{23}, C_{39} which removes a.f. signals which would cause blurred tuning indication. The a.f. output is applied to the cathode follower V_{5b}.

The use of a cathode follower as output stage has the advantage that the tuner can feed amplifiers with comparatively low input resistance (such as 10 kΩ) without loss of audio signal. If such a resistance were to be connected directly across the output of the de-emphasis network there would be a loss of more than 20 db due to the series resistor R_{21} and this resistor cannot be reduced without affecting the performance of the detector. A second advantage resulting from the use of a cathode follower is that its low output resistance permits the use of comparatively long screened leads to the following amplifier without attenuation of upper audio frequencies. The highest output resistance occurs when the gain control, R_{28}, is at its mid-position and has a value of about 12.5 kΩ; it is possible to load such a generator resistance with as much as 600 pF of shunt capacitance before the loss at 10 kc/s approaches 1 db. The cathode follower has quite a small a.f. input and can operate satisfactorily with a low anode current. The current is approximately 2 mA and is kept low to reduce the rise in temperature of the valve. The cathode follower is in the same bulb as the oscillator and it is advantageous to keep the temperature rise as small as possible in the interests of frequency stability.



The bulk of the smaller components, including the gang capacitor, are located below the chassis. The annotation enables most of them to be identified.

It is by no means easy to tune an f.m. receiver accurately to a desired transmission by ear and some form of tuning indicator was considered necessary. The obvious choice is a magic eye connected across the a.g.c. line, or across the electrolytic capacitor of the ratio detector. This is unsatisfactory if the receiver has the right shape of passband because the deflection of the eye remains substantially unaltered over a frequency range of approximately 100 kc/s on either side of the correct tuning point. If, as is common, the selectivity characteristic is asymmetric as a result of Miller effect the maximum a.g.c. voltage can give a positively misleading indication.

A precise tuning indication can be obtained from the output of the ratio detector which is zero when the receiver is correctly tuned, but is positive or negative if the receiver is mistuned. In fact the polarity and magnitude of the ratio detector output indicate respectively the sense and degree of mistuning. The tuning indicator is thus required to show accurately when the ratio detector output is zero and it was found that a magic eye operated under certain conditions could be used for this purpose.

The magic-eye circuit is so designed that the eye is closed (shadow angle zero) when there is no input to the control grid. If a positive voltage is applied to the control grid the eye opens, i.e. the shadow angle increases and if a negative voltage is applied the sectors of luminescence overlap, corresponding to a negative shadow angle. To avoid grid current and to enable the eye to respond to positive inputs a resistor is included in the cathode circuit and the anode and target potentials are then so chosen that the eye is closed for zero input voltage. This condition can be obtained with a high value of target potential, but a low value of anode load is required and the sensitivity of the eye is poor. By using a lower target potential a higher value of anode load can be used and satisfactory sensitivity obtained, but the brightness of the eye is poor. In the compromise solution adopted the target potential is approximately 100 V and the anode load is of the order of 250 kΩ. Where a tuner is normally operated with a large input signal the maximum sensitivity of the eye is unnecessary and a brighter display could be obtained by using a higher target potential of say 170 V and a lower value of anode resistor.

The mains unit is conventional and includes a mains transformer with two secondary windings, one supplying 40 mA at 250—0—250 V and the other supplying 3 A at 6.3 V. The smoothing circuit includes three resistors R_{22}, R_{25} and R_{32} and four electrolytic capacitors; for convenience the capacitors are in the form of two 16 + 16-μF components. The mains lead includes an r.f. filter L_{13} L_{14} C_{44} C_{45} which prevents radiation of r.f. energy from the lead outside the

chassis; this filter, to be effective, must be situated very close to the point where the lead leaves the chassis.

Before aligning the receiver it is advantageous to adjust the tuning indicator. To do this short-circuit C_{39} and replace R_{29} by a 1-MΩ variable resistor. Adjust R_{29} to give zero shadow angle, i.e. close the eye, and then replace the variable resistor by a fixed one of the same value. Remove the short circuit.

The alignment can now be carried out and for this purpose an a.f. amplifier is required and also an a.m. signal generator capable of giving an output at 10.7 Mc/s and between 87.5 and 100 Mc/s. With the amplifier connected to the tuner output apply a modulated signal at 10.7 Mc/s to V_4 grid and adjust L_{10} for maximum audio output. Switch off the modulation and with a plain carrier input to the limiter adjust L_{12} until it is accurately tuned as indicated by the magic eye. The correct tuning is achieved when the eye is just closed and with no overlap of bright areas and no shadow showing. As the core is rotated from this position the eye either opens or the bright regions overlap and display a brighter centre segment.

Now transfer the generator output to V_3 grid and connect the amplifier input across C_{26}. With a modulated r.f. input at 10.7 Mc/s adjust the cores of the second i.f. transformer to give maximum audio output from the amplifier. Transfer the generator output to V_2 grid and repeat the adjustment for the first i.f. transformer. These adjustments should be carried out at all times with the smallest output from the generator which can be heard adequately.

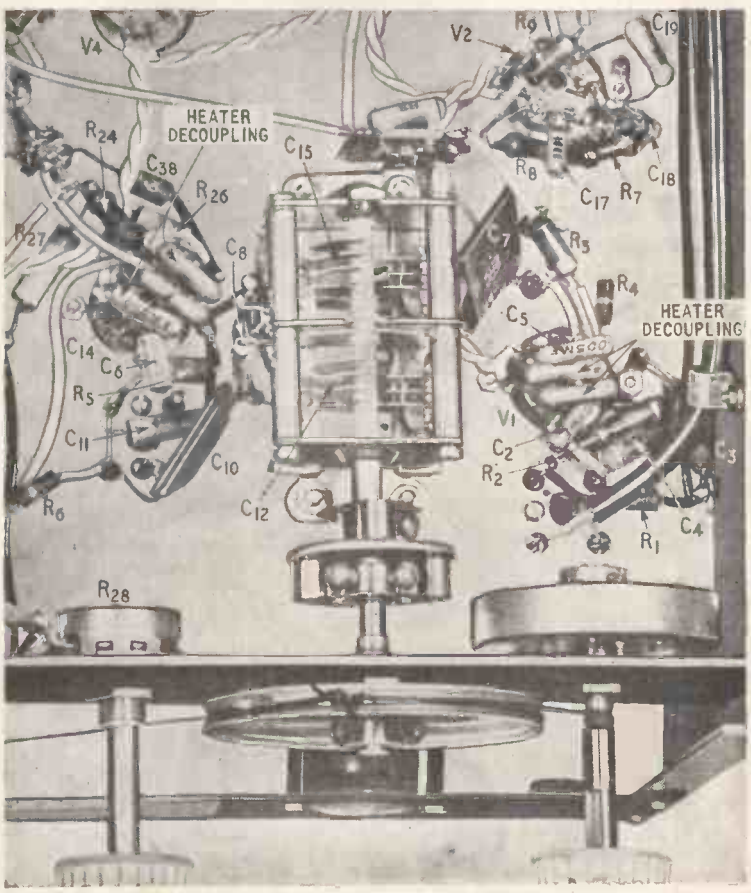
With the amplifier still connected across C_{26} transfer the generator to the aerial input socket of the tuner. Adjust the generator to give a modulated output at 87.5 Mc/s and set capacitors C_{12} and C_{15} to maximum. At this setting of the tuning capacitors the pointer should indicate 87.5 Mc/s. Tune in the signal by adjustment of L_4; if the signal can be heard at two core settings choose that corresponding to the smaller inductance. Then adjust L_3 to give maximum output. Now set the generator to 100 Mc/s and the tuning capacitor to minimum capacitance; the pointer should now indicate 100 Mc/s. Adjust C_{13} to tune in the signal and C_{16} to give maximum output. Repeat the inductance adjustment at 87.5 Mc/s and the capacitance adjustment at 100 Mc/s until no further improvement can be effected.

Disconnect the signal generator and reconnect the amplifier to the a.f. output socket of the tuner. Set the tuning control to approximately 94 Mc/s and adjust the inductance of L_2 to give maximum noise output.

Finally, to adjust the potentiometer R_{20}, connect an aerial to the tuner and find a weak signal. Adjust R_{20} to give minimum background noise; if the signal is frequency modulated this setting should also give best quality of reproduction. It is possible that a different setting of R_{20} may be required for a larger input signal. The value of R_{19} was found to be optimum for the particular ratio detector transformer and crystals used and should be generally suitable for commercial versions of it. If, however, the highest degree of a.m. rejection is required the value of R_{19} should also be adjusted.

Mechanical details of the tuner can be seen from the accompanying photographs. A conventional chassis of 16 s.w.g. aluminium measuring 10 in by 8 in by 2½ in is used. The tuning capacitor is mounted underneath the chassis and the coils above the chassis, and individually screened. The smoothing resistors dissipate approximately 4 W and are mounted above the chassis for good ventilation; if these components are located underneath there might be some frequency drift due to the increase in temperature of components near the resistors. The smoothing resistors are at h.t. potential and are placed away from the edges of the chassis to avoid, as far as possible, accidental contact with them.

The tuning spindle on the left-hand side of the front panel drives a cord which passes once round the 2¾ in diameter drum and over two pulleys riveted at the upper corners of the tuning scale, tension being applied to the cord by a spring inside the drum. The drum drives the tuning capacitor via a flexible coupling and the cord carries a pointer which slides along the top of the tuning scale, which is of 20 s.w.g.



This enlarged section of the underside of the chassis shows in greater detail the layout of the r.f. and oscillator stages.

steel. The tuning capacitor has no stops to limit its rotation to 180 deg and the necessary limitation is provided by a 6-BA cheese-headed bolt which is secured to the drum and strikes the heads of similar bolts secured to the front panel when the capacitor reaches its maximum and minimum settings. The pointer travel is nearly 4½ in but, because of the length of the slider, a space of 5½ in must be allowed between the magic eye and the right-hand pulley. Cord drives of this type tend to have a rather "dead" feel due to the friction present and this has been overcome by a lead flywheel secured to the tuning-spindle behind the front panel. The inertia of this wheel, though insufficient to give "spin-wheel" tuning improves the smoothness of the drive considerably.

The magic-eye holder is secured to the scale by two 3¼-in. lengths of 4-BA studding and the target is viewed through a ⅞-in. diameter hole in the scale.

For the benefit of constructors who prefer to wind their own coils, full details are included. There are, however, commercial coils quite suitable for use in this circuit and their type numbers are given in the list of parts. The layout and pin connections for the r.f. coils are given in Fig. 3; for the sake of clarity primary and secondary windings are shown as separate coils but they are in fact overlapping as mentioned in the specification.

Coil Winding Data—*Aerial Coil:* Primary—2¼ turns of 22 s.w.g. tinned copper wire in insulated sleeving inter-wound with earthy end of secondary. Secondary—4¾ turns of 18 s.w.g. tinned copper wire spaced so as to occupy 0.5 in. Former-Aladdin type PP5938. Core—Aladdin v.h.f. grade, colour-coded purple. Can—John Dale type TV2.

R.F. Inter-valve Coil: Winding—2¾ turns of 18 s.w.g. tinned copper wire space-wound so as to occupy a length of 0.3 in. Former, core and can as for aerial coil.

Oscillator Coil: Anode winding—2¼ turns of 18 s.w.g. tinned copper wire spaced so as to occupy a length of 0.3 in. Grid winding—1¼ turns of 22 s.w.g. tinned copper wire in insulated sleeving wound over earthy end of anode winding. Former, core and can as for aerial coil.

I.F. Transformer: Primary and secondary—23 turns of 28 s.w.g. single-silk and enamelled copper wire close-wound. Spacing between adjacent ends of windings—accurately $\frac{5}{16}$ in. Former—Aladdin type PP5937. Core—Aladdin, colour-coded grey. Can—John Dale type TV1.

Ratio-detector Transformer: Primary—35 turns of 36 s.w.g. single-silk and enamelled copper wire close-wound. Secondary—16 + 16 turns of 28 s.w.g. single-silk and enamelled copper wire, bifilar, close-wound. Tertiary—9½ turns of 36 s.w.g. single-silk and enamelled copper wire close-wound over paper interlay 0.002 in. thick over end of primary remote from secondary. Spacing between primary and secondary—$\frac{3}{16}$ in. Former, core and can as for i.f. transformer.

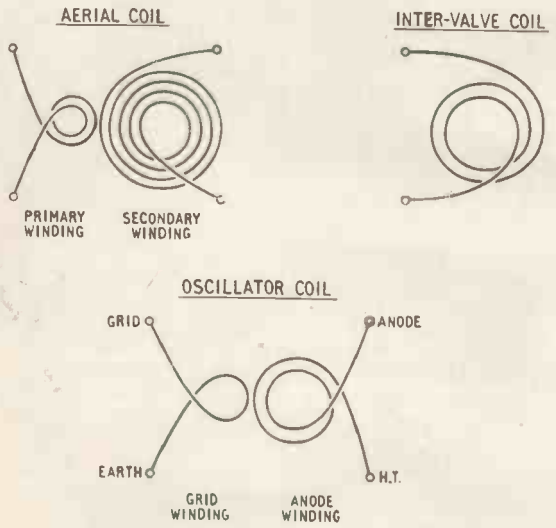


Fig.3. Winding sense and terminal connection of the r.f. and oscillator coils.

CLUB NEWS

Barnsley.—At the meeting of the Barnsley and District Amateur Radio Club on May 13th, H. H. Eyre (G5KM) will give a demonstration of i.f. crystal filter operation. Meetings are held at 7.0 at the King George Hotel, Peel Street, Barnsley. Sec.: P. Carbutt (G2AFV), 33, Woodstock Road, Barnsley, Yorks.

Birmingham.—The subjects for the May meetings of the Slade Radio Society are (13th) "Amateur Radio Direction Finding," by N. B. Simmonds, and (27th) "Past and Present in Amateur Radio," by E. G. H. Brown (G5BJ). The first of the season's d.f. tests for the Harcourt Trophy will be held on May 8th. The club meets on alternate Fridays at 7.45 at The Church House, High Street, Erdington, Birmingham. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

The Birmingham and District Short Wave Society, which meets on the second Monday of each month at 7.45 at the Y.M.C.A., 20, Soho Road, Hockley, Birmingham, 19, will be addressed by T. Burton on May 9th, when his subject will be aerials. Sec.: R. Yates, 28, Daimler Road, Yardley Wood, Birmingham, 14.

Canterbury.—The East Kent Radio Society continues to meet on alternate Tuesdays at 8.0 at The Two Brothers, Northgate Street, Canterbury. Details of the programme are available from the secretary, D. Williams, Llandogo, Bridge, Canterbury, Kent.

Cleckheaton.—A member of the Leeds Post Office staff will be talking on elementary direction finding to members of the Spen Valley and District Radio and Television Society at their meeting on May 4th. The club meets on alternate Wednesdays at 7.30 at the Temperance Hall, Cleckheaton. Sec.: N. Pride, 100, Raikes Lane, Birstall, nr. Leeds.

Coventry.—In addition to the regular meetings on May 9th and 23rd the Coventry Amateur Radio Society will be holding a two-metre field day on May 1st. At the meeting on the 9th K. Barber (G3HDP) will deal with receiver servicing and on the 23rd W. Grimbaldeston (G6WH) will speak on frequency modulation. Meetings are held at 7.30 at 9, Queens Road, Coventry. Sec.: J. H. Whitby (G3HDB), 24, Thornby Avenue, Kenilworth, Warwicks.

Two-Call Club.—The new president of the British Two-Call Club is Lt. Col. Sir Evan Y. Nepean, Bt. (G5YN, VS1YN, DL2YN), and Major K. E. S. Ellis (G5KW, DL2KE, HZ1KE) is the new vice-president. Membership of the club is open to British subjects who have held calls in two countries, or, alternatively, in two areas of the British Empire Radio Union. Sec.: G. V. Haylock (G2DHV), 63, Lewisham Hill, London, S.E.13.

Design for a 20-Watt High Quality Amplifier

By W. A. FERGUSON,* B.Sc.(Eng.), A.C.G.I., Grad.I.E.E.

Choice of Valves and Operating Conditions

IN recent years remarkable improvements have been made in the field of sound reproduction. Progress in the design of pickups, amplifiers and loudspeakers, coupled with the introduction of high-quality disc and tape recordings and v.h.f. sound broadcasting has set new standards for discriminating listeners. The amplifier and associated control circuits form the core of a sound-reproducing system and much interest has been focused on their design requirements and the manner in which high quality can be achieved.

The basic requirements of an amplifier designed for high-quality sound reproduction have previously been discussed in these pages[1, 2]. It is proposed here to discuss further some aspects of high-quality amplifier design, with emphasis on the output stage, and it is hoped to describe in a subsequent article a design for a high-quality 20-watt amplifier using 25-watt high-slope pentodes in the output stage.

The principal features of a good amplifier can be briefly recapitulated:

1. Very low harmonic and intermodulation distortion.
2. Linear frequency response in the audible range.
3. Good response to signals of a transient nature.
4. Low phase shift in the audible frequency range.
5. Low hum and noise level.
6. Adequate power output to allow peak passages to be reproduced without overload.
7. Low output resistance to provide electrical damping for the loudspeaker system.

Output Stage.—Although the power-handling capacity of an audio amplifier is not the most important factor from the listening point of view—a low distortion level being usually judged pre-eminent—it is nevertheless of prime importance from the point of view of the designer.

It is generally considered that for realistic reproduction of orchestral music in the home a peak output power of 10-15 watts is required, assuming the efficiency of the loudspeaker system to be about 5%. Apart from loudspeaker efficiency, the required power depends on the size and acoustic nature of the room and to a lesser extent on the taste of the listener. Thus, whilst 10 watts is found to be adequate in many, perhaps, the majority of cases conditions in large rooms and small halls may merit a power reserve of at least 20 watts.

There exists a choice of two basic forms of output stage from which an effective output of 10-15 watts can be delivered to the voice coil of the loudspeaker. These two well-known forms of output stage are:

1. The Class AB push-pull pentode or tetrode stage.
2. The Class A or Class AB push-pull triode stage.

The choice between these is largely a balance between economy and performance.

Pentode Output Stage.—The use of pentodes or tetrodes of the 12-watt anode dissipation class, operated in a conventional Class AB push-pull stage, enables an effective output of 12-13 watts to be obtained easily, assuming an output transformer efficiency of about 80%. This latter value is typical of present practice. The appropriate supply voltage, limited by valve ratings, is about 300-320 volts. The overall power efficiency of such a stage is fairly high, being 50% for a typical stage employing Mullard EL84 output pentodes. Harmonic distortion is, however, of the order of 3%-4% at full output, and in consequence a high degree of negative feedback is necessary to reduce distortion to low levels, say below 0.5% at rated output.

The conditions for Class AB operation normally recommended and published by the valve manufacturer are based on measurements made with continuous sine-wave drive. The bias under zero-drive conditions and the anode-to-anode load resistance are so chosen that optimum performance is achieved when the working point of the valves is displaced under drive conditions. This displacement is due to the influence of increased anode and screen-grid currents in the cathode bias circuit. For a typical output stage on a 310-volt supply using EL84 pentodes the rise in cathode current, and thus, cathode bias voltage at full drive, is about 40% with a sinusoidal input voltage.

When such a stage is used in the reproduction of speech or music, however, operating conditions are rather different. The mean amplitude of the input

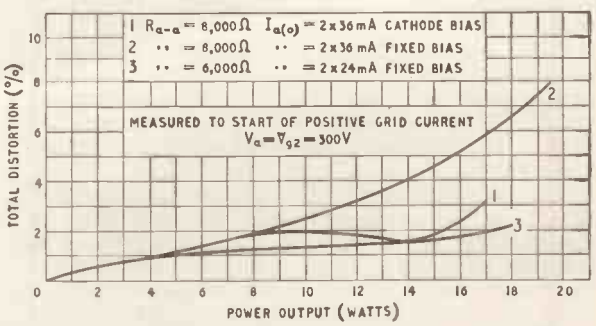


Fig. 1. Comparison of distortion curves under steady-state sinusoidal input conditions for a pair of EL84 valves in Class AB push-pull (1) with normal cathode bias, (2) with fixed bias under the same conditions, (3) load reduced for optimum fixed-bias operation.

* Mullard Valve Measurement and Application Laboratory.

signal is now very small compared with the peak values which occur from time to time and thus the mean variation of cathode current is also very small. Due to the relatively long time constant in the bias network the displacement of the working bias, even under peak signal conditions, is small enough for the stage to be considered as working with virtually fixed bias. If the normal Class AB stage (cathode biased) is measured under the corresponding fixed-bias conditions with a sine-wave input, it is found that at high output levels distortion is greater than when cathode bias is used. These two conditions are illustrated for the Mullard EL84 output pentode by curves 1 and 2 in Fig. 1. The quiescent bias is the same in both cases, curve 1 showing normal published operation with cathode bias, curve 2 operation with fixed bias. These results indicate that in practice, a cathode-biased Class AB stage designed on a sinusoidal drive basis will produce increased distortion when peak passages of speech or music are being reproduced.

One method of improving performance in practice is to adjust the quiescent operating conditions in the output stage so that they are nearly optimum for fixed bias working, although cathode bias is still used. This entails a smaller standing current and lower anode-to-anode load impedance. These changes result in larger variations in the instantaneous anode and screen-grid currents when the stage is driven, but the effect of these is at least partially compensated since the time constant in the cathode bias network has been increased at the same time. The excursion of the working bias is still kept very small under driven conditions.

It is found that good short-term regulation of the power supply is ensured by the use of large value (50μF) electrolytic capacitors for anode and screen-grid feeds. Peak currents corresponding to near overload conditions are effectively supplied by the capacitors with a reduction in line voltage of well under 0.5%, and the instantaneous power-handling capacity of the stage is not impaired.

Such a design, combined with a high degree of negative feedback (26 db), which includes the output stage and output transformer, is an alternative operating condition in the output stage of the 10-watt Mullard high-quality amplifier circuit[3, 4] and has proved very satisfactory in practice. A secondary feature of the use of these operating conditions is that the 12-watt output valves each run at a mean anode dissipation of only 7.5 watts. The corresponding fixed bias conditions in this case are illustrated in curve 3 of Fig. 1.

This form of operation is, however, suitable only for use in speech or music reproduction and cannot be used with a sine-wave input without excessive distortion. For this reason it is difficult to measure directly the distortion levels which obtain under practical conditions.

A second method of improving performance, described later, is to use distributed load conditions in the output stage. Depending on the precise loading used, the variation in anode and screen-grid currents can be reduced to such a level that almost identical performance is obtained under cathode and fixed bias conditions.

Triode Output Stage.—A low level of inherent distortion can be obtained in a push-pull triode stage operating under virtually Class A conditions. It is found that with 25-watt pentodes or tetrodes strapped as triodes a power output of 12-15 watts can be obtained at harmonic distortion levels below 1% using a supply voltage of 430-450 volts.

Maximum power output and the corresponding distortion vary appreciably with the value of load impedance and Fig. 2 illustrates typical performance of the Mullard EL34 high-slope output pentode, triode-connected in a push-pull stage operating slightly below its rated anode dissipation of 25 watts.

For anode-to-anode load impedances below 7,000Ω either a common, or separate cathode resistors (bypassed) can be used; above 7,000Ω improved operation is obtained with an unbypassed common cathode resistor. Operating conditions approach Class A as the anode-to-anode load impedance is raised and optimum performance for high-quality output stages is obtained with a load impedance of about 10,000Ω. An output of 14 watts is then delivered by the valves with total harmonic distortion well below 1%.

This type of output stage has found favour for a number of years in high-quality amplifiers giving about 12 watts effective output. Because of the low inherent distortion less negative feedback can be used to give acceptable linearity as compared with that required in pentode or tetrode output stages giving similar power output. Furthermore, in 3- or 4-stage amplifier designs, with most of the feedback applied over the whole amplifier, including the output transformer, it is then possible to achieve increased margins of stability for a given distortion level.

Distributed Load Conditions.—Increasing interest is being shown in various forms of distributed loading in the output stage[2]. These involve the application of negative feedback in the output stage itself. In the simplest form, the screen grids of the output valves are fed from suitably positioned taps on the primary of the output transformer and the stage can be considered as one in which negative feedback is

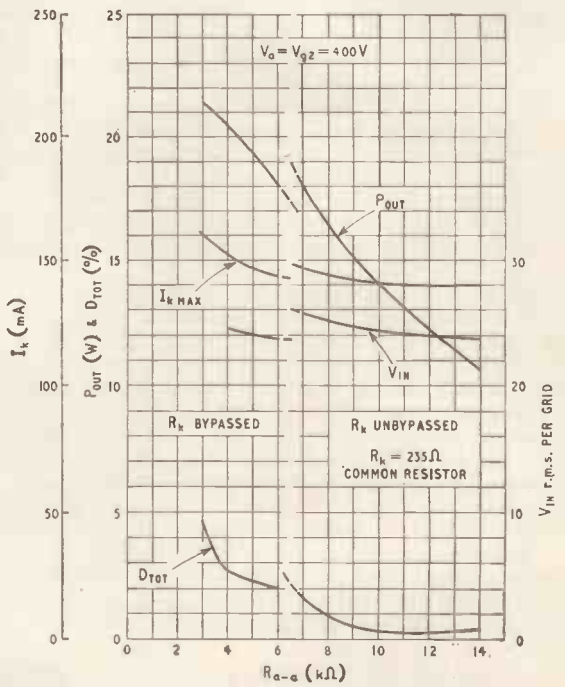


Fig. 2. Performance curves of two triode-connected EL34 valves in push-pull.

applied in a non-linear manner via the screen grids. The characteristics of the distributed load stage are intermediate between those for pentode and triode operation, approaching triode operation as the percentage of the primary winding common to anode and screen-grid circuits increases. It is found that under optimum conditions about two-thirds of the power-handling capacity of the corresponding pentode stage can be realized with much reduced distortion, whilst at power levels corresponding to triode operation, a similar order of distortion is obtained. At the same time the output impedance is reduced to a level approaching that obtained when a conventional push-pull triode stage is used.

Such a stage can thus be used with pentodes of the 25-watt class in high-quality amplifiers designed for power outputs well in excess of 15 watts, the overall power efficiency being appreciably greater than with triode operation. Conversely, the performance of 12-watt pentodes can be improved appreciably, although the power-handling capacity is somewhat reduced. However, effective power outputs of 10-12 watts can still be obtained.

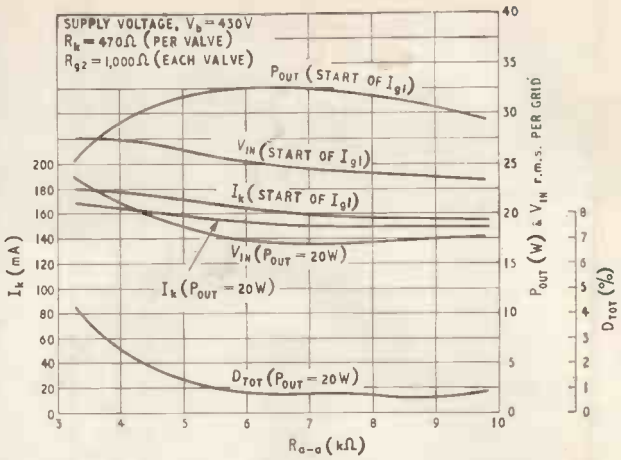


Fig. 3. Performance of EL34 push-pull pentodes under distributed-load conditions with screen tappings at 43% of primary turns.

A comparison is given in Table 1 of triode, pentode and distributed load operation for the Mullard EL34 and EL84 output pentodes. For valves of the EL34 type, comparison with triode operation is of most interest. It will be seen that distributed-load operation using a tapped primary output transformer enables the power-handling capacity to be more than double that possible with triode operation, whilst at the same time distortion in the stage can be held to a very low level.

Although with a common winding ratio of 0.2, i.e., with 20% of the primary winding common to anode and screen-grid circuits, the distortion level is comparable with triode conditions, it has been found that appreciable improvement is obtained at higher power outputs if the common winding ratio is further increased. Progressive improvement in overall performance has been obtained with the percentage of common primary winding increased up to 40-45%. Although with this increase power-handling capacity is still further reduced, at least 35 watts output can be obtained with distortion at the onset of grid current at about 2.5%.

Performance typical of the EL34 when used with an output transformer having a primary winding tapped at 43% of the turns is shown in Fig. 3. The output transformer used for these measurements was the Partridge type UL2 and the values of power out-

TABLE 1

Valve type	Mode of operation	Operating conditions					Total distortion (per cent)			
		V_a (V)	V_{g2} (V)	R_k (Ω)	R_{a-a} (kΩ)	R_{g2} (Ω)	at 10W	14W	20W	30W
Mullard EL34	Triode connection ..	400	*	470 (per valve)	10	*	0.5	0.7	—	—
	Distributed load: 43% common winding	400	400	470 (per valve)	6.6	1000 (per valve)	0.6	0.7	0.8	1.0
	Pentode connection ..	330	330	130 (common)	3.4	470 (common)	1.5	2.0	2.5	4.0
							at 5W	10W		15W
Mullard EL84	Triode connection ..	300	*	150 (common)	10	*	1.0	—		—
	Distributed load: 20% common winding	300	300	270 (per valve)	6.6	—	0.8	1.0		1.5†
	43% common winding..	300	300	270 (per valve)	8.0	—	0.7	0.9		—
	Pentode connection ..	300	300	270 (per valve)	8.0	—	1.5	2.0		2.0

*Screen grid strapped to anode. †See text.

put quoted are those delivered to the load in the secondary circuit.

With valves of the 12-watt dissipation class, such as the EL84, comparison with normal pentode operation is more significant. Appreciable reduction in odd harmonic distortion is again obtained under distributed load conditions and approximately 15 watts is delivered by the valves with a common winding ratio of 0.2.

From the figures in Table 1, little advantage would appear to be gained by further approaching triode conditions. There are, however, at least two advantages in using a tap at about 40% of primary turns, particularly with the EL34 where a high power output is still available. In the first place almost identical performance is obtained under cathode- and fixed-bias conditions, since with the closer approach to Class A triode working, variations in anode and screen-grid currents are reduced when the stage is driven. Secondly, as with normal triode operation, power output and distortion are less dependent on the precise value of load impedance. With a primary tap at about 40% of turns little change in performance is produced by a change in anode-to-anode load impedance of 6,000 to 9,000Ω. In addition the output impedance of the stage is still further reduced by the use of the larger common winding ratio.

Circuit Arrangements.—The penultimate stage of the amplifier must be capable of providing a well-balanced push-pull drive of adequate amplitude and low distortion content. With 25-watt pentodes such as the EL34 the maximum drive voltage required is approximately 2×25 volts r.m.s., whilst for valves of the EL84 type the corresponding input is about 2×10 volts r.m.s. Input voltage requirements are similar for triode, pentode or distributed-load operation.

Bearing in mind the need to ensure stability when feedback is applied over the whole amplifier, the circuit should contain the minimum number of stages, in order to reduce phase shifts to the minimum. Thus if the functions of phase splitting and amplification can be combined in the penultimate stage, so much the better. This can be conveniently achieved by using the cathode-coupled form of phase splitter[5]. A high degree of balance is possible with this circuit, combined with a low distortion level at maximum drive to the output stage. By using a high-impedance double triode, an effective stage gain of about 25 times can be simultaneously obtained. This, combined with a preceding high-gain stage, enables a high overall sensitivity to be obtained, even when a high degree of negative feedback is used. A high sensitivity in the main amplifier enables the output voltage requirements of pre-amplifier and tone control circuits to be reduced; low distortion in these circuits is then more easily obtained.

It should be remembered in this connection that circuits preceding the main amplifier must be capable of handling, without appreciable distortion, voltages much greater than are necessary to load the amplifier fully.

With the use of such a valve as the Mullard EF86, which is particularly suitable for use in a high-sensitivity input stage, due to its low hum and noise levels, it is found that when feedback is applied input sensitivities of 50 to 100 mV for rated output can be achieved whilst at the same time hum and noise levels are low enough for high-quality requirements.

Negative Feedback.—In an amplifier employing single-loop feedback from output to input, instability will occur if the loop gain—the product of amplifier gain without feedback and the attenuation of the feedback network—exceeds unity at frequencies for which the total phase shift round the loop becomes either 0 or 360° and so renders the feedback signal in phase with the input. The conditions for negative feedback imply a phase change of 180°, so that instability is approached as the additional phase shift in the amplifier and feedback network approaches 180 degrees[6].

Since phase shifts are often difficult to measure, it is normal practice to utilize for design purposes the relationship between phase shift and attenuation characteristics. A simple CR low or high pass filter produces an ultimate phase shift of 90° and a rate of attenuation which approaches 6db/octave asymptotically. Thus an ultimate phase shift of 180° corresponds to a final rate of attenuation of 12db/octave. To preserve adequate margins of stability it is usual to design for attenuation rates not exceeding 10db/octave in the region where the loop gain varies from say 10db through unity gain (0db) to −10db.

It is thus necessary to control the amplifier characteristics over a frequency range much in excess of the designed working band. As the degree of feedback increases, this control becomes more difficult and is usually limited by the leakage inductance, self-capacitance and primary inductance of the output transformer.

It is a formidable task in practice to provide a constant and high level of feedback over the whole audible frequency range in a 3- or 4-stage amplifier where the main feedback loop includes the whole circuit and the output transformer. An adequate margin of stability in such circumstances is very difficult to obtain. Thus it is more usual to find that the effective feedback decreases towards the upper and lower audible frequencies.

Adequate feedback must, however, be available:

1. At frequencies in the region of the fundamental resonance of the loudspeaker system, to provide the low output impedance needed for efficient electrical damping.

2. Up to the highest audible frequency for which harmonics lie within the audible range, a frequency which can be taken as around 10 kc/s.

Output Transformer.—The performance of a high-quality amplifier is ultimately dependent on the quality of the output transformer. The use of distributed-load conditions does not modify the essential features of a first-class component—on the contrary the output transformer may be a more critical component, since precise balance of primary windings must be maintained.

The requirements in a very high-quality design are well known and have been previously described in some detail[1]; it is not, therefore, proposed to do more than refer briefly to them. It may be said that the better the compromise effected between the requirements of high primary inductance, low leakage inductance and self-capacity, generous core size and low winding resistances, judged solely from the viewpoint of performance, the more expensive is the output transformer. This is particularly so if it is designed to handle power outputs in excess of 15 watts.

Whilst the best performance necessitates a costly component, it is possible to achieve, in amplifiers of

10-12 watts power output, a suitable compromise which results in a very high standard of amplifier performance with a transformer of moderate cost. A low value of leakage inductance is, for example, obtained more easily if the shunt inductance requirements are lessened, and appreciable negative feedback can then be used to offset the increased distortion at low frequencies due to lower primary inductance, reduced core size and less expensive core material.

Summary.—When the power handling capacity of a high-quality amplifier is not designed to exceed 10-12 watts it is possible to achieve extremely high performance with 12-watt pentodes or tetrodes. Such advantages as are possessed by 25-watt valves strapped as triodes are offset by a negligible increase in power reserve and the need for a larger and more expensive power supply.

The introduction of distributed load operation, using valves of the 25-watt class permits the design of efficient high-quality amplifiers with power-handling capacities up to 30-35 watts. Whilst it is very doubtful if such a power reserve is necessary for domestic sound reproduction—it necessitates in any case a loudspeaker system capable of handling such peak powers—amplifiers of this description find application where larger audiences are present.

It should always be remembered that the performance required of a high-quality amplifier must be judged in relation to the quality of the equipment with which it is to be used. If the use of a high-quality amplifier meriting the term is to be really justified, the pickup, pre-amplifier circuits and the loudspeaker system must themselves have a very high standard of performance.

The use of high-grade equipment in association with the power amplifier is implied in the design for the 20-watt amplifier using Mullard EL34 output pentodes under distributed load conditions, which it is hoped to describe in a subsequent article.

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[1] "Design for a High Quality Amplifier," by D. T. N. Williamson. *Wireless World*, April, 1947.

[2] "Amplifiers and Superlatives," by D. T. N. Williamson and P. J. Walker. *Wireless World*, Sept., 1952.

[3] "Inexpensive 10-watt amplifier," *Wireless World*, August, 1954.

[4] "A High-quality Ten Watt Audio Amplifier," by D. H. W. Busby and W. A. Ferguson. *Mullard Technical Communications*. Vol. 1, No. 9. Nov., 1954.

[5] "Push-pull Input Circuits, Part 5," by W. T. Cocking. *Wireless World*, May, 1948.

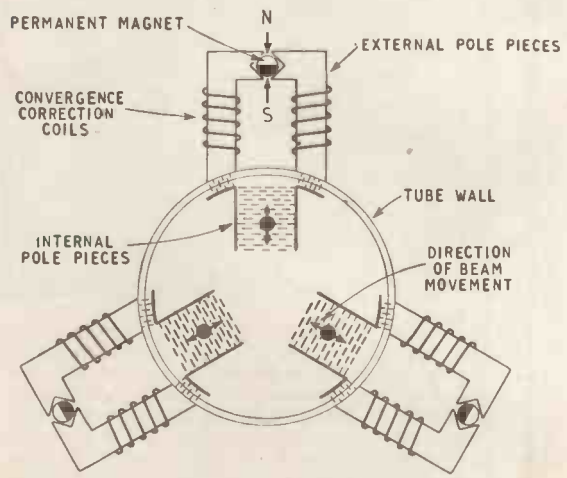
[6] "When Negative Feedback Isn't Negative," by "Cathode Ray." *Wireless World*, May, 1949.

21-in COLOUR TUBE

AN interesting feature of the new large-size tri-colour c.r. tube produced by R.C.A. is the use of a magnetic beam-convergence system with pole-pieces actually built inside the tube. The purpose of the beam-convergence system, which was electrostatic in the earlier 15-inch tube,* is to direct all three electron beams on to the particular group of three phosphor dots on the screen which is being scanned at any moment, so that one beam falls on the red phosphor dot, another on the green dot and the third on the blue dot. The convergence is helped in the first place by mechanical tilting of the electron guns. Each beam is then adjusted individually (see diagram) by the flux from an external permanent magnet, which is coupled through a pair of external ferrite pole-pieces to the pole-pieces inside the tube. The magnet is cylindrical in form and polarized as shown, so that by rotating it in the gap between the pole-pieces the component of its field which is coupled through to the internal system can be made to vary—and hence the convergence of the beam.

Coils are wound on the external ferrite pole-pieces, and these produce an additional magnetic flux which varies with the scanning angle in such a way as to maintain the correct beam convergence at all points across the screen. This is necessary because of the particular geometry of the tube, as explained in the description of the 15-inch version. The varying current to energize the coils is actually derived from the output circuits of the line and frame scanning generators. An additional facility

* "Colour Television Tube," *Wireless World*, May 1954.



Schematic of beam-convergence system, showing how the external magnets are linked to the internal pole-pieces through the glass wall of the tube.

Tri-colour cathode-ray tube, type 21AXP22.

is a magnetic deflection system, again utilizing internal pole-pieces, which permits one of the electron beams to be adjusted laterally (at right angles to the arrows shown).

The phosphor-dot screen in this 21-inch tube is deposited on the inner surface of the glass faceplate, instead of on a separate plate inside the envelope as in the earlier model, and the picture size obtained is $19\frac{5}{16}$in by $15\frac{1}{4}$in. In most other respects the tube is similar to the 15-inch one, except, of course, that it has a higher final anode voltage—actually 25kV.

Commercial Literature

Electronic Picture Recording for television using television methods of studio production and standard 35-mm film. Description of the technique and apparatus in an illustrated brochure from High Definition Films, 24, Old Broad Street, London, E.C.2.

Components and Accessories; a new list (No. 194) from A. F. Bulgin & Company, Bye-Pass Road, Barking, Essex.

Electronic Computing Service for solution of research and design problems in commerce and industry. The Elliott type 402 digital computor and some typical problems described and illustrated in an outsize brochure from Elliott Brothers (London), Computing Machine Division, Elstree Way, Boreham Wood, Herts.

Magnetic Tape Erasers for ¼-in tape and spools of up to 7-in diameter. The tape is not unwound but demagnetized *en bloc* on the spool. Recent models are suitable for the Grundig "Stenorette" spools. Leaflet from Harvey Electronics, Farnborough Road, Farnborough, Hants.

High-Stability Resistors (Constanta) of carbon deposited on porcelain rods. Miniature resistors are now available with 5 per cent stability in 0.05-, 0.1-, 0.25-, 0.5- and 1-watt ratings while in the 0.5 per cent category 0.05-watt rating can be supplied. Folder from G. A. Stanley Palmer, Maxwell House, Arundel Street, London, W.C.2.

Voltage Stabilizer Tubes; a guide to their application, containing sections on fundamentals, interpretation of published characteristics, design formulæ for associated components and data on Mullard types. From Mullard, Century House, Shaftesbury Avenue, London, W.C.2.

Intercommunication Equipment, for two-way operation, comprising a master unit and an extension unit which can be either permanently alive or only when required by the operator. Leaflet from Hifi, Derry Works, Derry Hill, Brierley Hill, Staffs.

Network Calculations, using a time-saving "potentiometer" method for steady-state and transient conditions, described in a monograph (price 1s) from Stockman Electronics Research Co., 543, Lexington Street, Waltham 54, Mass., U.S.A.

Electronic Instruments, for measurements of various physical effects, designed so that they can be used together in integrated groups for particular applications. Chart showing types of measurements with the corresponding groups of instruments needed from the Brüel & Kjær range. Also a short catalogue giving details of the instruments. From Rocke International, 59 Union Street, London, S.E.1.

List of Products of the Plessey organization accompanied by photographs showing production facilities in the various factories of the company. From the Plessey Company, Ilford, Essex.

Peak Voltmeter for measurement of transient voltages between 5V and 35kV to an accuracy of 10%. Instrument based on the firing voltage of a thyratron described briefly in a folder from Varley (Oliver Pell Control), Cambridge Row, Woolwich, London, S.E.18.

Phase Meters used for testing of production electrical and electronic equipment. Description of methods in a laboratory report from the Technology Instrument Corporation, Acton, Mass., U.S.A.

Electronic Moisture Meter, based on the measurement of the dielectric or propagation constant of the material to v.h.f. Leaflet from Shaw Electronics, 31 Market Street, Bradford, Yorks.

Current Metering Socket (the "Amp-Check") for wiring permanently in circuit to permit an ammeter to be inserted without switching off the current. Leaflet from Phillips & Bonson, Imperial House, Dominion Street, Moorgate, London, E.C.2.

Silicone Insulating Materials, notable for high thermal stability. A range consisting of silicone resins and elastomers in various combinations with glass fibre, mica and asbestos described in an illustrated brochure from Midland Silicones 19 Upper Brook Street, London, W.1.

Marine Radio Telephone and direction finder for small craft with 8 crystal-controlled transmission channels between 1.4 and 8Mc/s. Consumption is 30 watts receiving, 80 watts transmitting, with a choice of supply voltages. Leaflet from Intercommunications Equipment Co., 286-8 Leigh Road, Leigh-on-Sea, Essex.

A.M./F.M. Tuners and other associated equipments and components imported from Germany. Descriptive booklet with circuit diagrams from Technical Suppliers, Hudson House, 63 Goldhawk Road, London, W.12.

Tape Recorder, the "Editor Super," with frequency response of 40c/s-10kc/s at 7½in per second speed and mixing and monitoring facilities for separate radio/gramophone and microphone inputs. Features described in a leaflet from Tape Recorders (Electronics), 3 Fitzroy Street, London, W.1.

Vented Loudspeaker Cabinet based on the B.B.C. design described in *Wireless World* (Nov., Dec., 1950). Height 44in, width 28in and depth 18in, with speaker hole as required. Leaflet from Lockwood & Co., Lowlands Road, Harrow, Middlesex.

Loud Hailer, for use on board ship, with amplified talk-back facilities between the main control panel and up to five sub-stations. Descriptive leaflet from Easco Electrical (Holdings), Brixton, London, S.W.9.

Wafer Switches assembled to specification with any desired contact arrangement or wafer spacing. Price list of 82 "standard" arrangements and switch design chart from Specialist Switches, 24 Cranbourn Street, London, W.C.2.

Communications Receivers by Hallicrafters. Three new models covering 540-1680kc/s and three short-wave bands from 1680kc/s to 34Mc/s. Leaflets from the McElroy-Adams Manufacturing Group, 328 Lillie Road, London, S.W.6.

Band III Television Aerials, single- or multi-element arrays (including folded dipoles) for either separate mounting or on existing Band-I masts. Illustrated catalogue from Belcher (Radio Services), 59 Windsor Road, Slough, Bucks.

Ease of operation is the design keynote of this new valve-test table recently put into service at the G.E.C. Research Laboratories. All meters can be read from one position with a minimum of head movement while most of the controls are operated by the left hand, leaving the right one free for recording measurements. Knobs and keys for any particular test are arranged adjacent to one another and the range on which any meter is working is indicated by an illuminated disc. To reduce visual fatigue all non-essential markings have been removed from the meter scales, while the colour and brightness balance between scale, case and surround has been arranged so that the pointers stand out clearly.

V.H.F. and U.H.F. Reception

Effects of Trees and Other Obstacles

By J. A. SAXTON, D.Sc., Ph.D., M.I.E.E., and J. A. LANE, M.Sc.

Some experiments to determine the attenuation caused by screens of trees and thick woods at frequencies of 100, 540 and 1,200 Mc/s are described, and these and other data are used to estimate the attenuation over the frequency range 30-3,000 Mc/s. This work was carried out as part of the programme of the Radio Research Board. The nature of the diffraction loss and variation of field strength behind opaque obstacles of various kinds for the same frequency band is examined on the basis of the Fresnel theory of diffraction.

Official communication from the D.S.I.R. Radio Research Station, Slough

ALTHOUGH there now exists a considerable body of literature on various characteristics of the propagation of metre and decimetre wavelengths—wavelengths of interest, for example, in television broadcasting—there is one aspect of the overall problem which has been quite inadequately treated, namely the effects of trees and other obstacles on reception at such wavelengths. It is perhaps not surprising that this should be so, for experience shows that these effects are not readily amenable to a generalized quantitative evaluation. As a consequence it is not easy to make an accurate estimation of the effects to be expected in one set of conditions on the basis of experimental observations carried out under different conditions. Nevertheless, in view of the increasing use of v.h.f. and u.h.f. for television, it is important to be able to make some assessment of the effects in so far as they may, for instance, influence the choice of a site for an aerial.

The logical conclusion of the arguments presented above is that each case of reception in circumstances where the field being sampled is influenced by local disturbances, due to trees and other obstacles, should be treated on its own merits. This, in general, is true; on the other hand, such a course may not always be really practicable, and it is clearly desirable that some attempt should be made at least to provide a guide as to the order of magnitude of the effects to be expected. It is the purpose to review the somewhat scanty experimental observations which are available, and so to try to provide such a guide.

If an opaque obstacle casts a shadow in the region of a given receiving point, the intensity of the shadow may be approximately calculated by an application of the principles of Fresnel diffraction, [1,2] and some typical cases falling within this category will be examined. A sufficiently dense and extensive wood may approach opacity for ultra high frequencies, but with less dense woods the signal transmitted through the wood may be greater than that diffracted either over or round it when the receiving point is near to the wood: a knowledge of the attenuation of metre and decimetre waves through typical woods is therefore of interest. Although the experimental information on this point is sparse, there is enough to show in a general manner the way in which the attenuation of the received signal varies with wavelength over the range concerned.

Attenuation Through Trees:—The most extensive measurements of the attenuation due to trees along a transmission path are those described by McPetrie and Ford,[1] but their published results relate only to the frequency of 3,260 Mc/s (9.2-cm wavelength). These workers did, however, supplement the centimetre-wave observations with measurements at 540 and 1,200 Mc/s, and the present authors are indebted to them for permission to quote the results for the lower frequencies. Some observations of the attenuation produced at frequencies of 250 and 500 Mc/s by a small wood extending 150 metres along the transmission path have been published by Trevor[3] and apart from this no other data appears to be recorded in the literature. Additional information relevant to the problem is that obtained some years ago by McPetrie and Saxton in measurements at a frequency of 100 Mc/s, and which has hitherto not been seen in any publication.

Attenuation at 540 and 1,200 Mc/s:—The method of procedure in the experiments carried out by McPetrie and Ford, at frequencies of 540 and 1,200 Mc/s, was to radiate a signal of known power from a suitably located transmitter and to measure the strength of the received signal at several positions behind the obstacle. In some cases it proved convenient to measure for comparison the field strength on an adjacent site for which there was an unobstructed path between the transmitter and receiver; in others it was necessary to calculate the field strength which would have existed had the trees been absent, having due regard to the ground profile between the terminal points. Observations were made using both horizontally and vertically polarized waves.

The field strengths measured at 540 Mc/s after transmission through about 85 metres of a thick, mainly deciduous, wood showed that there was hardly any significant difference between the rates of attenuation for the two types of polarization, the actual values obtained being 0.18 db/m and 0.20 db/m for horizontally and vertically polarized waves respectively. These results were obtained during the summer-time and thus refer to trees in full leaf; unfortunately no comparable observations were made for leafless trees at the same site. The rate of attenuation (db/m) naturally varies with the thickness of the wood under examination, also on the degree of undergrowth, and it cannot be expected that very close agreement will

always be obtained between observations in different places. Trevor's measurements[3] at a frequency of 500 Mc/s in the U.S.A. also show that, for a fairly continuous wood of trees in full leaf, the attenuation is independent of wave polarization and about 0.12 db/m. For the same trees leafless, Trevor gives attenuation rates of 0.1 db/m and 0.08 db/m for vertically and horizontally polarized waves respectively.

In further experiments McPetrie and Ford investigated transmission through relatively thin screens of trees. In one case the screen consisted of a double row of beech trees about 17 m high in which the trunks were some 7.5 m apart, the spacing between the two rows being a similar distance. When the trees were leafless, individual objects in the background beyond the trees could be easily identified, but only small portions of the general background could be distinguished when the trees were in full leaf. In a second example there were four rows of lime trees about 27 m high with the trunks spaced about 6 m in both directions. Here, although some details of the background could be distinguished through the screen when the trees were leafless, this background was completely obscured at full leaf.

At a frequency of 540 Mc/s the attenuation in transmission through the beech-tree screen, even in full leaf, was too small for any definite rate per metre to be estimated; although variations of field strength over a range of 15 to 20 db were observed as the receiver was moved about in the clear ground behind the trees. The measurements through the rather more extensive lime-tree screen were also made when the trees were in full leaf, observations being made for both vertically and horizontally polarized waves at frequencies of 540 and 1,200 Mc/s. At 540 Mc/s the rate of attenuation of vertically polarized waves was found to be a little greater than for horizontally polarized waves, especially for receiving points immediately behind the trees: at 1,200 Mc/s, however, no definite difference between the rates of attenuation for the two states of polarization could be established. The average rates of attenuation through trees estimated from these measurements are as follows: at 540 Mc/s, 0.15 db/m and 0.25 db/m for horizontally and vertically polarized waves respectively: at 1,200 Mc/s, 0.35 db/m irrespective of the state of polarization. That the signals observed in the circumstances described above must have been mainly due to radiation transmitted through the trees, and could hardly have been influenced by diffraction over the top of the screen, may be shown by an application of the theory discussed later.

Attenuation at 100 Mc/s:—Just prior to the 1939-45 war a number of observations of the effects of trees on reception at a frequency of 100 Mc/s were made by McPetrie and Saxton. A variety of sites were examined, and the following examples are illustrative of the results obtained.

Measurements of field strength were made in the neighbourhood of a small clump of trees—roughly circular in shape, about 30 m in diameter, and not densely planted—first along a line passing through the centre of the clump and the transmitter, both at points in front of and behind the trees; and secondly along a line perpendicular to the first line and behind the trees. The results showed that such a short section of wooded path introduced no significant additional attenuation of the ground wave. The variations in field strength along the transverse line behind the trees, however, were considerable and covered a range of 20 db. These variations, which were more pronounced for vertically than for horizontally polarized waves, were presumably due to multipath transmission caused by diffraction.

In another series of observations at 100 Mc/s measurements were made of the field strength of signals after transmission through several hundred metres of a thick wood, mainly deciduous in character, and in full leaf, with some undergrowth. These measurements indicated attenuations of 0.06 and 0.03 db/m respectively for vertically and horizontally polarized waves. The attenuation due to trees is thus seen to be considerably less at 100 Mc/s than at 540 and 1,200 Mc/s, whilst the relative difference between the values for the two type of polarization is more pronounced at the lowest than at the two higher frequencies.

The spatial variations in the signal obtained as the receiving aerial was moved over a distance of a few wavelengths amongst trees were, in almost every case, less for horizontally than for vertically polarized waves. The maximum difference was observed in the case of transmission through a pine wood, with no undergrowth, where there was much more vertical than horizontal growth: the field variations here were predominantly of the order of ± 2 db for horizontal polarization and ± 10 db for vertical polarization. This represented an extreme case, however, and an analysis of the whole series of observations at 100 Mc/s shows that, for horizontally polarized fields, about 80 per cent of the receiving locations had a range of variation of less than 6 db; in the case of vertical polarization the same range of variation was found at 60 per cent of the locations. The majority of the observations were made with some trees of various kinds within a range of 5 to 100 m, and, whilst the above figures can only be regarded as approximate, it is interesting to note that they are similar to those quoted by Saxton and Harden[4] in an account of a recent field strength survey at 100 Mc/s, in which, however, trees were not always the only obstacles involved at a given receiving site.

Attenuation Through Trees as a Function of Frequency:—Although the conditions of experiment for all of the cases so far considered were by no means identical, it is obvious that the rate of attenuation through a given wood or screen of trees increases with frequency, and this general feature is illustrated in Fig. 1. Of the values of attenuation discussed above only those appropriate to trees in full leaf have been plotted, there being insufficient data to draw distinctive curves for the leafless state. It might, in any case,

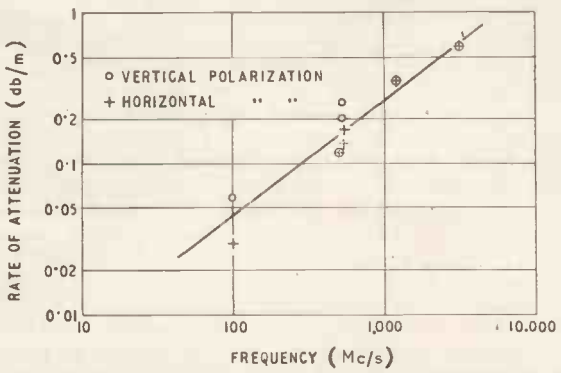


Fig. 1. Rate of attenuation in woods with trees in leaf as a function of frequency.

be argued that from the practical point of view, it is mainly important to know the worst conditions likely to arise, and these definitely correspond to trees in full leaf. (The point for 3,260 Mc/s plotted in Fig. 1 is obtained from the published work of McPetrie and Ford[1] referred to earlier.) It is also indicated in Fig. 1 how, as the frequency decreases through the u.h.f. and v.h.f. bands, there is a tendency for the attenuation to be less for horizontally than for vertically polarized waves. It must be stressed that Fig. 1 can only be used as a guide to the order of magnitude of the attenuation likely to be caused by woods, the actual value in any given case must depend on the density of the trees, and to some extent on their character, whether deciduous or otherwise.

Attenuation Produced by Other Obstacles:—In addition to trees the most important of the other obstacles affecting field strength characteristics at a given receiving location, apart from hills, are buildings. There are even fewer published measurements of the attenuation caused by buildings than there are for that due to trees; the only measurements known to the authors, in fact, being those of McPetrie and Ford[1] for 3,260 Mc/s. These experiments showed that the attenuation produced by a typical brick wall (of thickness 23 cm) is of the order of 10 db when dry, and may be considerably more when wet right through. This result indicates values for the permittivity and conductivity of such walls from which it may be deduced that attenuations of the order of 5 db are probable at 30 Mc/s in similar circumstances. To all intents and purposes, therefore, any substantial building—containing several walls—in a transmission path may be regarded as opaque to v.h.f. and u.h.f. radiation. Such a building will thus throw a shadow, inside which the field strength is mainly determined by diffraction round the sides and over the top.

Evidence has been provided by Megaw[2] as well as by McPetrie and Ford[1] that a useful estimate may be made of the field strength behind opaque obstacles by an application of the principles of Fresnel's diffraction theory. This method of approach should be satisfactory in the v.h.f. and u.h.f. bands, not only for the shadows produced by well-defined hills or ridges, but also for the rather more local shadows cast by buildings or by dense woods. Indeed, McPetrie and Ford have shown that the field strength distribution behind a single tree at 3,260 Mc/s is quite well accounted for by the Fresnel theory; whilst according to Megaw, to some extent the same is true for the case of diffraction by a steel mast at 600 Mc/s.

It is hardly feasible here to consider the diffraction fields behind obstacles of a wide variety of shapes, but in the following chapters calculations are made for what are probably the two most important forms of obstacle occurring in practice.

Diffraction by Opaque Obstacles:—The two classes of diffraction phenomena to be examined are (1) diffraction over an opaque obstacle of considerable extent transverse to the path of propagation (e.g., a thick screen of trees or a continuous row of buildings), and (2) diffraction round a tall opaque obstacle (e.g., a single tall building). These two classes correspond to the optical cases of diffraction by straight edges and opaque strips respectively, as treated by Fresnel. The optical theory refers to ideally sharp edges and very thin strips, and the obstacles with which this paper is concerned do not really conform to these conditions: there is, however, little doubt, in view of the fact that the distance of the source is generally very great compared with the thickness of the obstacles, that the predictions of the simple theory are reasonably accurate.

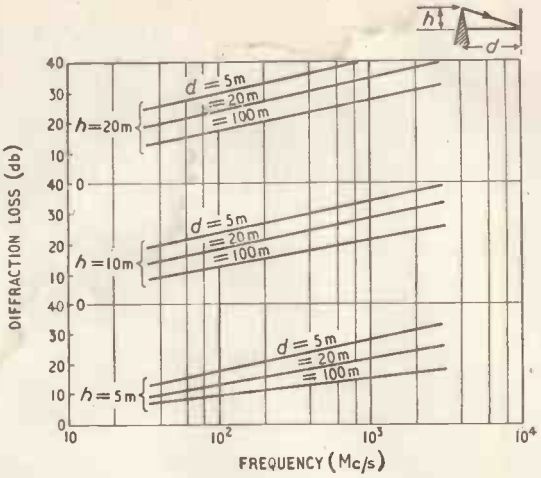


Fig. 2. Diffraction loss at a straight edge. (Fresnel theory)

Diffraction at a Straight Edge:—Typical examples of the diffraction loss at a straight edge are given in Fig. 2 for frequencies in the range 30 to 3,000 Mc/s. The distance of the transmitter from the obstacle is assumed to be large compared with *d*, the distance from the obstacle to the receiving point. The loss has been calculated for locations of the receiving aerial 5, 10 and 20 m below the line from the transmitter passing through the top of the obstacle, and is relative to the field which would have existed at the diffracting edge had the obstacle not been there. In the curves of Fig. 2 only the contribution of the direct wave from the edge of the obstacle has been considered; and in a more rigorous treatment it would be necessary to include the effect of the wave arriving at the receiver after reflection at the ground between the diffracting edge and the receiving aerial, but the neglect of this component is probably not serious for many of the cases of greatest practical interest. For example, in a typical broadcast receiving installation in the v.h.f. and u.h.f. bands the height of the aerial above ground may be expected to be about 10 m, and under these conditions, for the deep-shadow region relatively close to the diffracting obstacle, it may be shown that the angle at which the ground-reflected component is diffracted is such that the amplitude of this component is much smaller than that of the direct wave.

A further point to be borne in mind is that the loss given in Fig. 2 is relative to the undisturbed field at the height of the diffracting edge, and since, for the practical case of a distant transmitter, this field will generally be greater than that which would have existed at the receiving point had the obstacle not been present (approximately in the ratio of the heights of the obstacle and the receiving aerial) the "true" diffraction loss will be somewhat less than indicated in Fig. 2. This correction to the curves may readily be estimated from a knowledge of the heights of the obstacle and receiver. For most practical cases, however, the curves of Fig. 2 will give a direct indication of the changes in field strength to be expected for various displacements of the aerial within the shadow region; and they also give a reasonably accurate picture of the variation of diffraction effects with frequency.

The relative gain produced by increasing the height

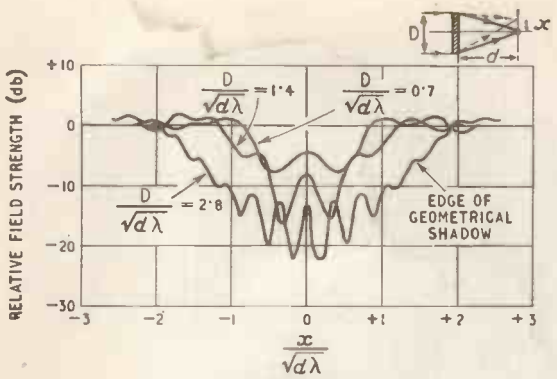


Fig. 3. Diffraction pattern behind opaque obstacles.

of an aerial situated within the shadow as compared with increasing the distance of the aerial from the diffracting edge is evident from Fig. 2. For example, at 500 Mc/s, the improvement in received signal on moving back from $d=20$ m to $d=100$ m behind an obstacle of effective height (h) of 10 m is about 6 db, whereas the same improvement could be obtained by raising the aerial by 5 m at the distance of 20 m. Provided the diffraction loss is appreciable—at least 12 db, say—the following equation may be used to calculate the loss for conditions not covered by Fig. 2:

$$E_o/E_d = 0.36\, h\, (f/d)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where E_o is the undisturbed field at the diffracting edge, E_d is the diffracted field at a point d metres behind and h metres below the edge, and f is the frequency in Mc/s.

Diffraction by an Opaque Strip:—Typical diffraction patterns behind an opaque strip are illustrated in Fig. 3, where the variation of field strength along a line perpendicular to that from the transmitter through the centre of the obstacle is shown for various distances d metres behind the obstacle of width D metres.

The individual curves all exhibit a local maximum at a receiving point located in the symmetrical position behind the obstacle (i.e., at $x=0$, x being the displacement from the symmetrical position), a result well known in optical theory and practice. The actual signal loss, however, relative to the field which would have existed in the absence of the obstacle, and the form of the diffraction pattern both show considerable variation with wavelength for a given d. In the case of a vertical opaque strip no correction is needed to allow for the presence of the earth since, to a very close approximation, the diffraction losses associated with the direct and ground reflected waves behind the obstacle are the same. Thus, at a distance of 10 m behind an obstacle of width 10 m the diffraction pattern at 240 Mc/s is that given in Fig. 3 by the curve for which $D/\sqrt{d\lambda}=2.8$, whilst that appropriate to the frequency 60Mc/s is the curve for $D/\sqrt{d\lambda}=1.4$. The magnitude of the diffraction loss, expressed in decibels, at the two minima on either side of the axis is approximately twice that at the symmetrical position on the axis. In general, provided the diffraction loss is appreciable (as in the case of edge diffraction) its value on the axis may be calculated from the relation:

$$E_o/E_d = 0.092\, D\, (f/d)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

E_o being the undisturbed field at the receiving point in the absence of the obstacle (the distance of the transmitter from the obstacle being assumed to be much greater than d), E_d the field at the receiving point and f the frequency in Mc/s.

In the reception of v.h.f. and u.h.f. radiation in built-up areas, for obstacles much wider than, say, 20 m, the diffracted field over the top is likely in general to be greater than that diffracted round the sides of the obstacle. It should also be pointed out that, when the diffraction loss in a given case is very large, as indicated by equations (1) and (2), it is probable that the effect of the shadow will be alleviated as a result of energy scattered to the receiving point from other obstacles in the locality, but it is difficult to make a quantitative assessment of the importance of this factor.

Conclusions:—Whilst the attenuation caused by a few trees in a transmission path at v.h.f. and u.h.f. may not be serious, significant attenuation can be caused by thick and extensive woods. For a continuous wood the attenuation is of the order of 0.02 db/m at 30 Mc/s, whilst the corresponding figure at 3,000 Mc/s is about 0.5 db/m; and there is evidence that for frequencies less than 1,000 Mc/s the attenuation rate is slightly greater for vertically polarized than for horizontally polarized waves. On the other hand a small number of trees, or even a single tree, can cause considerable spatial variations of field strength at points within the shadow region, and when siting a receiving aerial for v.h.f. or u.h.f. transmissions this fact should be borne in mind. The same is true if the receiving aerial has of necessity to be placed behind a building, since for all practical purposes most buildings of any size may be regarded as opaque in these bands.

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A NUMBER of scholarships, founded in memory of eminent electrical engineers to provide for the education and training of students, are awarded each year by the Institution of Electrical Engineers. This year a new scholarship (the Arthur Fleming) is available for a student wishing to follow "a works-based sandwich diploma course in electrical engineering." It is valued at £120 p.a. and is tenable for four years. Details of this and the other scholarships available this year are given in "Scholarship Regulations" obtainable from the I.E.E., Savoy Place, London, W.C.2.

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"Needles for Talking Machines"

Present Trends Reviewed Against the Background of Early Invention

By S. KELLY*

DURING the fifty or sixty years which we have been blessed (?) with the gramophone, the ubiquitous needle has probably resulted in more inventive effort and original thinking than that applied to all the rest of the bits and pieces which comprise the reproducing system. During this period the needle, or stylus as we now prefer to name it, has gone the full circle. Sapphire or diamond in 1900, steel needles from about 1910 to 1935 when sapphire again made a tentative appearance; but it was not until after the war, and particularly with the advent of microgroove records that the sapphire and more recently the diamond have achieved the overwhelming popularity which they enjoyed at the turn of the century.

The original commercial stylus was that used on the Edison phonograph and was the theoretically correct shape, namely spherical. Fig. 1(a) shows a photograph of one of these early styli. Compared with present-day dimensions of 0.001in radius, they were enormous, actually 0.025in dia. Fig. 1(b) shows for comparison a "miniature" (0.030in diameter) shank with 0.001in radius sapphire. Fig. 1(c) is a mounted spherical sapphire for an early type of disc machine. The original Edison sapphires were used on "hill and dale" records and apparently, within the then prevailing limitations of the art, gave satisfactory results. According to the inventor, sapphire was necessary because it was the only material which would take the high polish required to mitigate damage to the soft wax cylinder.

At this stage it is interesting to note that the styli were made by the late Principal Alderman Fred Lee of Coventry, and during the period 1900-1910 he supplied approximately 4,000 styli per week to the U.S.A. He can rightly be named the father of the stylus industry. About 1910 the disc finally ousted the cylinder for domestic reproducers and it was from this date that the steel needle became firmly established for the next thirty odd years.

Nowadays we automatically assume that the ancients of the pre-electrical recording era were virtually savages compared with the now civilized exponents of the art of sound reproduction. An examination of the early literature reveals that if precise technical knowledge of the finer points of electromechanical analogues were missing, it was more than made up for

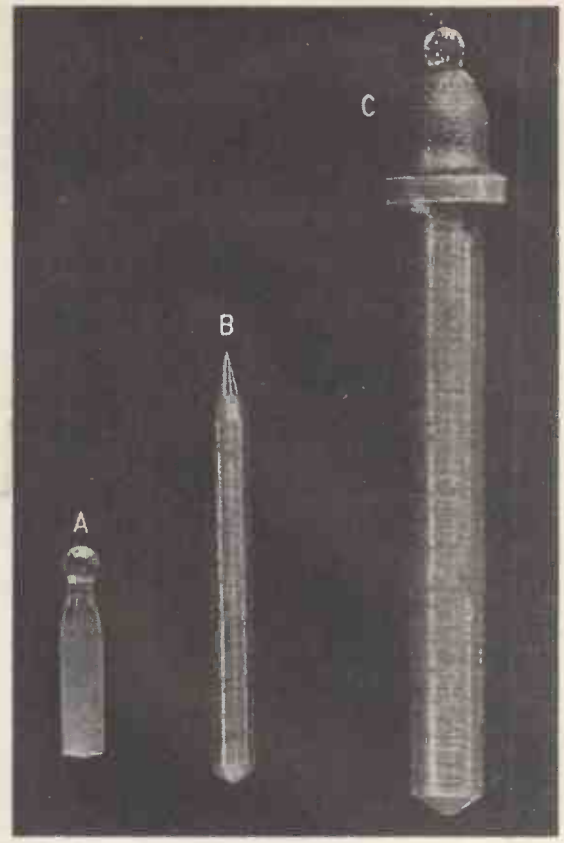


Fig. 1. (A) Edison sapphire stylus with spherical head compared with a modern microgroove stylus (B). An early spherical-tipped stylus for a disc machine is shown at (C).

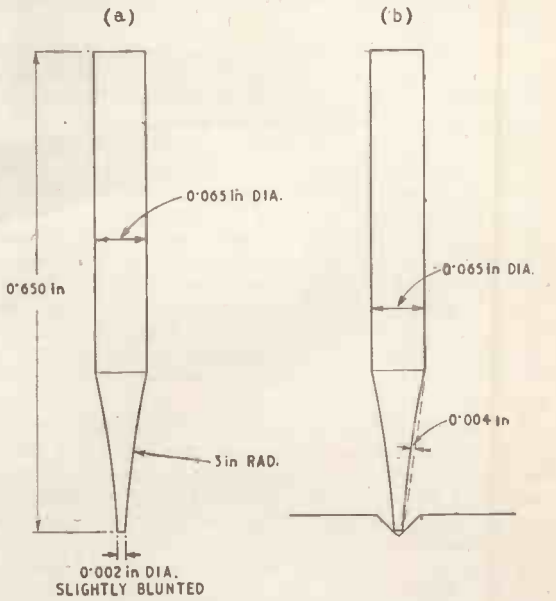


Fig. 2. Two steel needles (circa 1907) designed (a) to trace the bottom of the groove and (b) to make contact only with the walls.

* Kelly Acoustics, Ltd.

by careful experiment and acute perspicacity. Record and needle wear were already serious problems, and in 1907 it was found "that owing to the extreme nicety with which the delicately defined groove of the record must be followed by the needle of the reproducing mechanism, in order that the finest recorded vibrations may be accurately reproduced, great difficulty has been heretofore experienced. This is due to the minute but practically serious wear of the needle and groove which results from their frictional contact throughout the long and devious course of the record groove, and to the modification of the original sounds which ordinarily result from a scratchy action of the needle in following the sinuous patch to which it is confined. The material preferably employed is high grade steel wire" (as shown in Fig. 2(a)).

"The improved effect of this novel shape of record-needle tip is very marked, both in the securing of more accurate reproductions of the exact original sounds free from the unpleasing tones commonly introduced in the reproduction; and in the avoidance of wearing action upon the record whereby its usefulness is ordinarily soon destroyed or impaired. The point so rests in the *bottom of the groove* as to greatly reduce friction and "scratch" while at the same time accurately following the delicate deflections of the groove; and the relative diameters and lengths of the so-called "concaved" tip and round body, as indicated by the dimensions of the drawing give sufficient rigidity to the needle to prevent alteration of the tones because of undue yielding in the needle structure."

This solution of the problem was by no means the only one and another inventor about the same time had other ideas for the optimum dimensions of a needle for talking machines. He claimed:—

"My experiments indicate that the body of the needle should be 0.065in in diameter; the diameter of the point-face 0.002in; the maximum concavity of the curve forming the tapered point should be 0.004in; the length of the point 0.235in; the length of the cylindrical body 0.451in, and the total length 0.685in. (See Fig. 2(b).)

"It is believed the reason for the increased efficiency of the improved needle is largely due to the form of the point and the position it occupies in the groove. Its concavity insures *contact on the sides of the groove at two points only*, and the flat face at the termination of the point lies always above and out of contact with the bottom of the groove, thus the area of contact is extremely limited resulting in greatly lessening the objectionable 'scratch' ordinarily very noticeable. The form of the point permits it to penetrate to sufficient depth in the groove to insure perfect engagement therewith, and the attenuation of the point permits the latter to follow accurately slight sinuosities in the lateral bends or convolutions of the groove, by which the sound vibrations are reproduced, thus avoiding 'slurring'.

"Whether the above theoretical reasoning be correct or not, the fact remains that a needle formed as shown and described produces results far in advance of those produced by any other needle known to me. The improvement is especially marked in the reproduction of instrumental music and the tones of the singing or speaking voice. The clearness of detail, accentuation and the tone qualities of the human voice are distinguishable to the faintest inflection and intonation. In band music the broad tones of the bass horns are reproduced with softness and true tonal value, preserving all the effect of their great sound volumes. On the middle register and high notes there is a clearness of tone and distinctness of sound identical with actual playing.

"The improved needle by reason of its form and peculiar engagement with the groove, wears but little and apparently reproduces the last notes of the record as clearly and distinctly as the first, and also acts less destructively on the record, thus prolonging its term of usefulness."

How long during the playing of a record this ideal was maintained is a matter for conjecture. Both gentlemen used approximately the same material and almost the same dimensions, but it would appear that the latter experimenter's explanation is more nearly in accord with our present-day ideas on the correct functioning of the stylus and the record groove.

Needle Replacement

The trouble of having to change needles after every record soon became apparent.

"The mechanism (shown in Fig. 3) relates to machines of the character known as 'talking machines,' more particularly those employing disc recordings, and the object is to provide a multiple needle holder which may be mounted upon a suitable supporting arm whereby attachment may be made to the recording or reproducing element of the talking machine.

"The multiple structure is rotatable and operates in such a way as to permit the needles carried thereby to be used consecutively and afterward removed at one time and others set in their places, and it may be made of any suitable material, preferably metal."

One imagines that the mass of moving parts was not of paramount importance!

Until the advent of electrical recording, with almost limitless amplification of energy, numerous attempts were made at improving the transmission of energy from the record to the sound box, and 1909 saw the production of collar type loud-tone needles. Although it functioned somewhat differently from later types, it "consisted of a round rod carrying at a short distance from its lower extremity, which is cut to a point, a metallic collar of which the upper surface is destined to lean against the head of the needle carrier which is bound to the diaphragm of the sound-box of the machine. This arrangement considerably augments the surface of contact of the needle with the carrier and in consequence the amplitude of the sound waves

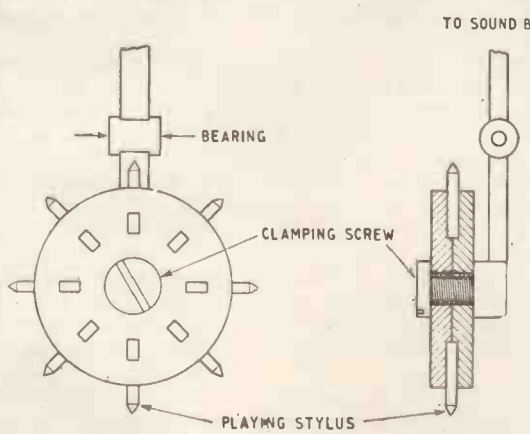
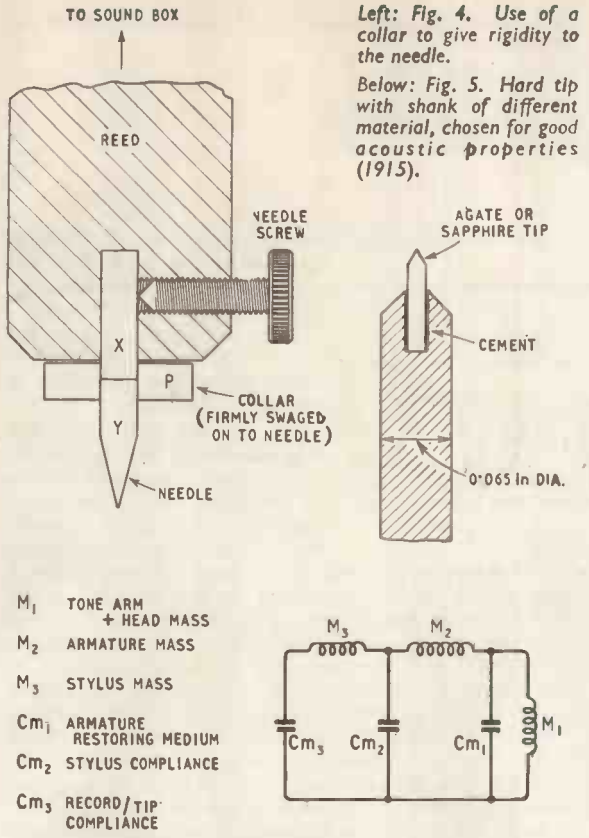


Fig. 3. Rotatable magazine for rapid stylus replacement.



Left: Fig. 4. Use of a collar to give rigidity to the needle.

Below: Fig. 5. Hard tip with shank of different material, chosen for good acoustic properties (1915).

Fig. 6. Electrical analogue of the mechanical parameters of a pickup.

engendered by the movement of the disc or cylinder. The diagram (Fig. 4) shows the general arrangement and provision is made for a sapphire or like point to be constructed on the same principle. A shank X is inserted in the round metallic piece P and on the opposite side is inserted a sapphire (or other suitable precious stone) Y of which the point is slightly blunted or rounded.

"Numerous experiences have proved that in order to arrive at an improvement and an augmentation of the force of the sounds emitted by the machine, the thickness of the round metallic piece P must have a certain relation with the diameter of the shank A, that is to say the said thickness must be equal or very nearly equal to the diameter of the shank. The lower surface must further be fixed to the shank at the beginning of the reduced part."

Needle scratch was an ever-present problem, and by 1915 the whole of the animal, vegetable and mineral kingdoms had been explored in order to produce a needle or stylus for talking machines in which "the sound produced would be improved and purified, and also be capable of operating upon sound records formed of relatively hard materials without wearing away or otherwise deteriorating such records.

"With these ends in view a stylus was produced for talking machines having a body of relatively hard, slightly elastic, insulating material, a cylindrical recess in one end of the body, and an agate point cemented in the socket, said agate having a smooth conical or rounded end projecting from the body. (See Fig. 5.)

"One of the many advantages is that no shrill tones are produced, the always present scratch is minimized, and a very mellow rendering of the sound is obtained as the improved stylus softens the sound and gives a full and natural tone. A needle may be used about four hundred times without requiring substitution. Furthermore, it reduces the wear on the record and also tends to eliminate imperfections in the record."

It can be said that generally design of steel needles more or less stagnated after this period. Improved materials in the special chrome steels, and later tungsten wire in a copper sheath were produced but all metallic needles suffered from the defect of a rapid and untimely end, usually about four grooves from the inside of the record when a final crescendo had roused one's emotions almost to a frenzy only to be shattered by the raucous sounds which were suddenly emitted; then a lively dash to the talking machine to disengage the offending sound box and needle before one's precious records were irretrievably ruined!

It is often said that nothing is new, and skipping many years we come to 1948 when a new stylus was announced for sound reproduction, "more particularly a sapphire styli (*sic*) for reproducing sound on all records. The object was to produce a form of stylus which gives high quality reproduction with minimum wear, and consequently long life to the record."

The sapphire stylus consisted of "a tapered conical portion flat ground on the point of a diameter of from 0.001 to 0.005 inches so that the point enters a standard record sound groove and only makes substantially point contact with the inclined side walls of the sound groove."

One of the important advantages of the disc-type record over the cylinder was the much higher modulation which could be engraved upon it. With few pre-war (1939-1945) exceptions, all reproducing heads, whether acoustic or electric, suffered from a very high inherent stiffness with the result that the playing weight had to be relatively enormous, 4oz being common. Under these circumstances the force exerted at the point of contact between the stylus and the record was such as to tend to shatter any sapphire stylus, or at the best to reduce the life of the stylus to only a relatively short time, and out of all proportion to its cost, with the attendant risk that if the stylus did chip records could be ruined.

During the 1930's the needle armature, with its attendant reduction in mass and hence extended high-frequency response, made its appearance. At a somewhat later date miniature steel needles with a still lower mass, and miniature thorn needles made their debut.

Record Wear

Up to this time the only stylus available with these medium and heavyweight pickups which offered some degree of protection to the record was the thorn type, and this protection was more apparent than real unless the records were kept meticulously clean and no pieces of abrasive material became embedded in the thorn during the sharpening process. By virtue of the very compliant nature of the material (about twenty times that of steel) the forces existing between the record and the stylus are considerably reduced, and it is to this fact that we owe the continued existence of many precious old records which would have been irretrievably ruined had they been reproduced by the blunt

steel instrument now mercifully relegated to the museum.

With the concept of high-compliance, low-mass pickups a sapphire stylus of small radius became feasible. A comparison of the heavyweight pickup using a steel needle stylus and a modern lightweight unit may not be inappropriate. Fig. 6 shows the basic analogue for the two pickups. Their constants are tabulated below, together with the approximate forces involved for standard 78 r.p.m. records.

Stylus	M_1	M_2	M_3	Cm_1	Cm_2	Cm_3	Playing Weight
							(grams)
Loud tone..	112	0.600	0.235	10^{-7}	1.35×10^{-9}	10^{-9}	112
Soft tone ..	112	0.600	0.060	10^{-7}	8.5×10^{-7}	5×10^{-9}	85
Cantilever..	30	0.020	0.013	2×10^{-6}	2×10^{-7}	1.5×10^{-8}	8

M_1, M_2, M_3 in grams; Cm_1, Cm_2, Cm_3 in cm/dyne. All values refer to needle tip.

From the table it will be seen why the soft tone needle did in fact give a "softer tone" than the loud-tone "blunderbuss," namely that the shunt effect of Cm_2 was very much greater.

During the 1930s serious investigations were undertaken, notably by Pierce and Hunt, into the various forms of distortion which were inherent in disc recording and reproducing systems, these various distortions being due solely to the physical dimensions of the stylus and record, and assuming the rest of the system to be linear. It was shown that one of the most serious forms of distortion was due to pinch-effect at high frequencies resulting in harmonic and intermodulation distortion, and they suggested that a method to overcome this would be the use of a stylus which would not only transmit lateral vibrations to the transducer but also decouple effectively the vertical vibrations. This was the genesis of the cantilever stylus.

The cantilever stylus can be made with an effective mass at 10 kc/s as low as 3 milligrams, although the more usual type (see Fig. 7) used in commercial units had a mass of approximately 13 milligrams, made up as follows:—

Sapphire	1.00
Bush	0.75
Arm (effective)	6.00
Head	5.50
	13.25

An effective stylus mass of approximately 13 mgm appears to be somewhat excessive in view of present-day recordings using high velocities at the upper end of the frequency band, and some effort should be expended in reducing this mass.

It will be seen from the dimensions of Fig 7 that the stylus uses a rondel of 0.020in in diameter. If the rondel is reduced to 0.015in in diameter the stylus weight is halved, and if the bush is eliminated a total 1.25 mg is saved. This saving of 1.25 mg would be thrown away if the stylus arm of Fig. 8 were used, because the 0.035in diameter blank removed from the end weighs approximately 1.55 mgm. Fig. 8 shows a method of exploiting this reduction in mass. An undersized punch is used to pierce the hole for the stylus and the "rag" thus thrown up is used in place of the bush as the rondel support. No material is blanked out from the hole, all of it being used to form the approximately cylindrical projection used for supporting the stylus. The "rag" on the underside is tightly swaged round the stylus and sometimes a cement such as shellac or one of the artificial resins is used as an additional safeguard. The arm shown in Fig. 8 is completely satisfactory and gives an effective mass as shown above:—

Sapphire	0.50
Arm (effective)	6.00
Head	3.00
Total	9.50 milligrams

showing a saving of 4 mgm over Fig. 7. A simplification in tooling would be to increase the width of the arm to 0.035in and reduce the thickness to 0.009in. The effective mass of the stylus arm will be the same, the lateral compliance will be reduced by 50% and the vertical compliance will be approximately

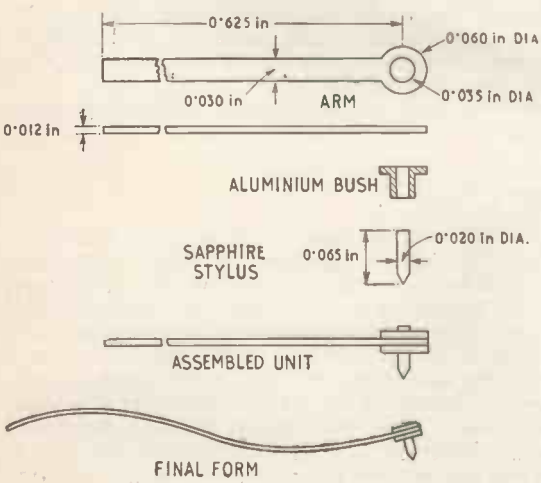
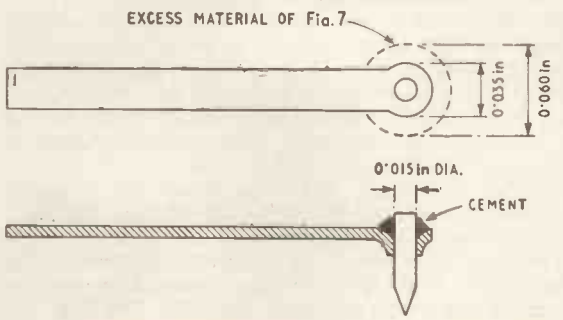


Fig. 7. Construction of a typical cantilever stylus.

Fig. 8. Alternative construction without aluminium bush.



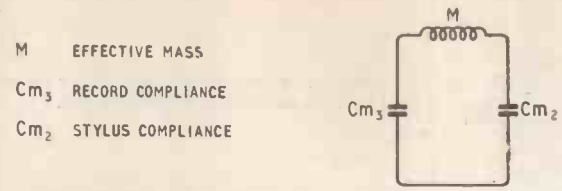


Fig. 9. Electrical analogue of cantilever stylus. Typical values of Cm_3 are 2.5×10^{-8} for plastic microgroove records and 1.1×10^{-8} for standard shellac.

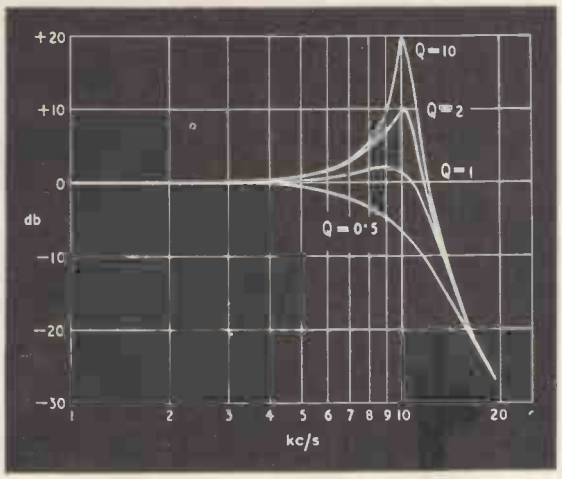


Fig. 10. Effect of load resistance on the response of the low-pass analogue of Fig. 9.

doubled; this can result in an improved high-frequency transmission characteristic, because of the 20% increase in resonant frequency.

The ultimate will probably be a rondel of 0.007in to 0.010in in diameter, 0.020in long in a pure beryllium arm.

The analogue of Fig. 9 shows the cantilever behaving virtually as a low-pass filter, while the effective mass M is given by $\frac{dLWT}{3}$ and the compliance Cm_2 by $\frac{4L^3}{EWT^3}$, where: L=length, W=width, T=thickness, d=density, E=Young's modulus.

From these equations it is seen that for maximum high-frequency transmission the Young's modulus should be at a maximum and the density a minimum. The table below shows Young's modulus (E), density (d), and a goodness factor $G=\frac{E}{d}K$, where K is any convenient constant, in this case 10^{-11}.

Substance	Young's Modulus	Density	G
Beryllium copper ..	12.5×10^{11}	8.2	1.53
Phosphor bronze ..	12.0×10^{11}	8.8	1.36
Steel C.08	19.0×10^{11}	7.7	2.46
Steel C.38	20.0×10^{11}	7.7	2.60
Monel	18.0×10^{11}	8.8	2.05
Aluminium	7.3×10^{11}	2.7	2.70
Beryllium	12.7×10^{11}	1.8	7.05

From the above figures it will be seen that pure

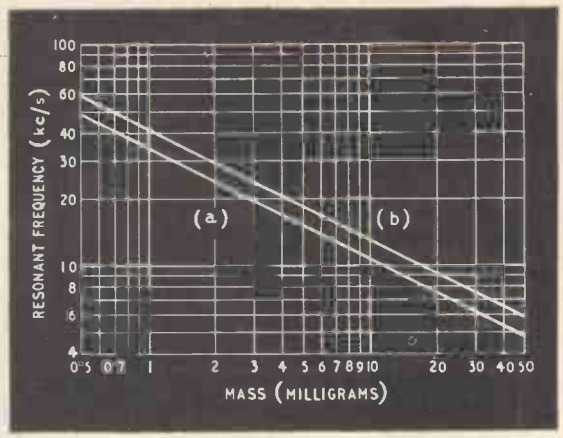


Fig. 11. Relationship between stylus resonance and effective stylus mass under the conditions specified in the text. (a) microgroove, (b) standard shellac records.

beryllium is by far the best, but unfortunately it is not commercially available. Using currently available materials, and provided that the dimensions of the stylus are modified accordingly, there is not a great deal to choose between the other metals, although steel will probably be the general commercial choice.

Fig. 10 shows the effect of varying load resistance of the low-pass analogue shown in Fig. 9. Under normal working conditions the resistive component of the terminating impedance is extremely small, so the system behaves as a resonant circuit comprising the effective mass of the stylus assembly and the record compliance in series with the stylus compliance (the reactance of the rest of the pickup moving system which is in parallel with this latter compliance is usually sufficiently great to be neglected). Fig. 11 shows the relation between "stylus resonance" and effective stylus mass (a) when applied on a standard vinyl microgroove record, at a playing weight of 8-10 gm, and stylus radius of 0.001in; and (b) when applied on a 78 r.p.m. shellac record and 0.0025in radius stylus at a playing weight of 8-10 gm. It will be found that reducing the playing weight will often reduce this resonant frequency on vinyl records due to the smaller area of contact between the stylus and the groove walls and hence an increased value of compliance.

The resonance can result in an increase in output of 10-15 db in a lightly damped system (this also means the needle tip impedance has increased by ×3 to ×6 at this frequency). The obvious method of reducing this resonance is to apply additional damping. Unfortunately all semi-solid materials have a high reactance to resistance ratio, with the result that if sufficient damping is applied to make the system aperiodic at this frequency, the overall compliance of the pickup is reduced considerably. In one case the low frequency compliance of the system was 4.5×10^{-6} cm/dyne and application of a piece of plasticized cellulose 0.020in in diameter by 0.060in long, cemented between the stylus head and the case of the pickup, reduced the resonance from +12 db to +2 db, the resonant frequency remaining at about 15 kc/s, but the low-frequency compliance was reduced to 1.1×10^{-6} cm/dyne. In other words, the low-frequency impedance, and hence the playing weight was considerably increased. Fig. 12 shows the reason-

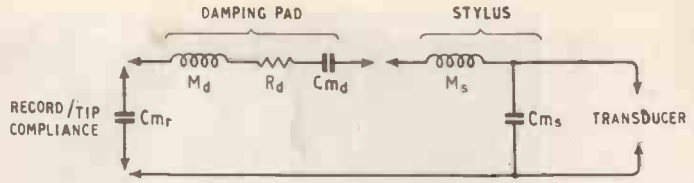


Fig. 12. Electrical analogue of the stylus with the addition of a damping pad.

ing behind this statement, where Cm_d is about 1.5×10^{-6} cm/dyne.

If the damping material is cemented only to the stylus tip and the other end left free, the high frequency resonance can be damped by virtue of the inertia of the damping material effectively clamping the remote end and as the frequency is progressively increased. The effective mass referred to the stylus tip will be increased by approximately 1.25 mgm, the low-frequency complicance will not be affected and the resonant peak can be reduced to +2 db or less. The actual frequency or resonance will be reduced, but the overall response will be improved because of the "flattening" of the resonance curve.

Cantilever Cross-sections

The majority of cantilever arms at present used are of rectangular cross-section with the idea of obtaining a maximum lateral stiffness to prevent undue high-frequency loss; and at the same time allowing for adjustment of the vertical thickness to give the correct ratio of overall transducer lateral compliance to vertical compliance (which latter should be confined entirely to the cantilever arm). In practice this ratio is between 5 and 10. If the ratio is reduced to much less than 5 considerable attenuation will take place, especially at high frequencies, and if the vertical stiffness is too great a subsidiary difficulty may be experienced in that the vertical resonance of the complete pickup and tone arm may be moved up into the lower audio band, say 100-300 c/s, with disastrous results to reproduction if the transducer is sensitive to vertical impulses. By suitably proportioning the dynamic constants of the rest of the pickup the cantilever arm may be made of circular cross-section, which can materially reduce the production costs of the complete stylus assembly. It also leads the way to a reduction in effective mass of the cantilever arm for a given stiffness. The compliance (reciprocal of stiffness) for a cantilever or rectangular cross-section is given by the formula $\frac{4L^3}{EWT^3}$ and for a cantilever or circular cross-section by $\frac{4L^3}{3E\,R^4}$. The effective mass referred to the stylus tip of each of these cantilevers is $\frac{dLA}{3}$ where A = cross-sectional area. As before stated, we wish to reduce the effective mass by the greatest possible amount for a given value of compliance. In the case of the rectangular cantilever there is not a lot we can do, except possibly make it of channel section. In the case of the circular material, however, it can be made in the form of a tube, and if the value of the outside and inside diameters are in the ratio of 1.125 and 0.875 to the diameter of the solid rod the effective mass will be reduced by half for the same stiffness. The logical development from that is to form the tube into an elliptical cross-section in order that the correct ratio of vertical and lateral compliance be obtained. This novel form of producing a headache for the stylus manufacturers is offered to pickup designers "for free."

The quantities of styli produced at all times during this era have mounted to prodigious propertions. An article in the *Talking Machine World*, dated 15th August 1911, describes one manufacturer as producing "needles for talking-machines" at a rate of 6,500,000 per day. This, of course, was in America. However, to-day there is at least one company in the United Kingdom producing sapphire styli at a rate of 140,000 per week and the capacity of other individual production units is probably not far short of 100,000. Possibly some statistician will produce figures giving the number of miles (in light years?) travelled by all the "needles for talking-machines" in their devious convolutions produced to date.

As is well-known, the average velocity on a 78 r.p.m. record is of the order of 3 cm/sec and in the case of the best acoustic reproducers (playing weight 100 grams) the sound pressure was of the order of 10 dynes/cm² at a distance of one metre. The available power at the stylus point at 1 kc/s under the above conditions is about 1.5×10^{-3} watt and the acoustic output power is about 10^{-4} watts, giving an efficiency of 6 per cent. In the case of an electrical reproducer the available mechanical power is the same, and the acoustic level is approximately the same. However, the total power consumed from the supply mains is usually of the order of 60/100 watts, giving an overall efficiency of an electrical reproducer of 0.0001 per cent or, in other words, the efficiency is 60,000 times worse than the acoustic reproducer. It is a sad commentary on our so-called technological advances that in our pursuit of "high fidelity," we use not a sledge hammer to crack the walnut but almost the whole resources of the Battersea Power Station; and it is suggested that possibly the correct approach to this art of sound reproduction is to learn again our first principles of acoustics and develop the art to its logical conclusion without any playing about with electrons and such new-fangled notions.

Grateful acknowledgement is made to Fred Lee & Co. (Coventry), Ltd., Technifon, Ltd., and Sapphire Bearings, Ltd., for information and samples.

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J. A. Pierce and F. V. Hunt, *J.S.M.P.E.*, Vol. 31, August, 1938.

"Two-valve Superhet" ; Modifications

AN improvement in performance of the above receiver (described in our March, 1955, issue) can be effected by connecting the 1-MΩ triode section grid leak of the ECL80 valve to the cathode of this valve instead of to the chassis and by reducing the value of the 3.3-kΩ smoothing resistor to 1.5kΩ. Incidentally, C_k should be between 1 and 2 pF.

MORE DISTORTION

What Causes Musical Unpleasantness?

By "CATHODE RAY"

LAST month we dismissed frequency distortion as no longer a problem,* and concentrated on non-linearity distortion. The object was to decide, if possible, what the distortion figures given nowadays by makers of sound-reproducing equipment mean. They are usually "percentage harmonic distortion," but there is often a strong undercurrent of suggestion that they ought to be intermodulation. If they were, would we be any the wiser?

Well, after reviewing the elementary facts of harmonic production by non-linear equipment, I referred to an experiment I described in 1938 to demonstrate that the unpleasantness of non-linearity distortion is due not so much to the harmonics as to intermodulation products. These only occur when there are at least two frequencies present in the original signal, and the experiment was to apply two different frequencies and note that at an amplitude great enough for considerable harmonic distortion they sound quite clear when heard separately, but perfectly horrible when together, even if the total amplitude is then no greater. On the other hand they sound clear together if the amplitude is substantially reduced so that the distortion is slight. I mentioned that some doubt had been expressed whether it was safe to conclude from this one experiment that most of the unpleasantness of distortion is due to intermodulation. Even though at this much later date that is generally accepted, it seemed to me there would be no harm in looking into the matter more closely. And so (limiting our enquiry to musical programmes) we considered what it is that makes some combinations of sound frequencies blend smoothly and harmoniously and others harshly. Generally speaking, the smaller the numbers in which the frequency ratio can be expressed, the less conspicuous is the addition of the second frequency (assumed to be the higher one). The simplest of all (not counting 1 : 1) is of course the 2 : 1, or octave, and the higher frequency is then so concordant with the lower as to form a new starting point for the musical scale; for example, if the two frequencies are 100 c/s and 600 c/s (fundamental and sixth harmonic) the 600 can be reckoned in relation to the nearest octave above 100, namely 400, and the ratio of frequencies can be regarded as 600 : 400, or 3 : 2, a basic musical harmony. For this reason the even harmonics have to be higher than the odd before they are noticeably discordant; the lowest odd harmonic that sounds definitely discordant is the 7th, but the lowest discordant even harmonic is the 14th. After considering the relationship between the shapes of equipment transfer (input/output) characteristic curves and the resulting harmonics, we concluded that with properly designed and operated equipment, in which only second and/or third harmonics are appreciable, the harmonics alone wouldn't cause any harshness of tone, though they might perhaps shift the balance of tone upwards in frequency and also make it sound richer or thicker (according to personal reactions). In arriving at this conclusion we considered only the harmonics in relation to their own fundamentals. But how about the harmonic frequencies of different notes played at the same time? For instance, two of the notes in the common chord are in the frequency ratio 5 : 8 and the third harmonic of one and the second harmonic of the other are therefore in the ratio 15 : 16, roughly a semitone apart, and that is not a pleasant musical sound. But unless both second and third harmonics are comparable in strength with the fundamentals (which, if due to distortion, would *not* be typical of properly designed and operated equipment!) this discordant tone would be relatively very weak. I am told that musical composers are aware of the inadvisability of prescribing chords for strongly harmonic-producing instruments if they want to obtain a smooth-sounding result.

Experiment Repeated

And now we are ready to compare the results of purely harmonic distortion with what the same knowledge of musical harmony would lead us to expect the effects of intermodulation to be. Anybody who may have been so painstaking as to compare the account of my experiment given last month with the original in 1938 has no doubt been itching to accuse me of cheating. The original frequencies were given as 50 and 400; last month's, as 100 and 533. Well, perhaps I did cheat. Having recently repeated the experiment, I believe that if my original frequencies had been *exactly* as stated, in 8 : 1 ratio, they wouldn't have made such an unpleasant noise as they did. Using an exact frequency ratio, the two reproduced together by a distorting triode or pentode do not lose all trace of their individual character, as in the pre-war experiment, though they do sound much more distorted than simply their separately distorted selves added together. But if the ratio is not exact—say 50 c/s and 410 c/s—the result fully deserves my earlier description. As the upper frequency is varied, the unpleasantness goes through marked fluctuations, being sometimes very bad indeed and sometimes by comparison almost tolerable (though of course not by "hi fi" standards!)

This fits in perfectly with our musical ideas. With exactly 50 and 400 c/s, the second-order intermodulation products (as they are called), $f_1 \pm f_2$, are 350 and 450. These, of course, are the 7th and 9th harmonics of 50 c/s, and 400 c/s is the 8th, so the only difference as compared with harmonic distortion of 50 c/s alone is that these three harmonics are abnormally strong. In fact, this seems to be quite a good way of finding out what exaggerated upper-harmonic distortion sounds like. If the intermodulation were mainly

* Don't take that too literally, of course!

third-order, $f_1 \pm 2f_2$, the frequencies created would be 300 and 500, the 6th and 10th harmonics, which ought to sound smoother than the musically discordant 7th and 9th. Fig. 1 shows the frequency pattern.

A critic complained that frequencies such as 50 c/s and 400 c/s are an unlikely basis for musical programmes. Had they been, say, 200 and 600 or even 150 and 400 the intermodulation products would have been the same frequencies as non-discordant harmonics. If, in order to demonstrate the objectionableness of intermodulation I deliberately chose frequencies such as 50 and 410, or 200 and 410, I would be wide open to the criticism that such ratios do not occur in music at all, except perhaps the kind of music in which the worst discords could pass unnoticed. So this time I chose 100 c/s and the rather odd figure of 533, because although these actual frequencies do not come on musical instruments with standard tuning, they are in the ratio (which is what mainly counts) of notes G and C, which very frequently do occur together in music, being the so-called dominant and tonic of the scale of C major. Unless both second and third harmonic distortions are grossly excessive, any jarring tone is almost or quite negligible. But the corresponding intermodulation product frequencies are 433 and 633, and 333 and 733, respectively (Fig. 2). These are out of tune with any notes on the musical scale, harmonious or discordant, so the unmusicalness of the sound is hardly surprising.

Here, then, we have two frequencies which are harmonious with one another and with one another's lower harmonics, but whose intermodulation frequencies are altogether unmusical by any standard. The listening test confirms these expectations. On the other hand frequencies could be chosen for the two input tones that would yield concordant intermodulation products, and this too is confirmed by one's ears. I don't know whether it would be practicable to compose music using only notes that could not, when sounded together, be distorted into discordant intermodulation tones, but I fancy composers would find it rather a serious restriction. And not only are the intermodulation tones introduced by distortion into typical musical programmes likely to be more discordant than the harmonics, but they are far more numerous. One has only to try to reckon the number superimposed on orchestral music to guess how the confused " muddy " sound of non-linear reproduction is caused. The doctrine that most of the audible unpleasantness of non-linearity distortion is due to intermodulation tones rather than harmonics is, I conclude, in general justified, at least for the lower-order distortion that is normal in reasonable apparatus.

Distorted Discords

One criticism that has been voiced is that modern composers like nothing better than a good hearty discord, and so discordant distortion products are not so serious as I made out. But (1) the amount of listening to music by that kind of composer is a small fraction of the whole, (2) even that kind of composer does not (except for a few obscure experimenters) write music for notes outside all recognized musical scales, and (3) in spite of what such music may sound like to some, the occurrence and nature of the discords is intended to be as composed and not as it may happen to result from chance distortion. A similar reply can be made to the criticism that intermodulation tones are generated in our ears because they are non-

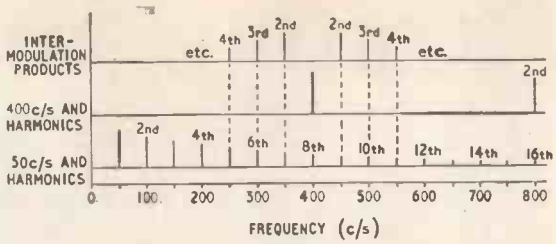


Fig. 1. This diagram shows, above a frequency scale, the harmonic frequencies of a 50-c/s signal, the same for a 400-c/s signal (only fundamental and second are within range), and the frequencies of the products of intermodulation between the two.

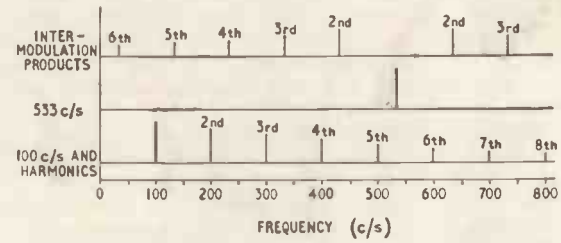


Fig. 2. Similar to Fig. 1, but with fundamental frequencies of 100 c/s and 533 c/s.

linear, and therefore distortion doesn't matter. But this ear distortion becomes prominent only when the sound is loud, so the distortion coming from reproducers, which doesn't disappear when we walk away and hear it more distantly, sounds unnatural.

Very well then, let us take the relative unpleasantness of intermodulation as established, and pass on to measurement of the distortion. And here there seems to be a tendency to argue that because intermodulation is the cause of the unpleasantness it is the thing that should be measured, rather than harmonics. It may quite possibly be true that it is better to measure intermodulation than harmonics, but this is not the argument to prove it. Remember, we can't measure unpleasantness as such; we can only look for something to which unpleasantness seems to be more or less proportional. If we find that unpleasantness is proportional to the percentage of intermodulation products, then it may seem natural to measure that. But it could be equally appropriate to measure percentage harmonics, even if they themselves contributed nothing to the unpleasantness, *provided that they were directly proportional to the intermodulation.* It is rather like voltage measurement. A difference of potential causes mutual electrostatic attraction, whereas it does not directly cause a magnetic field, but nevertheless voltmeters actuated by magnetic fields are far commoner than electrostatic voltmeters. The magnetic voltmeters are worked by current, which (according to Ohm's law) happens to be directly proportional to a voltage.

The relationship between harmonics and intermodulation is even closer than that between voltage and magnetic field, because harmonics are actually a particular kind of the same thing as intermodulation. This is a suitable moment for clearing up the numbering of these things. At one time it was quite usual to call the double-frequency harmonic the first harmonic. I believe musicians still do (they also often use the word " partial " for " harmonic.")

It was quite reasonable. But it was also rather awkward that the *n*th harmonic should be $n+1$ times the frequency, so to make the *n*th harmonic *n* times the fundamental frequency the fundamental is now reckoned as the first harmonic. Similarly the simple sum and difference intermodulation products, of frequency $f_1 \pm f_2$, were (and are) sometimes called the first-order intermodulation products; and this too was awkward because the kind of distortion causing them also caused what we now call *second* harmonic. So the rule is that the order number of the general intermodulation product $pf_1 \pm qf_2$ is $p+q$. With $f_1 \pm f_2$, p and q are both 1, so the order is 2. In this way the order of intermodulation is always the same as that of the harmonic produced by the same kind of distortion. If you didn't at first see my point about the vast number of intermodulation products compared with harmonics, it should be clearer now. Seventh-order distortion of two frequencies comprises only two seventh harmonics—$7f_1$ and $7f_2$—but all these intermodulation products: $6f_1+f_2$, $5f_1+2f_2$, $4f_1+3f_2$, $3f_1+4f_2$, $2f_1+5f_2$, f_1+6f_2, $6f_1-f_2$, $5f_1-2f_2$, $4f_1-3f_2$, $3f_1-4f_2$, $2f_1-5f_2$ and f_1-6f_2. Both mathematical calculation and practical test show that this distortion also produces fifth, third and first harmonics and intermodulation products. So imagine the result with a full orchestra playing!

Next, see what happens to the distortion products just listed when f_2 becomes equal to f_1. The only harmonic frequency, of course, is $7f_1$ (because $7f_2$ is the same). All the sum intermodulation products also boil down to $7f_1$. The difference products are $5f_1$, $3f_1$ and f_1, which also were there before. So harmonic distortion is not an entirely separate subject from intermodulation, but can be regarded as a special case of it. No wonder then if there is a close numerical relationship between figures for harmonic distortion and those for intermodulation.

It would take too long to go through all the calculations here and now to show what the relationship is, because it depends on the kind of distortion. But the data have been clearly tabulated in the article by Callendar and Matthews I mentioned last month. There are also some very interesting comparisons between calculations and experimental results in a paper by W. J. Warren and W. R. Hewlett*. All I can do in the space left is to outline some of the main principles.

We have already seen that the relative strength of each harmonic produced by distortion depends on the shape of the transfer characteristic of whatever is causing the distortion. The same goes for intermodulation products. And I have mentioned that the shape that generates, say, second harmonics, is also the shape that generates second-order intermodulation. Conveniently enough for the memory, it is the second-power (or square-law) shape. What does that mean? Well, suppose we take first of all a linear device, say a resistor. The equation stating the relationship between the voltage applied and the current flowing through it is commonly known as Ohm's law: $I=E/R$. In algebra, however, it is a custom to use small letters for variables and capitals for constants. The whole meaning of Ohm's law is that however the current and voltage may vary, the ratio of the two—the resistance—is constant. So we can write the same thing

$$i=\frac{1}{R}e$$

and because 1/R is the conductance, for which the usual symbol is G, we can make a neater job:

$$i=Ge$$

If we plot a graph of i against e, by choosing some fixed value of G and then choosing various values for e to give corresponding values for i, giving points to join up into a line, we find that the line is always a straight one. That is what we mean when we say that the resistor is *linear*. We can alter the slope of the line by choosing a different value for G; that would mean a different, but still linear, resistor. We could also shift the line bodily (which would be useful for approximately imitating the nearly-linear part of a valve characteristic) by adding another constant, say I_o, to stand for the current flowing when there is no voltage:

$$i=I_o+Ge$$

Our e stands for any value of input voltage varying in any way at all, but supposing we use a definite kind of input voltage, with a sine waveform, we can substitute for e the equation of that waveform, usually written $e=E\sin\omega t$, where E is the peak voltage and ω is 2π times the frequency. The result of the substitution is

$$i=I_o+GE\sin\omega t$$

from which we see that the current also has the same sine wave form and frequency. What we have done is to prove that a linear device—resistor, valve, amplifier or what not—is distortionless (as if we didn't know!).

To study non-linear devices we try to find an equation which, when graphed, closely imitates the characteristic curve of the device. One of the commonest shapes, especially where valves are used, is the one that bends increasingly in one direction, as in Fig. 3. This can be imitated by adding a square or second-power term to the equation, with its own constant to decide the amount of curvature:

$$i=I_o+G_1e+G_2e^2$$

When the signal waveform is substituted for e the new term becomes $G_2(E\sin\omega t)^2$, and this is equal to $\frac{1}{2}G_2(1-\cos 2\omega t)$, which shows that a signal of twice the frequency (i.e., the second harmonic) is produced. To imitate the device's curve more accurately it is usually necessary to add some higher even-number terms, and each brings in its own harmonic and also harmonics of all the lower even numbers.

If the curve bends over equally at both ends it

* An Analysis of the Intermodulation Method of Distortion Measurement," *Proc. I.R.E.*, April 1948, p. 457.

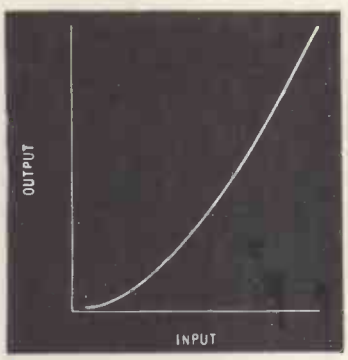


Fig. 3. Type of transfer characteristic giving rise to even-number distortion.

can be shown in a similar way that odd-number terms are needed in the equation, and odd harmonics are produced.

The same procedure is adopted in studying intermodulation, except that e must be (at least) two sine (or cosine) waves of different frequencies. The algebra and trigonometry needed to reckon up all the frequencies in the output, and the amplitudes of each, becomes really formidable, and that is why it was very kind of Messrs. Callendar and Matthews to go through it all and present the results in convenient tables. They show that the relationship between the powers of e in the characteristic equation and the harmonic frequencies produced by the corresponding distortion holds good for intermodulation products—that an even power causes intermodulation products of that order and all lower even orders, and similarly for odd powers.

Distortion Measurement

The fact I have been leading up to in all this is that if the equation of a distorting device's transfer characteristic is known, the amplitude of every harmonic and intermodulation product follows (provided, of course, that we have the skill and patience to deal with all the necessary calculation!). So there is, corresponding to any combination of harmonics resulting from a given combination of input signals, one particular combination of intermodulation products. And vice versa. Theoretically at least, if either harmonics *or* intermodulation are known, both are known. So theoretically at least it doesn't matter which is measured. There is a fixed rate of equivalence between the two.

But that doesn't mean that for every 1% harmonic distortion the intermodulation distortion is some fixed number of %. It isn't nearly as simple as that. In general, there is a different ratio between harmonics and intermodulation for every order (second, third, etc.), and that number is not fixed but depends on the respective amplitudes of the two or more input frequencies, and on the amount of distortion of other orders. The reason for this last is that the amount of second-order distortion (say) depends not only on the second-power term in the equation but also all higher even-power terms. This complication drops out if the distortion is exclusively second or third, as approximately it often is. Another complication can be avoided by always using the same ratio of signal amplitudes for intermodulation testing; a commonly-used ratio is 4 : 1. If the single signal used for harmonic testing has the same peak value as these two combined (i.e., 5 times the amplitude of the weaker) then with second-order distortion alone each of the two intermodulation products, reckoned as a percentage of the weaker signal forming its "carrier wave," is 1.6 times the percentage harmonic distortion. With third-order distortion alone, the corresponding ratio is 1.92. And if both "sidebands" are counted, these two figures are doubled. Fortunately these ratios are not very much affected by reasonable amounts of higher-order distortion, and practical tests with the 5 : 4 : 1 signal ratio show that the intermodulation product percentage of any order is usually 1.5-2 times the same-numbered harmonic percentage. Because the carrier wave is only one-fifth of the amplitude used for harmonic testing, however, the intermodulation product itself is smaller than the corresponding harmonic, so it is not really correct to say (as American writers do) that intermodulation measurement is more sensitive.

All this is on the assumption that there is no frequency distortion. Of course if the various frequencies are amplified by different amounts in the "device," that upsets the calculations accordingly.

For the sake of simplicity, everybody wants to sum up the distortion in a single number. But looking at Figs. 1 and 2 again we may well ask how this can be done. Even single-signal harmonic measurement is liable to produce a considerable number of harmonics of assorted amplitudes, and intermodulation measurement yields vastly more. Is there any way of combining those groups of percentages into one, in such a way that it gives a fair indication of the unpleasantness of the distortion?

It would be very nice if there were, and several ways have been proposed, but I am afraid that the answer is, if not an outright negative, at least doubtful. One of the most popular schemes of measurement is to apply a single tone at the input, measure the total output (fundamental plus harmonics due to distortion), and then insert a bridge filter between output and meter to stop the fundamental completely, so that what is measured is the total harmonics. The ratio of 100 times the second reading to the first is "percentage total harmonics." This scheme is popular because it can be worked with comparatively simple apparatus and gives a single figure. But unfortunately that figure is not a *fair* measure of unpleasantness. Although the subject is full of controversy, one thing universally agreed is that a given amount of third harmonic distortion is worse than the same amount of second, and that the high harmonics are worse still. To make the "total" figure take this into account it was proposed in 1936 that harmonics should be measured separately and each multiplied by $n/2$ before being combined. For the second harmonic n is 2, so its reading is unaffected; the third is multiplied by 3/2; the fourth 2; and so on. By the way, whether the individual harmonics are "weighted" like this or not, they must not be just added together to give the total; as I explained in "Total Power" (March, 1952) when adding up a number of simultaneous voltages or currents it is necessary to square each, add them all together, and take the square root of the result.

According to D.E.L. Shorter of the B.B.C.*, this system still doesn't give enough weight to the unpleasantness of the high-order distortion, and he reckons that multiplying each harmonic reading by $n^2/4$ lines up better with listening tests. You can see, of course, how difficult it is to discover exactly how much worse one kind of distortion sounds than another; for one thing it probably depends a good deal on the kind of programme being heard. So any weighting system is rather arbitrary. I doubt whether anyone would be prepared to swear that fourth harmonic is either 4/3 or 16/9 times as bad as third, or even that it is equally bad. And besides the extra calculation, measuring all the harmonics separately necessitates much more expensive apparatus, especially for the Shorter weighting, in which the very high harmonics are multiplied so much that one has to be able to measure accurately very small percentages of them.

How about intermodulation measurements? They

* "The Influence of High-Order Products in Non-Linear Distortion," *Electronic Engineering*, April 1950, p. 152.

are even more controversial. The most popular method (again, because it requires simple apparatus and gives a single reading) applies a strong low-frequency signal and a quarter-strength high frequency signal, and measures the total of the "sidebands" around the latter; e.g., those shown on the top line in Fig. 1. The procedure has been described in *Wireless World* by Thomas Roddam (April 1950) and E. W. Berth-Jones (June 1951). It comes under the same criticism as the total harmonic distortion method, over which it seems to have no very obvious advantages.

Another system, called the C.C.I.F. method, varies the frequencies of both input signals in such a way that one signal is always a certain number of c/s (say 1,000) more than the other. The frequency of the second-order intermodulation product $f_1 - f_2$ is therefore constant and hence relatively easily measured. This method is very highly spoken of in some circles, but since it indicates only second-order distortion, it presumably pronounces a push-pull amplifier having strong third-order distortion as absolutely perfect. To my mind this is a fatal objection.

The simpler methods have their uses (e.g., production tests of units having possibly varying amounts of similar distortion), so long as one doesn't regard them as unpleasantness meters. For thorough investigation it seems to be necessary to have a wave analyser for separately measuring every distortion product, and preferably to supplement it by visual examination of the transfer characteristic and of the output when the fundamental has been removed. For most purposes I should say that harmonics are enough, but there is an exception if one wants to know what the distortion is like near the upper frequency limit, because then the harmonics are all "off the map," but two signals inside the limit can still intermodulate to give a distortion product right inside the audible range.

Nobody would be more pleased than I to be able to hand out a simple cut-and-dried solution to this problem of distortion measurement. Perhaps some painstaking and well-provided organization will give a team of research workers a year or two to find out what reasonable conditions and method of test take into fair account every cause of unpleasantness of distortion.

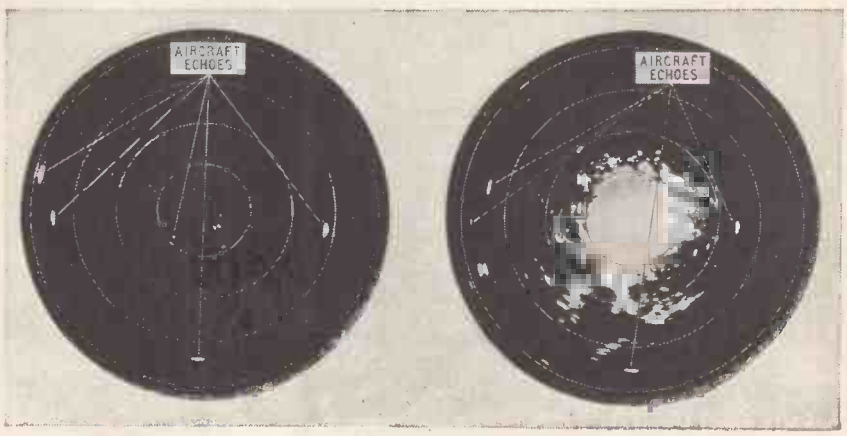
AIRFIELD RADAR DEVELOPMENTS

Crystal-controlled and with Permanent-Echo Suppression

THE clutter of permanent echoes (p.e.'s) familiar to all operators of radar equipment, and which is particularly troublesome on airfield radar screens, can now be successfully eliminated by an ingenious cancellation system embodied in the latest Type S232 airfield radar introduced by Marconi Wireless Telegraph Company. Known as "Moving Target Indicator" (MTI) it provides permanent-echo suppression better than 46 db. Another unusual feature is that it is crystal-controlled throughout, which to a large extent accounts for the good p.e.-suppression.

Briefly, the operation of the equipment is as follows:—the output from a crystal-controlled reference oscillator on 5.625 Mc/s is mixed with an harmonic of another crystal-controlled oscillator and the beat frequency amplified and multiplied to give the final output frequency, which in this case is in the frequency range 500 to 610 Mc/s (50 cms). The output power is between 50 and 60 kW at a pulse length of 2 to 4 μsec as required and at a pulse repetition frequency of 500 to 800 c/s.

The received (echo) signals after conversion to an intermediate frequency of 45 Mc/s together with the eighth harmonic of the 5.625-Mc/s reference oscillator (also 45 Mc/s), are fed to a homodyne detector. The output from this detector is therefore proportional to the difference in phase of the two input signals. As the phase of the reference oscillator is fixed, echoes from stationary objects will have the same phase difference on all successive echoes, but those from a moving target will have a continuously changing phase. It is only necessary to compare the homodyne output produced by successive echoes in order to determine whether an echo is moving or not. A special liquid delay line is used for this purpose and in this device identical signals resulting from permanent echoes cancel out and only those whose phases have changed between successive echoes appear in the output circuit. Here they are rectified and fed through a video amplifier to separate cathode followers and thence by coaxial cables to p.p.i. display consoles. Up to eight p.p.i. display units can be used with one aerial head so that the equipment can be used for long-range, short-range or segmental viewing simultaneously in several different places. As demonstrated by an experimental equipment installed at London Airport, this radar is capable of detecting aircraft at ranges of from $\frac{3}{4}$ to 100 miles.



P.p.i. displays showing permanent-echo suppression (MTI system) with the Marconi Type S232 airfield radar. On the left MTI switched on, on the right, switched off. Range markers at intervals of 5 nautical miles.

Manufacturers' Products

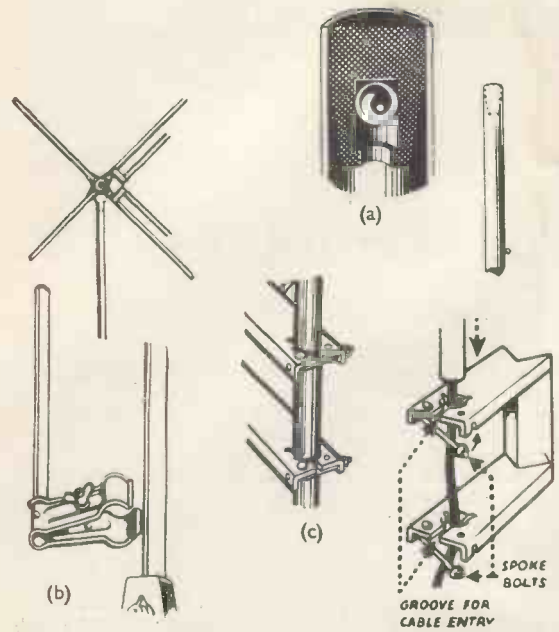
NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

Television Aerials

IMPROVEMENTS to existing models and the introduction of Band III add-on elements comprise some of the latest changes made in the television aerials produced by Antiference.

One of the most interesting is a vibration damper to alleviate the audible howl sometimes produced by wind causing vibration of the elements. When transmitted down a chimney shaft it can be most annoying.

The damper consists of a hollow plastic plug containing



Antiference aerial damper (a), new harness bolts (c) and "Addex" Band III units (b).

a small weight having a slight lateral movement and inserted in the end of each aerial rod. The movements of this weight oppose the vibrations of the rod and silence the aerial. It is also claimed that a further advantage of the new device is that it tends to alleviate signal "flutter" caused by vibration of the aerial. It is shown at (a) in the drawing above.

Another improvement concerns the mast clamps on the chimney harness. Captive "spoke-bolts" are fitted in place of loose bolts and greatly simplify the erection of the mast when complete with aerial and feeder; (c) in the drawing.

The Antiference "Snapacitor" fitting, which relies on a capacitance in place of the usual electrical connection between feeder and the aerial elements, has been improved by employing a more effective type of anodizing of the contiguous surfaces. The capacitance of the coupling is by this means raised to 1,000 pF or more.

The same type of coupling is used for the new add-on elements which have been brought out to convert a Band-I aerial for Band-III reception. These are known as "Addex" units and are available for plain dipoles, "H" or "X" aerials. Where the high- and low-band stations are not co-sited reception from opposite directions can be effected by fitting a suitable Addex kit to an Antex (X) aerial. It is not applicable to other types. Prices range from 7s 6d to 15s for a set.

The address of the maker is Bicester Road, Aylesbury, Bucks.

Four-Band Coil Pack

THE majority of coil packs cover the three recognized broadcasting wavebands only; i.e., short, medium and long, but in the latest addition to the Denco range of packs a fourth band is included with a coverage of 50 to 160 metres. The other three bands have coverages of 16 to 50 metres, 194 to 550 metres and 800 to 2,000 metres respectively when tuned by a 500-pF gang capacitor using an i.f. of 465 kc/s. The additional waverange takes in the 80- and 160-metre amateur bands and the wavelengths employed by trawlers and coastwise shipping.

Known as the model CP3F it comprises a small chassis of $2\frac{1}{2} \times 4\frac{1}{4}$in with an overall depth of 1in, excluding the switch spindle, carrying 4 oscillator and 4 signal circuit coils with adjustable dust iron cores, 8 trimming capacitors, oscillator tracking capacitors and a 2-pole 4-way switch.

The makers are Denco (Clacton) Ltd., 357-359 Old Road, Clacton-on-Sea, Essex, and the price is 49s plus 16s 4d U.K. purchase tax.

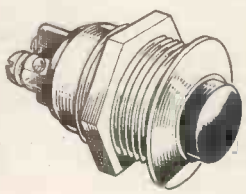
Light-Action Push Switch

A RECENT addition to the range of Bulgin switches is a spring-loaded push-to-make, single-pole switch for use in test equipment and apparatus where temporary excitation only of the circuit is required. It is a single-hole fixing type with a large screwed bush, forming also the main body of the switch, measuring $\frac{3}{4}$in in diameter. It measures 1in deep behind the bezel rim and will take panels up to $\frac{1}{16}$in thick. The case is completely insulated from the contacts.

The switch is rated at 110 V, 1 A or 30 V, 2 A in a.c. circuits with some derating for d.c. over 12 V. The push-button is of generous size, measuring $\frac{1}{2}$in in diameter and operates without undue pressure. Self-aligning and self-cleaning internal contacts undoubtedly contribute to the very light action. The finish is chromium and black.

Known as the Type MP12 the new switch costs 3s 9d and the makers are A. F. Bulgin & Co., Ltd., Bye Pass Road, Barking, Essex.

Left: Denco Model CP3F four-range coil pack.



Above: Bulgin new push-switch type MP12.

The Ratio Detector

By M. R. MURRAY*

Principle of Operation in F.M. Receivers

RATIO detectors are so called because they produce two voltages whose ratio varies with the frequency swings of the incoming f.m. signal. The difference between these two voltages provides the audio output. A ratio detector circuit can easily be distinguished from other double-diode discriminators because its diodes are connected back-to-back (see Fig. 1), that is, the tuned secondary circuit L_2C_8 of the transformer is connected from the cathode of one diode to the anode of the other. The main advantage of the circuit, which will be decisive in set design, is that it reduces the number of i.f. stages required. Other detectors do not remove unwanted amplitude modulation superimposed on the f.m. signal by impulsive noise or gain variations in the receiver, and a separate i.f. stage has to be provided solely for this purpose.

How is the amplitude modulation removed? The two voltages mentioned above are added together in the circuit, but although their ratio varies the sum of the two is held constant. At low audio frequencies this sum is prevented from varying by the " flywheel " action of a 5- or 8-μF stabilizing capacitor, C_3 in Fig. 1. When amplitude modulation on the f.m. input to the ratio detector makes the signal rise momentarily, both diodes are driven harder and the extra current flows into C_3; current is drawn out from C_3 when the signal falls on the downward half-cycle of the amplitude modulation, so that successive half-cycles of the a.m. cancel each other out. At higher unwanted audio frequencies the damping effect of the diodes on the L_2C_8 tuned secondary circuit varies during the a.m. cycle and compensates for the a.m. variations.

The circuit can be arranged in a symmetrical or balanced form in which the voltages are produced across two equal capacitors connected in series across the diode load (Fig. 2), but preference may be given to the unbalanced circuit (Fig. 1) in which only the lower of the two capacitors is retained. Removing one capacitor makes for economy and leaves the circuit sufficiently capable of suppressing unwanted amplitude modulation. However, a difference voltage can no longer be taken from the common connection of two capacitors, and by the time the circuit has been rearranged it is not at all obvious how the audio output arises. This article therefore is concerned chiefly with the unbalanced circuit, since the explanations can readily be adapted to include the Fig. 2 circuit where both capacitors are present.

The internal impedances of the ratio detector diodes must be small and at least approximately equal, and one diode must have its own cathode pin connection. Suitable diodes are a''_d and a'''_d of the Mullard EABC80. Subscript has been used to indicate voltages applied to k''_d and a'''_d, and in this way to make it quite clear that the a'_d diode is not used in the ratio detector. Actually, the a'_d diode is the a.m. detector and rectifier for a.g.c. voltages.

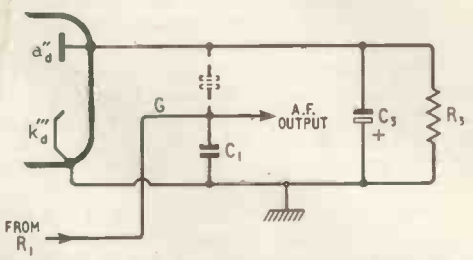


Fig. 2. Part of a balanced ratio detector circuit, showing how it is related to the unbalanced version. C, here corresponds to C, in Fig. 1.

The transformer, or ratio filter, is similar to that required for other discriminators, and only a brief description of the effect of frequency swing upon phase need be given here.[1]

The L_1C_P and L_2C_8 circuits a retuned to a central intermediate frequency of, say, 10.7 Mc/s. Current and voltage in the tuned circuits will only be in phase at the central intermediate frequency. Primary L_1 has a current which lags (or leads) the f.m. input voltage as the signal frequency is swung higher (or lower) than the intermediate frequency. Secondary L_2 picks up the flux generated by the primary current and produces voltages in its two halves whose phase θ varies at the same audio frequency as the phase of the primary current. Tertiary winding L_3 is not tuned, and injects an i.f. reference voltage from the primary into the secondary. This voltage

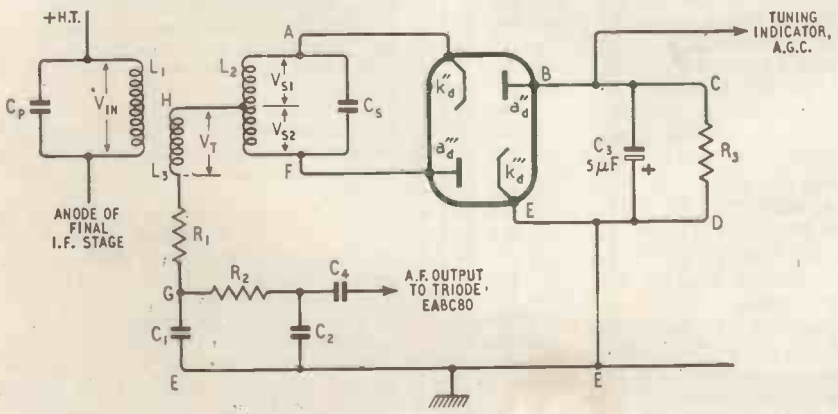


Fig. 1. Typical ratio detector circuit of the unbalanced type.

* Mullard Technical Service Department. This article is based on one which originally appeared in *Mullard Outlook*.

combines vectorially with the "phase swinging" i.f. voltage across each half of the secondary and makes the ratio of the voltages taken off to the diodes vary at audio frequency.

To interpret the vector diagram (Fig. 3) it is sufficient to know that the lengths of the arrows have not been drawn to scale as they usually are to represent the number of volts, etc.; while the angles between the arrows can be read off as phase differences in degrees. Start, then, by picking out the input voltage V_{IN}; the phases of all the other quantities are measured with reference to it. In the secondary the induced current I_S lags (or leads) V_{IN} when the signal frequency is higher (or lower) than the intermediate frequency. The voltages across the two halves of the secondary are V_{S1}, V_{S2}. They respectively lag and lead I_S, whatever the position of I_S, by 90°. Because the secondary is centre-tapped V_{S1} and V_{S2} are equal and 180° out of phase with each other, so on the diagram they are drawn with equal and opposite arrows. The phase angle between I_S and V_{IN} ($= \theta$) varies with the frequency swing, so that I_S is waggling to left and right of V_{IN}, while V_{S1} and V_{S2} are see-sawing up and down, at the audio (modulating) frequency.

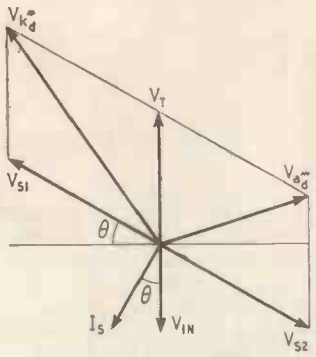


Fig. 3. Vector diagram illustrating the mechanism of the ratio detector.

Next pick out V_T on the diagram; it is the tertiary voltage injected into the secondary from the primary, and is in series with the voltage across each half of the secondary. Now the tertiary consists of a few turns wound closely over the anode end of the primary. So V_T does not waggle; it is fixed and can be drawn 180° out of phase with V_{IN}.

The voltage $V_{k''_d}$ applied to cathode k''_d is the vector sum of voltages V_{S1} and V_T in series. This vector sum is formed on the vector diagram by the "parallelogram law," that is, the sum $V_{k''_d}$ is the diagonal of a parallelogram whose sides are V_{S1} and V_T. Similarly, the voltage $V_{a'''_d}$ applied to a'''_d is found by drawing a parallelogram using V_{S2} and V_T as the two sides.

If V_T had not been injected into the secondary, the voltages taken off from the secondary would be V_{S1} and V_{S2} whose lengths on the diagram remain constant as I_S is waggled to and fro. By combining V_{S1} and V_{S2} with V_T, however, two voltages $V_{k''_d}$ and $V_{a'''_d}$ are obtained which are equal only at the intermediate frequency when I_S is in phase with V_{IN} ($\theta = 0$). But when I_S lags V_{IN}, then $V_{k''_d}$ is greater than $V_{a'''_d}$ (as in the diagram), and diode a''_d passes more current than diode a'''_d; or when I_S leads V_{IN} the position is reversed and $V_{a'''_d}$ is greater than $V_{k''_d}$. With a suitably designed circuit the ratio $V_{k''_d}/V_{a'''_d}$ follows faithfully the original audio modulation as I_S is made to waggle to left and right of V_{IN} by the frequency swings contained in the signal.

The current through each diode has two paths in the secondary system; those for a''_d are (i) BCDEFA and (ii) BCDEGHA, while for a'''_d they are (i) FABCDE and (ii) FHGE. The paths numbered (ii) have a common section $L_3R_1C_1$, and because of the way the diodes are connected their currents through $L_3R_1C_1$ oppose each other. At the intermediate frequency, when $V_{k''_d} = V_{a'''_d}$, there is no audio output voltage at G: above the intermediate frequency current flows in the direction HGE (when $V_{k''_d}$ is greater than $V_{a'''_d}$) or in the direction EGH below the intermediate frequency ($V_{a'''_d}$ greater than $V_{k'''_d}$). Thus the a.f. voltage taken off at G depends on the frequency swing of the incoming signal; it follows the ratio $V_{k''_d}/V_{a'''_d}$, and therefore reproduces the waveform of the original studio sounds.

There is also an "i.f." variation in the vectors shown in Fig. 3. They can be imagined as contracting to zero length then, expanding out again but in the opposite direction, contracting back to zero again, and finally returning to their original length in their original direction; and they complete this cycle the same number of times per second as the frequency of the signal after it has passed through the frequency changer. In actual fact, the vectors do not return exactly to their original direction, for in the meantime their i.f. frequency will be changing and θ will have changed too—but the to-and-fro waggle of I_S, of course, is at audio frequency. These i.f. variations in $V_{k''_d}$ and $V_{a'''_d}$ are rectified by the two diodes, the secondary system being by-passed to earth at the i.f. by C_1. Further filtering out of the i.f. is performed by the C_2R_2 de-emphasis network usually placed at this point; but the main function of the de-emphasis network is to compensate for treble boost applied at the transmitter. In f.m./a.m. receivers the "pure" a.f. output is passed via a d.c. blocking capacitor C_4 and a volume control to the triode grid of the EABC80. In a line-up designed solely for f.m. reception a double diode such as the EB91 could be used in the ratio detector.

REFERENCES

1 "Cathode Ray." "Frequency Modulation, Part 3," *Wireless World*, July, 1951; with corrections, August, 1951.

2 Seeley, S. W., and Avins, J. "The Ratio Detector," *RCA Review*, June, 1947.

1955 A.R.R.L. HANDBOOK

A CONSIDERABLE quantity of new material is included in this, the 32nd, edition of the Radio Amateur's Handbook, which is compiled by the American Radio Relay League, the U.S. equivalent of our R.S.G.B. Almost all its 27 chapters are affected, but by omitting outmoded designs of equipment and techniques the very latest in amateur practice is included without any increase in the size of the volume. It remains the same at 608 pages, of which 67 are given over to valve and transistor data, two more than last year.

The mobile radio chapter has been almost entirely revised and contains descriptions of the most up-to-date equipment extant in amateur circles. These are applicable to this country, and for that matter everywhere where amateur radio flourishes.

It is often the little things that give the final polish to amateur work; for instance, the handbook explains the correct way to lash a bunch of wires in a receiver, how to operate a break-in system to the best advantage, how to get the most out of DX working and such-like. Information of this kind is not easily found elsewhere.

Copies of the handbook are obtainable from the Modern Book Co., 19-23, Praed Street, London, W.2, or ordered from the Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.1, for delivery from the U.S.A. The price is 30s (31s 6d by post).

NORTHERN RADIO SHOW

AS already announced, the second post-war Northern Radio Show, organized by the Radio Industry Council, will be held in the City Hall, Manchester, from May 4th to 14th. The show will open daily from 11.0 to 10.0, except on the 10th when it will close at 11.0. Admission to the exhibition, which will be officially opened at 3.30 on the 4th by Her Royal Highness the Princess Royal, will be 2s (children 1s). There will be special rates for parties of 25 and over, and trade season tickets will be available, price 5s.

As will be seen from the following list of 53 exhibitors the majority are domestic receiver manufacturers, although some accessory and component manufacturers are also participating. As at the London Show the exhibition will include a studio from which the B.B.C. will broadcast sound and television programmes. The B.B.C. is providing a demonstration comparing broadcast reception on medium waves with frequency-modulated v.h.f.

	Stand No.
Aerialite	46
Antiference	6
Ambassador Radio & Television	15
Arrell Electrical Accessories	25
B.B.C.	56
Balcombe, A. J.	11, 13
Belling & Lee	54
British Radio and Television	39
British Railways	10
Bush Radio	36, 103
Cole, E. K.	53
Co-operative Wholesale Society	51
Cossor, A. C.	4, 17
Decca Record Co.	9, 23
E.M.I. Sales & Service	49
Edison Swan Electric Co.	47
English Electric Co.	22
Ferguson Radio Corpn.	16
Ferranti	29
Garrard Engineering Co.	3
General Electric Co.	37, 43
Grampian Reproducers	26
Gramophone Co.	35
Granada Theatres	41
Invicta Radio	19
Kemsley Newspapers	104
Kolster-Brandes	14
McMichael Radio	28
Marconiphone Co.	38
Mercantile Credit Co.	40
Mullard	8, 20
Multicore Solders	50
Murphy Radio	55
National Provincial Bank	1
Pam Radio & Television	31
Permanoid	25
Philips Electrical	34, 48
Pilot Radio	21
Practical Wireless	5
Pye	18
Radio Gramophone Dev. Co.	27
Regentone Radio & Television	52
Slingsby, H. C.	100
Sobell Industries	30
Stella Radio & Television	24
Taylor Electrical Instruments	12
Telerection	44
Ultra Electric	32
Vidor	33, 102
Waveforms	45
Whiteley Electrical Radio Co.	7
Wildbore, J. E.	42
Wireless & Electrical Trader	2

MAY MEETINGS

Institution of Electrical Engineers

London.—May 2nd. "A Simple Introduction to Telegraph Codes" by H. V. Higgitt.

May 5th. "The Electrical Activity of the Brain" by Dr. W. Grey Walter.

May 11th. Group of papers on "Transistors and other Semi-conductor Devices" including "Junction Transistor Noise in the Frequency Range 7-50 kc/s" by W. L. Stephenson and "Noise in Silicon Microwave Diodes" by G. R. Nicoll.

The meetings will be held at 5.30 at Savoy Place, W.C.2.

Physical Society

Acoustics Group.—May 12th. "Measurement of Equal Loudness Contours" by R. S. Dadson and D. W. Robinson at 5.30 at Imperial College, London, S.W.7.

Institute of Physics

Non-Destructive Testing Group.—May 6th. "Xeroradiography" by R. L. Durant (Ministry of Supply) at 6.30 at 47, Belgrave Square, London, S.W.1.

British Institution of Radio Engineers

London Section.—May 18th. "The Development of the Underwater Television Camera" by D. R. Coleman, D. A. Allanson and B. A. Horlock, at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

British Sound Recording Association

London.—May 20th. Annual convention at 7.0 at the Waldorf Hotel, Aldwych, W.C.2.

Electroencephalographic Society

There will be a meeting of the above society on May 21st at the Maudsley Hospital, London, S.E.5.

Incorporated Practical Radio Engineers

South Coast Section.—May 12th. "Band III Aerial Equipment" (Antiference) at 7.30 at the Kings Arms Hotel, Castle Street, Christchurch.

Midlands Section.—May 4th. "Philco Television Receivers" at 7.30 at the Crown Hotel, Broad Street, Birmingham.

RANDOM RADIATIONS

By "DIALLIST"

The Achilles Heel

ACHILLES, if you remember, was dipped as a baby into a certain sacred spring, whose waters had the power of rendering invulnerable any part of the human frame wetted by them. By an oversight Aphrodite, his mamma, omitted to push under the one heel by which she was holding him. When he grew up and became in due course a fully fledged hero spears and arrows and things just bounced off him without doing the slightest harm. But one day a javelin got him in his one vulnerable spot —that unwetted heel—and that was the end of him. And ever since then the expression "the heel of Achilles" has been used to signify the weak spot in otherwise robust beings or things. Now, I wonder what you'd pick out as the Achilles heel in the television receiver of to-day. My own experience is necessarily limited; but I've discussed the matter with a good few dealers and servicemen and most of them, after hearing the Achilles story are of the opinion that whoever mothered the television set must have held on to both heels during the ducking process. There are in fact two far-too-frequent sources of trouble. The first is the e.h.t. winding of the line output transformer and the second, the e.h.t. rectifier.

Kicks in the Neck

USING the flyback to induce from 4 to 25 kV by shock-excitation is pretty well universally accepted practice nowadays. But the winding in which that shock-excitation takes place gets 10,125 kicks in the neck during every second that the TV set is in use and it should always be so designed and made that it has an ample factor of safety. Too often this is not the case, as many viewers know from sad experience. The e.h.t. rectifier, again, is not always of a type fully up to the work in hand and can cause a lot of trouble if it isn't. I wonder sometimes that valve manufacturers are not more conservative in the limits that they lay down, or don't stick their toes in harder when set makers propose to use a particular e.h.t. rectifier of theirs in what might be called borderline conditions. It doesn't do their reputation much good when such a valve needs frequent renewal—and matters are made still worse when replacements are in such short supply that the unfortunate viewer has to wait for weeks before his dealer can put his TV receiver into action again.

Band III Service Areas

ONE'S FIRST impression on examining the I.T.A.'s expected-service-area map of the London district was that it perhaps erred a *leetle* on the optimistic side. I hope I'm wrong; and I've no doubt that as time goes on and as experience is gained an even larger area will be well served from Croydon. But as to the immediate future two recent statements make one think a bit. The first, by Belling & Lee, is that owing to the small size of its elements the Band III aerial will have to be more elaborate than that for Band I if it is going to be an equally efficient collector at a given range. Various factors limit the number of elements that can be usefully employed in a Yagi array. The second statement (from Ekco this time) is that the amplitude of the Band III signal fed to sets of theirs fitted with convertors will need to be twice as great as that of the Band I signal to give the same results on the screen. Both B. & L. and Ekco know what they're talking about. Adding up, one is forced to the conclusion (if one hadn't arrived at it already!) that if it is going to cover adequately the area served by a Band I transmitter, a Band III transmitter will need to have a power output many times greater. That, I think I'm right in saying, has been found in America, where Band III stations are authorized to use considerably larger outputs than their opposite numbers on Band I. There must, I suppose, be some particular reason why we decided to use vertical polarization for our Band III system; but it was surely something of a leap in the dark. Had we chosen horizontal polarization, a mass of data, culled from some years of American experience, would have been at our disposal. As it is, we are launching out into an entirely unexplored TV field. Perhaps it's another instance of our legendary national predilection for being different.

Sorting Things Out

WHAT a business it is to pull up one's roots and move from a house in which one has lived for many years! I speak from vivid experi-

ence, for that's what I did less than a week before I sat down to write these notes. Like, I suspect, most folk who are fond of making up and trying out new things for sound and television as they come along, I had amassed a vast and varied collection of bits and pieces; I could never bear to throw anything away for fear that I should need it. The result was that shelves, cupboards, drawers and boxes, crammed higgledy-piggledly with gear ranging from toroidal tuning coils to tweeters, from odd lengths of wire to obsolete valves, occupied every available part of my own particular stamping ground. Weeks before the move I kept telling myself that it was high time to make a start on sorting out what I really wanted from what could be dispensed with. Being by nature, however, a confirmed putter-off I didn't get down to it till only a few days were left and I've a haunting fear that I'll find myself saying sadly: "If only I'd kept *that*, it would have been just the thing for this job."

Radiating at Random

Going through stacks of files and making a bonfire of old and useless letters and papers was one of the worst parts of the job. But it was not without its rewards. One letter was, to me, particularly interesting. Written over 20 years ago, it was from the Editor of *Wireless World*, confirming his acceptance for a trial run of a new feature to be called "Random Radiations" and signed "Diallist." *Wireless World* was then a weekly and remained such up to the outbreak of the last war. As "R.R." has appeared in every issue since January 18th, 1935, this present set of notes must be somewhere about the four hundred-and-thirtieth of the series! "Free Grid" can, I believe, beat that hollow, if he can be induced to work out his figures. "R.R." has brought me over the years a vast amount of correspondence from people in almost every part of the world. And it has led to the formation of not a few close and valued friendships. One letter I shall never forget. It came early in those lean and rather ghastly years which immediately followed the war from a generous-hearted New Zealand reader who "hoped I wouldn't mind if he sent along some food parcels." I'm not an emotional person but I was nearly moved to tears. We've never met, and probably we never shall; but his family and mine have written to one another ever since and it's a very real friendship.

UNBIASED

By FREE GRID

Base Uses

"DO right and fear no man; don't write and fear no woman" is an old and true maxim. Through ignoring this advice many a man has been mulcted of a tidy sum in a breach of promise action. Modern invention has, however, rendered it completely out of date as a South American court has awarded exemplary damages against a man despite the fact that he did right and didn't write.

"Cuddles can be costly if accompanied by the whispering of sweet nothings in the shell-like ear of a girl who is a Bachelor of Science," as the learned judge remarked, in giving judgment. It appeared that the lady had a tiny microphone concealed in her hair and a pocket tape recorder hidden "elsewhere about her person." I don't know what this latter expression means, but presumably a female B.Sc. would conceal it in the top of her blue stocking.

Another application of a tape recorder has been brought to my notice by the makers of a well-known instrument on this side of the herring-pond. Tape recordings were recently used by an anæsthetist to provide what is called "distraction-anæsthesia" for a patient in the dentist's chair.

I have no wish to detract from the merits of this idea, but I am compelled to point out that there is nothing new in it. Thousands of years ago Chinese teeth extractors used thumbscrews to distract the patients' attention from the comparatively minor pain of manhandling a molar. Even the idea of using music as a "distractor" is not entirely new, for the original purpose of a military band was to drown the cries of the dying on the battlefield and thereby distract the attention of the hale and hearty from sounds which might undermine their morale.

Music has always been held to be of great psychological value, as we know from the old saying "Music hath charms to soothe the savage breast. . . ." But it must be the right kind of music, as every snake charmer knows, and the tape recorder is the only instrument suitable for providing it. If you switch on a wireless set you don't know what you are going to get and gramophone records—even L.P. ones—are too short for a major operation. There must be no break while a record changer does its stuff.

Cuddles can be costly

Planned Listening

IN these days of ubiquitous planning, system is being applied to almost every human activity. I see that in the U.S.A. there is even a society making plans for rebuilding the world in the event of its destruction in an atomic war. But amidst all this activity people still seem to listen and view haphazardly instead of planning their radio enjoyment for a week ahead after studying the programmes as I do.

Now to a large extent I blame this on the set makers for, so far as I know, there are still only two sets on the market with a built-in programme time-switch. Even in these two sets, the programme clocks are only capable of being set for twelve hours ahead. So far as I know there is not even a 24-hour programme clock on the market. What is really wanted, of course, is an instrument whereby programmes could be preset for the whole week.

Presumably there is no great demand for programme clock sets, and there are, I believe, two reasons for this. In the first place the public has the good sense to agree with me that it is a seven-day clock that is wanted, and in the second place no great effort has been made to put over the idea of planned listening.

My demand for planned listening and looking may seem a trumpery idea; so was the idea of railways before 1825. Indeed, the old Duke of Wellington called the idea "damned dangerous."

Eros or Cupid

A READER who wrote to approve of my condemning the B.B.C. announcers for their incorrect pronunciation of "polio" suggested that I should castigate them for their manhandling of Eros, the little god on the fountain in Piccadilly Circus. There is not much that slips past my observant eye or ear, and I actually dealt with the pronunciation of Eros over 23 years ago, and I reproduce here the sketch I used then. The lapse of time is vividly illustrated by the fact that I likened the B.B.C.'s pronunciation to a Piccadilly cabby's references to his steed ("This 'ere 'oss"). Horse cabs certainly don't ply in Piccadilly now, and I believe there were only two in 1932.

From my scrapbook

I notice that I also referred to the seven-metre broadcasting experiments which the B.B.C. was then conducting with a view to supplementing the m.w. service with metre-wave transmissions.

To conclude, the correct pronunciation of Eros should, of course, be Cupid. I defy even the B.B.C. to make a hash of that.

W.W. Diary 1980

AS I sat the other evening entering up the events of the day in my *W.W.* Diary I fell to wondering how much longer it will continue to be published in its present form. The only grouse I have against the present diary is that, although it undoubtedly suits the needs of many of its buyers, it is not a great deal of use to Mrs. Dale or me as the daily events of our lives are far too numerous to be recorded in the small space provided unless resort is made to the truncated *staccato* method of self-expression used by Mr. Jingle.

By 1980 all our wireless receivers will be for sight as well as sound and all will be provided with tape decks for recording voice or vision. The *W.W.* Diary will then consist of a self-contained magazine slipped into a special tape-deck chamber of its own enabling us to record our daily thoughts which can be played back through the loudspeaker at will.

I also make bold to say that all the technical information will be available on a separate tape and will be reproduced, not as the spoken word but as the printed word on the TV screen.

FLAT TUBES

SAVE SPACE

DG 16-21

FOR "A" SCAN RADAR AND INSTRUMENT APPLICATIONS

The screen of the DG16-21 cathode ray tube is a rectangle measuring 5½ x 1½ inches — the logical shape for radar 'A' scan and many instrument applications. A number of these tubes can be stacked vertically to provide multiple displays within a confined space . . . they are the answer to those problems in design where circular tubes make equipments excessively bulky.

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The DG16-21 has a green luminescent medium persistence screen. Versions with other screens are contemplated and your comments are invited.

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MVT 173

Response is not all the story

THE FERROGRAPH was the first portable Tape Recorder to be designed and wholly manufactured in Britain. To-day the bewildered buyer may well hesitate when confronted with a choice of so many makes offered. But if he is serious — and not lightly choosing something for his casual enjoyment — he would do well to ponder the following fact.

Frequency response is often popularly quoted in advertisements as 50-12,000 c.p.s. This, of itself, means nothing in evaluating the excellence or otherwise of a recorder. Two other interdependent factors must be regarded, viz.—signal/noise ratio and distortion, if the true worth of the instrument is to be gauged.

Furthermore, the limits in which the response is held must be given or the statement is again valueless. The Ferrograph frequency response is guaranteed to be within ±3 db up to 10,000 c.p.s. at 7½ i.p.s., although the response does, of course, extend much beyond this.

No exaggerated claims are made for the Ferrograph since its established reputation makes such claims unnecessary. Simple conservatism has always been a feature of Ferrograph publications and advertisements, and experience has shown the discerning user prefers it that way.

MODEL 2A/N
3¾ and 7½ i.p.s.
76 gns.

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Dealerships in several of the principal towns are still open and applications are invited.

Ferrograph

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Twin Track (to International standards)
Playing British and American pre-recorded tapes

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45 minutes per track at 7½ i.p.s. (other speeds pro rata)

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in less than 60 seconds

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giving positive reading

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Less than 0.2% at 7½ i.p.s.

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Better than 50 db, 200/12,000 c.p.s. Unweighted, including hum, 45 db.

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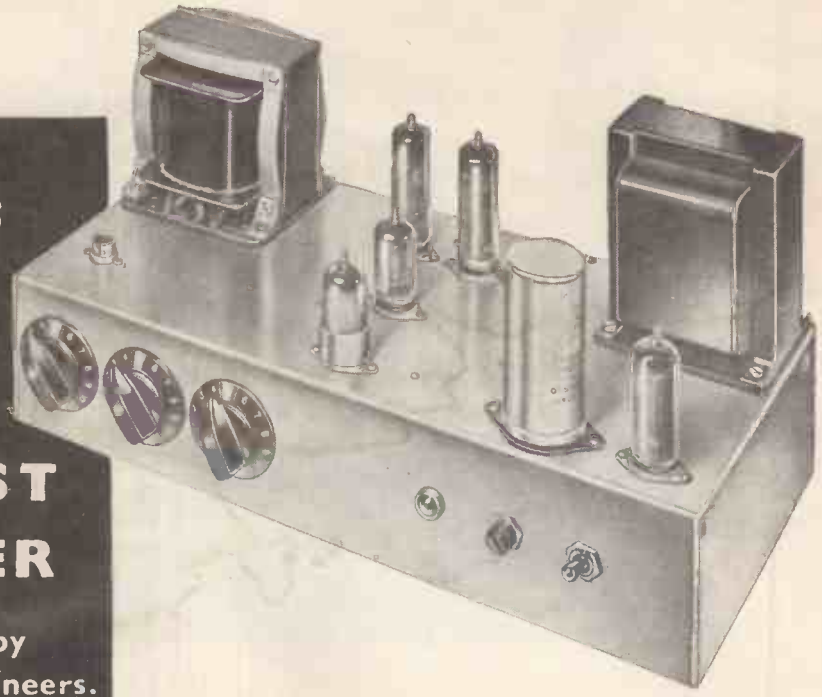
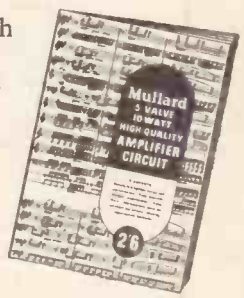


Here's an entirely new amplifier circuit which brings high quality sound reproduction within the reach of thousands more enthusiasts. It has been designed by Mullard research engineers with special regard for easy construction and low cost. Full details of the circuit are included in the 2s. 6d. book which is obtainable from radio dealers, or direct from Mullard Ltd. Valve Sales Department—2s. 10d. post free. Get your copy now.



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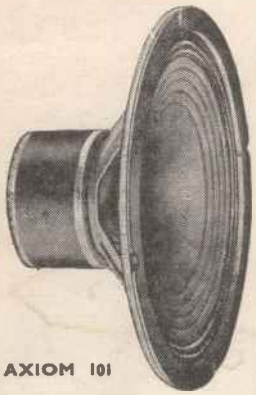

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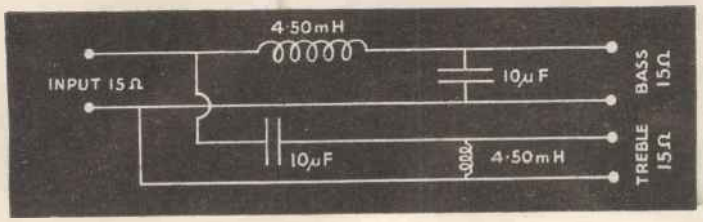

AXIOM 101, 5 watts.

Frequency coverage	40/15,000 c.p.s.
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Price	**£6/12/1 (inc. Tax)**

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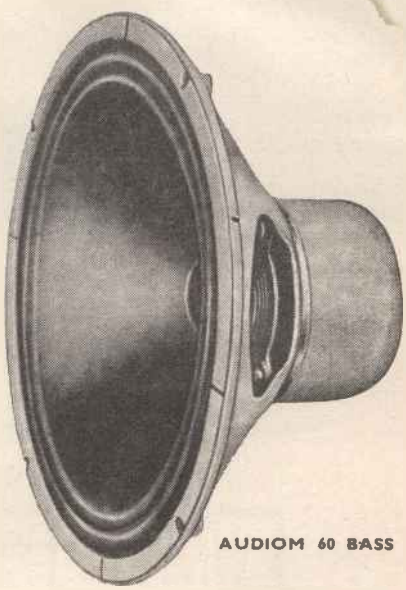
4.50 mH CHOKES, Type "1005," **price 37/- pair**

We shall be pleased to forward full details of this crossover system on request.



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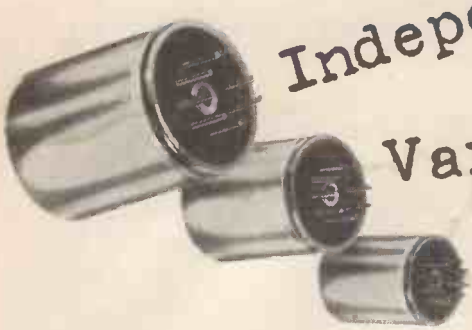

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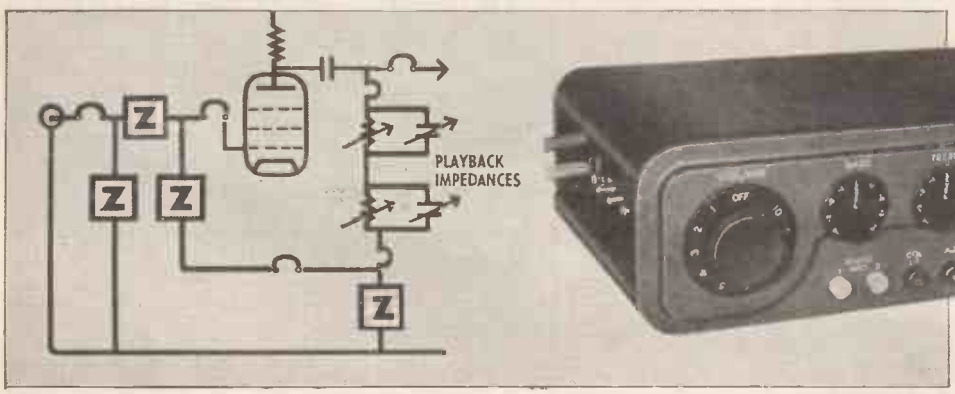
When a designer contemplates the input stage from a gramophone pickup he can (a) amplify and then compensate, (b) compensate before amplification, (c) compensate over the first stage by feedback.

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.



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,, Model 7 Meter	£19 10 0	£2 18 6
,, Electronic Test Meter	£40 0 0	£6 0 0
,, Universal Bridge	£34 0 0	£5 2 0
,, Signal Generator	£30 0 0	£4 10 0
,, Universal Avominor	£10 10 0	£1 11 6
,, D.C. Avominor	£5 5 0	15 9
,, Heavy Duty Meter	£15 0 0	£2 5 0
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,, Leather Cases for 7, 8, 40 and Heavy Duty Meter	£3 0 0	9 0
Taylor 45B Valve Tester	£25 10 0	£3 16 6
,, 66A Signal Generator	£22 10 0	£3 7 6
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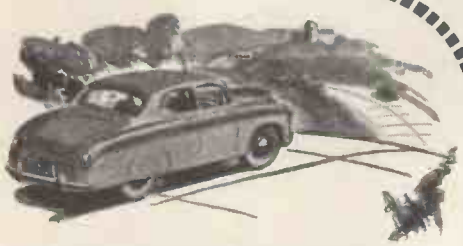
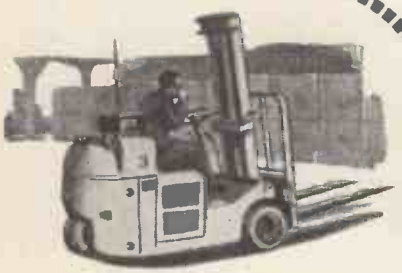
REPORTER

LOW COST—SMALL SIZE
LOW BATTERY DRAIN
MOBILE RADIO TELEPHONE





On airfields, in dockyards, in civil engineering and industry, operations reach their peak of speed and efficiency with the Pye "Reporter". All mobile personnel over a wide area can be contacted instantly through this compact and economical equipment which is quickly fitted to any vehicle. Control is simpler and swifter because wasted time and misunderstandings are eliminated. The Reporter enables four vehicles to do the work of five.
Pye Telecommunications are the largest suppliers of commercial 2-way radio in Europe and supply over 75% of British requirements.

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Melbourne, Australia

Pye Limited
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Pye (Ireland), Ltd.
Dublin, Eire

Pye Corporation of America
5th Avenue Building
200, 5th Avenue, New York

PYE LIMITED . . CAMBRIDGE . . ENGLAND

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

RECTIFIER DIVISION: Edinburgh Way, Harlow, Essex. Telephone: Harlow 26811

Simon is *Sound* recording

When you listen to a Simon Portable you're hearing Sound Recording at its lively best. Ask your dealer for a demonstration. Try its simple controls. Hear its faultless reproduction of speech and music—remember that for P.A. or record reproduction you can use the high quality amplifier independently of the recorder

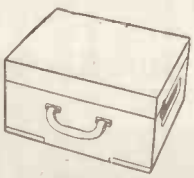
THE **ONLY** PORTABLE RECORDER

with a 10-watt High Fidelity push-pull amplifier, with less than 1% distortion at full output and incorporating Bass and Treble tone controls.

THE **ONLY** PORTABLE RECORDER

which becomes at the turn of a switch a

Tape Recorder
Record Player
10-watt P.A. Amplifier



The SP/1 is precision built to top standards. All electronic components are of the highest quality. All mechanical parts are plated.

★ *Fast rewind and wind-on.*
Servo self-energising brakes provide very rapid stop from full speed.

★ *Monomaster Finger-tip control.*
★ *2-stage capstan.*
★ *Three motor drive.*
★ *10 watts push-pull output.*
★ *Simple loading.*

Simon PORTABLE **TAPE RECORDER** MODEL SP/1 **79** GNS.

DELIVERY EX-STOCK
H.P. FACILITIES WITH PLEASURE

Ask for illustrated literature on Information Sheet T1/6.

SIMON SOUND SERVICE LTD. (Dept. W.)

48-50 GEORGE ST. LONDON W.1
Phone: WELbeck 2371 (5 lines)

THYRATRONS

for Industrial Purposes

XENON-FILLED TRIODES

These valves are suitable for a wide variety of control applications. The inert gas filling ensures stable operation over a wide range of ambient temperatures.

HYDROGEN-FILLED PULSE MODULATOR TRIODES

Designed to discharge pulse-forming networks in high power, high voltage pulse generators. Short deionization time and low time jitter provide for precise triggering at high repetition frequencies.

Technical data sheets are available on request.

Type	Filling	Max. Dimensions		Filament or Heater		Max. Peak-Inverse Voltage (Volts)	Max. Peak-Forward Voltage (Volts)	Max. Peak Current (Amps)	Max. Mean Current (Amps)	Approx. Tube Drop (Volts)	Peak Power Level (a)	American Equiv.	C.V. Number
		Length (MM)	Dia. (MM)	Volts	Amps (Approx.)								
AFX.212	Xe	54	19	6.3	0.25	350	350	0.11	0.025	11	—	6D4	1949
AFX.203	Xe	176	57	2.5	4.0	300	280	1.7	0.40	11	—	C1A	2868
FX.215	H_2	286	97	2.5	27.5	16,000	16,000	200	0.20	100(b)	2.0×10^9	—	2203
FX.219	H_2	222	65	6.3	10.6	16,000	16,000	325	0.20	100(b)	3.2×10^9	5C22	2520
FX.225	H_2	175	65	6.3	6.1	8,000	8,000	90	0.10	100(b)	2.0×10^9	4C35	1787
FX.227	H_2	132	40	6.3	2.25	3,000	3,000	35	0.045	100(b)	0.3×10^9	3C45	372

Xe — Xenon H_2 — Hydrogen

(a) — Product of Peak forward Voltage, Peak Current and pulse repetition frequency.

(b) — Under conditions of pulse operation.

ENGLISH ELECTRIC

ENGLISH ELECTRIC VALVE CO. LTD.

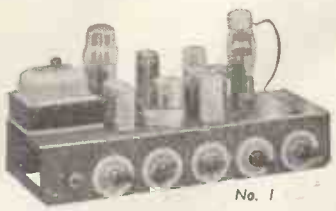
Waterhouse Lane, Chelmsford
Telephone: Chelmsford 3491

AP300/13

REAL HIGH FIDELITY *at modest cost . . .*

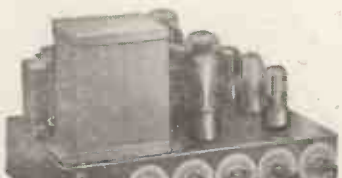
Manufacturer-to-Consumer policy saves you at least one-third cost!

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 0.1 v. 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 Cabinet, 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" or Transcription. 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.

MODEL TA 3-speed unit, with plug-in turnover head Type G.C.2, £10/16/-, or with Acos HGP 33 or 37 heads, £10/14/-, or with two separate high fidelity Acos HGP35 heads, £12/17/-. 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, 54/6, Decca Crystal, 33/-, Garrard Standard Magnetic, 28/-, miniature magnetic low impedance, 28/-, miniature magnetic high impedance, 38/-. Post on heads 1/-. Unit can be supplied with any combination of above heads and is carefully adjusted for stylus pressure on despatch.

MODEL RC80M, less heads, £15/5/-, with new turnover head, £17/9/6, with two separate Acos HGP35 heads £19/9/-, carriage 5/-.

COLLARO PICKUPS AND HEADS. Studio Pickup Arm, 13/10. Studio Pickup head type "O" or "P," £3/0/9. Pickup complete £3/14/7. Studio Transcription Pickup Arm with Studio "P" head, £4/15/9. Ditto with Transcription head, £5/2/5.

TRANSCRIPTION MOTORS IN STOCK.

COLLARO TRANSCRIPTION MOTOR, Model 2000, Mk. II, £13/9/6. Model 2010, including Transcription pickup and PX cartridge, £18/12/-. Carriage 5/- in either case.

NEW CONNOISSEUR variable speed on all 3 speeds £25/15/5.

GARRARD Model 301, £25/3/6.

Cabinets available to house any of the above motors together with pick-up, price £3/7/6. Carriage 5/-.

SNIP NO. 1

GARRARD LATEST MODEL RC80M AUTO-CHANGER. Fitted with full-length Pick-up Arm to take 3-pin plug-in heads, manufactured end of Oct. 1954. PRICE LESS HEADS, £15/5/-, carriage paid. These extraordinarily versatile units can be supplied fitted with the following combinations of Pickup Heads at the following prices:

With two Decca XMS ffrr Magnetic Heads, £20/15/-.
With two Decca Crystal Heads, £18/10/-.
With Decca Crystal for L.P. and Garrard Miniature Mag. for Std. Takes miniature fibre or steel needles. £18/13/-.
With adaptor and two Acos HGP39-1 Heads, £20/5/-.
With adaptor and one Acos HGP39-1 Head for L.P. and Garrard Miniature Mag. High Impedance for Std. Takes miniature fibre or steel needles, £19/17/-.

The above combinations of heads are matched for output and the stylus pressure is carefully adjusted before despatch. Carriage paid.
Above mounted in Portable Cabinet 90/- extra.
IMMEDIATE DELIVERY from STOCK guaranteed.

"MONARCH" latest model, 3 speed **AUTO CHANGER** with ACOS HGP37 head, price £13/10/-. Carriage 5/-. Leaflet 2½d. Mounted in Portable Cabinet 70/- extra.

"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.

HIRE PURCHASE FACILITIES
***NOW AVAILABLE** on orders of £15 or over.*
Send one-third deposit with order, balance over 6 or 12 monthly instalments. *State which required.*

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11, KINGS COLLEGE RD., ADELAIDE RD
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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).

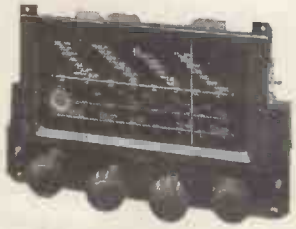
TREBLE BAFFLE veneered to match, optional extra 50/-.

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, price 10 gns. Oak or Mahogany veneers 10/- extra. Special finishes to order. Carriage according to area, we will quote.

Northern Radio Services (CONTD.)

"SYMPHONY" RADIO FEEDER UNITS

NO. 1 "SYMPHONY" TUNER. A T.R.F. model designed for the quality reception of local stations. Quality is adequate for amplifiers of the highest fidelity class. Infinite impedance detection. Controls: gain, wave-change and radio/gram switch. Illuminated engraved glass dial. Latest miniature valves. Overall dimensions: 9in. wide × 6in. deep × 6in. high. Power required: 6.3 v. at 1 amp. and 250/300 v. at 15 m/a. Price £7-7-0. Carr. & pkg. 5/-.



NO. 2 "SYMPHONY" SUPERHET TUNER. Three wave-bands, advanced circuit, very newest valve types, floodlit glass dial with bronze escutcheon provided. Suitable for use with the best amplifiers. Overall dimensions: 12in. wide × 8½in. high × 7in. deep. Controls: on/off/gain, radio/gram, wave-change and tuning. Dial cut-out: 8in. × 4¼in. reading horizontally or vertically (state which required). Tuner can be readily mounted at any angle. Requires 6.3 v. at 1.5 amp. and 250/300 v. at 20 m/a. Price £11-11-0. Carr. & pkg. 5/-.

No. 2/VS "SYMPHONY" SUPERHET TUNER. As No. 2 but incorporating on the wave-change switch an extra position for radio, thus making two radio positions. One is the standard one with 9 kc. separation and the extra one providing virtually T.R.F. band-width and quality on local stations. Price £13-13-0. Carr. & pkg. 5/-.

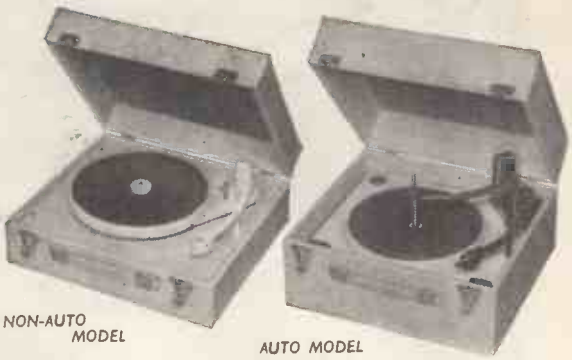
All above tuners are made to plug in to any of our "Symphony" Amplifiers in a matter of seconds by means of the octal plug fitted at the end of a flexible multi-cable. They are ideal for providing in conjunction with our "Symphony" Amplifiers, the same high quality on radio as is obtained from these amplifiers on gramophone, but they are equally suitable for use with other high fidelity amplifiers, and where the output circuit requires modification to match a given amplifier this can be carried out free of charge. Either of the two Superhet models can be fitted with a magic eye tuning indicator for £2-2-0 extra. Furthermore, they can be fitted with a pre-amplifying stage to match the Decca Magnetic Pickups or the Collaro Studio type "P" pickup head for use with amplifiers which would not otherwise have enough gain for these comparatively low output pickup heads. In these cases, two separate correction circuits—one for standard and one for LP as recommended by the pickup manufacturers—are incorporated in the radio/gram switch. Please send for our catalogue giving further details.

TAPE DECKS AND AMPLIFIERS

TRUVOX TAPE DECK MARK III. TR2/U. Latest version to take pre-recorded tapes. Price 22 gns. Illustrated leaflet 2½d.

TAPE AMPLIFIER TYPE C, expressly designed by Truvox to work perfectly with their Deck, 3 valves plus rectifier and Magic Eye level indicator. Price 16 gns.

NEW MODEL PORTABLE RECORD PLAYERS



NON-AUTO MODEL

AUTO MODEL

We are pleased to announce the entry on to the market of two "Symphony" Record Players designed to represent the greatest value in this line ever offered. Model No. 1 contains the Collaro 3-speed single record playing unit AC3/554 and model No. 2 contains the Collaro Autochanger RC54. They are available with either Type "O" insert, "P" insert or transcription insert. Prices (in attractive rexine case), No. 1 £10-19-6, No. 2 £14-19-6. Carr. 7/6. Transcription insert 6/9 extra.

GOODMANS CORNER CABINETS (right) for the AXIOM 150 Mark 2 manufactured by us to Messrs. Goodmans' specification and approved by Messrs. Goodmans. Height, 44in. Price: complete kit in plain board with 1in. thick felt, 8 gns. Price: ready built, 10 gns. Finished in figured walnut, 16 gns. Other veneers to order. Carriage extra according to area.

GARDNERS RADIO

There are 399 Standard types of 'SOMERFORD' Transformers and Chokes IN STOCK . . . . .

GARDNERS RADIO LTD., SOMERFORD, CHRISTCHURCH, Hants. Tel. 1024

ANNOUNCEMENT

FM RECEIVER ALIGNMENT GENERATOR MODEL 1324

This Alignment Generator will be available later this year to provide the Service Engineer with a compact test set with which all essential alignment procedures on FM Broadcast Receivers may be undertaken.

Accurate trimming for correct overall and IF response curves is easily carried out and facilities will be provided for discriminator alignment and checks on its sensitivity and distortion.

Watch for the release date and price.

COSSOR Model 1322 | Telecheck and Marker Generator for Bands I and III

Model 1322 — used in conjunction with a cathode ray oscillograph — provides equipment for the display, measurement and correct adjustment of RF and IF response curves of television receivers. This entirely new instrument comprises a swept oscillator covering the Television BANDS I and III (5-75 Mc/s. and 155-255 Mc/s.) and a frequency marker oscillator so that precise calibration of the oscillograph display may be made; accuracy of the frequency of the marker pips being verified by reference to an internal crystal. The alignment oscillator is set to the video carrier to which the receiver is tuned and the sweep (either 1 Mc/s. or 10 Mc/s.) is automatically derived from the time base voltage of the display oscillograph. The response of the "strip" under test to the frequency band applied is then presented on the screen of the cathode ray tube. The RF output of Model 1322 is available at 75 ohms and is adjustable from a maximum of 40 millivolts to a minimum of 10 microvolts through a coarse and fine attenuator.

TELECHECK CONVERTER FOR BAND III Model 1321

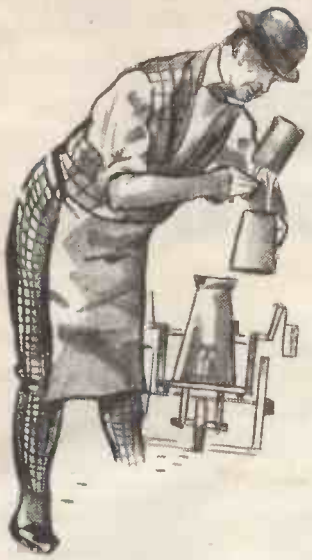
This adaptor provides owners of Model 1320 "Telecheck" with an extension of the frequency range of the original instrument into the BAND III television channel. Thus, alignment procedures adopted for BAND I RF/IF "strips" are available also for BAND III receivers. A selection of the desired BAND is made by means of a switch. Pattern generator facilities for picture time base linearity checks have been retained. Model 1321 Adaptor is designed for permanent attachment to the standard "Telecheck" providing a neat, light and compact unit. Mounting is effected by four screws and the inter-connecting wiring is carried in a single insulating sleeve.

COSSOR ELECTRONIC INSTRUMENTS

Write for illustrated leaflets about both these instruments:

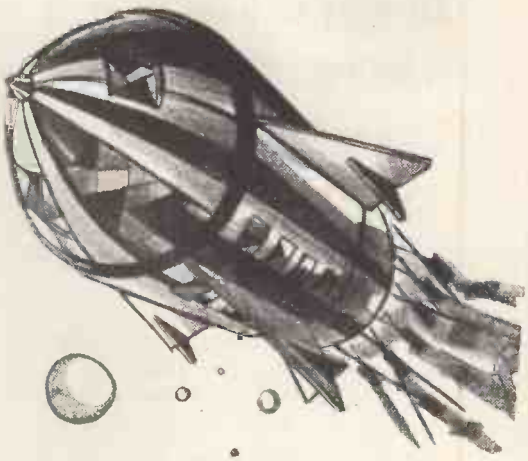
COSSOR INSTRUMENTS LIMITED (Dept. 1) HIGHBURY GROVE · LONDON · N.5

Telephone: CANonbury 1234 (33 lines) *Telegrams: Cossor, Norphone, London* *Cables: Cossor. London*



Local Colour

It isn't so very long since this form of delivery ceased to satisfy the increasing demand. In fact, there are still some people who were sorry to see the old milk float superseded by the horse-drawn cart—and now there are not so many of these either.



Wide Range

But deliveries must keep up with the times, and already there have been experiments with long-range rockets to deliver postal packets at speeds which would make airmail look as if it were at a standstill.

International Coverage

We at Classic have the importance of safe, speedy delivery well in mind. We don't actually use rockets, but we do use all the best methods, and our export despatch department rather prides itself on the safe delivery of orders. They get plenty of practice, too. We find that the demand for Hi-Fi equipment is world wide, and more and more people are turning to Classic, where they can choose from a *completely* comprehensive selection of TR, Hi-Fi, or FM equipment—a selection that is right up to date.

Send for our 16-page illustrated catalogue (U.K. 6d. Special Export Edition 1/- Airmail Extra) and you'll see just how comprehensive our selection is.

CLASSIC ELECTRICAL

COMPANY LIMITED

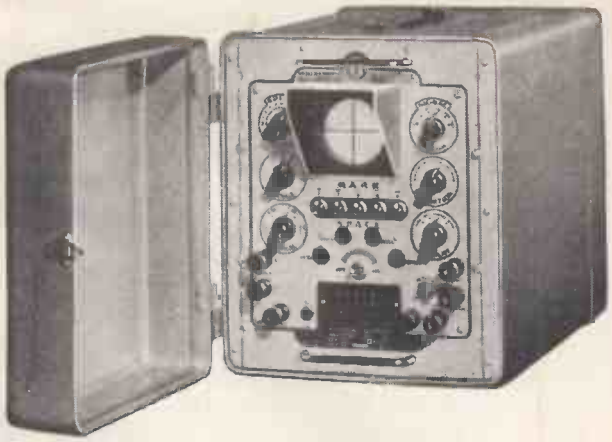
THE HI-FI SPECIALISTS

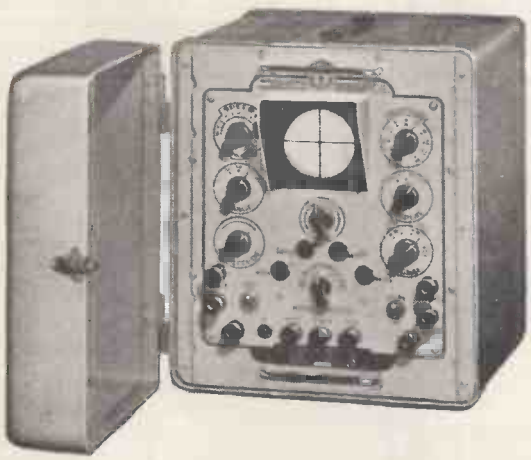
352-364 LOWER ADDISCOMBE ROAD, CROYDON, SURREY Telephone : ADDiscombe 6061

a new T.D.M.S

The T.D.M.S. 5 & 6 are portable sets designed to measure distortion at any point in a radio teleprinter or line telegraph circuit without interfering with normal transmission.

The equipment consists of two units each $16\frac{1}{2}$" x $10\frac{1}{2}$" x 12" both mains driven and electronically controlled; either may be used independently for certain tests or both may be used in combination to cover a comprehensive range of testing operations.





T.D.M.S. 5

Sends an automatic test message or characters or reversals at any desired speed and/or percentage of distortion. The CRO has a circular time base for distortion measurements or relay adjustment.

T.D.M.S. 6

For distortion measurements on working circuits without interrupting service. Each element of a start-stop signal appears separately on the spiral time base display. Adjustable speeds from 20–160 bauds.

You are invited to apply for a copy of a descriptive leaflet which describes the equipment in detail

Automatic Telephone & Electric Co. Ltd.

Radio and Transmission Division, Strowger House,
Arundel Street, London, W.C.2. Telephone: TEMple Bar 9262. Cablegrams: Strowgerex London.

ATM REGD. TRADE MARK

AT 14501—BX 107

And NOW—a range of 'CERAMICAPS' for your LAB TESTED 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.

RESISTORS					
Ref.	Type	Loading	Max. Volts	Range	Dimensions
T	¼ watt	¼ watt	250	10 ohms to 10 megohms	⅛" x ⅝"
R	¼ watt	1 watt	500		⅜" x ¼"
Tolerance available ±20%, 10%, 5%					
HIGH STABILITY RESISTORS					
HS3	¼ watt	¼ 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 Tolerances ±2%, 10% 500 - 5000 pf 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

Hi Fi INFINITE DAMPING FACTOR AMPLIFIER

The PF91 amplifier, with the PF91A remote control unit, is a versatile and practical combination for those who demand realism in sound reproduction from record players, tape recorders, microphones or radio tuners.

PF91
Power Amplifier. Undistorted output up to 12 watts. Frequency response substantially flat from 2 to 160,000 c.p.s. Infinite damping factor.

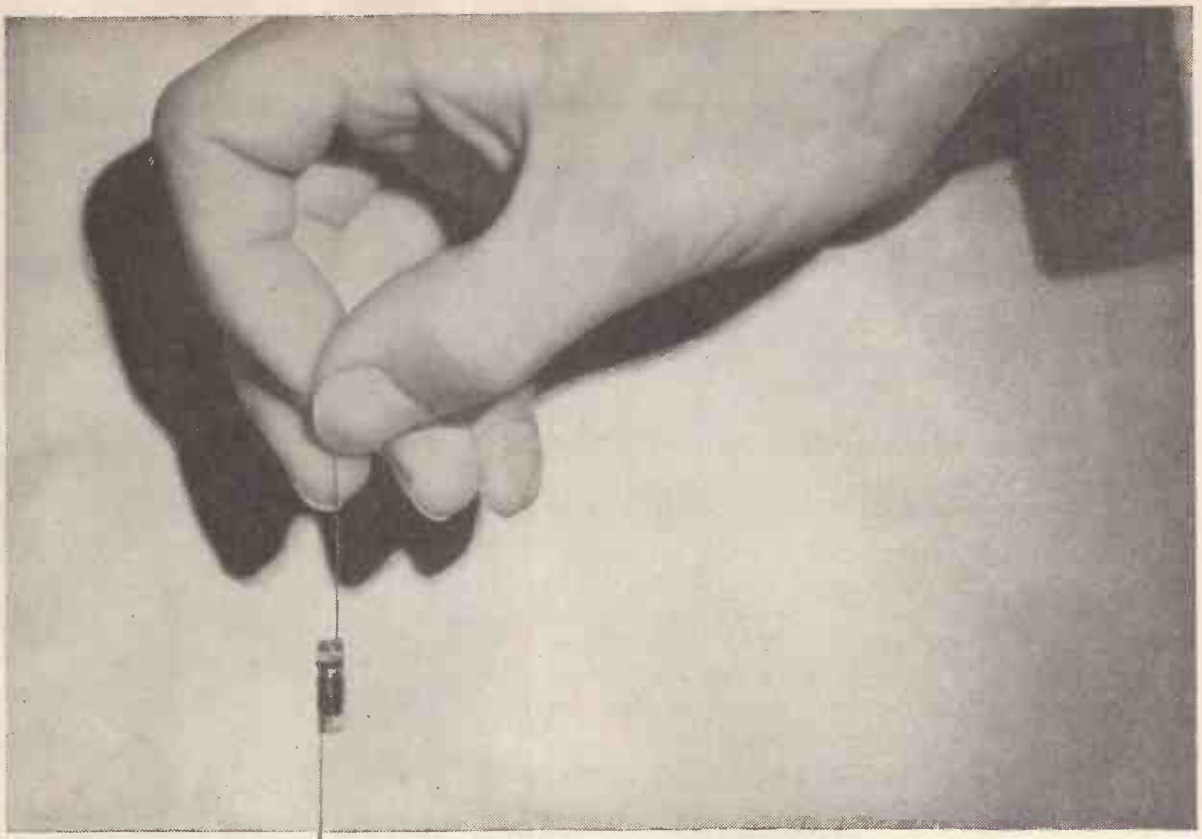
MODEL PF91
28 GNS

MODEL PF91A
12 GNS

Demonstrations of the PF91 can be arranged through Pye Hi-Fi agents. Please write for a fully illustrated booklet to Pye Limited, Box 49, Cambridge.

PYE LIMITED · CAMBRIDGE · ENGLAND

and **EIRE · AUSTRALIA · NEW ZEALAND · CANADA · SOUTH AFRICA · U.S.A. · MEXICO**



More pF per in *

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put a quart of capacitance into a pint of space.
If you have a problem which demands
a capacitor of excellent electrical performance
and the smallest possible size,
you may well find the solution if you
contact Suflex

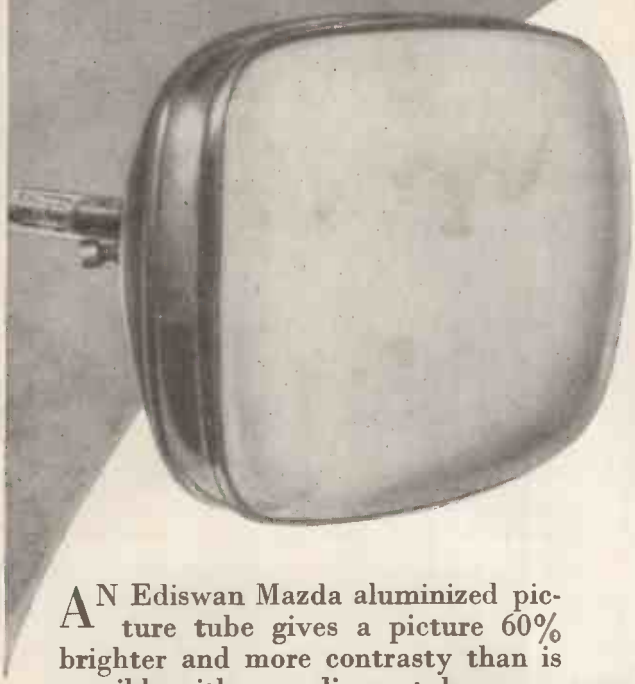
SUFLEX *Limited*
LONDON

* for example, 100 pF in a capacitor $\frac{1}{2}$" long, about $\frac{3}{16}$" dia.

The Suflex range of good electrical products includes
Polystyrene capacitors • Silicone/varnished insulating sleeving • Plastic sleeving • Plastic covered wire • PVC/Nylon lacing cord • Glass/Nylon dial drive cord • Copper wire braids • Cotton braids

35 BAKER STREET, LONDON W.1. *Telephone: WELbeck 0791 Cables: Suflex, London*

This ALUMINIZED Picture tube gives

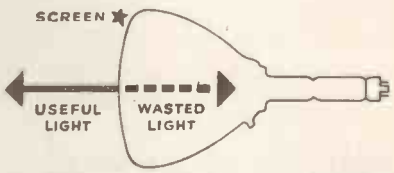


60% brighter pictures more contrast extra tube life

AN Ediswan Mazda aluminized picture tube gives a picture 60% brighter and more contrasty than is possible with an ordinary tube.

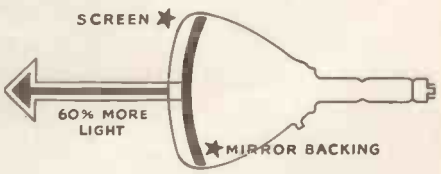
In addition, Ediswan aluminizing protects the screen from ion burn and, with the new Ediswan ion trap tetrode gun to protect the cathode, tube life is increased.

Ediswan production methods, which include the special in-line vacuumizing system, ensure a higher, more uniform standard of lasting efficiency. For complete satisfaction demonstrate and recommend Ediswan Mazda aluminized picture tubes.



WITHOUT ALUMINIZING

Without aluminizing, tubes waste half their light (see diagram above). To counteract this the brilliance must be increased and the tube life is shortened.



WITH EDISWAN ALUMINIZING

Ediswan aluminized tubes have a mirror backing to the screen. All the light is thus thrown forwards giving brighter, clearer pictures and extra life.

RV9

EDISWAN
MAZDA

ALUMINIZED CATHODE RAY TUBES

THE EDISON SWAN ELECTRIC COMPANY LIMITED, 155 Charing Cross Road, London, W.C.2 and Branches.

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

NATION WIDE SERVICE

6 fully equipped cathode ray tube service depots provide better, quicker tube testing should the need arise. Stocks of tubes are available in 26 Ediswan Offices. Only Ediswan give such complete backing to the Trade.

A HIGH Mu PENTODE
with low hum, noise and microphony

TYPICAL OPERATING CONDITIONS

Anode Voltage (Va)	250	250	250	250
Screen Voltage (Vg_2)	80	100	160	200
Grid Bias (Vg_1)	1.25	1.7	2.75	3.5
Anode Current (mA)	7.8	7.9	10.5	12.3
Screen Current (mA)	2.45	2.5	3.3	3.85
Mutual Conductance (mA/V)	7.0	7.0	7.45	7.6
Anode AC Resistance (ra) (Megohms)	0.55	0.55	0.4	0.3
Input Capacity (Hot) ($\mu\mu$F) ...	20	19.9	19.7	19.5

RATING

Heater Voltage	V_h	4.0
Heater Current (Amps)	I_h	1.0
Maximum Anode Voltage	V_a	250
Maximum Screen Voltage	Vg_2	250
Mutual Conductance (mA/V)	g_m	7.7

Taken at V_a=250; Vg_2=100; Vg_1=1.5

BASE

British 7 pin
Pin No. 1 Metallising
Pin No. 2 Anode
Pin No. 3 Suppressor Grid (g_3)
Pin No. 4 Heater
Pin No. 5 Heater
Pin. No. 6 Cathode
Pin No. 7 Screen (g_2)
Top Cap Control Grid (g_1)

The AC/SP3 RH is available in two grades. The valves in both grades are characteristically identical, the grading 'A' or 'B' relating only to relative levels of hum, noise and microphony. B Grade valves are suitable for the majority of applications, but for particular applications where the noise level is very important Grade A may be preferred.

Under typical operating conditions with V_a=250v, R_a=150 KΩ, Rg=150 KΩ, Rg_2=500 KΩ, R_k=1 KΩ, with the heater fed from a centre-tapped A.C. supply the equivalent hum voltage at the grid of an average grade A valve is approximately 5μV, whilst the combined noise (excluding hum generated by the valve and grid resistances, using a high quality A.F. amplifier) is not greater than 8μV.

The following table compares the noise, hum and microphony from the two grades of valve.

HUM	NOISE
'A' × 5.6 down on 'B'	'A' × 2 down on 'B'

MICROPHONY
'A' × 8 down on 'B'

SV3

THE EDISWAN MAZDA AC/SP3 RH is an indirectly heated Pentode with a special heater construction designed to reduce hum due to A.C. fields within the valve.
Provided precautions are taken to minimise hum due to external wiring, the AC/SP3 RH may be used in the early stages of amplifiers where the reduction of hum, noise and microphony is of primary importance.

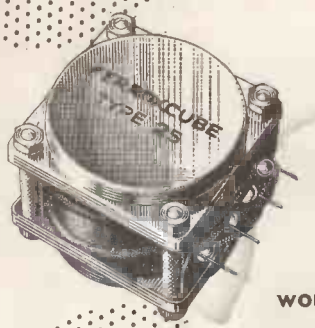
Full technical information on request.

EDISWAN
MAZDA
VALVES & CATHODE RAY TUBES

The Edison Swan Electric Co. Ltd.
155 Charing Cross Road, London, W.C.2
and Branches

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

Telephone: Gerrard 8660. Telegrams: Ediswan, Westcent, London



High Q inductance coils

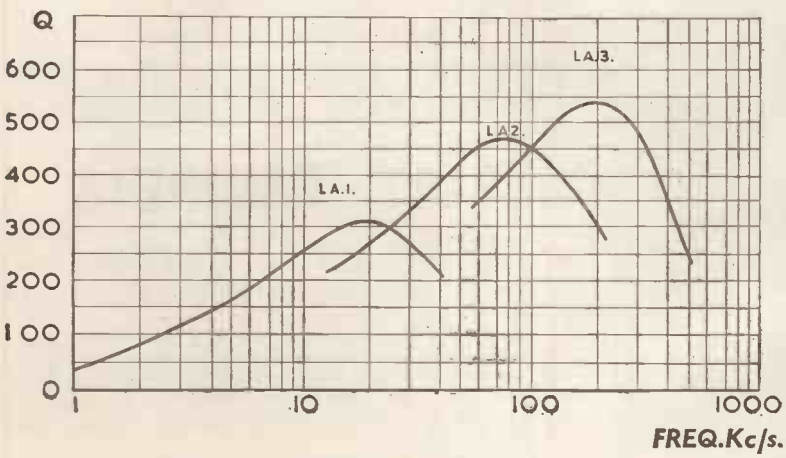
wound on Ferroxcube cores

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

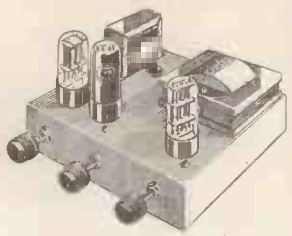
Mullard

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

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

PREMIER RADIO COMPANY

4-WATT AMPLIFIER



MAY BE BUILT FOR **£4.10.0** Plus 2/6 Pkg. & Carr.

Valve line-up 6SL7, 6V6 and 6X5, 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.

UNITELEX 5-watt Amplifier Type MG4/MG4A

For Gramophone and Microphone operation, enclosed in metal case, output suitable for 15 and 3 ohms Speakers, switched input BVA miniature Valves, separate treble and bass tone controls, for A.C. mains 200/250 v.
Price, enclosed in metal case, £9/19/6.
Price, less metal case, £8/18/6.
Packing and Postage 7/6.

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
,, K3/100	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.	120 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.	19/6

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 P. and P. **35/6**

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-volt Accumulator 13/6
2004 Charges 2, 6 and 12 v. accumulators at 1 amp. 19/11

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

CABINETS—PORTABLE

Model PC/1 Brown Rexine covered **15/11**
Overall dimensions 15in. × 13½in. × 5in.
Clearance under lid when closed 2½in.

Model P2/C Grey Lizard Rexine covered **45/-**
Overall dimensions 15in. × 13in. × 6in.
Clearance under lid when closed 3in.

Model PC/3 Rexine type covering in various cols., 69/6.
Overall dimensions 16½in. × 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.

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, 4BA × 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)

H.P. Terms : Deposit £10.4.9 and 12 monthly payments of £2.16.11,

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/-.

H.P. Terms : Deposit £9.6.0 and 12 monthly payments of £2.11.9.

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.

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 £1/0/6.
Amplifier Kit (including Speaker). £11/-/- plus packing and carriage 5/-.
Hire purchase terms, Deposit £2/15/- and 9 monthly payments of £1/0/7.
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 £1/5/9.
Portable Cabinet (rexine covered). £4/19/6, plus postage and carriage 5/-.
Microphone, £2/15/-, 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:
Deposit £3.18.9 & 12 m'nthly payments of £1.1.11

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 6.3 v. 3 A. 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	
3.5 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. ..	2½ × 2½		7/6
500 mA.	2½ round	M/C	10/6
30 A.	2½ × 2½	M/C	8/6
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/-

★ **SEND 2½d. STAMP FOR OUR 1955 CATALOGUE** ★

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/-
SP351A, 350-0-350, 150 mA., 4 v. @ 2-3 a., 4 v. @ 3-6 a., 4 v. @ 1-2 a., 4 v. @ 1-2 a..... 30/-
SP352, 350-0-350, 150 mA., 5 v. @ 2-3 a., 6.3 v. @ 2-3 a., 6.3 v. @ 2-3 a..... 30/-
SP425A, 425-0-425, 200 mA., 6.3 v. @ 2-3 a., 6.3 v. @ 3-5 a., 5 v. @ 2-5 a..... 52/6
250-0-250, 80 mA., 6.3 v. @ 4 a., 5 v. @ 2 a..... 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

E.H.T. primary 230 v., secondary 1.75 Kv., 2 × 4 v. tapped 2 v 37/6
E.H.T. TRANSFORMER, primary 210 v., 230 v., 250 v., secondary 4 Kv. and 2 v..... £3/7/6
E.H.T. TRANSFORMER, primary 210 v., 230 v. 250 v., secondary 5Kv. and 2 v..... £3/12/6

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 900-2,000 metres. 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.

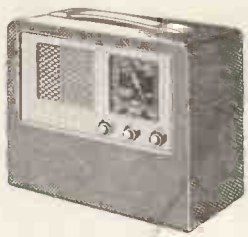
TRF RECEIVER

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. Waveband 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 WALNUTor IVORY BAKELITE or WOOD.

INSTRUCTION BOOK 1/- (post free) which includes Assembly and wiring diagrams, also a detailed Stock List of priced components.

ALL-DRY BATTERY PORTABLE RADIO RECEIVER



MAY BE BUILT FOR **£7.8.0** Plus 2/6 Pkg and Carr.

4 miniature Valves in a Superhet Circuit covering medium and long waves. Rexine covered Cabinets 11½in. x 10in. x 5½in. in two contrasting colours. Wine with Grey Panel, or Blue with Grey Panel, please state choice when ordering. **THE SET MAY BE USED EVERYWHERE**—*home, office, car or holidays.* **INSTRUCTION BOOK, 1/6 (Post Free) which includes Assembly and wiring diagrams, also a detailed Stock List of priced components.**

DECCA MODEL 33A
RECORD PLAYER
ADAPTABLE FOR STND. OR L.P.

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/-.

3-SPEED AUTOMATIC RECORD CHANGER

Made by World-famous manufacturer. The Unit designed to play 12in., 10in. and 7in. Records intermixed in any order at 33⅓, 45 or 78 r.p.m. Capacity 10 records. New reversible dual stylus crystal Pick-up has extended frequency range. An essential feature is the simplicity of design. For use on 100/125-200/250 volts 50 cycles. A.C. mains.

LIMITED QUANTITY ONLY. Plus packing and carriage 5/-. BRAND NEW, guaranteed and in manufacturers' original carton.

£11.11.0
LIST PRICE £16/10/-.

MINIATURE TUNING CONDENSERS

2-gang .0005 mfd. with trimmers..... 6/9

PREMIER VARIABLE IMPEDANCE "MATCHMAKER" M.O.15 OUTPUT TRANSFORMERS

Designed to meet the demand for an efficient variable ratio Output Transformer 11 ratios from 13 : 1 to 80 : 1 all centre tapped and can be used to match any output valves either single or push-pull Class "A" " AB1" "AB2" or "B" to any low impedance speech coil or combination thereof. Primary Inductance 50 henries 15 watts audio 100 mA. Price 45/-.

LOUDSPEAKERS

ELAC—2½in. dia., Moving Coil, 15 ohm 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 £8/12/6
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 thermocouple, 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. Hall Type, £2/10/-.
CRYSTAL MICROPHONE—Rothermel 2AD56. Especially recommended. £2/15/- 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, £2/10/-.
ACOS. "MIC30" 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 19/6.

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

Managing Editor:
HUGH S. POCOCK, M.I.E.E.

Editor:
H. F. SMITH

MAY 1955

In This Issue

VOLUME 61 NO. 5
PRICE: TWO SHILLINGS

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OF PUBLICATION

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VALVES, TUBES & CIRCUITS

29. EF89 & UF89: IMPROVEMENTS IN I.F. AMPLIFIERS FOR F.M./A.M. RECEIVERS

I.F. amplifiers for f.m. reception are normally 'neutralised' in order (i) to achieve satisfactory stability and (ii) to minimise the effects of capacitive feedback from anode to signal grid in producing phase distortion and distortion of the bandpass curve. An i.f. voltage is led back on to the screen grid through a neutralising capacitor, and passes through the interelectrode capacity $c_{g1\text{-}g2}$ to the signal grid; there it cancels out the voltage passed through the capacity $c_{a\text{-}g1}$, the two voltages being of equal magnitude and opposite phase. The neutralising capacitor forms the fourth arm of a bridge network, and its value is chosen to balance the bridge. Unfortunately a bridge which has been balanced for f.m. reception may not remain balanced during a.m. operation.

The Mullard EF89 is a medium slope variable-mu pentode whose introduction will tend to make neutralising requirements less critical. Unneutralised r.f. and i.f. circuits can be considered under some conditions where previously neutralising would have been required.

The maximum amplification realised with the EF89 is higher than that obtained with previously available valves such as the EF41. An indication of the maximum amplification obtainable from an r.f. and i.f. pentode is given by a quality factor defined as the ratio of slope to anode-to-grid capacitance. When designing the EF89, the small anode-to-grid capacitance of the EF41 ($c_{a\text{-}g1} < 0.002$pF) was used as a starting point, and the design of the EF41 modified to produce the highest practicable slope without increasing the capacitance.

Under normal operating conditions, with a 9mA anode current, the slope is 3.5mA/V for a grid bias of -2.0V.

For f.m. reception the first stage of i.f. amplification is provided by the heptode section of the ECH81 (which during a.m. reception functions as a conventional triode heptode frequency changer). The second i.f. amplifier will be the EF89, feeding into the ratio detector (diodes a''_d and a'''_d of the EABC80).

The EF89 has been so designed that when it follows the ECH81 connected as the a.m. frequency changer, the a.g.c. voltage can be applied to both valves if desired. (Normally of course a.g.c. is not necessary for f.m. reception.) At high input signals overcontrolling does not occur, that is, an increase in signal strength does not lead to a decrease in output, and the distortion associated with overcontrolling is avoided. The cut-off characteristics of the EF89 and ECH81 mixer heptode are so matched that, when the grid voltage is changed from -2V to -16.5V, the slope of the EF89 falls to one-tenth of its original value whilst the slope of the ECH81 heptode falls to one-twentyfourth. The cross-modulation curve is better than for the EF41, and the a.g.c. voltage therefore can be allowed to take the slope down to a small value without appreciable distortion.

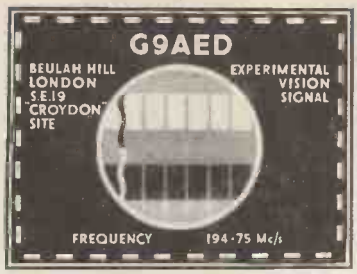
The EF89 may be used also as a variable-mu r.f. amplifier. The screen grid is brought out to its own pin connection (No. 8), and the internal screening is connected to two separate pins (Nos. 1 and 6). These connections are very helpful in the design of r.f. (and, for that matter, i.f.) amplifiers, in that no additional damping is introduced by earthing the suppressor grid and screening. The suppressor grid connection to the chassis should have the lowest possible resistance (R_{g3} max = 10kΩ).

The UF89 is rated at 12.6V, 100mA and is intended for d.c./a.c. mains receivers. In all other respects it is identical with the EF89 (6.3V, 200mA), and the same operating conditions apply to the E- and U-versions.

PRELIMINARY DATA: EF89

HEATER		
V_h	6.3	V
I_h	200	mA
CAPACITANCES		
c_{in}	5.5	pF
c_{out}	5.1	pF
c_{a-g1}	<0.002	pF
c_{g1-h}	0.05	pF
CHARACTERISTICS		
V_a	250	V
V_{g3}	0	V
V_{g2}	100	V
V_{g1}	−2.0	V
I_a	9.0	mA
I_{g2}	3.0	mA
g_m	3.6	mA/V
r_a	1.0	MΩ
TYPICAL OPERATING CONDITIONS		
$V_a = V_b$	250	V
V_{g3}	0	V
R_{g2}	51	kΩ
R_k	160	Ω
I_a	9.0	mA
I_{g2}	3.0	mA
g_m	3.5	mA/V
r_a	1.0	MΩ
R_{eq}	4.2	kΩ
g_m ($V_{g1} = -20$V)	240	μA/V
LIMITING VALUES		
$V_{a(b)}$ max.	550	V
V_a max.	300	V
p_a max.	2.25	W
$V_{g2(b)}$ max.	550	V
V_{g2} max.	300	V
p_{g2} max.	0.45	W
I_k max.	16.5	mA
R_{g1-k} max.	3.0	MΩ
V_{h-k} max.	100	V
BASE	B9A	

Pin:—	1	2	3	4	5	6	7	8	9
	s	g_1	k	h	h	s	a	g_2	g_3



"BELLING-LEE" BAND III EXPERIMENTAL TRANSMITTER

G9AED is the call sign allocated by the Postmaster General to the "Belling-Lee" band III experimental transmitter which, through the helpful co-operation of the Independent Television Authority, will be situated on part of the site of their temporary mast and transmitter at Croydon. The site is actually named on the 1in. ordnance map sheet No. 170, as "Beulah Hill" with a map reference 333696.

Transmissions are due to commence on April 1st.

The test card is primarily intended for the investigation of ghost images and provides the following features:—

(a) A wavy line in black and white, followed by white, grey and black. This line is wavy to differentiate from the vertical range marks. With ghost signals the wavy line predominates, the positive or negative ghosts can be identified.

(b) Vertical lines numbered 1, 2, 3 and 4 indicating the additional path in miles that the ghost has travelled, i.e., if the reflecting object is situated directly behind the receiving aerial, in line with the trasnmitter, the distance of the reflecting object is exactly half the extra distance travelled by the delayed image.

(c) A circle to enable approximate linearity adjustments to be made to the receiver.

(d) The black and white border to the card corresponds to the similar design on test card C and indicates the edge of the picture.

The "Belling-Lee" mast is a 75ft. self-supporting "Skytower" to which has been added a 16ft. top mast carrying the aerial system comprising four stacked bays, each of four vertical half wave folded dipoles spaced equidistant. Thus there are sixteen dipoles designed to give all round coverage and, it is hoped, a power gain of four.

The transmitter, which has been designed and constructed in its entirety in the "Belling-Lee" research laboratory at Enfield, has an output of 250 watts, thus the E.R.P. of the station will approximate 1 kW. The equipment will be housed in a temporary wooden hut measuring 24×10 feet.

It is hoped to transmit between the hours of 10 and 12 and certain unspecified periods during the afternoon, excluding Saturdays, Sundays and public holidays. It should be appreciated that the equipment is just as liable to develop a "technical hitch" as is that used by other television services and that it has not been possible in the time to build stand-by equipment for every stage, so in the event of breakdown there will be a certain amount of unavoidable inconvenience.

Advertisement of
BELLING & LEE LTD.
Great Cambridge Rd., Enfield, Middx.
Written 24th March, 1955

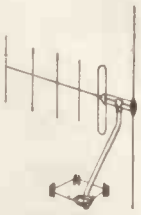
"BELLING-LEE" NOTES

Combined band I, band III aerials are available for fringe, normal and local reception. Those shown below are for use where transmitters are co-sited. Single feeder only required.

Left:—Director "H"+2×6
Band I Ch. 1
Band III Ch. 8 & 9
L916/L £17/17/0

Right:—Reflector "H"+2×3
Band I Ch. 1
Band III Ch. 8 & 9
L915/L £12/12/0

Right:—Dipole+5
Band I Ch. 1
Band III Ch. 8 & 9
L913/L . . £6/15/0

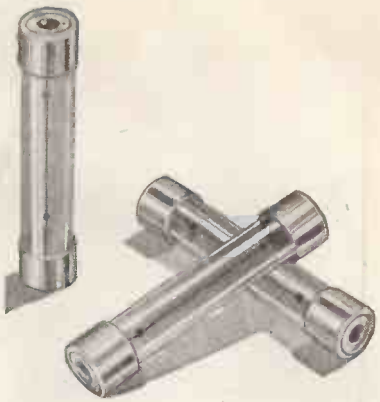


Left:—Dipole+2
Band I Ch. 1
Band III Ch. 8 & 9
L912/L . . £4/15/0
L912/WS . . £3/8/0

Above :— Combined "Lofrod"
Band I Ch. 1 & 2
Band III Ch. 8 & 9
L910 . . £1/10/0

Above :—Combined dipole
Band I Ch. 1 & 2
Band III Ch. 8 & 9
L911/W . . £3/3/0
L911/L . . £4/4/0

Above:—Combined aerials for Midland will differ in appearance. More precise details and prices will become available when the site of the transmitter is known.



"BELLING-LEE" "MAG-NICKEL" FUSES

Ratings now available up to 750 mA

OUR well-known range of "Mag-Nickel" delay fuse-links are now available up to 750 mA. These fuses conform to the dimensions (1¼" x ¼") and blowing requirements of the standard L.1055 fuse, but can withstand a surge current of 10/30 times their rated current for a period not exceeding 0.01 second, without affecting their normal length of life. Available in 250 mA (brown), 500 mA (yellow) and 750 mA (green) ratings, the colour coding conforming to B.S. 646(B).

"Mag-Nickel" Delay Fuse L.338

BELLING & LEE LTD
GREAT CAMBRIDGE RD., ENFIELD, MIDDX., ENGLAND

EMITAPE "88"

The Recording Tape preferred by the Experts

Emitape is preferred by the research scientist and the development engineer in industrial fields — by the specialists and teachers in medical and scholastic professions and music — in fact wherever true-to-life sound recording is critically important. They are in excellent company — Emitape is also used by 'His Master's Voice', Columbia and Parlophone and the world's leading broadcasting organisations.

Special Features

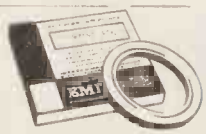
- HIGH SENSITIVITY
- ANTI-STATIC P.V.C. BASE
- HIGH TENSILE STRENGTH
- FREEDOM FROM CURL
- EDITING LEADER AND TRAILER STRIPS

TAPE ACCESSORIES

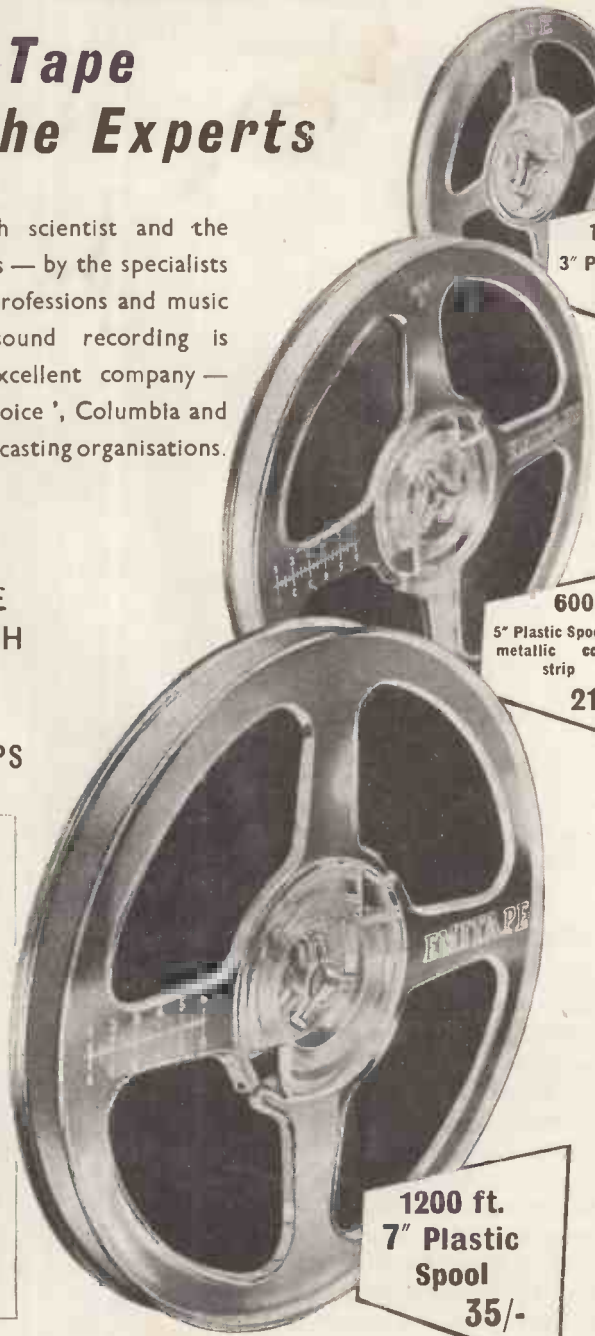
NON-MAGNETIC SCISSORS AP.39 PRICE 16s.

P.V.C. TAPE JOINTING COMPOUND AP.77 PRICE 4s. 6d.

MAGNETIC TAPE JOINTING BLOCK AP.46 PRICE 8s.



GUMMED JOINTING TAPE AP.37 PRICE 6s. 6d. WHITE P.V.C. EDITING TAPE IN 150 ft. ROLL AP.38 PRICE 4s. 6d.



175ft 88/3 3" Plastic Spool 7/6

600 ft 5" Plastic Spool with metallic contact strip 21/-

1200 ft. 7" Plastic Spool 35/-

Full particulars of Emitape and accessories obtainable from your local dealer.

Manufactured and distributed by:

E.M.I. SALES & SERVICE LTD.

RECORDING EQUIPMENT DIVISION

HAYES, MIDDLESEX TELEPHONE : SOUTHALL 2468

Export enquiries for products mentioned in this advertisement should be addressed to :

E.M.I. INTERNATIONAL LTD.

HAYES, MIDDLESEX, ENGLAND

Why Ediswan Clix P.T.F.E. Valveholders are widely used in B.B.C. Television equipment

Large quantities of Ediswan Clix P.T.F.E. Valveholders are used in B.B.C. Television equipment. Only the combination of the finest insulation—P.T.F.E., the most efficient contact material—Berylium copper—and Ediswan Clix design and manufacture can match the requirements of efficiency and reliability in this and all other stringent valveholder applications.

Ediswan Clix P.T.F.E. Valveholders are fully type approved for Services Grade 1, Class 1 conditions. Full details of these valveholders and other components in the Ediswan range are given in catalogue CR. 1681. Manufacturers and Development Groups may have a copy on request.

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CLIX

RADIO, TELEVISION & ELECTRONIC COMPONENTS

THE EDISON SWAN ELECTRIC COMPANY LIMITED, *Member of the A.E.I. Group of Companies*

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

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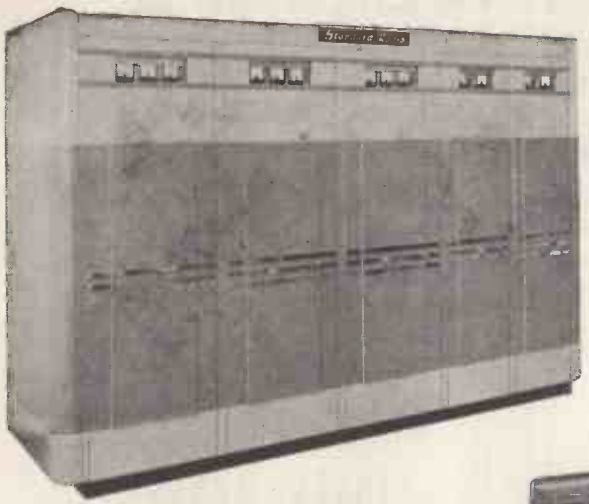
F

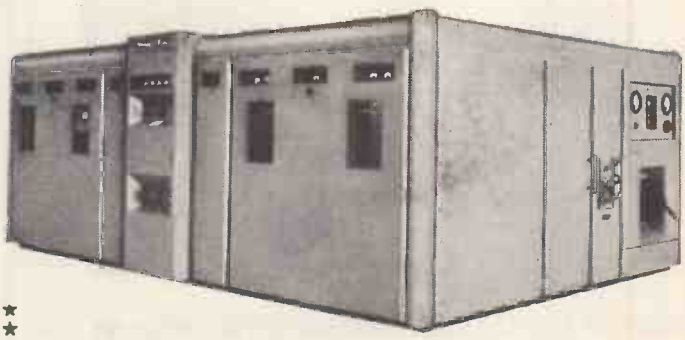
Standard in 6 Continents

The D.S. RADIO POINT-TO-POINT TRANSMITTER



Powerful 40 kilowatt D.S.13's were used to transmit Her Majesty the Queen's Speech direct from Auckland, New Zealand, to the United Kingdom on Christmas Day, 1953.

More than 180 of these transmitters are in use throughout the World



✲ **Available for early delivery**

D.S. series of transmitters

D.S.10	**3/5 kW**	*Double Sideband*
D.S.12	**4 kW**	*Independent or Single Sideband*
D.S.13	**40 kW**	*Independent or Single Sideband*

Write for Radio leaflets :

Type **D.S.10** No. 179/41
Type **D.S.12** No. 129/41
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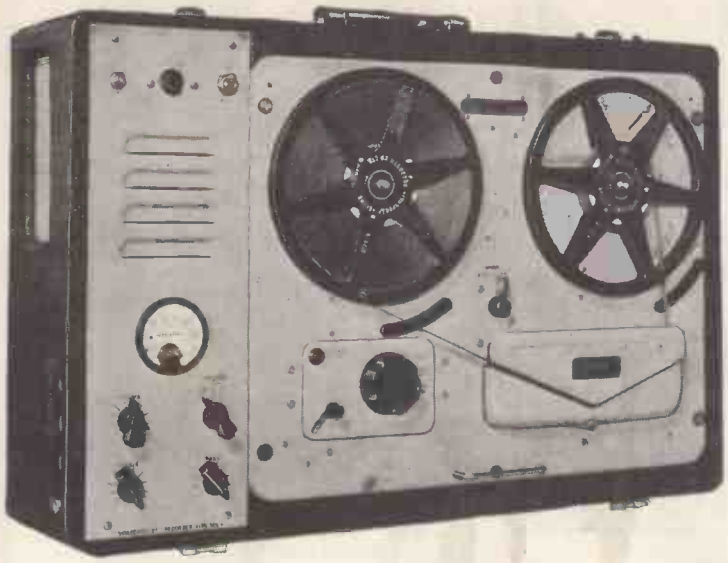
Standard Radio

Standard Telephones and Cables Limited

Registered Office ; Connaught House, 63-Aldwych, London, W.C.2.

RADIO DIVISION · OAKLEIGH ROAD · NEW SOUTHGATE . LONDON. N.11

VORTEXION TAPE RECORDER



★ The total hum and noise at 7½ inches per second 50-12,000 c.p.s. unweighted is better than 50 dbs.

★ The meter fitted for reading signal level will also read bias voltage to enable a level response to be obtained under all circumstances. A control is provided for bias adjustment to compensate low mains or ageing valves.

★ A lower bias lifts the treble response and increases distortion. A high bias attenuates the treble and reduces distortion. The normal setting is inscribed for each instrument.

★ The distortion of the recording amplifiee under recording conditions is too low to be accurately measured and is negligible.

★ A heavy mu-metal shielded microphone transformer is built in for 15-30 ohms balanced and screened line, and requires only 7 micro-volts approximately to fully load. This is equivalent to 20ft. from a ribbon microphone and the cable may be extended 440 yds. without appreciable loss.

★ The .5 megohm input is fully loaded by 18 millivolts and is suitable for crystal P.U.'s, microphone or radio inputs.

The amplifier, speaker and case, with detachable lid, measures 8¼in. x 22½in. x 15¾in. and weighs 30 lb.

PRICE, complete with WEARITE TAPE DECK £84 0 0

★ A power plug is provided for a radio feeder unit, etc. Variable bass and treble controls are fitted for control of the play back signal.

★ The power output is 3.5 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

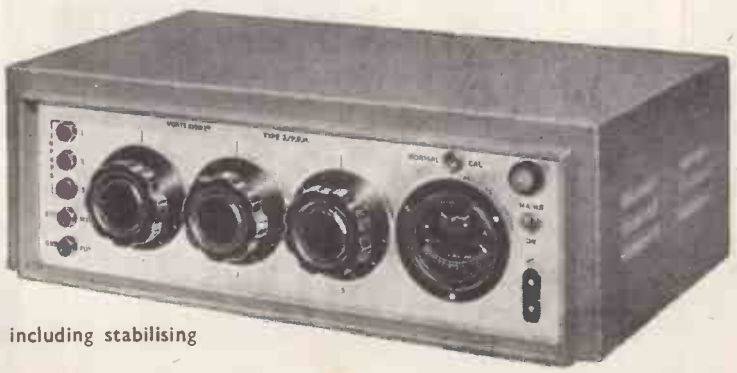
★ The play back amplifier may be used as a microphone or gramophone amplifier separately or whilst recording is being made.

★ The unit may be left running on record or play back, even with 1,750ft. reels, with the lid closed.

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.**

3-WAY MIXER AND PEAK PROGRAMME METER

FOR RECORDING AND LARGE SOUND INSTALLATIONS, ETC.



One milliwatt output on 600 ohm line (.775V) for an input of 30 micro-volts on 7.5-30 ohm balanced input.
Output balanced or unbalanced by internal switch. The meter reading is obtained by a valve voltmeter with 1 second time constant, which reads programme level, and responds to transient peaks.
Calibration in 2 db steps, to plus 12 db and minus 20 db referred to zero level. Special low field internal power pack supplies 8 valves including stabilising and selenium rectifier, consumption 23 watts.

Manufactured by

VORTEXION LIMITED, 257-263, The Broadway, Wimbledon, London, S.W.19

Telephones: LIBerty 2814 and 6242-3 Telegrams: "Vortexion, Wimble, London."

In the U.S.A.

and all over the world you will find

LEAK

EQUIPMENT

This advertisement, prepared by our American Agents, is appearing in current U.S.A. technical publications and is reproduced here for the interest of our friends in this country.

Leonard Carduner (President, British Industries Corp., New York): Mr. Leak, please tell our readers what the "Point One" amplifier combination does in a high fidelity music system.

H. J. Leak: As you know, Mr. Carduner, the amplifier is actually the "heart" of the system. Your record player, radio tuner, or tape recorder feeds electrical impulses into the pre-amplifier and amplifier. These, in turn, strengthen the signals and feed them into a speaker.

It is difficult to strengthen a signal without distortion. "Point One" means that the Leak reproduces voice and instruments with insignificant harmonic distortion of 0.1% at 8 watts! This gives the illusion of the actual "presence" of the performer.

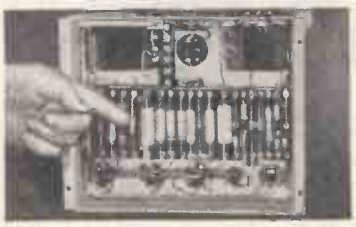
L.C.: In demonstrating the "Point One" amplifier at Audio Fairs, the most impressive thing we do is to turn the amplifier on its side, show people the terminal board "custom" construction used in American scientific instruments, almost never in radios.

H.J.L.: We had a practical reason for this . . . because every terminal connection is easily accessible. It keeps servicing costs down.

L.C.: Yes, and many have praised the control panel of the "Point One" pre-amplifier, because it offers every sensible adjustment to match the new hi-fi records . . . and full 25 db bass and treble range.

H.J.L.: In fact, the "Point One" has more adjustments than the Leak amplifiers supplied to the B.B.C., but no superfluous settings to add unnecessary cost.

L.C.: Well, you have one very important exclusive feature. Plug-in jacks on the Leak front panel make it easy to give any tape recorder the full benefit of the Leak circuit, in recording and playback! People with portable tape recorders, who put them away when not in use, can connect them instantly. Practical features like this make the "Point One" most enjoyable to use.



TL/10 & POINT ONE 27 Gns. COMPLETE, *In Great Britain.*

AMPLIFIER PRE-AMPLIFIER *A price made possible only by world-wide sales.*

Write for illustrated literature 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*

SPECIAL PAGE FOR INDUSTRIAL USERS

POTTED MAINS TRANSFORMERS

These are of really superior construction fitted in cast metal cases and compound filled. Terminals come to ebonite baseboard. All are upright mounting and have 220/230 normal 50 cycle mains input and fully screened primary.

Type 5F1. 265-0-265 at 300 m.a.; 6.3 v. at 7 amp.; 4.4 v. at 2.5 amp.; Price 35/- plus 3/6 carriage.

Type 5F2. 365-0-365 at 150 ma.; 4 v. at 2.5 a.; 6.9 v. at 4.2 a. Price 32/6, carriage and packing 3/6.

Type 5F3. 1540 v. 2 v. at 2 a.; 4 v. at 1 a.; This is an ideal transformer for televisors and scopes using V.C.R. 97, etc. Price 25/-, carriage 2/6.

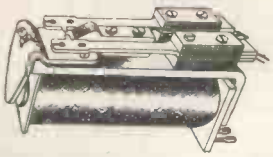
POTTED CHOKES

These chokes are in similar type cases and therefore match the above transformers.

Type 5F4. 5 H. at 300 m.a. Price 10/-, carriage and packing 2/6.

Type 5F5. 10 H. at 150 m.a. Price 12/6, post and packing 2/6.

RELAYS P.O. 3000 TYPE



Ref. 5A1. 2000 ohm, slow close coil plat. contacts, one break, two make. Price 12/6 each.

Ref. 5A2. 2000 ohm. standard coil, plat. contacts, change over make before break, two make, 1 break. Price 15/-.

Ref. 5A3. 200 ohm. standard coil, plat. contacts, two make, Price 7/6 each.

Ref. 5A4. 10 ohm. standard coil, one pair plat. contacts, also mounted but not operated by the relay, are thermal change-over contacts, make before break. Price 8/6 each.

RACKS AND RACK EQUIPMENT

Standard 6ft. rack, heavy gauge channel construction, tapped holes and standard 19in. centres. Price £4/15/- plus carriage. Ditto, but enclosed with sheet metal sides (vented) and with door, fitted handle and locking bars. Price £5/15/-.

Ref. 5A8. Safety switch, cuts off mains directly door is opened. Price 6/6.

MOUNTING PLATES FOR ABOVE RACKS

Fitted with side supports to hold chassis, chassis will be included if requested but this will already have several holes punched and drilled.

Ref. 5A5. 14in. front plate with chassis supports. Price 17/6.

Ref. 5A6. 12in. front plate with chassis supports. Price 16/6.

Ref. 5A7. 10½in. front plate with chassis supports but cut out for meters and other items. Price 8/6.

AUTO TRANSFORMERS

For working American equipment off our mains etc., etc., Input tapped 200-240 v. Output 115 v. In addition to those listed below, we have special this month 150/200 watt totally enclosed in metal box with input and output leads. Price 47/6, plus 2/- post and packing.

Totally enclosed and screened.

	Price	Carr.
50 watt	£1/2/6	1/6
100 watt	£1/16/-	1/6
150 watt	£3/-/-	2/-
250 watt	£4/10/-	2/6
500 watt	£5/10/-	2/6
Unscreened.		
1 KVA (1,000 w.)	£8/10/-	5/-
1.5 KVA (1,500 w.)	£7/17/6	5/-
2 KVA (2,000 w.)	£10/17/6	7/6
3 KVA (3,000 w.)	£12/7/6	10/-
5 KVA (5,000 w.)	£19/5/-	12/6

SLIDER RESISTORS

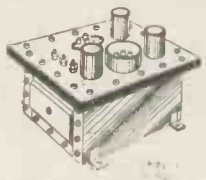
Heavy Duty Type.

Size 7in. × 1½in. 11 ohms 4.5 amp., 22/-; Size 9in. × 1½in. 1.2 ohms 15 amp., 15/-; Size 13½in. × 1½in. 3 ohms 10 amp., 15/-. 1 ohm 25 amp., 15/-.

R. F. HEATER CONSTRUCTORS KIT

All the parts including metal chassis for building a 250/500 watt R.F. Heater for dielectric or induction heating is available as a kit complete with theoretical diagram and practical notes—price for the complete kit of parts is £40 plus carriage at cost.

RADAR TRANSFORMER



For pulse work at 4 kV., this is Ministry style No. 224261 Type 2. Oil filled and fitted with two valve holders and ceramic insulators. It contains a pulse transformer, a choke and a filament transformer, all of which are designed to operate on 4 kV., 25/- each.

AMERICAN FORCES UNITS I-122A and TR-24A

These provide a means for rotating an aerial (or other medium) to any desired azimuth. The operation is briefly as follows:—

1. Dial on control panel is turned to desired azimuth.
2. The Selsyn in the indicator generates a voltage which after being amplified causes the driving motor to rotate the tower.
3. As the tower rotates towards the null position the voltage applied to the drive motor decreases and is removed before the tower stops. If the tower stops before correct position voltage is again automatically applied. If the tower rotates beyond the correct position, the reverse relay operates and causes the tower to move backwards, until it stops at the null point where it remains at rest.

PROTECTION DEVICES

1. Circuit breaker prevents voltage being applied before valve 7 has warmed up.
2. Circuit breaker prevents the drive motor from over-loading.

SELSYN MOTORS

Both receiver and transmitter selsyns are three phase rotor induction motors. The operation is briefly as follows:

Stators of transmitter are connected to corresponding stators of receiver. Note the rotor of one is connected to single phase supply. A voltage would appear on the rotor terminals of the other. This voltage will be of the same frequency as the voltage applied but its value will depend upon the relative angular positions of the rotors of the two selsyns.

DRIVING MOTOR

This is a two phase squirrel cage induction motor geared to the antenna mast. In order to operate the motor from a single phase source a condenser is connected in series with one of the phase winding. Direction of rotation is reversed by switching the condenser from one phase to the other by means of reversing relay.

IMPEDANCE AMPLIFIER

When the two selsyns have an angular displacement a voltage is generated in the receiving selsyn. This is amplified by two independent amplifiers. THE IMPEDANCE AMPLIFIER controls the magnitude of an impedance connected in series with the antenna motor and consequently controls the motor. THE CONTROL IMPEDANCE consists of the anode circuit of Valve 7, matched to the motor by means of Transformer 102. When Valve 7 has negative bias the anode circuit has high impedance. When conducting, however, the impedance falls to just a few ohms. The effect of which will vary the voltage to the motor and thus control its speed of rotation.

THE RELAY AMPLIFIER

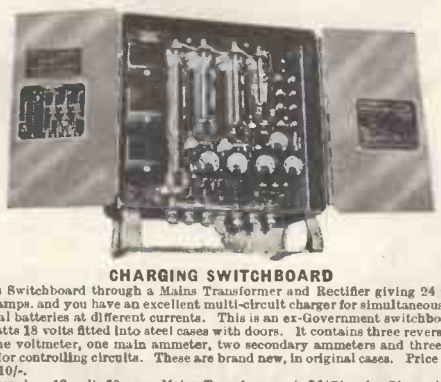
The output of the selsyn receiver is also applied to the relay amplifier, through transformers so that it is either in phase with or 180° out of phase with the amplifier voltage depending upon which side of the present position the antenna rests. The relay controls the direction of rotation of the motor.

POWER SUPPLIES

The equipment is fitted with power components for 117 volts 60 c.p.s. but will operate off our Mains if supply is connected through a step-down transformer of 1 K.W. rating. Price £55 the two units, or separately I-122A £25, TR-24A £35, carriage extra at cost.

MAGNETRONS

Precision made for RADAR type Nos. CV.186 and CV.64. Unused, guaranteed. Any not functioning correctly will be replaced. Price £2/10/-. Post and insurance 10/-.



CHARGING SWITCHBOARD

Feed this Switchboard through a Mains Transformer and Rectifier giving 24 volt D.C. up to 50 amps. and you have an excellent multi-circuit charger for simultaneously charging several batteries at different currents. This is an ex-Government switchboard rated at 550 watts 18 volts fitted into steel cases with doors. It contains three reverse current relays, one voltmeter, one main ammeter, two secondary ammeters and three variable resistors for controlling circuits. These are brand new, in original cases. Price £4/10/-, carriage 10/-.

We can supply a 12 volt, 50 amp. Mains Transformer at £4/5/-, plus 5/- carriage.

IMPORTANT NOTICE.

The equipment described on this page is not available at our normal retail shops—it can be seen at our special sales department address as below. Order and enquiries should also be addressed as below:—

E.P.E. LTD., SPECIAL SALES DEPT., BOURNE HOUSE, GROVE ROAD, EASTBOURNE, SUSSEX.

HIGH POWER TRANSFORMERS

For R.F. Heaters, transmitters, etc., etc. These are open wound type for maximum cooling and have the normal 200-250 primary fully screened.

Type 5F6. 1,000 v. at ½ amp., e.g. .5 K.V.A. Price £8/10/-, carriage and packing 5/-.

Type 5F7. 1,500 v. at 1 amp., e.g., 1.5 K.V.A. Price £15, carriage and packing 7/6.

Type 5M1. 1000-0-1000 v. at 1.5 amps., e.g. 1½ KVA. Price £12/10/-, carriage and packing 7/6.

Type 5M2. 1000-0-1000 v. at 500 mA. and 4 v. at 4 a. Price £7/10/-, carriage and packing 4/6.

Type 5M3. 375-0-375 v. at 250 mA. and 4 v. at 4 a. Price 37/6, carriage and packing 3/6.

AUTOMATIC MOTOR STARTER

For remote control of D.C. motor between 1 and 3 kw., adjustment for 100 v. or 230v. Unused and in first-class condition, complete with metal and wired glass cover. Price £10, carriage 5/-.

POWER FILAMENT TRANSFORMERS

Type 5M4. 4 v. at 4 a. 2-0-2 v. at 10 a. Price 18/6, carriage and packing 3/6.

Type 5M5. 3.15-0-3.15 at 10 a. 4-0-4 at 10 a. 4-0-4 at 2 a. 4 at 4 a. 2.5-0-2.5 at 3 a. Price 27/6, plus carriage and packing 3/6.

Type 5M6. 24 v. at 2 a. tapped 32 v., 30 v. and 28 v., for relays, etc., 22/6, plus 3/6 carriage and packing.

POWER CHOKES. Open wound type and feet with clamps.

Type 5M7 30 Henry at 500 ma., 35/-.
Type 5M8 20 Henry at 500 ma., 32/6.
Type 5M9 15 Henry at 500 ma., 27/6.
Type 5M10 10 Henry at 500 ma., 22/6.
Type 5M11 25 Henry at 250 ma., 18/6.
Type 5M12 3 Henry at 10 amps., 18/6.
Type 5M13 200 Henry at 5 ma., 15/-.

POWER FOR TR1154/55

We can offer brand-new, and unused, the two rectifier units for mains operating the transmitter TR1154 and its associated receiver R1155. Both rectifier units are completely enclosed in metal cases and operate directly from normal 50 cycle A.C. mains. Price £17/10/- the pair, carriage and packing £2 extra.

TRANSMITTER 1131

This is a high powered transmitter for operating over the same frequency range as the Receiver 1132, i.e., 70-130 megacycles. It is a very bulky transmitter and probably contains around £300 worth of equipment. As far as we know these have never been used but of course have been in store for a long time and therefore they will need attention before being put into operation. We offer these less valves £37/10/-. Buyer collects. We also have a quantity already stripped so if you are needing spares for this transmitter please get in touch with us now.

R1132

We have a small quantity of these receivers still available less valves. Their condition unfortunately is not good but they appear to be repairable, and, of course, contain a multitude of spare parts. At 30/- each they represent a real bargain. If not collecting, please include 5/- for packing and carriage.

RECEIVER TRANSMITTER 38

This is the British equivalent of the walkie-talkie. It operates on the frequency range 7.4-9 mc/s. It has many novelty applications in the home and can eventually be turned into a useful little portable receiver. Complete and with valves, unused but not guaranteed, price 37/6, post 2/6 extra.

STABILAVOLT

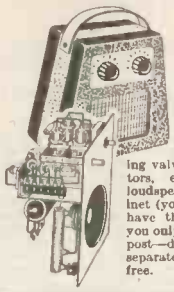
This is a valve designed and constructed to facilitate the taking off stabilized voltage.

These are brand new and unused. Price 10/6 each, post 1/- extra.

THE TWIN 20

This is a complete fluorescent lighting fitting. It has built-in ballast and starters —stove enamelled white and ready to work. It is an ideal unit for the kitchen, over the work-bench, and in similar locations. It uses two 20-watt lamps. Price, complete less tubes, 29/6, or with two tubes, 39/6. Post and insurance, 2/6. Extra 20-watt tubes 7/6 each.

ALL MAINS THREE



A handy midget A.C./D.C. 3-valve mains receiver giving powerful reception over long and medium waves. All component parts, including valves, coils, resistors, etc., but not loudspeaker and cabinet (you may already have these) will cost you only 19/6 plus 1/6 post—data available separately 2/- post free.

ELPREQ TAPE RECORDER

This instrument combines the Mk. IIIU Truvox Tape Deck and the Cleveland Wide Band Amplifier with a special high flux speaker and forms one of the finest tape recorder combinations available to-day. It will, of course, play pre-recorded tapes as well as make its own recordings of radio, music, meetings, telephone conversations, letters, etc., etc. The price, complete with reel of tape and ready to operate, is

39 Gns.

Carriage and insurance 12/6. Hire Purchase terms if required.

MINIATURE PORTABLE T.V.

Uses standard conventional circuitry employing a total of 13 valves and 2 crystal diodes. The Cathode-ray tube used is a 2½in. Service type VCR139A. The layout is extremely clean, straightforward and professional. The wiring, whilst naturally being a little more intricate due to miniaturisation, is nevertheless completely accessible. The total cost comes to £16-£17. Its size will be approximately 9½×8×6in. Full construction data, layouts, diagrams, templates, etc., running into some 50 sheets, is available, price 5/- post free.

MINI-MAINS FOUR

Uses a 4-valve circuit with high-efficiency coils—covers long and medium wave bands and fits into the neat white or brown Bakelite cabinet—limited quantity only. All the parts, including cabinet, valves, in fact, everything, £3/19/6 plus 2/- post. Constructional data free with the parts or available separately 1/6.

P.V.C. HEATER WIRE

This has a resistance of 16 ohms. per ft. It is wound on non-hygroscopic insulation and covered over with P.V.C. shrunk sleeving. Quite suitable for use underground or under water. Ideal also for twisting around pipes to stop freezing or to preheat liquid. Price 1/- per yard.

YOURS FOR £1 ONLY

COMMUNICATIONS RECEIVER R1155

This set, as most will know, is considered to be one of the finest communications receivers available to-day. The frequency range is 75 kc/s to 18 Mc/s. It is complete with 10 valves and is fitted in a black metal case. Made for the R.A.F., so obviously a robust receiver which will give years of service. Slightly used but completely overhauled and guaranteed in perfect working order. PRICES Grade 2 £7/19/6, Grade 1 £9/19/6, or new and unused £11/19/6. Or will be sent against deposit of £1. If you cannot call to collect please include an additional 10/- to cover cost of transit case and carriage. This partly returnable to you if and when you return the transit case.

MAINS POWER PACK FOR R1155

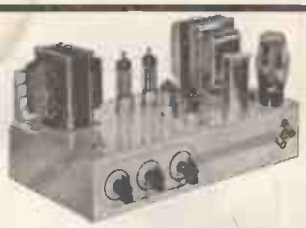
With Pentode output stage. Plugs into socket on receiver so no internal modifications are required. Price £5/10/- complete with speaker ready to work, carriage 3/6. If bought with receiver, deposit is 11/-.

NOBLEMAN GRAM

A 70 Gn. RADIOGRAM direct from makers for only 40 Gns. Or £4 deposit. A beautiful piece of furniture yet a most up-to-date radiogram—figured walnut lined sycamore—radio raised to comfortable level —compartment for records—5-valve A.C. mains superhet, covers long, medium and short waves—all latest refinements, negative feed-back tone control, etc.—large multi-coloured edglet dial—latest "Hi G" three-speed auto-changer with the famous pick-up—plays all types of records perfectly. Free Delivery in London Area. Elsewhere £2.

RECORD PLAYER BARGAIN

3-speed record player with pick-up using the famous Acos "Hi G" turnover crystal—motor also by very famous maker—speed selection is by Bakelite knob. All on unit board ready for installation. A wonderful bargain at £6/10/- plus 5/- carriage—Hire Purchase 15/- deposit.



MULLARD AMPLIFIER "510"

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 pick-ups. The price of the unit completely made up and ready to work is £12/10/- or 25/- deposit, plus 10/- carriage and insurance. Alternatively, if you wish to make up the unit yourself we shall be glad to supply the components separately. Send for the Mullard amplifier shopping list.

CABINETS FOR ALL

We confidently believe we carry the best stock of cabinets in London. The one illustrated is The Bureau, a really beautiful cabinet elegantly veneered in walnut and finely polished. The control board is revealed when the front is dropped. Both radio board and motor board are left uncut to suit your own equipment. Price is 16 guineas, carriage 12/6. We have many other types in stock. Pay us a visit, or send for Cabinet List.

THE CONTEMPORARY

In the modern trend is this very stylish contemporary console. Veneered in oak with contrasting mouldings, and is ideal for use with modern furniture or with other contemporary fittings or furnishings. The radio and motor board is uncut and its size, 30×15½in., provides ample room for all equipment. Price £8/15/-, carriage, etc., 12/6.

BARGAIN FOR CONSTRUCTORS

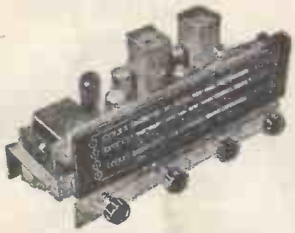
Modern style cabinet in contrasting veneers, with metal chassis, three knobs, coloured scale, and pointer. Price 29/6, post, etc., 2/-. All other components to build 2-waveband superhet. Price £5. Data, 1/6 (free with components).

GRAMOPHONE AUTO-CHANGER

The latest model by very famous manufacturers. 3 speed, mixes 10in. and 12in., with crystal turn-over pick-up, brand new and perfect in original cartons. Price £11/10/-. Carr., etc., 12/6.

E. P. E. LTD. (SEE OVER)

BEST SELECTION OF RADIO CHASSIS IN LONDON



THE "WINDSOR 5"

This is a 5-valve A.C. superhet covering the usual long, medium and short wavebands. It has a particularly fine clear dial with an extra long pointer travel. The latest type loctal valves are used and the chassis is complete and ready to operate. Chassis size 15in. × 6in. × 6in. Price £9/19/6 complete with 8in. speaker. Carriage and insurance 10/-. H.P. terms if required.

TABLE RADIO CABINET

Due to a special purchase, we are able to offer this very fine cabinet, size approx. 15½ × 14 × 6½in. Walnut veneered and satin finished, 37/6, carriage and packing 3/6. Note.—This cabinet is the correct one for the Windsor chassis above with 6½in. speaker.

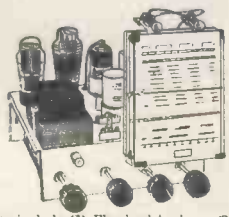
SUPERHET RADIO BY BEETHOVEN

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.

SAVE £1

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 59/6. H.P. deposit on cabinet and chassis is 32/- only.



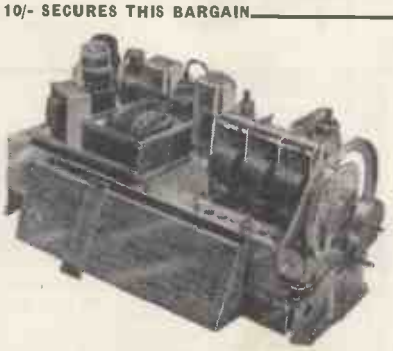
THE EXPORT 5

3-WAVE BAND 5 VALVE SUPERHET CHASSIS

Brand new, tested and ready for immediate operation, full vision scale size 6in. × 8in. covering the long wave 900-2,000 metres, medium wave 185-550 metres, and short wave 16-50 metres. Complete with valves and covered by our six months' guarantee. First-class parts, Parmeko mains, transformer Erie resistors, Hunts condensers, etc. Special points include (1) Flywheel tuning. (2) Dust cored I.F.'s. (3) Sockets for extension speaker and pick-up. (4) 4-watts output. Price £8/10/-, carriage, packing and insurance 7/6 extra.

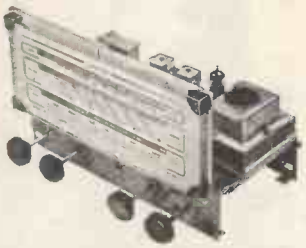
10/- SECURES THIS BARGAIN

The set, a product of one of our famous manufacturers, has H.F. stage, tuning indicator, and all modern refinements, covers 5 wavebands including short waves to 11 metres. Offered less valves, power-pack, scale and drive, otherwise complete and unused, price £5, or 10/- deposit, balance over 12 months, carriage 7/6 (uses octal range valves).



THE

CLEVELAND "ORGANTONE"



The Cleveland "ORGANTONE" is a 5-valve 3-wave band superhet covering long, medium and short wave. Built to a very stringent specification. Osram miniature valves are employed and low loss iron cored coils 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 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.

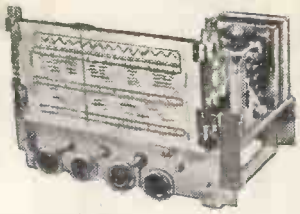
Price £11/10/- or £1/5/- deposit—carriage, etc., 7/6.

A circuit diagram and photograph available price 2/- post free.

ANOTHER CLEVELAND CHASSIS—"THE TREMENDO"

The first Cleveland chassis was good, but this one is really superb. It has a 7-valve circuit with 6 watts output, fitted with independent bass and treble controls. It is really an efficient B.F. circuit coupled to a high-fidelity amplifier. The chassis size is the same as the Organtone, namely 12 × 7 × 7 with the 10½ × 4½ multi-coloured scale, and it is built to the same exacting specification as the Organtone. Price £14/10/-, carriage and packing, 7/6. H.P. terms if required.

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/- Ref. B3.

Pushpull 6-valve 3-wave £15/15/- Ref. B3PP

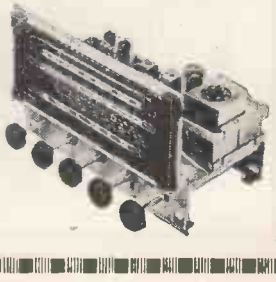
	£	s.	d.	Ref.
Pushpull with R.F. stage 3-wave 7-valve	18	18	0	B3PP/RF
6-wave L.M. and 4 short waves (band spread)	15	15	0	B6
6-wave with pushpull	18	18	0	B6PP
6-wave with pushpull and R.F. stage	23	2	0	B6PPRF

All available on H.P.—deposit 15 per cent, balance over 12 months

THE ARMSTRONG F.C. 48

Among high class radio chassis, the name Armstrong is probably the most famous, and their new model FC48 certainly lives up to tradition. Of course, only the best of everything has been used and extreme attention has been paid to the lining up. It is virtually a 10 valve circuit, for among its eight valves two double triodes are employed. Special features of this chassis are (a) 8-watts output in a pushpull circuit with ample negative feed-back to ensure the highest fidelity; (b) provision for using F.M., e.g., power brought out to sockets and indicator on dial; (c) independent bass and treble controls with visual indication of setting, (d) four wave-bands covering 16-51, 50-120, 190-550, and 1,000-2,000 metres. The size of this chassis is 12½in. × 9in. × 9½in. Price £23/18/-, plus 7/6 carriage and insurance.

THE LATEST DULCI



This is the Model F3PP. Developed especially to meet the increasing demand for high fidelity equipment Particularly suitable for replacement in a radiogram. This is a 7-valve 3-wave band superhet with pushpull output, incorporating separate bass and treble controls thereby ensuring a maximum control of fidelity, volume and tone. Wave band coverage 16-50, 190-550, 900-2,000 metres. Valve line X79, 6BA6, ECC83, GZ30, and two 6AQ5. This chassis is suitable for use on A.C. mains from 100-110 v., and 200-250 v. Price 17 guineas or £2 deposit, carriage and insurance 7/6.

THIS MONTH'S NEW OFFERS

Hi-Fi EQUIPMENT

We carry good stocks of the latest equipment and except for very busy periods we can usually give demonstrations. To name a few items of stock which we carry and recommend.

SPEAKERS

The latest W.B. cambric cone speaker units all in die cast frames with universal impedance speech coils 3 ohm., 7.5 ohm., and 15 ohm.

Model H.F. 812 8in.	£3	5	6
Model H.F. 912 9in.	£3	9	6
Model H.F. 1012 10in.	£3	17	6

Also in die cast frames but with 3 ohm. or 15 ohm. speech coils.

Model H.F.510 5in.	£1	19	6
Model H.F.610 6in.	£2	12	6
Model H.F.1214 12in.	£9	15	6

We also carry a range of G.E.C. Wharfedale and Goodmans Hi-Fi speakers.

PICKUPS

ACOS HI-G HEADS for use with Garrard or Collaro plug-in units in brown or ivory 42/- each.

THE B.J. ARM, new type to give correct tracking over the whole recording. Extra lightweight, suitable for Decca, Garrard and Chancery heads £2/19/6.

ACOS GP20 HI-G with the new HI-G plug-in heads, all designed to obtain the nearest to perfect reproduction—pressure only 3 grammes. Complete with either head £3/7/6/ extra head £2/2/-.

THE NEW LEAK TL-10 AMPLIFIER WITH "POINT-ONE" PRE-AMP. In the amplifier world the name Leak probably stands highest. It is symbolic of precision sound engineering. The TL-10 has an output of 10 watts and with its pre-amplifier will operate from any good pickup. A continuously variable input attenuator in the pre-amp. permits the use of crystal, moving iron or moving coil pick-up. Provision is made for tape recording and play-back as an exclusive feature. Easy accessible jacks being provided on the front panel for speedy hook-up. The complete amplifier with pre-amp. £28/7/-, or TL-10 amplifier only 17 gns. or 'Point-One' amp. only 10 gns.

"SNIPER-SCOPE"

Famous wartime "cats eye" used for seeing in the dark. This is an infra-red image converter cell with a silver caesium screen which lights up (like a cathode ray tube) when the electrons released by the infra-red strike it. It follows that as light from an ordinary lamp is rich in infra-red these cells will work; burglar alarms, counting circuits, smoke detectors and the hundred and one other devices as will the simpler type of photo cell. Here then is a golden opportunity for some interesting experiments, price 5/- each. Data will be supplied with cells if requested.

ELECTROLYTIC CONDENSERS

Recent manufacture. Not Gov. surplus.

SINGLE SMOOTHING TYPES.

8 m.f.d. 150 v.	1/6
8 m.f.d. 450 v.	1/11
8 m.f.d. 500 v.	2/6
16 m.f.d. 350 v.	2/3
16 m.f.d. 450 v.	2/9
16 m.f.d. 500 v.	3/9
32 m.f.d. 350 v.	2/11
32 m.f.d. 450 v.	4/9
32 m.f.d. 500 v.	5/9
64 m.f.d. 350 v.	3/9
64 m.f.d. 450 v.	5/9
100 m.f.d. 350 v.	4/-
100 m.f.d. 450 v.	4/9
150 m.f.d. 350 v.	4/9

MULTIPLE TYPES

8-8 m.f.d. 450 v	3/11
8-8 m.f.d. 500 v.	4/6
16-8 m.f.d. 450 v.	3 11
16-8 m.f.d. 500 v.	5/-
16-16 m.f.d. 450 v.	4/11
16-32 m.f.d. 350 v.	4/9
32-32 m.f.d. 350 v.	4/9
32-32 m.f.d. 275 v.	5/6
50 m.f.d. 25 v.	5/6
250-60 m.f.d. 350 v.	9/6

BIAS TYPES

25 m.f.d. 24 v.	1/-
50 m.f.d. 12 v.	1/-
50 m.f.d. 50 v.	2/-

THE CLEVELAND OCTAVIAN

In this instrument is combined the exceptional qualities of the G.E.C. metal cone loudspeaker in its ideal cabinet (the Octagonal illustrated below) and a most modern 3-valve amplifier. This combination will give a realism of musical reproduction not easily obtained even at twice or three times its price and is definitely the reproducer for bringing out the full frequency now available in long playing microgroove recordings. If you can, please come to one of our branches and hear this fine instrument—failing this, then take our word that it is really good and send an order today. Price 27 guineas or £4/10/- deposit, balance over 12 months. Amplifier available separately at £10/10/-.

OCTAGONAL SPEAKER CABINET

Conforming exactly to the designer's specification —for G.E.C. metal cone speaker—price £12/10/- or 37/6 deposit, carriage and insurance 5/- extra. G.E.C. metal cone (extra octave) speaker £8/15/-.

A NEW APPROACH to an almost universal problem....

An electronic computor to indicate football results is the subject of our latest publication. The computor uses 3-valves and information is fed into 12 ratio arms. The result 'home,' 'draw' or 'away' is indicated on a centre zero-meter, suitably scaled.

The information to be fed into the ratio arms can be derived from the operator's own pet methods, or alternatively the data freely available in newspapers and popular magazines can be used. The circuit is quite an interesting one but is not at all difficult to construct or operate. When complete the unit is entirely self-contained and mains operated.

The price of all components needed, excluding metal and chassis, is £3/10/-, plus 2/6 post. Our Publication "A New Approach" is given free with orders, alternatively will be supplied separately at 2/6, post free.

BENDIX RA-1B COMMUNICATIONS RECEIVER

Originally intended for the American Forces this fine receiver. (A small quantity of which has been released by the Ministry of Supply) is available to you if you act promptly Designed to receive C.W. or R.T. it uses probably the finest Vernier tuning and band spreading arrangement possible, it covers the following bands:—

Band 1	.15	to	.315 mc.	i.e. 20 to 200 metres
Band 2	.315	to	.680 mc.	
Band 3	.680	to	1.5 mc.	
Band 4	.18	to	3.7 mc.	
Band 5	3.7	to	7.5 mc.	
Band 6	7.5	to	15.0 mc.	

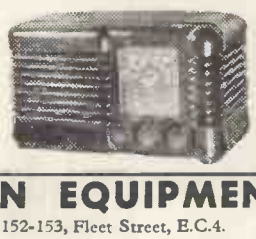
The sensitivity is 4 micro volts for full output. It uses 8 valves and operates from batteries (12 or 24 volt) or from the mains through a power pack. It has built in output stage with a jack socket for phones. Controls, all of which are brought to the front panel, include: aerial switch, aerial compensating condenser, main tuning condenser, band selector, C.W. switch, power on/off switch, and volume control.

Very compactly built in crackle finished case, these sets are brand new having never been used and in perfect working order—special price this month is £14/10/- each or 45/- deposit, balance over 12 months—carriage and insurance 10/-. Order now to avoid disappointment. Circuit diagram and component data given free with sets, or available separately price 2/6, post free.

A PRESENT FOR WIFE OR MOTHER

Probably the most tiring part of dressmaking is the cutting out operation. Any dressmaker then will be pleased to receive a pair of electric (mains operated) scissors. The scissors illustrated not only prevent the fatigue of cutting out, but also permit more control as they have only to be guided. These Swiss made scissors will cut all materials but not fingers they are in fact 100% safe even for young children to use. Price is 66/6 post free.

MADE-UP—READY TO WORK



The astonishing "Occasional 55"—two wave band T.R.F.—completely assembled and ready to switch on—complete with all valves and 5in. speaker—Covers both medium and long wave bands and uses dust cored coils in a unique modern circuit which gives almost superhet performance. Price 26/5/-, plus 3/6 post—Bakelite or wooden cabinet available price 16/6, post 2/6.

FRICTION DRIVE MOTOR

Operates from standard 50 cycle mains—a thoroughly good job with dozens of applications—limited quantity only—17/6 each, post and packing 1/6.

SPECIAL BATTERY VALVES

All 1.5 v. heaters. 1T4, 1R5, 1S5, 3A4, offered as a set 30/- the four.

THIS MONTH'S SNIP

Mains transformer and choke by Haines Radio Ltd. Standard 50 cycle input with 10 volts tappings. Secondaries: 500-0-500 volt at 500 milliamp and 6.3 volts at 6 amps., also choke to match 10 Henry's at 500 milliamps. Limited quantity only at 45/- the pair. Carriage and packing 5/- extra.

P.M. SPEAKERS

All by best makers. Rola, Elac, Plessey, Truvox, etc.

5in. p.m.	19/6
6½in. p.m.	17/6
8in. p.m.	19/6
10in. p.m.	25/-
12in. p.m.	35/-

COMPONENT BARGAINS

(all new and unused.)

ELAC FOCUS MAGNET. Type No. R25-7D. Price 12/6, plus 9d. post.

OUTPUT TRANSFORMERS. Standard pentode matching ordinary 2/6, push pull centre tapped, 3/6.

COILS suitable for F.M. and T.V. with dust cores and fixing lugs. 12 assorted 5/6.

I.F. TRANSFORMERS. Medium small size exceptional high Q potted construction, tuning over 450-470 K.C.'s., 5/6 per pair.

2-GANG TUNING CONDENSER. Midget .0005, 5/6.

HALF MEG. POTS. With switch, 1/9, less switch 1/3, double pole switch, 2/- (all short spindle but room for knob).

1 MEG. POTS. Less switch 1/3, short spindle preset 1/-

CERAMIC CONDENSERS. 1,000 pf. and 800 pf., 3/6 doz.

TRIMMERS. 3-30 pf., standard compression type, 4/- doz.

RESISTORS

50 assorted ½ and ¼ watt resistors. Ranging between 10 ohm. and 10 megohm (Our selection.). Price 5/- pkt. Ditto 1 watt, 7/6.

TRANSFORMER 100 WATTS

These are transformers with a wound primary tapped 200, 220, 240, but no secondary. There is ample window space, however, for the hand winding of secondary to suit your own requirements. Approximately two turns per volt are required. The amps. taken out will depend upon volts, e.g., 10 amps. at 10 volts, 50 amps. at 2 volts, etc.. etc. Price 10/-, post and packing 2/-.

CHASSIS ASSEMBLY

3 colour, 3 waveband scale covering standard, Long, Medium, and Short wavebands, scale pan. chassis punched for standard 5-valve superhet, pulley driving head, springs, etc., to suit. Scale size 14¼in. x 3¼in. Chassis size 15in. x 5in. x 2in. deep. Price 15/-, plus 1/6 post. Note.—This is the one that fits our 39/6 table cabinet.

ELECTRONIC PRECISION EQUIPMENT LTD.

249, Kilburn High Road. Kilburn. (Now Open)

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.

The asymmetric sideband filter behind the high-power vision transmitter at Holme-Moss. (*By courtesy of the B.B.C.*)

CLYNE RADIO LTD.

18, TOTTENHAM COURT ROAD, LONDON, W.1

MUSeum 5929/0095.

All goods specially selected for quality and value. Prompt Service—Money-back guarantee—It will pay you to visit our new rebuilt shop premises. Situated 50 yds. only from Tottenham Court Road Tube ! (Genuine)

HIRE PURCHASE
We are pleased to announce advantageous hire purchase facilities on any single item over £5. Ask for details, mentioning what you are interested in. We regret we cannot extend this facility to kits.

VERY LATEST 3-SPEED AUTO-CHANGER BY FAMOUS MANUFACTURER

Further limited quantity-mixer, turn-over crystal head. Cream finish. Our price £11/10/- only, plus 3/6 p. & p., or 50/- deposit plus p. & p., and 12 monthly payments of 16/9.

COLLARO RC/54 PLAYER ! Just released. Fawn leatherette covered portable case, incorporating very latest Collaro 3 speed mixer-changer. Cream finish. Lightweight turn-over crystal pick up head. Only £13/19/6 cash, plus 5/- p. & p. Complete, or, 69/6 deposit plus p. & p. and 12 monthly payments of 19/8.

REGAL. A well-made cabinet in medium coloured walnut veneer. Size 29½ × 14½ × 29½in. Uncut motor-board measures 25½ × 13½in. Record or tape storage aperture alongside motor board measures 3½in. wide × 12in. deep. Price £9/19/6 plus 10/- P. & P. H.P. terms available.

We have in stock the identical cabinet to this above illustrated, but slightly larger. Measurements: 29½in. high × 31in. × 14½in. Uncut motor-board measures 25½ × 14½in. Aperture 5½ × 12in. deep. Price £10/17/6. plus 10/- P. & P. We carry a very large selection of portable cabinets for all purposes. A stamp will bring illustrated cabinet list.

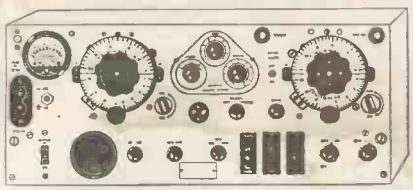
R1155A RECEIVERS. Guaranteed serviceable in original packing cases. £7/19/6. Fully assembled Power Pack and output stage, to plug straight into R1155 for A.C. 200/250 volts at 79/6. We have a few brand new R1155A at £11/19/6, also in original packing cases—Deduct 10/- if purchasing either receiver together with power pack. Plus 10/- packing and carriage.

R1124 RECEIVER UNIT. Coverage 30-40 Mc/s. Including 6 valves—3 type 9D2, 1 each, 5D2, 15D2 and 4D1—Six valve-screening cans, 24 ceramic trimmers, 6 ceramic valve holders, resistors, condensers, I.F.T.'s coils, etc. In very good condition, a bargain at 16/6 each only, plus 3/6 packing and postage.

RECEIVER TYPE 25/73. (The receiver section of TR1196.) Supplied complete with full data for conversion to 3-wave-superhet receiver. Unit is complete with 6 valves 2-EF39, 2-EF36, FK32 and EBC33, also standard I.F.T.'s 465 Kc/s. Price 27/6 plus 2/6 P. & P.

TR1196 TRANSMITTER PORTION. We can also supply the transmitter portion of the above receiver incorporating valves, EL32, EF50, CV501. Type 600 relay, transformer, coils, switches, etc. Limited quantity at 12/6 only, plus 2/6 P. & P.

LAST FEW ONLY! EX-NEW ZEALAND ARMY TRANSMITTER/RECEIVERS.



TYPE ZC1 MK. I.—Built into substantial steel cabinet mounted on easily removable resilient mountings. The instrument is fully tropicalised. We regret we have sold out Mk. II version previously advertised!! We have few only left, Mk. I general specification as for Mk. II, but single waveband only; with frequency coverage 2-6.5 Mc/s. Front panel layout very slightly different to Mk. II illustration. Transmitter output up to 2 watts depending on type of aerial used, gives ranges up to 35 miles on morse and 30 miles speech, in average country. Considerably greater ranges may be obtained by the use of horizontal aerials. H.T. is supplied by a built-in vibrator pack, requiring 12 volt input. Valve line-up, 2-6V6GT, 7-6U7G, 6K8G and 6Q7GT. 465 Kc/s. I.F.T.'s. Set weighs 58½lb. Measurements 22½in. × 10½in. × 10in. These units are new condition, and price is £5/19/6 only, plus 10/- packing and carriage. This price includes fully illustrated 50-page instruction booklet including full circuit diagrams, suggested aerials, fault-finding, etc. An unrepeatable bargain ! !

REMOTE CONTROL UNITS.

These units originally intended for use with the above transmitter/receiver, when inter-connected can be used as ordinary telephones or for practice morse-working one-to-one. Complete in handsome steel case, can be operated by ordinary torch battery. Has built-in morse key and buzzer unit. Price for each is 15/-. Suitable headphones can be supplied at 7/6 plus 5/- for carbon hand microphone. The whole plus 2/6 P. & P. Each unit includes full operating instructions—and is brand new.

OTHER ACCESSORIES AVAILABLE. Moving Coil Microphones for transmitter 7/6 each. 100 yd. drum twin cable with plugs both ends, 10/-. 70 yd. drum ditto, 7/-, etc., etc. M/C earphones 7/6.

METERS

F.S.D.	Size	Type	Fitting	Price
50 microamp	D.C. 2in.	M.C.	R.P.	50/-
100 microamp	D.C. 2½in.	M.C.	F.R.	45/-
500 microamp	D.C. 2in.	M.C.	R.P.	13/6
500 microamp	D.C. 2in.	M.C.	F.R.	18/6
1 mA.	D.C. 2in.	M.C.	F.R.	17/6
1 mA.	D.C. 2½in.	M.C.	F.R.	22/6
1 mA.	D.C. 2½in.	M.C.	Desk Type	27/6
5 mA.	D.C. 2in.	M.C.	F. Sq.	7/6
10 mA.	D.C. 2½in.	M.C.	R.P.	9/-
10 mA.	D.C. 2½in.	M.C.	F.R.	10/-
50 mA.	D.C. 2in.	M.C.	F. Sq.	8/6
150 mA.	D.C. 2in.	M.C.	F. Sq.	7/6
200 mA.	D.C. 2½in.	M.C.	R.P.	10/-
1 amp.	R.F. 2½in.	Thermo	R.P.	10/-
3 amp.	R.F. 2in.	Thermo	F. Sq.	6/-
5 amp.	D.C. 2in.	M.C.	F. Sq.	13/6
6 amp.	R.F. 2½in.	M.C.	Thermo F.R.	7/6
20 amp.	D.C. 2in.	—	R.P. (with shunt)	10/6
25 amp.	D.C. 2½in.	M.I.	F.R.	6/6
30 amp.	D.C. 2½in.	M.I.	F.R.	12/6
15 volt	A.C. 2½in.	M.C.	F.R.	10/-
20 volt	D.C. 2in.	M.C.	F. Sq.	7/6
15-0-15 volt	D.C. 2½in.	M.C.	F.R.	17/6
150 volt	D.C. 2in.	M.C.	F.R.	15/-

R.P. = Round projection. M.C. = Moving Coil. Thermo = Thermo-couple.
F. Sq. = Flush Square. F.R. = Flush Round. M.I. = Moving Iron.
METER RECTIFIERS. 1 mA. by G.E.C., at 8/6, also 5 mA. by Westinghouse at 8/6.

EX-W.D. CATHODE RAY TUBES. Guaranteed full picture. VCR97 at 40/-. VCR517C at 35/-. Also VCR139A—Ideal for oscilloscope 2½in. screen at 35/-. We also have VCR97 with slight cut-off, very suitable for oscilloscope, testing purposes, etc., at 15/- only. All these tubes are brand new, in original packing, and tested before despatch. Please add 2/6 packing and carriage for any of the above tubes.

AMERICAN INDICATOR UNIT TYPE BC929A. Brand new incorporating 3in. tube 3BP1, with mu-metal shield, 2-6SN7GT, 2-6H6GT, 6X5G, 2X2, 6G6G, 9 potentiometers 24 v. aerial switch motor, transformer, and a host of small components. The whole unit which measures only 8¼in. × 8¼in. × 13½in. is brand new, enclosed in black crackle box, and can be supplied at 65/-, plus 5/- p. & p.

BRAND NEW C.R. TUBES.—By leading manufacturer. 14KP4A. Latest type 14in. rectangular 6.3 v. heater. 12-14 Kv. In original sealed cartons. Limited quantity only at £13/19/6. Plus 15/- packing, carriage and insurance.

TRIPLETT RECTANGULAR METER. 4in. scale. Knife-edge needle. Basic movement 0-100 microamps. At present graduated for multi-range meter. Brand new in sealed cartons, 90/-, plus 2/- p. & p.

STOP PRESS ! ! !

2½in. ROUND FLUSH MOUNTING METER by WESTON, blank scale ready for re-engraving, FSD 650 microamps, brand new, 27/6 only.

22 SET POWER UNITS No. 4MK1 ZA10478—Complete with 4 metal rectifiers each 250 v. 60 mA. 2-12 v. 4 pin Mallory Vibrators, transformers, condensers, resistors, signal 1 amp. indicator, etc., etc., in good condition. Complete in metal box size 10½in. × 6in. × 8in. Weight 19lb., 27/6, plus 5/-.

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. F.W. bridge type..	9/6
6 or 12 v. 2 a. F.W. bridge type....	11/3
6 or 12 v. 2.5 a.....	12/6
6 or 12 v. 4 a. F.W. bridge type....	15/-

CHARGER TRANSFORMERS. Input 230 v.

6/12 v. 1 a.....	9/9
2 6/12 v. 2 a.....	14/6
2 6/12 v. 4 a.....	17/6

ARMSTRONG F.C.48 Their very latest high quality replacement chassis having provision for F.M. feeder unit. 8 valves, four wavebands. Independent bass and treble with unique thermometer visual indicator. Ready for use £23/18/- plus 5/- p. & p.

METER SPECIAL ! We have a limited quantity of aircraft electrical thermometers Brand new, by Weston. 2in. moving coil meter, flush square fitting. These meters have a luminous scale graduated 40-140 degrees centigrade, but the full scale deflection is approximately 150 microamps! Price 12/6 each only, plus 1/- P. & P.

VIBRATOR PACK. Brand new, by Mallory. 12 volt input, 150 v. 40 mA. output. Complete with synchronous vibrator, 27/6.

DECCA LIGHTWEIGHT PICKUPS. Complete with either standard or L.P. Crystal Cartridge insets. Complete with Rest and Tracking instructions, 32/6 plus 1/6 P. & P. Also their very latest type, as above, but with turn-over head 47/6 only ! Plus 1/6 P. & P.

6-VOLT VIBRATOR PACK. Ex-W.D. 6-volt input, output 140 v. 30 mA. Fully smoothed and rectified, incorporating Wearite 6 volt 4 pin vibrator type N8B6. Unit size only 6½in. × 5in. × 2½in. Price 15/- plus 1/6 P. & P. New condition.

SPECIAL OFFER—TRANSMITTING VALVES. These are brand new originally boxed, and guaranteed O.K. Type 813, 80/- ea. Type 866A, 17/- per pair, both post free. Also type 29C1 at 20/-. 12E1 at 40/- ea.

VALVES. We have a very comprehensive stock of surplus valves at competitive prices. A stamp will bring Valve Price List.

SPECIAL OFFER—METERS. Taken from equipment, but guaranteed perfect. 2in. round, 0-20 amp., 2in. round, 0-40 amp. 2in. round 0-50 amp. 3/9 ea., or 3 for 10/6 2½in. round panel-mounting 0-500 mA., 5/-. All the above plus P. & P. please !

R.F. UNITS. All new condition and complete. Case size 9½in. × 7½in. × 5in. Type 24.—20-30 Mc/s. 15/-. Switched Tuning. Type 25.—40-50 Mc/s. 19/6. Switched Tuning. Type 27.—65-86 Mc/s. 45/-. Variable Tuning. Type 26.—50-65 Mc/s. Variable Tuning 35/-. We have a limited supply of RF27 new condition and complete, but tuning dial damaged. Price only 30/- each. ALL these units Post Free!

LOUDSPEAKER SPECIAL ! ! 12in. 3 ohm Plessy P.M. 37/6 plus 2/6 P. & P.

TRANSFORMER SPECIAL ! ! Drop-through tropicalized. 110-210-240 v. primary. 350-0-350 at 120 mA. 6.3 v. 6 a., 6.3-1½ a., 5 v. 3 a. 21/- plus 2/6 P. & P.

AMERICAN CONTROL UNIT C58/APT1. Box measures only 5in. × 3½in. × 2in. Incorporating 2in. round 0-1 mA. meter 200 ohm. pot, 2 toggle switches, indicator lamp, etc. Price 22/6, post free.

HEADPHONES. Brand new, ex-Govt., by S. G. Brown. Type CLR. Low resistance, 7/6 per pair. Type CHR high resistance, 12/6 per pair. We can also supply very special brand new American ex-Govt. lightweight high resistance phones by Trimm at 15/- per pair.

"VOLTALYTE" 2 volt 60 amp. ACCUMULATORS MULTI-PLATE Type in Celluloid containers. Size 3in. × 3in. × 4½in. high at 9/6 each plus 2/- P. & P. Or 3 for 28/6, post free.

No. 38 TRANSMITTER/RECEIVER WALKIE-TALKIE. Range approx. 5 miles. Coverage 7-4-9 Mc/s. The set only, complete with valves at 30/-, in very good condition.

RECORD PLAYER CABINETS. Specially made to house any type of single record unit. Finished in dove-grey leatherette. Baseboard measures 14½in. × 12½in. Clearance above and below board 3in. 45/- plus 3/- P. & P.

24 VOLT ROTARY CONVERTER. Input 24 v. D.C. Output 200/250 v. A.C. 100 watts. Complete in black steel box 18½in. × 11½in. × 8½in. Weight approx. 30lbs. Completely smoothed incorporates Sodium Lamp transformer. Brand new 92/6.

Please add postage under £1. C.O.D. or Cash with order. C.O.D. charge extra—open 9 a.m.–6 p.m. Monday to Friday. Sorry, but we close at 1.0 p.m. on Saturday.

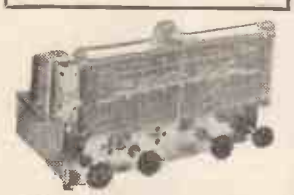
OUR NEW "POPULAR" AMPLIFIER. A.C. Mains 2/3 ohms. 4 watts output. Suitable for either crystal or magnetic pick-up. Valve line-up, 6V6GT, 6S7GT, 5Y3GT. Provision for radio feeder unit. Volume and tone controls. Built in crackle-finished steel box, with chrome carrying handle. Attractive bakelite engraved front panel. Box measures 9¼in. × 7¼in. × 6¼in. Price only £6/12/6 carriage paid. Ready for use.

We have in stock the very latest "Elpico" Feeder Unit type RF720. 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.

No. 17 Mk. II TRANSMITTER/RECEIVER. Built into a strong wooden cabinet 15in. × 14in. × 9in. Complete with headphones and microphone. Range 5-8 miles with simple aerial. 44-61 m/cs. (5-7 metres). Uses standard 120 v. H.T. and 2 v. L.T. batteries. Illustrated instruction book supplied with each unit. 50/- each plus 7/6 post and packing.

THE R.C. 3/4 WATT AMPLIFIER KIT.—Just released! Compare the advantages! Treble, bass, AND middle tone controls! For crystal or magnetic pickup! A.C. Mains. 200/250 v

Valve line-up, 6V8GT, 6S7 metal, 6X5GT. Negative feedback. Built on stove enamelled steel chassis, measuring only 8in × 4in × 1¼in. Four engraved cream knobs are included in the price of the complete Kit with all necessary practical and theoretical diagrams, at £4/5/- only, plus 2/6 packing and post, or Instruction Book, fully illustrated, for 1/-, post free! This amplifier can be supplied assembled, tested, and ready for use at £5/5/-, plus p. & p. Hearing is believing!



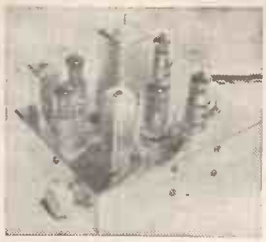
SUPER-QUALITY 6-VALVE RADIOGRAM CHASSIS

Very limited quantity by Britain's leading quality manufacturers, 3 waveband, superhet, valve line-up, 6V6G, EZ40, ECH42, L63, EF41 and EBC41. Combined pick-up amplifier and A.F. amplifier on Radio and Gram. Employs a special circuit for gramophone pre-amplification. Large glass dial horizontal tuning measuring 11in. × 3½in. Chassis measurement: 14½ × 9 × 8in. This is a superior chassis designed to sell originally in a Radiogram costing £79. Our price is £12/19/6 only, tax paid, plus 5/- packing and carriage. We will gladly demonstrate this chassis or any other working item from our stocks, to personal callers!

Carrying cases in black leatherette finish An extremely well-made case with chrome locks and corner-pieces for extra strength. This cabinet will house any 12in. Hi-Fi speaker, but can be put to a number of uses. Front panel and lid are removable. Size: 18½in. × 10½in. × 16½in. high. 47/6, plus 5/- post and packing.

F.M.!! (Frequency Modulation)

We are pleased to announce our complete Kit for the "Denco" F.M. Feeder Unit. This unit provides an A.F. output suitable for feeding into the audio section of a standard broadcast receiver where triode/pentode output are available. Within an average of 30 miles from a V.H.F. transmitter one I.F. stage should be adequate, but our complete Kit supplied includes all components and valves for an extra I.F. stage if necessary, or if the unit is used at greater distances. Full Constructional details, theoretical circuit and point-to-point wiring diagram can be supplied for 1/6 post free, or the complete Kit right down to the last nut and bolt, at only £6/7/6, plus 2/6 packing and postage. This unit can be supplied if desired, ready assembled, aligned and tested, at £8/10/- plus 2/6 packing and postage.



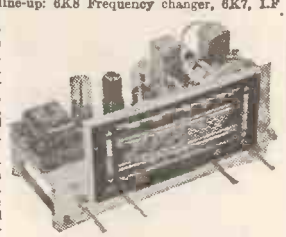
If required we shall be pleased to align this unit for constructors not possessing the necessary equipment, for a charge of 7/6. N.B.—Valve line-up is 6AM6, 12AH8, 2-6BA6 and 6AL5. Chassis measures only 6½ × 5½ × 1½in. Demonstrations at 18, Tottenham Court Road!!

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, 10½in. × 10in. wide. Maximum depth at base 5in. tapering to 3½in. at top. Sloping front. Very attractively finished in light walnut and peach. Each component brand new and tested prior to packing. Complete instruction booklet with practical and theoretical diagrams is provided. Booklet available at 1/6, post free. Our price for complete kit, £6/9/6!!! Please add 2/6 packing and carriage. If preferred, we can supply Cabinet Assembly only, comprising Cabinet and bracket 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.

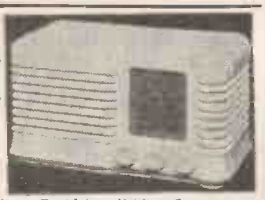
THE R.C. GRAM REPLACEMENT CHASSIS KIT

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: 13½in. × 5½in. × 2½in. Dial size: 10in. × 4½in. 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/E 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 and 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 diagrams. Each component brand new and tested prior to packing. Our price £5/10/- complete—Remember this set is being demonstrated at our shop premises! We proudly claim that our fully illustrated instruction booklet is the most comprehensive available for this type of receiver—Booklet available at 1/6 post free This is allowed if kit is purchased later—Please, 2/6 packing and carriage for complete kit.



DULCI RADIO/RADIOGRAM CHASSIS

This very popular range of superior chassis can be supplied from stock. We will gladly demonstrate any to personal callers. All incorporate latest type valves 6BE6, 6BA6, etc. Flywheel tuning, negative feedback over entire audio section. Engraved knobs—3 tone position for Radio and Gram. All are built on chassis ize 11½in. × 7in. × 8½in. high. All A.C. 100/110 and 200/250 v.—Dial size 8½in. × 4½in. for horizontal tuning. Attractive appearance.

Model B.3, Long, Medium, Short Waves (5 valves). Cash Price £12/12/-. H.P. Terms £3/4/- deposit and 12 months at 17/8.

Model B.3 Plus Push Pull Stage. (6 valves). Cash Price £15/15/-. H.P. Terms, £3/19/- deposit, 12 months at £1/2/2.

Model B.3 Double Feature Push Pull and R.F. Stage (7 valves). Cash Price £18/18/-. H.P. Terms, £4/13/- deposit, 12 months at £1/6/9.

Model B.6. (Medium, Long and Four Short Wavebands, bandespread.) Cash Price £15/15/-. H.P. Terms, £3/19/- deposit, 12 months at £1/2/2.

Model B.6, Plus Push Pull Stage (6 valves). Cash Price £18/18/-. H.P. Terms £4/13/- deposit, 12 months at £1/6/9.

Model B.6. Double Feature Push Pull Plus R F. Stage (7 valves). Cash Price 22 gns. H.P. Terms £5/15/6 deposit, 12 months at £1/12/6.

All chassis fully guaranteed 12 months. Please include 7/6 packing, carriage and insurance. Illustrated leaflet available. Suitable speakers available. Ask for speaker list

THE R.C. RAMBLER ALL-DRY PORTABLE KIT

Full assembly details with practical and theoretical diagrams can be supplied at 1/6 post free. This is a truly professional 4-valve superhet—all dry—for medium and long waves. A cream plastic top panel, with dial engraved in red and green, adds to the very imposing appearance of this model which is housed in an attractive cream and grey leatherette covered attache-case type cabinet; measuring only 9in. × 7in. × 5½in. Weight less batteries, 4½lb. with batteries 6½lb. This set really has everything! Built-in frame aerial, high quality, extremely sensitive, and very adequate volume from the 5in. speaker. Valve line-up: 3V4, 1R5, 1S5, 1T4. Also the required components, exactly as specified, including cabinet, can be supplied from stock at the special inclusive price of £7/7/- plus 2/6 p. & p. (less batteries). Uses Ever-Ready 90 v. H.T. type B126 at 9/3. Also L.T. 1.5 v. A.D.35 at 1/4

RAMBLER MAINS UNIT!—At last we are able to offer our special mains units kit for using our popular all-dry "Rambler" on A.C. Mains. Complete kit, which when assembled fits snugly into battery compartment, can be supplied at 47/6, plus 1/6 packing and postage. Price includes all required components, and full assembly instructions. N.B.—This unit is completely self contained in a metal box measuring 7in. × 2½in. × 1½in. and is ideally suitable for ANY all-dry battery portable requiring 90 v. H.T. and 1.5. v L.T.

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. **THE NEW R.C. HIGH-FIDELITY AMPLIFIER.** P.P. 6V6 output. Freq. 25—18,000 cps—60 db 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 1/6. Attractive metal cover, now available, with built in carrying handle 19/6.

LATEST 3-SPEED AUTO-CHANGER, long arm model complete with C. and D. high fidelity heads. Limited quantity at £17/10/- plus 5/ p. & p. H.P. terms available. **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. We have in stock at our usual competitive prices, ALL the required components for Osram and Mullard amplifiers. Available ex stock. The LEAK TL10 Amplifier complete. 27 guineas, or H.P. terms available.

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. **AMPLIFIER BARGAIN. "THE EMPRESS"** Super quality push-pull 4 valve 4 watt amplifier. Ideal for record or radio tuner reproduction. Measures only 7½in. × 7½in. × 3½in. Valve line up EL42, EL42, EZ41, EC83, for use with one or two 3 ohm speakers. Price £7/7/- plus 3/ p. & p.

CLYNE RADIO LTD.

18, Tottenham Court Road, London, W.1.

SELENIUM RECTIFIERS

L.T. Types

2/6 v. ½ a.h.w.... 1/9
6/12 v. ½ a.h.w. 2/9

F.W. Bridge Types

6/12 v. 1 a. 4/11
6/12 v. 1.5 a. ... 7/9
6/12 v. 2. a 9/9
6/12 v. 3 a. 12/9

H.T. Type H.W.

120 v. 40 mA.... 3/11
250 v. 50 mA.... 6/9
250 v. 80 mA... 7/9
250 v. 150 mA. RM4 250 v. 250 mA. 9/9 11/9
300 v. 275 mA. 12/11

F.W. (Bridge Type)

250 v. 80 mA.... 11/9

CO-AXIAL CABLE. 75 ohms ¼in., 7d yard. Twin screened feeder, 10d. yd.

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. 0.3 a., 6/9 doz.; 4.5 v. 0.3 a., 6/9 doz.

ELECTROLYTICS (Current production) NOT ex Govt.

Tubular Types

8μF 450 v. ... 1/9
8 mfd. 500 v.... 2/6
16μF 350 v..... 2/3
16μF 450 v. ... 2/9
16μF 500 v. ... 3/9
32μF 350 v. ... 3/9
32 mfd. 500 v.... 5/9
8-16μF 500 v.... 4/11
25μF 25 v. 1/3
50μF 12 v. 1/3
50μF 50 v. 2/3
100 mfd. 12 v.... 1/9
100 mfd. 25 v.... 2/3

Can Types

8 mfd. 350 v.... 1/3
8 mfd. 450 v.... 2/3
8 mfd. 500 v.... 2/9

Can Types

16 mfd. 350 v.... 1/11
16μF 450 v..... 2/9
24μF 350 v..... 2/11
32μF 350 v..... 2/11
32 mfd. 450 v.... 4/9
64 mfd. 450 v.... 4/9
100 mfd. 450 v. 4/9
8-8μF 450 v.... 3/11
8-8 mfd. 500 v. 4/9
8-16μF 450 v.... 2/11
16-16μF 450 v. 4/11
16-32μF 350 v. 4/9
32-32μF 350 v. 4/9
32-32μF 450 v. 5/11

R.S.C. TRANSFORMERS

FULLY GUARANTEED, INTERLEAVED AND IMPREGNATED

MAINS TRANSFORMERS

Primaries 200-230-250 v. 50 c/s.

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250 v. 60 mA. 6.3 v. 2 a., 5 v. 2 a., Midget type, 2½-3-3in. 17/6
350-0-350 v. 70 mA., 6.3 v. 2 a. 5 v. 2 a. ... 19/9
250-0-250 v. 100 mA., 6.3 v.-4 v., 4 a., c.t., 0-4-5 v. 3 a. 26/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a. ... 23/9
250-0-250 v. 100 mA., 6.3 v. 6 a., 5 v. 3 a., for R1355 conversion 31/-
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.... 23/9
300-0-300 v. 100 mA., 6.3 v.-4 v. 4 a., c.t., 0-4-5 v. 3 a. 26/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a. 23/9
350-0-350 v. 100 mA., 6.3 v.-4 v., 4 a., c.t., 0-4-5 v. 3 a. 26/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a. 33/9
350-0-350 v. 150 mA., 6.3 v. 2 a., 6.3 v. 2 a., 5. v. 3 a. 33/9
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t., 6.3 v. 4 a., c.t., 5 v. 3 a., suitable Williamson Amplifier, etc. 49/9
450-0-450 v. 250 mA., 6.3 v. 6 a., 6.3 v. 6 a., 5 v. 3 a. 69/6

TOP SHROUDED DROP THROUGH TYPE

250-0-250 v 70 mA., 6.3 v. 2.5 a..... 13/9
260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.... 16/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.... 18/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a. 22/9
300-0-300 v. 100 mA., 6.3 v.-4 v. 4 a., c.t., 0-4-5 v. 3 a. 23/9
350-0-350 v. 100 mA., 6.3 v. 4 a., c.t., 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. 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. 29/9

E.H.T. TRANSFORMERS. 2,500 v. 5 mA., 2-0-2 v. 1.1 a., 2-0-2 v. 1.1 a., for VCR97, VCR517 ..... 36/6

FILAMENT TRANSFORMERS

Primaries 200-250 v. 50 c/s.

6.3 v. 1.5 a..... 5/9
6.3 v. 3 a. 8/11
12 v. 1 a. 7/9
0-2-4-5-6.3 v. 4a 16/9
6.3 v. 2 a. 7/6
0-4-6.3 v. 2 a.... 7/9
6.3 v. 6 a. 17/6
12 v. 3 a. or 24 v. 1.5 a. 17/6

CHARGER TRANSFORMERS

All with 200-230-250 v. 50 c/s. Primaries: 0-9-15 v. 1½ a., 11/9; 0-9-15 v. 3 a., 16/9; 0-9-15 v. 5 a., 19/9; 0-9-15 v. 6 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, 8,000 to 3Ω 4/9
Battery 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 to 15Ω 15/9
Push-Pull 10-12 Watts to match 6V6 to 3-5-8 or 15Ω 16/9
Push-Pull 20 Watts high-quality sectionally wound, 6L6, KT66, etc., to 3 or 15Ω ... 47/9

SMOOTHING CHOKES

250 mA., 3 H., 50 ohms 11/9
150 mA., 7-10 H. 250 ohms 11/9
100 mA., 10 H., 150 ohms potted 9/9
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

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, Preset type, 1/9 each

EX GOVT. 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.

EX-GOVT. BLOCK PAPER CONDENSERS

2 mfd. 800 v. ... 1/9
4 mfd. 500 v. ... 2/9
4 mfd. 1,000 v.... 4/3
4 mfd. 1,500 v.... 4/9
4 mfd. 2,000 v.... 6/9
6-6 mfd. 450 v.... 5/9
8 mfd. 500 v. ... 5/9
8-8 mfd. 500 v.... 6/11
15 mfd. 500 v. ... 7/9
4 mfd. 400 v. plus 2 mfd. 250 v., 1/11.

M.E. SPEAKERS. All 2-3 ohms, 8in. R.A. field, 600 ohms, 11/9. 10in. R.A. field, 1,500 ohms, 23/9. 10in. R.A. field, 1,000 ohms, 23/9.

SPECIAL OFFERS. Mains Trans. 200-250 v. 50 c/s. Primary Secs. 250-0-250 v. 200 mA. 6.3 v. 8 a. 5 v. 3 a., 21/9. Small output Transformer, 5,000 ohms to 3 ohms., 1/11.

GOODMANS 3½in. P.M. SPEAKER (ex equip.), with battery pentode trans., 12/9.

HEAVY DUTY BATTERY CHARGER

For normal 200/250 v. A.C. mains input. To charge 12 v. battery. Variable charge rate of up to 10 amps. Fitted Meter and Fuses. Guaranteed 12 months. Carr. 7/6. £6/19/6.

DRYDEX HANDLAMPS. Suitable for garage lights, etc. (Normal price 29/6). Limited number. Brand new boxed, fitted with bulb, 19/6.

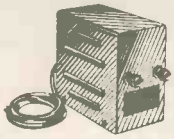
H.T. ELIMINATOR AND TRICKLE CHARGER KIT with louvred crackle finished case, Mains input 200-250 v. Output 120 v. 40 mA., and 2 v. ½ a. Price with circuit, 29/6.
Or in working order, 37/6.

THE SKY CHIEF/2 T.R.F. RECEIVER

A design of a 3-valve 200-250 v. A.C. Mains receiver with selenium rectifier. For inclusion in either of cabinets illustrated above. It employs valves 6K7, SP61, 6F6G, and is specially designed for simplicity in wiring. Sensitivity and quality is well up to standard. Point-to-point wiring diagrams, instructions, and parts list, 2/6. This receiver can be built for a maximum of £4/19/6 including cabinet. Available in brown or cream bakelite, or veneered walnut.

P.M. SPEAKERS. All 2-3 ohms. 6½in. Plessey, 16/9. 8in. Plessey, 16/9. 10in. R.A., 26/9. 10in. Plessey, 19/9. 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 GREEN CRACKLE LOUVRED STEEL CASE, MAINS TRANSFORMER, FULL WAVE METAL RECTIFIER, FUSES, FUSE-HOLDERS AND CIRCUIT. Any type assembled and tested for 6/9 extra.



R.S.C. 6 v. or 12 v. BATTERY CHARGER

For normal A.C. mains input 200-230-250 v., 50 c/s. Selector panel for 6 v. or 12 v. charging. Variable charge rate of up to 4 AMPS. Fused, and with 5 amp meter. Well ventilated metal case with attractive crackle finish. Guaranteed for 12 months, 69/6. Carr. 2/6.

EX.GOVT. MAINS TRANSFORMERS

All 230 v. 50 c/s. input.

8.8 v. 4 a. 9/9
48 v. 1 a. 9/9
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. 29/6
400 v. C.T. 150 mA. 4 v. 5 a., 6.3 v. 6 a., 6.3 v. 0-6 a., 4 v. 6 a., 4 v. 6 a., 4 v. 3 a., 4 v. 3 a., 5 v. 2 a. 22/9

EX-GOVT. AUTO TRANSFORMERS

15-10-5-0-195-215-235 v. 500 watts 27/9
Double wound 10-0-200-240 v. to 10-0-275-295-315 v. 1,000 watts 69/6
0-230 v. in steps of 11 volts from 57.5 5 KVA (21 amps.) £6/15/-
Double wound 0-110-240 v. to 0-130-140-150-160-170 v. 1,500 watts 69/6
Carriage on any of above 5/- extra.

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

CHASSIS

18 s.w.g. undrilled aluminium amplifier type (4-sided).

14in. × 9in. × 2¼in. 6/11
14in. × 10in. × 3in. 7/11
16in. × 10in. × 3in. 8/3

18 s.w.g. aluminium receiver type.

6in. × 3⅜in. × 1½in. 1/11
7½in. × 4¾in. × 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. HIGH FIDELITY 25 watt AMPLIFIER A 4

A NEW DESIGN FOR 1955

HIGH GAIN "PUSH PULL OUTPUT." BUILT-IN PRE-AMP. TONE CONTROL STAGES. INCLUDES 7 valves, sectionally wound output transformer, block paper reservoir condenser, and reliable small components. AN INPUT OF ONLY 20 millivolts IS REQUIRED FOR FULL OUTPUT. THIS MEANS THAT ANY TYPE OF MICROPHONE OR PICK-UP IS SUITABLE. Two separate inputs controlled by separate volume controls allow simultaneous use of "Mike" and Gram., or Tape and Radio, etc., etc. Individual controls for Bass and Treble "lift" and "cut." Six negative feedback loops giving total of 24 D.B. Frequency response ± 3 D.B. 30-20,000 c/s. Hum level 66 D.B. down. Certified total harmonic distortion of only 0.35% measured at 10 watts. Comparable with the very best designs. SUITABLE FOR SMALL HOMES OR LARGE HALLS, CLUBS, GARDEN PARTIES, DANCE HALLS, etc., etc. For ELECTRONIC ORGAN OR GUITAR. For STANDARD OR LONG PLAYING RECORDS. Size 12 × 10 × 9in. For mains A.C. 200-250 v. 50 c/s. Power consumption 175 watts. Outputs for 3 and 15 ohm speakers. The kit is complete in every detail. Chassis is fully punched. Easy to follow point-to-point wiring diagrams, are supplied. EXTRA HIGH SENSITIVITY, HIGHEST QUALITY for 50/- extra Or assembled ready for use **9 Gns.**

H.P. Terms on assembled units. Deposit £2 and 10 monthly payments 22/6. plus carr. 10/-
Terms to include cover, mike, speakers, etc., on request. Cover as illustrated if required, price 17/6 extra.

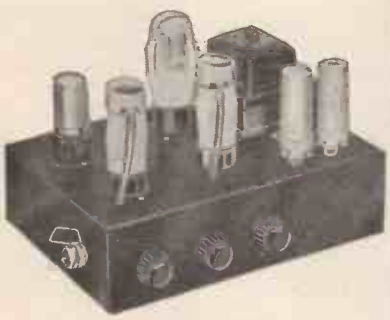
W.B. "STENTORIAN" High fidelity P.M. Speaker HF1012, 10 watts, 15 ohm (or 3 ohm) speech coil. Where a really good quality speaker at a low price is required we highly recommend this unit with an amazing performance. £3/17/6.

MICROPHONES. Crystal, hand or Desk type, high fidelity Acos, 50/-. Stand type with base and adjustable stand, £6/19/6. Both suitable for use with our amplifiers.

PLESSEY 3-SPEED MIXER AUTOCHANGERS with crystal pick-up having alloy stylus with separate sapphire points for long playing or standard records. (Will play 2,000 records before replacement stylus required.) Brand new, cartoned, guaranteed. For 200-250 v. A.C. mains. Limited stocks at only 10 gns. plus 5/- carr.

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).

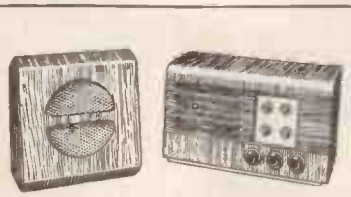
R.S.C. 4-5 WATT HIGH GAIN AMPLIFIER TYPE A5



A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 50 millivolts input is required for full output so that it is suitable for use with the latest high-fidelity pick-up heads, in addition to all other types of pick-ups and practically all mikes. Separate Bass and Treble controls are provided. These give full long playing record equalisation. Hum level is negligible being 71 D.B. down. 15 D.B. of negative feedback is used. H.T. of 300 v. 25 mA. and L.T. of 6.3 v. 1.5 a. is available for the supply of a Radio Feeder Unit, or Tape Deck pre-amplifier. For A.C. mains input of 200-230-250 v. 50 c/s. Chassis is not alive. Kit is complete in every detail and includes fully punched chassis (with baseplate), with green crackle finish, and point-to-point wiring diagrams and instructions. Exceptional value at only £4/15/-, or assembled ready for use 30/- extra, plus 3/6 carr.

A PUSH PULL 3-4 WATT HIGH GAIN AMPLIFIER FOR £3/7/6.

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, 6d.



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 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 35/- each. The Master Unit can be supplied assembled and tested for 30/- extra.

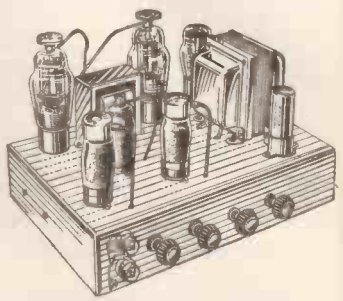
PERSONAL SET BATTERY SUPERSEDER KIT.

All parts for an "All Dry" Battery Eliminator. Complete with case. For 4 valve receivers requiring 90 v. 10 mA. and 1.4 v. 250 mA. Fully smoothed. Outputs from normal. 200-250 v. 50 c/s mains. Price with circuit, 35/9. Or ready for use, 42/6. Size of units 5¼-4-1¼in.

BATTERY SET CONVERTER KIT. 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. A3 10 WATT "PUSH PULL" HIGH FIDELITY AMPLIFIER.

With Self Contained Pre-amplifier and Tone Control.



This amplifier, whilst having sufficient output to fill a small hall, is the ideal amplifier for the quality enthusiast who knows that though the average listening level is less than one watt it is necessary, for the very highest quality, to have an output of at least ten times this figure in order to obtain completely distortionless reproduction of sudden loud sounds.

The layout of the components has been planned to give the very maximum of performance with the minimum of constructional effort. Large safety factors in every component A.C. and H.T. fuses, punched chassis with baseplate, screened input plugs, valves, and with easy-to-follow point-to-point wiring diagrams. Everything is supplied down to the last nut and bolt.

Two independent inputs are provided with two associated independent volume controls so that programmes can be mixed together if desired, such as microphone announcements superimposed on a musical programme, or two independently controlled microphones, or even just gramophone/radio, fading over from one to the other. Variable base lift and cut with variable treble lift and cut tone controls are fitted, giving full long playing record equalisation for uncorrected pick-ups. They are also provided so that the user can alter the tonal value to suit his personal taste and surroundings. Because of the large negative feedback employed the output transformer can be so designed that it provides all the specified power even with large variations of loudspeaker impedance. Terminals are provided for 3 ohm and 15 ohm loudspeakers.

H.T. and L.T. available for the supply of a Radio Feeder Unit.

Six Negative Feedback Loops.
130 millivolts input only required for full output.
Frequency response + 3 DB 50-20,000 cycles.
Negligible hum and distortion.
For A.C. mains input 200/230/250 v. 50 c/s.

COMPLETE Kit of Parts **7 GNS.** (carriage 5/-)
Supplied assembled and tested for 45/- extra.
H.P. TERMS AVAILABLE ON ASSEMBLED UNITS.

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 tage. 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 11-6-7¼in. 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.

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, 2/6 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.

"Hi-Fi" EQUIPMENT and KITS
TO SUIT ANY BUDGET

TWO COMPLETE "Hi-Fi" AMPLIFIER KITS

"STERNS" HIGH QUALITY 8-10 WATT AMPLIFIER

Having a front panel which is very attractively finished in deep gold, and on which the controls are clearly identified. The ideal amplifier for general home use and for small halls, etc.

Price of COMPLETE KIT including Valves and Drilled Chassis, etc. (Plus 2/6 carr. and ins.). **£7/10/-**

We will supply it Completely Built for **£9/10/-** (Plus 5/- Carr. & Ins.)

Designed for high quality reproduction up to an output level of 10 watts, having 6V6s in Push-Pull and incorporating negative feedback. It is suitable for use with all types of Pick-ups and most types of microphones and the output transformer provides for use of 3 and 15 ohm speakers.

BRIEF FEATURES

- Valve line up 6Z5, 6SN7, 5Z4, with 6V6s in push pull.
- The undistorted output level of up to 10 watts is produced from an input of .25 volts.
- First class reproduction of Radio (where a Tuning Unit is used) and Record Playing.
- Separate Bass Boost and Treble Controls provide an excellent range of frequency control.
- Very satisfactory results are obtained with an average type of high impedance Moving Coil or Crystal Microphone, a clear speech level of approx. 5 watts output being obtained.
- Power supplies (HT and LT) are available for a Tuning Unit.
- For operation on A.C. Mains 200-250 volts 50 cycles.

THE ASSEMBLY MANUAL is available for 1/- and includes detailed layouts and component Price List.

"STERNS" 12 Watt "HIGH FIDELITY" Push-Pull AMPLIFIER

A very high quality Unit attractively finished in deep gold with each control clearly identified on the front panel. Comprising a Main Amplifier Chassis and a Remote Control Pre-Amplifier-Tone Control Unit. The remote control unit measures only 9 × 4 × 2½in. and contains four controls, being: Bass-Treble-Volume and a Radio, Gram, Microphone Switch control. It incorporates its own feedback circuit on the Bass Channel. Loop negative feedback is employed on the Main Amplifier which has a valve line up of 6J5-6N7-5U4 with two PX25's in push-pull and 6J5 and 6SN7 are used in the remote control unit.

THE COMPLETE KIT IS AVAILABLE FOR **£14/-/-** (Carr. & Ins. 6/- extra.)
THE COMPLETE UNIT ASSEMBLED AND READY FOR USE **£17/-/-** (Carr. & Ins. 7/6 extra.)
H.P. Terms £4/5/- Deposit, 12 Months at £1/3/11.

The measured frequency range of the amplifier with this unit shows an excellent response from 14,000 cycles down to 20 cycles, the bass and treble controls allowing independent control of gain at both ends of the frequency range from zero to a gain of 50. It can be seen, therefore, that ample correction is provided to suit any type of pick-up with any type of recording. Input voltage for maximum output is 70 mV and 6.3 volts at 2 amps. and 30 mA. H.T. is provided for tuning unit, etc. This Amplifier compares well with the Williamson and similar designs at a fraction of their cost. The complete set of assembly instructions is available for 2/-.

SPECIAL PRICE REDUCTIONS
FOR COMPLETE EQUIPMENT

SELECT A TUNING UNIT and AMPLIFIER or TUNING UNIT, AMPLIFIER and RECORD PLAYER (and a SPEAKER if required) and we will supply at a REDUCED PRICE. H.P. TERMS ALSO QUOTED.

WE HAVE IN STOCK... THE DENCO F.M. FEEDER UNIT

Consisting of a 5 valve Superhet design incorporating R.F. (6AM6) and F/C (12AH8) Stages followed by Two I.F.s (6BA6's) and Ratio Discriminator 6AO5, the coverage provided being 88-100 Mc/s.

THE COMPLETE KIT including VALVES and DRILLED CHASSIS is available for £6/13/6

It is suitable for use with any type of High Fidelity Amplifier. (Plus 4/- Carr. and Ins.) The descriptive manual, including circuit and Component Layout, etc., is available for 1/6.

THE COMPLETELY ASSEMBLED CHASSIS, ready for use, aligned and tuned EACH PRICE INCLUDES TWO I.F. STAGES. £8/17/6 Plus 6/- Carr. & Ins.

The NEW "LEAK" TL/10 AMPLIFIER and "Point One" PRE-AMPLIFIER

This Amplifier has a maximum output of 10 watts and maintains in every respect the world renowned LEAK reputation for precision engineering: fine appearance and fastidious wiring. The Pre-Amplifier will operate from any make or type of pickup. A continuously variable input attenuator at the rear of the Pre-amp. permits the instantaneous use of crystal, moving iron and moving coil pickups. H.T. and L.T. supplies are available for a Radio Tuning Unit. An input attenuator is fitted. S.A.E. for descriptive leaflet.

PRICES :

(a) The COMPLETE AMPLIFIER WITH PRE-AMPLIFIER, £28/7/-, or £7/2/- Deposit and 12 months at £2.
(b) The TL/10 MAIN AMPLIFIER ONLY: £17/17/-, or £4/7/- Deposit and 12 months at £1/5/4.
(c) The "POINT ONE" PRE-AMPLIFIER ONLY: £10/10/-, or £2/12/6 Deposit and 12 months at 15/-.

!! ANOTHER OUTSTANDING OFFER !!

A PORTABLE RECORD PLAYER *incorporating The* **New COLLARO 3-SPEED AUTOCHANGER MODEL R.C. 54** *for only* **£14/14/-** Plus 7/6 carriage and insurance).

H.P. TERMS: Deposit £3/14/- followed by 12 monthly payments of £1/0/5.

This is a really GENUINE BARGAIN ... The PORTABLE CASE is extremely well made and covered with grey rexine, and, as will be seen by the illustration, has space available to accommodate an Amplifier thereby enabling a complete "RECORD REPRODUCER" to be quite easily made. The COLLARO MODEL R.C.54 is a "mixer" 3-speed Autochange Unit incorporating the famous light-weight STUDIO "O" Crystal Pick Up, and it is undoubtedly one of the best Autochangers made.

Our MODEL AMP. 3 AMPLIFIER will operate perfectly with the Collaro Changer and can quite easily be accommodated in the above Portable Case. It comprises a 3 valve A.C. Mains design employing a 6K6 Output Valve for about 3 Watts and incorporates an efficient Tone Control. Price £4/4/- assembled and including a 6½in. P.M. Speaker.

WE CAN SUPPLY... COMPLETE KIT or ASSEMBLED CHASSIS FOR THE OSRAM 912 AMPLIFIER. Designed by General Electric Co.

A modern high quality 12 watt Amplifier for the HOME CONSTRUCTOR, having a Valve line-up of U709, B309, Z729 and two N709's in Push-Pull.

The Assembly Instructions include five "easy stage-by-stage" diagrams and are available for 3/6.

Price of COMPLETE KIT **£21/4/-** (Plus 7/6 Carr. and Ins.)

WE WILL SUPPLY THE COMPLETELY ASSEMBLED AMPLIFIER for **£25/-/-** (Plus 7/6 Carr. & Ins.)

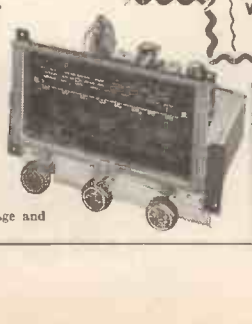
H.P. Terms: £6/5/- Deposit and 12 months at £1/15/2.

"STERNS" MODEL CP3G 3 WAVEBAND SUPERHET TUNING UNIT

A highly sensitive tuning unit providing for excellent reception of stations on the short wavebands (16-50 metres) medium waveband (200-550 metres) and the long waveband (800-2,000 metres). We can supply this tuner to correctly operate with each of the Amplifiers.

- Valve line-up: 6K8G (Frequency Changer), 6SK7g (I.F. Amplifier), 6Q7g (Detector, A.V.C. and 1st A.F. Amplifier), and 5Z4g (rectifier).
- A gramophone position is incorporated with the wavechange switch and the 6Q7g valve becomes the 1st A.F. Amplifier for he gramophone pickup.
- The illustration shows the Tuner with four controls—Tuning, Volume, Tone and the Wavelength Switch (Tone and Volume operate as both Radio and Gram.)—but if your Amplifier already has the Tone and Volume Controls we can omit both. When ordering please state what is required.
- Overall chassis dimensions are 12in. × 8½in. × 8in. including the full vision dial Size 8½in. × 4½in.
- For A.C. Mains only, power supply required—H.T. 250 volts 30 mA., L.T. 6.3 volts 1½ amp.

Price, completely assembled and including built-in power supply **£10/10/-**. H.P. Terms. Deposit £2/12/6. 12 months of 15/-.
Price completely assembled excluding Power Supply £9. Carriage and Insurance 7/6 extra. (Dial Escutcheon is 4/6 extra.)



WILLIAMSON AMPLIFIERS BY GOODSELL

These Amplifiers hardly need enlarging upon, it being sufficient to say that they have now become the accepted standard for quality reproduction by which all others are judged. Two Models are available:

MODEL G.W.18. Built completely to specification and giving 15 watts output.
Price **£33/15-** (Plus 7/6 Carriage and Insurance). H.P. Terms, Deposit £8/9/ and 12 months at £2/7/5.

MODEL G.W.12. Uses slightly lower H.T. voltage to produce 10-12 watts output but otherwise is built completely to specification.
Price **£27/10/-** (Plus 7/6 Carriage and Insurance). H.P. Terms Deposit £6/17/6 and 12 months at £1/18/8.

THE MODEL P.F.A. TONE CONTROL UNIT

This Control Unit has established a reputation for its excellent quality of reproduction, and ability to give adequate gain for any type of pick-up.

Price **£20/-/-** (Plus 7/6 Carriage and Insurance). H.P. Terms. Deposit £5 and 12 months at £1/8/2.

WE HAVE THEM IN STOCK AND WILL BE PLEASED TO DEMONSTRATE
or send S.A.E. for illustrated and descriptive leaflet.

When submitting orders, please include postage and packing

STERN RADIO LTD.

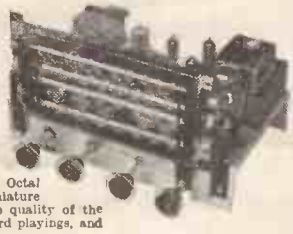
RECEIVER CHASSIS — *Modernise your old Radiogram* — RECORD PLAYERS

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

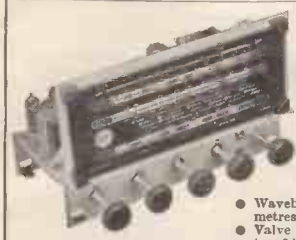
(£12/7/6 with the miniature valves)

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 waveбands 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 waveбands and pre-selective feedback.
- A 4 position Tone Control operation 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 1/6. It contains very detailed practical drawings and circuit diagrams and a complete Component Price List.



!!! THE LATEST !!!

RADIO-RADIOGRAM CHASSIS

Model F3PP. A 7-valve 3-waveband Superhet Chassis with Push-Pull Stage. This Chassis has been designed with particular regard to the quality of reproduction. It incorporates SEPARATE BASS and TREBLE CONTROLS thereby ensuring the utmost flexibility of Tone on both Radio and Gram.

Briefly:

- Waveband coverage 16-50, 190-550 and 900-2,000 metres.
- Valve line-up X79, 6BA6, 6AT6, ECC83, GZ30 and two 6AQ5's in push-pull for approx. 6 watts output.
- Negative Feedback and delayed A.V.C.
- Has independent mains supply socket for gram. connection.
- Overall size of Chassis 12in. × 8in. high × 7in. with dial size 11¼in. long × 4¼in.

For use on A.C. Mains 100/110 volts and 200/250 volts.

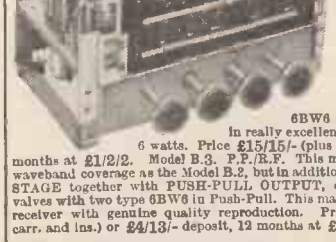
Cash Price, tested and ready for use **£17/17/0** (plus 7/6 carr. and ins.)

H.P. Terms: Deposit £4/7/- and 12 monthly payments of £1/5/4.

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 were 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 grain. 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.

This 3-SPEED AUTOCHANGER is by a Famous Manufacturer and is offered for

£11'10'0 (Plus 7/6 carr. & Ins.) Normal Price £16/10/0

Hire Purchase Terms £2/17/6 Dep. and 12 months at 16/4.

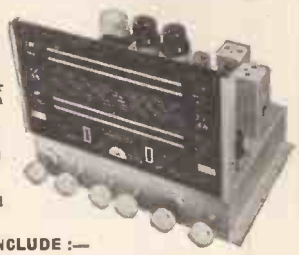
- These units will autochange on all three speeds, 7in., 10in. and 12in.
- They play MIXED 7in. 10in. and 12in. records.
- They have separate sapphire for L.P. and 78 r.p.m., which are moved into position by a simple switch.
- Minimum baseboard size required 14in. × 12¼in., with height above 5¼in. and height below baseboard 2¼in. A bulk purchase enables us to offer these BRAND NEW UNITS at this exceptional price.

WE HAVE THE LATEST 3-SPEED AUTOCHANGERS IN STOCK

SEND S.A.E. FOR DETAILS

WE CAN ALSO OFFER THE LATEST 3-SPEED NON-AUTOCHANGE UNIT

THE NEW ARMSTRONG F.C. 48



A high quality replacement Radio or Radiogram Chassis having provision for an F.M. Feeder Unit.

PRICE ASSEMBLED and READY FOR USE **£23'18'0**

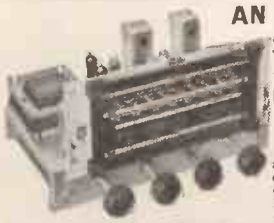
(Plus 7/6 Carr. and Ins.)

H.P. Terms £5/18/- Deposit and 12 months at £1/13/9.

OUTSTANDING FEATURES INCLUDE :—

- 8 Valves including 2 double Triodes.
- 8 Watts output from push-pull tetrodes. Heavy negative feedback 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, 1,000-2,000 metres.
- Large four-colour illuminated dial.

AN OUTSTANDING OFFER



A BULK PURCHASE ENABLES US TO OFFER THIS "PUSH-PULL" 7-VALVE SUPERHET RECEIVER

For only **£12/19/6** (Carr. & ins. 7/6 extra)

H.P.—£3/4/6 Dep. 12 mths. at 18/4.

These receivers Models AW3-7 are made by a well-known set of manufacturers 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 waveбands 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 Cahsis 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.

SPECIAL REDUCTIONS FOR COMPLETE EQUIPMENT

SUMMARY—Select a RECEIVER CHASSIS and we will supply it TOGETHER WITH THE ABOVE 3-SPEED CHANGER AND AN 8-inch or 10-inch P.M. SPEAKER as follows:—

THE £11/10/- AUTOCHANGE 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	£28 0 0	£7 0 0	12 of £1 19 5
(c)	" " B6PP/RF	£31 2 0	£7 15 0	12 of £2 3 9
(d)	" " Armstrong F.C.48	£36 4 0	£9 1 0	12 of £2 10 11
(e)	" " AW3-7	£25 5 0	£6 7 0	12 of £1 15 5
(f)	" " F3PP	£30 2 0	£7 10 0	12 of £2 2 0

An additional charge of 10/- is made in each case to cover Carriage and Insurance.

109 & 115 FLEET ST.

LONDON, E.C.4. Phone: CENTRAL 5812-3-4

!! Home Constructors !!

YOU CAN ASSEMBLE The Stern "Fidelity" TAPE RECORDER FOR ONLY £40

H.P. Terms are shown below.

!! IT ONLY NEEDS CONNECTING UP !!

We are completely satisfied that this Tape Recorder, although supplied at a Genuinely low price, provides absolute Fidelity Recordings and, in addition to being completely dependable, has a performance at least equal to recorders marketed at a far higher price. The actual assembly of the Tape Recorder is extremely simple and only involves a few connections. The Truvox Tape Deck and the Quality Amplifier are supplied tested and ready for use, and all that is required to complete the Recorder is to connect the two together (a connection chart is supplied for this purpose) and secure them by the screws provided into the Attache Case. The items illustrated and described below form the complete equipment.

- WILL TAKE ALL STANDARD TAPES UP TO 1,200ft.
- WILL PLAY THE NEW PRE-RECORDED TAPES
- WILL PROVIDE 2 HOURS' PLAYING AT 3¾in. or 1 hour at 7½in. per second.
- INCORPORATES AN ELLIPTICAL P.M. SPEAKER 7in. × 4in., with EXTENDED FREQUENCY RANGE.

SEND S.A.E. FOR DESCRIPTIVE LEAFLET.

THE NEW TRUVOX MODEL TR7U TAPE DECK

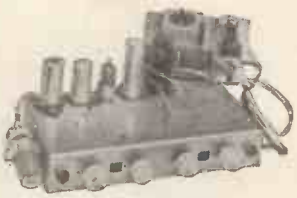
THE NEW TRUVOX MODEL TR7U TAPE DECK. 3 Shaded-Pole motors. Drop-in Tape Loading. Push Button Control. Separate Push Button Brake. Fast forward and fast-reverse. Silent drive eliminating Wow and Flutter. Half Track working and 2 speeds, 3¾in. and 7½in. per sec. Positive Azimuth Adjustment. Overall size only 14½in. × 12¾in.

ACOS CRYSTAL MICROPHONE MODEL MIC-33-1. A highly sensitive mike which accurately matches the input arrangement of the amplifier.

SCOTCH BOY MAGNETIC RECORDING TAPE. Supplied with a 1,200ft. reel of Scotch Boy plastic tape famous for its true brilliant quality. The Recorder will take all standard makes of tape.

MODEL T.R.I./F. QUALITY AMPLIFIER

This amplifier has been expressly designed to meet the requirements of enthusiasts for fidelity reproduction, and in particular to CORRECTLY operate the above TRUVOX DECK. It is supplied complete with a matched Elliptical 3 ohm P.M. Speaker, it incorporates an efficient Tone Control arrangement and has a Magic Eye Level Indicator (Operative on Record). In addition it can be used as a general purpose Amplifier for high quality reproduction of gramophone records direct from a Gram Unit.



PORTABLE ATTACHE CASE

This, as may be judged from the illustration opposite, is a neat, compact and attractively finished case, being covered with maroon rexine and having an ivory coloured speaker escutcheon. It contains concealed pockets to accommodate the Microphone, Mains Lead and a spare 1,200ft. reel of tape.

GUARANTEED FOR 12 MONTHS (B.V.A. VALVES 90 DAYS)

PRICE SUMMARY

WE WILL SUPPLY ALL FIVE UNITS LISTED ABOVE, i.e., THE COMPLETE BUT UNASSEMBLED RECORDER FOR £40/-/-. H.P. Terms: Deposit £10 and 12 monthly payments of £2/15/10 or in two parts as follows:—

	CASH PRICE	DEPOSIT	12 monthly payments of
(a) TRUVOX Mk. TR7U TAPE DECK MODEL TRIF AMPLIFIER WITH SPEAKER, 1,200ft. REEL OF TAPE..	£33 10 0	£8 10 0	£2 6 8
(b) ATTACHE CASE AS ILLUSTRATED ACOS CRYSTAL MICROPHONE ..	£6 10 0	—	—

See note below re packing charge

NOTE: Please send 30/- to cover cost of packing, carriage and insurance. We will refund £1 if the packing case is returned to us intact.

EACH UNIT IS AVAILABLE SEPARATELY AS FOLLOWS:

	CASH PRICE	DEPOSIT	12 monthly payments of
(a) TRUVOX Mk. TR7U TAPE DECK	£23 2 0	£5 17 0	£1 12 4
(b) AMPLIFIER MODEL TRIF WITH SPEAKER	£14 14 0	£4 16 6	£1 0 5
(c) PORTABLE ATTACHE CASE	£5 0 0	—	—
(d) ACOS CRYSTAL MIKE "33"	£2 10 0	—	—
(e) REEL OF TAPE 1,200ft.	£1 15 0	—	—

Please include £1 when ordering (a) or (c) for packing charge, this whole amount will be refunded if case is returned to us intact.

IT CAN BE SUPPLIED COMPLETE *and* READY FOR USE *for* £50

(as illustrated above).

FOR USE ON A.C. MAINS. H.P. Terms: Deposit £12/10/- and 12 monthly payments of £3/10/-. Including MIKE and 1,200ft. REEL of TAPE.

STERN RADIO LTD.

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. Portable case available separately, 37/6.

THE "MINI TWO-THREE"

An "Alldry" Battery Portable of midget size, 6¾in. × 4½in. × 3¾in. 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 IT4—IT4—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.

"PERSONAL SET" BATTERY ELIMINATOR

A complete Kit of parts to build a Midget "Alldry" Battery Eliminator, giving approx. 69 volts at 10 mA. and 1.4 volts at 250 mA.

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 4¾in. × 1¾in. × 3¾in. 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 at 10 mA. and 1.4 volts at 250 mA. Size of assembled unit 7in. × 2¾in. × 1¾in. Price 47/6

!!CONSTRUCTORS!!
A NEW SUPERHET TRANSPORTABLE
THE "SUPER THERE"

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**

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.

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.

A DUAL-CHANNEL PRE-AMPLIFIER and TONE CONTROL UNIT

Attractively finished in "Old Gold" and providing full control of BASS and TREBLE in conjunction with a main volume 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-ups 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 9in. × 4in. × 2½in., 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 (6SN7 and 6J5), £3/16/9. Complete assembly data are available separately for 1/-. Completely assembled and ready for use, £5/5/-.

A BULK PURCHASE ENABLES THIS SPECIAL PRICE REDUCTION OF THE FAMOUS SHAFTESBURY PORTABLE AMPLIFIER

Suitable for home use and small Halls. Has matched inputs for both Record Players and Microphone. Also provides for the "mixing" and "fading" of both Gram. and speech as request.

COMPRISING

(a) A 4-Valve High Gain Amplifier for use on A.C. or D.C. mains 200-250 volts with 5 watts output. Incorporating independent Volume Controls for Mike and Gram., either of which can be faded at will, a variable Tone Control and independent input sockets for Mike and Gram.

(b) A Transverse Carbon microphone which obtains its polarizing current from the amplifier—no batteries are necessary.

(c) An 8in. Goodmans P.M. Speaker with the "Ticonal" magnet for first-class reproduction.

BATTERY CHARGER KITS

All kits are for A.C. Mains 200-250 volts. They comprise a Metal Rectifier and Transformer tapped for 6 or 12 volt charging, and a tapped Resistor, with Selector Switch, to enable the charging rate to be varied. A M/coil meter 5 amp. max., 13/6 extra.

For 6 or 12 volt batteries at max. 1 amp. £1/17/6

For 6 or 12 volt batteries at max. 2½ amp. £2/5/3

For 6 or 12 volt batteries at max. 4 amp. £3/2/6

An easily followed Wiring Diagram is included with each kit.

SPEAKER BARGAINS

PLESSEY, 10in. 3 ohm V/coil	£1/5/0
GOODMANS, 10in. 3 ohm V/coil	£1/13/6
TRUVOX, 12in. 3 ohm V/coil	£2/7/6
ROLA, 12in. 3 ohm V/coil	£3/19/6
BAKERS, 12in. 15 ohm V/coil	£4/19/6
GOODMANS, 12in. 15 ohm V/coil	£5/19/6

(Carriage and Ins. 1/6 extra.)

THE NEW W.B. "STENTORIAN" HI FI SPEAKERS ARE IN STOCK

Model H.F. 6-inch	£2/10/6
Model H.F. 8-inch	£3/0/6
Model H.F. 9-inch	£3/7/0
Model H.F. 10-inch	£3/13/6

These speakers are of the very latest design and provide quality reproduction for the lower-price range, 3 or 15 ohm models are available.

THE COMPLETE EQUIPMENT is all contained in the **PORTABLE CARRYING CASE £18'0'0**

Having been reduced from £30/9/-. HIRE PURCHASE TERMS. DEPOSIT £4/10/- and 12 monthly payments of £1/5/4 ● Light in weight ● Easy to CARRY ● GENUINELY PORTABLE. An illustrated leaflet containing free data is available on receipt of S.A.E.

A COMPLETELY ASSEMBLED 4 VALVE T.R.F. CHASSIS

Including a 5 in. P.M. SPEAKER and VALVES

£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 12BA6 — 12AT6—12A6—35W4. It incorporates Permeability Tuned Coils, thus ensuring excellent selectivity and sensitivity. The overall size of the complete chassis including speaker is 10¼in. × 4¼in. × 6¼in. An attractive Cabinet size 11¼in. × 5¼in. × 6¼in. is available for 16/6 (plus 2/6 carriage and insurance).

109 and 115 FLEET ST.

LONDON, E.C.4. *Phone:* CENTRAL 5812-3-4

RADIO - GRAM CHASSIS

5 VALVE, SUPERHET LATEST B.V.A. MIDGET SERIES VALVES

3 WAVEBANDS:—*L.W. 800m-2000m, M.W. 200m-550m, S.W. 16m-50m*

Chassis size 13½in. × 5½in. × 2½in. Attractive Glass Dial 10in. × 4½in. edge lit by 2 pilot lamps. Horizontal or Vertical Station Names and 4 control knobs, walnut or ivory to choice. 4 position W/C switch, L.M. S. and Gram. P.U. sockets. Modern circuitry, all coils adjustable dust cored and only quality components used throughout. Delayed A.V.C. and neg. feed-back. A.C. mains 200/250 v. Double wound transf. isolates chassis from mains. Aligned and calibrated ready for use.

BRAND NEW & GUARANTEED £9.15.0 Carr. and ins. 4/6

3-ohm speakers suitable for this chassis available 8" 17/6 10" 20/-

This chassis is a genuine bargain and delivery is reasonably good.

BARGAIN VALUE IN RECORD PLAYERS

By Plessey—3 speed Model 33½, 45 and 78 R.P.M. This brand new autochanger Mixer Unit will play 7, 10 and 12 inch records. Xtal Cartridge Type Pick Up with Sapphire Stylus—plays 4,000 records. Spring mounting. Base board size 15½in. × 12½in. Height 5½in. Depth 2in. Special Bargain Price whilst stock lasts.

Price **9½gns.** only

★MIXER TYPE MECHANISM — DUO POINT SAPPHIRE STYLUS★

WE SPECIALISE IN RADIO COMPONENTS

The following are a few items from our stock—send for our Bargain Lists, price 3d.

COAXIAL CABLE

Latest semi-air spaced Polythene insulated 80 ohm coaxial by leading manufacturer. Feeder losses cut by 50 per cent (maker's guarantee) ½in. diam., stranded conductor, highest quality. Only 9d. per yd. 8/9 per doz. yds. P. & P extra.
50 ohm Standard Coaxial cable ½in. diam., 8d. yd.
80 ohm Twin Screened Feeder, 1/- yd.
80 ohm Balanced Twin Feeder 6d. yd.

CONDENSERS

TUBULAR

.001 350 v.	9d.
.0005, .005, .01, 500 v. Moldseal ..	9d.
.05, .1, 500 v. Moldseal	1/-
.02, .1, 350 v.	9d.
.1, 600v. Mallory	1/-
.25, .5, 350 v.	1/6
.1, 1500 v.....	3/6

MICA and SILVER MICAS
3 pf., 5 pf., 50 pf., 100 pf., 150 pf., 200 pf., 300 pf., 500 pf., 680 pf., 1000 pf., etc.
6d. each. 5/6 per doz.

ELECTROLYTICS

Leading Makes New Stock

TUBULAR—wire ends

25/25 v., 50/12 v.....	1/9
50/50 v., 4/500 v.....	2/-
8/450 v.	2/3
8/500 v.	2/9
8+8/500 v.	4/6
8+16/450 v.	5/-
16/450 v.	3/6
16+16/450 v.	5/6
32/350 v.	4/-
32+32/350 v.	5/6
32+32/500 v.	7/6

CAN TYPES

8+8/450 v.	4/6
8+16/450 v.	5/-
8+16/500 v.	5/6
16+16/450 v.	5/6
16+16/500 v.	6/-
32/350 v.	4/-
32+32/450 v.	6/6
60/350 v.	6/6
60+100/350 v.	11/6
100+200/275 v.	12/6
1500/6 v.	4/6
1000/1000 6 v.	6/6

CLOSE TOLERANCE SILVER MICAS

1% TYPES. 56 pf. to 500 pf., 1/9; 515 pf. to 5000 pf., 2/-; 1.5 pf. to 50 pf. (tolerance 1 pf.) 1/9.
10% TYPE. 5 pf. to 500 pf., 1/-; 600 pf. to 3000 pf. 1/3.

MAINS TRANSFORMERS

Fully interleaved and impregnated. Made in our own workshops to highest grade specification. Fully guaranteed. All primaries tapped 200/250 v. All secondaries full wave.

HEATER TRANSFORMERS.

6.3 v. 1.5 a., 12 v. .75 a., 4 v. 2 a. 5 v. 2 a., 7/6. 6.3 v. 3 a., 4 v. 4 a., 10/6.

CRT HEATER ISOLATION TRANSFORMERS.

Low leakage windings, with or without 25% sec. boost voltage. 1 : 1 or 1 : 1.25 ratio. 2 v., 10/6; 4 v., 10/6; 6.3 v., 10/6; 13.3 v. 10/6 etc. Ditto, but with mains primaries 12/6 each.

MAINS TRANSFORMERS.

60 mA., 250 v. or 300 v. secs., 5 v. or 6.3 v. 1 amp rect., 6.3 v. 2.5 a. Htrs., 21/-. Ditto 80 mA., 250 v. 300 v. or 350 v. secs., 4 v. or 5 v. 2 a. Rect., 4 v. or 6.3 v. 4 a. Htrs. 25/-.
Ditto 120 mA., 250 v. to 325 v. secs., 5 v. or 6.3 v., 2.5 a. Rect., 6.3 v. 4 a. Htrs., 32/6.

All Universal mounting. Fully shrouded 1/3 extra.
L.F. CHOKES: 10H 65 mA., 5/-; 15H 100 mA., 10/6; *20H 150 mA., 12/6; *3H 200 mA., 13/6.
*Fully shrouded 1/3 extra.
Rewinds or specials made to order up to 500 V.A.

RESISTORS

20% Tolerance leading makes only. All values 10 ohms to 10 Megohms, ¼ w., 4d.; ½ w., 5d.; 1 w., 6d.; 2 w., 9d.
1% HIGH STABILITY.
½ watt, 100 ohms—10 Megohms, 2/- each.

WIRE WOUND RESISTORS

Wire ends. Silicone coated, 25 ohms—10000 ohms, 5 w. 1/3; 10 w., 1/6; 15 w., 2/-;
15000 ohms—33000 ohms, 5 w., 1/9; 10 w., 2/3.
47000 ohms—50000 ohms, 5 w., 2/3; 10 w., 2/9;

WIRE WOUND POTS

Standard 3-watt type—long spindles. 100 ohms, to 50000 ohms, 5/6; 100000 ohms, 6/6.

PRE-SET W/W POTS

T.V. knurled slotted knob type. 25 ohms to 30000 ohms, 3/-; 50000 ohms, 4/-; 50000 ohms to 2 Megohms (carbon track), 3/-.

MAINS DROPPERS

with 2 variable sliders.
.15 amp. 1500 ohms ½in. × 2½in., 4/3.
.2 amp. 1000 ohms 1½in. × 2½in., 4/3.
.3 amp. 750 ohms 1½in. × 2½in., 4/6.

VOLUME CONTROLS

1in. semi Midget Type, Long spindles All values. 10000 ohms to 2 Megohms Less sw., 3/-; S.P. sw., 4/-; D.P. sw., 4/9 All individually boxed. Guar. 12 months

T.R.S. RADIO COMPONENT SPECIALISTS

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Phone: THO 2188 Hours 9am—6pm. 1pm. Wed. Open all day Saturday
BY THORNTON HEATH STATION · BUSES 130A, 133, 159, 166, 190
Terms: C.W.O. or C.O.D. Post & Packing up to ½lb., 6d., 1lb., 1/-, 3lb., 1/6, 5lb., 2/- 10lb., 2/6.

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POST OFFICE TYPE MAGNETIC RELAYS

3,000 and 600

Contractors to:

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COILS up to 80,000Ω.
CONTACTS up to 8 amps.
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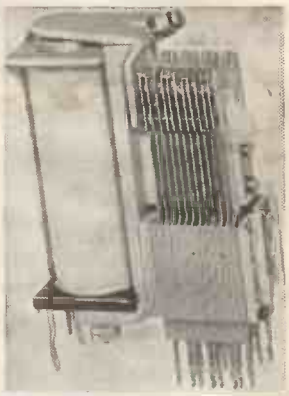

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PROTOTYPE Relays made to specification.

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TELEPHONE EQUIPMENT

Brand new and boxed American Desk telephones with built in ringer complete with handsets as shown. 59/6.

Ditto:— of English manufacture, complete with distributor boards. 49/6 each.

Telephone Secrecy Equipment:— Army No. GAC-YBO2700. Complete frequency scrambler units for secret telephone conversations which cannot be tapped or overheard, for operation from 230 v. A.C. or 12 volt D.C. Offered in brand new condition at a fraction of their original cost. £5 each. Limited number only available.

G. W. SMITH & CO. (RADIO) LTD.

3-34, LISLE STREET, LONDON, W.C.2

Telephone: Gerrard 8204/9155.

MAINS TRANSFORMERS

Primary, 200-250 v. P. & P. 2/-.
300-0-300, 100 mA., 6 v. 3 amp., 5 v. 2 amp., 22/6.

Semi-Shrouded, drop-through. 380-0-380 v., 120 mA., 6.3 v. 4 amp., 5 v., 2·5 amp., 22/6.

Drop thro' 350-0-350 v. 70 mA., 6 v. 2.5 amp., 5 v. 2 amp., 14/6.

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' 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. Onput 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/-.

Primary, 230 v., fully shrouded, screened primary, 13 v. 1 amp., 7/6

Pri 200 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.

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.

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 spindles 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.

Twin Gang, .0005, with feet, size 3½×3×1½in., 6/6.

3-gang .0005, with feet, size 4½×3×1½in., 7/6.

T.V. Coils, moulded former, iron-cored wound for re-winding purposes only. All-can 1½×1½in., 1/- each, 2 iron-core All-can 2½×½in., 1/6 each.

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.

PERMEABILITY TUNED T.V. UNIT Input 300 ohm balanced line, coverage 54 Mc/s—89 Mc/s and 174 Mc/s—217 Mc/s. Vision I.F.:—45 Mc/s., sound 40.5 Mc/s. Uses 6AK5 RF valve, 6AK5 as mixer, and 6C4 oscillator. Provision for auto-gain control. Dimensions 9in. wide, 6½in. deep, 4in. high, 9in. blank-scale. Width including scale-overlap 14in. Four stages permeability tuned. Complete with 3 valves. Post and Pkg. 3/-. £2/19/6.

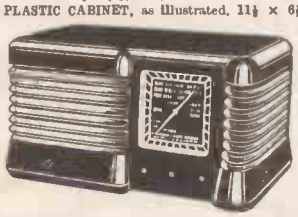
T.V. CONVERTER for the new commercial stations complete with 2 valves. Frequency:—can be set to any channel within the 186-196 Mc/s. band. I.F.:—will work into any existing T.V. receiver designed to work between 42-68 Mc/s. Sensitivity:—10 Mu/v. with any normal T.V. set. Input:—arranged for 300 ohm feeder. 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, 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.

USED 12in. TUBE, aluminized, heater cathode-short, 10KV max. 2 v. heater complete with line and E.H.T. transformer 9 KV with ferrocart core, line and width control, EY51 rec. winding frame O.P. scan coils and 12in. Perspex escutcheon. £6/17/6. P. & P. 7/6.
As above but with 12in. non-aluminized tube 8KV max. £5/17/6. P. & P. 7/6.

GENERAL PURPOSE 3-IN-1 MAINS TRANSFORMER. Input 200/250. Sec. 250 v. 350 mA., 6.3 v. 4 amp. twice, 2 v. 2 amp. 600 v., 350 mA., 6.3 v. 4 amp. twice, 2 v. 2 amp. Auto-transformer, 110, 250 v., 250 watt. 19/6. P. & P. 3/6.

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 waveband scale, station names, new wave-band, back-plate, drum, pointer, spring, drive spindle, 3 knobs and back, 22/6. P. & P. 3/6.



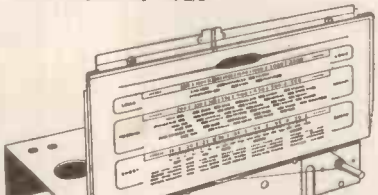
AS ABOVE, with superhet chassis, 23/6. P. & P. 3/6.
Used metal rectifier, 230 v. 50 mA., 3/6. gang with trimmers, 6/6; M. & L. T.R.F. coils, 5/-; 3 obsolete ex-Govt. valves 3 v/h and circuit, 4/6; heater trans., 6/-; volume control with switch, 3/6; wave-change switch, 2/-; 32×32 mfd., 4/-; bias condenser, 1/-; resistor kit, 2/-; condenser kit, 4/-.

Cyldon 5 channel T.V. Tuner, uses EF80 and 12AT7 less valves, 12/6, post paid.
Radiogram Chassis, 5 valve 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 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 F.B.O., new condition, 7/6 each.
465 Kc. Xtal for CR100, 12/6.
4-gang tuning condenser for CR100, 9/6.

CONSTRUCTOR'S PARCEL, medium and long wave A.C. mains 230/250 2-valve plus metal rectifier, comprising chassis 10½×4½×1½in., 2 wave-band scale, tuning condenser, wave-change switch, volume control, heater trans., metal rectifier, 2 valves and v/holders, smoothing and bias condensers, resistors and small condensers, and medium and long wave coil, litz wound, 22/6. P. & P. 2/6 extra. Circuit and point-to-point, 1/3.

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, 2 pulleys, pointer, 2 bulb holders, 5 pax. 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 x 6 x 4in. Incorporating metal rectifier, main on-off switch, and output switch, 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 3-way, 3/6; Miniature type, long spindle 3-pole 4-way, 4-pole 3-way and 4-pole 2-way, 2/6 each. 2-pole 11-way twin wafer 5/-; 1-pole 12-way single wafer 5/-. P. & P. 3d.

POTATO AND VEGETABLE PEELER
By famous manufacturer. To suit models A200 and A700. Capacity 4½lbs., complete with water pump. All aluminium construction, white stove-enamelled finish. Originally intended for adaption on an electric food-mixer, can be easily converted for hand operation. 39/6. P. & P. 3/-.

Mains Droppers. 0.3 amps., 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.

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.

Scan coils, low line low impedance frame, complete with frame transformer, to match above, 27/6. P. & P. 2/-.

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/-.

As above, but complete with line and frame blocking transformers, 5 Henry 250 mA. choke, 100 mfd. and 150 mfd. 250 wkg. 380 mA. A.C. ripple. £2/19/6 P. & P. 3/-.

Valve Holders, moulded octal Mazda and laoctal, 7d. each. Paxolin, octal Mazda and loctal, 4d. each. Moulded B7G, B8A and B9A, 7d. each. B7G moulded and B9A with screening can 1/6 each.

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, each, 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., less Vernier adjustment, 15/-.

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.

Standard 465 Kc. iron-cored I.F.s, 4×1½×1½in., per pr., 7/6. Wearite standard, iron-cored. 465 Kc. I.F.s, 3½×1½×1½in., 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, ½in. deep by very famous manufacturer. Pre-aligned adjustable iron-dust cores, per pair, 12/6.

Best Buy at Britain's

HEAVY DUTY L.T. TRANSFORMERS. Standard tapped primary. Type A, 30 v. 36 Amp. or Type B, 50 v. 16 amp. Size 6in. x 5¼in. x 8in. high. Weight 24 lb. BRAND NEW, not ex-Govt. Suitable for soil heating, rectifiers, chargers. etc., special offer, 55/- each, plus 5/- carriage.

EX-ADMIRALTY. Primary 250 v. 50 c/s. Secondary 5-0-5 v., 5-0-5 v., and 5-0-5 v., all at 5 amps., each winding. This means, in effect, that you can have 5, 10, 15, 20, 25, 30 v. at 5 amps. or other possible combinations. Size 4¾in. x 4¼in. x 6in. high. Weight 12 lb. BRAND NEW. A very useful transformer at only 39/6.

EX-ADMIRALTY. Primary 230 v. 50 c/s. Secondary 620-550-375-0-375-550-620 v. (620 v. at 200 mA., 550 v. at 250 mA.). Two rectifier windings at 5 v. 3 amps. each. Total rating 278 vA. Upright mtg. weight 24 lb. BRAND NEW, 42/6.

E.H.T. TRANSFORMERS. For VCR97, etc. Mains input. Output 2,500 v., 4 v. 2 a. and 2-0-2 v. at 2 a. Fully guaranteed at 35/-, plus 2/- postage. SPECIAL SURPLUS SNIP. 230 v. 50 c/s. input. 2 kV. R.M.S. output (2.8 kV. when rectified). Size 2¾in. x 2in. x 3¾in. high. Upright mtg. ONLY 15/- plus 2/- postage.

EX-MANUFACTURERS' SURPLUS. Drop through type. Pri. 200-250 v. 50 c/s. Secondary 310-0-310 v. 70 mA., 6.3 v. at 3 a., 4 v. at 2 a. Can be used with either 4 or 6.3 volt rectifier. Only 9/6 plus 1/6 postage. A similar type, 325-0-325 v. 100 mA., 6.3 v. 4 a., 4 v. 2 a., supplied to callers only, 12/6 each.

METAL RECTIFIERS. Heavy duty, funnel cooled, 2 units required for bridge. Size 12in. x 12in. x 4½in. Input 36 v. R.M.S. Output 50 amps., £7/10/- per pair, plus 5/- carriage. BRAND NEW ex-Govt.
RM4, 250 volts, 250 mA., only 12/6 each.
Selenium, 300 volts, 100 mA. Brand new, ex-W.D., 6/9 each. 12 v. 1 amp. Full wave bridge, 7/6 each.

E.M.I. OUTPUT METER. Desk type incorporating a 2½in. 1 mA. meter together with instrument rectifier, etc. 2 ranges 0-500 milliwatts and 0-5 watts and decibel scale. Brand new in original manufacturers' boxes with instructions. Price 35/-, post 1/6.

METER BARGAINS, ALL BRAND NEW

15 v. (50~) mov. iron 2½in. pnl. mtg....	8/6
3,500 volts moving coil 3½in. projection	10/-
150 milli-amp. 2in. sq. pnl. mtg.	7/6
20 amp. moving coil 2½in. dia.	7/6
1 mA. 2½in. barrel flush pnl mtg.....	22/6
1 milli-amp. 2½in. barrel desk type ...	25/-
100 micro-amps. barrel pnl. mtg. scaled 0-1,500 in 15 clear divisions. Only...	42/6
500 mA. Thermo Couple 2in. sq. pnl. mtg.	5/-

METER RECTIFIERS 1 mA. Salford Instruments, 8/6. 5 mA. Salford Instruments, 6/9. 2 mA., S.T.C. as used in E.M.I. Output Meter, 5/6. All are full wave bridge and brand new.

COMMUNICATIONS RECEIVER R. 1155 World-wide reception is ensured by the R.F. and 2 I.F. stages. Five wavebands, 2 L.W., M.W. and 2 S.W. Magic-eye, large dial and vernier make tuning simple. Contained in attractive black crackled cabinet, its handsome appearance does justice to its superb performance. Supplied with FREE BOOKLET giving circuit data and details of the power pack required for A.C. mains operation. Fully aerial-tested before despatch. Gladly demonstrated to callers.
BRAND NEW. "MINT" condition, in ORIGINAL MAKER'S TRANSIT CASES, £11/19/6. Shop soiled models, as new, £9/19/6. A few only used models, £7/19/6. 10/6 carriage on each. Send S.A.E. for full details of power packs and receivers, or 1/3 for booklet. D.F. Loops and Visual Indicator Meters available.
A.C. MAINS POWER PACKS AND 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 8¾in. x 4¼in. x 6½in. less speaker, price £4/10/- plus 3/6 carriage.
Type B. With built-in 5in. speaker in black metal case size 13½in. x 5½in. x 7¼in. 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 11¼in. x 10¼in. x 6in. A de Luxe job. Price £6/10/- plus 3/6 carriage.
NOTE: 10/- REDUCTION WHEN PURCHASING ANY OF THE ABOVE POWER PACKS WITH RECEIVER.

R.F. UNITS. ALL BRAND NEW and BOXED. RF24, 20-30 Mc/s, 12/6. RF25, 40-50 Mc/s, 17/6. RF26, 50-65 Mc/s. 29/6 and RF27, 65-85 Mc/s, 32/6.

45 Mc/s PYE STRIPS Vision unit for London frequency. Complete with 6 EF60 and EA50. Circuit provided. Brand new. £3/10/- each.

VALVE VOLTMETERS. Ex-R.A.F. Operate from standard A.C. mains, stabilised H.T. supply. Three ranges: 50/200/500 volts D.C. Meter employed 2½in. 1 mA. F.S.D. Contained in handsome wooden instrument case size 14in. x 8½in. x 9in. Complete with all valves and tested prior to despatch. In brand new condition and a real bargain at only 79/6 plus 5/6 carriage.

HOUR-METERS. Indicate the time any given A.C. mains operated apparatus has been in use. Ideal for life testing, process timing, etc. BRAND NEW and BOXED. 39/6 each.

BLOCK CONDENSERS. 8 mfd. 600 v. D.C. wkg. at 71° C. size 4 x 2 x 4½in. high. Very suitable for all good quality amplifiers, etc. Brand new. Price 5/- each.

VALVE BARGAINS
New and in original boxes. 6AG5, VR53 (EF39), VR56 (EF36), 6K7G, 6C5Met., 6SH7-Met., VT501 (TT11), all at 6/6. RK34, E1148, 954, 2X2, VU120A, all at 2/6. Replacement bargain EL50, 5/-.
New, ex units 6AK5, VR91 (EF50), Sylvania, VT52 (EL32), 807, 7/6. VR65 (SP61), 3/6. VT501 (TT11), 3/6. CV6, VR78. VR92 (EA50), 1/6 each, 15/- dozen.

RACKS. 6ft. "U" channel P.O. type for 19in. panels, heavy angle base. Price 79/6, plus carriage at cost.

H.R. HEADPHONES. Consist of two high resistance earpieces with adjustable metal headbands. Price, less cord, 6/6.

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.

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.

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.

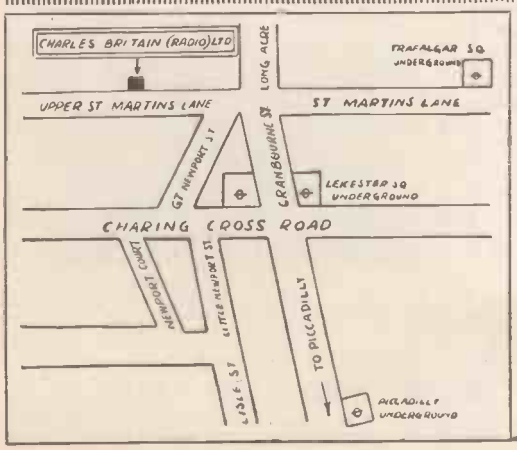
HEAVY DUTY POTENTIOMETERS. Wire-wound on porcelain former, 2½in. diam. 20 W. 1,200 ohms, 6/6 each. Colvern-type wire-wound 5,000 ohms, 2¾in. diam. 7/6 each.

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.
100 kc/s ½in. pin spacing. British, ex new units, 15/- each.

U.H.F. SIGNAL GENERATORS by R.C.A. TYPE 710A. Cover 370 to 560 Mc/s. Large directly calibrated dial. Carrier level and 400 c/s. modulation monitored by large 200 micro-amp. meter. Precision piston attenuator. For A.C. mains operation 117 volts 50/60 c/s. Complete with instruction manual. BRAND NEW. £35.

TEST SET TYPE 87. Ex-R.A.F. corresponds to TF796. Incorporates a signal generator covering 150 to 300 Mc/s. Also pulse generator. Operates from standard A.C. mains. Contained in handsome grey instrument case size 23in. x 10in. x 8½in. Basis of the audio signal generator described in "W.W." Aug./Sept. 1949. Complete with all valves and in brand new condition. Price £4/19/6. Circuit included.

BARGAINS, BARGAINS, BARGAINS. HUGE STOCKS OF COMPONENTS, RECEIVERS, VALVES, AT SPECIAL REDUCED PRICES FOR CALLERS.



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. x 4in. x 6in. high. Price 7/6 each. BRAND NEW.

B.F.O.s. Ganging Oscillators, 18-19-21 & 22 sets; 1403 Transmitters, Indicators 233, Valve voltmeters at Clearance Prices.

CHARLES BRITAIN (Radio) Ltd.

11 UPPER SAINT MARTIN'S LANE
LONDON, W.C.2. *TEMple Bar 0545*
One Minute from Leicester Sq. Station (up Cranbourn St.)
Shop Hours: 9-6 p.m. (9-1 p.m. Thursday) *Open all day Saturday*

"MUST HAVE" BARGAINS!

BC.610 MODULATION TRANSFORMERS. Brand New spares for this famous American Transmitter. In Maker's Original Cases. ONLY £5 each.

RF UNITS TYPE 26 and 27. For use with the R.1355 or any receiver with a 6.3 v. supply. These are the variable tuning units which use 2 valves EF54 and 1 of EC52. Type 26 covers 65-50 Mc/s (5-6 metres) and Type 27 covers 85-65 Mc/s. (3.5-5.0 metres). Complete with valves, and BRAND NEW IN MAKER'S CARTONS. ONLY 29/6 each.

"PYE" 45 MC/S I.F. STRIP. Ready made for London Vision Channel, this 5-stage strip contains 6 valves EF50 and 1 EA50. Supplied with circuit and details of very slight mods. required. BRAND NEW, ONLY 69/6 or less valves 50/.

MODULATOR TYPE 67. Contains fully smoothed normal A.C. Mains Power Pack, transformer being 345 v.-0-345 v. at 200 mA., 6.3 v. 5 a., 6.3 v. 250 mA., 5 v. 2 a., 6 valves SP61, 3 of EA50, 2 of EB34, and 1 of 5Z4. BRAND NEW IN MAKER'S CASES ONLY 47/6 (carriage 7/6).

TRANSFORMERS. Manufactured to our specification and fully guaranteed. Upright mounting, fully shrouded, normal primaries.

425 v.-0-425 v. 250 mA., 6.3 v. 4 a., 6.3 v. 4 a., 5 v. 3 a., 65/-.
350 v.-0-350 v. 160 mA., 6.3 v. 6 a., 6.3 v. 3 a., 5 v. 3 a., 47/6.
350 v.-0-350 v. 150 mA., 6.3 v. 5 a., 0-4-5 v. 3 a., 37/6.
250 v.-0-250 v. 100 mA., 6.3 v. 6 a., 5 v. 3 a., 37/6.
250 v.-0-250 v. 60 mA., 6.3 v. 3 a., 5 v. 2 a., 21/.

Please add 2/- per transformer postage.

TRANSFORMERS, FILAMENT. 6.3 v. 2 a., 7/6 (postage 1/-), 6.3 v. 3 a., 10/6.

TRANSFORMERS, EHT. Upright mounting.

EHT for VCR97 Tube 2,500 v. 5 mA. 2 v.-0-2 v. 1.1 a., 2 v.-0-2 v. 2 a., 42/6.
EHT 5,500 v. 5 mA., 2 v. 1 a., 79/6.
EHT 7,000 v. 5 mA., 2 v. 1 a., 89/6.
EHT 7,000 v. 5 mA., 4 v. 1 a., 89/6.

Please add 2/- per transformer postage.

TRANSFORMERS, EX W.D. AND ADMIRALTY, built to more than 50 per cent. safety factor with normal A.C mains primaries. Brand New and unused. 330-0-330 v. 100 mA. 4 v. 3 a., 22/6.

L.T. 6.3 v. 7.7 amp., 4.2 v. 2.5 amp. 4 v. 1 amp., 19/6.

L.T. HEAVY DUTY. Has 3 separate windings of 5 v.-0-5 v. at 5 amps., and by using combinations will give various voltages at high current. ONLY 39/6. Please add 2/6 per transformer postage.

COMMUNICATIONS RECEIVER R.1155

The famous ex-Bomber Command Receiver known the world over to be supreme in its class. Covers 5 wave ranges: 18.5-7.5 Mc/s., 7.5-3.0 Mc/s., 1,500-600 kc/s., 500-200 kc/s., 200-75 kc/s, and is easily and simply adapted for normal mains use. full details being supplied. Aerial tested before despatch, BRAND NEW AND UNUSED IN MAKER'S TRANSIT CASES, ONLY £11/19/6

BRAND NEW BUT SHOP-SOILED, also tested working before despatch, £9/19/6 (carriage 10/6).

A.C. MAINS POWER PACK OUTPUT STAGE, in black metal case, enabling the receiver to be operated immediately, by just plugging in, without any modification. Can be supplied as follows, WITH built-in 6½in. P.M. Speaker, £5/5/-, LESS speaker, £4/10/- (carriage 3/6).

DEDUCT 10/- IF PURCHASING RECEIVER AND POWER PACK TOGETHER.

Send S.A.E. for illustrated leaflet, or 1/3 for 14 page booklet, which gives technical information, circuits, etc., and is supplied free with each receiver.

COMMUNICATIONS RECEIVER RA-1B

Just released by the Air Ministry, this is a superb 6 waveband American Receiver covering 150-315 kc/s., 315-680 kc/s., 680-1500 kc/s., 1.80-3.70 Mc/s., 3.70-7.50 Mc/s., 7.50-15.0 Mc/s, Takes in all important bands, including Trawlers. Illuminated vernier scale is most accurately calibrated, and slow motion tuning is completely free from backlash. Incorporates AVC, CW, and Sensitivity controls. Valves are 5 of 6K7G, 1 of 6L7G, 1 of 6R7G, and 1 of 6K6G (output). Case size 10in. x 7in. x 14in. finished in black crackle. Power requirements 6.3 v. and 250 v. All receivers aerial tested before despatch. ONLY £11/19/6 (carriage etc., 10/6).

BENDIX TRANSMITTER TA-12-D

Another magnificent item of American equipment. Wave ranges are 1050-1700 kc/s., 2.0-3.4 Mc/s., 3.0-4.8 Mc/s., 4.3-7.0 Mc/s., and 1 spot frequency on each can be selected. Valves employed are 3 of 807 and 4 of 12SK7. A "MUST" for every transmitting enthusiast. BRAND NEW. ONLY £4/19/6 (carriage etc., 10/6)

METERS

F.S.D.		SIZE AND TYPE		PRICE
5 milliamp.	D.C.	2in. Flush square		7/6
100 „	D.C.	2½in. Flush circular		12/6
150 „	D.C.	2in. Flush square		7/6
500 „	thermo	2in. Flush square		5/-
500 „	thermo	2in. Proj. circular		5/-
20 amps.	D.C.	2in. Proj. circular		7/6
40 amps.	D.C.	2in. Proj. circular		7/6
30-0-30 amps.	D.C.	Car type moving iron		5/-
15 volts	A.C.	2½in. Flush, circ., mov. iron		8/6

All meters Brand New in Maker's Cartons.

100 MICROAMPS METERS

2½in. circular flush mounting. Widely calibrated scale of 15 divisions marked "yards" which can be rewritten to suit requirements. These movements are almost unobtainable today and being BRAND NEW IN MAKER'S CARTONS are a snip at ONLY 42/6.

HOUR METERS

For checking running time of equipment up to 9,999 hours. Operates from normal 50 cycles mains. BRAND NEW IN MAKER'S CARTONS. ONLY 39/6.

MODEL MAKERS MOTOR. Reversible poles. Only 2in. long and 1½in. diameter, with ¼in. long spindle. Will operate on 4, 6, 12 or 24 volts D.C. ONLY 10/6.

12 v. AMERICAN DYNAMOTOR. Output 255 v. 60 mA. Ideal for car radio or running electric shaver from car battery ONLY 22/6.

SPECIAL OFFER. Ex-Admiralty L.T. TRANSFORMER. Normal mains input, output 4 v. 20 amps. C.T. New and unused, these have become damaged, but are still usable, the damage being confined to broken fixing lugs, and/or broken bakelite terminal panels. Formerly sold at 30/-, now offered at 17/6 (post, etc., 2/6).

POCKET VOLTMETERS. Not Ex-Govt. Read 0-15 v. and 0-300 v A.C. or D.C. BRAND NEW AND UNUSED. ONLY 18/6.

SUNDRIES. Warning light assemblies, Red, Green, or Clear, 2/- ea. Miniature plugs and sockets, 3 way 7d. pair, 4-way 9d. pair, 5-way 10d. pair. Jack plugs, 2/- each. ⅜in. coil formers with slug 10d., ¼in. 8d. Valveholders I.O. & M.O. Amphenol, 6d. ea., B3G (diode) 6d., B9G ceramic 10d., Brit. 5-pin Ceramic 1/-. Co-axial plugs and sockets, Pye 6d. ea., Belling, plug 1/3, socket 1/4, coupler for joining cable 2/ (post 3d. per item).

POTENTIOMETERS, less switch, long spindle, 1K, 3K, 5K, 10K, 20K, 25K, 100K, 250K, 500K, 2M, 2/9 ea. short spindle 50K, 75K, 1M, 2/ ea. WITH switch long spindle, 1K, 2K, 2.5K, 10K, 15K, 20K, 25K, 50K, 75K, 250K, 500K, 2M, 3/9 ea. (post 3d.).

SPRAGUE .1 mfd. 600 v. metal tubulars, 10d. ea., 9/6 dozen (add post).

SILVER MICAS AND MICAS. 2pf, 5pf, 10pf, 11.5pf, 15pf, 20pf, 25pf, 40pf, 47pf, 50pf, 75pf, 80pf, 100pf, 115pf, 160pf, 300pf, 430pf, 440pf, 1050pf, 2300pf, .0001 mfd., .00016 mfd., .0002 mfd., .00025 mfd., .001 mfd., .002 mfd., .005 mfd., 5d. each, or 3/6 per dozen 1 type.

INTERNATIONAL OCTAL PLUG Fits into I.O valveholder, 2/- (post 3d.).

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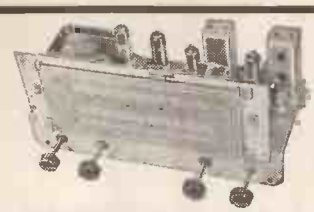

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8+8/500 v.	4/6	16+16/450 v.	5/6
32/350 v.	4/-	16+16/500 v.	6/-
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SLIGHTLY used B.A.S.F., Scotch Boy, Ferrotapes; 1gn each.—Box 2957. [4515

L.H.F. Exchange Mart for used quality equipment; send s.a.e. for lists.—31, Lancaster Ave., Manchester. 4. [0067

AS new, E.M.I. L2B battery tape-recorder as used B.B.C.; cost over £100 with extras; will accept £70 o.n.o.—Box 2326. [4382

GRUNDIG TK9, as new, Golden mike, £55; Truvox Mk. III deck, £15; Truvox amp., unused, new, £13.—Taylor. 191, Ashton Rd., Denton, M/c. Den. 3182. [4387

PRESTO disc recorder, 33 & 78, complete with amplifier, £45; also Memovox U.S. Signals Corps micro-groove recorder, with large quantity unused acetate discs, £20.—R.T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0164

GRAMOPHONE AND SOUND EQUIPMENT —WANTED

£45 offered for Grundig tape-recorder model 700L or TK9 in as new condition; please write J. Kidd, 47, Southcote Lane, Reading. [4376

NEW COMPONENTS

TRANSISTORS and associated parts, types up to 50 M/cs, outputs of avg. speech power.—Bel, Marlborough Yard, N.19. Arc. 5078. [0185

OSRAM 9-1-2 high quality amplifier constructional details, circuits, component list 3/6, post free.—Franklin & Hall, 371, Havant Rd., Farlington, Portsmouth. [4394

AMMETERS 0-4 amps D.C., 1¾in diameter, 10/6; metal rectifiers, 6-12v 0-4 amps, 15/6; mains transformers for battery charging tapped 4, 10, 16 and 20 volts, 25/-; wirewound resistors, 0-250ohm 25w, 8/6; electric motors, ¼hp, 230v, A.C., s/p, 85/-.—Kingston Electrical Supplies, 134, London Rd., Kingston-on-Thames. Kin. 7534. [4456

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, 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, 1⅛×3, clip, 3/6; 32+12, 350v, 1¾×2, clip, 4/-; 16, 350v, ¾×2, lug, 1/9; 10, 450v, ¾×2, lug, 1/6; 16, 450v, ⅞×2, tag, 2/9; 20, 450v, 1×2, 2/3; 32, 450/525v, 1⅛×2, clip, 3/9; 15+15, 450v+20mf 25v, 1⅛×3, lug, 4/6; 200, 6v ⅝×1¾, clip, 1/6; 100, 12v, ⅝×1¾, clip, 1/9; 8, 450v, 1×2, clip, 2/-; 50, 12v ¾×1⅛, tag, 1/6; 150, 25v, ¾×1¾, clip, 2/-; 250, 12v, ¾×1¾, wire, 2/3; 40+40, 275v, 1¾×2, clip, 3/3; 24+24+16, 350/425v, 1⅛×2, clip, 4/9; 4, 150v, ⅝×1¾, clip, 1/1; 500, 12v, 1⅛×2¾, clip, 2/-; 8, 350v, ¾×2, clip, 1/9. 32+32, 350/425v, 1⅛×2, clip, 5/-; 2, 450/525v, ¾×1¾, tag, 1/6; 8, 450v, ¾×2, clip, 1/9; 64+120, 275v, 1¾×4½, clip, 5/6; 1,000+1,000, 6v, 1×3in, lug, 3/3; all all cans, some with sleeves, all voltages, WKG, surge where marked, new stock guaranteed.

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.

TELEVISION chassis, cadmium plated, steel, size 14×13×2¼in, complete with 13 valve holders (9-B9A Pax, 1-B9A Cer, 2-B7G Cer, 1-Int. Oct. amph.), 20 various tag strips, cut away for metal rect., line trans., etc.; 9/11 each, post paid.

FRONT and rear tube mounts to fit above chassis, 3/- pair, post paid.

P.M. focus rings, wide angle, tetrode tube, fully adjustable, 12/- post paid.

RADIO CLEARANCE, Ltd., 27, Tottenham Court Rd., London, W.1. Tel. Museum 9188. [0015

SOUTHERN RADIO SUPPLY, Ltd., 11, Little Newport Street, London, W.C.2. See our displayed advertisement, page 155. [0016

SUPREME RADIO, 746b, Romford Rd., Manor Park, London, E.12. Tel. Ilf. 1260. Est. 19 years.

SPRAGUE 0.1 mfd 350v w/end condensers; 6d ea. or 5/6 pr. doz.

ELECTROLYTIC cond., 8 mfd 450v wkg., sleeved tubular w/end; our price 1/11 ea.

32 mfd 350v tag end all/can, small; 1/9 ea.

SPECIAL e/cond line, 64+120 mfd 275v wkg., 350v surge, 1¼in all/can; our price 10/- ea.

MICROPACK 25 mfd 25v bias cond., very small; 1/4 ea.

E.F.50 valves, Red Sylvania, new boxed; 10/6 ea.

CERAMIC EF50 v/holders; 7d ea.

PHILIPS Beehive type 30 pf trimmer cond.; 1/- ea.

B7G screening can with spring, and skirted B7G v/hldr., 1/4½ complete; B9A type, 1/11 complete.

2-POLE 2-way w/c switches; 1/- ea.

R.M.1 metal recs., 3/11 ea.; R.M.2 type, 4/3 ea.; R.M.3 type, 5/11 ea.; R.M.4 type, 18/- ea. 14A.86 metal rectifiers, 16/6 ea.; 14A.100, 19/6 ea.

STEEL chassis, ready punched for s/het layout, 14in×6in×3in; 2/6 ea.

ALL parts in stock for Denco F.M. unit, Mullards 5/10 high quality amplifier, etc.

MANY other radio and television component parts in stock at very keen prices; your enquiries welcomed.

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

METAL-GLASS seals; single-way, hermetically sealed terminals for soldered connections and fixing; mostly 1kv and 2kv sizes, new (surplus), 6/- per 1,000 assorted.—P. B. Crawshay, 94, Pixmore Way, Letchworth, Herts. Tel. 1851. [0087

WANTED, EXCHANGE, ETC.

WANTED, receivers A.P.R.4, also T.N.16, 17, 18, 19, etc., and any radio test gear.—LESLIE DIXON & Co., 214, Queenstown Rd., Battersea, S.W.8. Macaulay 2159. [0176

WANTED, tuning units, TN17, TN18, TN19, for R54/APR4; £50 each offered.—Box 4963. [0261

WANTED, set manufacturers' or ex-Government radio equipment, large or small quantities of valves, electrolytics, speakers, meters, also components.—LOWE BROS., 9a, Diana Place, Euston Rd., N.W.1. Eus. 1636/7. [4485

WANTED, HRO coils, Rxs, etc., A.R.88s, BS348s, S27s, etc.—Details to R.T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0163

WANTED, B.C. 610 Hallicrafters, ET 4336 transmitters, and spare parts for same; best prices.—P.C.A. Radio, Beavor Lane, Hammersmith, W.6. [0079

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

ALL U.S.A. V.H.F. test and communication equipment: TS174, TS175, TS47, B.C.221 freq. meters; receivers 1294, 1359, Hallicrafters S.27, S 27CA, U.S.A.; APR4 and tuning units TN16, 17, 18 and 19, RCA AR88D-LF, Hallicrafters SX28; valves 707A-707B, 2K28, 2K39, 2K33, 2K41; highest offers given by return.—Ger. 8410 and 4447. Universal Electronics, 22, Lisle St., Leicester Sq., London, W.C.2. [0229

VALVES WANTED

RL.18 (CV.1197) any quantity, must be good condition.—Box 2490. [4414

ALL types of valves required for cash; state quantity and condition.—Radio Facilities, Ltd., 38, Chalcot Rd., N.W.1. Primrose 9090. [4074

CABINETS

LEWIS RADIO have the best selection and finest finish.—See page 154. [0224

WALNUT radiogram and television cabinets, soundly constructed; stamp for details.—R. Shaw, 69, Fairlop Rd., Leytonstone, E.11. [4330

CABINETS for radio and television: E. Kahn & Co., Ltd., are now equipped to accept orders from large manufacturers of radios, television sets and gramophones.—Contact London Office, 1/3, Morwell Street, W.C.1. [4479

METERS WANTED

WE urgently require meters of all types, meter components, test equipment, etc.; any quantity, large or small; prompt cash.—ANDERS ELECTRONICS, Ltd., 91, Hampstead Rd., London, N.W.1. Euston 1639. [3738

BUSINESS AND PROPERTY

LOCK-UP shop, Croydon, electrical, radio, television; £500; s.a.v.—Box 2928. [4505

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.

LOUDSPEAKERS repaired promptly.—Model Loudspeaker Service, Bullingdon Rd., Oxford. [4141

MAINS transformers, E.H.T.s, chokes, field coils, etc., promptly and efficiently rewound or manufactured to any specification.—LADBROKE REWIND SERVICE, LTD., 820a, Harrow Rd., London, N.W.10. [0222

TELEVISION and radio service to the trade. First-class workmanship fully guaranteed.—D. Savage, 44, Sirdar Rd., Westbury Ave., N.22. [4482

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. [4296

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

NOTICE that Melton Electronics, Ltd., 387, Ashley Rd., Parkstone, Poole, Dorset, manufacture transformers, chokes, line and frame outputs, R.F. and E.H.T. coils, and a complete range of "C" core types.—YOUR enquiries for rewinding all Commercial Types will receive immediate attention. [4303

REWINDS and conversions to mains and output trans, pick-ups, fields, clock coils, etc., from 4/6; PP equipment a speciality; all work guaranteed.—N.L. Rewinds, 173, High Rd., Willesden Green, N.W.10. Tel. Wordsworth 7791. [4503

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 specialize 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

NOTICES

BRITISH SOUND RECORDING ASSOCIATION. Details of membership, open to the professional sound recording engineer and all others interested in recording high quality reproduction and other branches of audio engineering, together with details of the London lecture programme and the Manchester, Portsmouth and Cardiff Centres, may be obtained from the Hon. Membership Secretary, H. J. Houlgate, A.M.I.E.E., 12, Strongbow Rd., Eltham, S.E.9. [0031

PATENTS

THE proprietor of British Patent No. 567462, entitled "Electronic Tube" offers same for licence or otherwise to ensure practical working in Great Britain.—Enquiries to Singer, Stern & Carlberg, 14, E. Jackson Blvd., Chicago 4, Illinois, U.S.A. [4356

PUBLIC ANNOUNCEMENTS

THE INSTITUTION OF ELECTRICAL ENGINEERS.
SCHOLARSHIPS.
THE Council of The Institution of Electrical Engineers will consider for award this year five Research Scholarships, one Graduate Scholarship and six Student Scholarships.
RESEARCH Scholarships.—Farranti, value £500 p.a. for two years. Oliver Lodge, value £420 for one year, may be extended. I.M.E.A., value £420 for one year, may be extended. Swan Memorial, value £120 for one year. C. P. Sparks Fund, value £100 for one year.
GRADUATE Scholarship.—For full-time post-graduate study Duddell, value £400 for one year. (May be awarded as a Student Scholarship.)
STUDENT Scholarships for study at undergraduate level at a University or a Technical College. Duddell, value £200 p.a. for three years. Arthur Fleming, value £120 p.a. for four years (for a sandwich diploma course). Salomons, value £60 for one year. David Hughes, value £60 for one year. Paul, value £75 p.a. for four years. Thorrowgood, value £25 for one year.
THE closing date for the receipt of applications is 2nd May, 1955, for Student Scholarships and 1st June, 1955, for Graduate and Research Scholarships. Full particulars of the conditions of award attached to each scholarship and nomination forms may be obtained on application to the Secretary The Institution of Electrical Engineers, Savoy Place, W.C.2. [4372

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.

SENIOR engineers.
JUNIOR engineers.
TECHNICAL assistants
ARE invited to apply for positions where energy, initiative and skill will be well rewarded; the work relates to the development of television circuits, and the design of components for large scale production; experience of television receiver design is required in respect to means of scanning and focusing or the design of R.F. and I.F. circuits; the positions are permanent ones which offer scope for advancement to senior positions; the commencing salary will be in accordance with experience, based on a generous and progressive scale. —Write, giving full personal particulars, to the Personnel Manager, The Plessey Co., Ltd., Ilford, Essex. [4403

DESIGN and Development Engineers.
APPLICATIONS are invited from the following to undertake important work on a wide range of interesting problems in connection with Guided Weapons Research and Development:—
SERVO Research Engineers. (Ref. W.W./8.) TO work on electro-pneumatic and hydraulic servo-mechanisms. Degree or H.N.C. essential.
INSTRUMENT Research Engineers. (Ref W.W./7.)
TO work on Gyroscopic instruments and accelerometers with associated pick-offs. Degree or H.N.C. essential.
ELECTRONIC Engineers. (Ref. W.W./10.)
TO carry out work, associated with the above, on electronic circuitry or magnetic amplifiers. Degree or H.N.C. essential.
GRADUATE Engineers or Physicists. (Ref. W.W./9.)
TO solve problems on analogue computors. Previous experience desirable. Degree, electronic experience and a mathematical leaning essential.
GOOD salary and bonus. Pension scheme incorporating Life Assurance. Thirty-eight-hour, 5-day week.—Apply, quoting appropriate reference above, to the Assistant Manager, The Fairey Aviation Co., Ltd., Weapon Division, Heston Aerodrome, Hounslow, Middx. [4492

THE PLESSEY Co., Ltd.

VACANCIES exist in new well equipped and expanding laboratories of the Chemical and Metallurgical Division, for junior and senior metallurgists, chemists and ceramists with progressive ideas; experience in any of the following an advantage.
SEMICONDUCTORS.
ELECTROLYTIC capacitors.
MAGNETIC materials.
ELECTRICAL ceramics.
POSITIONS offered are permanent and pensionable and offer considerable scope for advancement; salaries will be generous and commensurate with qualifications and experience.—Write in confidence to the Technical Manager, The Plessey Co., Ltd., Towcester, Northants. [4407

ELECTRONIC Engineers.

A DEVELOPMENT section for work on Government contracts is to be created at a new, modern and attractively situated G.E.C. factory. There are posts of varying responsibility requiring men with practical Electronic Development experience and with qualifications ranging from H.N. Cert. to Hons. Degree.—Applications, which will be treated in strict confidence, should be detailed and addressed to Personnel Manager, S.E.I., Ltd., School St., Hazel Grove, Cheshire. [4425

DRAWING office training.

MARCONI'S.
WIRELESS Telegraph Co., Ltd.
OFFER a six months' course with fixed salary at their Drawing Office School, Chelmsford, from July 1955 onwards.
AFTER successful completion of the course, permanent posts will be available in the company's design drawing offices at Chelmsford.
QUALIFICATIONS:
AGE limit 28.
MUST have workshop experience.
MUST produce evidence of drawing ability.
PREFERABLY have O.N.C. Mech. or Elec.
A limited number of posts will also be available in the company's installation drawing offices at Chelmsford for which men with practical experience in the installation and maintenance of electrical equipment would be preferred; a few posts will also be available at Acton, London.
FIVE-DAY week; pension and life assurance scheme; social and athletic club.
APPLY (in writing) giving full details of education, training, experience etc. (including H.M. Forces), to The Secretary, Marconi's Wireless Telegraph Co., Ltd., New St., Chelmsford, Essex. [4495

DEVELOPMENT engineer.

MUIRHEAD & Co., Ltd., Beckenham, Kent, have a vacancy for physicist or electrical engineer (with degree or similar qualifications) on the development of data transmission devices, miniature motors and instrument servo mechanisms; salary according to experience; pension scheme.—Apply in writing to Personnel Manager. [4399

IMPORTANT vacancies for

ELECTRICAL Engineers for
GUIDED Weapon Test Equipment.
THE following electrical engineers are required to develop and/or use electronic and electro-mechanical test gear:—
ELECTRICAL Engineer (ref. W.W./46) to lead a small test and fault-finding team. Applicants should have electronic experience, preferably in one or more of these fields: servo-mechanism, analogue computors, radar, micro-wave, pulse, communication or telemetry. Degree or H.N.C. standard essential.
DEVELOPMENT Engineer (ref. W.W./48). Young graduate required to design and develop electronic and pneumatic test equipment. Hons. electrical engineering degree essential.
ASSISTANT Engineer (ref. W.W./49) to compile inspection test instructions for component and missile testing. H.N.C. standard and electronic experience essential.
THESE interesting appointments offer scope for advancement together with good salary and bonus. Pension scheme.—Send details of experience and qualifications, quoting appropriate reference, to the Assistant Manager, The Fairey Aviation Co., Ltd., Weapon Division, Heston Aerodrome, Hounslow, Middx. [4386

ESSEX EDUCATION COMMITTEE.

SOUTH-EAST Essex Technical College and School of Art, Longbridge Rd., Dagenham.
REQUIRED 1st September, 1955.
ASSISTANT Grade B for radio and television servicing and
TELECOMMUNICATIONS. Salary £525×£25 to £820 plus London Allowance, with additions for approved experience, training and qualifications. Application forms (returnable within 14 days) and details from Clerk to the Governors. [4442

BRITISH Empire Cancer Campaign.

ELECTRONICS technician required to construct special apparatus for research and to assist with maintenance and operation of million volt electron accelerator; age 22-35 preferred; appointment will be either in the technical grade £470-£545 or in senior technical grade £570-£655, according to age and qualifications.—Apply to Director, Research Unit in Radiobiology, Mount Vernon Hospital, Northwood, Middx. [4397

TELEVISION engineers able to drive required by leading and progressive dealers; good salary, conditions and prospects.—Singer's, 350, Edgware Road, W.2. Pad. 7915. [4213

DE HAVILLAND.

ADVANCED guided weapon projects.
SPECIALIST Servo Engineers are required for positions in an expanding organisation engaged on research, design and development work.
PERMANENT and progressive posts, both senior and junior, are available for men with ability and enthusiasm who can offer sound knowledge and experience of hydraulic servo mechanisms. Promotion prospects are good and conditions of employment are generous and enlightened.
WE operate a five-day week and assistance is given in obtaining single lodging accommodation within easy reach of the works.
THREE grades of specialist engineers are required, as follows:—
(i) SERVO Engineers with a theoretical background, having some practical experience of servo design. Candidates for these posts need not have any electronic experience. (Ref. 134.)
(ii) SERVO Engineers with a practical outlook. Candidates should possess a good knowledge of electronics and preferably be acquainted with hydraulics. (Ref. 135.)
(iii) ELECTRONIC Circuit Engineers for the detailed circuit design of the control equipment associated with hydraulic servos. (Ref. 136.)
APPLY in confidence, quoting reference number of position sought, to The Personnel Manager (Technical Employment), de Havilland Propellers, Ltd., Hatfield, Herts. [4488

ESSEX EDUCATION COMMITTEE.

SUPERVISORY Officer (technical) required to take charge of maintenance and repair of radio, gramophone and 16 mm film equipment in schools, etc. Good qualifications in radio theory essential; experience with 16 mm equipment and tape recorders an advantage. Salary £600×£25—£725. Further particulars and application forms obtainable (s.a.e.) from Chief Education Officer, County Offices, Chelmsford.

SENIOR technical engineering staff.

A London engineering company invite applications from project engineers who are capable of taking charge of microwave, electronics and mechanical engineering development in connection with guided weapon and other applications; these positions are permanent and offer ample opportunity for further advancement. The commencing salaries, which will be in the region of £1,000 per annum upwards according to qualifications and experience, will be subject to review on a generous scale; engineering degree or H.N.C.—Replies, which will be treated in utmost confidence, should give full details of qualifications and experience and be addressed to Box 2828. [4477

DEVELOPMENT Engineer required for

CYPRUS INLAND TELECOMMUNICATIONS AUTHORITY for one tour of three years in the first instance with prospect of a second tour. Salary scale £1,500 rising to £1,750 a year with gratuity at rate of £150 a year. Free passages. Outfit allowance £30. Free furnished house. Liberal leave on full salary. Candidates must hold City & Guilds Full Technological Certificate or equivalent and have at least 10 years' experience as an Executive Engineer with the G.P.O. or a manufacturing firm in the maintenance of V.H.F. multi-channel equipment and associated Carrier & V.F. telegraph equipments at major V.H.F. terminals. They should also have comprehensive experience of current line planning methods and of Field Survey work together with the preparation of fundamental plans and printing schedules.—Write to the Crown Agents, 4, Millbank, London, S.W.1 State age, name in block letters, full qualifications and experience and quote M2C/40697/WF. Candidates at present employed by the G.P.O. should submit their applications through their Establishment Division. [4428

BRITISH ELECTRICITY AUTHORITY.

EASTERN Division.
APPLICATIONS are invited for the following superannuable post in the Technical (Electrical) Department based at Ipswich:—
GENERAL Assistant Engineer
(TELECOMMUNICATIONS).
SALARY Grade 6. £600×£25—£725/£785 per annum.
APPLICANTS should preferably possess Higher National Certificate in Electrical Engineering or equivalent qualifications and have considerable experience in the maintenance of automatic and line transmission telephone apparatus. Some knowledge of power supervisory systems and V.H.F. radio would be an advantage.
THE duties will be concerned with the Authority's telecommunications systems in East Anglia.
APPLICATIONS stating age, qualifications and experience, should be sent to the Controller, British Electricity Authority, Eastern Division, Northmet House, Southgate, N.14, within 14 days of the appearance of the advertisement.
W. N. C. CLINCH, Controller. [4393

UNIVERSITY COLLEGE OF NORTH WALES.

APPLICATIONS are invited for the post of Technician in the Department of Applied Electricity. Salary £340 by annual increments of £15 to £415 (efficiency bar), then £440 by £20 to £480 per annum. Experience in the servicing of electronic apparatus is desirable. APPLICATIONS giving particulars of age, experience, etc., and the names and addresses of two referees, should be sent to reach the Registrar, University College of North Wales, Bangor, not later than Monday, 16th May, 1955. [4468

HER MAJESTY'S Oversea Civil Service.
ENGINEERS, Posts and Telegraphs Department, Federal Government of Nigeria.
DUTIES include (a) the supervision of African and European staff, installing and maintaining several types of wireless equipment, particularly V.H.F. single and multi-channel, or (b) the supervision of staff and the installation and maintenance of manual telephone exchanges; the planning installation and maintenance of associated subscribers networks and the maintenance of carrier equipment and telegraphs used on physical or V.H.F. Radio Circuits, or (c) the carrying through of telephone Subscriber underground cable development schemes including the balancing of loaded cables, and telecommunications duties of a general nature if necessary.
APPOINTMENT is either pensionable on probation in the salary range £910-£1,560 per annum gross or on contract in the salary range £1,116-£1,898 per annum gross with a gratuity of £150 per annum on satisfactory completion of contract. Free first class passages are provided for the officer, his wife, and assistance of up to £75 each for a maximum of 2 children is granted in respect of their passages or maintenance in the United Kingdom. Leave is granted at the rate of 7 days for each month of resident service in tour of 18-24 months and government quarters are provided, if available, at low rental.
CANDIDATES, between 25 and 35 years of age, must have passed, or be exempt from Parts A and B of the examination for A.M.I.E.E. or hold a University Degree in Electrical Engineering (preferably telecommunications) or be Assistant Engineers in the British Post Office with considerable experience in modern telecommunications practice. Preferably given to candidates with experience in the installation and maintenance of V.H.F. multi-channel equipment.
APPLY in writing to the Director of Recruitment, Colonial Office, Great Smith St., London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number BCD 108/14/05. [4429

ONE or two research engineers are required by THE ENGLISH ELECTRIC Co., Ltd., at their Guided Weapons Division at Luton.
FOR extended studies into miniature high-speed turbines and pumps, hydraulic servo systems and their associated control valves.
THE suitable men should be well qualified in mechanical engineering but an ability for original thought, and to work without supervision is of paramount importance.
SALARIES will be generous to the right applicants and housing assistance is possible. These posts offer excellent prospects for original work for which every facility will be offered.
APPLICATIONS to Dept. C.P.S., 336-7, Strand, W.C.2, quoting Ref. 1181D. [4438

AUTOMATIC TELEPHONE & ELECTRIC Co., Ltd., LIVERPOOL, 7.
COMMUNICATION engineers and DRAUGHTSMEN.
THE expanding programme of the Transmission Department offers vacancies in both senior and junior categories for line transmission laboratory engineers, and apparatus design engineers, and also for draughtsmen with experience in telecommunications or light current engineering.
SPECIALIST experience in any branch of line transmission engineering is desirable for some of the posts.
POSITIONS offered are on the company staff with contributory pension fund and usual staff conditions.
APPLICANTS should write to Personnel Manager, Automatic Telephone & Electric Co., Ltd., Strowger Works, Edge Lane, Liverpool, 7, giving full details of age, qualifications and experience. [4243

MAINTENANCE and Construction Engineer required for CYPRUS Inland Telecommunications Authority for one tour of three years in the first instance with the prospect of a second tour. Salary scale £1,400 rising to £1,600 a year with gratuity at rate of £150 a year. Free passages. Outfit allowance £30. Free furnished house. Liberal leave on full salary. Candidates must hold C. and G. Full Technological Certificate or equivalent and have at least 10 years' experience as an executive engineer with the G.P.O. or equivalent employment in the construction and maintenance of 2,000 type non-director automatic exchanges, V.H.F. multi-channel and associated carrier and V.F. telegraph equipment and other duties associated with the running of a telecommunications section. Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/40698/WP. Candidates at present employed by the G.P.O. should submit their applications through their Establishment Division. [4443

T.V. engineer required, N London, one able to make dept. pay; excellent returns and accommodation available.—Box 2949. [4511

PARTRIDGE Transformers, Ltd., have a vacancy for an engineer experienced in transformer testing and development; to take charge of transformer testing department. WRITTEN applications giving details of past experience, qualifications and age to the Chief Engineer, Partridge Transformers, Ltd., Tolworth, Surrey. [4475

ENGINEER, experienced radio and L.F. amplifiers for factory installation service, preferably own transport.—Apply Gensign, 73, Great Peter Street, London, S.W.1. [4480

APPLICATIONS are invited for pensionable posts as
ASSISTANT examiners in the Patent Office to undertake the official scientific technical and legal work in connection with Patent Applications; there are a small number of similar posts in the Ministry of Supply; applications may be accepted up to 31st December, 1955, but early application is advised as an earlier closing date may be announced; interview boards will sit at frequent intervals.
CANDIDATES must be between 21 and 28 years of age during 1955 (up to 31 for permanent members of the experimental officer class) and have first or second class honours degree in physics, chemistry, mechanical or electrical engineering, or mathematics; candidates taking their degrees in 1955 may apply before the result of their degree examination is known.
STARTING emoluments in London, including extra duty allowance for 45½ hour week, between £532 and £729 (men) £642 (women) according to periods of National Service and post-graduate experience rising to £896 (men) and £799 (women); promotion to examiners —£934 to £1,279 (men), £820 to £1,144 (women), normally after 5 years (3 or 4 years in exceptional cases); good expectation of promotion to senior examiner; candidates are recruited by selective interview.
APPLICATION forms and further information from the Civil Service Commission, Scientific Branch, 30, Old Burlington St., London, W.1, quoting number S 128/55. [4494

ASSISTANT Lecturer (Radio Engineering) required for the
ENGINEERING Dept. Nigerian Federal Government, for two or three tours totalling 36 months. Appointment either (a) on temporary terms with salary scale (including expatriation pay) £807, rising to £1,453 a year plus resettlement grant at rate of £100/£150 a year, or (b) with prospect of permanency with salary scale (including expatriation pay) £750, rising to £1,315 a year. Outfit allowance 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 United Kingdom. Liberal leave on full salary. Candidates, with H.N.C. in Electrical Engineering, must have had sound training in radio receiving and transmitting work and must be able to teach feeder and aerial theory; theory and practice of all types of recording apparatus and general audio and acoustic theory. They should have had wide experience in the industry and experience of teaching.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M2C/40373/WF. [4507

WIRELESS Station Superintendent required for the
POSTS and Telecommunications Department, Gold Coast Local Civil Service, 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. and Gds. Final Certificate in Telecommunications (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. [4391

TECHNICAL instructor (broadcasting) required by the Broadcasting Service, NIGERIAN Federal Government, for two tours of 12 to 15 months each, with possibility of permanency. Salary scale (including expatriation pay) £1,307 rising to £1,453 a year plus gratuity at rate of £150 a year. Outfit allowance of £60. Liberal leave on full salary. Free passages for officer and wife. Assistance towards cost of children's passages or grant up to £150 annually for maintenance in U.K.
CANDIDATES should have instructional experience and should have a good theoretical and practical knowledge of radio communication as applied to M.F., H.F. and V.H.F. transmitters and receivers, with a knowledge of mathematics, electricity and magnetism.
WRITE to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/30513/WF. [4451

TELECOMMUNICATIONS (Radio Transmission) Engineer required by large organisation in the North-West to train for position in Technical Publicity Department.
APPLICANTS should be aged between 25-30 years, and should have a good general educational background with the ability to write clear concise English; a sound knowledge of modern telecommunications techniques, including V.H.F. and U.H.F. multi-channel systems and frequency-shift signalling practices, essential.
THE position is on the established staff of the Company, with contributory Pension Fund, and usual staff conditions and amenities.—Please write to Box No. 434, Dorland Advertising, Ltd., 18-20, Regent Street, London, S.W.1, giving details of age, qualifications and experience. [4241

SENIOR draughtsmen.
DUE to expansion of the Electronics Division of the Plessey Company, Ltd., there are several vacancies for experienced men in the following fields:
1. DESIGN of a wide range of electronic equipment, including work to Service requirements.
2. MECHANICAL design of precision mechanisms for quantity production.
THESE vacancies carry attractive salaries and long-term prospects in reward for hard work and offer good staff conditions including superannuation and insurance schemes.—Applications, which will be treated in confidence, should be addressed to:
THE Plessey Company, Ltd., Vicarage Lane, Ilford, Essex. [4474

E.M.I. ENGINEERING DEVELOPMENT, Ltd.
COMPUTOR Engineers.
APPLICATIONS are invited from senior and junior electronic engineers with experience in the design of digital computors to take part in a large scale development programme for commercial accounting systems; the posts carry good starting salaries and outstanding opportunities.
VACANCIES also exist for assistant programmers.
APPLICANTS should write in confidence with full details to—Personnel Dept. (ED/226), E.M.I. Eng. Dev., Ltd., Hayes, Middx. [4411

AMBITIOUS and energetic engineers are invited to apply for the following posts:—
1. SENIOR position for a competent valve engineer to study and advise on the use and application of valves in a wide range of electronic equipments and to liaise with valve manufacturers. Applicants must have experience suitable for the position, and a sound knowledge of microwave valves.
2. SENIOR microwave engineer for development of microwave components and aerials; qualifications and experience essential.
3. SENIOR engineers capable of controlling a project from "breadboard" to production; applicants must have at least three years' development experience.
THESE posts are for permanent pensionable staff in a rapidly expanding development division offering unique opportunities for advancement to those who are prepared to work hard and produce results; write to.—Chief Development Engineer, Decca Radar, Ltd., 9, Davis Rd., Tolworth, Surrey. [4434

THE PLESSEY Co. has vacancies for development engineers familiar with one of the following subjects:—
(a) VARIABLE capacitors.
(b) SWITCHES for radio or electrical appliances.
(c) V.H.F or U.H.F. circuits and tuning mechanisms.
(d) RELAYS and vibrators.
(e) LOUDSPEAKERS and acoustics.
A GOOD salary and a progressive future are offered to men who can design components suitable for high production rates, while maintaining standards of quality and performance; there are also vacancies for qualified engineers and draughtsmen with less experience who will be able to undertake responsible design work after a period in the laboratory; all posts are permanent and pensionable and a modern laboratory provides efficient and agreeable working conditions.—Send particulars of qualifications, experience, and salary to the Personnel Manager, The Plessey Co., Ltd., Ilford, Esssex. [4404

THE Plessey Company has vacancies for development engineers familiar with one of the following subjects:
(A) VARIABLE capacitors.
(B) SWITCHES for radio or electrical appliances.
(C) V.H.F. or U.H.F. circuits and tuning mechanisms.
(D) RELAYS and vibrators.
(E) LOUDSPEAKERS and acoustics.
A good salary and a progressive future are offered to men who can design components suitable for high production rates, while maintaining standards of quality and performance; there are also vacancies for qualified engineers and draughtsmen with less experience who will be able to undertake responsible design work after a period in the laboratory; all posts are permanent and pensionable and a modern laboratory provides efficient and agreeable working conditions.—Send particulars of qualifications, experience and salary required to the Personnel Manager, The Plessey Company, Ltd., Ilford, Essex. [4478

A. H. HUNT (CAPACITORS), Ltd., require engineers for design and development of paper, mica and ceramic capacitors.
APPLICANTS should have previous training in electrical engineering at least to intermediate B.Sc. standard.—Apply to Personnel Manager, A. H. Hunt (Capacitors), Ltd., Bendon Valley, Garratt Lane, Wandsworth, S.W.18. [0057

SENIOR TV engineers required; must drive; salary from £650 p.a.—Apply E. Coyne, 120, Ladbroke Grove, W.10. Bay. 1947. [0082

ELECTRICIANS required by The Steel Company of Wales, Ltd. (Steel Division), Port Talbot, for work on industrial electronic equipment.
CANDIDATES should have previous experience and/or technical background as basis for period of training.
THOSE wishing to apply should write stating age, experience, etc., to the Personnel Superintendent, The Steel Company of Wales, Ltd. (Steel Division), Abbey Works, Port Talbot, Glam. [4422

THE Chemical and Metallurgical Division of the Plessey Co., Ltd., is engaged in the development of interesting new products for the electronics, radio and T.V. industries.
CHEMISTS, metallurgists, and ceramists are required for development work on semiconductors, electrical ceramics, magnetic materials and electrolytic capacitors.
ATTRACTIVE posts are available for junior and senior grades in new, well equipped and expanding laboratories.
POSITIONS offered are permanent and pensionable and offer considerable scope for advancement; salaries will be generous and commensurate with qualifications and experience.—Write in confidence to the Technical Manager, The Plessey Co., Ltd., Towwcester, Northants. [4406

SENIOR sales engineer required by Telephone Manf. Co., Ltd., Martell Rd., West Dulwich, London, S.E.21, with a minimum of 10 years qualified experience.
MUST have comprehensive knowledge of the use of polarised relays in telecommunications, servo mechanisms, electronic circuits and allied applications.
PENSION and staff bonus schemes after qualifying period.
WRITE giving full particulars to Personnel Dept. [4380

FERRY AIRPORTS, Ltd. require radio mechanics licensed and unlicensed with knowledge of current British and American equipment for duty at our Ferryfield base.
APPLICATION should be made to Personnel Office, Ferry Airports, Ltd., Blackbushe Airport, Nr. Camberley, Surrey, where interviews will be held. [4374

TELECOMMUNICATIONS (Line Transmission) Engineer required by large organisation in the North-West to train for position in Technical Publicity Department.
APPLICANTS should be aged between 25-30 years, and should have a good educational background with the ability to write clear concise English; a sound knowledge of modern telecommunications techniques, including coaxial and other multi-channel carrier telephone and telegraph systems, essential.
THE position is on the established staff of the Company, with contributory Pension Fund, and usual staff conditions and amenities.—Please write to Box No. 438, Dorland Advertising, Ltd., 18-20, Regent Street, London, S.W.1, giving details of age, qualifications and experience [4242

RADIO Salesman required, experienced, good salary and prospects.—Phone Secretary, Ambassador 4033, or call Premier Radio Company, 207, Edgware Rd., London, W.2. [4440

EXPERIENCED TV service engineer; old-established firm; good salary; small flat available.—Full particulars to W. J. Elliott, Ltd., Chequer St., St. Albans, Herts. [4340

PERSONAL Assistant of high ability and integrity required by owner of retail radio and electrical business of good standing; state age and full details of career.—Box 2929. [4501

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. [4502

RESEARCH Engineers, preferably of degree standard, and with a sound knowledge of communications and, particularly, electronics, required for experimental work relating to underwater sound apparatus.
APPLICATIONS, giving past experience, technical qualifications, age and salary required, should be addressed to the Personnel Manager, Kelvin & Hughes, Ltd., New North Rd., Barkingside, Ilford, Essex [4390

CHEMISTS, metallurgists and ceramists are required for the Chemical and Metallurgical Division of the Plessey Co., Ltd.; attractive posts are available for junior and senior grades.
APPLICANTS should be interested in the development of semiconductors, electrical ceramics, magnetic materials and electrolytic capacitors and experience in any of these fields would be an advantage.
POSITIONS offered are permanent and pensionable and offer considerable scope for advancement; salaries will be generous and commensurate with qualifications and experience.—Write in confidence to the Technical Manager, The Plessey Co., Ltd., Towwcestr, Northants. [4405

CHIEF Mechanical Designer for Research Department of large manufacturers of electronic equipment. Prev exp. in electronic industry essential. Salary up to £1,500 p.a. North London area.—Write Box 2359. [4388

A VACANCY exists in mid-Herts for a keen and conscientious radio mechanic for service work on industrial electronic equipment; write full details of experience, age and wages required.—Box 2489. [4415

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

ASSISTANT to the Chief Engineer required by an established instrument company in the Home Counties, now pioneering new developments in the field of electronic technology.
WHILE academic qualifications are not essential, applicants should have a sound theoretical training and considerable PRACTICAL experience. The salary will be according to experience—£1,200 per annum is envisaged. There is a pension scheme.—Box 1540. [4193

AIRCRAFT electrical design draughtsmen required, excellent opportunities for advancement.—Apply Personnel Department. Vickers-Armstrongs, Ltd., Hursley Park, nr. Winchester. [4176

TV and radio engineer, fully experienced; £12 p.w. to right man, and normal shop hours, able to drive.—Radio & Electrical Services, 35, Westbury Ave., Wood Green, N.22. Bow 2068. [4421

ASSEMBLER/FITTER, aged 21-30, experienced precision electro mechanical assembly. —Full details L.M.K. Manufacturing Co., Ltd., Harlequin Avenue, Great West Rd., Brentford, Middlesex. [4448

(1) PHYSICISTS and Electronic Engineers are required for the Chemical and Metallurgical Division of the Plessey Co., Ltd. Attractive posts are available for junior and senior grades in new, well-equipped and expanding Physics and Electronics Laboratories. APPLICANTS should be interested in the development and application of semi-conductors, dielectric, piezoelectric or magnetic materials.
POSITIONS are permanent and pensionable and offer considerable scope for creative work; salaries will be generous and commensurate with qualifications and experience.—Write in confidence to the Technical Manager, The Plessey Co., Ltd., Towcester, Northants.
(2) THE Chemical and Metallurgical Division of the Plessey Co., Ltd., is engaged in the development of interesting new products for the electronics, radio and TV industries.
PHYSICISTS and Electronic Engineers are required for development, applications and instrumentation work on semi-conductors, ferro-electric and ferromagnetic materials.
ATTRACTIVE posts are available for junior and senior grades in new, well equipped and expanding Physics and Electronics Laboratories.
POSITIONS are permanent and pensionable and offer considerable scope for advancement. Salaries will be generous and commensurate with qualifications and experience.
WRITE in confidence to the Technical Manager, The Plessey Co., Ltd., Towcester, Northants.
(3) THE Plessey Company, Ltd.—Vacancies exist in new, well-equipped and expanding laboratories of the Chemical and Metallurgical Division for junior and senior Physicists and Electronic Engineers with progressive ideas; experience in any of the following fields an advantage:
Magnetic measurements.
Acoustics.
Piezoelectricity.
Design of electronic apparatus.
Radio interference suppression.
Design of electromagnetic devices.
POSITIONS are permanent and pensionable and offer considerable scope for advancement; salaries will be generous and commensurate with qualifications and experience.—Write in confidence to the Technical Manager, The Plessey Co., Ltd., Towcester, Northants. [4260

THE Edison Swan Electric Company, Ltd., have vacancies in their Special Products Development Laboratory for Engineers for Development work on a wide range of electronic instruments and apparatus for Medical, Industrial and Government use.
PLEASE write, stating experience, age and salary required, to 155, Charing Cross Road, London, W.C.2, reference SP/LAB. [0083

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

SENIOR and junior electronic engineers required for high fidelity sound reproduction projects; applicants should give full details of qualifications and experience by letter to Chief Engineer, Pye, Ltd., St. Andrew's Rd., Cambridge. [4487

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 full details of career.—Box 2930. [4502

TELEVISION.—Expert fault locator/repairer, mostly for workshop, but able drive; experienced particularly Ekco, Pye, and all radios; good wage to first class technician.—Refs. to Watson's Radio, c/o "Ravenscrag," White Knowle Rd., Buxton Spa. [4437

ELECTRICAL SERVICE (EDGWARE), Ltd., 93, Edgware Rd., W.2, require urgently a senior T/V and radio service engineer; able to take complete charge of service dept.; clean licence, good refs., congenial, top salary.—Pad. 2342. [4264

TRANSFORMER and filter design engineer required to take charge of design and manufacture; qualifications and experience essential.—Apply to Personnel Manager, Pye Telecommunications, Ltd., Ditton Works, Cambridge. [4287

McMICHAEL RADIO, Ltd., Slough, Bucks. have vacancies from time to time for electronic engineers to be engaged on Government projects; those wishing to be considered are invited to write fully to the Chief Engineer, Equipment Division. [0198

REQUIRED by old-established West Country dealer holding all leading agencies, a top-class service engineer having experience with wide range of makes TV and radio. Permanent position with top salary. Suitable modern residence will be provided and with garage if required.—Fullest particulars to Box 2954. [4514

MODEL shop mechanics are required by a firm in S.W. London for work on electronic equipment; first-class men, able to read circuit diagrams and use simple machine tools, will be offered rates in the region of 5/3 an hour.—Write Box 2795. [4471

TECHNICAL Assistants required for development of electro-mechanical and electronic instruments (marine). Work involves initial experiments, sea-going trials, pre-production models and factory liaison. Occasional visits overseas are arranged
QUALIFICATIONS—Practical: 5 years' workshop or drawing office experience. Academic: City & Guilds Telecommunications Final Group Certificate, or equivalent.
APPLICATIONS, stating salary required, should be addressed to the Personnel Manager, Kelvin & Hughes, Ltd., New North Rd., Barkingside, Essex. [4508

DEVELOPMENT engineer with a sound knowledge of circuits as applied to light-duty mechanisms; interesting work on new projects, excellent opportunity for man with the right experience and training; London, S.E. area; state age and salary required.—Box 2286. [4378

RADIO Engineer for Bulawayo, Southern Rhodesia. Design and development engineer with at least five years' experience on domestic radio. Salary £1,200 per annum, with free air passage to Rhodesia.—Application should be made to Box 2947. Applicants will be interviewed in London. [4509

MULLARD RESEARCH LABORATORIES have vacancies for several technical assistants to be trained, at full salary, as microwave valve engineers; successful candidates will be engaged upon the design, construction and electrical measurement of valves in the research and development stages.
THE positions are permanent, progressive and carry attractive salaries; applicants, without National Service liabilities, should have scientific qualifications of, or equivalent to G.C.E. (advanced level), O.N.C., H.N.C.; however these requirements might be waived if the applicant has experience in a suitable technical field; salaries are based on qualifications experience and age, and are in keeping with present-day levels; general prospects within the organisation are excellent.—Apply Personnel Manager, Mullard Research Laboratories, Cross Oak Lane, Salfords, Near Redhill, Surrey.

TECHNICAL assistants.—A small number of opportunities exist to enter the factory laboratory of a leading radio and television receiver manufacturer for young men of H.N.C. and O.N.C. standards; these positions provide interesting work in the pre-production stages of large scale manufacture.
COMMENCING salaries will be in accordance with age, experience and qualifications.—Please apply in writing to the Personnel Officer, Mitcham Works, Ltd., New Rd., Mitcham Junction, Surrey, quoting reference G.1. [4497

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

ENGINEER with sound basic knowledge of light electrical and A.F. engineering for sound recording equipment department; pension scheme.—Apply, stating experience, qualifications, age and salary required, to the Personnel Manager, B.A.F., Ltd., Woodger Rd., London, W.12. [4433

MANAGER for large electronic company in N. London, exp of mass production and small batch production of coils and transformers, etc., for radio, television and radar equipment. Control of 300 employees. Good salary and prospects. Pension scheme, etc. Age 35-55.—Write Box 2360. [4389

ELECTRONIC engineers with degrees in physics or engineering required for important and interesting work on the research and development of special equipment; good opportunity and high salary rate.—Write to Managing Director, Microcell, Ltd., 56, Kingsway, London, W.C.2. [4402

SERVICE engineers required in both Birmingham and London for industrial radio frequency equipment; applicants should have completed their National Service and should preferably be able to drive.—Apply in writing to Radio Heaters, Ltd., 46, Gray's Inn Rd., London, W.C.1. [4401

TELEVISION field and bench service engineers required immediately for modern service department of leading radio retailers in East London; wages up to £14 per week or according to ability; permanent position.—Apply for interview to Leytonia Radio, Ltd. Tel. Leytonstone 1396. [4271

DEVELOPMENT engineer required for work on transistor oscillators, previous experience need not include transistor applications but a fundamental knowledge of time base circuits is desirable.—Applications to Personnel Manager (Quote A.12063), Ferguson Radio Corp., Ltd., Gt. Cambridge Rd., Enfield, Middx. [4518

HONOURS graduate in physics or electrical engineering is required to work in a laboratory engaged in research and development on frequency control problems relating to communication systems. The position is open to men and women and affords excellent opportunities for detailed study of the theoretical and practical aspects of the subject.
LIVING accommodation for single or married persons can be made available.
BOX W., R2421, A.K. Advg., 212a, Shaftesbury Ave., London, W.C.2. [4491

RADIO testers and mechanical inspectors required (male): must have experience on service equipment and used to working to Government specifications; high rates of pay to first-class men; excellent conditions in modern factory in the West London area; write fullest details to—Box 2492. [4413

A FIRST-CLASS television engineer is required by Cadman's, 19, City Arcade, Hanley, S.O.T. Established 21 years. Applicants must be able to handle all types of television repairs speedily and efficiently; permanent situation and good pay are offered to a really good man. —Applicants should send full particulars. [4470

ASSISTANTS (scientific); the Civil Service Commissioners invite applications for pensionable posts; applications may be accepted up to December, 31, 1955, but early application is advised as an earlier closing date may be announced either for the competition as a whole or in one or more subjects; interview boards will sit at frequent intervals.
AGE at least 17½ and under 26 years of age on January 1, 1955, with extension for regular service in H.M. Forces, but candidates over 26 with specialised experience may be admitted.
CANDIDATES must produce evidence of having reached a prescribed standard of education, particularly in a science or mathematical subject. At least two years' experience in the duties of the class gained by service in a Government department or other civilian scientific establishment or in technical branches of the Forces essential in one of the following groups of scientific subjects:—
(i) ENGINEERING and physical sciences.
(ii) CHEMISTRY, bio-chemistry and metallurgy.
(iii) Biological Sciences.
(iv) GENERAL (including geology, meteorology, general work ranging over two or more groups (i) to (iii) and highly skilled work in laboratory crafts such as glass-blowing).
INCLUSIVE salary scale £262 (at 18) to £545 (men) or £457 (women). Starting pay up to £402 (men) or £357 (women) at 25; somewhat less in provinces; opportunities for promotion.
FURTHER particulars from Civil Service Commission, Scientific Branch, 30, Old Burlington St., London, W.1, quoting No. S 59/55. [4420

ELECTRONIC Engineers and Physicists reqd. for rapidly expanding research dept. Candidates should have experience of electronic instrument development. Experience in pulse circuits or ultrasonics desirable but not essential. B.Sc. or H.N.C. standard.—Write full partics. to Glass Developments, Ltd., Brixton, S.W.2. [4237

TELECOMMUNICATION Development Engineers with good experience in carrier and/or telephone equipment required. Applicants who should be graduates holding a degree or H.N.C. should write details of qualifications, past experience and salaries earned to Personnel Manager, The Phœnix Telephone & Electric Works, Ltd., The Hyde, Hendon, N.W.9. [4435

A FIRST-CLASS television and radio engineer is required by R. J. Stratton, Ltd., of Lyme Regis, Dorset; applicant must be able to handle all types of television and radio repairs speedily and efficiently; good pay and opportunity is offered to a really good man; applicants should send full particulars in envelope marked "Radio Enquiry—Private." [4419

PHILIPS BALHAM WORKS, Ltd., 45, Nightingale Lane, S.W.12, requires graduate in electrical engineering or physics preferably with experience in electronics for development of nucleonic instruments: permanent appointment with excellent prospects.—Applications should be addressed to the Personnel Officer at the above address. [4400

THE TELEGRAPH CONDENSER Co., Ltd., require radio and TV engineer with laboratory experience for work in connection with printed circuits. H.N.C. standard. Superannuation scheme.—Write giving full details of education and experience, age and salary required to Personnel Manager, T.C.C., Ltd., North Acton, W.3. [4311

TECHNICAL writer required by a West London manufacturer of domestic radio and television equipment to take charge of a section engaged in the compilation of Service manuals and similar publications; previous experience of this work and a sound knowledge of electronic theory are essential; the position is permanent and pensionable.—Apply to Box 2399. [4396

DECCA RADAR, Ltd., require Testers for fault-finding and alignment on radar equipment. Applicants with experience in radio or television testing considered. Good prospects in an expanding department for suitable applicants.—Apply to Personnel Officer, Decca Radar, Ltd., 2, Tolworth Rise, Surbiton, Surrey. [4385

APPLICATIONS are invited from young physicists posessing honours degree for work on the development of transistors. Post-graduate work on semi-conductors and solid state physics would be an added qualification. Laboratories in ideal country surroundings. Applications to Personnel Manager, Standard Telephones and Cables, Ltd., Ilminster. [4235

BUSH RADIO Ltd., require senior and junior engineers in their laboratories at Chiswick, Kew and Plymouth; applicants should preferably hold a Higher National Certificate, B.Sc. Engineering or Physics, or equivalent qualifications; experience in the following fields of development would be an advantage; Domestic radio or television, electronic equipment for aircraft, communication receivers, pulse circuits and micro-wave techniques.—Write, giving full details and salary required, to the Chief Engineer, Power Rd., Chiswick, W.4. [4395

MULLARD LIMITED (Valve Division) require several Junior Engineers, preferably aged 20-25 and of Higher National Certificate or equivalent standard, as Assistants in their Technical Service Department to deal with data and Publications in one of the following capacities:—

(i) Preparing published data on Valves, Tubes and Transistors.

(ii) Answering technical correspondence and enquiries from Home Constructors and Service Engineers.

(iii) Editing laboratory reports and preparing technical articles for publication.

These positions offer an excellent opportunity to obtain a general grounding in all applications of Valves and similar devices prior to specialisation in a particular field. Good prospects of advancement for persons of ability. Write, stating age and giving full details of education, training and previous experience to **Personnel Officer, Mullard Limited, Century House, Shaftesbury Avenue, W.C.2.**

MORSE CODE Training

COURSES for BEGINNERS and OPERATORS, also a **SPECIAL COURSE** for passing the **G.P.O. Morse Test** for securing an **AMATEUR'S TRANSMITTING LICENCE.**

Send for the Candler
BOOK OF FACTS.
It gives details of all Courses.

Fees are reasonable

Terms; Cash or Monthly Payments.

THE CANDLER SYSTEM CO.
(55W) 52b ABINGDON ROAD, LONDON, W.8
Candler System Co., Denver, Colorado, U.S.A.

BASS REFLEX CABINETS

Walnut, Mahogany or Oak, 30" high, with gold anodised expanded metal grille.

12" Speaker Model £10. 0.0
10" " " £9.10.0
8" " " £9. 0.0
Carr. paid

GOODMANS & G.E.C.
Full range of cabinets for these speakers.

You can see your cabinet being made in our cabinet-making workshop.

Cabinets made to order.
Armstrong Chassis and Amplifiers.
The Leak TL/10 Amplifier.
LOUDSPEAKERS.

Open till 5.30 Saturdays

A. DAVIES & Co. (Cabinet Makers)
3 Parkhill Place, off Parkhill Road, London, N.W.3. GULLIVER 5775.

ELECTRONIC Engineer required for senior position in an expanding laboratory engaged on the development of electronic equipment, including control gear, servomechanisms and special purpose tape recorders. Applicants should state qualifications, experience and salary required.—Write full details to Box 2948. [4510

TWO graduate physicists or electrical engineers with an interest in electronic engineering are required for the development of equipment for the measurement of the properties of semi-conductor materials and devices; previous experience in the design and construction of electronic equipment is desirable for one of the vacancies.—Box 1971. [4286

SKILLED radio mechanics and assemblers (male) required; experienced on service equipment preferred but not essential; excellent conditions in modern factory, with good wages for the right type; ex-R.E.M.E. and R.A.F. personnel will also be favourably considered; Acton district; write fullest details to—Box 2491. [4412

BANGKOK.—Eastern merchants require mercantile assistant for radio and electrical agencies, technical background and good general education essential; age about 25; bachelor; annual increments; cost-of-living allowance; provident fund, pension scheme; free accommodation and passage.—Write, Box 1371, c/o Abbotts, Eastcheap, London, E.C.3. [4481

HONOURS graduates in physics or electrical engineering are required for advanced work in a quartz crystal laboratory; the positions offered afford excellent opportunities for young men or women to specialize in the study of piezoelectric materials from both the theoretical and practical viewpoints; an interest in mathematics and electronics would be an advantage for this work.
LIVING accommodation can be made available to successful applicants.—Write Box W.Q 9363, A. K. ADVG., 212a, Shaftesbury Ave., London, W.C.2. [4460

ENGINEER required for expanding West London company; degree or equivalent with sound knowledge of electronics required; experience with production and application of miniaturised precision electro-magnetic relays or similar equipment essential; this position is an executive one and only those with ability to organise and supervise development and production will be considered.—Box 1539. [4196

HATFIELD INSTRUMENTS, Ltd., who are now expanding their laboratories, required senior and junior electronic engineers with experience in the design and test of high grade radio and industrial laboratory equipment.—Apply in writing, in the first instance, stating age, experience and salary required, to Hatfield Instruments, Ltd., 175, Uxbridge Rd., Hanwell, W.7. [4452

A SENIOR Engineer is required for a responsible post on design of Communications Receivers and Low Power V.H.V. R/T Equipment. Applicants should have a good engineering or science degree, or equivalent qualifications and at least five years' experience in these fields in responsible positions.—Applications should be addressed to Personnel Department, S.E., Murphy Radio, Ltd., Welwyn Garden City. [4430

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Nobel Division, requires assistant technical officers in the Physics Research Section, Stevenston, Ayrshire. Candidates should have a Pass Degree in Science or its equivalent, and preference will be given to those with experience of electronics.—Applications should be made in writing to the Staff Manager, 460, Sauchiehall St., Glasgow, C.2. [4392

A SENIOR Communications Engineer is required for responsible post on design of Carrier Telephony Radio Links. Applicants should have a good engineering or science degree, or equivalent qualifications and at least five years' experience in a similar post.—Applications should be addressed to Personnel Department, S.C.E., Murphy Radio, Ltd., Welwyn Garden City. [4431

TECHNICAL writers for preparation of technical manuals, mainly in connection with navigational radar and associated electronic devices; engineers with suitable background but no specific writing experience would be considered; salary £550 to £750 p.a., according to qualifications and experience.—Apply in writing to Ref. RWD/CA, Decca Radar, Ltd., 1-3, Brixton Rd., S.W.9. [4446

SIEMENS BROTHERS & Co., Ltd., require technicians for their Research Laboratories at Blackheath, S.E.3 engaged in work on electronics and telecommunications; pensionable staff posts with good prospects of advancement.—Apply in writing to Siemens Brothers & Co., Ltd., Ref. 744/12, Woolwich, S.E.18, giving particulars of age, qualifications, experience and salary required. [4462

RADIO engineer for Bulawayo, Southern Rhodesia: design and development engineer with at least five years' experience on domestic radio; salary £1,200 per annum, with free air passage to Rhodesia.—Application should be made to Advertiser, 31, Burlington Ave., Kew Gardens, Surrey, with copy to P.O. Box 2096, Bulawayo, Southern Rhodesia. Successful applicant will be interviewed in London. [4076

ELECTRONIC engineer required by London firm to take charge of measurements laboratory and test gear design; experience of measurement of capacitators or telecommunication cables is essential; position involves direct responsibility to management and will suit engineer aged 25 to 32 who wishes to take up senior position; write details of qualifications, experience and present salary.—Box 2259. [4375

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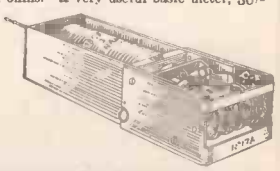

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JUNIOR engineers required in departments covering the design and construction of high grade television transmission equipment and a wide range of electronic equipment. Good fundamental knowledge required and some practical commercial experience desirable; pension scheme, 5-day week, good canteen.—Write, stating age, experience and salary required to Cinema-Television, Ltd., Worsley Bridge Rd., Lower Sydenham, S.E.26. [4383

EDISON SWAN ELECTRIC Co., Ltd., have a vacancy for an engineer to take charge of their Special Products' Development Laboratory, candidates should have an engineering degree or its equivalent, and should have experience in developing electronic equipment ready for factory production.—Please write full particulars, including age and salary required, to 155, Charing Cross Rd., London, W.C.2. Reference K. S. P. [0086

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

STANDARD TELEPHONES & CABLES, Ltd., have vacancies for engineers, mathematicians or physicists, with degree or Higher National Certificate and experience of automatic switching controls, computors, or digital techniques; vacancies also exist for junior engineers.—Apply, giving full details of qualifications, experience and salary required, to Personnel Manager, Corporation Rd., Newport, Mon. [4449

DEVELOPMENT Engineers.—A leading Manufacturer of Radio and Television Receivers has vacancies in its Laboratories for Electronic Engineers with experience in the Design and Development of this tpye of equipment. Situated in the Midlands. Salaries according to qualifications and experience.—Those interested should write, giving details of career and salary expected to the Personnel Manager (Ref. GLB.) Box 2541. [4427

ESTIMATOR.—Decca Radar, Ltd., invite applications for a responsible post as estimator in their laboratories; applicants must have a sound knowledge of mechanical and electronic engineering coupled with substantial suitable industrial experience; excellent starting salary with a rising scale; British nationality essential; pension scheme.—Reply, quoting RLA 84, to Decca Radar, Ltd., 2, Tolworth Rise Surbiton, Surrey. [4447

ELECTRICAL Foreman, with wide production experience 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; housing assistance; canteen and social facilities.—Please write, giving details of age, past experience, present salary, salary required, married/single, to Box 2950. [4512

DEVELOPMENT engineer required for work on transistor amplifiers, previous experience need not include transistor applications but applicant should be conversant with general radio engineering practice in particular with negative feed back technique. Class B amplification and design of detector circuits.—Applications to Personnel Manager (Quote 0960), Ferguson Radio Corp., Ltd., Gt. Cambridge Rd., Enfield, Middlesex. [4519

ELECTRONIC engineer reqd. for exceptionally interesting development work; applicants should have good academic training with 5-10 years practical experience of development, including some on communication equipment employing frequency modulation at U.H.F.; the post carries a good starting salary and excellent prospects; please write, with details to—Personnel Dept (ED/189), E.M.I. Eng. Dev., Ltd., Hayes, Middx. [4410

AMBASSADOR have vacancies for engineers in their Development Department due to an expanding production programme. The work entails the design of general radio and television circuitry, and production test gear; previous experience is desirable but not essential. H.N.C. or similar qualifications will count. The positions will carry staff status.—Apply by letter in first instance to Chief Engineer, Ambassador Radio and Television, Ltd., Princess Works, Brighouse, Yorkshire.

DESIGN draughtsmen are required by a firm in S.W. London for work on electronic equipment; there are excellent opportunities for men with initiative to establish themselves in an expanding company with a progressive policy; a technical background is essential, and familiarity with Ministry of Supply design standards is desirable; salaries in the range £700-£850 will be offered to suitable applicants for whom the posts will be permanent and pensionable.—Write Box 2796. [4472

RADIO Valve Engineers. Vacancies exist for several engineers to carry out pre-production, quality improvement and testing work in connection with an expanding programme of American type Miniature and Pinch type valves. Immediate work is available for fully experienced engineers and also for one or two juniors with the necessary technical background. Good salaries offered to the right applicants. Pension scheme. Modern canteen, and other facilities available.—Apply in writing to the Personnel Officer, British Tungsram Radio Works, Ltd., West Rd., Tottenham, N.17. [4513

DESIGNS engineer.—There is a vacancy for a designer of magnetic recording equipment in the Domestic Electronics Division of E.M.I.; a number of interesting projects are in hand giving scope for inventive ability to applicants who have knowledge of electrical circuitry or interest in small mechanisms; salary will be commensurate with ability and all applications will be seen by the Chief Designer.—Write in first instance, giving full details, to Personnel Dept., E.M.I., Ltd., Blyth Rd., Hayes, Middx. [4520

MAINS RADIO have vacancies in their development department for men with good knowledge of radio and television circuits and their practical application; the work will include the design and construction of radio and television receivers and test gear and should prove very interesting to those with a flair for experimentation; good salary, progressive staff positions.—Please apply to the Personnel Manager, Mains Radio Gramophones, Ltd., 359, Manchester Rd., Bradford, 5. [4453

SIEMENS BROTHERS & Co., Ltd., have vacancies in their laboratories at Woolwich for assistant engineers to carry out experimental work on electronics as applied to long-distance telephony; the work covers multi-channel carrier current telephony and telegraphy over long distance open-wire lines and cables in addition to VHF and UHF radio circuits; field trials for such new equipments afford opportunities for short periods of overseas experience, and young engineers can obtain overseas installation experience.
THE laboratories are also engaged on the development of specialised carrier current terminal equipment for use with submarine cable systems employing submerged repeaters; opportunities are available for dealing with mechanical design, the physical principles of component design and the miniaturisation of equipment.
THERE are vacancies for young engineers who wish to take up sales and project engineering work involving commercial as well as technical requirements; this work necessitates a period of laboratory training before undertaking overseas travel.
APPLICANTS should have Ordinary National Certificate or higher qualification; experience in the maintenance of multi-channel carrier telephone or telegraph equipment an advantage.
APPLY Siemens Brothers & Co., Ltd., Ref. 744/11, Woolwich, S.E.18. [4377

CANADA needs electronic engineers. Measurement Engineering Ltd., with expanding business in electronic instrument field, offer generous salary, excellent prospects, to keen man capable of starting and taking charge of a section to handle magnetic amplifier design. Applicants must be Phys. or Eng. graduates with several years industrial experience, including two years on magnetic amplifiers. The location is Ontario, within easy reach of Chalk River and Ottawa. Interviews London (England).—Box 2059. [4313

AN Electronic or Electrical Engineer, between the ages of 25 and 35 years, of degree standard, is required to take charge of the engineering department of a factory engaged in the manufacture of frequency control equipment. The successful applicant will be responsible for the design and specification of all new items, as well as routine engineering problems. The position offers a wide scope for a person possessing the necessary technical qualifications and initiative to expand the work along numerous channels.
LIVING accommodation can be made available to the successful applicant.
APPLY in writing to the Personnel Manager, Standard Telephones & Cables, Ltd., Crystal Factory, Harlow, Essex [4466

AN electronic or electrical engineer of degree standard is required to take charge of the engineering department in a factory which is part of a large organisation engaged in the manufacture of all branches of communications equipment. The successful applicant will be responsible for engineering development, design and specification of all new items, as well as routine engineering problems. The wide field of work to be covered offers considerable opportunity for advancement. Living accommodation for single or married persons can be made available.
BOX W., R2417, A.K. Advg., 212a, Shaftesbury Ave., London, W.C.2. [4490

NATIONAL INSTITUTE FOR MEDICAL RESEARCH. The Ridgeway, Mill Hill, N.W.7, requires an assistant for the instrument laboratory; min. qual.: G.C.E. ordinary level or equiv. with passes in English, Mathematics and Physics; experience of the production of experimental apparatus and some knowledge of electronics are desirable; initial salary £450 +London weighting of £20-£30 depending on age; 3 weeks holiday with pay; established superannuated post after probationary period; excellent conditions.—Apply in writing to Administrative Officer at above address. (Quote ref. 54) [4381

TEST Engineers are required by a Leading Midlands manufacturer for:—(1) Testing and Fault-Finding on Radar Units and other Electronic Devices. (2) Construction and maintenance of Test Equipment. (3) Testing and Fault-Finding on domestic Radio and Television Receivers. These progressive positions cover a wide range of activities and selection will be made not only on experience but also on ability to respond to further training. Ex-Service technicians are particularly suitable.—Applicants should write, giving details of career to date and salary expected to the Personnel Manager (Ref. GLB.), Box 2540. [4426

SCIENCE graduate, aged 21-26 years, required in Tolworth, Surrey area, for investigation and development work on ceramics dielectrics, sound electrical knowledge essential, some experience in this field an advantage; consideration will be given to man not yet qualified but who intends to do so.—Box 2847. [4483

CRAFTSMEN for Radio and Television Service required at Shrewsbury and Ludlow districts; applicants must be fully experienced in the repair and maintenance of all types of radio and television receivers; rate of pay at present 4/1 per hour; N.J.I.C. conditions.—Apply, in writing, to Mr. W. Winwood, Sub-Area Manager, Midlands Electricity Board, Spring Gardens, Ditherington, Shrewsbury. [4463

SENIOR and junior design draughtsmen required for interesting work in connection with electronic equipment, commercial radio and television and/or light electro-mechanical engineering. London area; the positions vacant offer ample scope and opportunity for future advancement to men of good ability; a high salary will be paid to the selected candidate; all recognised staff privileges available; please reply, giving full details of experience to—Box 2442. [4409

TELEPHONE engineers.—A well-known London company manufacturing Telecommunication equipment have vacancies in their sales section for (a) engineers for preparing tenders, (b) engineers for editing and writing technical publications, (c) engineers for instructing and training customers' engineers; should have good knowledge of carrier telephone and VF telegraph systems; canteen and sports club facilities; pensionable staff posts; state age, qualifications and experience.—Box 2287. [4379

BELLING & LEE Ltd., wish to engage a young graduate electronics engineer with experience of V.H.F. receiver layout and circuit design, the work being in connection with the development of measurement apparatus for their television aerial laboratory, and communal broadcast and television amplifiers; British nationality essential; contributory pension scheme.—Applications (which will be treated in confidence) stating age, experience and salary required, to the Secretary, Great Cambridge Rd., Enfield, Middlesex. [4384

DRAUGHTSMEN.—An expanding production programme has created a number of vacancies for mechanical designers, senior draughtsmen and detail draughtsmen; situated in the Midlands; the work involves the complete engineering of electronic apparatus for Government contracts and of domestic radio and television equipment.—Applicants interested in this type of work, with or without experience, are invited to apply, giving details of career and salary expected to the Pesonnel Manager (Ref. GLB.), Box 2438. [4398

LABORATORY Technician (Physics). Queen Mary College (University of London). Mile End Rd., E.1, preference for experience any or all duties re glassblowing, lecture demonstrations, research assistance, electronics, salary according to ability on scale £340 p.a. by £15/20 to possible £480 subject to efficiency review at £415, plus London Weighting £20 to £30 according to age, pension scheme, three weeks minimum annual leave; letters only to Registrar, stating age, full details experience and present work. [4484

THE GENERAL ELECTRIC Co., Ltd., Brown's Lane, Allesley, Coventry, requires mechanical development engineers, designer draughtsmen and draughtsmen, preferably with experience of radar-type equipments for work on guided weapons and like projects; also required, senior and junior electronic development engineers, particularly in the field of microwave and pulse applications; salary according to age, qualifications and experience.—Apply by letter, stating age and experience, to the Personnel Manager, Ref. R.G. [0259

THE TELEGRAPH CONDENSER Co., Ltd., invite applications from engineers fully experienced in radio and television design to assist Chief Development Engineer in development of printed circuits. Qualifications at least to A.M.I.E.E. standard. This position offers scope for the right man who must be capable of initiating and following projects to finality, including contact with customers. Superannuation scheme.—Write giving full details of qualifications and experience, age and salary required, to Personnel Manager, T.C.C., Ltd., North Acton, W.3. [4312

ELECTRONIC Engineers are required for field trials on guided weapons by The English Electric Company, Ltd., Luton, Beds. Applications are invited from men with good electronics experience gained in industry or H.M. Forces, preferably with H.N.C. or equivalent. Assistants with similar experience are also required, preferably with O.N.C. Housing assistance available to successful applicants normally resident in the Greater London area. Applications giving full details of experience and qualifications to Dept. C.P.S., 336/7, Strand, W.C.2, quoting Ref. 1324E. [4441

SENIOR design and development engineers required for work of an interesting nature in connection with microwave, electronic and mechanical development of guided weapons and associated equipment; the vacancies offer ample opportunity for advancement in a modern laboratory; the positions are permanent and the commencing salaries will be in accordance with experience and will be based on a generous and progressive scale; degree or H.N.C.—Please reply, in confidence, giving full particulars, to: The Personnel Manager, The Plessey Co., Ltd., Vicarage Lane, Ilford, Essex. [4496

STANDARD TELEPHONES & CABLES, Ltd., Corporation Rd., Newport, Mon, have a vacancy in their transmission laboratory for an engineer to work on the development of testing apparatus employing transistors; excellent opportunity for a qualified physicist or mathematician interested in the application of semi-conductors; previous experience is desirable but not essential.—Apply, giving details of qualifications, experience and salary required, to the Personnel Manager. [4450

D.S.I.R. require an assistant experimental officer at the Radio Research Station, Datchet, near Windsor, Berks, for abstracting scientific and technical articles on radio research and development; qualifications in physics or electrical engineering; minimum, G.C.E. (advanced level) in two scientific subjects, or equivalent; candidates over 22 would normally be expected to have pass degree H.N.C. or equivalent; some knowledge and experience of radio research or development is necessary and ability to read technical French and German an advantage; inclusive annual remuneration for a 45½ hour week, men £297 (age 18)—£659, women, £297 (aged 18)—£556. —Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King St., London, S.W.1, quoting A114/5A. Closing date 13 May, 1955. [4493

TECHNICAL sales/service manager required for British West African branches of large British company distributing domestic radio receivers, V.H.F. radiotelephone equipment, intercommunication telephones, domestic and commercial refrigerators, air conditioners, and office equipment; good technical radio background essential; refrigeration experience desirable; familiarisation course arranged with U.K. manufacturers prior to departure for Africa; first-class passage sea/air, free furnished quarters, full pay on leave after approximately 18-month tours, pension scheme; apply in own handwriting stating age (preferably between 21 and 30), whether married or single, full details education, qualifications, national service and business experience; original references should not be sent.—Apply T. S. D., Box 1134. [4489

MURPHY RADIO, Ltd., have vacancies in the Electronics Division Laboratories for qualified engineers to design and develop the following: 1. V.H.F. and U.H.F. Communications equipment. 2. Airborne and Ground radar equipment. 3. Computing devices and servo systems. 4. Nucleonic equipment and measuring instruments. 5. Transistors. The salary range is £600–£1,000 per annum depending upon experience. Further posts are available to engineers of H.N.C. standard of equivalent having less experience, the salary range being £450–£650 per annum. These vacancies are at Welwyn Garden City but one or two vacancies of a similar nature are available at the Ruislip Works.—Applications, giving age, full details of qualifications, experience and salary required, should be forwarded to Personnel Department, Murphy Radio, Ltd., Welwyn Garden City. [4432

R. B. PULLIN & Co., Ltd., invite experienced electronic engineers to apply for a vacant post in the company's electronic development division; applicants should possess an honours degree or equivalent qualifications, and should have had several years experience of the development of electronic circuits, preferably including work on electrical servos and magnetic amplifiers; the post is of a senior and permanent nature, it offers excellent prospects in a recently created and expanding laboratory, and the work calls for a high degree of individual technical responsibility and initiative; a commensurate salary will be paid; contributory pension scheme, canteen and recreational facilities; applications will be treated as confidential, and should be made in writing stating full details to the Superintendent, Electronic Development Division, R. B. Pullin & Co., Ltd., Phœnix Works, Great West Rd., Brentford, Middlesex. [4416

MINISTRY of Supply requires technical authors at Chessington (also for posts (b) at Farnborough and Malvern), for publications dealing with all aspects of (a) mechanical and electro-mechanical equipment related to guided weapons or telegraphy, tele-mechanics and radio (Ref. D87/5A); (b) airborne/ground electronic equipment relating to radio communications, radio/radar control, search and navigation or guided weapons (Ref. D88/5A); (c) aircraft instruments, training aids and photographic equipment (Ref. D89/5A); (d) aircraft electrical, instrument and radio installations or ground servicing and test equipment (Ref. D90/5A); qualifications: British of British parents; recognised engineering apprenticeship or equivalent with A.M.I.C.E. or Mech.E. or E.E. or A.F.R.Ae.S. or H.N.C. or O.N.C. or equivalent; experience: posts (a) development or operation and maintenance of equipment concerned, and for guided weapons knowledge of servo-mechanisms and electronic devices desirable; posts (b) development or operation and maintenance of radio equipment; posts (c) electrical and mechanical instruments particularly for aircraft, apprenticeship in instrument making preferred; posts (d) appropriate experience; except for (c) experience of writing or editing technical publications advantageous; vacancies in three grades at salaries between £645 and £1,015, according to age and qualifications; not established, but opportunities to compete for establishment may arise. APPLICATION forms from M.L.N.S., Technical and Scientific Register (K), 26, King St., London, S.W.1, quoting appropriate reference; closing date May 13, 1955. [4408

BRITISH OVERSEAS AIRWAYS CORPORATION require engineers for the overhaul and maintenance of flight simulators in their Central Training Unit, near London Airport; applicants should have a thorough knowledge of electronic techniques; practical experience in the maintenance of analog computors, aircraft radio equipment and remote indicating system an advantage; duties, 3-shift system covering 24 hours per day; salary according to qualifications, £640 to £756/12 p. ann., plus approx. £80 p.a. shift pay.—Applications to be addressed to Staff Supt. (Recruitment), B.O.A.C., London Airport, Hounslow, Middx. [4455

EXPERIENCED engineers are invited to apply for a position where energy, initiative and skill will be well rewarded; the work relates to the development of television circuits, and the design of components for large scale production; experience of television receiver design is required in respect to means of scanning and focussing or the design of R.F. and I.F. circuits; the position is a permanent one which offers scope for advancement to a senior position; the commencing salary will be in accordance with experience, based on a generous and progressive scale.—Write, giving full personal particulars to the Personnel Manager, The Plessey Company, Ltd., Ilford, Essex. [4473

AIR MINISTRY require experimental officers (min. age 26) at Ruislip, Middlesex, for general experimental duties concerned with radio and radar installations employed in the Royal Air Force; duties include technical investigations into existing systems, field measurements, design of modifications and development of ancillary equipment; short periods of duty overseas may be necessary; quals., minimum of Higher School Certificate (Science) or equivalent; some experience of communications systems or radar control is essential; salary within range £735-£900.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King St., London, S.W.1, quoting D 112/5A, closing date 13 May, 1955. [4458

AIR MINISTRY require scientific officer (male) at R.A.F. Station near Maidenhead, Berks, for operational research duties, theoretical studies and development work in the field of communications and general electronics; qualifications, First or Second Class Honours Degree in Physics or Electrical Engineering, or equivalent; salary within range £467/10 to £845; post unestablished with possibilities of establishment through the 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 A 113/5A, from M.L.N.S., Technical and Scientific Register (K), 26, King St., London, S.W.1. Closing date 15 May, 1955. [4459

RADIO (Meteorological) Technicians 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 £467/10 at age 25 or over, rising annually to £565, 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. [4467

RESEARCH assistant (male) required for research on the reactions of fish to water at different temperatures; work (in London) includes development, operation and maintenance of electrical and photographic recording apparatus; degree in mathematics or science preferred; practical knowledge of electricity required; salary of assistant experimental officer starting, according age and qualifications, between £290 and £520; pension scheme. —Applications, with particulars education, qualifications, national service, experience and addresses of two referees, to the Director, Freshwater Biological Association, The Ferry House, Far Sawrey, Ambleside, Westmorland, by 15 May. [4445

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TELEVISION and radio engineer seeks position abroad, 24 years' experience, age 41 and married; accept maximum responsibility. —Box 2488. [4418

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