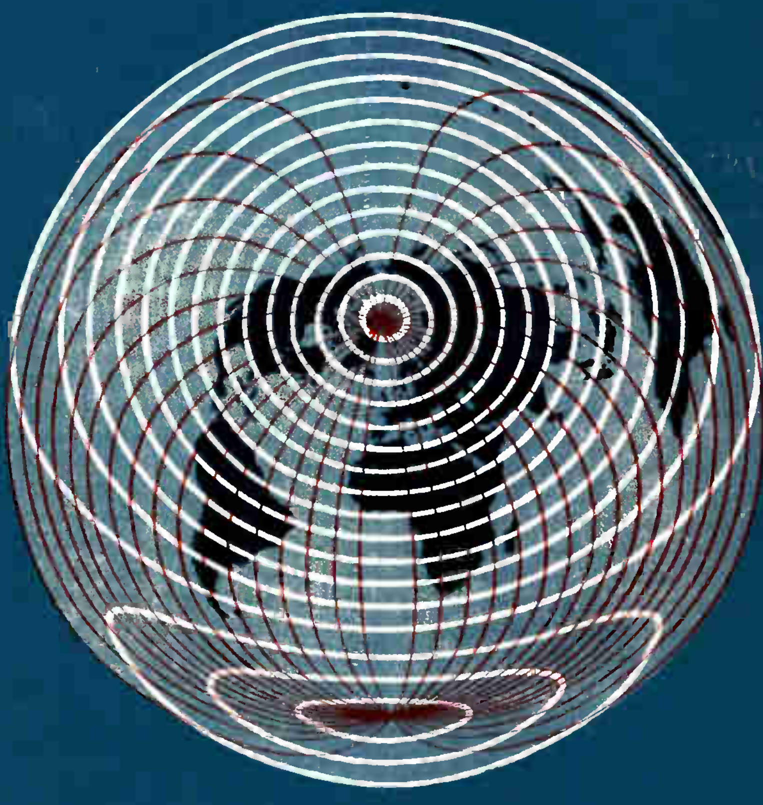
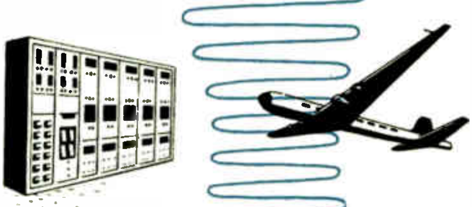
JANUARY 1958 TWO SHILLINGS

Wireless World

ELECTRONICS
Radio · Television



FORTY-SEVENTH YEAR OF PUBLICATION



Wireless World

ELECTRONICS, RADIO, TELEVISION

Managing Editor: HUGH S. POCOCK, M.I.E.E.
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JANUARY 1958

In This Issue

1	Editorial Comment	
2	World of Wireless	
6	Telephone Automation	
7	Reception on Band V	
11	Television Aerials for Bands IV and V	*By F. R. W. Strafford*
14	Band V on a Turret Tuner	*By P. R. Stutz*
17	Some Special Magnetrons	
22	Letters to the Editor	
23	Short-wave Conditions	
24	Cathode-Coupled Flip-Flop	*By T. G. Clark*
28	Magnetism in Materials—1	*By D. H. Martin*
31	Technical Notebook	
33	Starting Tape Driving Mechanisms	
36	Car Radio Receiver Design	*By J. C. Beckley*
40	A Pickup To Track at 2 Grams	
41	Valves, Transistors and Efficiencies	*By "Cathode Ray"*
45	Manufacturers' Products	
46	News from the Industry	
47	January Meetings	
48	Random Radiations	*By "Diallist"*
50	Unbiased	*By "Free Grid"*

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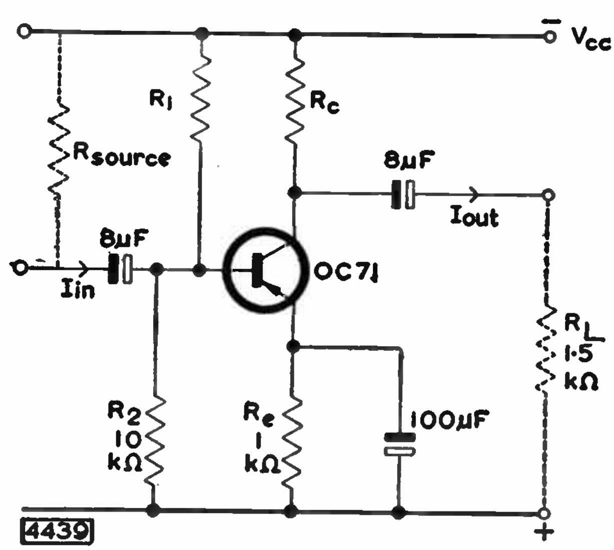
Transistor R.C. Coupled Amplifier Stages

Although it is desirable to design a universal standard transistor amplifier stage, this is not possible because signal level, supply voltage and maximum working ambient temperature each introduce problems which must be overcome in different ways. It is possible however to design and publish typical amplifier stages for several supply voltages, assuming a maximum working ambient temperature, making a compromise between gain and output.

The first stage in an amplifier must be designed to provide as high a ratio of signal to noise as possible, because the accumulated input and circuit noise will give a very impure output over a number of stages. In all other stages the requirement is maximum gain for minimum distortion at the required output level.

The recommended circuit using a Mullard OC71 transistor, with capacitive coupling produces a good gain for a relatively distortion free output. The circuit is suitable for use with supply voltages of 6V, 9V and 12V, stabilised up to 45°C ambient working temperature. Some modifications are indicated below for the user's guidance. It is important when modifications are made to ensure that the collector current should not go below 0.3mA, otherwise the input resistance and collector-emitter gain α' become very non-linear. The distortion and gain data shown in the accompanying table are typical for one OC71 stage from a series of identical ones in cascade. The source impedance R_{source} is assumed equal to the collector resistance R_C. A resistance of 1.5kΩ is used to shunt R_C, this value is equivalent to the input impedance R_L of the following stage. The current flowing in this 1.5kΩ is the output current considered in the distortion and gain measurements tabulated below. The gain figures apply to a transistor with average collector-emitter gain α'. These component values have been carefully chosen such that in each case the transistor operates satisfactorily up to an ambient temperature of 45°C. It will be seen from the table that the useful output current, for 5% total distortion, and stage gain increase with supply voltage. This distortion is predominantly second harmonic.



CIRCUIT VALUES AND GAIN FOR SOME TYPICAL OC71 TRANSISTOR STAGES

V_{cc} (V)	I_c (mA)	R_1 (kΩ)	R_2 (kΩ)	R_e (kΩ)	R_c (kΩ)	$\frac{I_{out}}{I_{in}}$	I_{out}*
6	1.0	39	10	1	2.2	23	200
9	1.0	62	10	1	3.9	28	260
12	1.0	82	10	1	5.6	31	270

* For 5% total distortion

The performance obtained with I_C = 1mA should be adequate in most cases, however the stage gain can be increased by reducing (not below 0.3mA) the collector current, this is only worthwhile at the lower supply voltages. For instance I_C=0.5mA, Re=2.2kΩ, R_C = 3.9kΩ gives 20% increased gain. Increased output can be obtained for a given distortion by increasing the collector current to, say, 1.5mA, altering circuit values accordingly. For minimum distortion it is preferable to keep the collector current in the range 1-2mA, in any case it should not be reduced below 0.3mA, and to keep the source impedance as high as possible.

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Wireless World

Training Technologists

"In the absence of natural resources commensurate with the size of its population, this country lives by trade and by the skill and efficiency of its industry, which must be sustained and expanded by the infusion of the best brains that can be found, trained and stimulated to work with enthusiasm."

THE truth of this typical aphorism is by now universally acknowledged; it is also axiomatic that existing channels of supply do not provide scientists and technologists in sufficient numbers for present, let alone future, requirements. For the sheer spadework of detail design and development the number of vacancies has long exceeded the supply; and at the top there will always be more than enough room for the Faradays and Blumleins of this world.

Where do the "star" men come from? According to Lord Hives, who spoke recently on the occasion of the introduction of the first report* of the National Council for Technological Awards, there is no evidence to show that any one educational channel is more likely than another to throw up the man of exceptional ability. The important thing is to open up as many channels as possible, so that no one who has the will to apply himself may be debarred by force of circumstance from proving his ability by the acquisition of a universally recognized qualification.

One of the reasons why the technical colleges of this country have been less well supported than the universities is the absence of a generally accepted degree or diploma (other than an external degree from London University) to set the seal on a sustained course of study. This has now been remedied by the Diploma of Technology (Dip. Tech.) which has been established by the National Council for Technological Awards, set up by the Ministry of Education.

Will Dip. Tech. be as good as a degree? For the purpose of qualifying for a post in industry it may well be better. An essential feature of the scheme is the freedom of colleges to develop their Diploma courses *in consultation with industry*, so that students will be well fitted for the industries they serve. In most cases work will be integrated in sandwich courses with industrial training. Teachers are to be encouraged to return periodically to industry, and it is proposed that senior members of industrial staffs should be given a special status in colleges which will enable them to take part in the academic activities. By these means it seems likely that a Dip. Tech. man will be more quickly useful than a man with an academic degree who may take some time to shake down in an industrial environment.

Although the composition of the Dip. Tech. courses will show wide variations, there is little doubt that the standard required will be uniformly high. We are impressed by the stiffness of the requirements laid down by the Council and the fact that more than half of the courses originally submitted for approval have been rejected. The governing body is not lacking in academic attainment, but is drawn mainly from industry and has acted and spoken with a sense of realism which is often absent from the pronouncements of professional "educationists."

It is not the business of the Council to initiate courses—these are prepared by individual colleges—so it cannot be made responsible for what appears to us to be an insufficient emphasis on the importance of electronics. Only one course (at the Northern Polytechnic) on the "Physics and Technology of Electronics" appears in the list of recognized courses in Appendix III of the report, though there are eight courses labelled "electrical engineering" and three "applied physics." No doubt these general subjects include some electronics, but they are now so wide and complex that any attempt to cover them completely in three or four years must surely run counter to the aims and objects of Dip. Tech. Essentially, this new qualification is a matter of expediency and has been created by the need for efficiency. There must be the broadest possible fundamental training at the beginning of the course, but specialization in the final years is inevitable and must tend to become even more narrow as the range of a subject increases with expanding knowledge.

The growing importance of electronics in the national economy is sufficient justification for the strongest possible representation on the Boards of Studies appointed by the Council. The collective experience of the Brit.I.R.E. should be added to that already available from the I.E.E., and many associations of specialists would have useful contributions to make. A separate Subject Panel in electronics should then be appointed, and this in itself would encourage the submission of more courses in electronics. We would also urge the larger electronics firms to use their influence with local colleges to submit more courses of a type appropriate to the needs of their industry.

Fears have been expressed that the advantages of a liberal education will be lost to those who elect to study for Dip. Tech. This need not be so, for the development of the critical faculty and a capacity for concentrated effort, resulting from the mastery of any one subject, are the best preparation for the continuous process of learning by which a liberal education is acquired.

*See "World of Wireless," this issue.

WORLD OF WIRELESS

Technological Education

ON the recommendation of the National Advisory Council on Education for Industry and Commerce the Minister of Education set up in 1955 the National Council for Technological Awards as an independent self-governing body "to create and administer technological awards . . . available to students in technical colleges who successfully complete courses approved by the council." The council's first report (covering the period from December 1955 to July 1957) was presented by Lord Hives, the chairman, at a meeting early in December.

The first award to be introduced by the council is the Diploma in Technology (Dip. Tech). The first of the 965 students now taking approved courses in a variety of technologies at eleven colleges will be taking their "finals" next June. There is some flexibility in the standards required of students for admission to a course but in general it is either five subjects in the General Certificate of Education or a good Ordinary National Certificate.

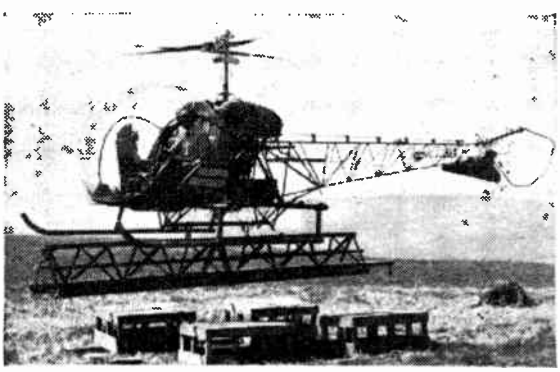
It is pointed out that approval of a course is not granted solely on its academic content but also on the general facilities available at the college. Moreover, the majority of the 50 approved courses are of the sandwich type with integrated college and works training.

The Dip. Tech., which is equivalent to a university honours degree, is the first award to be instituted by the council, which is now considering what post-graduate awards it should introduce.

The council, which has offices in 9 Cavendish Square, London, W.1, has two Boards of Studies, one covering engineering and the other technologies other than engineering.

Helicopter Aids S.H.F. Tests

THE Post Office Engineering Department has recently been carrying out propagation tests from a remote site five miles from Langholm, Dumfriesshire. It took six days to transport the mast, aerials, transmitting and receiving equipment, test hut and engine generator to the site over a mile of peat bog using a caterpillar tractor towing a sledge.



Air-lift for a section of the mast used for the Post Office s.h.f. tests referred to above.

In the light of this experience a helicopter was used for the return journey, the total time taken being only seven hours, spread over two days. Mast sections, paraboloid, and other heavy or bulky equipment was suspended from the machine.

Subscription Television

WE have heard a good deal about proposals for "subscription-TV" from the U.S.A. but not until October did the Federal Communications Commission lay down rules under which applications for operating such a service would be considered. Trial installations are to be limited to cities which already have four "grade A" television services.

Although these rules do not cover closed-circuit systems—the F.C.C. has no jurisdiction over wire transmission—it is of considerable interest to learn from Rediffusion, Ltd., that they have signed a 21-year agreement with the Skiatron International Corp., for the "survey, installation, supervision and maintenance of closed-circuit television systems in the Western Hemisphere."

At the recent luncheon of the Relay Services Association of Great Britain, Mr. Ness Edwards, a former P.M.G., said, "I hope that subscription television is going to be developed by this association." This, however, would need a major change in the P.M.G's licence under which relay companies operate.

Student Exchange

SINCE its formation in 1948 the International Association for the Exchange of Students for Technical Experience has arranged for nearly 5,000 students from 36 British universities and colleges to gain experience in industry abroad during their summer vacations. The annual report of the Association records that 34,602 students from 23 countries have participated in the scheme during the past 10 years.

By far the largest number of students among the 5,934 "exchanged" during 1957 came from Germany (1,219). The next highest being Austria (763) with Great Britain third (731). Of the 21 countries receiving students Germany accepted most (1,195) with Sweden second (1,160) and Great Britain third (784).

In the summaries of industrial and academic "spheres of influence" no mention is made of electronics, but it is obvious from the names appearing in the lists of participating companies and organizations, both in this country and abroad, that many of the students were in this field. The number of industrial and other organizations which received students in 1957 totalled 2,761 compared with 413 in 1948.

The secretary for the U.K. is J. Newby, Imperial College, Prince Consort Road, London, S.W.7.

Whilst on the subject of student exchange mention should be made of the Imperial College Vacation Work Scheme. A booklet "Vacation Training" has been issued by the College giving details of the scheme and a list of companies offering to accept students for vacation work.

Television trade tests to assist the industry and dealers are now radiated by the B.B.C. each weekday from 10 a.m. to 1 p.m.. Also all stations now use full power for these tests. Should it be necessary to operate a station on reduced power during the tests the words "reduced power" will be shown on Test Card C or a horizontal bar pattern accompanied by a 250-c/s tone will be transmitted for one minute in every five.

Popularizing V.H.F. Broadcasting.—The next in the series of demonstrations being conducted jointly by the B.B.C., B.R.E.M.A. and R.T.R.A. to foster v.h.f. broadcasting will be in East Anglia. Staged in the Samson & Hercules Hall, Norwich, on January 15th and 16th, it will include in addition to demonstrations an exhibition of v.h.f. receivers.

Wenvoe is to radiate the Third Programme and Network Three on v.h.f. in addition to its existing transmissions of the Light Programme and Welsh and West of England Home Services. The fourth service, which will be radiated on 96.8 Mc/s with a e.r.p. of 120 kW, is hoped to be introduced before the end of 1958. The temporary low-power v.h.f. transmitter at Bristol, which has carried the Third Programme since October, will then close down.

V.H.F. in Scotland.—With the opening of the v.h.f. station at Kirk o'Shotts on November 30th the B.B.C. f.m. service is extended to over 80 per cent of the population of Scotland. Kirk o'Shotts radiates on 89.9, 92.1 and 94.3 Mc/s, with an e.r.p. of 120 kW. The first Scottish v.h.f. station is at Meldrum, Aberdeen. A third station, at Rosemarkie, near Inverness, is planned to be opened in the spring.

B.B.C. Television.—Two new permanent television transmitters have been brought into service by the B.B.C. during December—Douglas, Isle of Man, and Sandale, Cumberland. Both replace temporary low-power transmitters. Douglas operates in Channel 5 with vertical polarization (e.r.p. 2.8kW), and Sandale in Channel 4 with horizontal polarization (e.r.p. 16kW).

Receiving Licences.—During October the number of combined television and sound receiving licences increased by 125,886, bringing the total to 7,524,071. Sound-only licences (including 326,161 for car radio) totalled 7,153,541, making an overall total of 14,677,612 at the end of October. The figures for October, 1956, were, television and sound 6,291,072, sound only 8,128,669 (including 310,301 for car radio), making a total of 14,419,741.

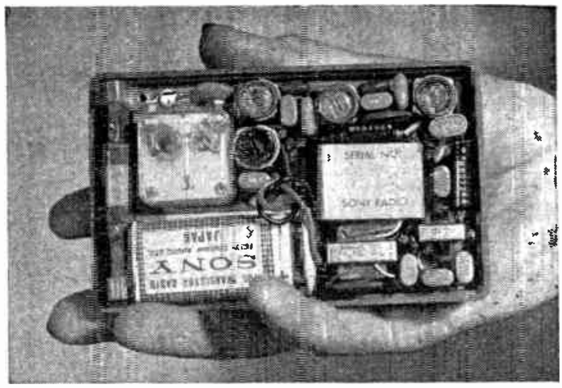
R.S.G.B. Membership.—Last year for the first time since 1948 the membership of the Radio Society of Great Britain increased. The number of members at June 30th was 8,495 compared with 8,102 the previous year. Nearly two-thirds of the members (5,490) hold transmitting licences.

Patents Digest.—A weekly summary of patents in the fields of electrical, electronic and nuclear power engineering is now published by Hunter Digests, Ltd., of 41, Whitehall (T.L.O.), London, S.W.1. "British Electrical Patents Digest," as it is called, costs 10 guineas for six months.

C.I.R.M.—The London office of the International Maritime Radio Committee, of which Col. J. D. Parker is secretary-general, has been transferred from Ludgate House, Fleet Street, to Shipping Federation House, Minories, E.C.3. (Tel.: Royal 1419.)

"**Nearest Approach Calculator**" (October issue, p. 175).—We have been asked to point out that this device is the subject of Patent Application 27407/56 by R. V. Brass and T. P. McLelland, who were mainly responsible for the development work.

"**Sensitive D.C. Null Detector.**" (December issue, p. 597).—The full-scale deflection of this instrument, as stated in the text, is 50 milli-microamperes and not 50μA as shown in the sub-title.



Transistorized personal portable, *SONY TR63. which is made in Japan, is now being sold on the Continent. It measures 4½ x 2¾ x 1¼in, weighs 10½oz and costs about £17 (in Germany 198 DM). It covers the medium-wave band using a ferrite rod aerial and selectivity is claimed to be —15 dB at 10 kc/s off resonance.*

"**E.B.U. Review**" is the new title under which the *Bulletin* of the European Broadcasting Union is being issued from January. It will be published from the Technical Centre, 4 rue de la Vallée, Brussels, in two parts (a) technical and (b) general and legal, the parts being issued in alternate months. The annual subscription for part (a) is 150 Belgian francs or 300 Belgian francs for both parts.

The "sunspot number," which is a measure of the number and size of disturbed areas on the sun, for October was the highest since records have been kept (about two centuries). The figure was 263. September also produced a high figure, 244. The Royal Society states that the previous highest record was 239 in May, 1778. September also provided a record in terrestrial magnetic activity; there were six great magnetic storms.

International Standardization.—Plans for the first plenary session of the International Organization for Standardization to be held in this country are in the hands of the British Standards Institution. The headquarters of the two weeks' conference (opening on June 9th) will be at the Royal Hotel, Harrogate.

Analogue computation methods (differential analyzers, rheo-electrical analogies, network analyzers, simulators, special calculators, etc., and their applications to science and industry) will be covered at the second International Analogy Computation meeting which is being organized by the Association Internationale pour le Calcul Analogique. Originally planned for June it will now be held from September 1st to 9th in Strasbourg, France. Further information is obtainable from F. H. Raymond, 138, Boulevard de Verdun, Courbevoie (Seine), France. The representative of the Association in this country is Professor S. C. Redshaw, Department of Civil Engineering, the University, Edgbaston, Birmingham, 15.

A Data Processing Section was recently formed by the Society of Instrument Technology (20 Queen Anne Street, London, W.1) and a series of meetings is being held in London. The next meeting is on January 28th when M. P. Atkinson, of the National Physical Laboratory, will speak on digital codes and coding. The secretary of the Section is W. T. Bane, 137 Kenilworth Court, London, S.W.15.

Information Engineering.—A graduate course in information engineering will again be held at the University of Birmingham in the 1958-59 session.

Applicants wishing to be considered for a D.S.I.R. grant, covering the fee of £81 and a maintenance allowance, should apply to the electrical engineering department of the University before February 3rd. Copies of the syllabus of the course are obtainable from the Supervisor of Graduate Courses, the Electrical Engineering Dept., The University, Birmingham, 15.

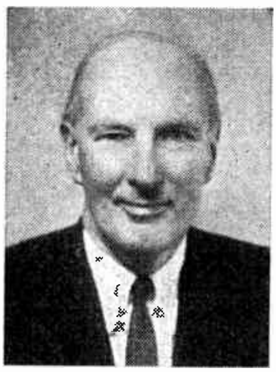
Servicing and maintenance of sound and television receiving equipment is covered by the course opening at the Wesley Road Evening Institute, Stonebridge, London, N.W.10, on January 6th. The fee for the course, which will be held on Mondays and Wednesdays until July 2nd, is 25s.

Communication Networks.—A course of lectures on modern electric network theory and design will be given by Dr. W. Saraga on six consecutive Wednesday evenings from January 22nd at the South East London Technical College, Lewisham Way, London, S.E.4 (fee 10s).

Southall Technical College introduces three new series of evening lectures in January. They are, "Sound Recording and Reproduction" (12 lectures), "Colour Television" (9 lectures), and "Design and Usage of C.R. Tubes" (12 lectures). The fee for each course is £1. The first course begins on 13th and the other two on 15th.

Personalities

B. St. J. Sadler, managing director of Redifon, Ltd., has retired after 13 years with the company. He was commercial manager of Marconi's Wireless Telegraph Co. before he joined Redifon. He is succeeded by **F. Youle**, B.Sc., A.C.G.I., A.M.I.E.E., who joined the company as sales manager in 1942 and became a director four years later. Since last July he has been general manager responsible for the factories and laboratories at Wandsworth and Crawley. Following his training in electrical engineering at the City & Guilds of London Institute, his industrial career began in 1921 with Marconi's where he spent some time in the development laboratories. He later became television sales manager of Marconiphone. From 1940 to 1942 he was in the Ministry of Aircraft Production.



F. YOULE

H. C. PRITCHARD

W. H. Apthorpe has retired from the managing directorship of Cambridge Instrument Company with which he started his career in 1900. After a few years he left to continue his technical education and returned in 1914 to take charge of the company's testing department. He is continuing with the company as deputy chairman. His successor is **H. C. Pritchard**, B.A., who, after graduating at Oxford, joined the Air Ministry and in 1939 was appointed head of the Navy section of the Royal Aircraft Establishment. After the war he became head of the Blind Landing Experimental Establishment at Martlesham and in 1949 was seconded to the Australian Government as chief superintendent of the Woomera rocket range where he stayed for three years. He subsequently left Government service and has been for the past four years with Elliott Brothers, latterly as group manager at Rochester. He is a Fellow of the Royal Aeronautical Society.

Sir Robert Watson-Watt has been awarded the Elliott Cresson medal of the Franklin Institute of America "for his contribution to the conception of pulsed radar and his leadership in its development." Sir Robert, now living in Canada where he runs the consultancy organization Adalia, Ltd., has recently completed his autobiography which is inevitably a virtual history of radar. It is entitled "Three Steps to Victory" and is being published by Odhams in February. Sir Robert is soon revisiting this country and will be addressing the Radar Association on February 12th on "The Early Days of Radar."

Dr. J. C. West has been appointed to succeed **Prof. P. L. Burns**, who is retiring from the chair of electrical engineering in Queen's University, Belfast. Dr. West graduated at Manchester University in 1943 and after service in the Royal Navy returned in 1946 to join the staff of the University's department of electrical engineering and was appointed senior lecturer in 1953. His early researches were in the field of electron optics but he has subsequently specialized in non-linear servo-mechanisms, and as a result of this work he has received the degrees of Ph.D. (1952) and D.Sc. (1957). Prof. Burns has been at Belfast since 1924, having entered the teaching profession at Hull in 1918. During the first world war he was at Manchester University where he was associated with Lord Rutherford on submarine detection.

Dr. T. G. Pickavance, at present deputy head of the general physics division of the Atomic Energy Research Establishment at Harwell, has been appointed by the National Institute for Research in Nuclear Science as director of its Rutherford High Energy Laboratory (Harwell). Dr. Pickavance, who is 42, is at present officer in charge of the group responsible for the design and supervision of the construction of the new large accelerator for the Institute. He has been at Harwell since 1946 and in his present position since 1955.

Major C. Collaro, O.B.E., who, as announced last month, resigned his position as chairman and managing director of Collaro, Ltd., has joined Camp Bird Industries, Ltd., as chairman. He succeeds **John Dalgleish,** who will continue as chairman and managing director of Camp Bird, Ltd., the parent company. Camp Bird Industries controls the electrical, electronics and communications group of the parent company. This group includes Ambassador, Hartley Baird and E-V (Sapphire Bearings).

C. E. Payne, B.Sc.(Eng.), M.I.E.E., chief engineer and a director of Ferguson Radio Corporation Ltd., has been co-opted to the governing body of Enfield Technical College. He has been closely associated with the college for some time on the educational and training schemes operated by the parent company Thorn Electrical Industries.

Clive Barwell, general publicity manager of Mullard, has completed 25 years service with the company. He was at one time production manager of one of the company's valve factories, but has been mainly concerned with publicity and public relations.

G. R. Scott-Farnie, M.Brit.I.R.E., has been appointed managing director of International Aeradio, Ltd., in succession to Air Commodore C. S. Cadell, C.B.E., M.A., M.Brit.I.R.E., who has resigned to join *The Times*. Both of them were members of I.A.L. on its formation in 1947. Mr. Scott-Farnie, who for the major part of the war was on special signals duties in the R.A.F. and from 1944 to 1945 was signals intelligence officer on General Eisenhower's staff, joined the company as operations manager. He operates amateur station G5FI.

G. R. SCOTT-FARNIE

R. E. ROBINSON

Three assistant managing directors have been appointed by the G.E.C. They are **T. W. Heather,** M.C., Comp.I.E.E., who will be responsible for the general products group, **A. L. G. Lindley,** the engineering group, and **R. E. Robinson,** M.I.E.E., the telecommunications group. The company has also appointed two new directors, **D. G. W. Acworth,** M.A., M.I.E.E., and **W. J. Bird.** Mr. Heather, who has been with the company 44 years, was elected to the board in 1938 and is also on the board of a number of other companies, including M.O. Valve Co. and Salford Electrical Instruments. Since 1944 he has been chairman of the G.E.C. education and training committee. Mr. Lindley, a mechanical engineer, joined G.E.C. as an apprentice in 1918. Mr. Robinson has concentrated on telecommunications throughout his industrial career which began in 1903 when he joined the Western Electric Company in London. In 1905 he went to the Bell Telephone Company in Antwerp and in 1908 became chief engineer of the Peel-Conner Telephone Works, then a G.E.C. subsidiary. Mr. Robinson, who was appointed director in charge of telephone and radio works in 1945, is a past chairman of the Tele-communication Engineering and Manufacturing Association.

John Dyer has resigned from the position of public relations officer for E.M.I. Electronics, Ltd., to which he was appointed in 1954, and has joined the staff of the British Electrical & Allied Manufacturers' Association as technical editor of *BEAMA Journal*. He was with the Philco organization for some time before the war and again from 1950-54. Mr. Dyer was at one time editor of *Wireless & Electrical Trader*.

Sergeant Edward J. Gane has been seconded by the R.A.F. to be senior wireless operator at the Royal Society Antarctic base at Halley Bay for 1958. He has sailed in M.V. *Tottan* which, after visiting the Norwegian base and Halley Bay, will be bringing home some members of the advanced party. Among them will be chief technician **Ronald Evans,** R.A.F., who has been senior wireless operator during the past year.

B. V. Baliga, chief engineer of All India Radio, is the new president of the Indian Institution of Telecommunication Engineers. He has been vice-president of the Institution since its formation in 1953.

Dr. James R. Killian, president of the Massachusetts Institute of Technology since 1948, has been appointed by President Eisenhower to the new post of Special Assistant to the President for Science and Technology. Dr. Killian, who is 53, has been closely associated with government research in the U.S. and was a member of President Truman's communications policy board.

Dr. A. W. Hull, consultant to the General Electric Research Laboratory, Schenectady, U.S.A., is to receive the Medal of Honour, the premier technical award of the American Institute of Radio Engineers. Dr. Hull, who is credited with creating a greater number of new types of valve than any other man, receives the award "for outstanding scientific achievement and pioneering inventions and development in the field of electron tubes."

OUR AUTHORS

J. C. Beckley, B.Sc.(Eng.), author of the article on the design of car radio receivers, graduated at London University in 1954 and since then has been on the staff of the Applications Research Laboratory of the Mullard Radio Valve Company. His work there is concerned with the design and development of valves and circuit techniques at radio frequencies.

T. G. Clarke, A.M.Brit.I.R.E., contributor of the article on the cathode-coupled flip-flop, is senior development engineer with Decca Radar where he has been responsible for the electronic design of several types of marine and windfinding radar. He is at present engaged on investigations into the use of storage tube systems in radar. During his military service he was a warrant officer in the R.E.M.E. and served as an instructor at various training establishments both in the United Kingdom and overseas.

Dr. D. H. Martin, the first part of whose article on magnetism in materials appears in this issue, is a lecturer in physics at Queen Mary College, University of London, where he is engaged in research into superconductivity and spectroscopy in the very far infra-red. He graduated with first-class honours in physics at the University of Nottingham in 1950 where for four years he undertook post-graduate research into the domain structure of ferromagnetic metals, concentrating on domain nuclear processes.

P. R. Stutz, B.Sc.(Eng.), A.C.G.I., Grad.I.E.E., author of the article on turret tuners for Band V, has been with Kolster-Brandes, Ltd, for the past nine years. He is a senior engineer in charge of a section engaged on television research and development, and represents the firm on the U.H.F. Working Party of the British Radio Equipment Manufacturers' Association. He graduated at the Imperial College of Science and Technology with an honours degree in electrical engineering in 1948.

OBITUARY

A. Cecil Barker died on December 10th, aged 58, at his home. The Close, Hurst Wickham, Hassocks, Sussex. He was trained as a singer and broadcast in the 1930s, and his interest in sound reproduction took the practical form of designing the "Duode" loudspeaker. This was patented in 1936 and manufactured during the pre-war period by Magnavox (Benjamin Electric). During the war Mr. Barker served in the Admiralty (A.S.R.E.) and in 1947 started the business of Duode, Ltd.

Frank S. Allen, works director of E. K. Cole, Ltd., and a director of Egen Electric and Ekco Electronics, died on November 20th aged 56. He joined the Ekco organization in 1941 as assistant works manager and four years later became general works manager of the radio division.

TELEPHONE AUTOMATION

The magnetic drum director at the Lee Green exchange showing the actual drum in the right-hand cabinet.

AN electronic switching system taking the place of trunk-call telephone operators is to be installed by the Post Office at Bristol as part of their national scheme for "automatization" of the telephone service. Known as GRACE (from Group Routing And Charging Equipment), it will enable subscribers to dial trunk calls just as they do local calls on the automatic system. The equipment, which is based on cold-cathode tubes, has been designed and developed in co-operation with the General Electric Company. It will register a dialled number, select a route to the distant exchange, ring the wanted number, and, when the distant subscriber answers, record the appropriate charge on the caller's local exchange meter. The word "Group," incidentally, derives from the new system of grouping exchanges which comes into force on 1st January.

To make an automatic trunk call the caller dials the national number of the distant subscriber. The first digit of all national numbers is "0," and receipt of this causes the call to be connected to a "call charger" equipment. The remaining digits of the number are received and stored in a register. Of these, the first 1, 2 or 3 digits identify the distant "Group." A "translator" equipment then inspects these digits and deduces from them the route and charge rate for the call. The translator incorporates a permanent store giving details of the routes and charge rates for calls from the originating exchange to all other "Groups" in the country.

The information passed back from the translator to the register is in the form of a charging rate digit and several routing digits. To avoid having to provide storage capacity for all these digits at once, they are passed to the register one at a time as required. The register uses a digit supplied by the translator to further the setting up of the call and then makes a fresh demand for another digit. The time taken by a register to use a digit is far greater than that required by the translator to supply it. The translator is therefore freed between demands for use by any other register, and it may serve up to 40 registers altogether.

The first digit returned to the register from the translator is used to select the appropriate charging rate in the call charger. Subsequent digits are used by the register to operate switches in the originating and distant exchanges to complete the connection. When the connection has been completed the register is released and made available for use with other call chargers in setting up further calls. The call charger remains connected throughout the call and, when the distant subscriber answers, levies the charge by operating the caller's exchange meter periodically, at intervals depending on the distance between the two "Groups" concerned.

Another equipment, developed by the Automatic Telephone and Electric Company and somewhat similar in function, was put into operation recently at the Lee Green (London) automatic exchange. This, however, is not dealing with trunk calls but replaces some of the electromechanical equipment in the automatic system. Moreover, it is based on a magnetic drum storage system, which provides the registers for the dialled numbers on some of its tracks and the information for translation into routing directions on a "library" of other tracks.

The associated electronic equipment here makes use of thermionic valves. One important part of it is a "scanner," driven by synchronizing tracks on the magnetic drum. This scans the subscribers' lines and, where dialling pulses are present, causes the dialled numbers to be put in the appropriate register on the drum. This scanning provides a means of keeping a running record of the state of each of the subscribers' lines, and the record is kept up to date merely by putting the most recent state in place of the old one. In this way the electronic equipment and the drum can be time-shared over any 114 subscribers' lines in as little as 17 milliseconds each. Moreover each of the 114 lines can be rescanned every 17 milliseconds, so that changes of state of up to 60 changes per second are recognized. This permits considerable economies in apparatus and is one of the reasons for developing the trial equipment.

MSF TRANSMISSIONS

A NEW edition of the pamphlet* describing the U.K. standard frequency service has been issued by the National Physical Laboratory. These transmissions are radiated almost continuously from the Post Office station MSF at Rugby on behalf of the N.P.L. Both the carriers (2.5, 5, and 10 Mc/s) and the modulation frequencies are maintained to $\pm$ 5 parts in 10^9. The MSF frequencies are now based on the resonant frequency of the caesium atom (9, 192, 631, 830 c/s).

The transmitted power on each of the carriers is 0.5 kW. A bottom-fed mast radiator is used for the lower frequency and quadrant dipoles for the other two.

The accuracy obtainable from MSF is, however, limited by propagation conditions which can cause changes in the received frequency amounting to $\pm$ 2 parts in 10^7. An additional transmission is therefore radiated daily for one hour (1429 to 1530) on 60 kc/s with a power of 10 kW.

The results of daily measurements made by the N.P.L. at Teddington on the MSF transmissions are given in our sister journal *Electronic & Radio Engineer* each month.

* "MSF-Standard Frequency Transmissions from the United Kingdom."

Reception on Band V

An Introduction to Circuit Techniques for the Ultra High Frequencies

THE announcement in last month's *Wireless World* that the B.B.C. has started transmitting on an experimental basis sound and vision signals in Band V must give rise to speculation on the kind of problems likely to be encountered in designing receivers for 650Mc/s.

The Band-V receiving problems are certain to be a little more difficult to solve than those encountered when Band III was first opened to television, but they are not likely to be exceptionally troublesome. Band V has been in use for television in the U.S.A. for a few years now and we are in the fortunate position of being able to study the circuit techniques adopted on that side of the Atlantic.

Some new valves had to be developed and while British prototypes have been made in this country it may be some time before they become generally available. However, the Band-V transmissions are only experimental, and who can say when a regular service will be inaugurated? Suitable valves are bound to be available to all when the time arrives.

R.F. amplification on 650Mc/s is not ruled out by any means, but if the current practice in the U.S.A. can be taken as a guide the r.f. amplifier is a luxury rather than a necessity on this band. Where it is used it takes the form of an earthed-grid amplifier usually with line-type circuits and one such arrangement is shown in Fig. 1. It would be justifiable to draw the inductors L_1, L_2, L_3, L_4 and L_5 in the familiar helical form, but it is desired at this stage to emphasize one of the main differences that will often be encountered in tuned circuits on u.h.f. On these frequencies coils, as we know them, are in most cases replaced by straight pieces of thick wire, by a hairpin, or even a strip of metal, while

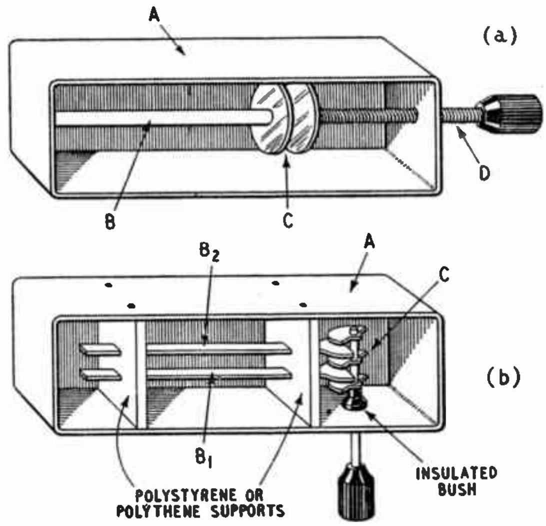


Fig. 2. Coaxial line (a) and balanced line (b) tuning elements for use on u.h.f.

an alternative would be sections of coaxial or twin wire transmission line as shown in Fig. 1(a) and (b) respectively. These lines are tuned by small capacitors, C in Fig. 2 and C_1, C_3 and C_6 in Fig. 1. In the case of Fig. 2(b) the open ends of the two metal strips can be joined together to form a hairpin, with the capacitor in its centre, or joined to the grid and anode of a valve.

Fig. 1(a) is sometimes called a trough-line circuit. The case A is usually "earthed" to the chassis but true earths are difficult to locate in u.h.f. equipments. The way out is to avoid as far as possible including any parts of containers or chassis in the tuned circuits. For this reason Fig. 1(b) is to be preferred for u.h.f. oscillators as the container is merely a screen.

The rod D in Fig. 2(a) is screw threaded and serves for adjusting the capacitor C. These troughs or boxes are invariably closed by a lid or cover-plate. The best material for these circuit elements, where the highest attainable Q is required, is silver, but as this is impracticable

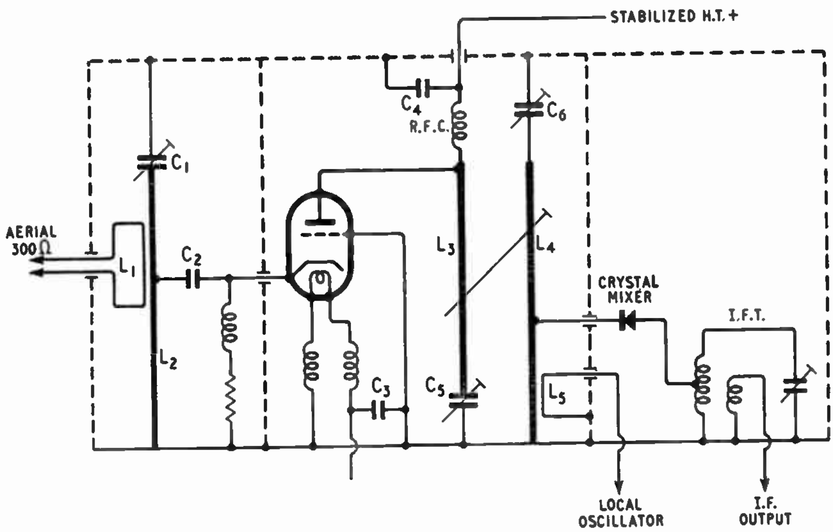


Fig. 1. Basic circuit of a u.h.f. earthed-grid r.f. amplifier.

silver-plated copper, or silver-plated brass is generally employed. Plain copper is the next best.

Fig. 1 has some shortcomings as a practical arrangement as it may need neutralizing. However, this does not invalidate it as an example of the basic principles involved. The component marked "crystal mixer" will be dealt with later.

A special type of valve is required for the r.f. stage in Fig. 1. R.F. pentodes are unsuitable at u.h.f. (at least existing types are) and triodes are invariably used at the higher frequencies. The Band-III cascode r.f. amplifier is a case in point. Cascode stages do not seem to be satisfactory at Band-V frequencies and the only alternative seems to be the earthed-grid triode. Ordinary triodes are not suitable, the requirements being very small spacing of electrodes to reduce transit time, unusual rigid construction to give frequency stability and multiple connections to some electrodes, but particularly the "earthed" electrode, as it is essential to eliminate as far as possible impedance common to two or more circuits.

Special valves have been available for some time

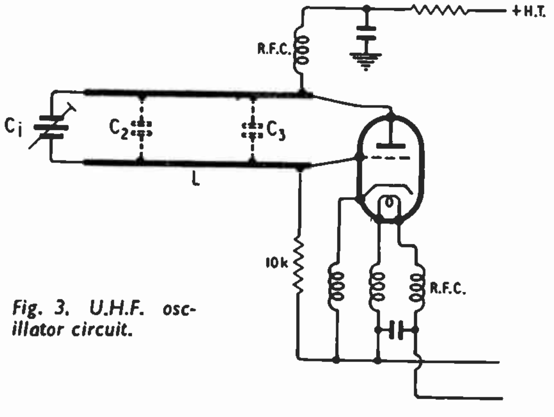


Fig. 3. U.H.F. oscillator circuit.

for use as earthed-grid amplifiers, but the form of construction has been too costly for use in domestic equipments. A cheaper form of assembly has recently been evolved and is typified by the G.E.C. A2521 which was described in "Technical Notebook" in the January, 1957, *Wireless World.* There are other makes in existence but the supply position is at the moment a little vague.

When an r.f. stage is not used the signals received on the aerial are fed *via* an r.f. pre-selector, consisting of a pair of coupled tuned circuits, to a crystal mixer. A crystal is generally used, one might say invariably, in u.h.f. "front ends," since crystals are more efficient for this function than a valve, unless it be a special type, and in general the noise level is lower. The crystal used in this position is a point-contact silicon type similar to those developed for radar receivers and exemplified by the B.T.H. CS2A and similar models, or the American 1N82. There are probably other types that would be equally suitable, but it is essential (and this cannot be overemphasized) that a low-noise type be employed.

The u.h.f. oscillator is possibly one of the most difficult problems in the design of Band-V equipment. Assuming the output from the Band-V mixer is to be fed into a standard television i.f. amplifier, with the sound on about 38Mc/s and the vision on about 34Mc/s, then the local u.h.f. oscillator must be about 36Mc/s higher in frequency than the signal; say between 686 and 690Mc/s. It will be realized that a very special valve is required for generating oscillations on this high frequency. However, the ability to oscillate in the region of 700Mc/s is only part of the problem involved; of equal or possibly more importance is the frequency stability of the oscillator.

Many factors are involved in the frequency stability of a u.h.f. oscillator. There are the inter-electrode capacitances of the valve and the effect of temperature on their capacitance values, also the capacitance of the valveholder and the effect of temperature on the inductor rod or rods. The variable tuning capacitor also has a temperature coefficient. Most of these will be positive, a rise in temperature bringing about a decrease in frequency since their individual values, whether of inductance or capacitance, increase. The customary way of compensating for this is to include one or more capacitors in the circuit having a negative coefficient of temperature and to connect it, or them, in the position which as near as possible gives an overall zero coefficient of temperature. Another factor influencing frequency stability is the steadiness of the h.t. voltage, any fluctuation being reflected in the stability of the oscillator. Thus a stabilized, or closely-stabilized, h.t. supply for the oscillator is essential.

A typical u.h.f. oscillator circuit is shown in Fig. 3. This circuit is based on the use of an all-glass type valve such as the EC93 with a B7G-arrangement of base pins. This is a special u.h.f. triode and should be generally available in the near future. The valve is also made on the Continent and there are some equivalents with different type numbers in America. In Fig. 3, L is a parallel-line tuning inductor of the kind shown in Fig. 2(b), the open ends being connected direct to the valve-holder pins, or if this is thought to be a little too drastic, by very short lengths of flexible copper braid. Direct connection is quite feasible but it demands careful assembly. C_1 is the tuning capacitor and since it is a split-stator type each half will need twice the capacitance of the single capacitor C in Fig. 1(a) to give the same capacitance coverage. The capacitance change of the disc-type capacitors is very small indeed until the two plates get very close. There are some very tiny commercial variable capacitors in existence which would be ideal for this purpose but they are difficult to acquire outside manufacturers' channels of supply.

Capacitors C_2 and C_3 are alternative positions for a negative-temperature coefficient capacitor for frequency stability control. Sometimes one at either end of the line is desirable and sometimes one only connected somewhere across the line will suffice. It is a matter for experiment. Bi-metal strip has been used as a compensating capacitor with one end soldered to one rod and the other end close to, but not touching, the adjacent rod.

Whilst it is not the purpose of this article to explain how to find one's way around the u.h.f. bands, it must be fairly obvious that a yard-stick of frequency is essential. Those who contemplate experimenting on Band V would be well advised to lose no time in providing themselves with a wave-meter covering say 500 to 1,000Mc/s. It is extremely tedious trying to find the frequency of an unknown oscillator, especially at u.h.f., if one has to rely on heterodyning by a much lower-frequency oscillator.

A serviceable absorption wavemeter is not a complicated or costly piece of equipment. In its simplest form it consists of a small, say 10+10-pF, split-stator capacitor with a short length of heavy-gauge wire or copper strip looped across the fixed sets of vanes. An indicator of resonance is required, the simplest arrangement is to use one of two oscillators as the "indicator" and listen to the beat note in telephones in one of them. When the absorption wavemeter is loosely coupled to one of the u.h.f. oscillators and tuned through resonance a sudden change in beat-note takes place. So much for the indicator, there are better types, but this will suffice in many cases.

Calibration of an absorption wavemeter is easily effected by rigging up two parallel wires terminated at one end in a single-turn loop loosely coupled to the rods B_1 and B_2 (Fig. 3). These wires (Lecher lines they are called) should be about 4ft long and rigidly spaced about 1in apart. Standing waves will appear on this line with current (and voltage) maxima and minima spaced at equal intervals along the line. Two adjacent maxima (current or voltage) will be exactly a half-wavelength apart, so that it needs only some kind of sensitive r.f. indicator run along the line and points of maximum reading marked on a paper strip below the lines. While any two adjacent maxima will suffice, we have always found it best to include three or four, ignoring the one nearest the pick-up coil at the end of the line. At 650Mc/s the two maxima will be 23cm apart and by taking half-a-dozen measurements a very serviceable calibration of the oscillator will be available for calibrating an absorption wavemeter. How to make the absorption wavemeter is another story, but it is by no means an involved one.

All the items needed for a simple Band-V front end have been briefly discussed and it is now

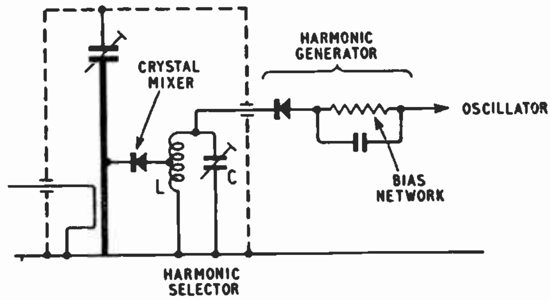


Fig. 5. Harmonic generator for a u.h.f. frequency changer.

possible to combine them into a serviceable unit. A simple type is perhaps one in which there is no r.f. stage and with the mixer output fed direct to the i.f. amplifier stage in a television receiver. It is not necessarily an ideal arrangement but it serves to illustrate the make up of a Band-V front end. The circuit is shown in Fig. 4. The signal picked up by the aerial is injected *via* the loop L_1 into the line indicator L_2 which is tuned by C_1. The line inductors L_2 and L_4, in conjunction with their respective tuning capacitors C_1 and C_4, form a band-pass, pre-selector filter coupled by the loops L_3 and L_5. The capacitors C_2 and C_3 are for padding each pre-selector circuit and in practice consist of small strips of copper soldered to the inductors and brought close to one side of the screening compartment.

Local oscillations from a u.h.f. oscillator are injected into the pre-selector circuit C_4, L_4 *via* the crystal mixer and loop L_6 in the oscillator compartment. C_5 is one way of showing a lead-through capacitor, this incidentally is of small capacitance since it is in parallel with part of the i.f. coil L_9. This coil is tuned by C_{11} and damped by R_3 to give the required i.f. bandwidth. L_{10} is a coupling coil feeding the i.f., at low impedance, to the main i.f. amplifier. The unfamiliar symbol C_{10} is a stand-off capacitor. It is essential that all u.h.f. bypass capacitors should be of this or lead-through types as even a ½-in length of wire at these frequencies has appreciable impedance.

The reason it was stated that Fig. 4 is not an ideal arrangement is that with the front-end comprising only an r.f. filter and crystal mixer the i.f. output will usually be very small indeed and the first i.f. amplifying stage should have exceedingly low-noise characteristics. In most receivers this stage is fitted with an r.f. pentode which is not the best type in the circumstances, so that the Fig. 4 front-end circuit ought to be followed by a cascode, or equivalent low-noise amplifier.

As the B.B.C.'s experimental television transmissions in Band V conform initially to the British 405-line standard, reception can be effected by adding a simple front-end, like Fig. 4, and switching the Band-III cascode r.f. am-

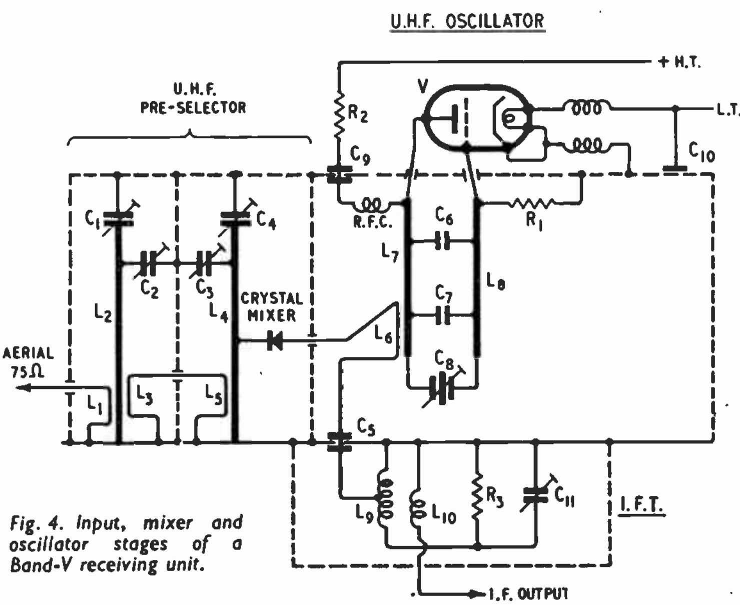


Fig. 4. Input, mixer and oscillator stages of a Band-V receiving unit.

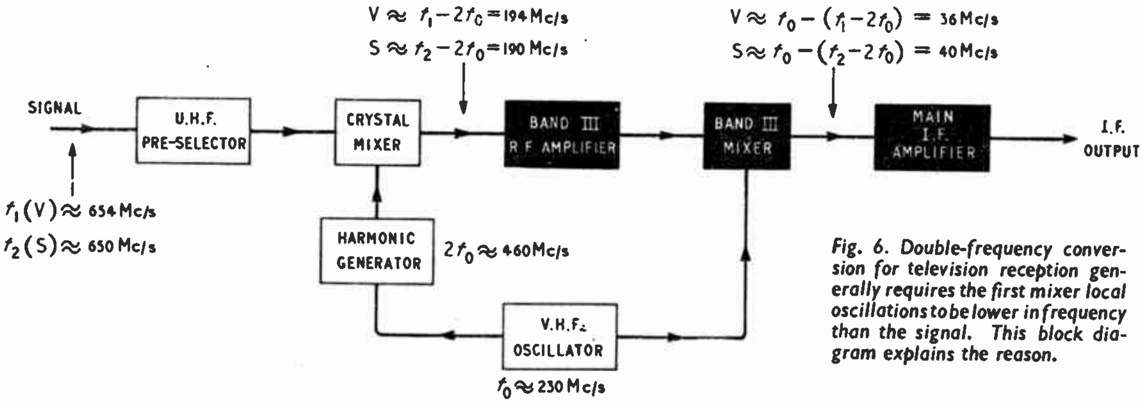


Fig. 6. Double-frequency conversion for television reception generally requires the first mixer local oscillations to be lower in frequency than the signal. This block diagram explains the reason.

plifier for use as a 34-38Mc/s i.f. stage. The Band-III oscillator can be switched off. With a turret tuner this is quite easily arranged.

Another scheme is to employ double frequency conversion and obtain the local oscillations for the first frequency changer from an harmonic of the Band-III oscillator. There are objections to double conversion as although only one oscillator need be employed interference can be produced by it and its family of harmonics.

Unless the oscillator stage is exceedingly rich in harmonics, which in a well-designed set it should not be, a harmonic generator has to be employed. One of the simplest is a crystal with a resistance-capacitance network in series and this is used quite extensively in the U.S.A. The circuit is very simple and is shown in Fig. 5, the circuit L, C being tuned to the desired harmonic. The Band-III cascode r.f. stage continues to function as such, but it might have to be tuned to a frequency different from the usual and possibly outside Band III in order to avoid interference from harmonics and fundamental of the oscillator.

It should be remembered that any system involving two frequency conversions for receiving television necessitates the correct choice of oscillator frequency for the first mixer; in the cases under discussion the crystal mixer. In most superheterodyne receivers conversion to i.f. can be effected with the local oscillations either higher or lower in frequency than the signal, since when extracting the difference, or beat, frequency of the two it matters not which is the higher. However, when two signals, such as sound and vision, are involved the i.f.'s that emerge will be transposed when the local oscillator is shifted over to the alternative beat.

It has been recommended by B.R.E.M.A. that the sound and vision i.f.'s should be about 38Mc/s and 34.5Mc/s respectively which requires that the local oscillator be *higher* in frequency than the signal.

When double-frequency changing is employed the first conversion must be made with the local oscillator on the *low* frequency side of the signal. The reason for this is best explained by means of a block schematic diagram such as Fig. 6. The frequencies marked against each stage are not necessarily those which would be employed in a practical case since the likelihood of interference from oscillator harmonics has not been taken into consideration. The example given here is to illustrate the basic principles involved.

We are indebted to Kolster Brandes, Ltd., and to Mullard, Ltd., for information on some of the principles and problems likely to be encountered in reception on Band V.

VALVE LIFE

IF asked the question "how long do the valves last in your radio or television receiver" few listeners, or viewers, would venture an answer. It is also doubtful if many users of commercial radio equipment would commit themselves. Would 30,000hrs. be too long?

A trial system of multi-channel radio equipment was installed in 1949 between the Marconi works at Chelmsford and a site at Woolwich for the purpose of compiling data on the reliability of equipment, which means primarily the reliability of the valves employed. The system operated continuously for 24 hours each day.

The original valves were removed in 1953, a log having been kept of any replacements required in the interim period. Many of the valves employed are ordinary receiving types found in domestic sets and the data relevant to their performances are given in the table here. This data was originally published in the October, 1957, issue of the Marconi journal, *Point to Point Telecommunications.*

Valve Type	Total Number Used	Failures		Average Working Time of all Valves (hrs.)
		Total Number	Average Life (hrs.)	
EF91	138	3	28,000	31,900
EB91	4	—	—	32,600
EAC91	2	—	—	32,600
ECC91	6	4	9,250	19,560
ECC32	8	1	26,500	29,000
KT66	12	—	—	32,600
SU4G*	16	9	4,600	5,000
U52*	16	32	6,060	8,090

*Alternative types were used during the trial.

"F.M. Discriminator Bandwidth." We regret that a sentence, which should have referred to co-channel interference, beginning "Fortunately, this has been anticipated . . ." on line 17, right-hand column of p. 572, December 1957 issue, was transposed. It should have followed the words ". . . to the same programme," five lines before the bottom of the preceding column.

Television Aerials For Bands IV and V

ADVANTAGES OF THE CORNER REFLECTOR DESIGN FOR U.H.F.

BY

F. R. W. STRAFFORD*

M.I.E.E.

SINCE November last, and for several months to come, the B.B.C. is radiating still and motion video transmissions on a frequency of 654.25Mc/s in Band V with a view to assessing all the technical factors involved should it be decided, at some future date, to provide a regular service in this band or in Band IV. During the spring the definition will be increased from 405 lines to 625 lines. It is uncertain whether the improvement noticed on a closed circuit between transmitter and receiver will be maintained under conditions of space propagation and one of the objects of the tests is, presumably, to check this doubt.

In order that a television picture shall maintain the original quality delivered from the camera it is essential to retain, throughout the entire transmitting and receiving system, the correct amplitude and phase relation of each picture element in relation to the next. The manner in which this is achieved is within the control of the circuit designer, but he cannot control the vagaries of propagation. True, a line-of-sight experiment over an open space, free from any sources of reflection, will closely simulate closed-circuit conditions but would take no account of the practical conditions of terrain variations, built-up areas, and isolated structures involved in providing a public service.

In considering the radiation of electromagnetic energy from an aerial it is desirable to regard the aerial as a point source. The energy will spread out into space and flow through a hemispherical boundary of ever-increasing radius. At a radius of a few hundred wavelengths a small area of this hemispherical boundary can be regarded as being perfectly flat so that all the energy flowing through any selected small aperture in space is in equiphase and plane-wave propagation prevails. Departure from plane-wave conditions is caused by adverse effects which worsen as the frequency of the wave energy is increased. At low frequencies, say 100kc/s, the earth appears as a mirror-like surface. If the wave were endowed with human faculties it would be unable to recognize anything smaller than the high mountains. Trees, buildings and hills would be invisible and so, apart from a slight tilt imparted to the wavefront by virtue of energy absorption by the resistance of the earth, plane-wave propagation is preserved over considerable distances in daytime. At night-time the effect of reflections from the ionosphere vitiates the conditions.

As the frequency is increased the earth no longer retains its mirror-like properties and at, say, 1Mc/s hills and large structures are becoming visible in varying degrees. At frequencies of the order of 100Mc/s small structures and trees become visible until, at several hundred megacycles per second, the fine detail of structures and the foliage of trees are clearly outlined.

This "visibility," increasing as it does with frequency, is responsible for such effects as absorption, reflection and diffraction, and their combined effects tend to diffuse the wavefront of the energy and so disturb the equiphased front originally radiated from the transmitting aerial. Thus the relative phase and amplitude of the picture elements transmitted in the sidebands will be disturbed and loss of definition will result. Multi-path propagation produces displaced images (ghosts) and it is now well known that these tend to be worse on Band III than on Band I and may be expected to deteriorate further with a threefold increase in frequency.

At first thought it might seem that little can be done to correct for these effects but a directive receiving aerial will reject most of the multi-path reflections since it is known that the more serious reflections emanate from objects at the side and rear of the aerial.

The effects of departure from plane-wave conditions can be minimized by using as small an area as possible for the aerial consistent with providing useful gain. For example, a pair of half-wave dipoles spaced several wavelengths apart and fed in phase to the receiver might show loss of both gain and definition as compared with the same arrangement spaced at one half wavelength. As a somewhat crude analogy, if one wishes to view a distant object through a small gap in the foliage of a tree a wider spacing of the eyes could result in only one eye being able to see the object with consequent impairment of brightness and detail. Because an aerial will possess different characteristics when operating under diffused-wavefront conditions it is customary to refer to the plane-wave characteristics as being under the ideal conditions.

If a radiating oscillator is set up some fifty wavelengths from a receiving aerial on flat ground quite clear of buildings and obstructions the gain and directivity of any experimental aerial may be compared with that of a simple half-wave dipole. If the oscillator is replaced by a powerful transmitter beyond the horizon, and the tests are repeated in a built-up area, lower gain and a change in the directional characteristics of the experimental model invariably result. The change in gain is due to departure from plane-wave propagation, and the change in directivity to reflections from buildings and other reflecting objects.

This accounts for the fact that certain types of aerial do not appear to live up to their plane-wave performance in some fringe areas while others, with

*Radio and electronic consultant.

inferior plane-wave characteristics, are the better performers!

A further requirement of a suitable aerial is that it will maintain its gain and directivity, not only over the sideband frequency range, but throughout the whole band allocated to the service. Finally, there should be no serious mismatch of impedance between the aerial and its feeder. A reasonable standard would be a mismatch of not greater than two to one.

Before reviewing aerials in terms of satisfying the foregoing requirements for Bands IV and V an examination of the table will be helpful.

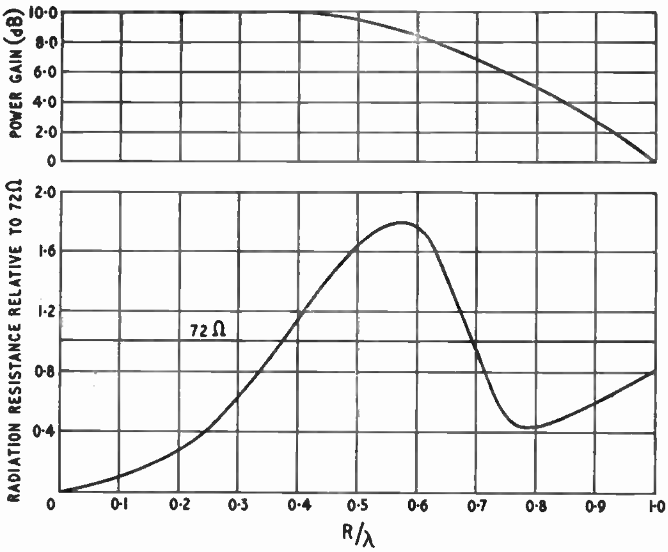
Band	Coverage (Mc/s)	Mid-frequency (Mc/s)	±% deviation
I	41—68	54.5	25
III	174—216	195	10
IV	470—585	527.5	11
V	610—960	785	22

The widest deviation occurs on Band I where experience has proved that H and Yagi type aerials employing parasitic elements must be optimized dimensionally for each channel.

On Band III it is just possible to maintain good characteristics over two neighbouring channels. With some compromise three channels may be covered, but, ideally, the Yagi type of aerial is really only suitable for a single channel if full use is to be made of its properties. Such an aerial, if optimized on a single channel, might reverse its directivity in some part of the band.

These arguments apply equally to Bands IV and V, but there is a further fact which tends to make the Yagi type of aerial unsuitable for these elevated frequencies, and that is the dependence on plane-wave conditions for obtaining useful gain and directivity. Since the present tests are radiated with horizontal polarization there is good reason to assume that any future service will be based thereon so that consideration of possible aerials will be based on this assumption.

As a general consideration u.h.f. aerials with a gain of less than 3dB and front-to-back ratio of less than 6dB should be discarded except for exceptionally favourable sites close to the transmitter. Aerials unsuitable for the above reason, together with their inability to function correctly under diffused-wave conditions, will include H and Yagi types, and the small loop. Rhombic and other long wire aerials, are omitted on account of their length relative to the plane-wave gain achieved, and the need for resistive termination at the remote end for one-way directivity. The slot aerial, plus a sheet or mesh reflector, might be considered if it were not for the fact that its terminal impedance—of the order of 300 ohms—did not need transforming to the 75-ohm coaxial feeder which has now become the general standard. The frequency selectivity introduced by the impedance transformer restricts its original broadband characteristics.



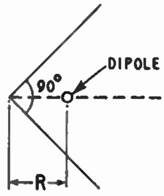


Fig. 1. Variation with spacing (R) of radiation resistance and gain for a corner reflector aerial.

The helical aerial[1] has excellent gain and directivity for its compactness but it is equally responsive to both vertical and horizontal polarization and a pair, oppositely wound, must be used to receive one plane of polarization only. Such an aerial would present packaging problems if mass-produced, but there is no real technical argument against its use as it has all the desirable characteristics including that of broadband.

This leaves the corner reflector aerial[2, 3] in which is located a half-wave dipole at a point R from the apex. (Fig. 1.) If the angle of the reflecting sheets is 90° the interesting characteristics of Fig. 1 are

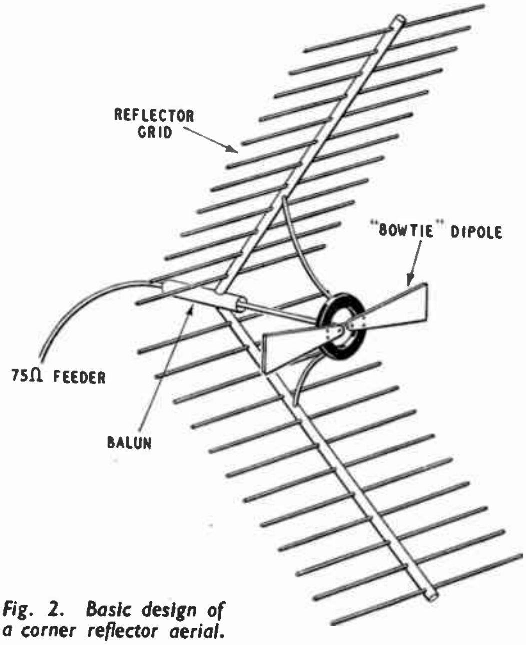


Fig. 2. Basic design of a corner reflector aerial.

obtained. These are for infinite sheets but it has been shown that sheets[3] one wavelength wide and two wavelengths long give results surprisingly close to the ideal. In fact, the dimensions may be reduced further without serious loss of performance. It will be observed that, up to $R=\lambda/2$, the radiation resistance rises from zero through 72 ohms up to 120 ohms. From $R=\lambda/4$ to $R=\lambda/2$ the mismatch to a 75-ohm feeder will not exceed 1·6 to 1, so that if the dipole is located at $R=3\lambda/8$ good matching will be maintained over a frequency deviation of plus or minus 33%. Also Fig. 1 shows that the gain will be closely maintained over this range of deviation from the design frequency. These characteristics are ideally suited to Bands IV and V because relatively compact and simple mechanical structures, without dependence on close-limit manufacturing tolerances, can be readily achieved. It is a pity that the corner reflector becomes rather unmanageable, on account of size, on Band III, and quite impossible, for both size and economy, on Band I, for it possesses all the desirable properties of a first-class general-purpose aerial.

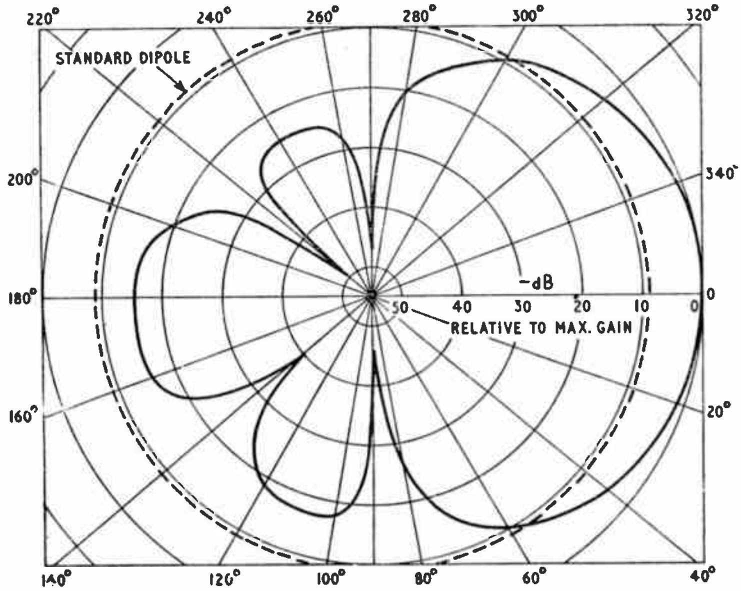


Fig. 3. Polar diagram of the corner reflector aerial.

The practical construction of the corner-reflector aerial permits of considerable latitude in the hands of the designer. The reflector may be of sheet, continuous, or perforated to reduce windage, or wire mesh may be used provided that the size of the mesh does not exceed about 0·1λ. According to Moullin[3] the screening or reflecting properties of a conductive mesh are at least 90% as good as a continuous sheet of the same material. Kraus[2] has shown that a row of rods may be used to make a corner reflector grid, and if these are spaced not much greater than 0·1λ a very convenient and attractive aerial results. Such an aerial was constructed about a design frequency of 654·25Mc/s as shown in the sketch of Fig. 2. The overall dimensions of each reflector grid are 10in wide by 18in long.

A "bow-tie" type of dipole is used as it has the required broadband characteristics. Fat cylinders could be used instead but they do not give a smooth impedance transfer at the feeder connections. Measured data of this type of aerial, taken under carefully controlled plane-wave conditions, gave the following results:—

1. Power gain relative to half-wave dipole, 8·7dB.
2. Half-power beam width, 64°.
3. Front-to-back ratio, 15dB.
4. Minima in excess of 40dB, at 90°, 140°, 220°, and 270°.
5. Mismatch ratio to 75-ohm feeder, 1·4.

These characteristics varied very slightly over a range of ±30Mc/s. It was not possible to extend the measurements over the whole of Band V, but the results indicate that the performance is most likely to be maintained, and this is a matter for further experiment. A simple quarter-wave balun was included in the design but its removal during the course of tests did not appear to have much effect. If much larger reflectors had been used, with a consequent increase in front-to-back ratio, the balun would probably prove an advantage, since it reduces the effects of pickup on the feeder which shows up as a reduction in the overall front-to-back ratio.

The directional response in the azimuthal (E) plane is shown in the polar plot of Fig. 3. Plotted in decibels it gives the *false impression* of poor directivity because of the size of the side and rear lobes. Had this diagram been plotted in voltage ratios, or better still, in voltage squared (power) ratios, the amplitude of the rear lobes, relative to the main lobe, would *appear* to show improved directivity. An examination of the diagram will reveal that, over the rear 180° of the aerial, the response is never less than 15dB below that of the main beam. As an integrated effect it probably averages 25dB below the main lobe.

It might be a good idea to standardize the amplitude scale of a polar co-ordinate graph say, in five steps of 10dB with 50dB coinciding with the centre of the chart and 0dB on the circumference. The *appearance* of the curve would then line up with the degree of directivity found between samples.

A pair of these aerials may be mounted side by side a little over a half-wavelength between centres. Provided that the respective outputs are connected in phase the gain will be increased by 3dB and the half-power beam width reduced to about 55°.

It is hoped to publish the results of practical tests with this aerial on the B.B.C.'s transmissions after both standards of definition have been used.

Acknowledgement. This article is based on work done on behalf of Kimber-Allen, Ltd., to whom thanks are due.

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[2] J. D. Kraus. *Proc. I.R.E.* vol 28, p. 513, 1940.
[3] E. B. Moullin. "Radio Aerials," (Clarendon Press, Oxford).

BAND V ON A TURRET TUNER

ADAPTING AN EXISTING BAND I — BAND III FRONT END FOR U.H.F. TELEVISION

BY P. R. STUTZ, B.Sc. (Eng.) Hons., A.C.G.I., Grad. I.E.E.*

WHEN the decision was taken to begin television test transmissions in Band V at a vision carrier frequency of 654.25 Mc/s, the problem arose of providing television sets capable of receiving these signals.

The type of receiver which has been adapted for u.h.f. reception uses the well-known turret tuner for channels in Bands I and III. The r.f. stage of this tuner is a double triode connected as a cascode amplifier which is followed by a triode-pentode frequency changer. A separate set of coils is used for each channel, mounted in a twelve-position turret.

In order to receive the u.h.f. transmissions, special coil strips or inserts are mounted in the turret†. To obtain satisfactory results these inserts use the double superhet principle. This necessitates a rather more complex insert than the type used on the lower frequencies of existing television channels in this country. A schematic arrangement of the u.h.f. inserts is shown in Fig. 1.

The incoming u.h.f. signal is first frequency converted to an intermediate frequency lying in the 135-Mc/s region using a u.h.f. germanium diode mixer. This signal is amplified by the cascode valve in the tuner. The signal is then frequency converted again, using the pentode mixer, to the normal 34.65-Mc/s vision intermediate frequency of the receiver. A harmonic of the triode local oscillator is used for the first frequency-changing operation and the fundamental for the second frequency conversion. For this particular channel, the third harmonic of the local oscillator is used: this harmonic is generated by a germanium diode from the fundamental and is selected by a resonant circuit.

As a result of using a harmonic selector circuit, the mixing diode obtains a local oscillator voltage with the unwanted harmonics and the fundamental reduced to a minimum. This ensures that a good noise factor is obtained and reduces unwanted responses.

The circuit diagram of the inserts is given in Fig. 2. The aerial input is for a 75-ohm unbalanced feeder, the same as is used on Bands I and III. The feeder is matched into the primary of a mutually coupled band-pass circuit tuned to the u.h.f. channel fre-

*Kolster-Brandes.

†The units are of American design and have been modified to 75-ohm aerial input and to suit the frequency of the test transmission.

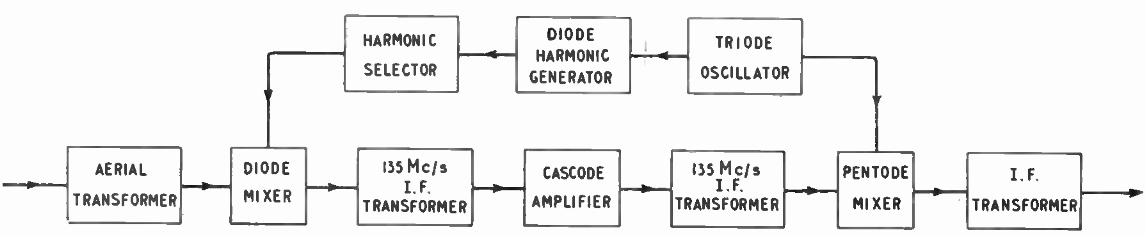


Fig. 1. Block schematic of the u.h.f. inserts for the tuner.

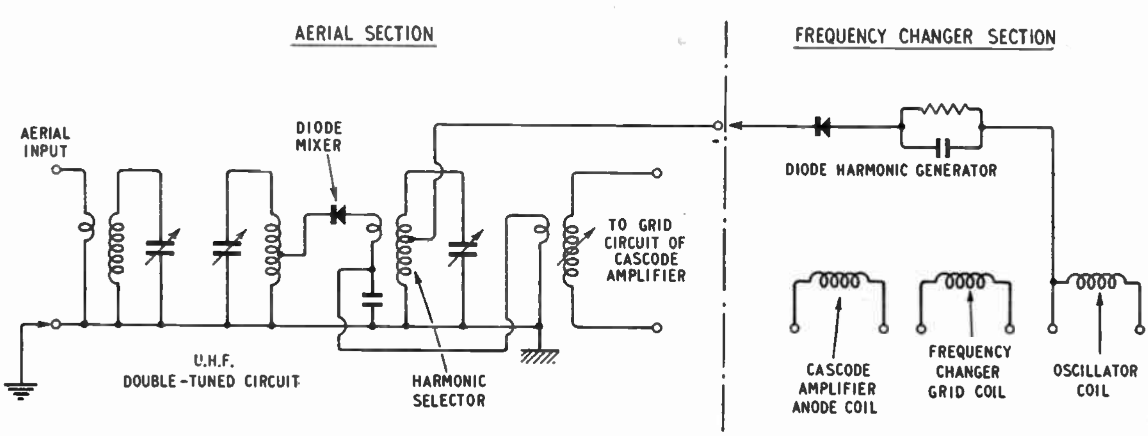
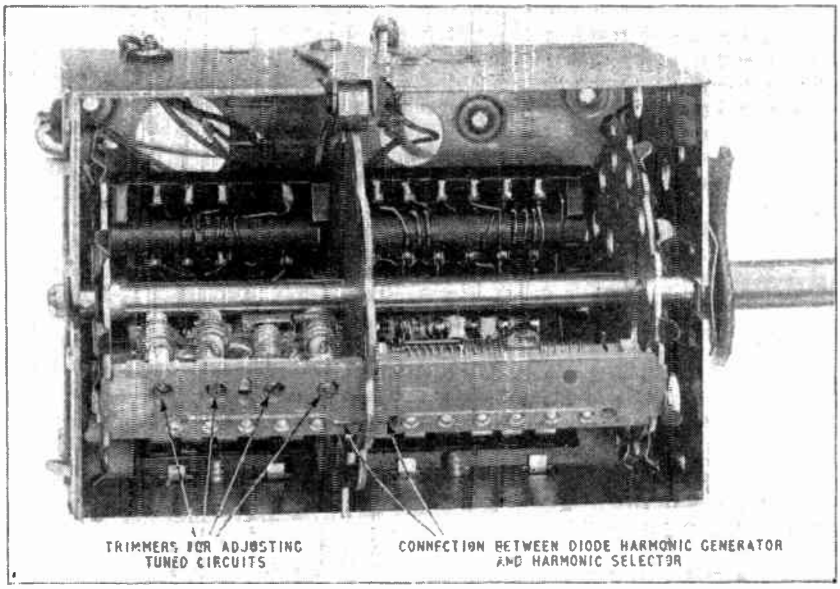


Fig. 2. Circuit diagrams of the two u.h.f. inserts.

quency. The output is matched into the diode mixer by means of a tap on the secondary tuned circuit. The i.f. output from the diode mixer is coupled into the grid circuit of the cascode amplifier using an impedance-matching transformer tuned to 135 Mc/s. The diode used for obtaining the third harmonic of the triode oscillator is connected to one side of the local oscillator winding via a biasing network. As this diode is mounted on the frequency-changer section and its output has to be fed to the harmonic selector on the aerial section, a special link is required between the two sections of the u.h.f. inserts. This link between the two sections can be seen on the photograph of the inserts in position in the turret tuner. On the frequency-changer section, there is the coil connected in the anode circuit of the cascode amplifier which, together with the other coil connected to the grid of the pentode mixer, forms a band-pass coupled circuit tuned to a centre frequency of about 135 Mc/s. The local oscillator coil on this frequency-changer



An existing tuner with the u.h.f. inserts in position on the turret.

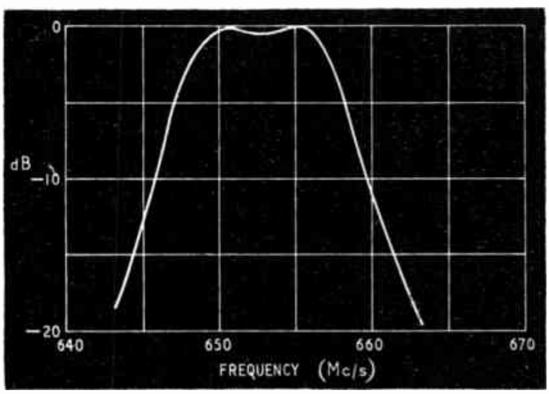


Fig. 3. Frequency response of the u.h.f. tuner, measured from the aerial input to the pentode mixer stage.

section is designed for a fundamental frequency of 172.225 Mc/s.

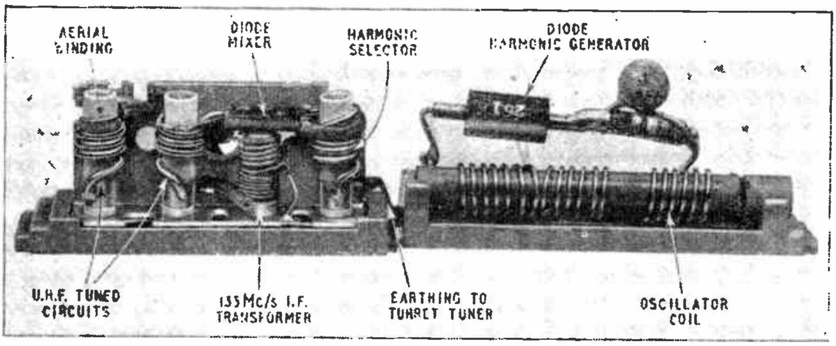
The circuits on the aerial section are tuned by means of the trimmers shown in the photograph. The coils on the frequency-changer section are tuned by adjustment of the end turns, except for the local oscillator coil which has a brass core accessible from the front of the tuner, in the same manner as with the coil strips for the existing television channels. Constructional details of the inserts can be seen in another photograph on the next page.

In assessing the performance of these u.h.f. inserts, one of the more important considerations is probably the noise factor. This type of unit was found capable of a noise factor of about 17dB; this figure compares quite well with other types of tuner which do not use a stage of u.h.f. amplification before the mixer diode.

The overall selectivity of the arrangement is quite adequate, as can be seen from the curve of

Responses from an insert tuned to 654.25 Mc/s vision.

Oscillator Harmonic (Mc/s)	Vision Frequency (Mc/s)	Sound Frequency (Mc/s)	Measured Amount Down on Required Response (dB)	Comments
	137·575	134·075	28	Ist i.f.
Fundamental 172·225	34·65 309·8	38·15 306·3	65 53	Final i.f.
2nd harmonic 344·450	206·875 482·025	210·375 478·525	63 35	
3rd harmonic 516·675	379·100 654·250	382·60 650·750	40 0	Required channel.
4th harmonic 688·90	551·325 826·475	554·825 822·975	38 46	
5th harmonic 861·125	723·550 998·700	727·050 995·200	49 55	
6th harmonic 1033·350	895·775 1170·925	899·275 1167·425	45 Not measured.	



Showing the construction of the two u.h.f. inserts and how they are linked together when on the turret.

Fig. 3. Unwanted responses due to oscillator harmonics are sufficiently down on the main response to be considered negligible, as can be seen from the measurements given in the table. Rejection at the 135-Mc/s i.f. is sufficient for all normal purposes. The value of the rejection seems to be controlled by stray coupling from the aerial input to the cascode amplifier grid.

It is thought that with future units it may be possible to improve this figure if necessary, as the layout of the units used was originally intended for a 300-ohm balanced aerial input.

The voltage gain of a tuner using these u.h.f. inserts is somewhat less than that of the same tuner working on Bands I and III, owing to the loss of gain in the aerial section. The difference in gain of the tuner between Band V and Band III will be about 10dB.

The stability of the local oscillator is obviously important for convenience of operation. The drift was found to be about three times greater than that experienced on Band III, but was found in practice to be tolerable.

The range of the fine tuner control is about three times greater than that on Band III channels but, despite this, it was found perfectly simple to tune in the picture on a receiver.

The considerations leading up to the choice of 135 Mc/s as the first i.f. have not yet been mentioned. Owing to the fact that the triode local oscillator is used for both frequency-changing operations, there is a relationship between the oscillator harmonic chosen and the first i.f. Also, to avoid reversing the relative positions of the sound and vision carriers, the first frequency conversion must be done with the local oscillator low. This leads to:

$$f_o = f_{if(1)} + f_{if(2)}$$

$$f_o = \frac{f_{uhf} + f_{if(2)}}{N + 1}$$

where f_{uhf} = frequency of Band-V channel

f_o = oscillator fundamental frequency

N = harmonic of the oscillator used

$f_{if(1)}$ = the first i.f.

$f_{if(2)}$ = the second i.f. (34·65 Mc/s vision)

It was considered desirable that the frequency of the local oscillator fundamental and the first i.f. should be chosen so that they were located between Bands I and III and cleared the band allocated to v.h.f. radio transmissions. This led automatically to the choice of the third harmonic of the local oscillator for this particular channel and a value of 135 Mc/s for the first i.f.

A small practical point worth mentioning is the care that had to be exercised in the choice of mains isolating components for the aerial feeder. If this is not done and unsuitable values and layouts are chosen, the noise factor and sensitivity of the receiver will be impaired.

The performance of the u.h.f. inserts on the test transmissions came fully up to expectations, the pictures obtained being free from any unwanted beats or patterning. In practice these inserts were fitted to an unused channel position in the turret, thus leaving the receiver free to receive the normal transmissions in Bands I and III as well as the u.h.f. transmissions.

Books Received

The B.B.C. Riverside Television Studios: The Architectural Aspects, by E. A. Fowler. B.B.C. Engineering Monograph No. 13 includes an appendix on the sound proofing, and the acoustic treatment used to secure the optimum reverberation time. Pp. 25; Figs. 10.

The B.B.C. Riverside Television Studios: Some Aspects of Technical Planning and Equipment, by H. C. Nickels and D. M. B. Grubb. B.B.C. Engineering Monograph No. 14 includes description of television and sound studio and distribution apparatus and also telecine equipment. Pp. 32, Figs. 18. The above B.B.C. Engineering Monographs are each priced 5s and may be obtained from B.B.C. Publications, 35, Marylebone High Street, London, W.1.

Glossary of Abbreviations, compiled by S. T. Cope, covers names of technical, scientific, industrial and professional organizations, with particular reference to the telecommunications industry. Pp. 38. Price 2s 6d. Marconi's Wireless Telegraph Co., Ltd., Baddow Research Laboratories, West Hanningfield Road, Great Baddow, Essex.

Electronic Voltage Stabilizers for Laboratories, Computors and Control Systems, by J. Miedzinski, B.Sc., and S. J. Zgorski, describes series valve stabilizer with twin-triode amplifier and gas discharge voltage reference tube to give up to 50 mA at 320 or 400V. Pp. 19; Figs. 8. Price 12s 6d. Electrical Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey.

The "Mercury" Switched F.M. Tuner, by G. Blundell, gives description and constructional details for a new Jason circuit incorporating a.f.c. and a Foster-Seeley discriminator. Pp. 20, Figs. 9. Price 2s. Data Publications, Ltd., 57, Maida Vale, London, W.9.

Some Special Magnetrons

—AND HOW THEY ILLUSTRATE BASIC IDEAS

THE magnetron consists essentially of an anode and cathode which are concentric cylinders. The anode has a number of subdivisions, usually referred to as segments, in which high-frequency oscillations can be produced. These segments generally take the form of resonant cavities so that oscillations are essentially only possible at a number of discreet frequencies. Power from the oscillations is generally coupled out from a single segment, a wide variety of methods being used.

The cathode is at a high negative d.c. potential relative to the anode. A powerful magnetic field in the direction of the anode and cathode axis prevents more than a small proportion of the electrons emitted from the cathode from reaching the anode under static conditions, most of them being returned to the cathode.

Under dynamic conditions, the r.f. field produced by the oscillations gives energy to electrons whose phase with respect to this field is favourable. This enables them to reach the anode where they give up their potential energy to sustain the oscillations. The field also produces a "bunching" effect[1], or in other words tends to concentrate electrons as they proceed to the anode into groups with a favourable phase. Those electrons for which this does not occur soon return to the cathode, and bombarding it, increase its temperature.

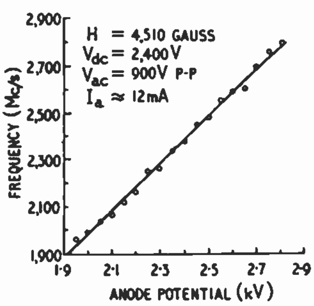


Fig. 1. Linearity of tuning in voltage tunable magnetron.

The anode segments generally have a constant phase difference between individuals. This phase difference may be thought of as being produced by r.f. waves travelling round the anode, when the phase change in distance round the anode will be related to the phase change in time of the travelling r.f. wave.

We can thus draw a useful analogy with the travelling wave tube[1]. The magnetic field (by the left-hand rule) imparts an angular motion to the electrons about the anode and cathode axis. This motion will not be essentially modified by the r.f. fields, and the electrons will stream past the anode segments either individually or in bunches as they approach. By analogy with the travelling wave tube we will expect maximum interaction to occur when the electron bunches and r.f. waves have the same velocity.

Relationships between Operating Parameters.—The need for this equality between the velocities of the electron bunches and r.f. waves gives a relationship between the operating voltage, magnetic field, and frequency. The frequency is also usually largely fixed by the resonant properties of the anode segments.

By adopting certain simplifying assumptions it is possible to obtain this relationship in a quantitative form which is close to that obtained by more sophisticated methods.

The electrons can be assumed to leave the cathode with zero velocity and to proceed towards the anode under the influence of the static electric and magnetic fields only, until the r.f. field becomes significant. Here, for optimum interaction, the angular velocity round the anode of the electrons and the r.f. field must be the same. We then assume that from here outwards the electrons become "locked" to the r.f. wave, so that their angular velocity remains constant until they reach the anode[2].

When the r.f. field is negligible, the electric field will be entirely in a radial direction. The angular equation of motion for an electron of mass m and charge e may then be written

$$\frac{m}{r}\frac{d}{dt}\left(r^2\frac{d\theta}{dt}\right) = eH\frac{dr}{dt} \quad \ldots \quad (1)$$

Integrating this equation we obtain

$$r^2\frac{d\theta}{dt} = \frac{eH}{2m}(r^2 - r_c^2) \quad \ldots \quad (2)$$

where r_c is the cathode radius, and the constant of integration is obtained by putting $d\theta/dt=0$ at $r=r_c$. If r_1 is the radius at which the electrons become locked to the r.f. wave, equation (2) gives the corresponding angular velocity ω, as

$$\omega_1 = \frac{eH}{2m}(1 - r_c^2/r_1^2) \quad \ldots \quad (3)$$

It is reasonable to assume that when oscillations are only just sustained the energy fed into the electrons is as small as possible. If this is the case nearly all of the energy will be used to keep the electrons in a circular orbit locked to the r.f. wave, and there will be only a small amount left to provide radial motion. Thus we can neglect the rate of change of the radial component of velocity. The radial equation of motion can then be written as

$$-mr\left(\frac{d\theta}{dt}\right)^2 = eE_r - Her\frac{d\theta}{dt} \quad \ldots \quad (4)$$

where E_r is the radial field. Integrating this equation from $r=r_1$ to $r=r_a$ (where r_a is the anode radius), and remembering our assumptions that $d\theta/dt=\omega_1$, and that *radial* r.f. fields are negligible we obtain

$$e(V - V_1) = (He\omega_1 - m\omega_1^2)\left(\frac{r_a^2 - r_1^2}{2}\right) \quad (5)$$

where V_1 is the voltage at r_1. V_1 can be obtained very simply from the conservation of energy since we are assuming that r.f. fields are negligible inside r_1.

[1] "Cathode Ray," "Valves for Microwaves," *Wireless World* vol. 43, September 1953, p. 417, and October 1953, p. 482

[2] This type of approach is developed in greater detail in H. W. Welch, Jnr., and W. G. Dow, "Analysis of Synchronous Conditions in Cylindrical Magnetron Space Charge." *Jour. Appl. Phys.*, vol. 22, April 1951, p. 433

Thus, equating the potential energy lost to the kinetic energy gained, we obtain

$$eV_1 = \tfrac{1}{2} m r_1^2 \omega_1^2 \quad .. \quad .. \quad .. \quad (6)$$

Substituting equation (6) in equation (5) to eliminate V_1, and then using equation (3) to eliminate r_1, we obtain

$$2V = H\omega_1(r_a^2 - r_c^2) - \omega_1^2 r_a^2 m/e \quad .. \quad (7)$$

Finally, we must obtain a relation between ω_1 and f the oscillation frequency. In the idealised case where the r.f. field has a simple sine wave variation both in angle and time, the r.f. potential at a point between anode and cathode can be written

$$V_{r.f.} = V_{r.f.}(r) \cos 2\pi n\theta \cos 2\pi ft \quad .. \quad (8)$$

where $V_{r.f.}(r)$ is a function of r only, and n the number of repeats of the field pattern round the anode. Since the magnetron anode is closed upon itself (unlike the newer backward wave oscillators[3]) n must be a whole number. (This restriction on n is one of the reasons why the magnetron can only oscillate at certain frequencies.) Equation (8) can then be rewritten as

$$V_{r.f.} = \frac{V_{r.f.}(r)}{2}[\cos 2\pi(n\theta+ft)+\cos 2\pi(n\theta-ft)] \quad (9)$$

which represents two progressive waves travelling round the anode in opposite directions with angular velocity $2\pi f/n$. Actually the angular variation of the r.f. field is more nearly a set of square pulses whose steps occur at the discontinuities in the anode produced by the segments (see for example Fig. 6). This was discussed in detail by Hartree[4], who showed that there were a number of other possible angular velocities for the r.f. waves. These are of the form $2\pi f/(kN \pm n)$ where k is a positive integer and N the number of segments. Substituting this set of values for ω_1 in equation (7) we obtain finally

$$V = \frac{\pi f H}{kN \pm n}(r_a^2 - r_c^2) - \frac{2\pi f^2 r_a^2}{(kN \pm n)^2}\frac{m}{e} \quad .. \quad (10)$$

This is, in fact, the well-known Hartree threshold relationship[4], and is generally confirmed in practice to within a few per cent.

Voltage Tunable Magnetrons.—It has been mentioned that anode structure resonances usually restrict oscillation to a number of discreet frequencies. Other types of microwave oscillator, such as the backward wave oscillator[3], have been developed to avoid this restriction. It is not however a fundamental limitation of the magnetron, and non-resonant anode structures have also been used to obtain wide-band operation.

If we refer to equation (10) it can be seen that, when there are no other restrictions, for a given mode of oscillation (i.e. a given k,n), the frequency is determined only by the voltage and the magnetic field. The field cannot be varied conveniently, so that in such magnetrons the frequency is varied by varying the voltage. For a sufficiently large magnetic field H, equation (10) moreoever shows us that the frequency will be proportional to the voltage, and a fuller analysis[5] confirms this. This is a very useful characteristic, for example, in obtaining undistorted frequency modulation. In practice a "sufficiently large" field in this context is not particularly high compared with usual magnetron fields.

To avoid resonances a structure consisting of two sets of interlocking fingers (interdigital) has generally been used. In this case all major frequency sensitive elements except the capacity between the two sets of fingers are removed from the interior of the valve; and the exterior cavity can more easily be made non-resonant. For example, this type of structure lends itself to direct mounting in waveguide, the fingers lying across the narrow dimension. In this arrangement ideally the guide only imposes its cut-off property in the valve.

A description of such a magnetron is given in a paper by J. A. Boyd[6], of Michigan University. Fig. 1, taken from this paper, shows the linearity of the voltage-frequency relationship.

The power output of such magnetrons is very dependent on the total shunt impedance of the r.f. circuit, and this should be as high as possible. Here a limiting factor is the capacity between the two sets of fingers. Boyd used rounded digits in order to reduce this capacity as much as possible. Another model of similar structure, but with this capacity doubled, showed a greatly inferior performance.

As regards the external circuit, it is difficult to give this a high shunt impedance over a wide band. Thus a compromise must be made between power output and band-width. Boyd was able to obtain powers of the order of half a watt over 2,000 Mc/s, or four watts over 200 Mc/s.

Boyd also found that in order to produce coherent oscillations it was necessary to limit the anode current by keeping the cathode temperature low. This disagrees with some other observations of voltage tuning using a different structure discussed later. Such temperature limitation is, however, certainly useful in keeping the anode current, and thus the output power, approximately constant. The extent to which this can be achieved in Boyd's valve is shown in Fig. 2 (also taken from reference (6)). Boyd found that in c.w. operation, owing to variations in the electron bombardment of the cathode, temperature limitation could not be obtained unless a directly heated cathode was used. The total cathode heating power required is greater for such a cathode so that the bombardment is a smaller fraction of this power.

When there are no powerful frequency determining elements noisy operation is likely. However

[3] See for example, R. Warnecke and P. Guenard, "Some recent Work in France on New Types of Valves for the Highest Radio Frequencies," *Proc.I.E.E.* vol. 100, Part III, Nov. 1953, p. 351.

[4] D. R. Hartree, "Mode Selection in a Magnetron by a Modified Resonance Criterion," *C.V.D. Report*, Mag. 17.

[5] H. W. Welch, Jnr., "Prediction of Travelling Wave Magnetron Frequency Characteristics: Frequency Pushing and Voltage Tuning," *Proc. I.R.E.*, vol. 41, Nov 1953. p. 1631.

[6] J. A. Boyd, "The Mitron—An Interdigital Voltage Tunable Magnetron," *Proc. I.R.E.*, vol. 43, March 1955, p. 332.

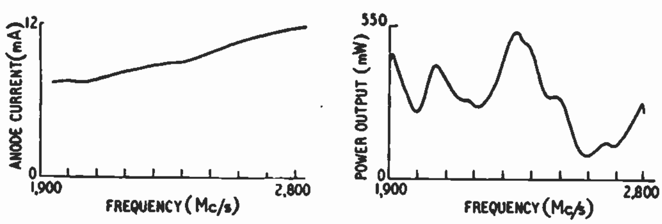


Fig. 2. Constancy of anode current and output power with temperature limited emission.

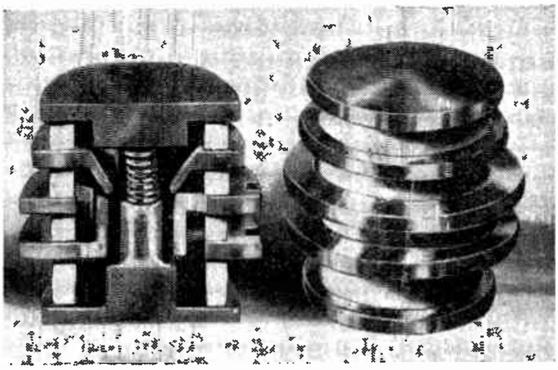


Fig. 3. G.E. Company of America voltage tunable magnetron.

when used as a local oscillator Boyd's valve had a noise figure only $\approx$3dB worse than a klystron.

In normal magnetrons the r.f. field is at right-angles to the cathode axis, from one cavity to the next. In interdigital valves, however, this field is parallel to the cathode axis from one set of fingers to the other. Because of this asymmetry of the cathode with respect to the r.f. field resonance and electronic interaction effects due to the cathode structure are more serious and difficult to avoid in interdigital valves.

A version of this type of magnetron only about half an inch long has been developed by the G.E. Company of America[7], and is shown in Fig. 3 reproduced from page 244 of *Electronics* for October 1956. The spiral cathode is offset from the interaction space. This is possibly to reduce the effects due to the cathode discussed above. This offsetting would also decrease the electron bombardment which was troublesome in the Michigan valve. The extra, shaped, electrode may help to focus the emitted electrons into the interaction space.

Scaling.—The remaining two types of magnetron we shall discuss were developed to produce the highest frequencies.

In considering these magnetrons it is necessary to elaborate the Hartree threshold relationship a little. We have not introduced the fact that there will be a minimum voltage at which a magnetron can oscillate. This is that voltage for which electrons at the anode have just given up all their potential energy in order to attain the angular velocity of the r.f. field with which they are interacting, so that no energy is left to build up oscillations. The minimum voltage is also that voltage at which, under static conditions, the electron orbits just graze the anode, so that the r.f. field necessary for them to reach the anode can be vanishingly small. From the first definition, the minimum voltage V_o is given immediately by

$$eV_o = \tfrac{1}{2}mr_a^2\omega_1^2 \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

$$\text{i.e. } eV_o = \frac{2\pi^2 mr_a^2f^2}{(kN\pm n)^2} \quad \ldots \quad \ldots \quad (12)$$

The first definition of V_o also gives an immediate upper limit for the efficiency. To give output, only the potential energy from the d.c. field is useful, the kinetic energy being wasted. Thus, considering a single electron, the efficiency will be at most one minus the minimum possible kinetic energy at the anode divided by the potential energy obtained from the d.c. field,

$$\text{i.e. } \eta \leqslant 1 - V_o/V \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

Remembering that there will be further losses in the output circuit, it is thus usual to operate at several times the minimum voltage.

Another useful concept which follows rapidly from the definition of V_o is that of "scaling." If we substitute V_o for V in the Hartree threshold relationship (equation (10)) we can obtain a corresponding value H_o for H. Equation (10) then reduces to the simple form

$$V/V_o = 2H/H_o - 1 \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

Of the most fundamental conditions of operation only the anode current requires a corresponding I_o to be defined. Several such definitions have, in fact, been proposed. The simplest is that current which would be drawn at zero magnetic field when the magnetron is acting simply as a diode, although this is much greater than any operating current so that it does not correspond to any minimum. I_o is then given by the relation

$$I_o = \frac{8\sqrt{2}}{9}\pi\sqrt{e/m}\,\frac{V_o^{3/2}l}{r_a} \quad \ldots \quad \ldots \quad (15)^8$$

where l is the anode length,

$$\beta = u - \frac{2u^2}{5} + \frac{11u^3}{120} - \frac{47u^4}{3300} + \ \ldots,$$

and $u = \log_e\left(\frac{r_a}{r_c}\right)$.

Since the early days of magnetron development much use has been made of the fact that if, using I_o, V_o, H_o as units, we operate under the same conditions, then the efficiency and stability are similar for *different* designs of magnetron, provided that the anode segments remain of similar shape. In this way by altering the size of a successful design it can be "scaled" to work at a different wavelength.

Minimum Voltage Magnetrons.—Returning to our immediate problem, from equation (12) we can see that if we wish to obtain higher frequencies we must either reduce r_a, increase V_o, or increase $(kN\pm n)$. We will consider the third possibility later. As regards the other two possibilities, it is clear that there will be practical limits to decreasing r_a or increasing V. A less obvious consideration which arises in c.w. operation is that the anode power, and hence current, at which oscillations begin must be sufficiently low. This will also in practice limit the maximum voltage and minimum size. Reducing the size of the anode also reduces the possible power dissipation.

Another possibility is to operate nearer the minimum voltage. Looking at this the other way round we can then increase V_o (for a fixed V), and thus increase f. It is however clear from equation (13) that the efficiency will fall.

In the sense that operation remains based on the equalization of velocities we have described, no essential change is produced by working near the minimum voltage. However, the bunching influence of the r.f. field which we have also discussed will

[7] T. R. Bristol and G. J. Griffin, Jnr., "Voltage-Tuned Magnetron for F-M Applications," *Electronics*, May 1957, p. 162.

[8] I. Langmuir and K. B. Blodgett, "The Effect of Space Charge and Residual Gases on Thermionic Currents in a High Vacuum" *Phys. Rev.* vol. 2, December, 1913, p. 450.

largely disappear, and this leads to considerable practical differences.

It will be necessary to provide the required equality of the electron and r.f. wave velocities as far as possible even in the static case in order to do without the help of the r.f. field. If we return to equation (2) we can see that if r_c the cathode radius is small, then the angular velocity varies only slightly with changing r. In this case we have a stream of electrons at various radii but with the same angular velocity which can interact with an r.f. wave with this velocity.

We can develop this point more exactly when we realise that in such a valve there will be an optimum value for the radius at which velocity equalization occurs. If this is too small, the r.f. fields will be too weak, and little interaction will occur. On the other hand, if this is too large, insufficient interaction can occur before the electrons reach the anode.

Substituting equation (3) in equation (7) to eliminate H, and then using equation (11) to eliminate ω_1, we obtain the relation

$$\frac{V}{V_o} + 1 = 2\left[\frac{1 - r_c^2/r_a^2}{1 - r_c^2/r_1^2}\right] \quad \cdots \quad \cdots \quad (16)$$

We can see that if r_1 is fixed, as V approaches V_o, r_c must approach zero. This agrees with our earlier general reasoning. When V becomes large r_c tends to r_1. Thus r_1/r_a can be obtained from a knowledge of the optimum r_c/r_a for normal operation of the magnetron when scalled to operate at some lower frequency. If we wish to operate somewhat above V_o equation (16) can then give us the optimum r_c/r_a. Conversely, equation (16) suggests that, for a given r_c/r_a, there will be an optimum operating voltage V to establish velocity equalization at r_1. Thus we can expect operation of this type to occur over a fairly limited range of voltage and thus also of magnetic field.

This limited range of operation was observed in the original G.E.C. work on the subject[9]. When the voltage was varied more than about 10%, operation occurred in a number of " modes " (different n numbers in equation (10)). This was clearly seen by changes in the oscillation frequency. The different modes will of course have different minimum voltages. They may also have different values for the optimum radius r_1 for velocity equalization, due to the different r.f. field patterns.

These properties of limited range of operation and wide degree of mode selection are quite different from those of normal magnetrons. Here operation is generally in the $n = N/2$ mode (π mode), over a wide range of voltages.

Results obtained at Columbia University Radiation Laboratory, New York[10], using cathodes of different sizes support the general result of equation (16) that the operating voltage approaches the minimum as the cathode size is decreased. These results also suggest that the proportional range of voltage in which operation is possible also decreases as the cathode size is decreased.

In later G.E.C. work[11] only the π mode was observed. This could have been due to the use of narrow-band output coupling arrangements: wide-band coaxial coupling was used in the original experiments. At higher anode currents considerable increases in efficiency were obtained, for example, up to $\approx 30\%$ overall in valves operating around $V_0/V = 0.6$. In view of output coupling losses, this must represent nearly the theoretical limit of 40%. There was no sign of any falling off in efficiency for currents up to $0.08\ I_0$. A practical feature of this type of operation is that the cathode has to be very accurately centred; any slight off-centring produces a marked fall in efficiency and increase in back-bombardment of the cathode.

Spatial Harmonic Magnetrons.—In our search for higher frequencies we must now return to the other possibility shown by equation (12) we have already mentioned, that of increasing $(kN \pm n)$. Magnetrons are generally designed to operate in the π mode where the phase difference between adjacent resonators is π, and which correspond to $n = N/2$, $k = O$. Modes corresponding to smaller n numbers are well known, but modes with $n > N/2$ (corresponding to harmonics of the individual resonators) have only rarely been observed, and seem unimportant in magnetron operation.[12]

We are thus left with the possibilities of increasing N, the number of resonators, or operating with non-zero values of k. However, if the number of resonators is increased, the relative wavelength separation for the various modes is decreased. Interference between such modes is then more likely. The limit in this direction has already practically been reached in conventional designs.

We must now consider operation with non-zero values of k, that is spatial harmonics of the r.f. pattern round the anode. Early attempts to observe this operation, using values of $(k + \frac{1}{2})N$ of 12 or more and anode diameters greater than 0.1λ were unsuccessful. This is probably because the r.f. field fell off too rapidly from the anode to produce any interaction. An analysis shows that, at least in the absence of space charge, this field is proportional to

(*Continued on page 21*)

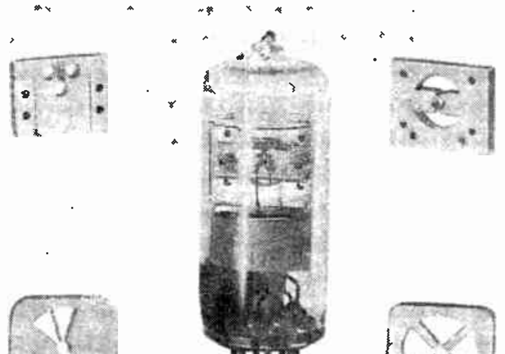


Fig. 4. G.E.C. (British) spatial harmonic magnetron and anodes.

[9] W. E. Willshaw and R. G. Robertshaw, " The Behaviour of Multiple Circuit Magnetrons in the Neighbourhood of the Critical Anode Voltage," *Proc. Phys. Soc.*, vol. 63, Part B 1950, p. 41.

[10] Z. Fraenkel, " The Development of a Tunable CW Magnetron in the K-Band Region ", *I. R. E. Trans. E. D.*, Vol. ED-4 No. 3, July 1957, p.271.

[11] T. M. Goss, R. G. Robertshaw, J. R. Tew and W. E. Willshaw, " A Review of the Performance of Magnetrons Operating at Low Magnetic Field ", *L'Onde Electrique*, Vol. 37, Oct. 1957, p.804

[12] G. B. Collins, " Microwave Magnetrons ", McGraw-Hill, p.17.

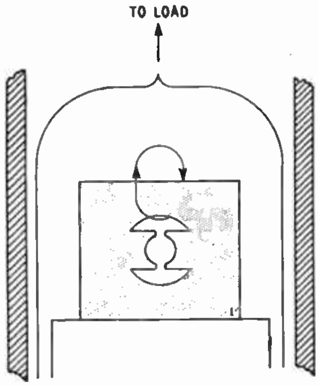


Fig. 5. Magnetic coupling to load in a spatial harmonic magnetron.

$(r/r_a)^{M-1}[1-(r_c/r_a)^{2M}]$ where M is the value of $(kN \pm n)$. Thus the successful G.E.C. workers[13] were led to the use of anodes of 4 or 2 segments only, with operation with M values around 6.

Although this approach thus does not give an increase in $(kN \pm n)$, it does result in a considerable simplification in the mechanical and electrical structures of the anodes used. Considering, for example, the case where $k = 1$ and $M = 3N/2$, the form of the spatial harmonic of the r.f. field concerned is the same as that of the r.f. fundamental in a valve with 3N segments. In some ways we can consider that we are using a valve with 3N segments, but in which 2N of them are "missing." In this case the problem of distributing the segments round the anode is considerably eased. Some of the asymmetrical anode structures used very forcibly suggest this idea of missing segments, an example being shown at the top left of Fig. 4. In this case, in fact, there would not be room for the full number of segments (12) round the valve.

Fig. 4 also shows a complete valve for operation at about 9,000 Mc/s, and illustrates the neat construction possible using an ordinary B7G valve base and glass envelope.

The first experiments were made with asymmetrical anode structures. Another example is shown at the bottom of Fig. 4. (This is not to the same scale as the other anodes in Fig. 4.) Unfortunately the results obtained were not very repeatable owing to difficulties in accurately machining the long narrow slots used in the design. Consequently a change was made to symmetrical anode structures of two and four segments as at the right of Fig. 4.

The use of a symmetrical anode structure permits a very simple magnetic coupling to the load by means of the current circulating round one of the cavities as shown in Fig. 5 (taken from reference (12)). In the case of the original asymmetrical anodes this simple coupling is not so easy to obtain. Oscillations in the two adjacent cavities are out of phase so that the couplings for the two cavities tend to cancel out. This may be avoided by slightly rotating the segments as in the anode at the bottom left of Fig. 4, for in this case coupling occurs mainly to one segment. In the original anodes a radiating probe between the cavities parallel to the cathode was used, as can be seen at the bottom of Fig. 4.

We assume, as before for simplicity, that the r.f. wave round the anode can be represented by a set of square pulses whose steps occur at the discontinuities at the anode gaps. An example is shown in Fig. 6 (taken from reference (12)) for one case in a 4 segment asymmetrical anode. In this case the r.f. wave can be Fourier analysed into a set of component sine waves of different amplitudes. These sine waves correspond to different values of $(kN \pm n)$. In this way it is possible to predict the types of interaction that can occur. Modes have been observed which are not predicted by this analysis, but this is attributed to slight constructional asymmetries. Conversely it is possible to design anode structures suitable for working in particular modes. This is done essentially by altering the angular position of the gaps. In the case of symmetrical anode structures this involves altering the thickness of the vanes between the segments.

A performance chart of one of the asymmetrical anode valves is shown in Fig. 7 (taken from reference (12)), the numbers showing the relevant values of $(kN \pm n)$. Owing to the simpler anode resonance structure of such valves with few segments it is possible to achieve a useful tuning range by coupling the valve to a simple external-cavity tuner. The simple anode structure also permits pulse operation with very short oscillation build up times. Preliminary measurements suggest that the limit in this

[13] R. G. Robertshaw and W. E. Willshaw, "Some Properties of Magnetrons Using Spatial Harmonic Operation." I.E.E. Monograph No. 168R. To be published in Part C of *Proc. I.E.E.*

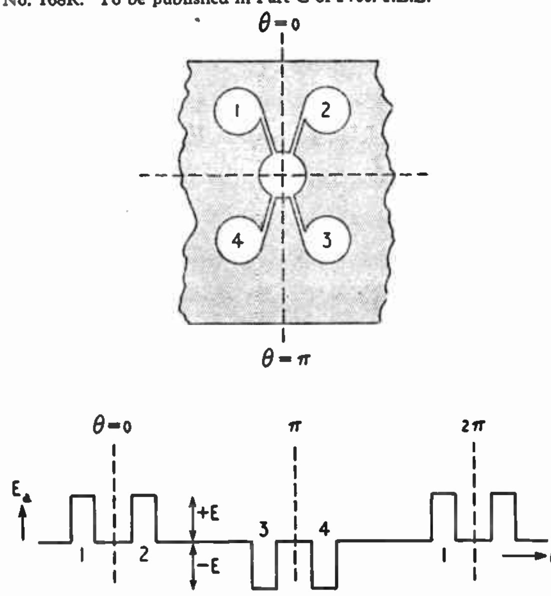


Fig. 6. Typical anode and associated r.f. wave in spatial harmonic magnetron.

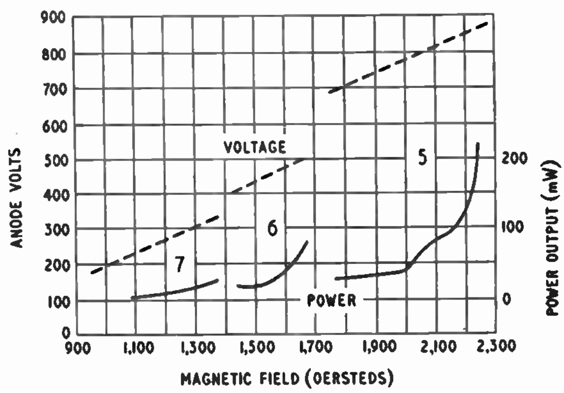


Fig. 7. Performance chart of spatial harmonic magnetron.

direction is less than 0.1 μsec. The limit is set so far by the shape of current pulses that can be generated with existing apparatus.

Reference to Fig. 7 shows that, in a given mode, if the voltage is increased the power is increased up to a certain point, where it suddenly drops to zero. This is because at high anode currents the space charge forces in the electron bunches defocus these bunches. Interaction is then no longer possible. Spatial harmonic operation of valves is much more prone to this type of " drop out " than normal operation.

If the coupling of the valve to the load is made very heavy the normal resonances are suppressed and voltage tuning becomes possible. Again in these valves the simple anode structure permits this to be more readily carried out, and 2 to 1 frequency ranges have been achieved. The power available is however very much less than in normal operation. Although temperature-limited emission was not used operation was not noisy. This contradicts previously mentioned results on such voltage tuning obtained by Boyd[6], of Michegan University. M.G.L.

LETTERS TO THE EDITOR

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

" Do it Yourself " Interference

I SHOULD like to allay the fearsome forebodings of your correspondent Douglas Walters regarding the subject matter of my recent "Build your own Radio Set" programmes.

Early on in the series I told viewers that I was receiving letters from dealers, and from boys who had been told by their dealers, pointing out that the set would not oscillate. It was suggested that I had wrongly specified a reaction capacitor of 0.0001μF whereas that specified by the makers of the coil was 0.0003μF. My reply to viewers was that this was done deliberately as the smaller size just gave enough feedback to increase the volume, but no oscillation over the band was possible. It was pointed out that a reacting receiver could cause interference in other sets and to obviate this dealers were asked to keep to the specification and the lower value.

I have made up three models of the receiver concerned and can only obtain a "squeal" with a new battery at the lower end of the medium waveband. I find the DAF 96 valve difficult to persuade to oscillate and cannot believe that its 69 volts and couple-of-hundred *micro*-amps is going to make it a very powerful transmitter even if some enterprising lad gets it going well. In the indoor aerial conditions under which most of these builders are using it, I find the radiation from the receiver difficult to detect in the next room.

From many letters I have received since the series ended, it is apparent that most builders of the set are getting good reception and I hope that I have added over 25,000 youthful enthusiasts to those of us who love the hobby. Perhaps I may use this opportunity to thank the B.B.C. Engineering Staff, various manufacturers and thousands of dealers for their interest and help both to myself and to many novice set-builders (of both sexes!).

Kenton, Middlesex. GILBERT DAVEY.

ALTHOUGH I agree with your correspondent Douglas Walters that the type of receiver to which he refers is very likely to lead to a lot of curious noises on medium wavelengths, I cannot see why he is so worried about it.

Having been chased off the long and medium wavebands by the scream of a hundred line timebase oscillators which made reception unenjoyable when not actually impossible, I am now using v.h.f., and, so to speak, "fireproof."

So far as oscillations on these wavelengths are concerned, those who watched the programme were, for the most part, "doing it themselves" with a vengeance! Surely any interest in the well-being of the medium waveband is somewhat belated. I doubt whether the youngsters will be noticed among the noises already there.

Worksop. H. S. CHADWICK (G8ON).

Interference Suppression

WHILE one must approve of the laws regulating ignition systems, the question is "Why only motor vehicles?" What is being done about electric shavers, hair driers, trolley buses, and, in the country, electric fences?

While I suffer to some extent from motor interference, it is only a very small part of the sum total of interference from which one suffers.

I am contemplating the purchase of an electric cooker with a simmerstat. I understand the simmerstat is quite unsuppressed, and is apparently quite legal.

Although I am a very considerable user of short waves, being an amateur radio transmitter, and suffer considerably from interference of all kinds, I do feel that too much attention is being paid to car ignition and too little to the multitude of other causes of interference which now plague us. Let us start a propaganda drive to suppress all these other sources.

London, N.W.3. E. M. WAGNER.

TV Whistle

YOUR Editorial in the October issue on the subject of the "ideal" receiver has prompted me to make a general complaint about one aspect of television receiver design—the noisy line output transformer.

I think I can truthfully say that I have not yet come across a receiver with a line output transformer which was inaudible at normal viewing distance.

I may be unusual in that at 35 I still have good sensitivity at about 10 kc/s, but what about the hordes of children who view television? Does the whistle not annoy them? My last visit to the Radio Show two years ago was spoilt by the whistle pervading (so it seemed) the whole building.

It has taken 35 years to get rid of the whistle from sound broadcasting (FM be praised) and I wonder if it will take as long to produce a whistle-free TV receiver, for I will have no other in *my* home.

Cardiff. D. A. THOMS.

Optical " Noise " Filter

THE reference to the above in "Technical Notebook" (October issue) reminded the writer of an effect noted in school at the age of 12/13 years. It was observed that if the blackboard were viewed through a small aperture (actually a curled up forefinger) the writing became much clearer. Possibly the effect is similar to that of a pin-hole camera, although it is recalled that the physics master thought that the reason in this case was rather more obscure.

At this time the writer was in need of spectacles although, through lack of a comparative standard, unaware of the fact. It was the above-mentioned observation that provided the comparative standard and, subsequently, the spectacles.

It would seem that an effect similar to the triangular frequency response utilized in, for example, a camera head-amplifier occurs. Perhaps a reader having knowledge of optical effect would be able to comment further on this subject.

East Molesey. T. G. CLARK.

IS not this effect due to the physical nature of the iris of the eye which automatically opens wider when it is shielded from extraneous light by the tube held over it?

Norwich. E. R. SLAUGHTER.

Genesis of Sound Reproduction

THE British Sound Recording Association has offered to try to help supplement the national collection of sound recording and reproducing apparatus and other acoustic and electro-acoustic equipment in the Science Museum, South Kensington.

Our main appeal is to and through members of the Association, but if any non-members have equipment which they would like to give to the B.S.R.A. Historic Collection, I should be very pleased to have details from them at the address below.

I should make it clear that we are not collecting *recordings* of historical interest, the proper repository for which is the British Institute of Recorded Sound, 38 Russell Square, W.C.1.

Disley House, Carlton Road, Reigate, Surrey.

PETER FORD, Hon. Historian, B.S.R.A.

How Little Distortion Can We Hear?

IT is a pity that Mr. Lazenby (September, 1957, issue, p. 435) gave little attention to more practical conditions for distortion detection. The results quoted showed that the simplest (single frequency sine wave) signals were not the most suitable for the detection of distortion, as slightly more complex signals (containing two or more frequencies) allow the formation and detection of intermodulation products. Although I realize that not everyone will agree with this, some of the results using speech and music suggest that for still more complex signals one's sensitivity to distortion is decreased again. There is an example of this on the Vox record "This is High Fidelity," where the same amount of distortion sounds much less objectionable in a complex orchestral passage (mainly strings) than in a simple piano or horn solo. Another point is that significant distortion in the reproduction of music is only likely to occur at peaks of sound, and in such peaks the signal wave form is almost always very complex.

Edgware. D. J. KIDD.

Help for the Blind

NO doubt many of your readers know of the existence of a library of "talking books" for the blind. These have been recorded on long-playing records and are reproduced by portable battery- or mains-operated gramophones specially designed for the purpose. Such is the demand for these reproducers that there is at present a normal waiting period of about one year for new readers.

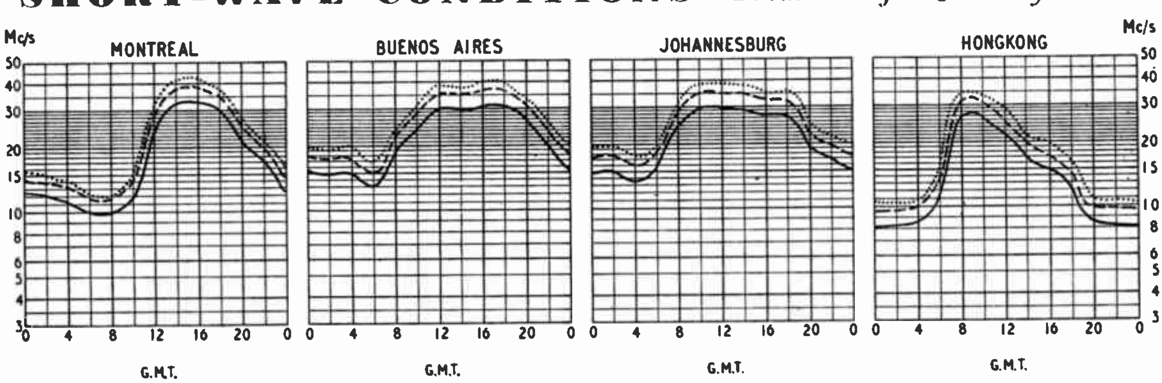
There are a number of problems in operating and maintaining these sets. Most of the readers are old and many have never seen or previously handled a set of this nature. In one distressing case a reader had been listening to the needle scratch for days, not realizing that the equipment had to be switched on. In another, the set which had ceased to function was returned to London, and smashed in transit, all because of a faulty flex lead, which had in any case been left behind, unseen, in the house.

Helpers with a knowledge of audio amplifiers are urgently needed in London and in many other areas in England to instruct new readers in the use of their sets and to investigate cases of faulty performance.

If you would like to assist or would like further information, please write to me at J. Gladstone & Co. Ltd., Galashiels.

D. FINLAY-MAXWELL.
Honorary Organizer of
Voluntary Helpers, Nuffield
Talking Book Library for the Blind.

SHORT-WAVE CONDITIONS *Prediction for January*



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

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

.... FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

——— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

Cathode-Coupled Flip-Flop

A Reliable Design Procedure

By T. G. CLARK,* A.M.Brit.I.R.E.

THE science of electronics is too frequently practised as an art, even by quite senior engineers, and, with a minimum of "know how," circuits are "bodged" to meet design requirements. In general, however, it is possible to produce a paper design that, when assembled practically, will produce a result within 5 to 20% of that predicted. Furthermore, less time is wasted by proper design methods. The introduction of feedback techniques into the design will render the operation stable and predictable. Having designed a circuit to within reasonable limits final adjustment may be effected by means of pre-set controls.

The cathode-coupled mono-stable multi-vibrator (shown in Fig. 1) is used extensively as a generator of pulses having durations ranging from micro-seconds to minutes. It is the object of this article to show that, using 5% tolerance components and the published valve characteristics, it is possible to design such a flip-flop to an accuracy of the order of 10%. Moreover, provided that a standard configuration is accepted, further design reduces to the simple equation

$$t_0 = KCR$$

It is not proposed to discuss the effect of tolerance variations upon the end result, for, as previously indicated, a pre-set control will take full account of such variations.

The information required to initiate the design is as follows:—

(1) Pulse duration, or durations.
(2) Pulse amplitude.
(3) Pulse polarity.
(4) Available h.t. supplies.

Circuit Operation.—Referring to Fig. 1, the grid resistor R of V2 is returned to a positive potential, Eg, whilst the grid of V1 is returned to a lower positive potential. The design is such that the anode current of V2 flowing in R_5 creates a potential that, in conjunction with the potential upon V1 grid, causes V1 to be cut off. The initial stable condition then, is that V2 is conducting heavily whilst V1 is cut off.

Trigger pulses of suitable polarity, as indicated in Fig. 1, upset the stable state as follows:—Positive pulses at V1 grid cause negative pulses at the anode and these are communicated through C to the grid of V2, thus causing the common cathode to drop. This switches on V1 thereby enhancing the original negative fall at the anode. The action is cumulative and results in V2 being switched off and in V1 being switched on for a period determined by the recovery time of V2 grid circuit. When the grid of V2 has recovered to a point within the grid base of the valve, essentially the same cumulative action resets the circuit to the stable state.

Since R_5 is common to V1 and V2 it will be seen that R_3 must be greater than R_4 in order to produce a drop at the common cathode during the operative period.

Typical waveforms and voltage levels are shown in Fig. 2. These waveforms are self-explanatory and of a type given in many text-books. For present purposes it is sufficient to note that, in terms of the total potential grid excursion, i.e. from -50 V to $+$Eg, the grid base of the valve is negligible. In addition, the difference between the quiescent potentials of V2 grid and the common cathode is also negligible. "Cut on" then occurs at the common cathode potential obtaining during the pulse. This potential may be varied by means of the potential at V1 grid, thus providing control of the pulse duration. Outputs of opposite phase may be taken from anode and cathode, the cathode output being at a relatively low impedance. It is not desirable that outputs should be taken from the anode of V1 or the grid of V2, since the loading of the external circuit will affect the predicted performance. However, if a negative going pulse of approximately 150 V is required, then an output may be taken from V2 grid, provided that the external circuit is of high impedance.

The simple description given earlier may be modified by a number of effects. For example, the trigger pulse should be of

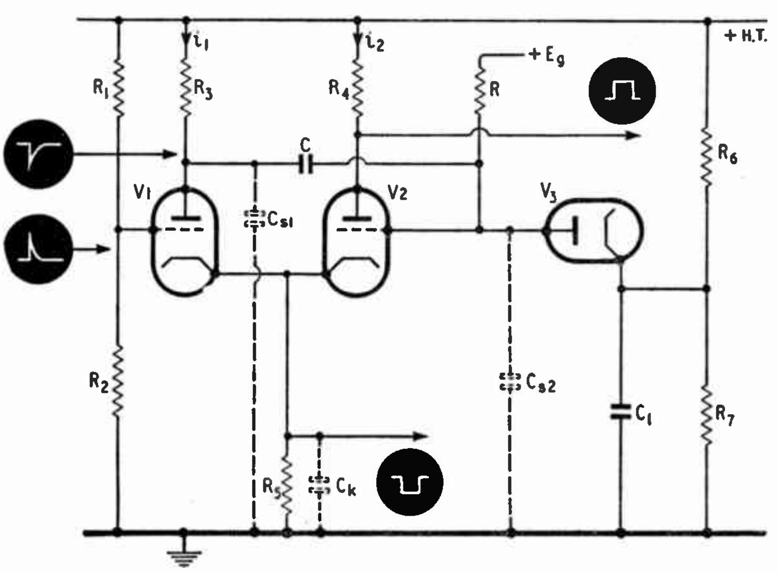


Fig. 1. Cathode coupled flip-flop circuit.

* Decca Radar Ltd.

adequate amplitude and duration having regard to the rise time of R_3 and the total stray capacity, $C_{s1}+C_{s2}$. Previously, it has been stated that an essential to the operation is that the common cathode must fall at the moment of initiation. If, in fact, the cathode does not drop adequately during the duration of the trigger pulse due to the effect of C_k, then regeneration will not occur and the circuit will behave simply as a cascaded amplifier. When using a trigger amplifier d.c. coupled into the anode of V1 the pulse duration will tend to be longer than that calculated, since V1 anode will fall by an amount dependent upon the anode current of V1 with the addition of an increment from the trigger amplifier.

The circuit operation depends upon the anode currents flowing during the respective "on" periods, so that design stability will be improved if these are subjected to negative current feedback. This may be accomplished by ensuring that the valves are operated during the respective "on" periods within the valve grid base, i.e. at a grid bias of about -1 V, and also by choosing an adequately large value for R_5. Valve V1 may be readily operated in the specified conditions by choosing a suitable value for its grid potential. For most purposes this is sufficient, but for more precise applications it is necessary to ensure that the quiescent grid potential of V2 is also within the grid base. (Normally, V2 grid is operated at zero bias due to grid current flowing in the grid resistor R.) The clamping diode, V3, in conjunction with the potentiometer R_6 and R_7 can be used to ensure that the grid cannot move more positive than the potential at the junction of R_6 and R_7, this potential being chosen to give the desired conditions. In order to ensure satisfactory clamping the parallel impedance of R_6 and R_7 must be very much lower than that of R. In addition, the capacitor C_1 should have a value very much greater than C in order to supply a re-charging pulse to C at the moment of clamping. In the absence of this capacitor a spike would occur on the lagging edge of the output pulse as the grid overshoots the clamp potential and then returns at a rate dependent upon C, R_6 and R_7.

In general, it is required that the rise and fall times of the output pulse should be as short as possible and, for this reason, the resistors across which outputs are taken are made as small as possible consistent with the limitation of valve anode dissipation. For a 12AT7 working at an h.t. potential of +250 V this means that, from Fig. 3, the sum of R_4 and R_5 should not be less than 6.8kΩ. Thus, if it is decided that the cathode resistor R_5 should have a value of 3.3kΩ, then the value of R_4 should not be less than 3.6kΩ. However, if the design requirement does not require fast edges to the output pulse, then R_4+R_5 may be made larger than this minimum value, thus achieving economy in the operating current.

Introduction to Design.—The principles underlying the design may be summarized as follows:—

(1) The conditions in the two valves are considered separately during the respective operative periods.

(2) The valve V1 is operated within the grid base, i.e. at a bias of -0.5 V to -1 V, in order to obtain current stabilization.

(3) Grid current onset in V2 is assumed to occur at $V_g=0$, and the anode current at this point is assumed to be moderately constant from valve to valve.

(4) The grid base of V2 is assumed to be negligible compared to the potential grid swing.

(5) For more precise applications, a clamping diode V3 is used to maintain V2 within the grid base during the quiescent period, in order to obtain current stabilization.

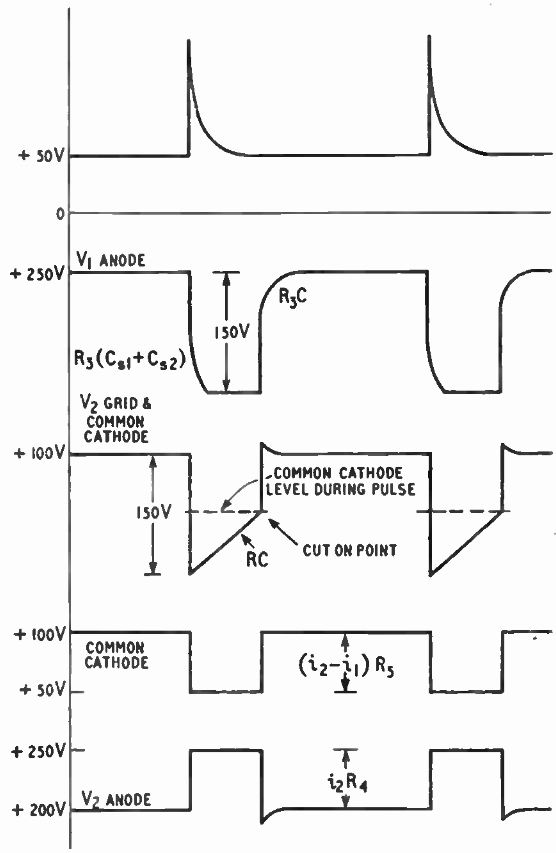


Fig. 2. Cathode coupled flip-flop waveforms with typical voltage levels.

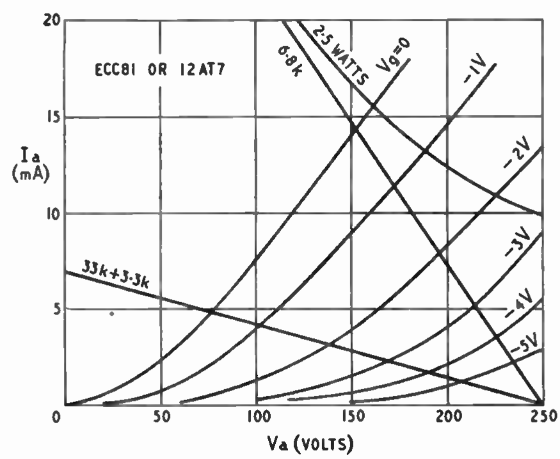


Fig. 3. Characteristic curves of ECC81/12AT7 with loadlines used.

(6) A clamping diode may also be used when the value of R would cause excessive grid current at $V_g=0$.

(7) A positive-going pulse of amplitude i_2R_4 may be taken from the anode of V2.

(8) A negative-going pulse of amplitude $(i_2-i_1)R_5$ may be taken from the common cathode.

(9) All components shown in Fig. 1, except C_1, should be 5% preferred values.

For present purposes R_3 will be 33kΩ and R_5 3.3kΩ. R_4 will be chosen having regard to the required amplitude of the output pulse, the maximum anode dissipation of the "normally on" valve, and the requirement that it should be smaller than R_3 in order that the common cathode may fall adequately during the pulse. It may be observed here that R_4 may be zero if a negative pulse only is required.

Consider, now, the load line for V1, the 36kΩ line of Fig. 3. For a bias of, say, −0.5 V a current i_1 flows, and this is the current in R_5 when V2 is cut off. The potential at the grid of V1 will be given by $(i_1R_5-0.5)$ V, and the ratio $R_2/(R_1+R_2)$ is established. Actual values may be chosen having regard to a convenient current flow and preferred values of resistors. The effective negative bias on V1 when V2 is conducting will be given by $i_2R_5-(i_1R_5-0.5)=R_5(i_2-i_1)+0.5$ V. This value is dependent upon the difference between the two operating currents and must be greater than the grid base of V1.

If it is required to operate V2 within the grid base the ratio $R_7/(R_6+R_7)$ must be chosen to operate V2 at a suitable negative grid bias relative to the cathode. Additionally, as we have already mentioned, the parallel sum of R_6 and R_7 must be very much less than the lowest value of R in order to ensure effective clamping.

Calculation of Pulse Duration.—Now that the operating conditions during the respective operative periods have been established it is possible to calculate the generated pulse width. Consider Fig. 4.

The amplitude of the exponential curve, relative to point A at any time t, is given by:—

$$E(t) = E\left\{1 - e^{-\frac{t}{T}}\right\}$$

where T = CR

$$\text{Therefore } e^{-\frac{t}{T}} = \frac{E - E(t)}{E}$$

$$\text{and } \frac{t}{T} = \log_e\left\{\frac{E}{E - E(t)}\right\}$$

$$\text{Giving } T = CR = \frac{t}{\log_e\left\{\dfrac{E}{E-E(t)}\right\}} \quad \ldots \quad \ldots \quad (1)$$

Putting the required time interval as t_o and the value of $E(t)$ to the "cut on" point as E_o, we have then, from Fig. 6,

$$E = Eg + i_1R_3 - i_2R_5$$
$$E_o = i_1R_3 - (i_2 - i_1)R_5$$

Since the grid potential of V2 during the quiescent period is very nearly equal to the common cathode potential and the grid base of V2 is negligible compared to the total potential grid excursion (to $+E_g$).

$$\text{Thus } CR = \frac{t_o}{\log_e\left\{\dfrac{Eg + i_1R_3 - i_2R_5}{Eg - i_1R_5}\right\}} \quad \ldots \quad (2)$$

$$\text{whence } t_o = KCR \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

$$\text{where } K = \log_e\left\{\frac{Eg + i_1R_3 - i_2R_5}{Eg - i_1R_5}\right\} \quad \ldots \quad (4)$$

and this is a constant for a given configuration in which only t_o and CR are variables.

For convenience equation (4) may be re-written

$$K = \log_e\left\{\frac{Eg/R_5 + i_1\dfrac{R_3}{R_5} - i_2}{Eg/R_5 - i_1}\right\} \quad \ldots \quad \ldots \quad (5)$$

$$= \log_e\left\{\frac{i_3 + i_1\dfrac{R_3}{R_5} - i_2}{i_3 - i_1}\right\} \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

where $i_3=Eg/R_5$

It may be shown that the circuit operation is less sensitive to variation of the individual components within the bracket if the bracketed term is made as large as possible consistent with other requirements. In the design to be discussed the value of this term is approximately 1·5. This value is quite suitable, and since the function is logarithmic, an optimum value cannot be given. From equation (6) it may be inferred that R_5 should be small. However, this contradicts the requirement for current stability.

As i_3 will be greater than i_1 it can be seen that, for the bracketed term to be positive, we must have $i_3 > i_2 - i_1\dfrac{R_3}{R_5}$

i_3 should be made large by using a high value for Eg. This is in accordance with the conception of having a large potential grid movement (returning to +Eg) in order that, (a) the grid base may be considered negligible and that, (b) the rate of change of the grid movement through the grid base shall be fast, thus minimizing time jitter on the back edge of the pulse.

Apart from the basic design considerations previously discussed there are a number of factors establishing limits to the circuit values. These may be enumerated as follows:—

(1) C should be not less than about 100 pF in order to obviate the modifying effects of the stray capacitance C_{g2}, unless a cathode follower is interposed between V1 and V2.

(2) R should not be less than about 0·5MΩ in order to limit grid current, except when a clamping diode is used. However, a low value of R will reduce the a.c. gain of V1.

(3) R should not exceed 10 MΩ from considerations of component stability and circuit leakage.

(4) When operating at high duty ratios C should have adequate time to recover. A time equivalent to at least 5 CR_3 should be allowed, and it may be that this consideration will dictate the choice of C and hence R.

(5) Components must be adequately rated. Cer-

(Continued on page 27)

tain components will have a dissipation dependent upon the duty ratio; this should be considered when designing a flip-flop of variable duration.

(6) Positive trigger pulses capacity coupled to V1 grid should not drive this valve into grid current, otherwise the recovery of the grid coupling capacitor will modify the circuit operation.

Practical Design.—As an example, the following specification will be discussed.

Pulse width	..	100 μs
Output ..	..	+ 50 V
H.T. Supply	..	+250 V
Other considerations		Variable duration not required. Fastest possible pulse edges consistent with using a standard valve type 12AT7. Extreme precision not required.

The design procedure then runs as follows

$$R_3 = 33k\Omega \quad , \quad Eg = +250\ V$$
$$R_5 = 3.3k\Omega \quad , \quad V_3 \ \text{not required}$$
$$\text{Try } R_4 + R_5 = 6.8k\Omega$$

From the characteristic curves of Fig. 3,

$$i_2 = 14\ \text{mA at Vg} = O$$
$$\therefore R_4 = \frac{50}{14} = 3.6k\Omega,$$

agreeing sufficiently with our values for R_5 and $R_4 + R_5$.

If this trial had been unsuccessful different values for R_4 and R_5 would have been tried. There would be no objection to varying R_5 within reasonable limits.

From the characteristic curves,

$$i_1 = 4.5\ \text{mA at Vg} = -0.5\ V$$

Therefore $i_1R_5 = +14.8$ V
and the voltage at V1 grid is given by

$$i_1R_5 - 0.5 = 14.3\ V$$

$$\text{Therefore} \quad \frac{R_2}{R_1 + R_2} = \frac{14.3}{250}$$

$$\text{i.e.} \quad \frac{R_1}{R_2} = 16.5$$

This ratio is obtained if $R_1 = 240k\Omega$ and $R_2 = 15k\Omega$, both of which are preferred values.

$$\text{Proceeding, } CR = \frac{100 \times 10^{-6}}{\log_e \left\{ \dfrac{250 + (33 \times 4.5) - (3.3 \times 14)}{250 - (3.3 \times 4.5)} \right\}}$$
$$= 250 \times 10^{-6}$$

$$\text{Let } C = 250\ \text{pF}$$
$$\text{Then } R = 1\ M\Omega$$

The pulse amplitude and duration of this design were 53 volts and 97 μs as measured on a Cossor oscilloscope.

Another flip-flop was designed by the same method but to a different specification. The durations measured on the same instrument were as follows:—

Calculated	Measured
406 ms	380 ms
263 ms	270 ms
128 ms	125 ms
73 ms	70 ms
41 ms	38 ms
26 ms	26 ms

All components shown in Fig. 1, except C_1, have an effect upon the circuit operation. Final trimming may be achieved by varying any such component.

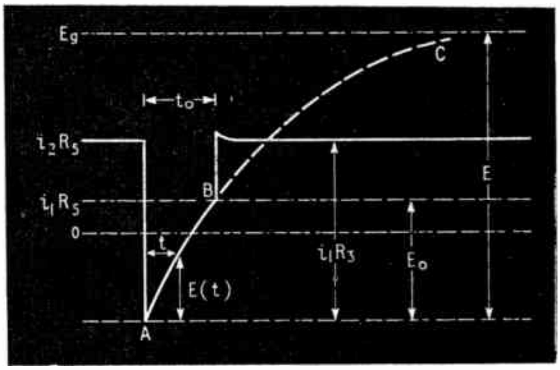


Fig. 4. Detail of V2 grid waveform.

The circuit of Fig. 1 has been used in production equipment as the heart of a decade counter with complete success. Greater precision than the basic circuit offers was obtained by utilizing an amplitude-limited negative pulse stream applied to V1 grid as terminating pulses.

A method of design has been offered which permits the engineer to design a flip-flop without excessive trial and error, and to achieve results within normal experimental error. The design formula for an established configuration has been reduced to $t_0 = KCR$.

Dates for Your "Wireless World" Diary

ANNOUNCEMENTS have already been made of the dates of many of this year's exhibitions and conventions, but for the convenience of readers we give below a list of the principal events in 1958.

Television Society Exhibition ... ... Royal Hotel, Woburn Place, London, W.C.I.	**March 4–6**
Physical Society Exhibition ... ... Royal Horticultural Society Halls, London, S W I.	**March 24–27**
International Instruments Show ... ... Caxton Hall, Westminster, London, S.W.I.	**March 24–29**
Electrical Engineers' Exhibition (A.S.E.E.)... ... Earls Court, London, S.W.S.	**March 25–29**
Convention on Radio Aids to Navigation ... I.E.E., Savoy Place, London, W.C.2.	**March 27–28**
Components Show (R.E.C.M.F.) ... ... Grosvenor House and Park Lane House, Park Lane. London, W.I.	**April 14–17**
Instruments, Electronics and Automation Show... Olympia, London, W.14.	**April 16–25**
Audio Fair... ... ... Waldorf Hotel, London, W.C.2.	**April 18–22**
International Convention on Microwave Valves I.E.E., Savoy Place, London, W.C.2.	**May 19–23**
National Radio Show (R.I.C.) ... ... Earls Court, London, S.W.S.	**Aug. 27–Sept. 6**
Farnborough Air Show (S.B.A.C.)	**Sept. 1–7**
Electronic Computer Exhibition ... ... Olympia, London, W.14.	**Nov. 28–Dec. 4**
OVERSEAS	
Symposium on Reliability and Quality Control... Washington, U.S.A	**Jan. 6–8**
I.R.E. National Convention and Show ... ... New York, U.S.A.	**March 24–27**
British Electrical Conference... ... ... Brussels, Belgium.	**May 16–17**
Solid State Physics in Electronics and Telecommunications (Conference) ... ... Brussels, Belgium.	**June 2–7**
International Analogy Computation Meeting ... Strasbourg, France.	**Sept. 1–9**
International Congress of Cybernetics ... ... Namur, Belgium.	**Sept. 3–10**

Magnetism in Materials

I.—The Physical Basis of Dia-, Para-, Ferro- and Ferri-Magnetism

BY D. H. MARTIN, Ph.D.

ALTHOUGH only four of the elements—iron, nickel, cobalt and gadolinium—are ferromagnetic, there is to-day available to the electrical engineer a remarkable range of magnetic alloys and compounds from which he must select the most appropriate for his particular application. In these articles I plan to examine more closely what conditions led to the distinctive and useful phenomenon of ferromagnetism, and then to illustrate how the bewildering variety of magnetic behaviour may be understood in terms of a few basic ideas.

All substances become magnetized when subjected to a magnetic field though sensitive apparatus is needed to detect the induced magnetization except in the case of the ferromagnetics. Most materials are either paramagnetic or diamagnetic. A specimen of the former kind will move, when placed in a non-uniform magnetic field, to the point where the field is most intense. This is because the induced magnetization is in the same direction as the field, as it is in the case of the ferromagnetics. The intensity of magnetization, however, is at least a million times less than that which would be induced in a ferromagnetic sample. Specimens of a diamagnetic material, on the other hand, move to where the applied field is least intense, for example, away from the pole-pieces of a magnet. This is because the induced magnetization is opposite in direction to the applied field; it is of the same order of magnitude as that in a paramagnetic sample. Almost all organic materials are diamagnetic and, among the elements, copper, silver, gold and hydrogen are examples of diamagnetics, and oxygen, aluminium and platinum of paramagnetics.

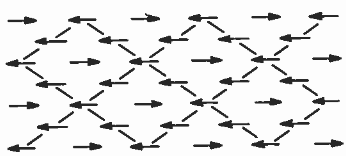


Fig. 1. Oppositely magnetized super-lattices illustrating the spontaneous magnetization within each domain of a ferrimagnetic material.

Materials are magnetic because atoms themselves behave as magnetic dipoles, that is exactly as minute bar magnets or as minute electric current circuits. This, of course, is not surprising since it is well known that electrons circulate within each atom around its nucleus. There is, moreover, experimental evidence of a direct nature for the dipolar properties of individual atoms. In a non-uniform field a dipole experiences a translational force proportional to its dipole moment and in the 1920s Stern and Gerlach directed a beam of atoms, which had been evaporated from a metal in a furnace, through the pole gap of an electromagnetic which produced a non-uniform field. The beam was deflected and the deflection was registered by condensing the atoms on a cold plate where, after a time, they left a visible trace. In this way precise measurements of atomic dipole moments were made and much was learnt about atomic structures.

A point of particular interest for our present purpose is that atoms of iron, nickel and cobalt do not have dipole moments which are very much larger than those of other atoms. The extreme ease with which a ferromagnetic may be magnetized to a high degree is certainly not due to its atoms possessing peculiarly high magnetic moments. It must, therefore be due to a particular kind of arrangement of the atomic dipoles, and I shall discuss this arrangement in some detail later. First I must describe briefly what happens in paramagnetic and diamagnetic materials.

Diamagnetism.—The several electrons in each diamagnetic atom or molecule move in orbits which are so directed that they give rise to a zero resultant magnetic moment in the absence of an applied field. There is a fundamental reason for electrons in atoms adopting such a balanced distribution and so diamagnetic materials are by no means uncommon. In an applied field, however, the magnetic forces which act on the electronic currents within each atom distort the orbits and thus induce a resultant magnetic moment, which is always opposite in direction to the applied field. This may be looked upon as an example of ordinary electromagnetic induction and the negative direction of the induced dipole corresponds to Lenz's law, which governs the direction of induced e.m.f. This process is diamagnetism.

Paramagnetism.—A paramagnetic atom, on the other hand, has a permanent dipole moment regardless of whether a field is applied or not. The magnetic fields due to the moving electrons in each atom do not cancel one another out. In the absence of an applied field the energetic thermal vibrations of the atoms in a paramagnetic sample cause their dipole moments to be directed in a completely random way, and the direction of each dipole changes rapidly with time. The overall magnetization of a sample is, therefore, zero. The fields attainable in practice are sufficiently intense only slightly to disturb this completely random arrangement. In the presence of an applied field each atomic dipole spends slightly more of its time in directions having components parallel to the applied field, and less time in directions opposed to the field. The sample as a whole, therefore, exhibits a weak magnetization and this is paramagnetism. In a hypothetical field of sufficient intensity the dipoles would approach a saturated condition, each being almost parallel to the field. This stage would be expected only if the magnetic potential energy of an atom became comparable to the energy of its thermal vibration. That is to say if

$$\mu H \approx kT$$

where μ, k and T are respectively the dipole moment of an atom, Boltzmann's constant, and the absolute temperature. Now μ is of the order 5×10^{-20} e.m.u. and k is 1.38×10^{-16} erg per °K, and H cannot in practice exceed about 100,000 œrsteds. Even with such intense fields, therefore, saturation effects should not be observable except at very low temperatures, a few degrees above absolute zero. Such effects have, in fact, been recorded recently in experiments conducted at about 4°K, that is −269°C. At more normal temperatures the intensity of magnetization, I, is strictly proportional to the strength of the applied field, H, and the ratio I/H, that is the susceptibility, is of the order 10^{-5} e.m.u. for most paramagnetic materials at room temperature. This is in contrast with susceptibilities of more than 10^3 in most ferromagnetic materials.

Ferromagnetism.—The characteristic feature of ferromagnetism is the attainment of a high intensity of magnetization in comparatively small fields, and even the retention of an intense magnetization when the field is switched off. As the field applied to a demagnetized specimen is increased the intensity of magnetization rises rapidly until saturation is attained when no further increase in magnetization is possible, however much the field may be increased. This occurs in fields of less than a few hundred œrsteds, for some materials in fields of only an œrsted or so. The saturation value of magnetization is just about what would be expected if nearly all the atomic dipoles were aligned parallel to one another. This is in fact the situation that exists in a saturated ferromagnetic material and the problem of ferromagnetism is to explain how this comes about in such small fields, in spite of thermal vibrations.

It is known that a sample of ferromagnetic material is made up of small contiguous regions, called domains, within each of which almost all the atomic dipoles are aligned exactly parallel to one another even in the absence of an applied field (see Fig. 3). This alignment is known as spontaneous magnetization and its direction in each domain is different from that in the neighbouring domains. Spontaneous magnetization is the basic characteristic feature of ferromagnetism. It can be destroyed only by heating the specimen above a critical temperature called the Curie point, which for iron is 770°C, for nickel 358°C, for cobalt 1,120°C and for gadolinium 16°C.

The arguments of the previous section on paramagnetism therefore indicate, since saturation effects persist at these high temperatures, that whatever force it is that aligns the atomic dipoles to give spontaneous magnetization, it must be equivalent to a large internal magnetic field of some ten million œrsteds! It was not until 1928 that the nature of these forces was discovered by Heisenberg. They are clearly too large to be ordinary magnetic forces and in fact they are due to an interaction, between neighbouring atoms, which requires the language of modern quantum physics for a full description. An atomic electron spins about its own axis as well as moving in an orbit round the nucleus. The elementary atomic dipole moments in ferromagnetic materials are in fact due entirely to the spin motions of certain of the electrons, the moments associated with the orbital motions cancelling out. Now a full quantum description of a spinning electron shows that between any two electrons there is an interaction, known as exchange interaction, which tends to set the spin dipole moments either parallel or antiparallel to each other, depending on the details of the situation. The effects of exchange interactions in simple molecules are well established, but a metal consists of many millions of interacting atoms and the theory has not yet been fully worked out in rigorous detail. There is no doubt, however, that spontaneous magnetization is due to an alignment of the spin motions of certain electrons in the material under the action of exchange forces.

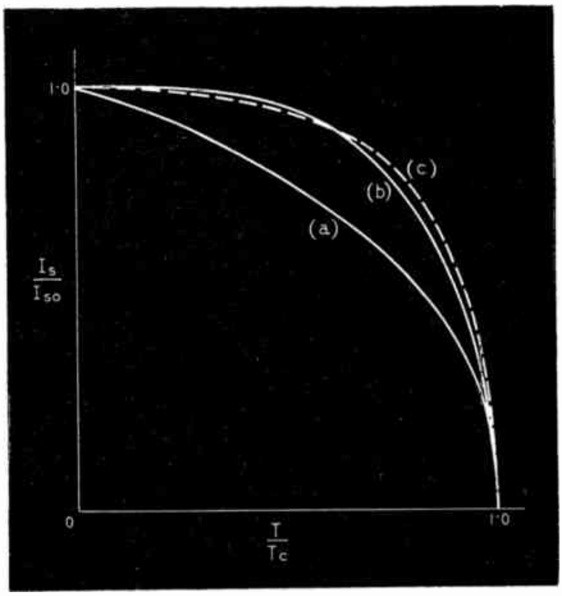


Fig. 2. Variation of the spontaneous magnetization I_s of iron, nickel and cobalt, with temperature T. I_{so} is the spontaneous magnetization at absolute zero of temperature and T_c is the Curie temperature. Curve (a) is given by the simple Weiss theory, (b) by an improved Weiss theory and (c) records the experimental values of iron, nickel and cobalt.

It is argued that the alignment will be parallel rather than anti-parallel if the number of interacting atoms is large and if the radius of the electron orbits is relatively small compared with the distance between the atoms. Now the electrons in an atom are arranged in "shells" at different distances from the nucleus. In an atom of an element belonging to the group known as the transition metals the resultant dipole moment is due entirely to the electrons in an inner shell known as the 3d shell. The magnetic effects of the other electrons cancel out. Of these metals, iron, nickel and cobalt have the smallest ratio of 3d radius to atomic separation. That they are ferromagnetic is therefore in accord with the conclusion above. It is of great interest to note that manganese and chromium, both of which are transition metals, but paramagnetic when pure, can be rendered ferromagnetic by alloying them with certain other metals, thus altering the inter-atomic distances. For example the Heusler alloys are ferromagnetic. They contain manganese, copper and aluminium but no iron, nickel or cobalt. Compounds of manganese with arsenic, with bismuth, with tin, and several other elements are ferromagnetic. Chromium compounds containing antimony, arsenic, platinum, or a number of other elements are ferromagnetic.

Gadolinium is the only pure element other than iron, nickel and cobalt which is known to be ferromagnetic, though it is suspected that dysprosium might be at very low temperatures. As in the transition metals, the atomic dipole moment of gadolinium is due solely to the electrons in an inner shell.

There is a group of non-metallic materials which exhibits properties resembling those of the ferromagnetic metals. They are intimate mixtures of iron oxide and oxides of divalent metals and have recently gained commercial recognition mainly because of their high electrical resistivity, as I shall discuss in more detail in a later section. They are known as ferrites, and the term ferrimagnetic has been coined for the rather different arrangement of atomic dipoles in these materials. They resemble ferromagnetics in that they are spontaneously magnetized and have a domain structure, and they are often included under that title. A ferrimagnetic must be a compound because two kinds of dipole are involved. Nearly all the dipoles of the one kind are aligned parallel to each other, while the others are also aligned but in the opposite direction. The situation is illustrated in Fig. 1. Spontaneous magnetization results from this anti-parallel arrangement since one kind of dipole is more numerous and/or has a larger dipole moment.

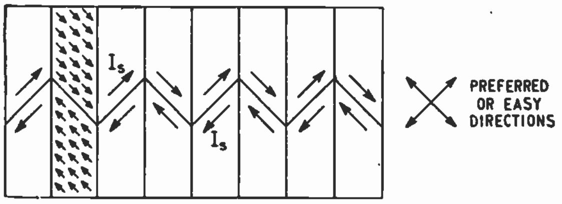


Fig. 3. Example of the arrangement of spontaneous magnetization in a domain structure. The alignment of atomic dipoles is illustrated in two of the domains.

The general formula for a ferrite is Fe_2MO_4 where M is any divalent metal, for example copper, silver, magnesium, manganese, lead, zinc, etc. The crystal structure is of the type known as a spinel, that is the oxygen atoms are arranged on a close-packed cubic lattice and the metallic atoms occupy the interstices between the oxygen atoms. There are two kinds of interstice and they are known as tetrahedral and octahedral sites. A metallic atom in a tetrahedral site is surrounded by four oxygen atoms and in an octahedral site by six.

The elementary dipoles in a ferrite are the metallic atoms, those in one kind of site forming one spontaneously magnetized super-lattice and those in the other forming the oppositely directed super-lattice. There are twice as many octahedral as tetrahedral sites and so an overall spontaneous magnetization results. Exchange forces are again responsible for the spontaneous magnetization, but whereas in a ferromagnetic metal the interaction favours parallel alignment, in a ferrimagnetic the interaction of predominant importance is that between a metallic atom in a tetrahedral site and its neighbours in octahedral sites, and this interaction is negative, favouring anti-parallel alignment, and the two oppositely magnetized super-lattices result. The intensity of spontaneous magnetization in a ferrite is, of course, considerably smaller than that in a ferromagnetic metal.

Only at absolute zero of temperature does the magnitude of the spontaneous magnetization in ferromagnetic materials correspond exactly to complete alignment of the elementary dipoles. Above this temperature thermal vibration of the atoms always causes a few dipoles to be unaligned. At the Curie point the thermal agitation is sufficient to override even the strong exchange forces and full disorder sets in with the complete disappearance of spontaneous magnetization.

The variation of the intensity of spontaneous magnetization, I_s, with temperature is shown for iron, nickel and cobalt in Fig. 2. Long before Heisenberg, in 1928, identified exchange interaction as the force producing spontaneous magnetization, Weiss had shown (1908) how the phenomenon could be understood in terms of a hypothetical molecular field and he derived an expression for the dependence of I_s on temperature which to a first approximation agrees well with the observed variation. He supposed that each elementary dipole behaved as if acted upon by a molecular field, which he assumed to be proportional to the mean magnetization of the specimen. The molecular field is now recognized as an approximate representation of the exchange forces, since the exchange force tending to set an atomic dipole in a particular direction is greater the larger the number of its neighbours already set in that direction, that is the larger the magnetization, I, in the material surrounding the dipole. Weiss used this assumption in elaborating upon the Langevin theory of paramagnetism which showed that the intensity of magnetization of a paramagnetic specimen depended upon H the applied field, and T, the absolute temperature, according to the relation:

$$I = I_0 \tanh (\mu H/kT).$$

μ and k are the atomic dipole moment and Boltzmann's constant respectively, and I_0 is the magnetization which would be observed if all the atomic dipoles were perfectly aligned. The presence of T reflects the effect of thermal vibrations. For H Weiss substituted WI, where W is the molecular field constant, thus

$$I = I_0 \tanh (\mu WI/kT).$$

This relation contains the dependence of I upon T. Since the applied field is zero, I is here the spontaneous magnetization, I_s. The relation above is plotted in Fig. 2 with the experimentally observed variation. The Weiss theory is only an approximation to the real state of affairs, and the fuller theories are complex and not yet fully worked out.

The molecular field representing the exchange forces proves to be of the order 10 million œrsteds. It will be clear, therefore, that the fields used in practice, which seldom exceed 10,000 œrsteds, are negligible in comparison and cannot change the magnitude of the spontaneous magnetization by a significant amount. The complicated changes in the overall magnetization of a specimen which occur when it is subjected to an applied field must therefore be due to changes in the direction of I_s in the domains of the sample. Recent studies of such changes have contributed enormously to our understanding of ferromagnetic behaviour and I shall describe the main features of domain theory in the following sections.

(To be continued)

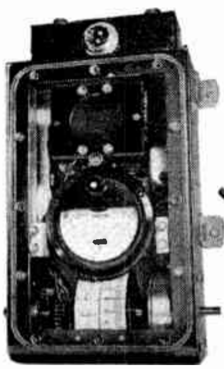
Technical Notebook

Gold Dip-Plating, using "Atomex" solution developed by the Baker Platinium division of Engelhard Industries, is claimed on a variety of metals, including copper, zinc, nickel, iron, steel and pewter. The plating takes place by ionic displacement so that no electric current is necessary. Thus there is no possibility of electrical shielding and a uniform deposit even in recesses is obtained. Control of temperature and pH is necessary, particularly when depositing on copper and for obtaining consistent colour in decorative work. The solution may be operated between 60°C and boiling point, except for deposition on copper, when the range is from 45° to 75°C. The pH is initially between 7 and 8, and should be kept in this region during deposition by adding small amounts of ammonia. Otherwise the solution becomes slightly acid and the pH drops to 6. All the gold in the bath can be used and the spent solution thrown away. Suitable container materials are polyvinyl plastics or glass.

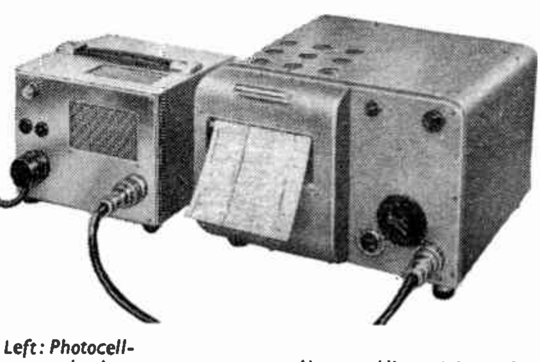
Gas Electrochemical Cell using hydrogen and oxygen (or air) has been developed by the National Carbon Company of America, and is described in the October 1957 issue of *Electronics*. Each gas is fed at a pressure of about one atmosphere into a hollow porous carbon rod surrounded by potassium hydroxide as the electrolyte. The reaction produces water, which is removed by evaporation. As this is the only by-product the cell theoretically has an infinite life. About one volt is developed, and it is hoped to produce as much as 1 kW per cubic foot of cell volume.

Photocell-Powered Ohmmeter, using a selenium cell as the source of electric current for a resistance bridge, has been developed by the Fairey Aviation Company for testing the firing circuits of guided missiles. The idea is to ensure that the electrical energy applied to the missile remains below the safety margin so that there is no danger of accidental ignition. Hitherto current or voltage limiting devices have been used, but of course these can break down. With the selenium cell the output under any condition of light saturation or failure cannot exceed a short-circuit current of 10mA or an open-circuit voltage of 0.7V. The bridge itself will measure 0-10kΩ in four ranges with a fundamental accuracy of ±0.3%. The actual accuracy achieved, however, depends on the measurement sensitivity, which in turn depends on the current resulting from the light falling on the photocell. The light intensities required to produce detectable galvanometer currents with different range and scale settings and a ±10% change of the "unknown" element vary between 0.7 and 13 foot candles. These are sufficient to give a measurement accuracy of approximately ±5%.

Ultra-Violet Galvo Recorder seen recently in operation at the Radar Research Establishment combines the sensitivity of galvanometer indication with the ability to give directly written records. This is achieved by using mirror galvanometers to reflect ultra-violet radiation from a mercury vapour lamp on to ultra-violet-sensitive recording paper. The trace is developed simply by exposure to daylight, and becomes visible immediately with low writing speeds and in less than ten seconds with high speeds. Made by New Electronic Products, the instrument provides six recording channels and has paper speeds of 0.2, 0.6, 2 and 6 inches per second. A trace velocity as high as 10,000 inches per second can be obtained, and the galvanometers will operate over a frequency range from d.c. up to 2 kc/s. The records are said to be permanent unless exposed for a considerable time to strong daylight, and will remain stable for weeks under normal room illumination and hold indefinitely if filed away in the dark. For real permanence they can be fixed by standard photographic methods.

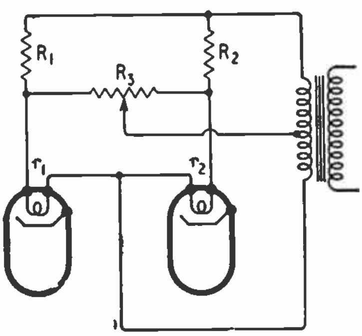


Left: Photocell-powered ohmmeter.



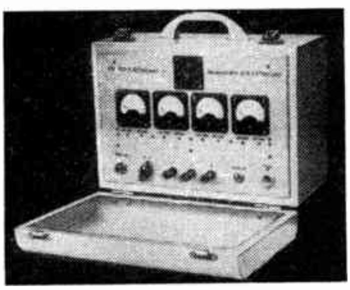
Above: Ultra-violet galvo recorder.

Valve Matching Circuit.—D.C. amplifiers commonly consist of balanced push-pull stages. Drift can take place if variations in heater voltage affect one valve of a pair more than



the other. A new circuit described by D. J. R. Martin in the December issue of *Electronic and Radio Engineer* makes it possible to adjust the sensitivity of a valve to heater-voltage changes. Pairs of valves can then be matched so that balance is maintained even when the heater voltage varies. The matching principle depends on the fact that when heaters are supplied from a high-impedance source, changes in heater *current* have a much greater effect than do changes in *voltage* when the valves are supplied from a low-impedance source. Differential adjustment of the source impedance "seen" by pairs of heaters in balanced amplifiers can therefore be used to equalize the sensitivities of the heaters to supply variations. In the circuit diagram, adjustment of R_3 alters the source impedance. For example, with the slider in the extreme right-hand position, r_2 is connected directly across a transformer winding, and therefore "sees" a very low source impedance, while r_1 "sees" an impedance made up of R_1 in parallel with something in excess of R_3. The left-hand valve is then supplied with heater power from a high-impedance source, so that it is affected more by power-supply variations than the right-hand valve. By adjusting R_3 the sensitivities of the valves can be equalized.

Transistorized Timer recently introduced by Venner Electronics uses 46 transistors but has a consumption of only 1 watt at 12V. It it constructed from nine packaged stages and has a range of time measurement of 0.1msec to 27.8 hours. The basic time reference is a transistorized crystal oscillator operating at a frequency of 10kc/s. Pulses from this are passed via a gate to four decade counters, and thence to a mechanical counter. The division ratio given by the four decades is 10,000, so that the mechanical counter receives 1 pulse per second. The elapsed time can be read in seconds from the mechanical counter, with four decimal places taken from meters, calibrated 0-9, connected to the decades. The gating is arranged so that the open or closed times of contacts can be measured, or the time between one pair of contacts opening or closing and another pair opening or closing. Operation by

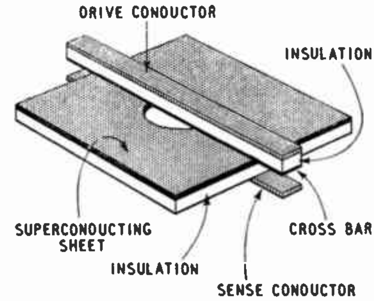


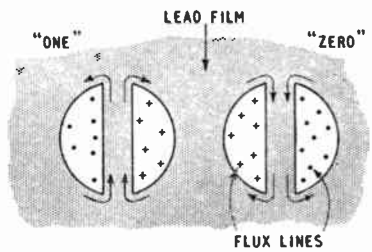
pulses is also catered for. Another timer has been developed by Venner for measuring the speed of road vehicles. This gives the time interval between the operation of two pressure switches which are actuated by the vehicle crossing two rubber tubes laid across the road at a known spacing. The switches open and close a gate which allows cycles of a 2.5-kc/s signal (obtained by frequency division from a 10-kc/s crystal oscillator) to be counted by three decades and displayed on three meters with digital scales. The frequency and rubber tube spacing are chosen so that the vehicle speed can be quickly calculated from the meter indication.

Helical Magnetization Patterns in magnetic wires, produced by the application of coincident circular and longitudinal fields, may provide the basis of a new kind of matrix store which is simpler and cheaper to manufacture than existing ferrite-core and magnetic-cell types. Exploratory work is being done by A. H. Bobeck at Bell Telephone Laboratories. The idea is that the matrix shall consist of arrays of vertical magnetic wires interwoven with horizontal copper wires. Current passed through the magnetic wires produces the circular fields around them and current through the copper wires the longitudinal fields. The preferred direction of magnetization in the magnetic wires can be shifted from the normal longitudinal path to a helical path by mechanical torsion or perhaps eventually by processing during manufacture. The storing of a binary digit requires two coincident current pulses —one in a magnetic wire and the other in a copper wire. Reading out is accomplished by applying a strong longitudinal field in the reverse direction, and the read-out signal is detected across the magnetic wire. It is thought that at least 10 binary digits per inch could be stored without interaction on a magnetic wire formed by coating a conductor with magnetic material. Transistors could probably be used for the drive circuits.

Integrated Tuning Assemblies giving a simultaneous change of capacitance and inductance are being developed by Plessey for u.h.f. tuners. They consist of variable capacitors with stators incorporating inductive loops. When the rotor (which has no connections made to it) is unmeshed from the stator it becomes in effect a short-circuited secondary coupled to the inductors, thereby reducing their inductance at the same time as the capacitance is reduced. This system has been known as a "butterfly" resonator in the past because of the particular shape of the rotor vanes.

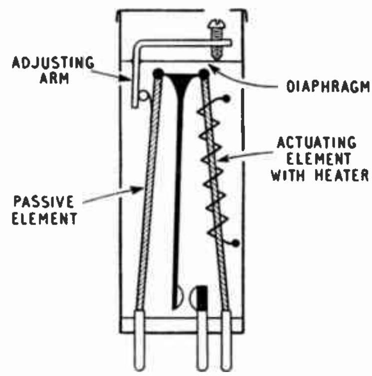
Superconductive Storage Element devised by International Business Machines and mentioned in our November, 1957, issue (p. 547) depends on the magnetic flux produced by circulating currents induced in a superconductive lead sheet. (The superconducting condition being obtained by operation at extremely low temperatures below 10°K.) The lead film deposited on an insulator, has a hole cut in it with a lead bar metallized across. When a current pulse is sent through the drive conductor the resultant build-up of magnetic flux links with the superconductor and induces currents in it, as shown in the next column. These circulate indefinitely because of the zero resistance and set up their own magnetic flux. Whether a "1" or a "0" digit is stored is determined by the direction of the induced currents. Actually, the initial build-up of induced current is quite complex because the presence of a magnetic field affects the threshold of superconductivity and the induced magnetic field opposes the driving field. Reading-out is achieved by sending a current in the reverse direction along the drive conductor. This causes the induced currents to collapse, and the resultant change of magnetic flux induces a current pulse of one direction or the other in the sense conductor. An experi-





mental element described in the *IBM Journal of Research and Development* for October, 1957, is said to operate about 100 times faster than ferrite-core stores and to require less than a half of their driving current.

Thermal Delay Relay with greater rigidity and resistance to shock than conventional bi-metal strips has an actuating element which is fixed at both ends and expands longitudinally when its heater is energized. A simple mechanism (shown diagrammatically in the sketch) multiplies the difference in expansion between this element and a similar passive element so as to move the contact arm towards or away from the fixed contact. Ambient temperature changes expand the two elements equally and so do not move the contact arm. The time delay is set by the adjusting screw and arm, which determine the initial contact gap and consequently the time required for operation. Made by G.V. Controls, the relay is available from Mercia Enterprises in various types and ranges, with time delays from 0.5 to 180 seconds.



Starting Tape Driving Mechanisms*

MECHANICAL DESIGN TO AVOID LOOP FORMATION AND SNATCHING

IN magnetic recorders used for analogue signals (including broadcast programme material) the tape mechanism can be divided into three parts, the take-off or feed reel and tension device, the take-up reel and drive, and the drive capstan and pinch wheel.

Such a combination is shown in Fig. 1 in which the tape tension on the feed side of the capstan is provided by means of a reel motor connected to exert an anti-clockwise torque as viewed from above. Ideally, the operation should be that the reeling devices set the desired tape tension and that the capstan is concerned only with tape motion. Practical considerations, however, set limits to the extent to which

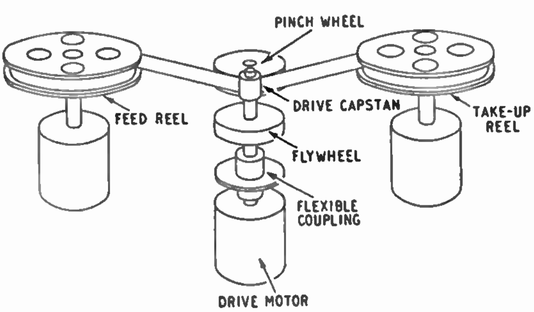


Fig. 1. Typical tape driving mechanism.

this ideal may be achieved, the most important being (a) the inertia of reels, reel motors and tape, and (b) the variation of the outside radius of the tape on the reels throughout the playing time.

Under running conditions the effect of the variation of the radius of the reeled tape may be minimized by using reel motors with suitable torque/speed characteristics, but the effects of inertia and of tape radius during the starting period cannot be modified without considerable elaboration of the mechanism. Consequently. it is difficult to avoid the formation of loops on the take-off side when the pinch wheel engages the tape with the rotating capstan. The formation of loops is generally followed by snatching as the take-up reel regains control. This irregularity of take-up tension can lead to undesirable effects such as uneven reeling, local stretching of the tape and, in bad cases, tearing.

Alternative Solutions.—One way of tackling the difficulty is to pass the tape through low-inertia "reservoirs" (e.g., vacuum boxes) on each side of the capstan and to control the reel motors by servo-mechanisms responsive to the position of the tape in each of the reservoirs. This method is often adopted if very fast start and stop times are required (e.g., for digital information in data processing equipment).

Another method is to tolerate the time required for acceleration of the reels and to engage the pinch wheel when the tape motion has reached its correct speed, i.e., when the tape speed is substantially equal to the peripheral speed of the capstan. While the tape is being run up to full speed, it must be prevented from touching the capstan. It is also possible to engage the pinch wheel before energizing any of the motors, but the time required to reach steady speed conditions will then be unduly long because of the inertia of the capstan flywheel. If the drive motor is of the synchronous type, the settling time will again be increased. Fig. 1 shows a flexible coupling between the drive motor and the capstan flywheel; these form a mechanical low-pass filter. Transient oscillation in this coupling on starting can add further to the delay in reaching the steady state.

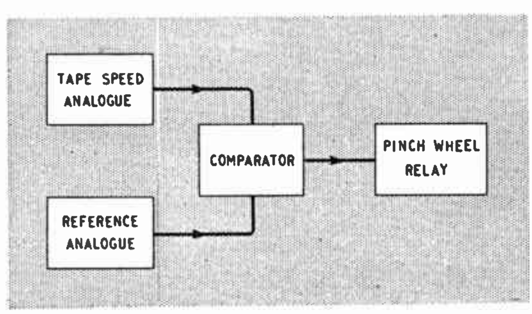
The following proposals make use of the second method suggested above, in which the acceleration time is tolerated, first, for the simple case where the desired tape speed has only one value and, secondly, for the more complex case where provision is made for more than one tape speed. In each case, the pinch wheel is actuated by an electromagnet, which is, in turn, energized via a relay. In each case, also, the tape speed is sensed by passing the tape over an auxiliary wheel, called a tape wheel, which has a speed-measuring device fitted to its spindle.

Single Speed Operation.—In the simple case, as shown in the block diagram of Fig. 2, it will be seen that an analogue of the speed is compared with a fixed reference, and when the difference drops below a threshold level, the relay is energized and the pinch wheel engages the tape with the capstan.

One convenient form of speed-measuring device consists of a magnet and an eddy current disc (or cup) such as are commonly used in indicating tachometers. One can imagine a tachometer, the hair spring of which is so biased that the needle is normally held against the zero stop until the speed reaches the required value. If the needle operates an electrical contact as soon as it moves away from the stop, a relay can be energized and this in turn can operate an electro-magnet which moves the pinch wheel to its operative position (Fig. 3).

Another speed-sensitive device which may be used is a tacho-generator, preferably of the permanent magnet type, arranged to give either a d.c. or an a.c. output. In either case, the output voltage is an analogue of the speed and, in the a.c. case, the frequency of the output is also an analogue of the speed.

Fig. 2. Basic principle of pinch wheel control.



* Communication from Telefunken G.m.b.H. via E.M.I., Ltd.

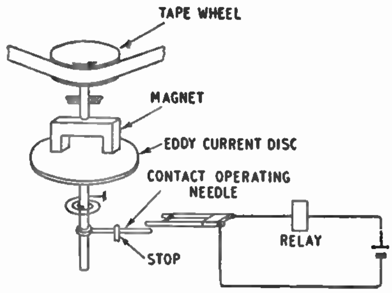
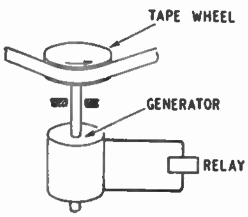
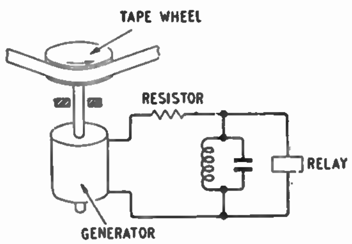


Fig. 3. Eddy current speed indicator.



Left: Fig. 4. Tacho-generator for deriving speed analogue.



Right: Fig. 5. Parallel tuned circuit as a frequency sensitive relay shunt.

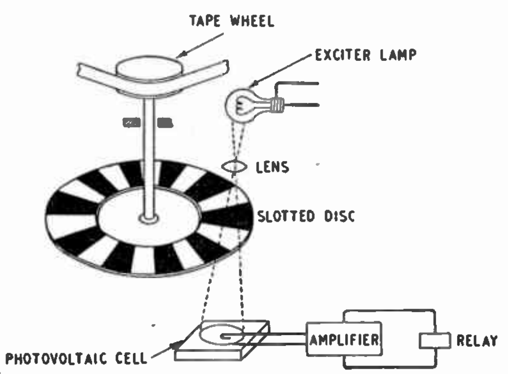


Fig. 6. Optical generation of speed analogue.

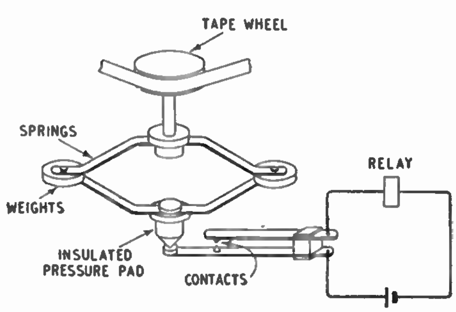


Fig. 7. Centrifugal switch.

A very straightforward embodiment of this principle, in which the speed analogue is the output voltage, uses the minimum value of operating current for the relay as a reference and so avoids the need for the separate reference shown in Fig. 2. Hence, all that is needed is to connect the generator direct to the relay but. in the a.c. case, a rectifier is necessary if the relay is not sensitive to a.c. (Fig. 4).

When the output frequency is used to provide an analogue of the speed, the resonant frequency of a parallel-tuned circuit may be used as a reference as shown in Fig. 5. At low tape speeds, the impedance of this circuit will be low compared with that of the series resistor, and the relay, which must be sensitive to a.c., is virtually short-circuited. However, as the speed approaches the required value, the effective impedance increases and eventually the relay becomes sufficiently energized to operate. A series resonant circuit can be used in much the same way, the internal inductance of the generator being tuned by a series capacitance.

It will be realized that each of the methods so far described involves loss of energy which is obtained from the tape driving motors, via the tape. The tape will experience a drag from this cause, in addition to that due to the inertia of the system. This may be obviated by the use of a more refined transducer which modulates an auxiliary power supply. Fig. 6 shows an example using this principle: power is supplied to the relay by light from an exciter lamp falling on a photovoltaic cell via a chopper, consisting of a low-weight slotted disc carried on the spindle of the tape wheel. The a.c. output from the cell is at a frequency which is an analogue of the speed. The reference may be a tuned circuit, of either the series or parallel type, as already described.

A centrifugal switch requiring a low operating torque and adding only a moderate inertia to the system may also be used. Fig. 7 shows a very useful form of this device in which two spring contacts are held apart by an insulated pad bearing on the lower spring. As the speed increases, centrifugal force acting on a pair of weights distorts the springs which carry the weights and relieves the pressure on the spring contact so that the pinch-wheel relay circuit is closed when the tape speed is correct. The frictional torque is very small because the load on the rotating parts is applied along the axis of rotation.

As the value of the speed analogue approaches that of the reference, the pressure of the operating contacts is at first so light that "chatter" is to be expected with each of the devices so far described. Therefore, the reference value must be so chosen that the pinch-wheel relay operates at a tape speed which is rather less than its final value, but not so much less that engagement of the pinch wheel causes the take-off tension to fall to zero. As the pinch wheel engages the tape, it is rapidly accelerated to full speed and the pressure of the operating contacts is thereby increased to a satisfactory value.

Multiple Speed Operation. Provision is often made for a choice of more than one speed, and accordingly the block diagram of Fig. 2 must be amended as shown in Fig. 8. It will be seen that the fixed reference must be replaced by a correct analogue of the capstan speed, assuming that the diameter of the capstan is not changed. If the capstan spindle speed is kept constant for both values of the tape speed by changing the capstan diameter, the fixed reference system remains suitable.

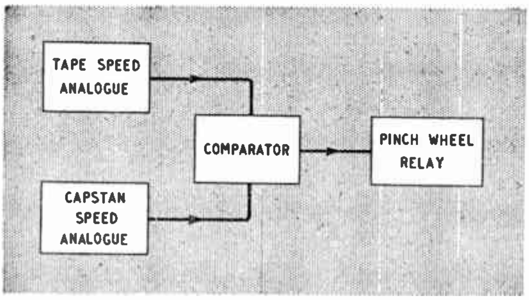


Fig. 8. Modified block diagram for multi-speed operation.

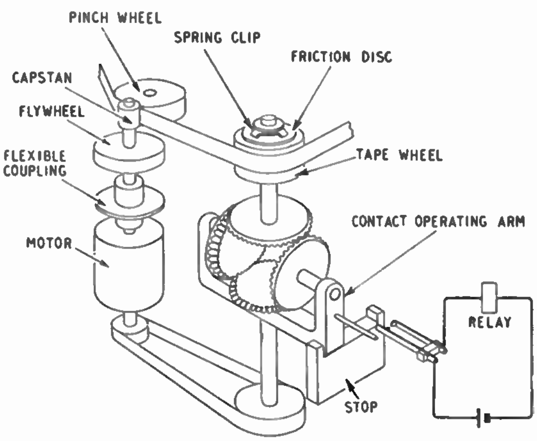


Fig. 9. Differential speed control of pinch wheel.

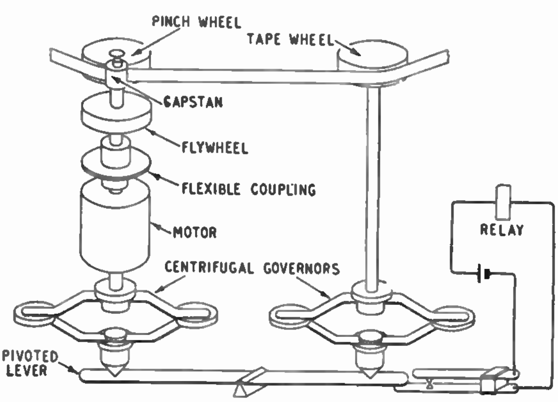


Fig. 10. Mechanical speed comparator.

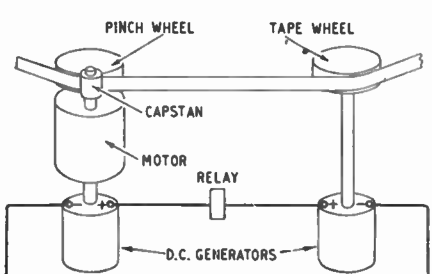


Fig. 11. Electrical speed comparator.

Because the input quantities are both of the same form, i.e. rotating spindles, a differential gear train is a suitable form of comparator, and an example of this is shown in Fig. 9. A simple differential will give an output speed proportional to the difference between its input speeds and an output torque equal to the difference between the input torques. The particular arrangement shown in Fig. 9 makes the speed difference zero and utilizes the torque difference to provide contact pressure. Accordingly, the difference between the capstan speed and the tape wheel speed is absorbed in a friction coupling, and it is the reversal of friction, which occurs when the latter speed overtakes the former, which causes the contact operating arm to move to its alternative position.

Several other mechanical systems designed on lines similar to that of Fig. 9, or closely related thereto, could be used but, since they all involve the use of slipping couplings, they cause drag on the tape wheel. These examples are by no means exhaustive and further devices, based on duplication of the simple schemes already discussed, are possible. For instance, a double version of the system shown in Fig. 7 could take the form shown in Fig. 10. The comparator then takes the form of a pivoted lever with the pressure pads of two centrifugal governors so arranged as to operate, one on each end of the lever.

The comparison may also be obtained electrically by duplicating the system of Fig. 4 as shown in Fig. 11. In this case, two d.c. generators are connected in series opposition to the pinch-wheel relay. When the tape wheel generator output equals that of the capstan generator, the current in the relay falls to zero, releases the armature and completes the circuit to the pinch-wheel magnet. Because the differential voltage becomes small, or vanishes, the drag on the tape under running conditions is low.

CLUB NEWS

Birmingham.—At the annual dinner of the Slade Radio Society the president, C. H. Young (G2AK), announced that 42 members had been enrolled during the year, bringing the membership to 112. The club meets on alternate Fridays at 7.45 at the Church House, High Street, Erdington. At the January 3rd meeting N. R. Nicholl (vice-chairman of the British Interplanetary Society) will speak on the instrumentation of space vehicles. Sec.: C. N. Smart, 110 Woolmore Road, Erdington, Birmingham, 23.

Bury.—The January meeting of the Bury Radio Society will be held at 8 0 on the 14th, when members will hold a debate on "Phone versus C.W." Meetings are held at the George Hotel, Kay Gardens. Sec.: L. Robinson, 56 Avondale Avenue, Bury, Lancs.

Prestatyn.—Meetings of the Flintshire Radio Society are held on the first Monday in each month at 7.30 at the Railway Hotel. Sec.: J. Thornton Lawrence (GW3JGA), Perran Porth, East Avenue, Prestatyn, Flint.

Rochdale.—A new club, to be known as the Roch Valley Radio Club, has been formed in the borough. Meetings are being held each Tuesday at 8.0 in the Windmill Hotel, Sudden. Enquiries to D. J. Power, 2 Clement Street, Rochdale, Lancs.

Wellingborough.—At the January 30th meeting of the Wellingborough and District Radio and Television Society, L. Parker (G5LP) will speak on "This DX Business." The club meets each Thursday at 7.30 at the Silver Street Club Room. Sec.: P. E. B. Butler, 84 Wellingborough Road, Rushden, Northants.

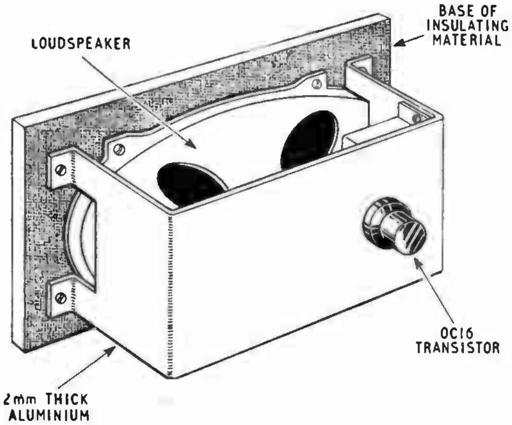


Fig. 1. Heat sink and output stage assembly.

HYBRID CIRCUIT FOR 12-VOLT OPERATION WITH TRANSISTOR OUTPUT

By J. C. BECKLEY,* B.Sc.(Eng.)

Car Radio Receiver Design

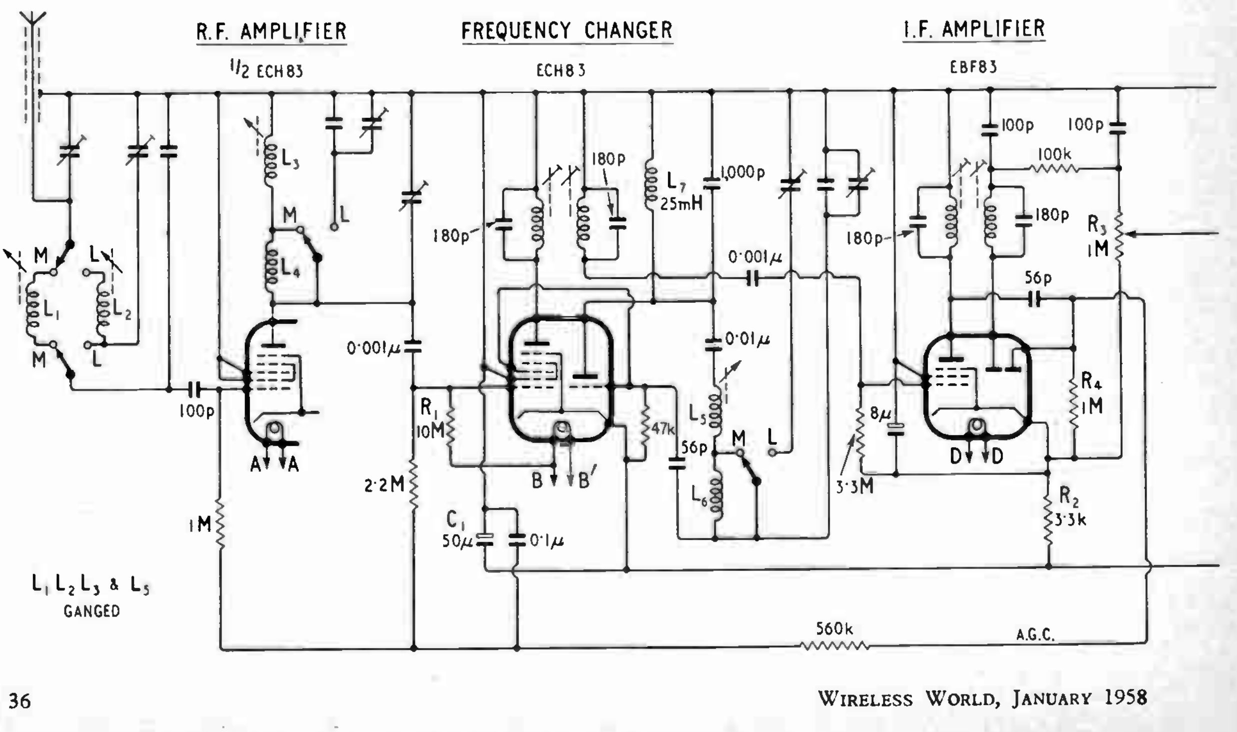
IT has been appreciated for many years that it is possible to obtain acceptable performance, in terms of voltage gain, from thermionic valves operated with low anode voltages such as are available from car batteries. However, it is not possible to obtain from a practical valve operating at low anode voltage anything like sufficient audio output power to drive a loudspeaker. Consequently, until quite recently, all car radio receivers and similar mobile equipment have incorporated standard mains valves and a vibrator, or d.c. convertor, to provide a high line-voltage.

The recently introduced power transistor is an excellent solution to the output power problem, because a suitable transistor with a 12-V supply can provide several watts output. Many of the present types of mains valve give a useful performance with an h.t. of only 12V, but a new range of valves specially designed for this application is now available.

A hybrid design for a car radio has a number of distinct advantages over all-valve and all-transistor receivers. The present cost of transistors makes an all-transistor receiver for this particular application expensive, but a relatively inexpensive hybrid receiver may be designed employing four valves plus one power transistor. The great superiority of the

*Mullard Ltd.

Fig. 2. Theoretical circuit of the hybrid car radio receiver with an OC16 power transistor in the output stage.



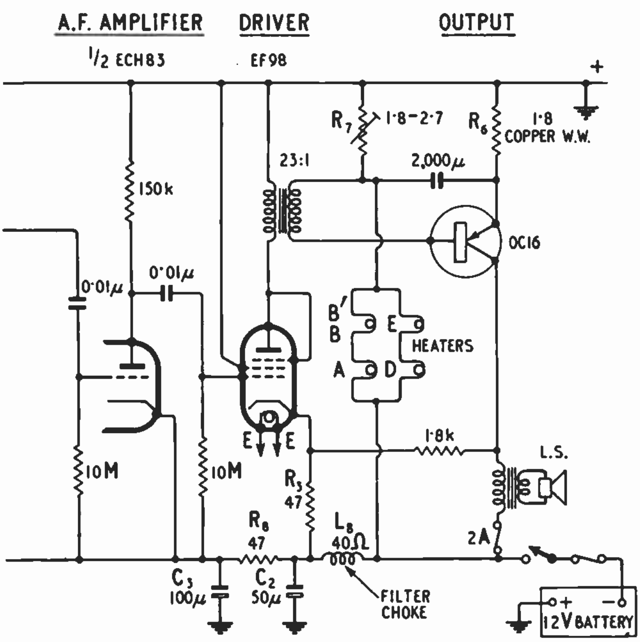
hybrid receiver is that the vibrator h.t. supply is dispensed with. Speaking generally, both the transistor and the valve have much longer working lives than the vibrator, and the potential reliability afforded by the hybrid design is therefore very much greater. Vibrator supplies usually involve an expensive transformer and, also, careful filtering of the d.c. output is necessary to avoid introducing interference from the vibrator. The characteristics of the new valves permit the design of receivers having the same performance as those equipped with normal h.t. operated types, so that nothing is sacrificed by omitting the vibrator pack. Moreover, the current drain of the hybrid receiver is about two or three times less than that of a conventional car radio.

A 12-V car radio receiver is described here for medium- and long-wave operation and it is designed around a normal production car radio tuning unit incorporating permeability tuned aerial, r.f., and oscillator circuits. The output stage is constructed as a separate unit mounted with the loudspeaker.

The new range of valves for application in hybrid receivers are the Mullard ECH83, EBF83, and EF98. The ECH83 is a frequency convertor of the well-known triode-heptode type. The ECH83 heptode section is also applied as r.f. amplifier and the triode section as a.f. voltage amplifier. The EBF83 is a double-diode pentode and combines the functions of i.f. amplification, detection and a.g.c. The EF98 is a straight pentode which has been designed to provide sufficient power output (a few milliwatts) to drive the transistorized output stage.

The output transistor is the Mullard OC16 power transistor, which can be operated at a high value of collector dissipation providing an output of about 2.5W.

Receiver Design.—The audio output obtainable with a single OC16 is considered to be sufficient for normal purposes. Push-pull operation has not been considered here because this design is intended to apply to an inexpensive receiver.



The quality of a car radio depends to a large extent upon the effectiveness of the a.g.c. since rapid and intensive variations of field strength may occur when the car is moving. In the hybrid car radio with a low anode supply voltage the control voltage is obviously small. In order to obtain effective control, therefore, the grid base of the controlled valves is kept small. In this receiver a.g.c. is applied to the r.f. and mixer valves only. No a.g.c. is applied to the i.f. valve as this would reduce the available control voltage.

The r.f., mixer and i.f. stages are operated with grid current bias. The values of grid leak chosen are a compromise between circuit damping and valve operating slope. The valves in the above stages have a high internal impedance (>500kΩ) so that normal r.f. coils and i.f. transformers are employed. The oscillator drive voltage required by the ECH83 mixer is much less than the value required for this type of mixer operating at high anode voltage. Thus, normal, medium- and long-wave permeability tuned oscillator coils may be used in the hybrid receiver, although the effective slope of the ECH83 oscillator section is not as high as ordinary types.

The Output Stage.—In order to obtain sufficient power output from the single OC16 (about 2.5W), it is necessary to operate the transistor at a high collector dissipation. The junction temperature must be limited by the use of an efficient heat sink. Fig. 1 shows the arrangement employed; the OC16 is mounted directly on 2-mm thick aluminium bracket approximately 300 sq cms in area. The transformers associated with the output stage are also mounted on the heat sink. The case of the OC16 is connected to the collector, the heat sink is therefore at collector potential and must be insulated from the main chassis.

The terminal voltage of a car battery varies considerably due to variations of load and charge conditions. A battery of nominal 12V is reckoned to have an average voltage of 14V and a possible maximum of 15V. Hence, the output stage is designed for a normal voltage of 14V and safe operation at 15V.

The circuit is designed for continuous operation at ambient temperatures up to 45°C. At 45°C the junction temperature does not exceed 75°C, the normal limit mentioned in published data. Operation at junction temperatures up to 90°C is possible for short periods (life expectancy at junction temperature of 90°C is greater than 200 hours) without serious effect upon the transistor. This allows occasional operation at ambient temperatures up to 60°C. The circuit is safe from thermal runaway at a battery voltage of 15 and junction temperature of 90°C.

Circuit Description.—The circuit of the receiver, which is shown in Fig. 2, is designed to permit direct connection to a car chassis; the positive line is therefore earthed.

The tuning unit provides separately tuned aerial circuits, L_1 and L_2, for medium and long waves and a single tuned r.f. coil, L_3, with an additional loading coil, L_4, for long waves. The input circuits are designed to match a low-capacitance aerial. The r.f. amplifier is the heptode section of an ECH83 and is operated with grids 2, 3, and 4 at h.t. potential. The valve has a grid leak of about 1.5MΩ taken to a point 1.5V positive with respect to the cathode.

The ECH83 is operated as a multiplicative mixer with a Colpitts oscillator. The oscillator circuit incorporates a single tuned coil, L_5, for medium-wave operation, an additional loading coil, L_6, being switched into circuit for long waves. The triode anode is connected to h.t. positive *via* a choke, L_7, which involves negligible d.c. voltage drop, but provides sufficient inductance to avoid restricting the normal frequency swing of the oscillator. An inductance of about 25mH is adequate for this receiver. The mixer section is operated with a grid leak of about 2.5MΩ connected to 1.5V positive. An additional positive bias is applied to the grid *via* a 10-MΩ resistor taken to the plus 6V point on the heater chain.

The EBF83 is grid-current biased by a 3·3-MΩ resistor returned to the cathode. A resistor, R_2, in the cathode circuit provides the positive voltage which is applied to the grid resistors of the r.f. and mixer stages. No a.g.c. is applied to this stage.

Detector and a.g.c. diode loads, R_3 and R_4 are returned to the EBF83 cathode. The detector load, R_3, is used as the volume control. The a.g.c. voltage is derived from the anode of the i.f. valve and is delayed by the positive voltage across the cathode resistor, further delay being applied to the mixer valve by the 10-MΩ resistor, R_1, taken to plus 6V. In this way the control characteristics of the r.f. and mixer valves are lined up to give optimum signal handling.

Standard medium-impedance 470-kc/s i.f. transformers are used in this receiver.

The detector output is fed into the triode section of the first ECH83. The triode is biased by grid current with R_{g1}=10MΩ. It functions as an a.f. voltage amplifier.

The EF98 a.f. driver stage is operated as a tetrode with g_3 connected to the anode. The output is transformer-coupled to the output stage. A low value resistor, R_5, is included in the cathode circuit across which negative feedback is applied from the output stage.

Output Stage.—The OC16 transistor is used in the earthed-emitter mode with a series emitter resistance R_6. Base bias is derived from a resistor R_7 in series with the heaters of the valves. The non-linear voltage-current characteristic of the heaters, decreases the effect of battery voltage variations on the bias voltage. A resistor of about 2Ω is required in the heater circuit in any case to drop the voltage across the heaters to about 12.6V with a nominal battery voltage of 14V. The low value of base bias resistance, and the use of an emitter resistor wound with copper wire (which has a small positive temperature coefficient), give effective stabilization of collector current with temperature. A fuse is included in the collector supply as protection against accidental short circuits between the heat sink, which is at collector potential, and the chassis.

Matching Driver Valve to Transistor.—As the input characteristic of the transistor is non-linear, the reflected load on the driver valve is similar. The performance of valves is generally expressed in relation to resistance loads, therefore it is necessary to determine a resistance load equivalent of the transistor input characteristic. Fig. 3 shows dia-

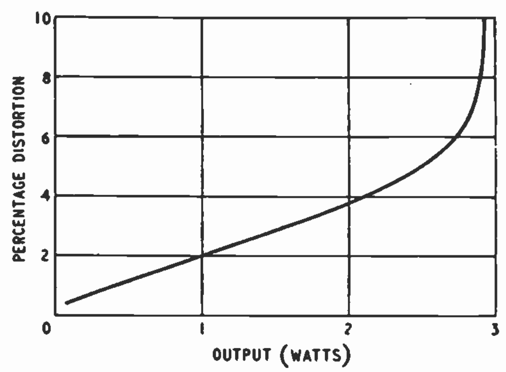


Fig. 4. Relationship between power output and distortion for OC16 transistor.

grammatically how the load line of a low-limit transistor appears on the EF98 V_a/I_a curves. Low-gain transistors generally have a low input impedance, thus the matching transformer ratio is chosen so that maximum power is available from the valve to drive low-impedance transistors. However, the optimum ratio is a compromise between perfect impedance matching and the primary inductance obtainable in an acceptable size transformer.

It is important that the matching transformer is phased so that increase of collector current corresponds to increase of anode current. This enables maximum power to be obtained from the valve and also helps to minimize second harmonic by partial cancellation of that generated in the valve and transistor.

Negative Feedback.—As previously mentioned negative feedback voltage from the OC16 collector is applied across a resistor, R_5, in the cathode circuit of the EF98. The feedback does not increase the drive requirements of the transistor. In addition to decreasing the distortion, the gain spread of the output stage, due to the relatively large spread of transistor characteristics, is considerably reduced by the application of feedback.

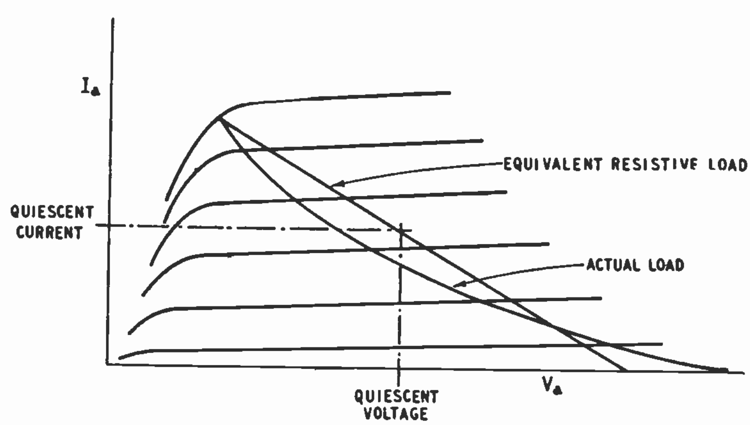


Fig. 3. Reflected load lines of output transistor on V_aI_a curves of EF98 driver valve.

(*Continued on page 39*)

The negative supply to the valves' cathodes is filtered by an r.f. choke, L_8, of about 40Ω d.c. resistance. The transistor supply is taken directly from the battery.

Decoupling of individual stages was not found necessary in this receiver. The choke L_8, together with a total capacitance of 100μF, C_1 and C_2, across the valve supply will generally provide sufficient decoupling, but if it should prove inadequate R_8 and C_3 may be included.

Receiver Performance.—(*i*). *R.F. Stage* (*ECH*83 *heptode section*).—The measured r.f. gain at several frequencies is given in Table 1 together with the r.f. circuit impedance.

(*ii*). *Mixer Stage* (*ECH*83).—Measured conversion gain at 1Mc/s = 17 times. I.F. transformer transfer impedance = 87kΩ. Conversion slope of ECH83 ≏ 200mA/volt. Measured oscillator grid voltage = 1.0 to 1.5V rms.

(*iii*). *I.F. Amplifier* (*EBF*83).—Measured gain at 470kc/s = 52 times. I.F. transformer transfer impedance = 55kΩ. EBF83 operating slope = 0.95mA/volt.

(*iv*). *A.F. Voltage Amplifier* (*ECH*83 *triode section*).—Measured gain at 1,000c/s = 6 times. Output voltage for 5% distortion = 1.8V rms.

(*v*). *Driver Stage* (*EF*98).—The optimum load of the EF98 operating with $V_a + g_3$ = 12.0V and V_{g2} = 12.6V is 4.5kΩ. The valve is grid current biased with R_{g1} = 10MΩ. Under these conditions a maximum power output of 13mW is obtained for 10% distortion.

Table 2 gives the EF98 input voltage required to drive the output transistor to full output and also for 1W output. Sensitivities are quoted for both average and low-limit gain transistors.

(*vi*). *Output Stage.*—

(*a*) *Heat Sink:*—The arrangement of Fig. 1 gave a total thermal resistance of 4.5°C/watt when tested in the laboratory. However, as the thermal resistance would vary, depending on the circulation of air and other local conditions, it is important to measure the thermal resistance under actual working conditions. A total thermal resistance of 4.5°C/watt (or less) under working conditions is essential for operation of the OC16 at the conditions mentioned here.

(*b*) *OC*16 *Operating Requirements:*—
Supply voltage = 14V.
Collector current = 475mA (Preset by R_7).
Collector dissipation = 6.6W (25°C to 45°C).
Collector load = 25Ω.
Base Voltage = 1.14V to 1.37V.
Base current = 6mA to 30mA.
Output power = 2.4W at start of clipping. (Into transformer primary) 2.9W at 10% distortion.

(Fig. 4 shows the variation of distortion with transistor output power.)

Overall Receiver Performance.—
Heater Chain ≏ 1.1A at 14V.
Measured Sensitivity.—Sensitivity figures are quoted for an a.f. output of 1 watt with an average transistor and a modulation depth of 30%. (See Table 3).
I.F. Selectivity.—The overall i.f. response is approximately 7kc/s for 6dB down.

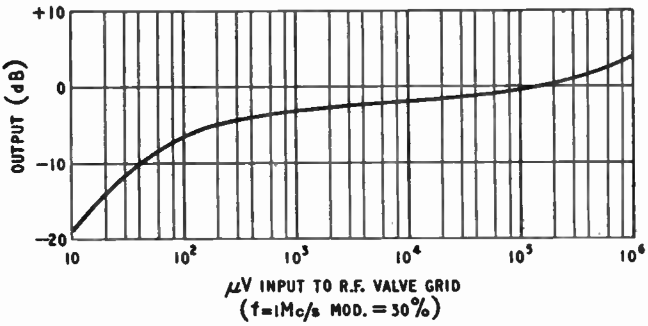


Fig. 5. A.G.C. characteristic of the receiver.

A.G.C. Performance (*See Fig.* 5).—The a.g.c. curve shows that a delay is maintained up to an input of about 100μV at the grid of the r.f. valve. The maximum signal handling of the receiver corresponds to an input of approximately one volt at the r.f. valve grid.

The receiver was tried in a modern car and no difficulty was experienced with interference from the dynamo or ignition system. It is possible that as the receiver has valve cathodes floating, interference may be introduced from the heaters. In this case it may be necessary to filter the heater supply by inserting a low resistance choke in series with the resistor R_7.

TABLE 1

Frequency	Circuit Impedance	Gain*
1,000kc/s	67kΩ	55 times
1,400kc/s	48kΩ	40 ,,
600kc/s	92kΩ	76 ,,
200kc/s	37kΩ	31 ,,

* Measured from r.f. valve grid to mixer grid. The above values of gain correspond to a valve slope of approximately 0.83mA/V.

TABLE 2

	Low-gain transistor	Average transistor
Input for 10% distortion in transistor output ...	1.0V rms	0.6V rms
Input for 1 watt output from transistor	0.6V rms	0.36V rms

TABLE 3

Frequency	Aerial Input*	R.F. Valve Grid Input
1,400kc/s	1.5μV	10μV
1,000kc/s	1.0μV	7μV
600kc/s	1.0μV	4μV
200kc/s	3.0μV	12.5μV

*Measurements of the aerial sensitivity were made with a 47-pF capacitor between the signal generator and the aerial input.

The receiver covers the medium and long wavebands only. It has been found that short-wave operation is possible if capacitive tuning is employed.

The results obtained with the hybrid receiver proved highly successful and very promising, not only for car radios, but also for the future development of other mobile communication equipment fed from a low-voltage supply source.

The author is indebted to L. H. Light for the design of the output stage, and for his advice in the preparation of this article.

A PICKUP TO TRACK AT 2 GRAMS

THE design of barium titanate transducer pickups with tracking weights of two grams or less was described at the 1957 I.R.E. National Convention by W. E. Glenn of the G.E. Company of America.

A sketch of the cartridge is shown in Fig. 1. The 2-mil barium titanate sheet is fastened on one side to a stainless steel wedge. Thus, if this wedge is bent, it will strain the barium titanate and so generate a voltage between its surfaces. The 7-mil diameter 20-mil long diamond or sapphire stylus is force-fitted into a hole in the 0.7-mil stainless steel quill-shaped tip, and further secured with a small drop of Araldite cement.

The cartridge is attached to the arm by butyl rubber to allow it to retract before the cartridge or record can be damaged if the pickup is dropped. The vertical bearing of the arm contains grease which damps the low-frequency resonance between the stylus compliance and arm mass, and also renders the pickup less susceptible to external vibration. The moment of inertia of the arm is reduced by the same factor as the tracking weight to secure the same stability with warped records as for a standard arm.

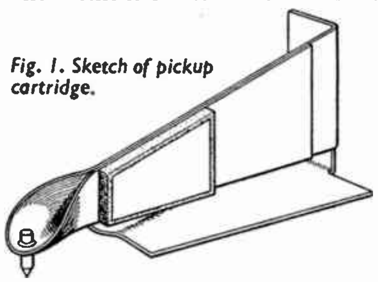


Fig. 1. Sketch of pickup cartridge.

The small section of the vertical wedge between the quill and barium titanate provides the lateral stylus compliance. The thickness of the quill is chosen so that the vertical compliance is about one-fifth of this. Vertical motion of the stylus does not produce any output because of the lateral symmetry of the quill.

The upper frequency of resonance f between the effective mass at the stylus tip and the groove wall and stylus compliance is proportional to t/L^2, where t is the wedge thickness and L the wedge length. The charge Q developed across the barium titanate is proportional to FL^2/t^2 where F is the flexing force. For a given resonance frequency f and tracking weight (which fixes F), this becomes $Q \propto f/t$. Thus to secure the maximum possible output, t is made as small as possible, and L then chosen to give a suitaably high resonance frequency f. To avoid the necessity for an input resistance of more than 1MΩ the capacity of the barium titanate element is made about 1000 pF by choosing a suitable width.

Cartridges with different stylus compliances corresponding to tracking weights from ½ to 2 gm. have been made. The effective mass at the stylus tip for the 2-gm version is 0.1 mgm. The output after compensation to the R.I.A.A. frequency characteristic is about 40 mV. The frequency response using a Cook 10-LP record run at 33⅓ and 78 r.p.m. is shown in Fig. 2, from which it is seen that the upper resonance frequency is about 40 kc/s.

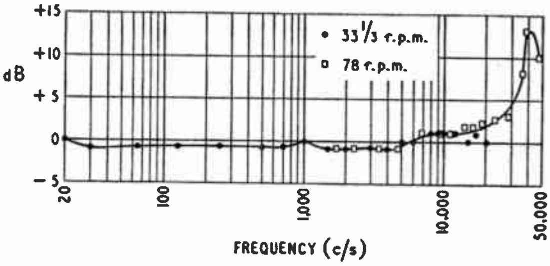
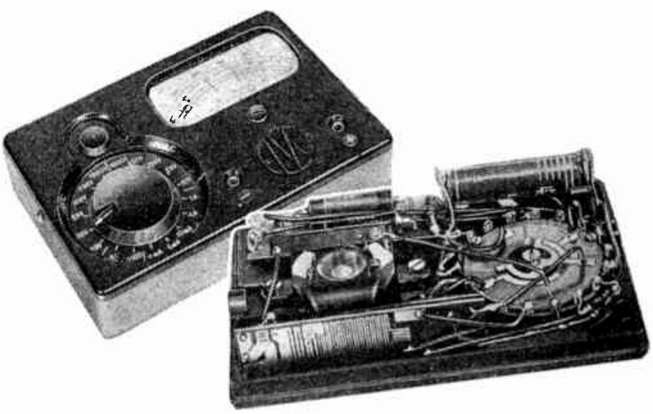


Fig. 2. Frequency response with Cook 10-LP record.

New Avo Multiminor

THIS new 19-range instrument has a maximum d.c. current sensitivity of 100μA f.s.d. The meter series impedances are 10,000Ω/V and 1,000Ω/V for the seven d.c. and five a.c. voltage ranges respectively. Potentials up to 1,000 V a.c. or d.c. can be measured. Two resistance ranges (0 to 20 kΩ or 0 to 2MΩ) are provided, using an internal 1½-V U12 cell with an adjustment to compensate for ageing. The full-scale error does not exceed 4%. Ranges are selected by a high-quality rotating switch, the 18 fixed silver-plated contacts being wiped by a double contact arm. Some of the resistors are printed; one on a switch-plate forming an integral part of the selector switch mechanism, and another forming the universal meter shunt. Two models at the same price of £9 10s are available, one for use in very humid climates. The address of the manufacturers is 92-96, Vauxhall Bridge Road, London, S.W.1.

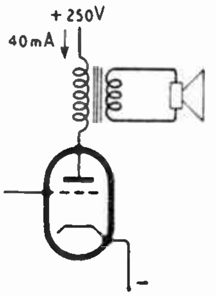


Valves, Transistors and Efficiencies

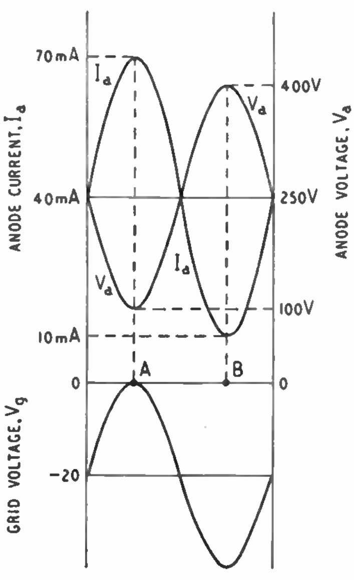
By "CATHODE RAY"

ONE of the little puzzles for the beginner is how it can be that a valve (or transistor) is heated less by a given number of watts put into it when it is working hard than when it isn't working at all. This is so contrary to our own experience, which is that the harder we work (physically) the hotter we get.

Take for example an audio output stage driving a loudspeaker, as in Fig. 1. Suppose it is receiving 40mA at 250V. That, of course, is an input power of $250 \times 40/1000 = 10$ watts. If the grid is receiving no signal, so that the anode current is pure d.c., the whole of this 10W goes into the valve, which is heated accordingly. But if now the grid is made alternately more positive and negative at audio frequency (and assuming for simplicity that the valve's characteristic curves are perfectly straight over the parts concerned, so that there is no distortion) the *average* anode current and voltage are just the same as before, yet some of the 10W of power is going into the loudspeaker. So the power going into the valve is that much less and it doesn't get so hot.



Above: Fig. 1. If a constant d.c. power is supplied, why does the valve's share become less when the grid is made alternately more negative and positive?



Right: Fig. 2. Variations of current and voltage in a typical example of Fig. 1 during one whole cycle.

Fig. 2 shows the sort of thing that is happening during one cycle of the a.f. signal. The sine wave at the bottom represents the grid voltage being swung above and below a −20V bias level. The anode current I_a increases and decreases in time with it, with an amplitude (shall we say) of 30mA, that it touches 70mA at maximum (A) and drops to 10mA at minimum (B). Suppose the impedance of the load at the frequency concerned is 5kΩ, purely resistive. Then when the anode current rises by 30mA there is a drop of $30 \times 5 = 150$V across the load, so the voltage at the anode falls by that amount to 100V. Similarly at the current minimum it rises to 400V, as shown in Fig. 2. As we see, the average current through the valve is the same as when there is no alternation, and this goes too for the voltage across it. Why, then, is there less power being dissipated as heat in the valve?

We can get a clue if we calculate the power at various phases, say for a start the peak points A and B. At A the power going into the valve is $100 \times 70/1000 = 7$ watts, and at B it is $400 \times 10/1000 = 4$ watts. If the signal swing were sufficient to reduce either I_a or V_a to zero, then obviously the power into the valve at those instants would be zero, no matter how large the other factor might be. The aim, then, is to make either factor—current or voltage—as near zero as possible while the other is high.

The average power during each whole cycle can most easily be found by reckoning how much is going into the load and deducting that from the total supplied—10W. The power in a resistance load is of course equal to the product of the r.m.s. values of current through and voltage across it. With a sine wave the r.m.s. value is equal to the peak value divided by $\sqrt{2}$. So in our example the power is $150 \times 30/1000 \div 2 = 2.25$W. The valve dissipation is thus reduced from 10W to 7.75W. And the efficiency (useful power ÷ power supplied) is 0.225, or $22\frac{1}{2}$%.

This, incidentally, though not an impressively high figure, is pretty good going for a triode, if there is to be only moderate distortion. But why be content with this; why not drive it harder, so that both I_a and V_a touch zero at the peak minima, the load resistance being adjusted to make this possible? The answer is provided by the I_a/V_a characteristic curves (Fig. 3), which are essential for finding out the best working conditions. Even although the triode curves here shown are somewhat idealized (I have never seen such good ones

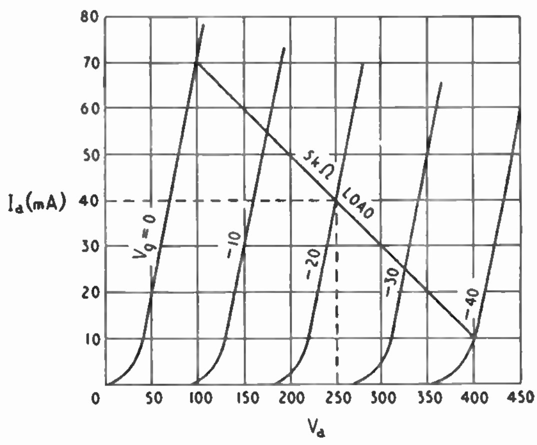


Fig. 3. Rather better than lifelike triode characteristic curves with "load line" corresponding to Fig. 2.

belonging to any real triode) it is clear that the power that can be put into the 5kΩ load—or indeed any load resistance—could not be materially increased without encroaching into the positive grid-voltage region or the bottom bend region, both of which would cause a quick rise in distortion.

The "$V_g=0$" curve is a particularly irksome restriction, because it prevents us from getting V_a down to anywhere near zero. This is one reason for the popularity of pentodes and kinkless tetrodes, whose curves have shapes that allow wider voltage swings (Fig. 4). Even so, in valves of the 10W order there is usually a useless minimum voltage of at least 50V.

Transistors present a much more attractive picture in this respect. Fig. 5 shows a typical set of I_c/V_c curves, which are spaced beautifully evenly and have a useless minimum of only about 0.2V! Even allowing for the working V_c being much lower than the corresponding V_a, this is a vast improvement. It is so near perfection that there is more than merely academic interest in enquiring into the efficiency of a perfect output stage—one in which both current and voltage touch zero. Fig. 6

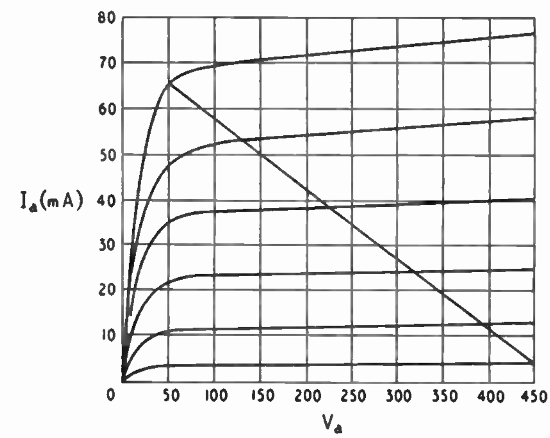


Fig. 4. Typical tetrode or pentode curves for comparison with Fig. 3, showing reason for higher power efficiency.

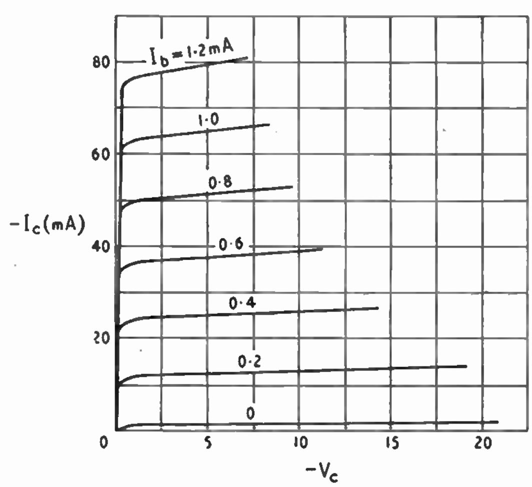


Fig. 5. Typical transistor curves, showing reason for still higher efficiency.

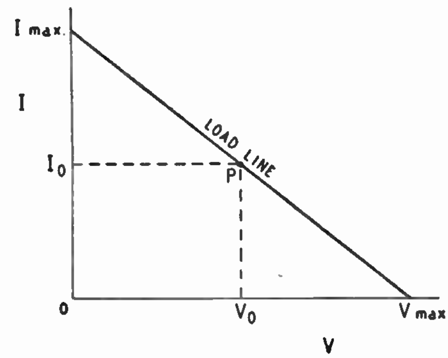


Fig. 6. Load line for an ideal output amplifier, restricted only by inability of current and voltage to be negative.

shows the load line in such a case. Current and voltage swing up and down from the working point P. For equal swings in both directions, obviously $I_{max}=2I_0$ and $V_{max}=2V_0$. The output power, calculated as before, is thus $I_0 V_0/2$; and the input is $I_0 V_0$. So the efficiency is exactly 50%.

That is for "Class A" amplification, in which the power fed in is the same for all amplitudes, because current and voltage swing equally up and down so that their averages are constant. If the efficiency is to be raised any higher, severe distortion is unavoidable, because even in this perfect device the current and voltage are assumed not to be able to go less than zero. That may seem to bar the way to even tolerable a.f. reproduction, let alone "hi fi." But what can be done is to amputate one half of every cycle completely, because that kind of distortion enables the efficiency to be increased very substantially, and although the distortion is drastic it can be put right by simultaneously amplifying the other half of each cycle and bringing the separate halves together into whole cycles. The method of doing this is known as "Class B" push-pull, and as we are at the moment considering only the power efficiency aspect I must assume you know all about the actual method. In essence it consists in adjusting the bias so that instead of the current starting from the half-way mark (I_0 in Fig. 6) it starts from zero. So the voltage starts at maximum and works downwards.

These conditions are shown for the working half-cycle in Fig. 7. The r.m.s. current through the load (as well as through the valve) is $I_{max}/\sqrt{2}$, and the r.m.s. voltage across the load is equal to V_{max} minus the voltage across the valve, so is $V_{max}/\sqrt{2}$. The output power is the product of these, namely, $I_{max} V_{max}/2$. The input power is equal to the product of the supply voltage (assumed constant) and the average current, which for a half sine wave is $2I_{max}/\pi$; result, $2I_{max} V_{max}/\pi$. So the efficiency is $I_{max}V_{max}/2 \div 2I_{max}V_{max}/\pi = \pi/4 = 78\frac{1}{2}\%$. During the second half cycle of this half of the amplifier there is zero current all the time, consequently no power at all; but the other half of the amplifier is doing its $78\frac{1}{2}\%$, so that is the theoretical efficiency of the whole output stage.

At the present time, the power that a transistor

(*Continued on page 43*)

can safely dissipate is its most serious limitation as far as a.f. amplification is concerned, so this matter of efficiency is particularly important. Suppose the maximum rated dissipation for a particular type is 0.25W. Then with Class A amplification the maximum theoretical sine-wave output (the efficiency being 50%) is also 0.25W. But in Class B only 100 – 78½% = 21½% of the power put in is dissipated in the transistor, so the output is 0.25 × 78½/21½ = 0.91W—nearly four times as much as in Class A.

So much for sine waves; what about square waves? For them, r.m.s. and average and peak current are all the same and could therefore all be equal to I_{max}. The voltage across the load—the output voltage—could be V_{max} throughout the half-cycle, and consequently the voltage across the valve would be zero all the time. This last fact is enough to establish that the efficiency would be 100%. In practice, of course, such a figure is unobtainable. As Fig. 5 shows, even a transistor has a certain minimum collector current (which increases steeply with temperature) at one end of the load line, and a minimum collector voltage at the other end. And then there is base current. But efficiencies over 90% are possible, so a very small transistor can generate quite a lot of square-wave power.

One aspect of this is that a transistor output stage would not (as one might have thought) be overheated by turning up the volume excessively far. On the contrary it would run cooler, because the sound programme would be distorted into approximate square waves, resulting in exceptional efficiency (regardless of the unprintable thoughts of any hi-fi exponents within earshot!)

Transitor D.C. Converters

Another aspect is the remarkably high performance of transistor d.c. converters. These are d.c. voltage raisers working on the same principle as the vibrator systems used for supplying power to car radio, except that they do the job electronically instead of mechanically. This is not the cue for an exhaustive treatise on these devices, but for the sake of any who are totally unacquainted with them (I did begin this time with beginners) I will explain the general idea.

When current is made to flow through an inductor (which is the thing you call a coil) a certain amount of energy is stored in it. Before the current can be stopped, that energy must somehow be released. This can be demonstrated with apparatus represented by the simple circuit diagram, Fig. 8. It consists of a car battery (or such like) and a coil with a large number of henries—say a winding on a large transformer. When the connection is made, energy is built up and stored in the magnetic field. The current may take several seconds to reach nearly its full value. Then break the circuit. But take care not to hold the wires in your bare hands, for I have no desire to be the defendant in a case of manslaughter. The release of energy much faster than it was built up makes it break out as a high voltage across the newly formed gap, resulting in a spectacular spark, far exceeding what one would get if an equal but non-inductive resistance were substituted for the coil.

In d.c. converters this relatively high voltage (which can be stepped up still further by means of a secondary winding on the core) is brought under control and rendered useful by adding a rectifier and reservoir capacitor, as in Fig. 9. The rectifier is connected in such a way that it prevents any current passing through it from the battery. But the voltage induced by L at " break " is in the opposite polarity, so finds it easier to send current through the rectifier to charge C than to put on a show of fireworks at the switch contacts.

Obviously, if one is to be able to draw a continuous flow of current from C it is necessary to replenish it at frequent intervals by turning the switch on and off. In vibrator units the switch is a mechanical one, operating on the same principle as an electric bell. The rate of replenishment cannot in practice be much more than about 100 c/s or its hum would be too audible and its rate of wear excessive. Besides acoustic noise to be muffled, its electrical noise has to be suppressed.

A valve oscillator could be used, but a valve is an inefficient switch. Even although in this role the question of distortion does not arise, so that a complete " off " can be obtained by using sufficient negative grid voltage, no amount of positive grid voltage achieves a complete " on "—the valve's resistance is always substantially more than none. And if the grid is driven positive it, too, uses up quite a bit of power.

But a transistor, as we have seen, is at its best when working as a switch. By means of a feedback winding on the transformer it can be made into a blocking oscillator, which in effect turns itself on and off at almost any desired frequency. Because it can replenish C many times faster than a vibrator, it has only a small fraction as much power to handle during each cycle. Even at that rate it is completely silent and hardly wears out at all. I am assured that the overall efficiency—which takes account of losses in the transformer as well as the transistor—can be

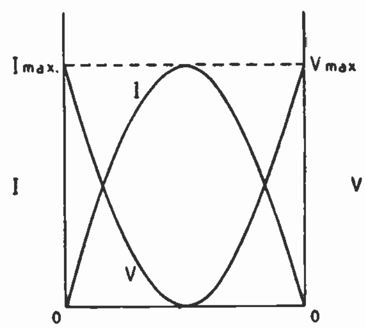


Fig. 7. Current and voltage conditions during the working half-cycle in an ideal Class B amplifier.

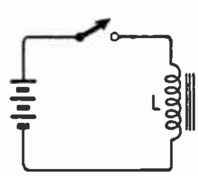


Fig. 8. The basic principle of vibrator and transistor d.c. converters or voltage raisers is the alternate storage and discharge of energy in the form of a magnetic field.

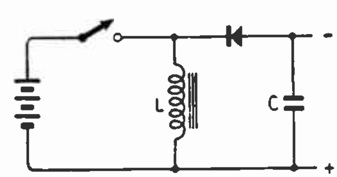


Fig. 9. If the inductive energy in Fig. 8 is transferred periodically to a capacitor it is available for drawing off continuously.

as high as 85%, but even the less efficient specimens seem to be much better than vibrators. So it looks as if the vibrator is doomed to extinction.

The transistor d.c. converter is more adaptable, too. It can be used to generate very small amounts of power, for which a vibrator would be clumsy. I very much doubt whether a vibrator would be satisfactory for running an oscilloscope from a low-voltage battery, but visitors to recent exhibitions have seen an all-transistor oscilloscope demonstrated. I suspect, too, that transistors are or will be in brisk demand for radiation counters, which the way things are going look like becoming standard household equipment!

During this digression in praise of transistor d.c. converters, the beginners I imagined to be puzzling over the problem of the unexpectedly cool valve may by now be puzzling over something else. They may have come fresh from being instructed to the effect that a power generator yields its greatest output when the resistance of the load is equal to that of itself, the efficiency then being 50%. This is a most important law, applying to all generators and loads. Another lesson showed them that valves (and transistors, if the teacher had got around to them) are equivalent to power generators. I have been talking about efficiencies of 80% and 90%, without a word on matching the resistances. So . . .!

Where is the fallacy?

There are really two (at least). One, of course, is jumping to the conclusion that the condition for maximum output is the most efficient condition. And if you say, in a superior way, that even a beginner wouldn't jump to any such thing, I would mention that in the early days of electricity supply the foremost engineers were very confused on this issue.

Numerical Illustration

A simple example ought to make the matter clear. The dotted line in Fig. 10 encloses an equivalent generator, giving an e.m.f. of 100V and having an internal resistance of 50 Ω. Let us calculate the output and efficiency for three values of R: 10 Ω, 50 Ω and 250 Ω. The output power is I^2 R, and I being $E/(r + R)$ it comes to $E^2 R/(R + r)^2$. The efficiency is this output power divided by the generated power, EI. Working these out we have:

Load resistance, R ..	10Ω	50Ω	250Ω
Output power	27.8W	50W	27 8W
Efficiency	16.7%	50%	83.4%

So the output power is reduced equally from its maximum—50W—by either dividing or multiplying R by 5 (the same applies to any figure), but dividing reduces the efficiency whereas multiplying increases it. If you worked out the algebra from the foregoing you will have arrived at the very simple formula for efficiency—$R/(R + r)$—which clearly increases continuously as R is increased (or r reduced). To get a high efficiency, then, see that R/r is as large as possible.

The other fallacy is that all this is really irrelevant! (But worth noting on the side.) We had been discussing the efficiency of valves and transistors as converters of d.c. to a.c., and although the " equivalent generator " is a very useful idea, having a very general application to things such as valves and transistors, it relates to the " signal " only and does *not* concern itself with the d.c. " feed " needed to bring the valve etc. to its most suitable working point. It is failure to appreciate this distinction that gets people into a muddle over the direction of current in the valve equivalent generator. They think that because the feed current flows (according to standard convention) from anode to cathode there is some obligation to take that as the reference direction for the signal current in the equivalent generator. But feed current has nothing whatever to do with the equivalent generator.

There is a related misconception that beginners

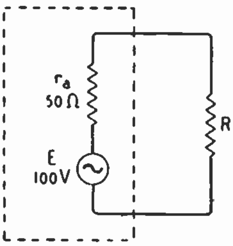


Fig. 10. The dotted line marks the boundaries of an "equivalent generator" supplying a load, R.

should beware of in connection with the maximum-output or matched-load law. An essential part of that law is constancy of the generated voltage, E in Fig. 10. In a valve equivalent generator $E = -\mu v_g$, where v_g is the signal voltage applied between grid and cathode. Generally speaking, with an output stage one is chiefly interested in the greatest output that can be obtained, without putting any fixed restriction on v_g. The really important restriction is the amount of distortion that can be tolerated, and the usual assumption is that v_g is kept adjusted to the point where the maximum tolerable distortion occurs. Where that point lies depends not only on the amount of d.c. power fed in but on the shape of the characteristic curves. We have found the efficiencies for full-sine-wave and half-sine-wave reproduction assuming perfect shapes—50% and 78.5% respectively— so we know the maximum theoretical output power of these waveforms, given the d.c. input. Because valve characteristic curves, and even transistor curves, are not perfect, the actual efficiencies, and therefore outputs for given inputs, are less; in some cases such as thermionic triodes, much less.

V.H.F. Sound Receiver I.F.

WHEN v.h.f. sound broadcasting started in this country, set manufacturers adopted an i.f. of 10.7 Mc/s as this was in use in the U.S.A. and on the Continent. Further consideration has recently been given as to the suitability of this frequency, mainly so far as interference to and from other services is concerned.

Whilst on purely technical grounds certain other frequencies showed a marginal improvement over 10.7 Mc/s, it is considered that those advantages would not justify abandoning this almost universally adopted frequency and the British Radio Equipment Manufacturers' Association has, therefore, endorsed its Technical Committee's recommendation that 10.7 Mc/s should be confirmed as the preferred i.f. for receivers used in the U.K., with the oscillator frequency on the low side of the signal frequency.

Manufacturers' Products

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

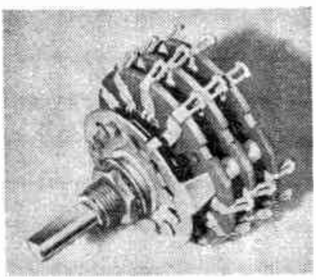
Oak Rotary Switch

A NEW Oak rotary switch known as the Model DQH, and replacing the existing Model QH, has been introduced by N.S.F., Ltd., 31-32 Alfred Place, London, W.C.1.

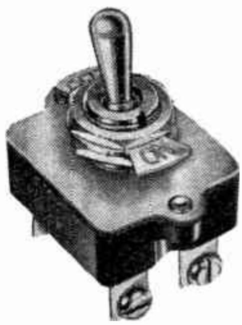
It incorporates an improved form of notched stator plate which is said to completely eliminate trouble due to loosening of the contact clips as a result of overheating during soldering operations.

The Model DQH has a 30° throw making available a maximum of 12 positions on a single wafer and any combination from 1 pole 12 positions to 6 poles 2 positions (on-off) can be provided.

Illustrated is a typical 3-section switch and this can be supplied fitted with an a.c. switch, but the rear two wafers are then omitted.



New N.S.F. Model DQH Oak switch.



Arcolectric miniature 10-amp switch.

Miniature 10-amp Switch

RECENTLY introduced by Arcolectric (Switches), Ltd., Central Avenue, West Molesey, Surrey, is an exceptionally compact double-pole on-off switch rated at 10 amps at 250 volts a.c. Known as the Type S254 it is designed on the snap-action, micro-gap principle, has silver contacts and is claimed to have been tested up to 250,000 operations at full rated load. A long pear-shaped "dolly" is fitted and the price is 5s.

Improved P.V.C. Cables

A NEW range of electrical wiring cables suitable for ambient temperatures up to 750°C (167°F) has been introduced by Permanoid Ltd., New Islington, Manchester, 4. They are insulated by p.v.c. compounded with a new long-chain polyester plasticizer known as "Diolpate" with a molecular weight of the order of 7,000. This has virtually no volatility at temperatures below that of decomposition, and as a result there is no migration. The insulation is also less affected by immersion in oils.

Calibration Tape

FREQUENCY response measurements and tape recorder replay head alignment can be performed with the aid of a new "Scotch Boy" twin track test tape. On one track eleven constant frequencies from 40 c/s to 10 kc/s (inclusive) are recorded to within ±1dB of the C.C.I.R. specification. Each of these frequencies lasts about ten seconds and is preceded by an announcement. On the other track is recorded a continuous 7½-kc/s tone for head alignment purposes. This 150-ft tape costs 49s 6d and is marketed by the Minnesota Mining and Manufacturing Co. Ltd., Wigmore Street, London, W.1.

Expanded Polystyrene

A CELLULAR structure is given to polystyrene in "Polyzote," a product of Expanded Plastics, Ltd., 675, Mitcham Road, Croydon, Surrey. This material is supplied in granular form for moulding with a chemical additive which forms a gas on heating, and fills the mould with a cellular mass, which on cooling has high strength and low density (1¼lb/cu ft).

Although used chiefly for heat insulation, the dielectric properties are good (resistivity $>10^{11}$ MΩ, permittivity 1.05, loss factor, tan δ, <0.0005) and it has considerable possibilities in radio and radar. One known application is for the casing of a high-altitude balloon radar sonde transponder where its light weight and transparency to radiation (the aerial system is enclosed) have obvious advantages. Not so obvious perhaps is the fact that the batteries retain their normal temperature and so function longer in the low ambient temperatures of high altitude.

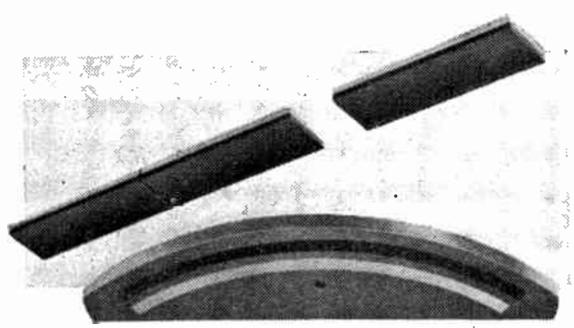
Moulded Resistance Elements

PRECISION resistance elements consisting of tracks of high-grade phenolic of the type used in some of their precision volume controls, can now be obtained from the Plessey Company to meet specific requirements. So far they have found applications mainly in industrial control equipment, but they are equally suitable for use wherever a stable, close-tolerance resistance is required for the variable element in precision equipment.

Elements have been produced in resistance values ranging from 25 Ω to 10 MΩ, at present with a tolerance of ±5% and with a linear or logarithmic resistance law. They are made in a variety of shapes and are said to maintain their stability when operated at temperatures ranging from −40°C to +100°C.

The illustration shows two of the forms they can take; one is a curved element, the other is a series of straight elements, each of 10kΩ, placed end-to-end. A sine/cosine moulded track unit has also been produced for a special type of potentiometer. It is stated that a moulded carbon brush is the most suitable type for the wiper.

The units are supplied to customer's individual requirements by The Plessey Co., Ltd., Swindon Components Division, Kewbrey Street, Swindon, Wilts.



Examples of moulded carbon track elements made by Plessey.

News from the Industry

Anglo-American Agreement.—The Radio Corporation of America has arranged to acquire from Marconi's technical information on the Doppler navigation system which will be used in the design of R.C.A. equipment for civil airlines. Marconi's have been producing Doppler equipment for the R.A.F. for the past three years and introduced a new type (AD2300) for civil use last June (see *W.W.*, August, page 396).

Solartron Expansion.—Work has begun on the first section of a new factory being built for the Solartron group at Tower Hill, Farnborough, Hants. This section of the one-storey building will have an area of 50,000 square feet and is planned to be in use by next August. The whole factory on the 15-acre site, which will include a helicopter landing space, is scheduled to cover 350,000 square feet.

Ekco Electronics, Ltd., designed and installed the complete nuclear instrumentation and control circuitry for PLUTO, the atomic research reactor which recently commenced operation at Harwell. Ekco are now working on similar equipment for the Australian HIFAR reactor at Lucas Heights and the DMTR reactor for Dounreay, Scotland.

Audio Group.—Three companies in the electro-acoustics field—Audio Amplifiers, Ltd., CQ Audio, Ltd. (formerly R.G.A. Sound Services), and Romagna Audio, Ltd.—have formed what is to be known as the Audio Group of Companies. The directors are Stanley Kelly and A. R. Neve. The headquarters are at 2, Sarnesfield Road, Enfield, Middlesex (Tel.: Enfield 8262). Stewart Hillman, formerly with Cosmocord, has joined the group as general sales manager.

Aerialite, Ltd., recently celebrated their silver jubilee and to mark the occasion the staff made presentations to the chairman (L. S. Hargreaves) and his co-directors. The staff, which was two in 1932, is now 2,000.

Peto Scott Electrical Instruments, Ltd., announce that A. T. Black has been appointed to its board. Mr. Black, who was until recently director of electronics production (munitions) in the Ministry of Supply, is also a director of Pena Copper Mines, the parent company, the title of which is being changed to Pena Industries, Ltd.

Decca airfield control radar (Type 424) has been installed by Rolls-Royce at their flight test airfield at Hucknall, near Nottingham.

Wayne Kerr have developed at their Tolworth, Surrey, laboratories an electronic instrument for detecting and measuring the water content in aircraft jet fuel. The equipment is designed to detect, whilst the aircraft is in flight, as little as five parts of water in one million parts of fuel. The icing-up of fuel filters at high altitudes presents a very serious threat to air safety and the Wayne Kerr instrument automatically switches on tank de-icing equipment if moisture is detected.

Modern Acoustics, Ltd., of Manor Way, Boreham Wood, Herts., a subsidiary of the Plessey Co., are to produce a new range of plugs and sockets. They will be manufactured under licence from Tuchel Kontakt of Germany. The world marketing rights outside Europe for the Tuchel design have been assigned by Plessey to their subsidiary.

EXPORTS

Thailand.—A report on the domestic receiver market in Thailand, prepared by the British Embassy in Bangkok, shows that during 1956 only about 4% of the imports were purchased from the United Kingdom. Nearly 50% of the receivers came from the Netherlands, 25% from Germany and about 15% from Japan. The U.K. had a greater share in Thailand's purchase of radio components and accessories—Japan, the Netherlands and Great Britain having 18%, 17% and 16% respectively. The U.S. supplied 24%.

Honduras Agency.—Agencia Acorda, Apartado 15, San Pedro Sula, Honduras, are interested in representing U.K. manufacturers of high-fidelity reproducing equipment, receivers and radio-grams.

Mobile radio-telephone transmitting and receiving equipment worth approximately £23,000 has been ordered from Marconi's by the Kuwait Oil Co. Five 50-watt base transmitters and associated receivers will be installed at one site (Ahmadi) and two 50-watt transmitters and receivers at two others (Raudhatain and Seismic Camp). The company's fleet of 37 vehicles is being fitted with 10-watt transmitter-receivers.

NEW ADDRESSES

Brighton Laminations, Ltd., makers of Bribond thermosetting and thermoplastic mouldings and printed circuits, have moved their headquarters to Burgess Hill, Sussex, but are retaining their Brighton works. The company has changed its title to Bribond, Ltd.

Farnell Instruments, Ltd., the instrument distributors of Leeds, have moved to Wetherby Industrial Estate, York Road, Wetherby, Yorks. (Tel.: Wetherby 2541). Their service department has been expanded and they are now in a position to undertake the development and manufacture of instruments to customers' requirements. The works manager is Mr. Sidebotham, who until recently was in the aircraft industry as head of an electronics research department.

Allen Components, Ltd., manufacturers of sound and television equipment, have moved from Richmond to 38, Felsham Road, London, S.W.15 (Tel.: Putney 3032).

H. W. Forrest (Transformers), Ltd., of 349, Haslucks Green Road, Shirley, Solihull, Warwickshire, have introduced a range of transformers (from 200mW to 20W) for use with a.f. transistors.

VENNER ELECTRONICS have developed for the Road Research Laboratories of the D.S.I.R. an electronic vehicle speed measuring instrument which is being tested by the Metropolitan Police. Basically, the device is for measuring small intervals of time and it is started and stopped by the front wheels of the vehicle passing over rubber tubes laid in the road (see page 32). The accuracy is plus or minus ½% at 30 m.p.h.

JANUARY MEETINGS

LONDON

9th. Television Society.—"A French portable television camera" by J. Polonsky at 7.0 at 164 Shaftesbury Avenue, W.C.2.

17th. B.S.R.A.—"The electrical production of music" by Alan Douglas at 7.15 at the Royal Society of Arts, John Adam Street, Adelphi, W.C.2.

17th. Institute of Navigation.—"The influence of atmospheric conditions on radar performance" by Dr. J. A. Saxton at 5.15 at 1 Kensington Gore, S.W.7.

22nd. I.E.E.—"Special problems of broadcasting in Sweden" by E. Esping at 5.30 at Savoy Place, W.C.2.

23rd. Television Society.—Fleming Memorial Lecture "Crystal valves" by T. R. Scott (S.T.C.) at 7.0 at the Royal Institution, Albemarle Street, W.1.

24th. R.S.G.B.—Presidential Address followed by "The human machine as a radio operator" by F. J. H. Charman (G6CJ) at 6.30 at the I.E.E., Savoy Place, W.C.2.

27th. I.E.E.—"An enquiry into the specification of transistors" by F. F. Roberts at 5.30 at Savoy Place, W.C.2.

28th. I.E.E.—Symposium on "Long-distance propagation above 30 Mc/s" (a) "Ionospheric forward scatter propagation" (at 2.30), (b) "Tropospheric propagation beyond the horizon" (at 5.30) at Savoy Place, W.C.2.

29th. Brit.I.R.E.—"Ultra-high-speed oscillography" by I. Maddock at 6.30 at the London School of Hygiene, Keppel Street, W.C.1.

ABERDEEN

10th. I.E.E.—"The remote and automatic control of semi-attended broadcasting transmitters" by R. T. B. Wynn and F. A. Peachey at 7.30 at the Robert Gordon's Technical College.

BIRMINGHAM

21st. Institute of Physics.—"The computer and its uses" by C. Robinson (English Electric) at 7.0 at the Birmingham Exchange and Engineering Centre.

27th. I.E.E.—"Transistor circuits and applications" by Dr. A. G. Milnes at 6.0 at the James Watt Memorial Institute, Great Charles Street.

BRIGHTON

15th. I.E.E.—"The B.B.C. sound broadcasting service on very-high frequencies" by E. W. Hayes and H. Page at 6.30 at the Technical College.

BRISTOL

13th. I.E.E.—"The B.B.C. sound broadcasting service on very-high frequencies" by E. W. Hayes and H. Page at 6.0 at Bristol University Engineering Laboratories.

CARDIFF

22nd. Brit.I.R.E.—"Applications of magnetic recording" by J. Cunningham-Sands at 6.30 in the Department of Physics, University College.

22nd. Society of Instrument Technology.—"The use of computers in process control" by W. G. Proctor (Metropolitan-Vickers) at 6.45 in the Physics Lecture Theatre, Cardiff College of Technology.

CHATHAM

23rd. I.E.E. Graduate and Student Section.—"Colour television" by A. Harris at 7.0 at the Medway College of Technology.

DUNDEE

9th. I.E.E.—"The remote and automatic control of semi-attended broadcasting transmitters" by R. T. B. Wynn and F. A. Peachey at 7.0 in the Electrical Engineering Dept., Queen's College.

EDINBURGH

20th. I.E.E.—"Some aspects of half-wave magnetic amplifiers" by G. M. Ettinger and "Some transistor input stages for high-gain d.c. amplifiers" by Dr. G. B. B. Chaplin and A. R. Owens at 7.0 at the Carlton Hotel, North Bridge.

21st. I.E.E.—"The importance of research in hearing and seeing to the future of telecommunication engineering" by Dr. E. C. Cherry at 7.0 at the Carlton Hotel, North Bridge.

FARNBOROUGH

8th. I.E.E.—"Colour television" by C. J. Stubbington at 6.30 at the R.A.E. Technical College.

GLASGOW

9th. Brit.I.R.E.—"Electronic calculator circuitry" by F. Baillie at 7.0 at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent.

21st. I.E.E.—"Some aspects of half-wave magnetic amplifiers" by G. M. Ettinger and "Some transistor input stages for high-gain d.c. amplifiers" by Dr. G. B. B. Chaplin and A. R. Owens at 7.0 at the Royal College of Science and Technology, George Street, C.1.

LIVERPOOL

3rd. Institute of Physics.—"Radio astronomy" by Dr. H. P. Palmer (Jodrell Bank Experimental Station) at 7.0 in the Department of Electrical Engineering, University of Liverpool.

20th. I.E.E.—"Ferrites" by W. A. Turner at 6.30 at the Royal Institute, Colquitt Street.

MALVERN

31st. Brit.I.R.E.—Annual General Meeting, followed by "Digital computers by R. Deighton at 7.0 in the Winter Gardens.

NEWCASTLE

8th. Brit.I.RE.—"The earth satellite project" by P. H. Tanner at 6.0 at the Institution of Mining and Mechanical Engineers, Westgate Road.

15th. Society of Instrument Technology.—"Modern types of electronic recorders" by F. A. Bergen (Cambridge Instruments) at 7.0 at King's College, Stephenson Building.

20th. I.E.E.—"Ferrites" by Dr. F. Brailsford at 6.15 at King's College.

PRESTON

6th. I.E.E.—"The B.B.C. sound broadcasting service on very-high frequencies" by E. W. Hayes and H. Page at 7.15 at the Electricity Board Demonstration Theatre, 19 Friargate.

RUGBY

29th. I.E.E.—"Recent developments in X-ray and electron-microscopy with some applications to radio and electronics" by C. W. Oatley and Dr. V. E. Cosslett at 6.30 at the Rugby College of Technology and Arts.

WOLVERHAMPTON

8th. Brit.I.R.E.—"Instrumentation of space vehicles" by N. R. Nicoll at 7.15 at the Wolverhampton Technical College, Wulfruna Street.

RANDOM RADIATIONS

By "DIALLIST"

Forward Scatter

IN the B.B.C.'s Annual Report for 1956-57 great concern is expressed about the encroachment by forward scatter transmissions into some sound and TV wavebands. I don't wonder, for forward scatter has been causing horrible interference with television reception in some parts of the country. As the report says, further developments of sound and television services may well be adversely affected, unless action can be taken to resist encroachment into bands allotted to broadcasting by international conferences. It's strange how unlooked-for interference so often arises in both sound and television. With the coming of high-power sound broadcasting stations there arrived the Luxembourg Effect; nobody expected that the Caen TV station would interfere with reception along our south coast, or that there'd be trouble with Liège when Norwich went up to full power. And there's another possible source of worry looming ahead. The Government of Southern Ireland has decided that the Republic must have a television service. It may not be easy to fit its station or stations in on channels where they don't cause despondency and dismay to viewers in some of our westerly districts*.

* There is no provision in the Stockholm Plan for Irish stations in Band I, but five are allowed for in Band III.—Ed.

Light and the Metre

FOR 75 years now the world's standard metre has been "M," the platinum-iridium bar housed at Sèvres, near Paris. But a change has been decided upon and as soon as it has been accepted by the International Committee of Weights and Measures, due to meet next October, it will be officially adopted by all countries. The new measuring rod is to be a wavelength of light, an idea which was first suggested 130 years ago. The light is that of an orange line in the spectrum of the 86 isotope of krypton—${}_{36}\mathrm{Kr}^{86}$. Multiply its length by 1,650,763.73 times and you have the new standard metre, which is more than 100 times as accurate as that derived from the old metal bar. With such a precise metre to work from it should be possible, one would imagine, to find an exact and universally accepted value for the velocity of light and wireless waves. A vast amount has been done on this problem by physicists and mathematicians, but no two solutions have ever been exactly the same. Admittedly, the differences are very small; but still they are differences and since the velocity of light is a widely used constant, they shouldn't be there.

Hills and Plains

WRITING from near Colne in Lancashire a reader tells me of the difficulties experienced in that hilly part of the country in receiving Band III television transmissions. Such frequencies, he feels, are quite unsuitable for any but the flatter parts of this country of ours. He has an interesting suggestion to make, though I'm afraid it's hardly a practicable one. Draw a line, he says, through Nottingham from coast to coast: to the south of it there are few hills worth mentioning: to the north it's nothing but hills. He'd like to see all transmission north of this line made in Band I and all those south of it in Band III. Even if his assumptions were correct, what a hullaballoo there'd be should such a change be made! Can't you imagine the tumult and the shouting? Thousands of TV receivers of the Band I only type would become useless in the south unless they were converted. Millions of aerials would have to be changed. And neither the B.B.C. nor the I.T.A. would be enthusiastic about altering their transmitters. Even were all this done, would it work out? I don't think so, I'm afraid, for there's quite a lot of hilly country south of this imaginary line. Much of the Welsh mountain country, Exmoor, Dartmoor, the Cotswolds, the Chilterns, the Quantocks and other areas that are far from flat lie there. It's an ingenious idea, but it just wouldn't do.

Canada's TV Problem

CANADA has already a publicly-owned television system which serves about two million owners of receiving sets. "This," wrote George Ferguson, editor of the *Montreal Star*, in a recent Canada Supplement of *The Times*, "extends at the moment from the Prairie Provinces in the West to Halifax, Nova Scotia. There remain the links with Newfoundland and British Columbia, but these will be pressed forward." The main question, I gather, is who is going to pay for the service and how? The service is run by the Canadian Broadcasting Corporation, which, unlike our B.B.C., is not financed from licence fees. The proposal to introduce receiving licences was met by the firmest possible opposition. Instead, the Government put a 15 per cent tax on both sound and television receiving sets. This, together with its income from commercial programmes, produces far less than is needed to keep the C.B.C. going and meet the huge capital expenditure envisaged in the next six years. It should be added that Canada has in addition to its growing C.B.C. network a number of privately-owned commercial TV stations.

Making Satellites Work

A NOVEL suggestion for getting further useful work out of artificial satellites was made recently by R. J. Hitchcock, head of a section in the department of the engineer-in-chief of Cable and Wireless, Ltd. Sputnik II is said to be working already by recording a variety of measurements of conditions outside our atmosphere and sending them back to earth; but Hitchcock's idea is something quite different. Briefly, it is that satellites could be used to store communications from one part of the world and later to transmit them to another part. It should, he says, be possible to feed to a satellite in a few minutes all the telegraph traffic normally passing in a whole day between, say, this country and the antipodes. Three-quarters of an hour later the satellite would have reached a point in its orbit from which the messages could be transmitted at high speed to their destination. All this presupposes that some form of power supply, constantly replenished by solar energy, will be developed—and there is nothing unlikely about that. We'd also need satellites which would stay put, once they'd been started in larger orbits, and not come flaming back to earth in a matter of weeks or months.

It Won't be Easy!

There would also be the problem of precession, but that might not matter all that much, for a great number of moonlets would be needed to deal with world-wide communications and the ones in the right sort of orbits at a given moment could be used to deal with particular services. In the light of our present knowledge, the cost of putting such a scheme into practice would be staggering; but we're only at the very beginning of the satellite era and as the years go on cheaper and more effective methods of launching and equipping them will doubtless be discovered. Nevertheless, there are going to be some pretty knotty problems for solution.

UNBIASED

By FREE GRID

Irritating Irrationalities

WE are all aware that, throughout the world, voltages, whether those of the grid system or those in our homes, are rated in multiples of 11. Thus in the U.S.A. the standard domestic voltage is 110 and over here we had 220. The grid deals in voltages of 11,000, 33,000, 66,000 and so on. All these are multiples of 11, instead of the more obvious ten. There are, of course, odd voltages scattered about, such as 130 and 160 on the Continent and, of course, 230, 240 and others in this country, which don't seem to be based on anything.

"Diallist" once told us that he believed the basing of voltages on 11 instead of ten was due to the fact that originally the e.m.f. of the standard Clark cell, which is 1.1 volts, was taken as a starting point. I believe "Diallist" to be correct in his opinion but if any egghead knows better let him say so.

It would be too difficult to alter all this now by changing voltage ratings all over the world. Surely, however, we could get round the difficulty by a similar ingenious dodge to that which we use to make ourselves get out of bed earlier in the summer. All we do is to say it is 7 a.m. when it is really 6 a.m. Could we not therefore abandon the volt and adopt the "Clark" as the unit of e.m.f.?

What does 'Stille' mean ?"

There is one irritating irrationality or insane illogicallity which is of such comparatively recent birth that it can and should be altered. I refer to the irritating speed rating of tape recorders where we have to write clumsy fractional speeds like 1⅞in/sec. 3¾in/sec and so on.

Soon, I believe, we are to have a still slower speed for office work, namely 15/16in/sec. I suppose these absurdities arose because in the pioneer days of magnetic recording 30in/sec was used and then this was halved. When it was halved again the trouble started.

There are far too many tape recorders in use to alter the speeds to 2, 4, 8, etc., in/sec. It would be perfectly easy, however, to follow the example of the sailor who calls a nautical m.p.h. a "knot" (*not* a knot per hour!). Let us call 1⅞in/sec one "Stille." Better still, to allow for slower and slower speeds in the future, let us call it 100 Stilles (or should I say Stillen?) I hope no *W.W.* reader is so sunk in ignorance as to wonder what the word "Stille" signifies.

Callee-Coming Indicator

JUST lately we have heard a lot about the progress of automation in the telephone service but not a single mention has been made of one grave defect in our 'phone system which could be so easily remedied by radio technique.

Like myself, many of you have probably experienced the mortifications of hearing the telephone ring just as you have got into the bath. It always seems to be at a time when there is nobody else in the house.

It may be only a call from your tailor with a polite reminder about his overdue bill. But it may be a call from your favourite blonde, and consequently you spring out of the bath and rush downstairs, wrapping a towel around your midriff as you run, for the sake of Mrs. Grundy's feelings, even though you know you are alone in the house.

Just as you are a few paces from the 'phone it ceases ringing and, as you squelch your way back to the bathroom, you are left wondering who had rung. It has so often happened to me that I determined to do something about it. As the result of my labours, the distant caller receives a definite indication that his callee is coming so that he hangs on rather than hangs up.

Strictly radio principles are used in my device and the beauty of it is that no breach occurs of the P.M.G.'s regulations which forbids subscribers to fix attachments to the telephone. Over the handset of the desk telephone I have placed a modification of a model grab crane such as is used in those automatic machines on seaside piers in which you are invited to risk a penny trying to get the crane to pick up a trumpery trinket. By the side of the crane I have placed a small tape machine fitted with a short endless-band tape.

The apparatus is connected to the output of a tiny s.w. receiver of the type used in radio-controlled model planes and boats. On my person I have one of the small transmitters sold for model control. Incidentally, these little transmitters now require a licence from the P.M.G. but the cost is only £1 for five years.

An impulse from the transmitter first sets the crane in motion. It grabs the handset, lifts it and transfers it to the table with its mike near the loudspeaker of the tape machine which is then triggered off and repeatedly bellows out "Hello caller; your callee is coming."

I have designed the tiny transistorized transmitter to fit in an old bowler I always wear when in and around the house, even in the bath.

Tongue Tinglings Explained

IN reply to my request for suggestions for a literally self-contained battery to supply a few volts in my proposed "Torso Two" receiver, I have had an interesting letter from a reader who writes from Orpington.

He points out that when dentists fill a cavity they have to be careful to match the metal filling with any others which already exist in the mouth. The reason is that if dissimilar metals are used, a small e.m.f. is generated and the resultant current causes unpleasant tongue tinglings.

As I have replied to him, I am afraid that many dentists are careless in this respect and probably that is why grandfather usually keeps his denture on the mantelpiece rather than in his mouth. It also accounts for the sharp taste I have with everything I eat and I must try to devise a suitable earthing system.

My correspondent suggests that use might be made of this effect to give me the volts I want. Unfortunately, however, I don't think the voltage would be high enough although the potentialities of such an arrangement are certainly worth the attention of the research worker who is seeking a permanent battery for a hearing aid. There is already a hearing aid combined with a pair of spectacles and so dentists might as well be brought into the syndicate.

So far as women and gum-chewers are concerned it would be only necessary to couple a simple generator to their jaws as the constant movement would keep it going. Actually, I believe this has been suggested before for another purpose. The idea then was that the constant movement of the jaws would steadily build up a high potential in a capacitor which would finally discharge and so give the female tongue wagger a sharp shock to signal the QRT to her.

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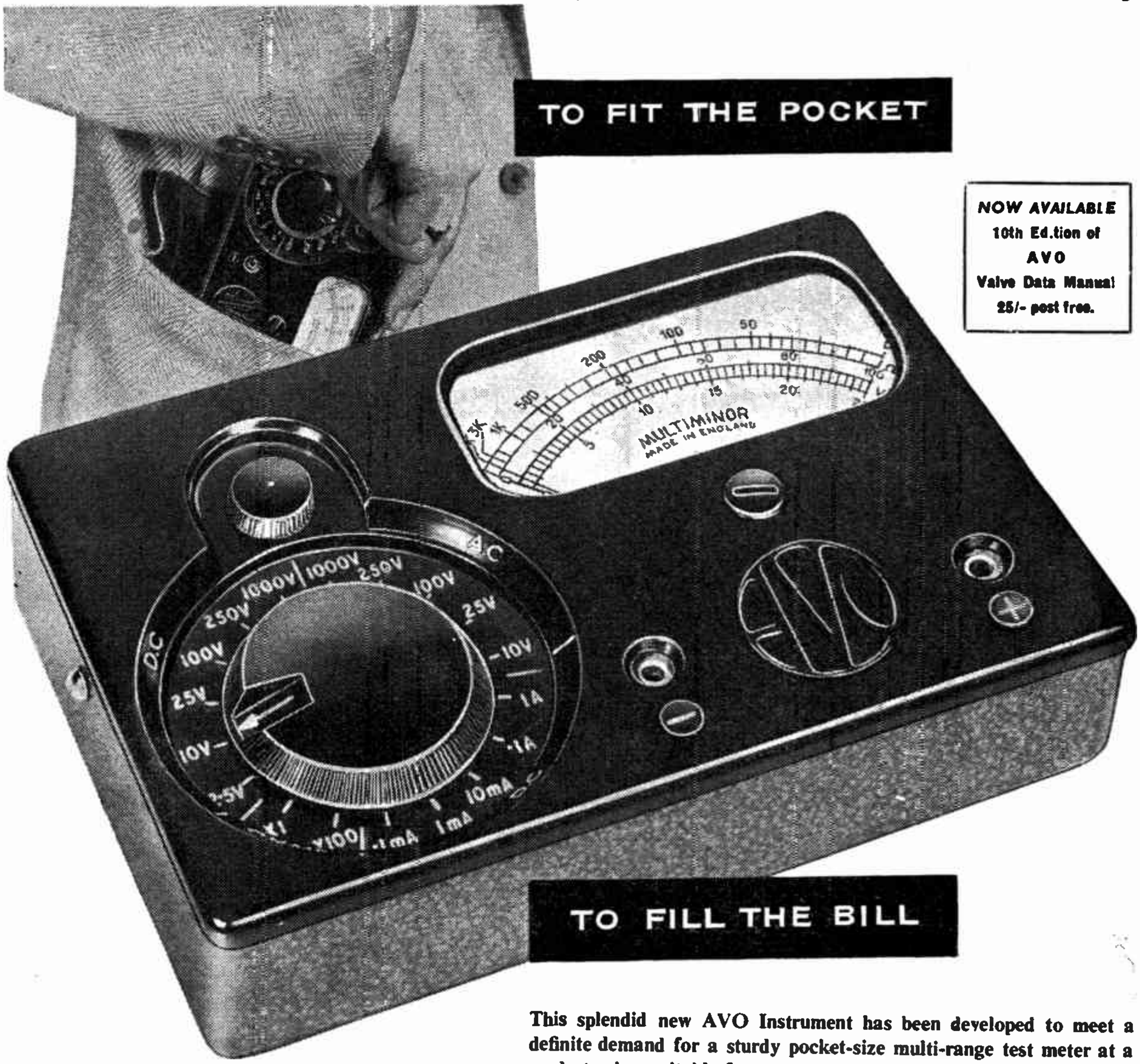

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This splendid new AVO Instrument has been developed to meet a definite demand for a sturdy pocket-size multi-range test meter at a modest price, suitable for use on modern electronic apparatus as well as for radio and television receivers, motor vehicles, and all kinds of domestic appliances and workshop equipment.

Readings are obtainable quickly and easily on a very open scale, and range selection is by means of a robust clearly marked rotary switch of the characteristic AvoMeter type. Measurements of A.C. and D.C. Voltage, D.C. Current, and Resistance are made by means of only two connection sockets.

19 Ranges

D.C. Voltage	A.C. Voltage
0— 100mV.	0— 10 V.
0— 2.5 V.	0— 25 V.
0— 10 V.	0— 100 V.
0— 25 V.	0— 250 V.
0— 100 V.	0— 1000 V.
0— 250 V.	
0—1000 V.	

Resistance	D.C. Current
0—20,000Ω	0— 100µA
0—2 MΩ	0— 1mA
	0— 10mA
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Sensitivity:
10,000 Ω/V on D.C. voltage ranges.
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Accuracy:
3% of full scale value on D.C.
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List Price: **£9/10s.**
complete with Test Leads and Clips
Size: 5⅛ x 3⅝ x 1⅜ inches
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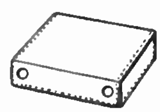

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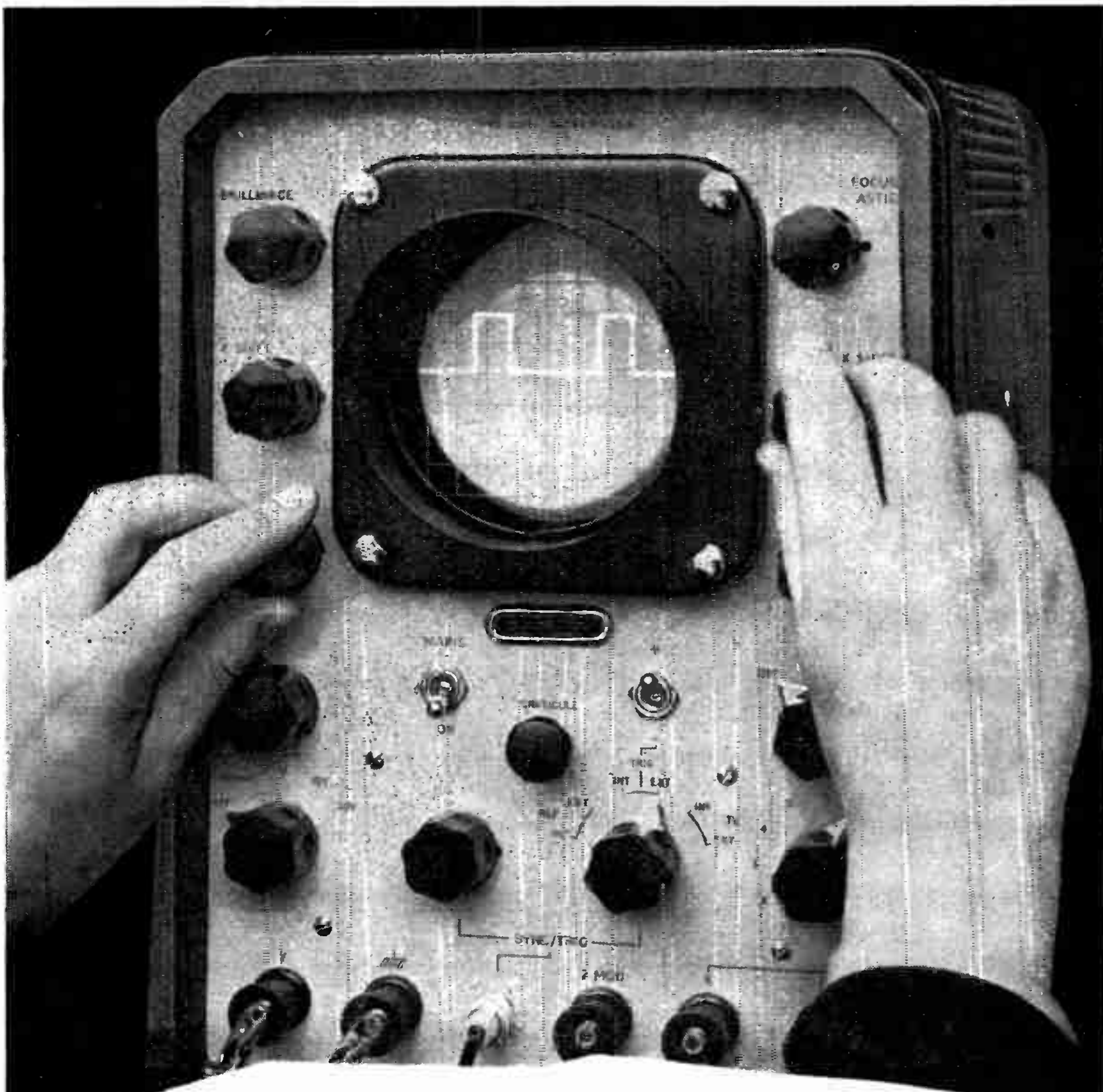

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BRIEF SPECIFICATION:

NOMINAL BANDWIDTH
1 c/s—9 Mc/s ± 1 Mc/s for 3 db down

SENSITIVITY CALIBRATION
By a 50 c.p.s. square wave

EXPANSION
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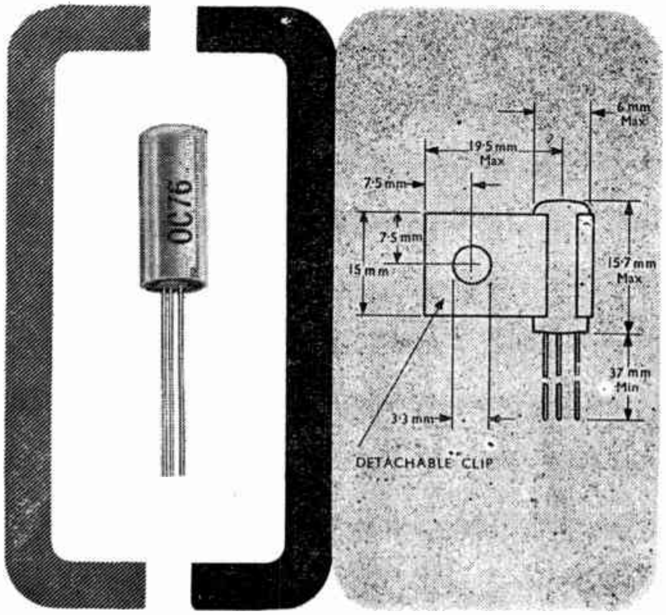

A germanium junction P.N.P. transistor available in quantity for industrial and d.c. converter applications in computing, switching and instrumentation.

OC76 industrial and switching TRANSISTOR

The new Mullard transistor OC76 is related to the well-known OC72 but is specially tested for non-sinusoidal industrial and d.c. transformer applications.

The pentode type knee of the OC76 characteristic is carefully controlled to give a low and uniform "bottoming" voltage. Its collector will withstand 30 volts d.c. in grounded base. In grounded emitter 30 volts d.c. may also be applied when the total base-to-ground impedance is less than 1 kΩ or the collector current is cut off by a reverse base bias.

This transistor is particularly suited for d.c. converters. For example, two OC76's in push-pull can be used to convert low input voltages to high output voltages with a d.c. to d.c. efficiency greater than 75% at power levels up to 700 milliwatts.

As a power oscillator, efficiencies of over 90% are possible with the OC76, while the high peak current of ¼ amp can be used to close large relays and operate small motors.

The OC76 is available in quantity. Full data is available from the address below.

Limiting values (absolute ratings)

Max. collector voltage	32V peak	32V d.c.
Max. collector current...	250mA peak	125mA d.c.
Max. junction temp.	75°C continuous opreation. 90°C intermittent operation (total duration 200 hours max.)	

Abridged Characteristics

Max. collector leakage current at Vc = —10V	10μA
Current amplification cut-off frequency	350kc/s
Collector knee voltage at Ic = 125mA	—0.4V
Power dissipation (without heat sink) at 25°C	125mW
Power dissipation (bolted to heat sink) at 45°C	100mW

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Can be employed

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(b) To measure field strength and interference.
(c) For harmonic analysis.
(d) As a selective Voltmeter.
(e) As a Bridge Detector.
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SPECIFICATION

Frequency Range:	30 kc/s-30 Mc/s in 7 ranges.
Amplitude Range:	30 kc/s-20 Mc/s: 1μV to 120 db above 1μV 20 Mc/s-30 Mc/s: 4μV to 120 db above 4μV.
Harmonic Measurement:	2nd harmonic 70 db and 3rd harmonic 90 db down can be measured.
Selectivity:	3 kc/s bandwidth.
Attenuators:	R.F. Attenuator 0-60 db in 20 db steps. L.F. Attenuator 0-60 db in 10 db steps and a 10 db variable attenuator.
Input Impedance:	75 ohms. A high input impedance probe unit is also provided.

OSCILLATOR Type 858

The Oscillator Type 858 is designed primarily for use as a calibrating Oscillator for the Wave Analyser Type 853, and as such provides fixed levels of output for setting up the instrument. It may however, be used separately as a c.w. oscillator of low harmonic distortion and stabilised output level.

SPECIFICATION

Frequency Range:	30 kc/s-30 Mc/s in 7 ranges.
Frequency Stability:	Better than 0.05% for a mains change of 25%.
Harmonic Distortion:	In general better than 1%.
Output Level:	Remains constant within ± 1 db over entire frequency range.
Outputs:	500 mV, 100 mV and 1 mV stabilised. A slidewire attenuator enables a continuous coverage to be obtained from 500 μV to 500 mV.

Full details of these or any other Airmec instrument will be forwarded gladly on request.

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Pye Limited, Tucuman 829, Buenos Aires. Argentine.

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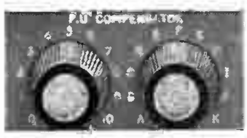
The Pye Mozart is available in a metal openwork case or chassis form, illustrated above — weighs 8¼ lbs, measures 3½" x 10½" x 5" and gives 10 watts output.



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The Mozart has input facilities for records, tape, and radio. New 'dialamatic' pickup compensation unit gives instant matching for most types of pickup.

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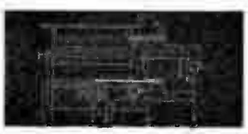
This is completely separate from the volume control and eliminates all mains interference.



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This brilliantly simplified printed circuit uses only 3 valves, a metal rectifier and a minimum of capacitors and resistors, allowing a great saving of space.

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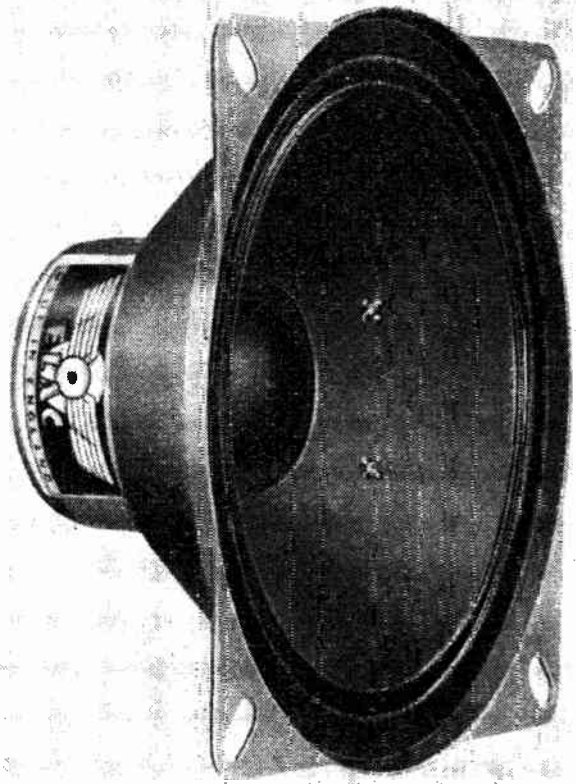

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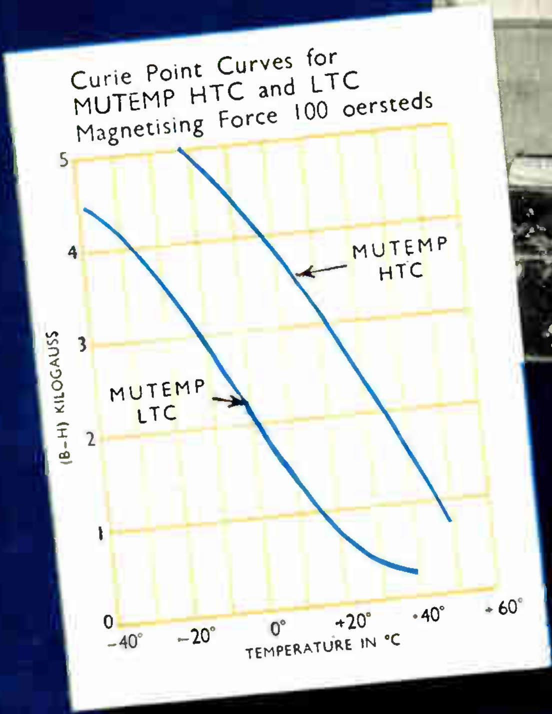

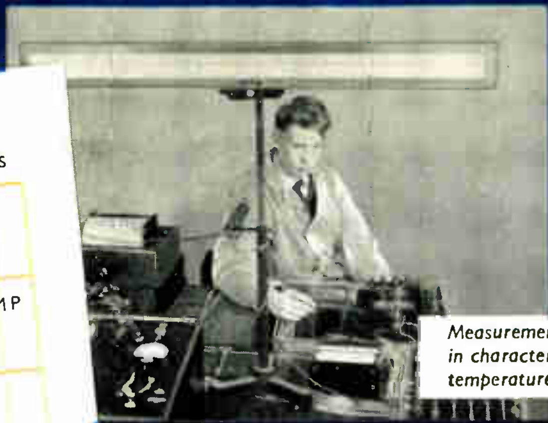

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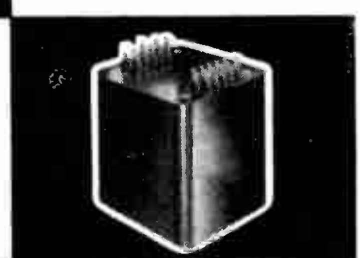

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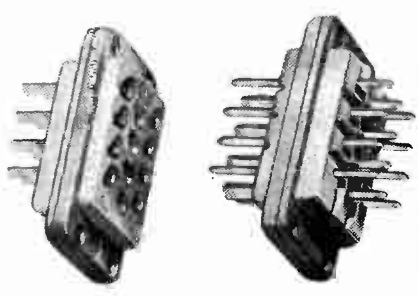

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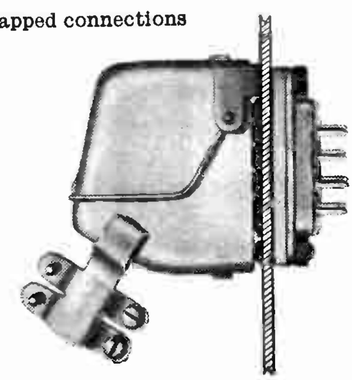

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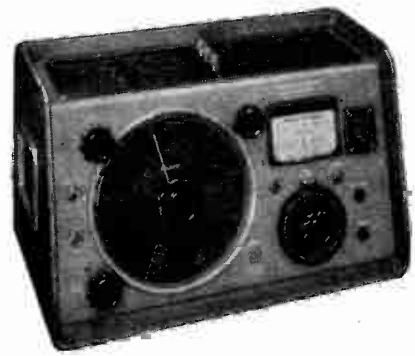
"For inductance or capacitance measurements the measuring bridge is energised by the output from a valve oscillator, the out-of-balance voltage from the bridge being applied to the built-in selective amplifier-detector and moving-coil indicator, while for resistance measurements the indicator is used directly as a centre-zero galvanometer, the necessary d.c. for the bridge being derived from the power pack supplying the oscillator and detector used for inductance and capacitance measurements."

One of the problems of the age is how to keep up with the younger generation. One can support the shame of being unable to help with homework, but the prospect of having to admit ignorance of electronic equipment is intolerable. For instance, what do you know about the Marconi Universal Bridge Type TF 868A? Could you impress our young friend with an authoritative description of the instrument's ingenious mechanical design which provides single-dial measurement of L, C, and R? You owe it to yourself to be really up-to-date about Marconi Instruments—after all, they are important tools of your trade. Start with the TF 868A. Our leaflet G112 contains full details, and we'll gladly send you a copy.



UNIVERSAL BRIDGE
Type TF 868A

Measures inductance or capacitance at 1 or 10 kc/s, resistance at d.c. Measurement Ranges: 1 μH to 100 henrys, 1 μμF to 100 μF, 0.1 ohm to 10 MΩ. Q Range: 0.1 to 10 at kc/s, 1 to 100 at 10 kc/s. Tan δ Range: 0.001 to 0.1 at 1 kc/s, 0.01 to 1.0 at 10 kc/s.

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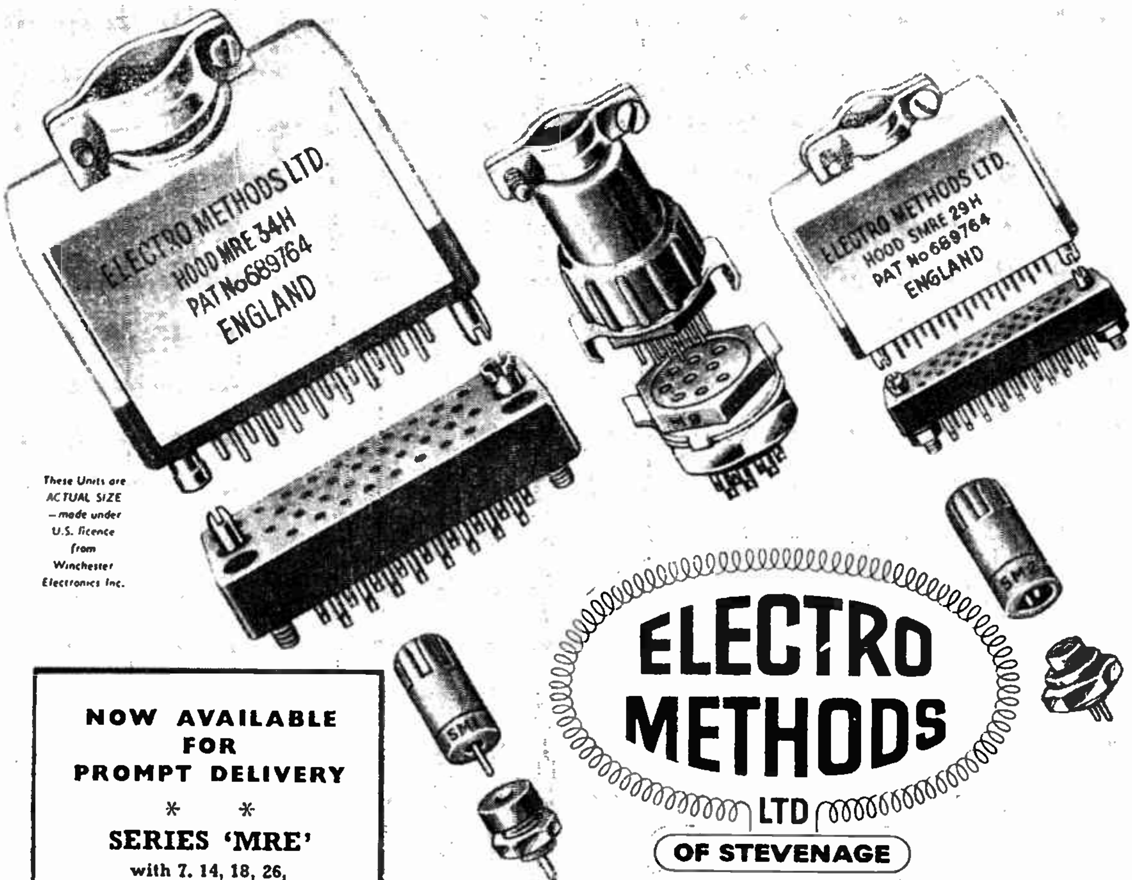

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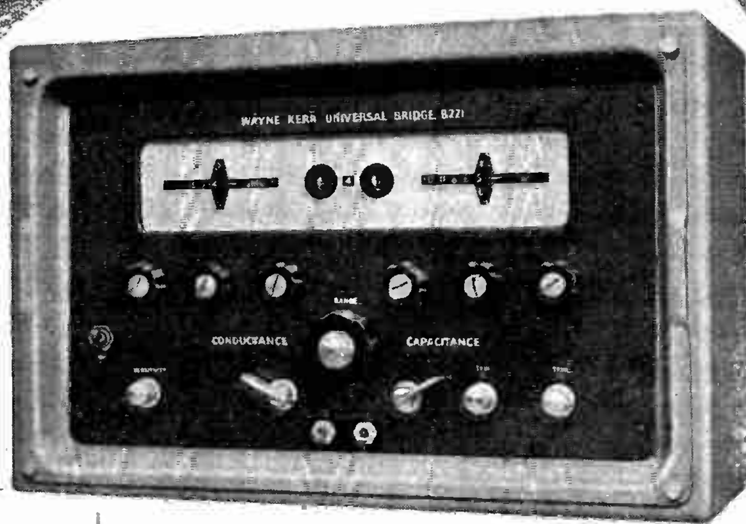
WAYNE KERR UNIVERSAL BRIDGE B.221



Specification

BRIDGE ONLY:
Capacitance: 0.0002 pF to 10 μF in 7 ranges. Accuracy ±¼%. Conductance: 0-± 100 mmho in 7 ranges. Inductance: 1mH to infinity in 7 ranges. Measuring Frequency: 10,000 radians/sec. (1592 c/s.) Power Supply: 110/115 and 200/250 V 40/60 c/s. Dimensions: 17" x 7" x 11¼" high. Weight: 25 lbs. approx.

WITH LOW IMPEDANCE ADAPTOR:
Capacitance: 1μF—100,000μF in 4 ranges. Resistance: 0-100Ω in 4 ranges: Discrimination on lowest range 50μΩ. Inductance: 0-10 mH in 4 ranges. Discrimination on lowest range 5mμH.

PRICES:
Bridge, £175. Low Impedance Adaptor £25

50 MICRO-OHMS TO 10,000 MEGOHMS .0002 PICOFARAD TO 100,000 MICROFARADS, 5 MILLIMICROHENRIES TO INFINITY

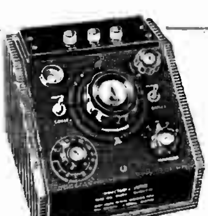
● *Accuracy to 0.25% is achieved with complete stability.* ● *Two decades and a continuously variable control indicate independently the resistive and reactive terms to four significant figures.* ● *Adaptors for measurement of conductivity, dielectric constant and loss factor of solids and liquids.*

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

Measurement is unaffected by the impedance of the test leads, which can therefore be of any length. Consequently the instrument is ideally suitable for the determination of temperature coefficient of components under test conditions or, in fact, any remote in situ measurement. A novel mechanism automatically displays the cyphers, decimals and units of measurement. This gives direct reading and avoids any confusion which might be caused by the large multiplying factors involved.

The basic range of the instrument covers impedances from 10,000 megohms to 10 ohms and this is extended to 50 micro-ohms by the use of the Low Impedance Adaptor. Other adaptors have been designed for measurement of conductivity, dielectric constant and loss factor of solids and liquids.

WAYNE KERR

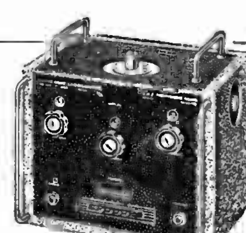


Inductance Meter Type M.149

A small portable instrument designed for the simple and direct measurement of inductance values between 0.05 μH and 100mH. Price £65.

Admittance Bridge Type B.901

An extremely stable transformer ratio-arm bridge designed for unbalanced measurements on aerials, feeders, cables and components at frequencies between 50 and 250 Mc/s. Price £175



THE WAYNE KERR LABORATORIES LIMITED, ROEBUCK ROAD, CHESSINGTON, SURREY. TELEPHONE: LOWER HOOK 1131

5 inch High Precision Oscillograph Tube 5BKPI

Quantity production of the 5BKP1 by ETEL is making it an economic proposition for more designers to incorporate a high precision oscillograph tube in a wider range of applications than has previously been possible.

This five-inch tube employs a two-stage distributed post deflection accelerator. High P.D.A. ratios may be used, and the distortions caused in normal P.D.A. systems largely eliminated, with consequent advantages in brightness and deflection sensitivity. With a P.D.A. ratio of 5½: 1 the maximum pattern distortion is 2% and the maximum deviation from deflection linearity is 2%.

As can be seen from the adjacent data the 5BKP1, with its high sensitivity and low plate input capacitances is specially suitable for wide-bandwidth oscillography. Full data is available on request.

Abridged data

Screen Metal backed P1 green fluorescent medium persistence. Other screens available to order.

Heater Vh = 6.3V · Ih = 0.55A

Capacitances x' to x" . . . . . 2.3pF · y' to y" 1.7pF
One x plate to all other electrodes less other x plate 3.6pF
One y plate to all other electrodes less other y plate 1.65pF

Typical Operation

Va1	1400	V
Va2	440 to 560	V
Va3	1800	V
Va4	4000	V
Va5	10,000	V
Vg	−45 to −90	V
Sx	26.5	V/cm
Sy	12.5	V/cm

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ETL2a

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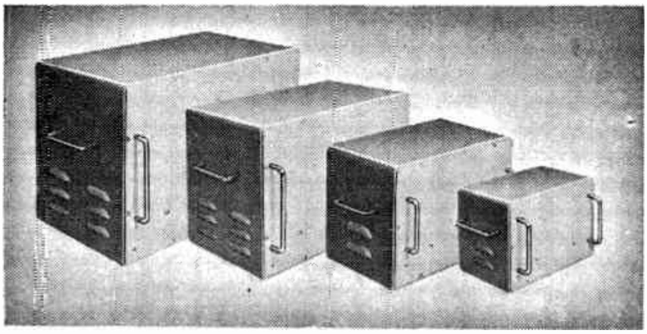

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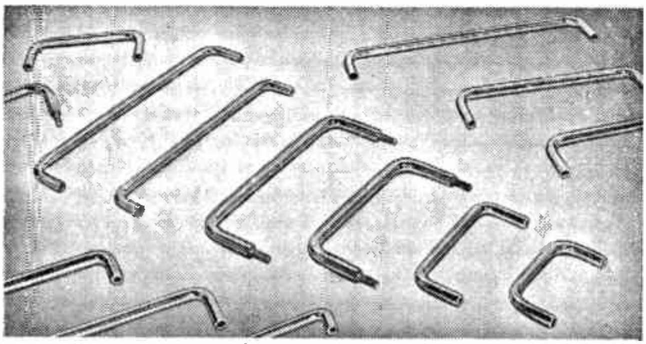

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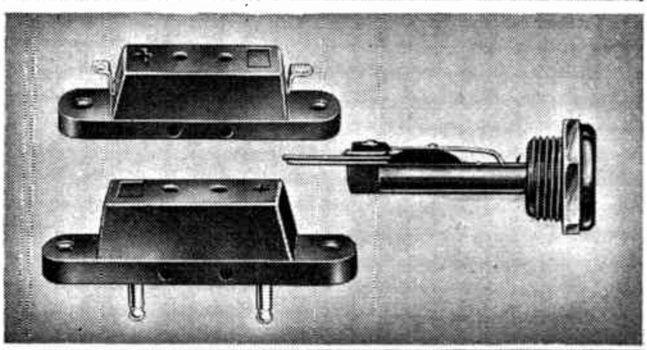
Made in standard range (4in., 6in., 8in. and 10in. centres). A wide variety of other sizes can be made to special order.



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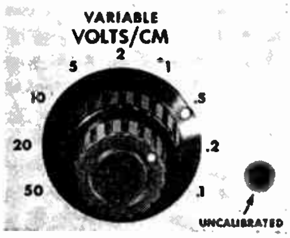
TECHNICAL DATA
on the NEW *Type 515 Oscilloscope*

DC-TO-15 MC PASSBAND

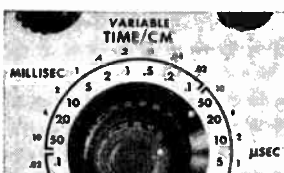
High in performance, but low in size, weight, and cost, the Type 515 fits a relatively new requirement area. Besides its extra capabilities in applications requiring vertical response out to 15 megacycles, it occupies less space and is easier to handle than most other general-purpose laboratory oscilloscopes.



Risetime of the dc-coupled vertical amplifier is less than 23 millimicroseconds. Sensitivity is accurately calibrated, 0.1 v/cm to 50 v/cm in nine steps. A variable control adjusts the sensitivity between calibrated steps and out to 125 v/cm. To help avoid accidental inaccurate readings, a warning light indicates an uncalibrated condition when the variable control is in use. A balanced network delays the signal 0.25 μsec to permit observation of the leading edge of the waveform that triggers the sweep. Direct input capacitance of approximately 36 $\mu\mu$f is reduced to approximately 10 $\mu\mu$f by use of the 10x attenuator probe supplied with the instrument.

SIMPLIFIED SWEEP CONTROL

All 22 of the Type 515's accurately calibrated sweeps are selected by the same control knob. This knob also indicates the sweep time-per-centimeter when the 5x magnifier is in use, making mental calculation of time intervals unnecessary. The normal sweep is expanded to 50 centimeters by the magnifier, and the horizontal-position control has sufficient range to display any 10 centimeters of the magnified sweep. To maintain uniform bias on the control grid of the cathode-ray tube for all sweep speeds and repetition rates, the unblanking waveform is dc-coupled.



Calibrated fixed sweeps extend from 0.2 μsec/cm to 2 sec/cm. A variable control makes the sweep range continuous from 0.2 μsec/cm to 6 sec/cm. Here again a warning light indicates an uncalibrated condition when the variable control is in use.

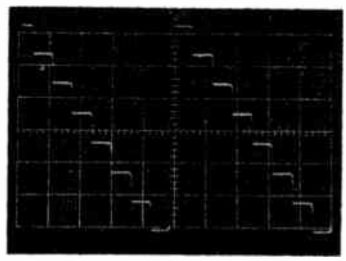
AUTOMATIC TRIGGERING

Automatic triggering is a real convenience in a great many oscilloscope applications. This one position, without further adjustment of the triggering controls, permits signals of widely differing frequencies and amplitudes to initiate the sweep, and provides a reference trace on the screen in the absence of an input signal. The automatic circuit operates at a natural rate of about 50 cycles, but synchronizes readily with incoming signals from 60 cycles to 2 megacycles.

Triggering versatility is one of the many highly-useful qualities of the Type 515. You can trigger the sweep from either the positive or negative slope of an internal, external, or line-voltage signal. On any of these signals, you can trigger the sweep at a selected amplitude level. You select either ac or dc-coupling through the trigger circuitry. You can synchronize the sweep with sine-wave signals up to and beyond 20 megacycles. You can block out the low-frequency component of a composite signal, permitting the high-frequency component to trigger the sweep. These complete triggering facilities make possible a steady display of just about any signal you are likely to encounter.

LARGE DISPLAY AREA

A full 6-centimeter by 10-centimeter linear display can be presented on the screen of the new Tektronix cathode-ray tube, Type T55P, developed especially for this instrument. Characteristics of this new tube help make possible the wide signal-handling range and excellent transient response of the Type 515. Accelerating potential is 4000 volts. A T55P2 is normally supplied, but a P1, P7, or P11 screen is available on request at no extra cost.



PORTABILITY

It's a bit unusual for higher performance to come in an oscilloscope that's smaller and lighter than previous models. But this combination of compactness and performance makes the Type 515 most convenient for those more-exacting field applications. Handling ease and simplified controls are characteristics also desirable in the increasing number of production-line test stations where high performance is a new requirement. The Type 515 weighs only 40 pounds and measures 9¾" wide, 13½" high, 21½" deep.

OTHER CHARACTERISTICS

Many of the other features you'd expect to find in any Tektronix Oscilloscope are part of the Type 515. Square-wave amplitude calibrator, sweep sawtooth and gate available at front panel, illuminated graticule, and electronically-regulated power supply are some of the "standard equipment". New style cabinet with removable sides speeds any maintenance that may be necessary.

TYPE 515 ... $750 (F.O.B. Portland, Oregon)
£290.0.0 (Delivered in England)

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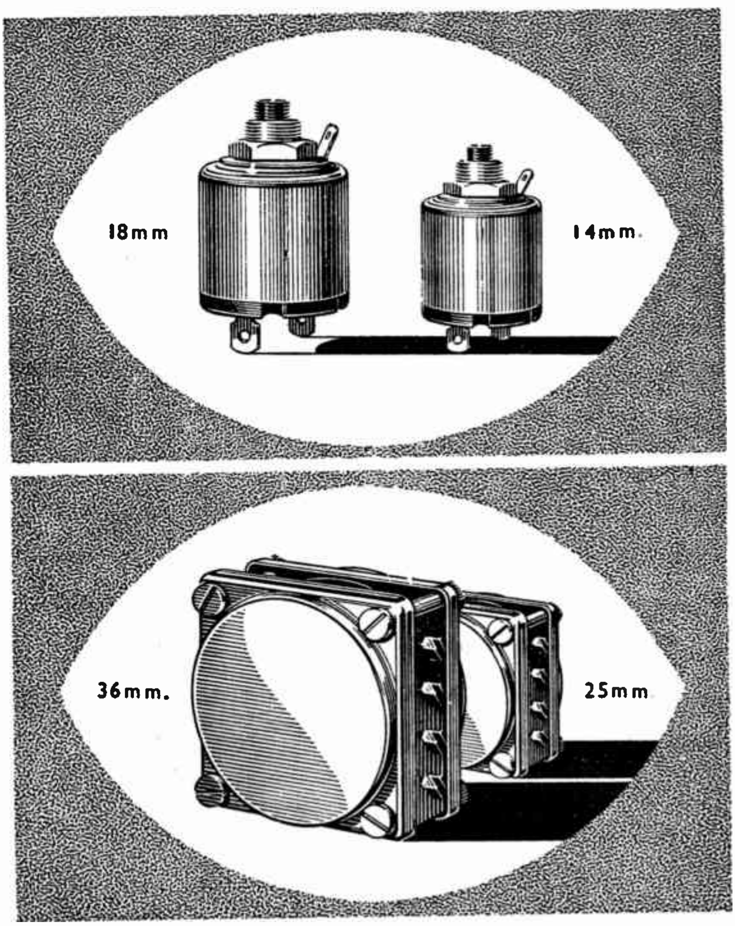

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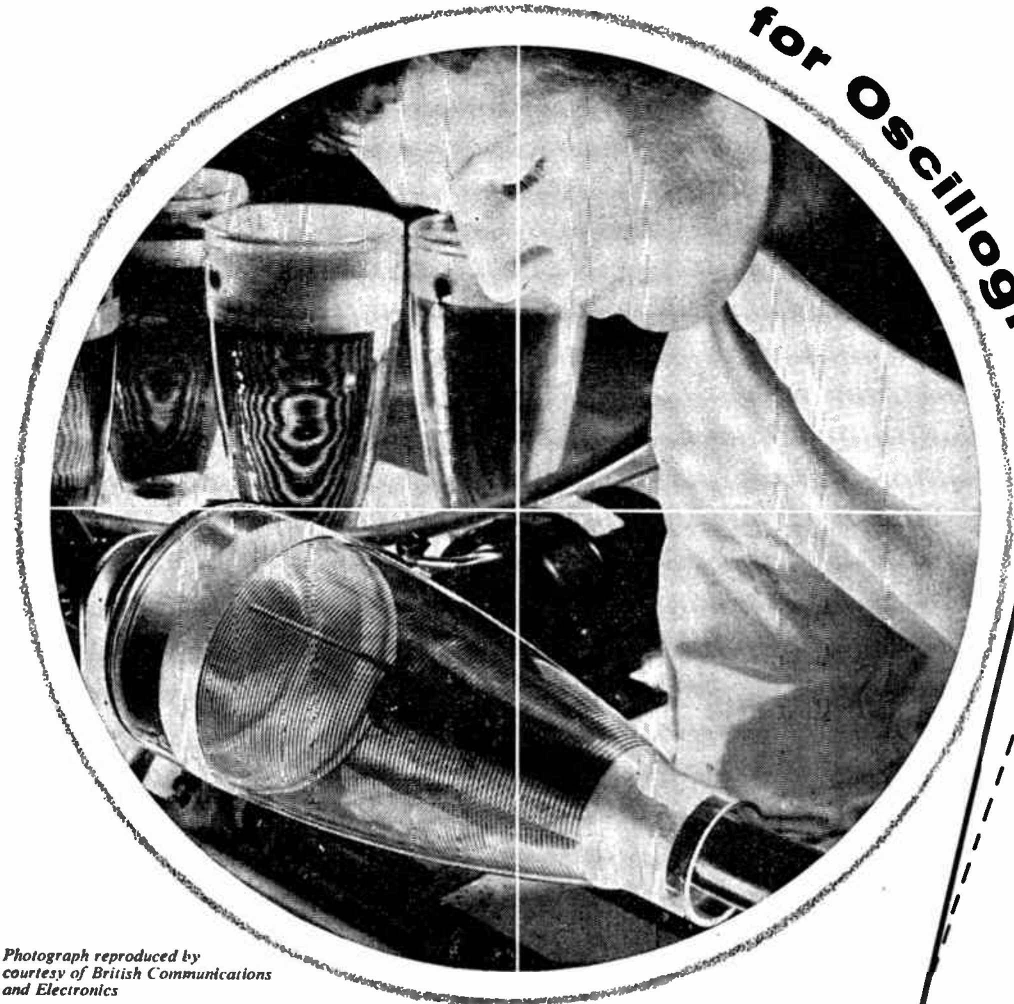
G.E.C. CATHODE RAY TUBES

for Oscillography



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The recently advertised 4GP., 5BHP and 6EP cathode ray tubes are only three of a wide range of instrument tubes marketed by the G.E.C.

The range includes both electromagnetic and electrostatic deflection tubes and all are generally available with any one of six standard screen phosphors. Other screen phosphors can be supplied to special order.

Should you have any cathode ray tube problems—consult the M-O Valve Company. You will most probably find a tube in the range which is ideally suited to your particular application. If not, the Company with its wealth of experience and technical facilities may be able to make a special tube for you.

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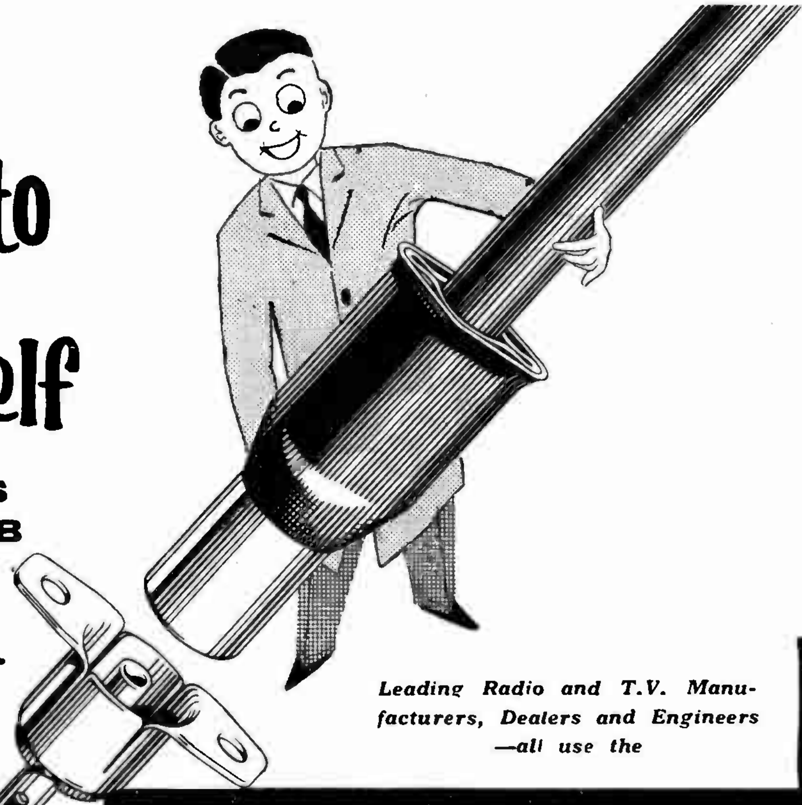

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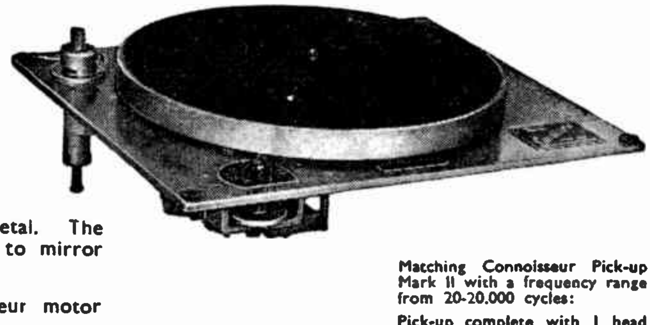

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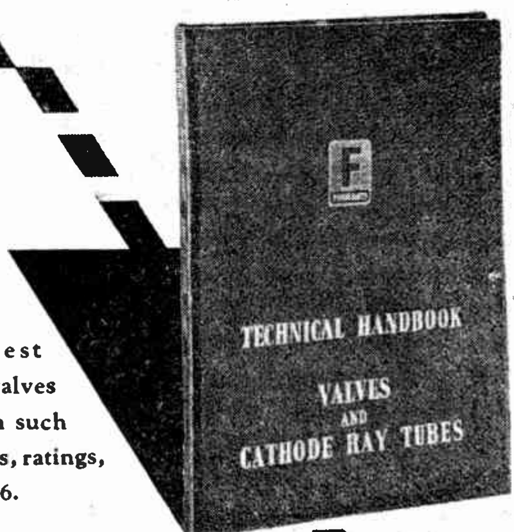

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			SX643	SX644	SX643	SX644
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Bi-phase	2	200	64-0-64	106-0-106	90	150
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PICK-UP and TRANSCRIPTION MOTOR

Fine Equipment For Reproducing Sound on Disc

Pick-Up (Mark II)

The Connoisseur Pick-up has a downward pressure of only 5 grams and has a frequency range from 20 c/s to 20 kc/s plus or minus 2 dbs on soft vinolite discs at 33⅓ r.p.m.
This is distinguished by its supreme quality and high-class finish. This is the unit for Hi-Fi enthusiasts.

1. 15 mV. obtained off a standard L.P. disc.
2. 100% screening of coil by magnet system.
3. Easily replaceable armature system.

Variable 3 Speed Motor

This is a hand-built product which meets with the most stringent requirements.

1. Three speeds with 4% variation by mechanical means. No braking action applied to motor.
2. The motor is a synchronous hysteresis type, running in substantial phosphor-bronze bearings.
3. The motor will remain in synchronisation with 25% variation of line voltage.
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This unit is being used in considerable numbers by Recording Studios and Sound Installations.

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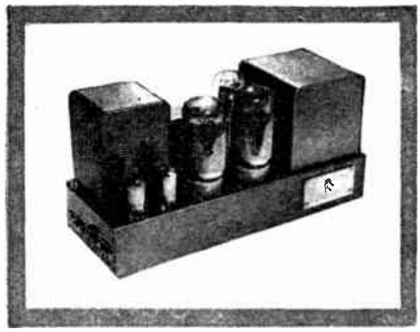

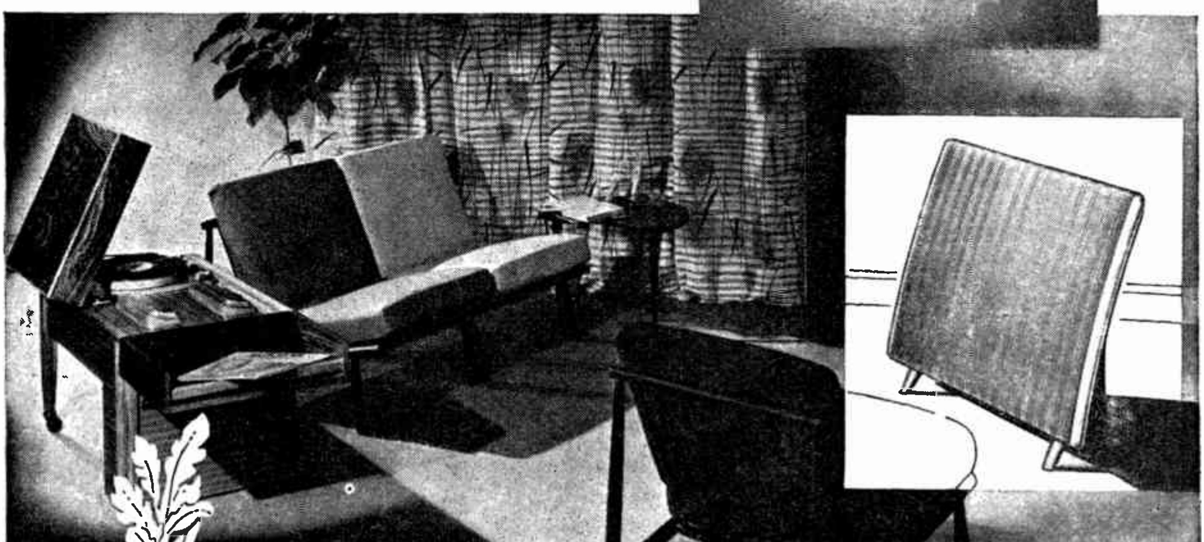

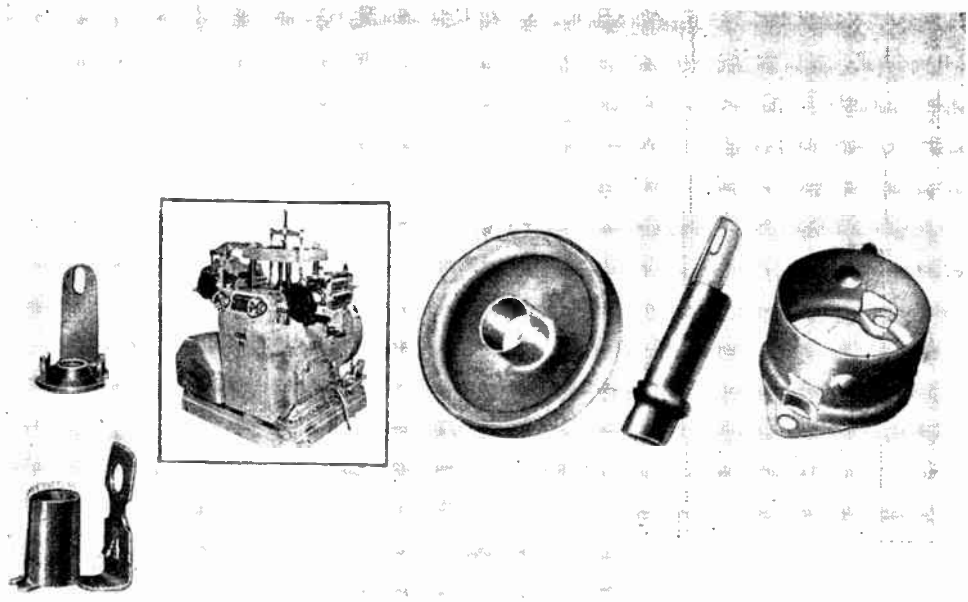

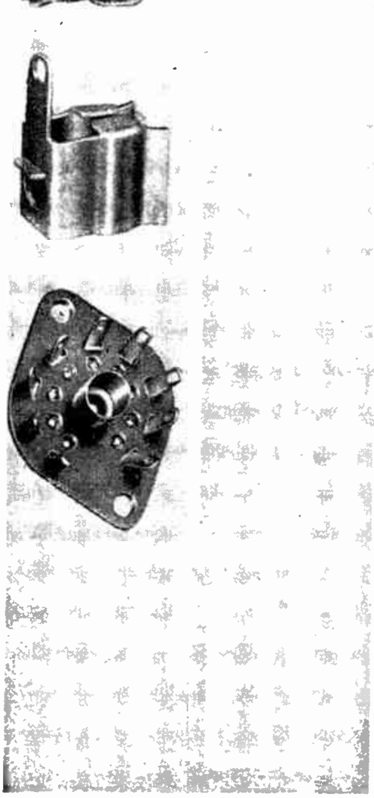

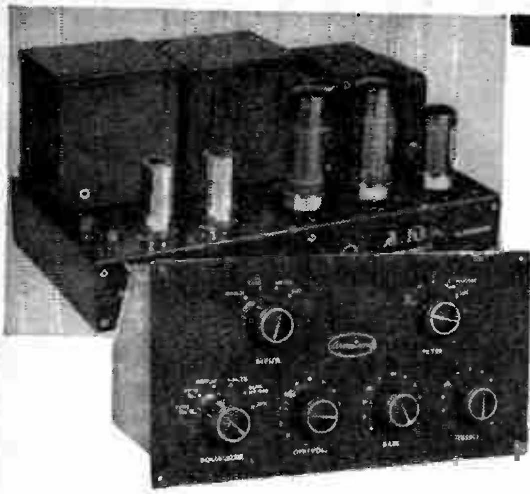

Armstrong A10

MARK II

HIGH FIDELITY AMPLIFIER & PRE-AMPLIFIER CONTROL UNIT

BRIEF SPECIFICATION *Output:* 10 watts rated; 20 watts peak. *Frequency Response:* 10-100,000 c.p.s., within 1dB 15-30,000 c.p.s. *Distortion:* less than 0.1%. *Damping Factor:* 40. *Hum Level:* Better than 80dB down. *NFB:* 3 loop, main overall loop 28dB. *Sensitivity:* 8mV (Gram input A) for 10 watts. *Spare Power Supplies:* 320v, 45mA and 6.3v, 2A. *Valves:* Pre-amp ECC83, EF86. Amplifier GZ34, ECC85, EF86, 2 x EL34's. *Controls:* 1. INPUT—Mic. Radio, Tape, Gram (in conjunction with 4 position pick-up matching selector). 2. EQUALISER—6 position. 3. FILTER—6 position. 4 & 5. BASS & TREBLE (both lift & cut 15dB). 6. VOLUME. *Tape Output Socket on rear of Control Unit.*

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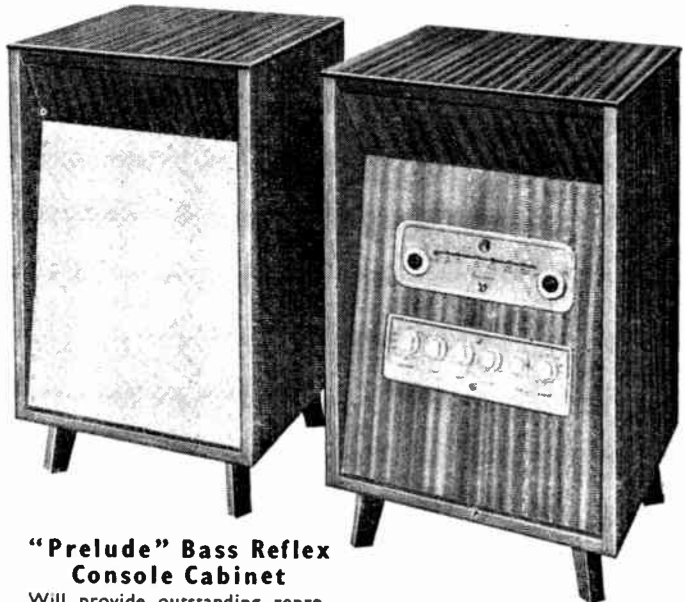

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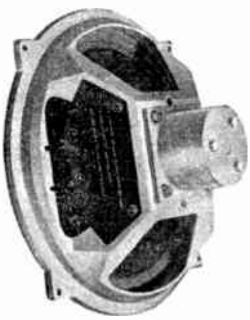

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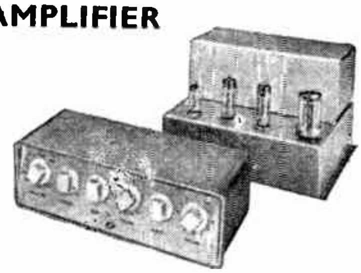

was acclaimed by all the leading experts when it was first introduced. In its improved form, it is now available with a choice of control units. Standard for crystal pick-up, and Major for all types. Main Amplifier, **£18.10.0.** Standard control unit, **£9.0.0.** Major control unit, **£19.10.0.**

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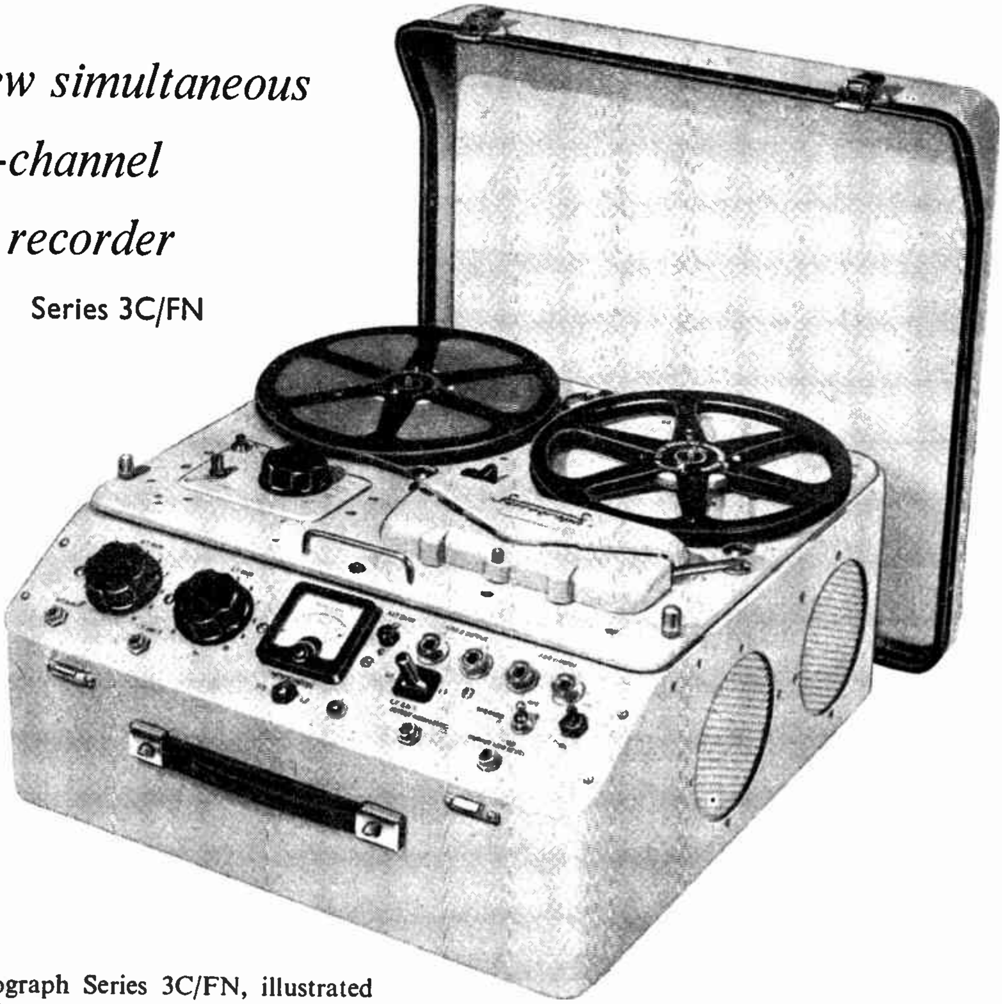
A new simultaneous dual-channel tape recorder

Series 3C/FN



THE Ferrograph Series 3C/FN, illustrated here, is a simultaneous dual-channel instrument, using staggered heads, which offers special facilities to those engaged in medical, aeronautical and other scientific research. Besides the normal ability to record simultaneously time pulses on one track and intelligence on the other, it becomes immediately obvious that many forms of comparative measurement, stereophonic sound, or indeed, any two activities capable of being translated into electrical phenomena (within its frequency and phase shift limitations) can be recorded simultaneously and replayed when required. Thus, the scope of such an instrument, when used for Research purposes, is almost unlimited.

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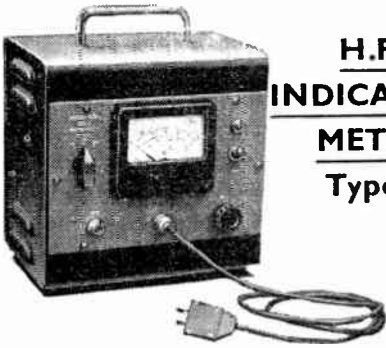

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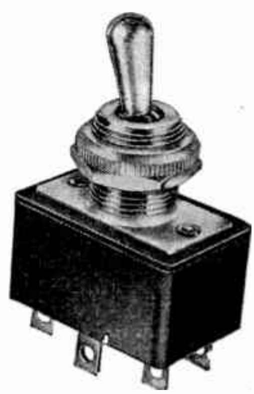

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In all commercial, industrial and sporting activities, for crowd control and in any place where there is need to amplify the voice, the Pye Transhailer is invaluable.

SPECIFICATION:

Power Output: 3–3½ watts
Distortion: 10%
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Batteries: 4 cells Ever Ready Type 1839 (or equivalent) or 8 cells Ever Ready Type UII (or equivalent)
Dimensions: Length 15½ ins. Diameter across mouth: 10½ ins.
Weight: 5 lbs. (incl. batteries)

PYE TELECOMMUNICATIONS LIMITED NEWMARKET ROAD CAMBRIDGE ENGLAND
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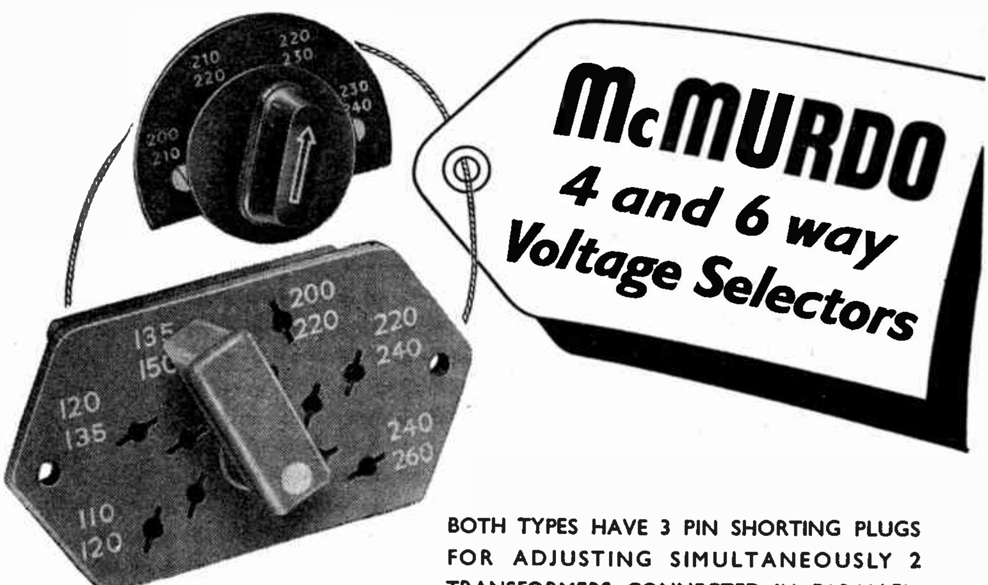
4 WAY
BVS/4

6 WAY
XVS/6



BOTH TYPES HAVE 3 PIN SHORTING PLUGS FOR ADJUSTING SIMULTANEOUSLY 2 TRANSFORMERS CONNECTED IN PARALLEL.

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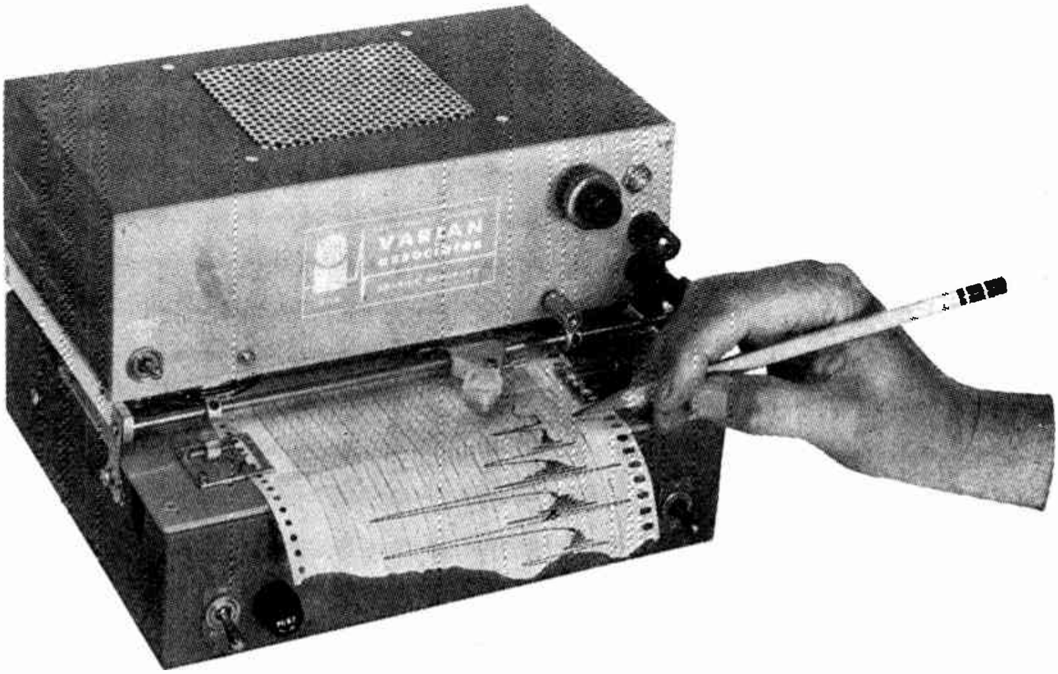
MVS7

SERVO GRAPHIC RECORDER

by VARIAN ASSOCIATES



THE G-10 RECORDER fulfils the need for a flexible, compact and moderately priced instrument for recording phenomena capable of representation by d.c. signals in the millivolt range. The G-10 utilizes the time proven automatic null-balancing potentiometer principle. It is suitable for local or remote recording and is used:

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★ with SHUNTS for d.c. currents of all values
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STABILITY insured by the use of precision measuring circuit resistors, a REFERENCE CELL with an excellent discharge characteristic, and an a.c. type servo amplifier;
LINEARITY afforded by high quality measuring slidewire;
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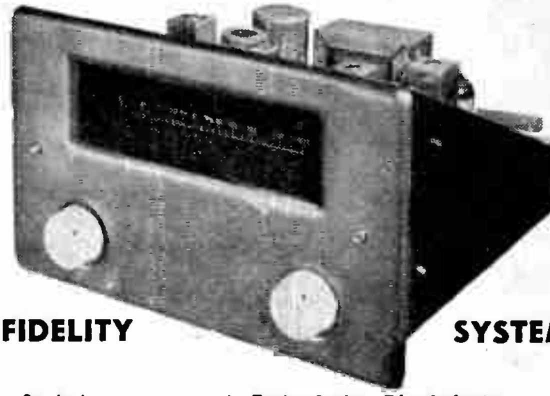

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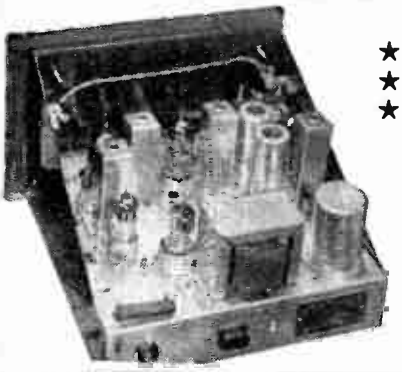

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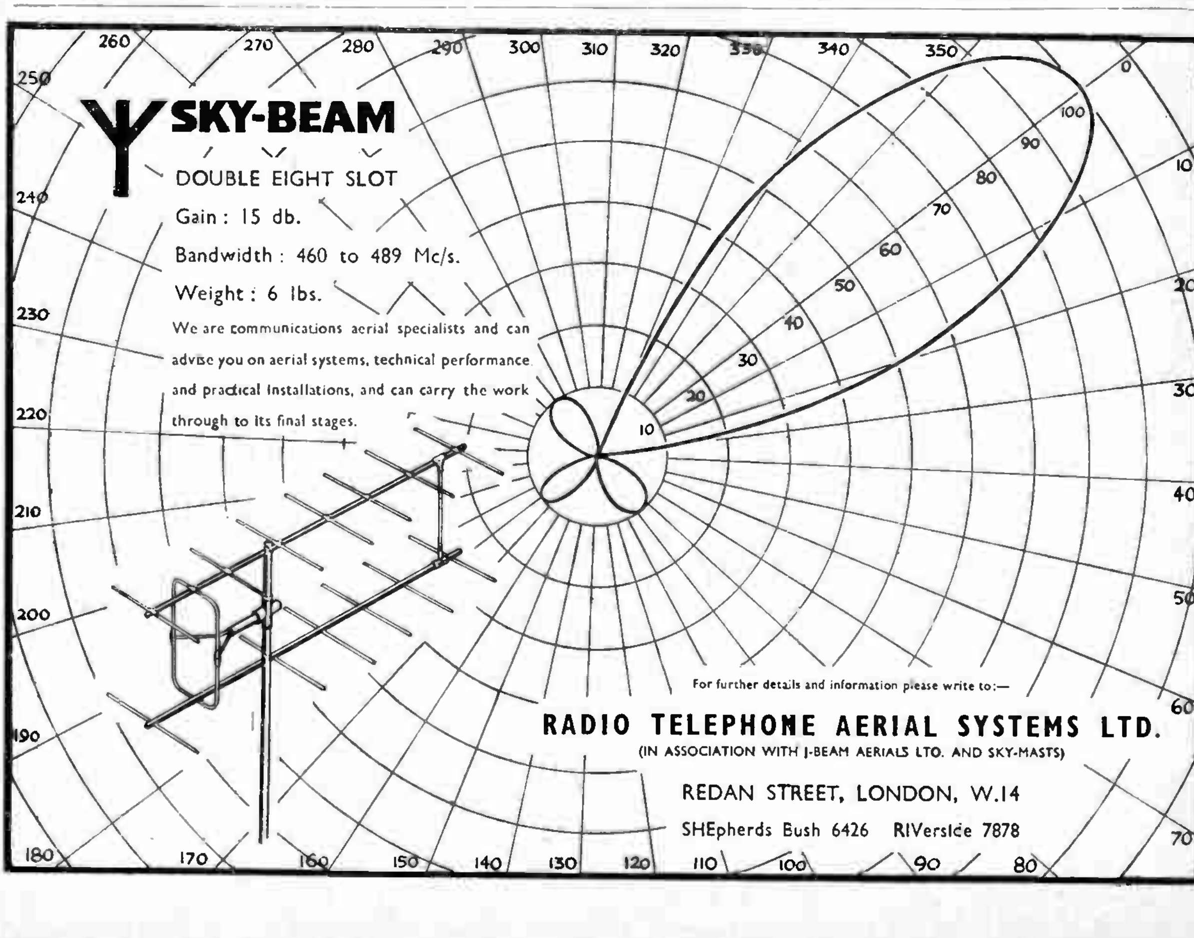

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GENERATORS AND SOURCES

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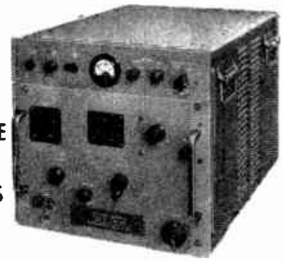
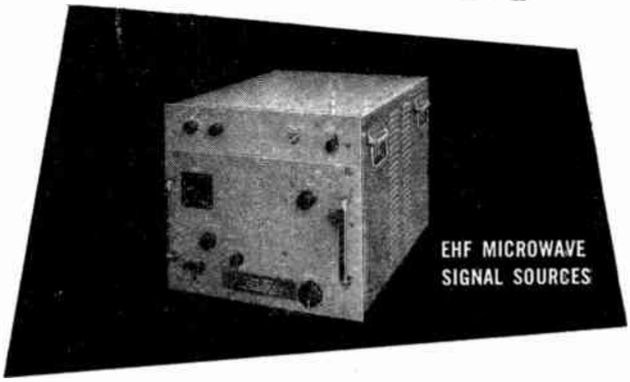
EHF MICROWAVE SIGNAL GENERATORS



18,000 to 50,000 mc/s WITH

PLUG-IN

TUNING UNITS



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EHF microwave Signal SOURCES

- **9 plug-in r-f tuning units cover the frequency range from 18,000 to 50,000 mc/s.**
- **Internal 1000 cps square-wave modulation.**
- **Capable of external modulation, both pulse and fm.**
- **Equipped with integral electronically regulated power supplies.**
- **Frequency calibration accomplished by a ± 0.1% direct-reading wavemeter.**

SIGNAL GENERATORS Basic Unit Model HU-2		FREQUENCY RANGE	SIGNAL SOURCES Basic Unit Model HU-1	
Plug-in Tuning Unit Model No.	Power Output Calibrated		Plug-In Tuning Unit Model No.	Power Output Average
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G2225		22,000—25,000 mc/s	S2225	10 mw
G2427		24,700—27,500 mc/s	S2427	10 mw
G2730	—10 to —90 dbm	27,270—30,000 mc/s	S2730	10 mw
G3033		29,700—33,520 mc/s	S3033	10 mw
G3336		33,520—36,250 mc/s	S3336	9 mw
G3540		35,100—39,700 mc/s	S3540	5 mw
		37,100—42,600 mc/s	S3742	Approx. 3 mw
		41,700—50,000 mc/s	S4150	Approx. 3 mw

Model SG-1218, Signal Generator and Model SS-1218 Signal Source are available to cover the frequency range 12,400 to 17,500 mc/s.

MODULATION:

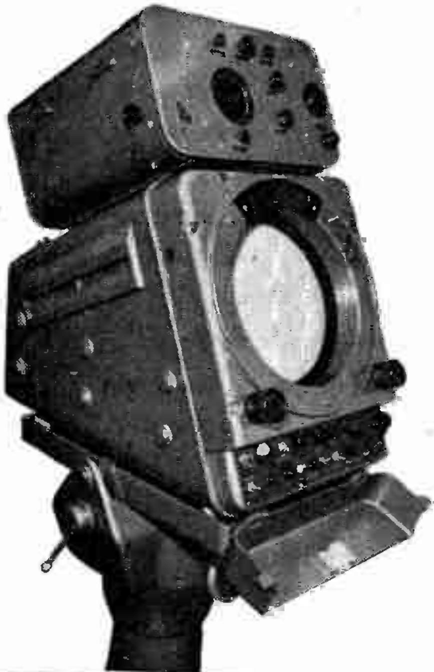
Internal modulating:
Frequency ...... 1000 cps square wave.
Requirements for external pulse modulation:
Pulse repetition frequency ... 100 to 10,000 pps.
Pulse width rate 0.5 to 10 microseconds
Pulse amplitude 10 volts peak, minimum.
Pulse polarity ... Positive.

Requirements for external frequency modulation:
Waveform ...... Sawtooth or sine wave.
Frequency ...... 50 to 10,000 cps.
Amplitude ...... Approx. 10 volts rms, to produce 40 mc/s deviation.

For Complete Information:

B. & K. LABORATORIES LTD. 57 UNION ST., LONDON, S.E.1.

Telephone: Hop 4567 *Cables: Banklabs · London*



TYPE 12TO3A

The Decca True Motion Radar† one of the most comprehensive marine radar equipments manufactured, uses a 'Cintel' Cathode-ray Tube for display purposes.

This tube is but one from a wide range in current production suitable for radar applications and radar is only one of the facets covered by the complete range of 'Cintel' Tubes.

†Photograph by courtesy of Decca Radar Ltd.

RADAR TUBES

*** over 200 tube types in the current catalogue. Full data on request.**

WORSLEY BRIDGE ROAD
LOWER SYDENHAM · LONDON SE26
A Company within the Rank Organisation Ltd. HITHER GREEN 4600

CINTEL

the DYNATRON v.h.f. tuner unit

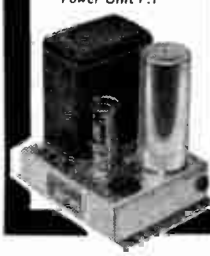
PROVIDES TRUE HIGH FIDELITY LISTENING

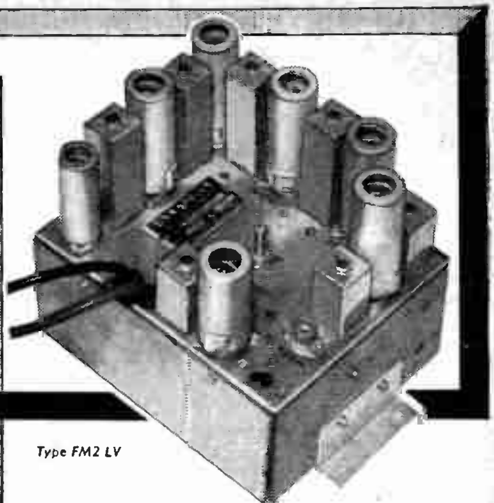
• 7/8 Valve Tuner • Pre-tuned 4 stations
Automatic frequency corrector • Single switch operated

This tuner is the most advanced unit available today. It brings to the discriminating listener true-to-life reception of music and spoken word through the medium of the B.B.C.'s 'Home', 'Light' and 'Third' VHF radio broadcasts.

The F.M.2 employs a Foster-Seeley type of discriminator and covers from 88-100 Mc/s. with four pre-tuned circuits. This unit is used by the B.B.C. and leading relay organisations use it as both a main and monitor receiver. For completing a high fidelity audio installation or converting a radio-gramophone, the Dynatron VHF tuner provides the complete answer.

Power Unit P.1





Type FM2 LV

7-valve FM2LV	8-valve FM2HV	Power Unit P.1
£25.0.6	£29.3.9	£7.15.0

Write for full details of this Dynatron F.M. Tuner and learn what true high fidelity listening really means.

Two versions are available—one with an output of 0.2V.; the other with an extra valve providing a variable audio output which can be adjusted between 0.3V. and 2.0V. R.M.S. A separate Power Unit, Type P1, is also available for use in installations where suitable voltages are not available.

DYNATRON

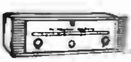
Dept. TU 103. DYNATRON RADIO LIMITED
CASTLE HILL MAIDENHEAD . BERKS

THE BEST OF BOTH WORLDS

Whether you want a self-contained plug-in-and-play High Fidelity instrument or a *complete* range of *matched* High Fidelity units—specify RCA. For over 25 years the world's recording studios have consistently preferred RCA. Now let RCA bring this same studio quality to your home.

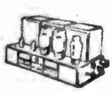
New Orthophonic High Fidelity

Matched Units



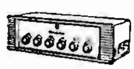
Super-sensitive FM Tuner
£24.3.0 plus £9.8.4 P.T

Panoramic Multiple Speaker System. £56.11.0



20 watt Power Amplifier.
£24.10.0

Transcription Turntable Deck
£22.6.0 plus £8.14.0 P.T.



Versatile Pre-amplifier Control Unit. £16.10.0

High Fidelity

PLUG-IN-AND-PLAY

Record Reproducers

Above is the RCA "PRESIDENT" High Fidelity phonograph, ready-to-play, automatic changing, console record reproducer of outstanding quality. Panoramic multiple speaker system; new triple control with balanced loudness feature; 20 watt peak push-pull power from extended range amplifier; elegantly styled in superb cabinets in walnut, light oak, or dark oak finishes.

68 GNS.
(tax paid)

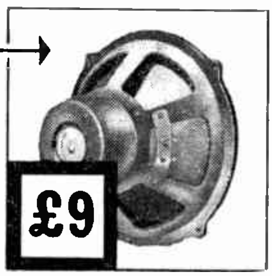
The RCA "VICE PRESIDENT" High Fidelity phonograph (illustrated right) is a beautifully styled record reproducer with a quality of reproduction never before associated with instruments of its size. Panoramic triple speaker system; 10 watts peak power from push-pull amplifier with frequency range 40-20,000 cycles; triple control system; 4-speed changer.

43 GNS. (plus £1.15.0 optional legs tax paid.

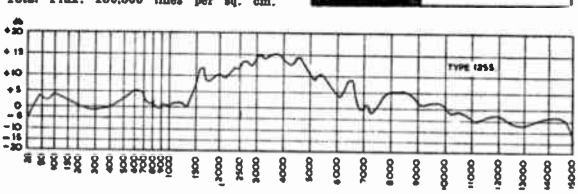
RCA GREAT BRITAIN LIMITED, Lincoln Way, Sunbury-on-Thames, Middx.
(An Associate Company of Radio Corporation fo America) Telephone: Sunbury-on-Thames 3101.

. . . you will realise that Grampian high fidelity equipment gives you the nearest approach to "Concert hall listening" in your own home. You will, for instance, appreciate the extraordinary delicacy of reproduction achieved by their new 12in. loudspeaker. A great deal of research and new manufacturing methods were necessary to produce a speaker unit with such an extended audio frequency coverage at such a reasonable cost.

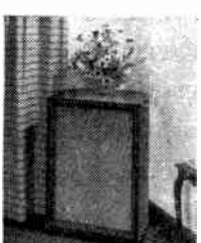
GRAMPIAN
12" SPEAKER UNIT →
Type 1255/15



Frequency Range .... 20-15,000 c.p.s.
Voice Coil Diameter.............. 1¾in.
Voice Coil Impedance: .... 15 ohms
Fundamental Resonance: ...... 40 c.p.s.
Power Handling Capacity: .... 10 watts.
Flux Density: 14,500 lines per sq. cm.
Total Flux: 130,500 lines per sq. cm.



CYCLES PER SECOND INPUT ½ WATT
RESPONSE CURVE for speaker unit 1255/15



A specially designed reflex cabinet suitable for either corner or side of room is now available as an easy-to-assemble kit of parts, complete with grille material ready to assemble, stain and polish. Although it is primarily intended for use with the Type 1255/15 speaker the cabinet will give excellent results with other units of similar specifications. Price **£11**

Deferred terms available if desired for both speaker and cabinet kit!

Full details from:

GRAMPIAN
REPRODUCERS LIMITED
Makers of quality high fidelity equipment
17 HANWORTH TRADING ESTATE, FELTHAM, MIDDLESEX
Telephone Feltham 2657/8

Remember- Radiospares components are delivered absolutely "by return"

Phoenix

EYELETTING
and light
PUNCHING
MACHINES

Autophoenix No. 6

A new and improved treadle operated machine for the automatic insertion and closing of eyelets in either flat or formed work in metals, plastics, fabrics, etc. The deep throat, high vertical gap and projecting base make this machine adaptable for eyeletting radio chassis, cylindrical shells, spinnings, mouldings, etc.

We manufacture a very full range of hand and automatic Eyeletting and Piercing Machines. Write for illustrated brochure to Dept. W.W.

HUNTON LIMITED
PHOENIX WORKS, 114-116 EUSTON RD., LONDON, W.1
Tel.: EUSton 1477 (3 lines) Grams: Untonexh, London

POWER-POINT for record reproduction

POWER-POINT is a revolutionary miniature ceramic record-player cartridge with two sapphire tips.

POWER-POINT is a proved sales success—over 3,000,000 have already been sold abroad!

POWER-POINT can be fitted to all popular pick-up arms.

POWER-POINT is so easy to handle and so quick to replace—it solves your stylus replacement problem!

POWER-POINT gives higher fidelity, longer life, and reduces record wear to a minimum.

POWER-POINT is backed by attractive display material and a carefully planned advertising campaign.

You can profit from POWER-POINT!

£1,000 IN PRIZES!

A EUROPEAN TOUR for winning Wholesalers and Retailers
T.V. Sets, Radios and Record Players for your customers!

For full details write to :—
E. V. LIMITED,
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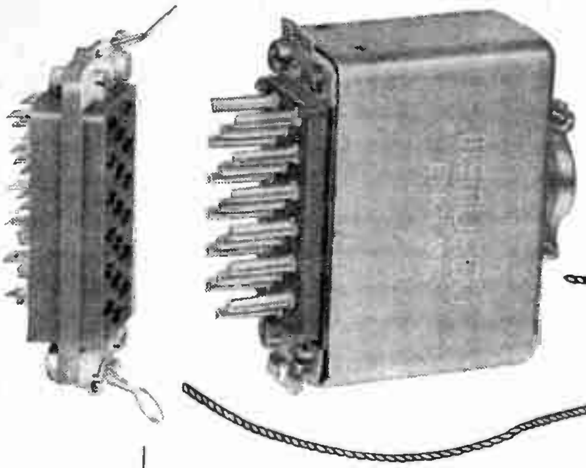
Telephone : Hyde Park 8292

OVER 3,000,000 POWER-POINTS ARE ALREADY IN USE ABROAD!



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8 WAY | 18 WAY

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Nylon—PF mouldings. Silver plated contacts. Solid drawn aluminium cans. Positive locking mechanism.
Breakdown voltage 3.5kV.

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- ★ *Tape Recorders*
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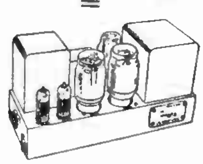
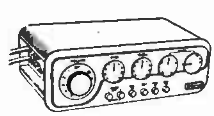
THE HI-FI SPECIALISTS



QUAD II AMPLIFIER



QUAD II CONTROL UNIT

LIST PRICE **£42**

For all Hi-Fi, Tape Recording, Instrument and Electronic requirements.

From our huge stocks of equipment we can supply your every need—on easy repayment terms, if required. If you are unable to call please use our highly efficient Mail Order Service.

Dealers for:—

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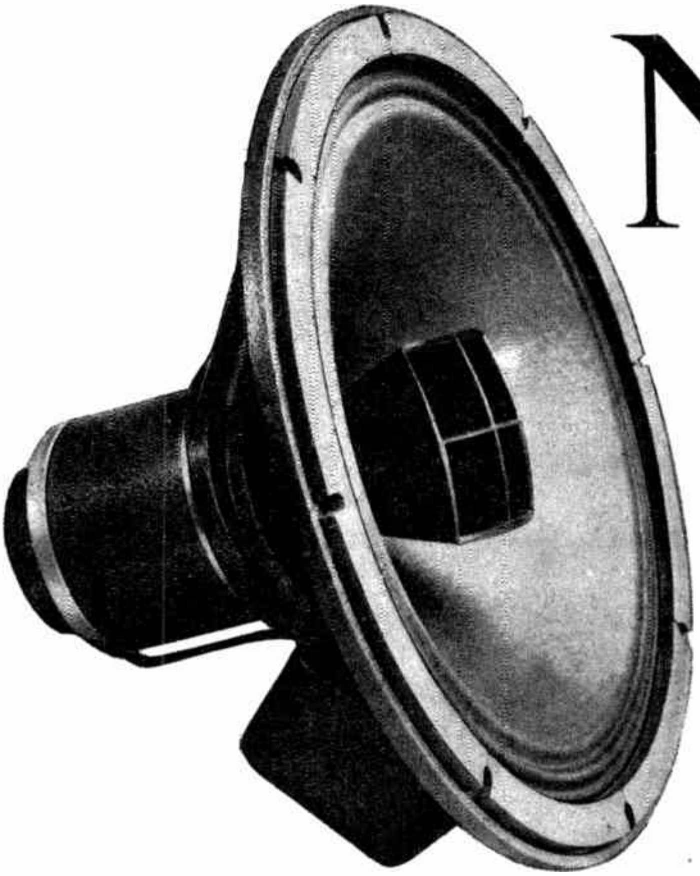
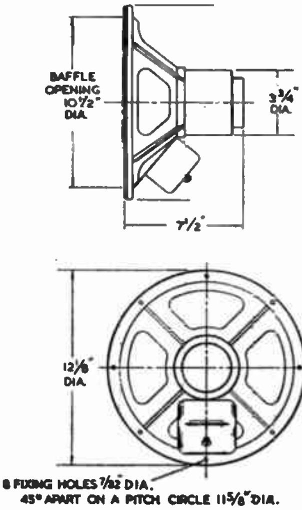


Now!

a full range dual concentric loudspeaker system with built-in dividing network

ALTOBASS 2000



The Altobass 2000 loudspeaker consists of a horn-loaded high-frequency unit mounted concentrically with a conventional low-frequency radiator to form one integral unit. A dividing network is built in to feed high and low frequencies to their respective voice coils. The HF pressure unit is loaded by a truly exponential horn commencing through the centre pole of the LF magnet and terminating in a multicellular assembly within the bass cone. This unique feature disseminates the full range over a wide area, thus eliminating any beam effect.

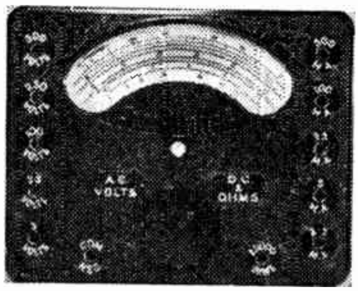
* ***dual concentric assembly***
* ***separate LF and HF diaphragms***
* ***multicellular exponential HF horn***
* ***cast aluminium chassis***

17 GUINEAS

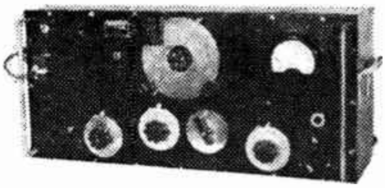
FULL SPECIFICATION DATA FROM ALTOBASS LIMITED, PERCY ROAD, LEICESTER

BRAND NEW ORIGINAL SPARE PARTS FOR AR88 RECEIVERS.

I.F TRANSFORMERS 1st, 2nd, 3rd, 4th (for type D) **12/6** each or complete set of 6, **60/-.**
I.F. Transformers, Crystal Load. **12/6** each.
Plates escutcheons (for D and LF), **15/-** each.
Dials (for type D), **10/-** each.
Filter Chokes (for D and LF), **22/6** each.
Output Transformers (for LF), **30/-** each.
Crystal phasing (D), **2/6** each.
Antenna trimmers (LF and D), **2/6** each.
Filter Condenser 3 × 4μF, **£2-10-0.**
Condensers 3×.25 μF (D and LF), **2/6** each.
3 × .01 μF (D and LF), **2/6** each.
RF Antenna inductors (D and LF), **7/6** each.
Mains transformers (LF), **£3** each.
Small knobs (for LF and D), **4/-** each.



AVO MINORS in leather case, fully tested, **£5-10-0.** Packing and Carriage 5/-.



MARCONI SIGNAL GENERATOR. T.F.144G. Covering 85 kc/s. to 25 Mc/s. Postage and packing 20/-. **£70.**

2 K.V.A. TRANSFORMERS. 230/50 v output adjustable by rotary switch. Can be easily adapted as a welding transformer. **£15.** Postage and packing 30/-.

R.109A RECEIVERS. Covering 2-12 Mc/s. 6 v. D.C. **£4/5/-.** Carriage paid.

HIGH RESISTANCE HEADPHONES 4,000 ohms. Brand New, Ex W.D. boxed, Type D.H.R., **11/-** per pair, postage 1/6.

LOW RESISTANCE HEADPHONES. Brand new, Ex W.D. boxed, Type C.L.R. and D.L.R., **5/6** per pair, postage 1/6.

1155L RECEIVERS COVERING TRAWLER BAND. Frequency range 200 kc/s.-500 kc/s. and 600 kc/s.-18.5 Mc/s. Working and guaranteed **£12/19/6.** Packing and carriage within U.K. £1.

MODULATION TRANSFORMERS (U.S.A. Collins), primary imp. 6,000 ohms. C.T., Secondary 6,000 ohms., 20W. **9/6** each.

SPARES for AR77E. Main Dial **8/-.** Band-spread Dial **8/-.** Clean dial window sheet **3/-.** Terminal boards **3/-** each. 10in. shaft for switch, **1/-.** Band indicator shutter plate, **3/6.** Each item 1/- postage.

AMERICAN VALVE TESTER Model 314. Individual lever switches for each tube element. Roll Chart for American type valves. 220/30 V. a.c. Brand new in nice wooden case with leather handles. Full instruction booklet. **£10.** Carriage 10/-.

CONDENSERS, RESISTORS, COILS, TRANSFORMERS. Very large selection in stock.

AMERICAN HANDY TALKIE. Type B.C.611 including two operating crystals (5-6 Mc. band), **£19/10/-.** Postage and packing 10/-.

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FAMOUS RCA TRANSMITTERS
TYPES ET 4336, K & L

Frequency 2 mc.-20 mc.
Power output: 350 w. telegraph.
240 w. telephone.
Type of modulation—Class B high level.
Audio input impedance 500 ohms.
Power supply 190 to 250 v. Single phase 50-60 c.
Tube complement: Crystal oscillators—807, Master oscillators—807, Intermediate amplifier—807, Power amplifier — 813(2), Modulator — 805(2), Rectifier — 866A(4).

Complete with Master Oscillators, crystal multipliers, speech amplifiers, microphones, keys, instruction manual. etc.

We guarantee full supply of all replacement parts for a minimum of 5 years after purchase.

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Built to your Specification

TYPES 3000 and 600
HIGH SPEED POLARISED and A.C.
to 400 VOLTS TROPICALISING—
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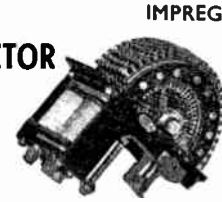

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From 3 to 8 Bank—To Specification

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Several types
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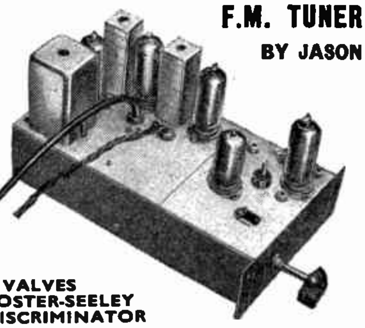
YOU'LL DO BETTER WITH PREMIER

THE MERCURY SWITCHED F.M. TUNER

BY JASON



5 VALVES
FOSTER-SEELEY DISCRIMINATOR

Complete set of parts can be purchased for £9.19.6 plus 2/6 p.p.
All the components can be purchased separately.
The main components are as follows.—

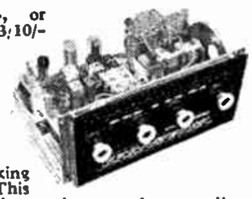
Chassis	6/6
2 side panels, pair	3/-
Prefabricated front-end completely wired and tested with IEF80 and IECF80 (incl. P.T.)	£6/5/-
Discriminator	11/6
2 I.F. Transformers at 5/9 each	11/6
Complete instruction book	2/-

POCKET VOLT TEST METERS

Two ranges, D.C. 0-250 v., 0-25 v., complete with leads in canvas case. In leather case 1/6 extra.
Plus 2/6 post and packing **12/6**

AM/FM RADIOGRAM CHASSIS

OF THE LATEST TYPE



Cash £22/10/-, or credit terms £3/10/- deposit and 8 monthly payments of £2/14/8. H.P. Terms £11/5/- deposit and 12 monthly payments of £1/0/11. Packing and Carr. 7/6. This chassis has 8 valves and covers short, medium and long FM and Gram. Printed circuit on F.M. ensures a high degree of stability. Overall size 14in. long, 6⅝in. high, 9in. deep. Dial size 12 × 5⅜in.

THE STAAR "GALAXY"

4-speed mixture Auto-changer. Finger-tip stop, start and speed change control. Size 10¼in. × 12¼in. A.C. mains 110-250 v. Price £9/15/- plus 4/6 pkg. & carr.
Credit Terms £1/15/- and 8 monthly payments of £1/5/9.

Build the

ONE VALVE BATTERY RECEIVER

AS SHOWN ON B.B.C. T.V.

This Receiver contains a DAF96 valve and a pair of 4,000 ohm headphones and is powered by a combined 67½ and 1½ volt battery.
Price complete with headphones and including battery **45/-**
Send for free diagram.

COLLARO R.C.456

4-SPEED AUTOCHANGER

Designed to play 12in., 10in. and 7in. Records intermixed in any order at 16, 33⅓, 45 or 78 r.p.m. Capacity 10 records. New reversible Dual Stylus Crystal Pick-up for use on 100/250 v. 50 cycle A.C. mains, £9/15/- plus packing and postage 5/-. Deposit 25/- and 8 monthly payments of 25/9.

COLLARO A.C.4/564

4-speed single player with Studio "O" head. A.C. Main, 200/250 volts, 50 c/s. Suitable for record speeds of 16, 33⅓, 45 and 78 r.p.m.

Special offer
£7 . 7 . 0
Carr. & Pkg. 5/-.

B.S.R. TU8 3-speed Record Player with pick-up £3/19/6.

2-VOLT 16AH BAKELITE CASED
ACCUMULATOR

By Oldham, Dagenite, Exide. New and unused, unspillable. 7½ × 4 × 2.
Price **6/6** plus 1/6 post and packing.

★ **IT WILL PAY YOU TO VISIT OUR NEW HI-FI DEMONSTRATION ROOM!**

PREMIER RADIO CO., DEPT. W.W., 207 EDGWARE ROAD, LONDON, W.2
Telephone: AMBassador 4033. PADdington 3271. (Open all day Sats.)

THE WEYRAD AM/FM RECEIVER

THIS RECEIVER WHICH HAS BEEN SPECIALLY DEVELOPED FOR THE AMATEUR CONSTRUCTOR PROVIDES COMPLETE COVERAGE OF THE SOUND BROADCAST BANDS—LONG, MEDIUM AND SHORT WAVE AM. WITH 87.5-100 Mc/s. V.H.F. FOR FM. WE HAVE PRODUCED A FULLY ILLUSTRATED BOOKLET WHICH GIVES INFORMATION ON THE ASSEMBLY AND ALIGNMENT OF THE 4-BAND SEVEN-VALVE RECEIVER, INCLUDING CHASSIS LAYOUT, CIRCUITS AND POINT-TO-POINT WIRING DIAGRAM.

★ "WEYRAD" B.61 COIL PACK, P.23 I.F. TRANSFORMERS, T.S.61 TUNING SCALE, Q2 I.F. FILTER, E.822 MAINS TRANSFORMER AND E.823 OUTPUT TRANSFORMER.

★ ALUMINIUM CHASSIS WITH ALL PUNCHING AND BENDING COMPLETE.

★ DESIGNED FOR LATEST TYPE MULLARD VALVES.

★ RECEIVER OUTPUT CAN BE MODIFIED FOR USE AS A RADIO FEEDER FOR QUALITY AMPLIFIERS.

THE BOOKLET & PRICE LIST ....2/6d.

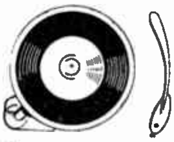
ILLUSTRATED FOLDER OF AM. COMPONENTS ....3d.

WEYMOUTH RADIO MANUFACTURING CO., LTD.

CRESCENT STREET, WEYMOUTH, DORSET.

with PREMIER

The latest
COLLARO
4-speed single player
unit complete with pick-up and turnover cartridge.... £4 14 6
plus 2/6 pkg. & carr.



CABINETS—PORTABLE

MODEL PC/2
Grey Lizard Rexine covered 45/-
Overall dimensions 15in. × 13½in. × 6¾in. Clearance under lid when closed 3in.

MODEL PC/2 DE LUXE
Two colours, wine and grey, with cutout for speaker and amplifier 55/6
Dimensions 15in × 14in. × 7½in

MODEL PC/3
Grey Lizard Rexine covered 69/6
Overall dimensions 16¾in. × 14½in. × 11in. Clearance under lid when closed 3½in.

MODEL PC/3 DE LUXE
As above but with cutouts for Speaker and Amplifier 79/6
Dimensions as above.

THE ABOVE CABINETS ARE COMPLETE WITH CARRYING HANDLE FASTENERS AND PANEL.
Packing and Postage 3/- each.

Junction Transistors 10/- each
Equivalent of the OC70 Type

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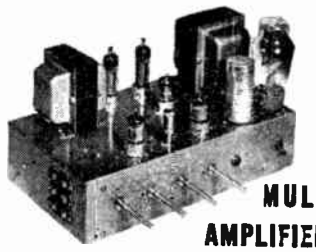

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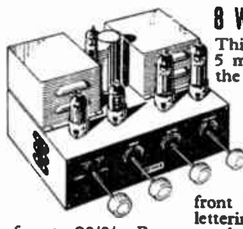

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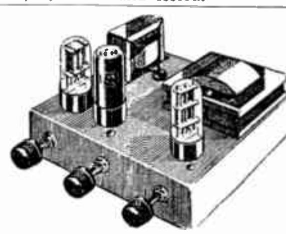

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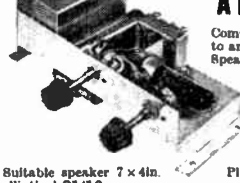

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Wireless World

ELECTRONICS, RADIO, TELEVISION

Managing Editor: HUGH S. POCOCK, M.I.E.E.
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JANUARY 1958

In This Issue

1 Editorial Comment
2 World of Wireless
6 Telephone Automation
7 Reception on Band V
11 Television Aerials for Bands IV and V *By F. R. W. Strafford*
14 Band V on a Turret Tuner *By P. R. Stutz*
17 Some Special Magnetrons
22 Letters to the Editor
23 Short-wave Conditions
24 Cathode-Coupled Flip-Flop *By T. G. Clark*
28 Magnetism in Materials—1 *By D. H. Martin*
31 Technical Notebook
33 Starting Tape Driving Mechanisms
36 Car Radio Receiver Design *By J. C. Beckley*
40 A Pickup To Track at 2 Grams
41 Valves, Transistors and Efficiencies *By "Cathode Ray"*
45 Manufacturers' Products
46 News from the Industry
47 January Meetings
48 Random Radiations *By "Diallist"*
50 Unbiased *By "Free Grid"*

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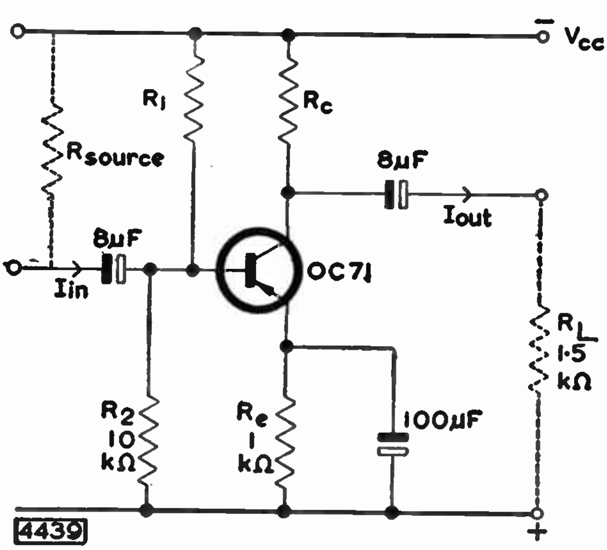
Transistor R.C. Coupled Amplifier Stages

Although it is desirable to design a universal standard transistor amplifier stage, this is not possible because signal level, supply voltage and maximum working ambient temperature each introduce problems which must be overcome in different ways. It is possible however to design and publish typical amplifier stages for several supply voltages, assuming a maximum working ambient temperature, making a compromise between gain and output.

The first stage in an amplifier must be designed to provide as high a ratio of signal to noise as possible, because the accumulated input and circuit noise will give a very impure output over a number of stages. In all other stages the requirement is maximum gain for minimum distortion at the required output level.

The recommended circuit using a Mullard OC71 transistor, with capacitive coupling produces a good gain for a relatively distortion free output. The circuit is suitable for use with supply voltages of 6V, 9V and 12V, stabilised up to 45°C ambient working temperature. Some modifications are indicated below for the user's guidance. It is important when modifications are made to ensure that the collector current should not go below 0.3mA, otherwise the input resistance and collector-emitter gain α' become very non-linear. The distortion and gain data shown in the accompanying table are typical for one OC71 stage from a series of identical ones in cascade. The source impedance R_{source} is assumed equal to the collector resistance R_C. A resistance of 1.5kΩ is used to shunt R_C, this value is equivalent to the input impedance R_L of the following stage. The current flowing in this 1.5kΩ is the output current considered in the distortion and gain measurements tabulated below. The gain figures apply to a transistor with average collector-emitter gain α'. These component values have been carefully chosen such that in each case the transistor operates satisfactorily up to an ambient temperature of 45°C. It will be seen from the table that the useful output current, for 5% total distortion, and stage gain increase with supply voltage. This distortion is predominantly second harmonic.

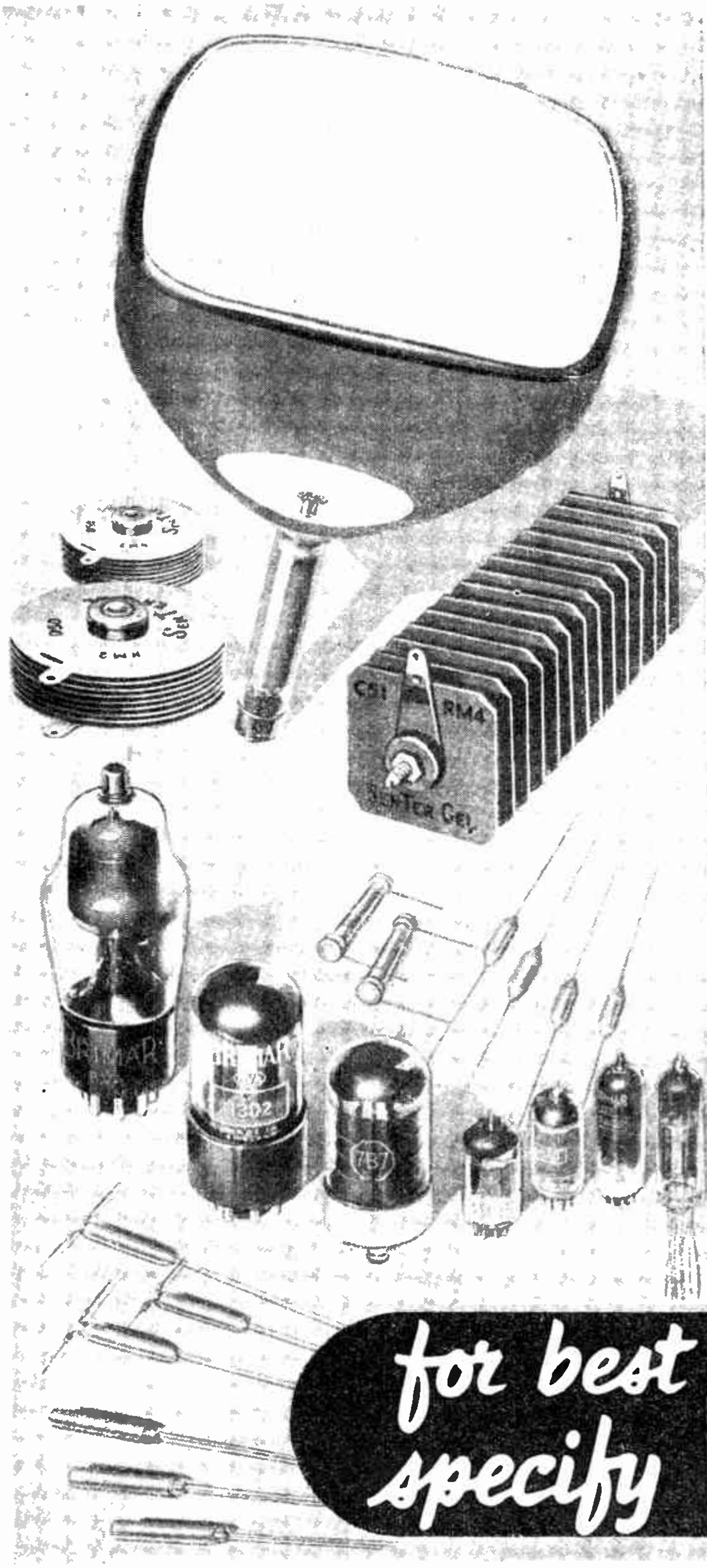


CIRCUIT VALUES AND GAIN FOR SOME TYPICAL OC71 TRANSISTOR STAGES

V_{cc} (V)	I_c (mA)	R_1 (kΩ)	R_2 (kΩ)	R_e (kΩ)	R_c (kΩ)	$\frac{I_{out}}{I_{in}}$	I_{out}*
6	1.0	39	10	1	2.2	23	200
9	1.0	62	10	1	3.9	28	260
12	1.0	82	10	1	5.6	31	270

* For 5% total distortion

The performance obtained with I_C = 1mA should be adequate in most cases, however the stage gain can be increased by reducing (not below 0.3mA) the collector current, this is only worthwhile at the lower supply voltages. For instance I_C=0.5mA, Re= 2.2kΩ, R_C = 3.9kΩ gives 20% increased gain. Increased output can be obtained for a given distortion by increasing the collector current to, say, 1.5mA, altering circuit values accordingly. For minimum distortion it is preferable to keep the collector current in the range 1-2mA, in any case it should not be reduced below 0.3mA, and to keep the source impedance as high as possible.



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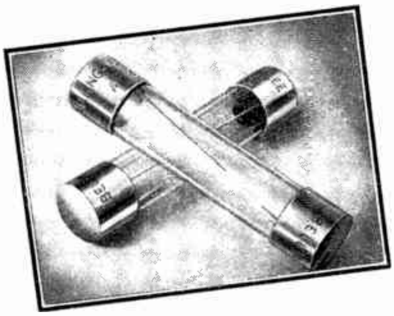

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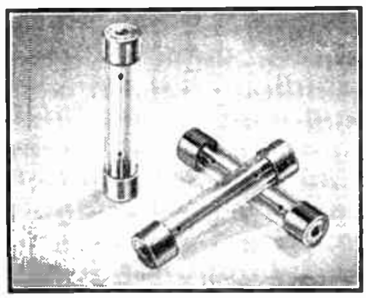

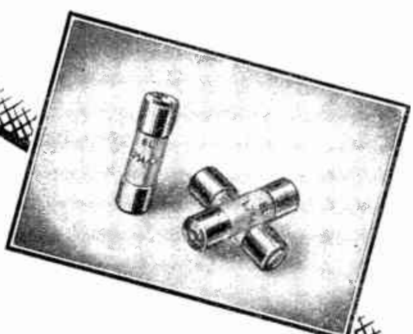

L.754 "Minifuse" (ceramic) size 00. Originally designed for meter protection, these unique fuses are ideal for protecting any delicate apparatus. 10, 15, and 25 mA, blowing within 10 ms, on 350% overload.

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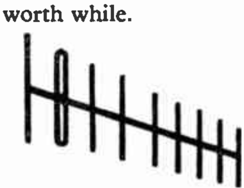

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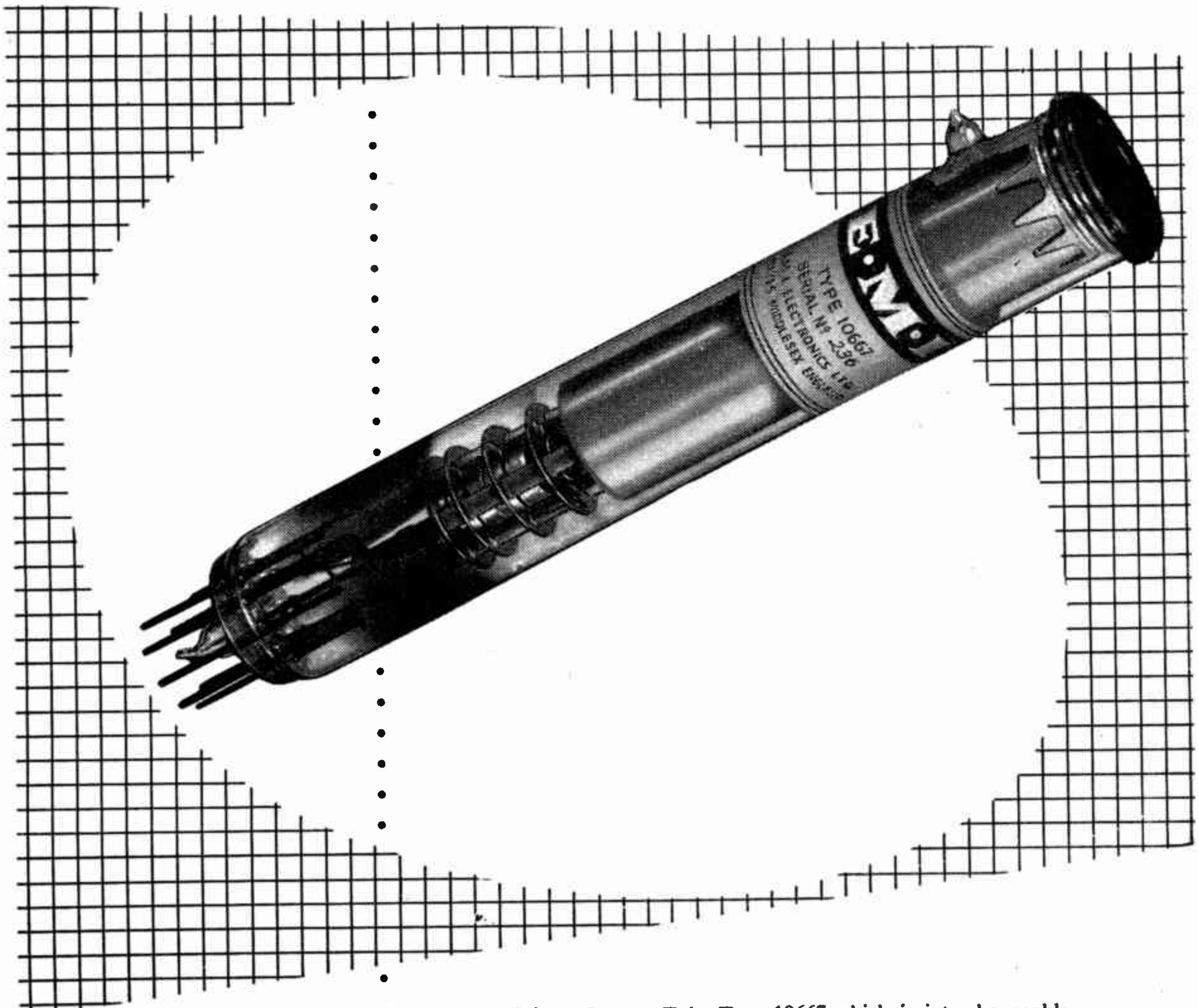

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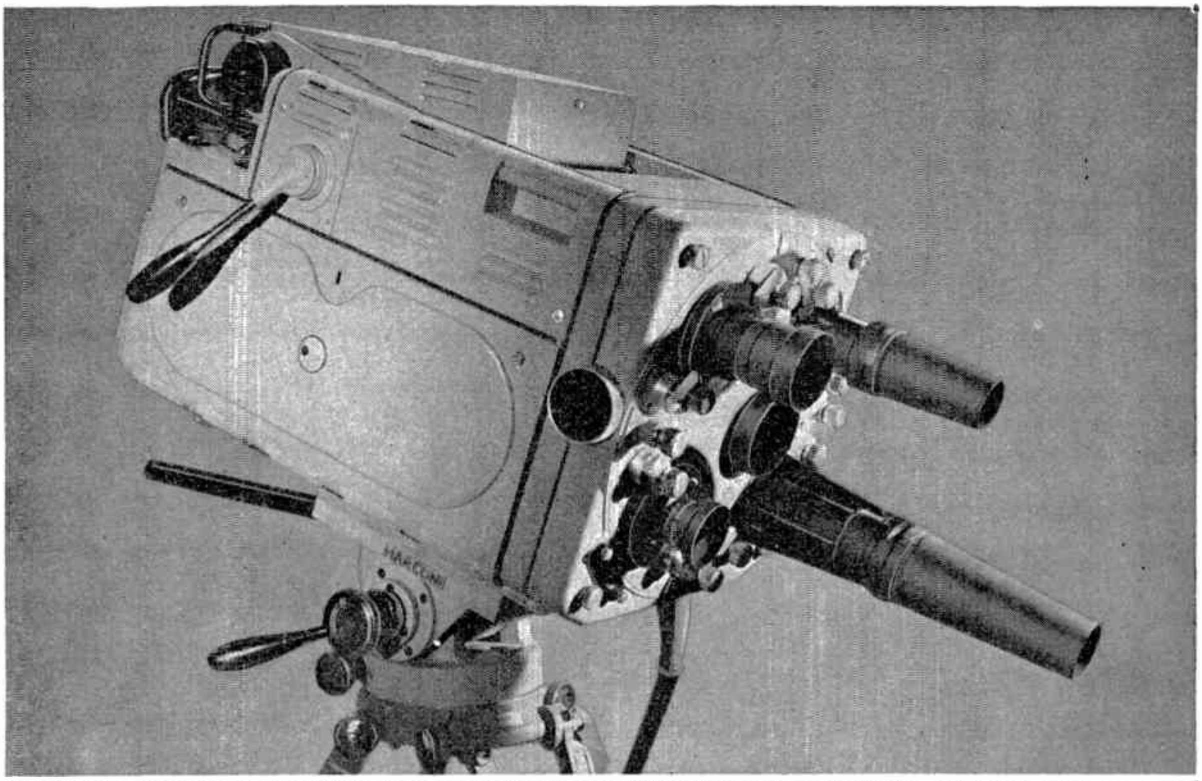

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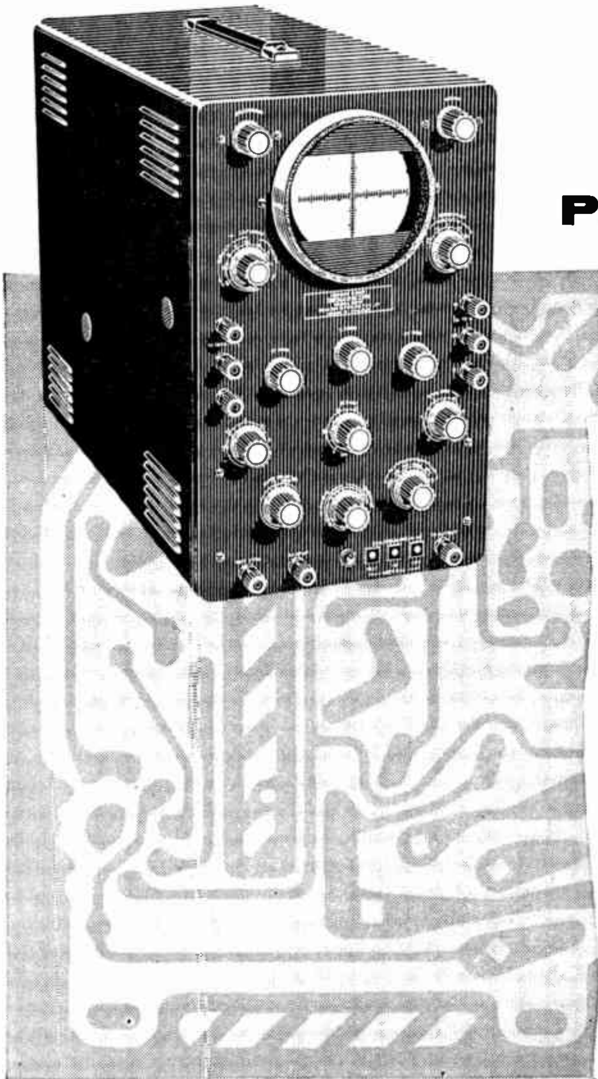

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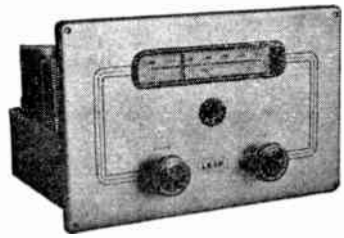
The full test report appeared in the February, 1957 issue of "Wireless World," pages 22 and 23.

*



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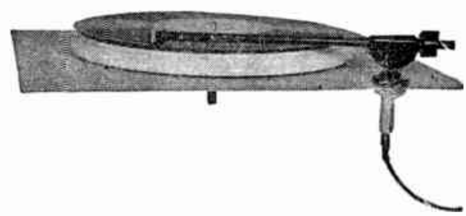

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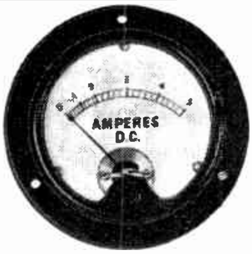

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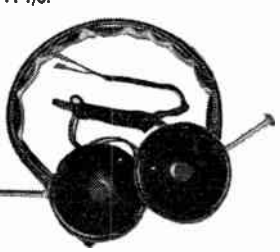

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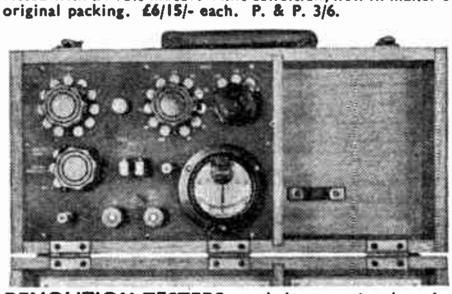
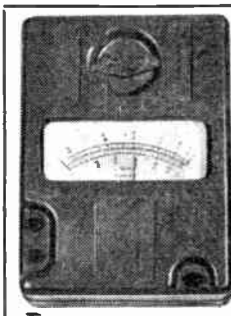


DEMOLITION TESTERS consisting two decade units and M/C Galvanometer. In solid wooden carrying case. Readily converted to Wheatstone Bridge. Excellent condition. 40/- each. P. & P. 3/6.



Evershed "MEGGER" Circuit testing ohms Meter. Pattern "S" complete with testing prods, inst. book etc., 2 ranges 0-3 ohms and 0-30 ohms. Brand new, guaranteed perfect, as illus. Offered at fraction of makers' price. £4/17/6 each. P. & P. 2/6.

250 Volt Evershed "WEE MEGGER" Insulation Testers. New condition. £10 each. P. & P. 2/6.

15in. RCA. U.S.A. **P.M. Speaker,** 15 ohms. Ideal for P.A. Will handle 30 watts. New, in maker's carton and case. £9/17/6 each. Carr. in England 15/-.

Londex Relay, 24 v. heavy silver contacts, two breaks. Fair condition. 4/6 ea. P. & P. 1/-.
High Speed Relay, Siemens, two bobbins 1,000 ohms, each. New. 10/6 each. P. & P. 1/-.

Fishing Rod Aerials, 12ft. (3 x 4ft. sections). Steel, copper plated, tapered top. Ideal aerial or fishing rod. Fair cond. 8/6 each. P. & P. 2/6.

Latest type Collaro Studio miniature Microphones, complete with screened jack plug. New. 37/6 each. P. & P. 1/-.

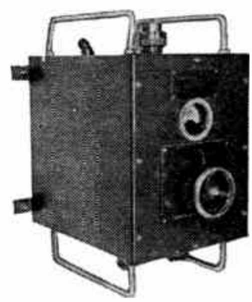
U.S.A. NAVY MODEL "MAN" Crystal Controlled Radio Transmitter and Receiver, for voice, by frequency modulated signals in the 30-40 megacycle band. Choice of eleven frequencies, powered by 6 v. battery. Complete with valves, crystals etc., and spares. Unused, £25. Carr. Eng. £1.

Muirhead Vernier Drive. Scaled 0-180° ratio 31/1, dia. 3in., as fitted to RF.26 Units. Complete with lampholder. In manufacturers' original packing. New. 8/6 each. P. & P. 1/6.

Neon Light, 230 v. A.C. M.B.C. Clear. 1/9 each. P. & P. 6d.
Neon panel mounting indicator lights, with flying leads, chrome bezel. 200/250 v. Red, clear and green. New. 3/9 each. P. & P. 6d.
Ultra Violet Bulb, AC/DC, 12 v. 36 watt. New. 5/6 each. P. & P. 6d.

Radial Stud Switch, 20 segs. 5in. sq. Complete with handle and housing. New. 5/- each. P. & P. 2/-.

Contactor Time Switch, two impulses per second. In sound-proof box. New. 11/6 each. P. & P. 3/-.



L.T. Transformer, input 230 v. Output 50 v., 50 ampere, but adjustable by voltage regulator switch on primary. In steel case fitted with mains switch, will take 100% overload. Grs. Wt. 150 lbs. Wound at 800 amps. per sq. in. As illus. above. New in manufacturer's cases. £15 each. Carriage in England £1.

Auto Transformer, step up, step down, 110 v.-200-220-240 v. Fully shrouded. New, not ex W.D.
300 watt type £2/2/- each. P. & P. 4/6.
500 watt type £3/3/- each. P. & P. 4/6.
1,000 watt type £4/4/- each. P. & P. 4/6.

Eddystone Mains Transformer, tapped primary, secondary HT 180-0-180 v. at 80 mA. L.T. 12.6 v. at 2 amp., 5 v. at 2 amp. In maker's cartons. 8/6 each. P. & P. 3/6.

Potted L.T. Transformer. Oil filled. Input 230 v. Output 2-4-14-22-30-38 v. at 7 amp. Conservatively rated. New £2/15/- each. Carr. in England 6/6.

Oil filled Transformers as above, input 230 v. Output 1-29-31-33-35V. at 4 amp. New £1/10/-. Carr. Eng. 6/6.

24 V. Blower Motor. AC/DC, will run on 12 v. Operational condition. 12/6 each. P. & P. 3/-.

U.S.A. Geared Motors, 27 v. D.C. giving twin outputs of 20 r.p.m. and 6 r.p.m. Size 7in. x 1¾in., ¼in. shaft. Will operate on 12 volts. Operational cond. 19/6 each. P. & P. 3/-.

Miniature 24 v. D.C. Reversible Recorder Motors, fitted governor and right angle gear drive. 3in. x 1in. x 1¼in. New 12/6 each. P. & P. 2/-.

Dynamotor. Input 12 v. D.C., output 300 v. D.C. at 215 mA. Supplied tested. £1/10/- each. P. & P. 3/6.

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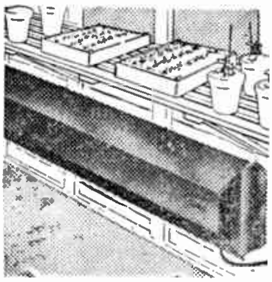
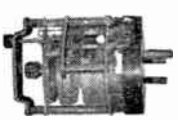
INSTANTUS HEATER



Convector heater 1 kW. rating, 4ft. long made from heavy gauge sheet steel (galvanised). Can be used for greenhouse, workshop, aviary, etc. etc. Price £2/10/-, or with thermostat, £4/5/-, carriage 5/-. GUARANTEED 5 YEARS.
2 KW MODEL. Free standing with copper-clad element ... . £5/17/6.
Ditto with thermostatic control £6/17/6.

Wrap our heater cable around the pipes in your loft to prevent a freeze-up. 21 yards £1/1/- post free.

SMALL CLOCK MOVEMENT



7-day mechanism beautifully made and fully jewelled few only sale price 18/6 each

WESTINGHOUSE (U.S.A.) METERS

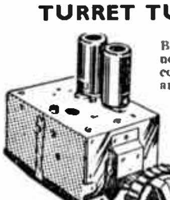
All moving coil flush mounting type, outside diameter of face 3½in.

0-500 v. D.C.	20/-
0-1.5 kV. D.C. external multiplier	25/-
0-2.5 kV. D.C. external multiplier	25/-
0-15 v. A.C.	15/-
0-1 mA.	25/-
0-50 mA.	15/-
0-100 mA.	15/-
0-150 mA.	15/-
0-250 mA.	15/-
0-500 mA.	15/-

BAND III CONVERTER

Suitable London, Midlands, North, Scotland, etc. All the parts including 2 valves, coils, fine tuner contrast control condensers and resistors. (Metal case available as an extra.) Price 19/6 plus 2/6 post and insurance. Data free with parts or available separately 1/6.

TURRET TUNER



Brand new stock, not surplus, with coils for Band I and III, complete with valves PCC84 and PCF80—I.F. Output 33/38 Mc/s with instructions and circuit diagram 79/6.

With knobs 3/6 extra, post and ins. 2/6.

Build this in ONE evening. 17" T.V.

Undoubtedly the most up-to-date televisor for the home constructor You can build it in an evening and the set when finished will be equal to a factory made equivalent. What other constructor T.V. has all these features?

- No technical knowledge required
- All miniature valves
- Metal rectifier
- Turret tuner
- 12-channel circuitry
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- Ferrox cube, E.H.T. and scan coils
- 34/38 mc/s. I.F.
- Suitable for any modern 12, 14 or 17in. tube

The building cost (less tube) is only £29/10/- plus 10/- carriage and insurance. Or £15 deposit and 12 monthly payments of 27/-. All parts guaranteed twelve months Full information and data free with parts or available separately, price 3/6.

TAPE DECK SNIP

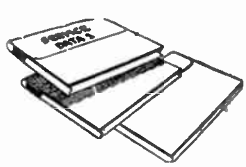
TAPE DECK—Made by the famous Truvox Company. This contains exactly the same essentials as the current model Only the styling is different. It also takes the stereophonic head.

SPECIFICATION: 3 B.T.H. shaded pole motors with silent friction drive eliminating wow and flutter. Push-button controls, electrically and mechanically interlocked Patented electric type push-button controlled brake. Tape loading on the drop-in principle, accommodation for reels of 7" diameter. Tracking sense to British and American standards. Playing times: up to 3 hours with L.P. Tape or 2 hours with Standard Tapes Two tracks side by side with safety gap. Positive Azimuth adjustment of Record/Player head. High Impedance Heads. Overall size 14¼"×12¼"×5" approx. 120 only of these fine decks offered at non-repeatable price of £17/10/- or £3/10/- down and eight monthly payments of £2. Non-callers add 10/- carriage and insurance.

Entirely Redesigned A.C./D.C. MULTIMETER KIT

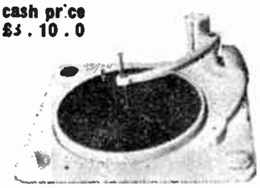
Measures A.C./D.C. volts and ohms. All the essential parts including metal case, 2in. moving coil meter, selected resistors, wire for shunts, range selector, switches, calibrated scale and full instructions, price 19/6 plus 1/9 post and insurance.

T.V. SERVICE SHEETS

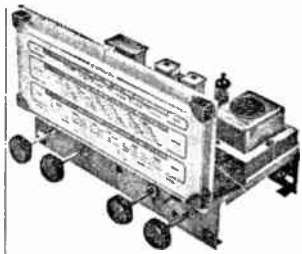


100 sheets covering the most popular post-war Televisors by leading makers—Cossor, Ekco, Ferguson, Pye, etc. etc. Special 25% reduction to W.W readers who order this month will receive the complete 100 sheets as printed, 15/- post free

Yours for £1.10.0 Down and 8 monthly payments of £1.0.0 or cash price £3.10.0



The latest most up-to-date Record Player made by the famous B.S.R company. Using Hi-Fi Crystal Pick Up and fitted with every modern device. Definitely a record changer which will give years of trouble-free music Not surplus but the current model.



THE ORGANTONE

5-Valve 3-wave band superhet covering long, medium and short wave.
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.
The output stage utilises variable negative feedback. A gram position is provided and reproduction of records is particularly good.
Chassis size is 12 × 7 × 7in.—scale size is 10½ × 4½in This receiver has been tested in particularly difficult areas and its stability and noise rejection have produced exceptional results. Price £11/10/-carriage, etc., 7/6. Or £2 deposit and seven monthly payments of £1/10/-. Carr., etc., 7/6.

DON'T BE CAUGHT LIKE THIS

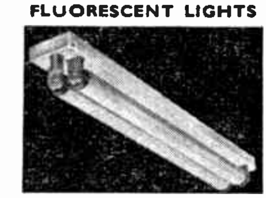
CAR STARTER CHARGER KIT

All parts to build 6- and 12-volt charger which can be connected to a "flat" battery and will enable the car to be started instantly. Kit comprising the following.

Mains transformer	22/6
5-amp. rectifier	17/6
Regulator Stud Switch	3/6
Resistance Wire	2/-
Resistance Former	2/6
Mains on/off Switch	2/6
0-5 amp. Moving Coil Meter	12/6
Construction Data	1/6
or if bought all together price is	52/6

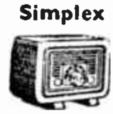
plus 3/6 post and packing.

FLUORESCENT LIGHTS



These are complete fluorescent lighting fittings. Built-in ballast and starters—stove enamelled white and ready to work. Ideal for the kitchen, over the work-bench and in similar locations.
Single 40. 4ft. 3in. long, uses a 40 watt tube.
Twin 20. Uses two 20-watt standard tubes Price 39/6 each, with tubes.
Carriage and ins. up to 150 miles 5/6, up to 250 miles 7/6.

Simplex Transistor Kit



Makes ideal bedroom radio, uses one transistor and one crystal diode. Complete less case 19/6, case 5/- extra, post and ins. 1/6.

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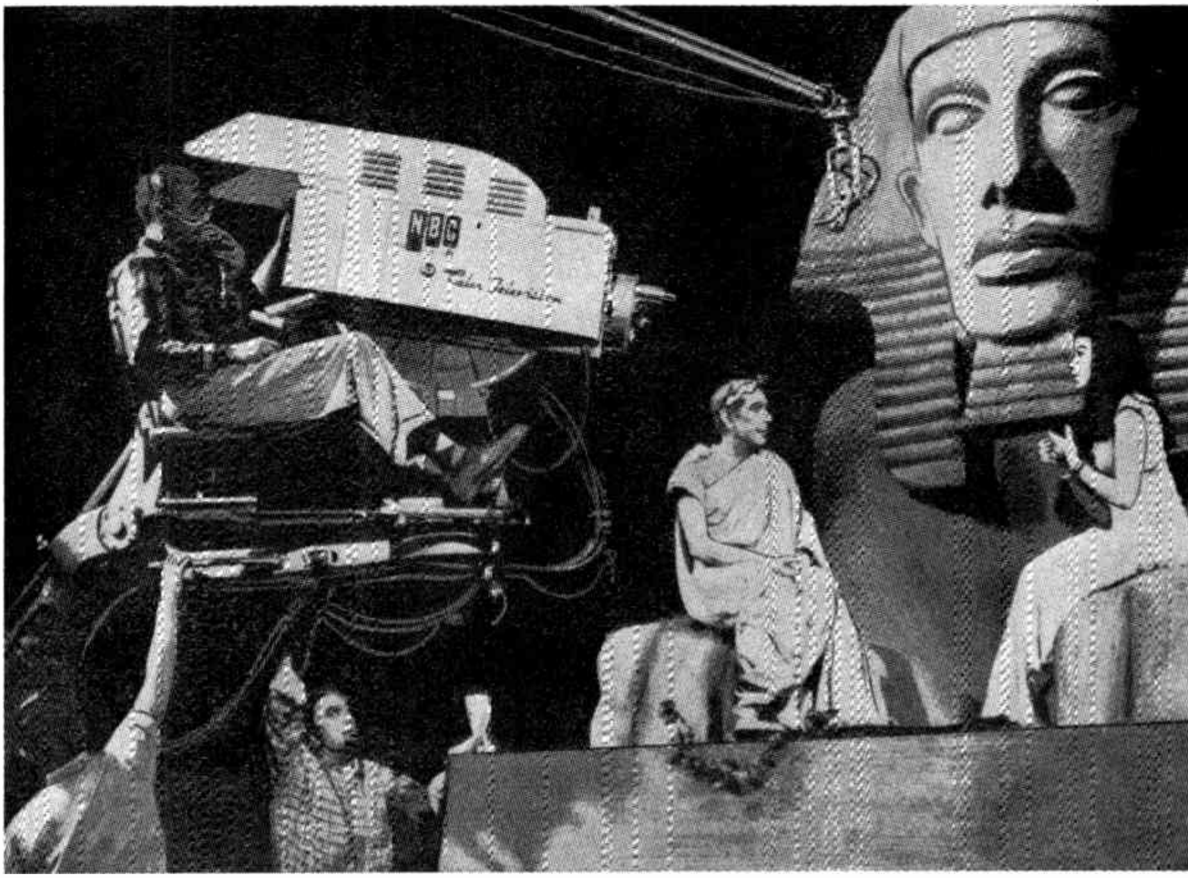
266 London Road, Croydon. Phone: CRO 6558. Half-day Wednesday.	42-46 Windmill Hill, Ruislip, Middlesex. Phone: RUISLIP 5780 Half-day Wednesday.	152-153 Fleet St., E.C.4. Phone: FLEET 2833. Half-day Saturday.	29 Stroud Green Road Finsbury Park, N.4. Phone ARCHWAY 1049 Half-day Thursday.

Post Orders should be addressed to E.P.E. LTD., Dept. 2, 66, GROVE ROAD, EASTBOURNE.
All enquiries to Eastbourne address and please enclose S.A.E., terms are cash with order



Shaw's "Caesar and Cleopatra" televised in color with RCA equipment

RCA Color Television...ready for you!

Two additional countries, Japan and Cuba, have joined the color parade with new installations of color television equipment. Using equipment pioneered and developed by RCA for compatible color and black-and-white transmissions, these nations are taking a big forward step into the future.

From the very beginning of color television, RCA has held undisputed leadership. That's why today, when broadcasters all over the world think of installing color facilities, or experimenting with color on a limited scale, they turn to RCA for equipment or experienced advice.

In hospitals and medical schools, RCA Closed Circuit Color Television brings new depth and efficiency to the teaching of surgery.

RCA Color Equipment adds brilliant dimensions to programming techniques, transforms commercial products into thrilling reality. Complete TK-41 Color Camera Chain with "all-in-one" Processing Amplifier provides identical control equipment for both live and film camera chains. Only two operating controls are needed for the entire camera chain. Overall stability, peak camera performance and highest picture quality are assured.

For complete technical information, write Dept. TV-49-A at the address below.

RCA INTERNATIONAL DIVISION

RADIO CORPORATION OF AMERICA

30 ROCKEFELLER PLAZA, NEW YORK 20, N.Y., U.S.A.

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BAND III CONVERTOR

for ANY SET in ANY AREA

This unit has been widely used since I.T.A. Transmissions began to convert all types of sets, Superhet and T.R.F., to receive on Band III.

Unlike many other convertors this unit is small enough to be fitted inside your cabinet, enabling the job to appear finished and perfectly safe for all to use.

The wiring is simple to follow, and alignment is not difficult.

- IT will convert any set, any age, T.R.F. or Superhet.
- IT includes station switching.
- IT provides pre-set contrast balancing.
- IT uses only one aerial input for both bands.
- IT provides manual tuning on Band III.
- IT is totally screened.
- IT completely rejects unwanted signals.
- IT requires no additional power supply where either 6.3 v. or .3 amp. heater is available.

CONVERTOR wired and aligned with fitting instructions	£3 10 6
KIT complete in every detail, less knobs	£2 10 6
KNOBS each	1 0
CIRCUIT and instructions in detail (free with kit)	1 6
KITS made up by customers checked and aligned, including post	12 6

When ordering please state present B.B.C. Station and I.T.A.

Orders over £2 post free.

C. & G. KITS

285, LOWER ADDISCOMBE ROAD
ADDISCOMBE, CROYDON, SURREY
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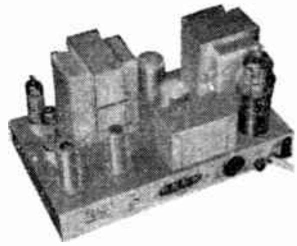
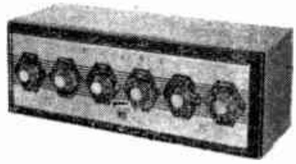
AMPLIFIERS



We are always happy to demonstrate any of a wide range of amplifiers and control units at our showroom. We stock many makes at prices to suit every pocket.



This month we feature the PILOT H.F.A.12 together with its control unit HFC 12. The amplifier, rated at 10 watts, gives a frequency response from 15-50,000 cps with extremely low distortion. The control unit has a wide range from a choice of six inputs. Other controls are a seven-position selector switch, bass, treble, filter, loudness and a muting switch. Price complete is 36 gns.

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SPECIALISTS IN

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MINIATURE TRANSFORMERS, PICK-UP, CLOCK AND INSTRUMENT COILS, ETC.
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CONTRACTORS TO G.P.O., M.O.S., L.E.B., ETC.

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LIVINGSTONE 2261 EST. 1933

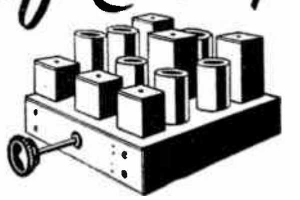
Switch-tuned F.M.

(FREQUENCY CONTROLLED)

a Sensitive Unit of Quality

Size 4½" × 4½" × 5½"
Wiring diagram and holed chassis available.

Send S.A.E. for full circuit and constructional information.



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T.R.F. Circuits
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Send 1/- in stamps for the lot!

OSMOR (Dept. WW18) 418 Brighton Road, South Croydon, Surrey Telephone Croydon 5148/9 **OSMOR**

OSCILLOSCOPE

This Ministry of Supply Monitor Type 61 is a First-Grade Synchroscope designed for D.C. Pulse and R.F. Envelope investigation, and employs a 3½in. CRT type VCR138A. The R.F. Frequency is 180-220 Mc/s approx.; and is tuneable in that range. Has internal 500 kc/s. Calibrating Oscillator on Y Plates. Existing Time Base Speeds are 50 cycles, 20 Micro-seconds fast, and 1,000 Micro-seconds slow. Conservatively rated Mains Power Pack is for nominal 115 v. and 230 v. Will make up into an excellent General-Purpose Oscilloscope at a cost of a few shillings, full modification date being supplied. Front panel size is 10½in. x 12½in., depth of unit being 19in. **BRAND NEW AND UNUSED, ONLY £12/10/-** (carriage, etc., 15/-).

R1155 SUPER SLOW-MOTION TUNING ASSEMBLY. As used on all late model 1155s. Easily fitted to "A" sets, etc. ONLY 12/6.

RCA RIBBON MICROPHONE. Table type, mounted on black-finished stand 7½in. high, with press switch in handle. BRAND NEW AND UNUSED. ONLY 59/6.

ROLA 6½in. P.M. SPEAKER. Mounted in Grey crackled metal cabinet 9in. x 9in. x 4½in., and with volume control. BRAND NEW AND UNUSED. ONLY 27/6.

12-VOLT 1-AMP BATTERY-CHARGER. Very robust, ex Admiralty. In Grey crackled metal case, size 6in. x 6in. x 4½in. BRAND NEW AND UNUSED. ONLY 35/-.

INSULATION TESTERS (MEGGERS). Read up to 20 megs. at 500 volts pressure. Overhauled, and in perfect order. With leather carrying case. ONLY £9/19/6, OR less case £8/10/-.

POWER UNIT TYPE 3. Primary 200/250 v. 50 cycles. Outputs of 250 v. 100 mA. and 6.3 v. 4 amps. Fitted with H.T. current meter, and voltmeter. For normal rack mounting and has grey front panel size 19in. x 7in. ONLY 70/- (carriage, etc., 7/6).

EHT TRANSFORMERS. 5.5 kV. (Rect.) with 2 v. 1 a., 79/6, 7 kV. (Rect.) with 2 v. 1 a., 89/6. 2.5 kV. (Rect.) with 2-0-2 v. 1.1 a., 2-0-2 v. 2 a. (for VCR 97 tube, etc.), 42/6 (postage 2/- per trans.).

500 MICROAMPS METER. 2in. circular as used on British No. 19 Wireless Sets. Calibrated 0-15 and 0-600 volts, resistance 500 ohms. A very fine instrument, and A SNIP AT ONLY 15/-.

WIRELESS SET
No. 19 MK. II

The famous Army Tank Transmitter-Receiver. Incorporates "A" set (TX/RX covering 2.0-8.0 Mc/s., i.e., 37.5-150 metres); "B" Set (VHF TX/RX covering 230-240 Mc/s., i.e., 1.2-1.3 metres), and Intercomm. Amplifier. Complete with 15 valves as follows: 6 of 6K7G, 2 of 6K8G, 2 of 6V6G, and 1 ea. 6B8G, 6H6, E1148, EF50, 807, and booklet giving circuits, notes, etc. Size 17½in. x 8½in. x 12½in. Of American manufacture as previously offered by us, but another large release by the Ministry of Supply enables us to make a substantial reduction in price. In magnificent condition.
BRAND NEW AND UNUSED, ONLY 65/- (carriage, etc., 10/-).
12-volt Power Units available 25/- (carriage 5/-).

TCS TRANSMITTERS

The renowned American TCS Model designed by the Collins Company for static or mobile use. Covers 1.5-12.0 Mc/s. in 3 bands, and is complete with 7 valves, employing 2 of 1625 in P.A. Stage, 1 each of 1625 in Buffer and Modulator Stages, and 3 of 12A6 in Oscillator Stage. Provision for VFO or Crystal Control. 4 Crystal positions. Radio Telephone or Radio Telegraph. Has Plate and Aerial Current Meters. Power requirements 12 v. LT & 400 v. HT. In black crackle case, size 11 x 13 x 11in., condition BRAND NEW AND UNUSED. ONLY £12/10/- (carriage, etc., 15/-).
The double Dynamotor Power Unit, Type 21881B for 12-volt operation, delivering 400 v. for Transmitter and 225 v. for Receiver, is available at £12/10/- (carriage, etc., 15/-).

METERS

F.S.D.	SIZE	AND TYPE	PRICE
50 microamps D.C.	2½in.	Flush circular	59/6
100 microamps D.C.	2½in.	Flush circular	39/6
250 microamps D.C.	2in.	Proj. circular	30/-
500 microamps D.C.	2in.	Flush square	27/6
1 m/a D.C.	2in.	Flush square	22/6
150 m/a D.C.	2in.	Flush square	7/6
200 m/a D.C.	2½in.	Flush circular	12/6
10 amps D.C.	3½in.	Proj. circular	20/-
20 amps D.C.	2in.	Proj. circular	7/6
40 amps D.C.	2in.	Proj. circular	7/6
15-0-15 amps D.C.	3½in.	Flush square	25/6
15 volts A.C.	2½in.	Flush circular moving iron	8/6
300 volts D.C.	2in.	Flush square	10/6
300 volts A.C.	2½in.	Flush circular	25/-

MARCONI SIGNAL GENERATORS TF-390G Frequency coverage 16-150 Mc/s. BRAND NEW IN MAKER'S ORIGINAL TRANSIT CASES, with instruction manual. For normal A.C. mains operation. A unique opportunity to acquire Laboratory Equipment at a fraction of original cost. ONLY £25.

MARCONI BAND III CRYSTAL CALIBRATORS. Frequency range 170-240 Mc/s. Incorporates 5 Mc/s. crystal for better than .001 per cent. accuracy. Directly calibrated dial, internal A.C. mains pack. Complete with spare set of valves and instruction manual in maker's transit cases. BRAND NEW. ONLY £4/19/6.

12-WAY SCREENED CABLE. In 10ft. lengths, fitted with plugs, originally made for use with the 19 Set. UNUSED. ONLY 17/6 per lead.

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.

CRYSTALS. British Standard 2-pin 500 kc/s. 15/-. Miniature 200 kc/s. and 465 kc/s. 10/- each.

SPECIAL MAINS TRANSFORMER OFFER. Normal 230v. A.C. Primary. Secondaries 330-0-330v. 100ma. 4v. 3 amps. Ex W.D., BRAND NEW AND UNUSED. ONLY 15/-. (Postage etc. 2/6).

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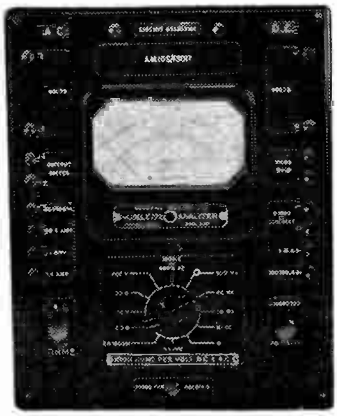
AVOMETER Model D. £ .19.6 (P. & P. 4/-)

D.C. Volts	A.C. Volts	D.C. Current	A.C. Current
150 mV.	7.5 V.	15 m/A.	75 m/A.
300 mV.	15 V.	30 m/A.	150 m/A.
1.5 V.	75 V.	150 m/A.	750 m/A.
3 V.	150 V	400 m/A.	1.5 Amps.
15 V.	300 V.	1.5 Amps.	7.5 Amps.
30 V.	600 V.	3 Amps.	15 Amps.
150 V.	750 V.	15 Amps.	
300 V.	1.5 KV.	30 Amps.	Resistance
750V .			0-4000 ohms.
1.5 KV.			0-10 K ohms.

Thoroughly overhauled. Complete with batteries and instructions. An extremely robust meter at a very reasonable price



SANGAMO WESTON Model E772 ANALYSER 10 Gns. (P. & P. 4/-)

A.C. and D.C. Volts	D.C. Current	A.C. Current
2.5 V.	100 micro-Amps.	0.5 Amp.
10 V.	1 milli-Amp.	1 Amp.
50 V.	10 milli-Amps.	5 Amps.
250 V.	50 milli-Amps.	
1000 V	100 milli-Amps.	Resistance
	500 milli-Amps.	0-100 ohms.
		0-1000 ohms.
Output meter		0-100 K ohms.
		0-10 Megohms.

Supplied in neat black Rexine covered carrying case, complete with all batteries and instructions. Thoroughly overhauled and in perfect working order.

MULLARD C & R BRIDGE
£7.10.0 (P. & P. 3/6)

Resistance	Capacity
1/10th to 10 ohms.	10 to 1000 pFd.
10 to 1000 ohms.	0.001 to 0.1 mFd.
1 K to 100 K ohms.	0.1 to 10 mFd.
100 K to 10 Megohms.	

Minus 20% to plus 25% comparison scale. Provision for "Open Bridge." "Calibrate" position. Large easily read scale. Sensitivity control. Operates from 100-250 v. A.C. mains. In very good condition. Carefully tested and checked before despatch.

HIGH RESISTANCE AVOMETERS. £14 (P. & P. 4/-)

This is a special model, similar in appearance to the type illustrated, and particularly useful for radio, T/V, and electronic servicing. Sensitivity 20,000 ohms per volt on D.C. and 1,000 ohms. per volt on A.C. D.C. current, 50 micro-A. to 1,000mA. D.C. Volts, 2.5 to 2500. A.C. Volts, 10 to 2500 Resistance, 0.1 ohm. to 5 Megohms. Supplied complete with batteries, and fitted with magnetic screen for protection from external fields. Has provision for offsetting the pointer by 30° for use as a Galvanometer.

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All three B.B.C. programmes at the turn of a switch.

MERCURY KIT. Includes front-end unit already built and aligned. £9/19/- post free. Credit Terms. Deposit £1/10/6 and seven monthly payments of £1/7/-. Instruction Book 2/3, included in kits. *Fully detailed price list free.*

PREFECT TUNER. A ready-built unit. Less power supply. £15/12/6. Credit Terms: Deposit £2/5/6 and seven monthly payments of £2/1/-. *Illustrated leaflet free.*

Both these tuners incorporate a good AFC system which ensures freedom from drift.

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Lenco GL.55 Transcription Unit	£17 10 4
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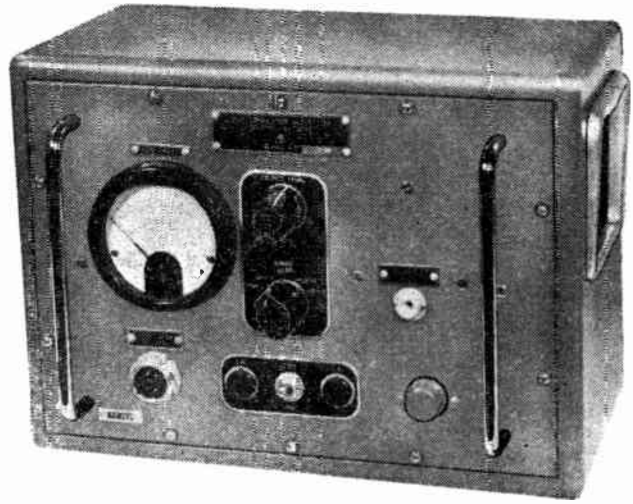

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- ★ Output impedance 71 ohms nominal.
- ★ Fully stabilised HT supply.
- ★ For CA.C. mains operation, 200-250 v., 45-65 c/s.
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CERAMIC SWITCHES. Heavy duty (Wearite type), 4 pole, 3 way, 3/6. 2 pole, 6 way, 4 bank, 10/-. **BRAND NEW.**

RCA OUTPUT TRANSFORMERS. As used in MI-11220 Amplifier. Primary for push-pull 6L6's. Secondaries 5, 7.5, 15, and 600 ohms, and tertiary for NFB. 25 watts power rating. Potted construction, with tag connections. Full circuit of RCA amplifier supplied. **BRAND NEW, 27/6.**

TRANSFORMER BARGAINS
Input 0-230/250 v. Output 240-0-240 v., 1.5 amps. RMS, 5 v. 1.75 amps., and 5 v. 12.5 amps. 7 x 7½ x 10½in high. Wt 50 lb. Potted, oil-filled, by Gresham. Gives 2.1 amp. D.C. when rectified, OR as ISOLATING TRANSFORMER, to obtain two 240 v. 360 w lines. Brand new £3/10/-. Carr. 10/-.

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MAINS ISOLATING TRANSFORMERS (Vortexion). Fully shrouded. For testing AC/DC sets in safety. 230 v. input. Output 230 v. 100 watts, 22/6, post 2/6.
U.S.A., potted type, input 210/220/230 v. 5 secondaries. 7.5 v. 4 a., 7.5 v. 4 a., 7.5 v. 8 a. and 2.5 v. 5 a. ALL centre tapped, and 6.3 v. 4 a. These can be connected to give many useful voltages up to 31 v. 4 a. Size 6in. x 5in. x 4in. Wt. 16 lb Price 35/-.

HEAVY DUTY SLIDER RESISTORS. 0.4 ohms, 25 amps., 250 watts, worm drive, 7/6. 10 ohms, 3.5 amps., worm drive, 10/6. 1 ohm, 12 amps., 150 watts, 7/6.

MINIATURE STC RELAYS. 250 ohms coil. DP C/O (double contacts). 1½ x ¾ x ¾in. Wt. 1 oz. 6 v. operation. 7/6.

VIBRATOR PACKS. Input 6 v. D.C. Output approx 100 v. D.C. at 30 m/Amps., fully smoothed and R.F. filtered. Size 6¼ x 5 x 2in. Fitted with Mallory 629C vibrator. Brand new. Boxed. 12/6.
ANOTHER, but 230 v. D.C. 100 m/Amps. With OZ4 valve and vibrator. Brand new. Boxed. 25/-.
INSULATION TESTERS by Record Electric. 0-50 Megohms. Test voltage 500. In perfect working order. ONLY £9/19/6, OR, less case, £8/10/-.
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HEAVY DUTY BLOWERS. For 200-250 v. A.C./D.C. mains, 300 watts. With 1¼ inch diam. twin "V" shape outlets. 2 lengths of hose. 4 spare filters and brushes. Suitable for industrial use, forges, etc. Brand new. £4/19/6.

MINIATURE 373 IF STRIPS. For FM tuner described in April and May "Practical Wireless." Complete with 3 of EF91, 2 of EF92, and 1 of EB91. A fresh release enables us to offer these once again, BRAND NEW, with circuit, 42/6, OR, less valves, 12/6. Post either 2/6.

METER BARGAINS

RANGE	TYPE	SIZE		PRICE
50 Microamp.	D.C. M/C	2½in.	Flush circ., scaled 0-100	59/6
100 Microamp.	D.C. M/C	2½in.	Flush circ., Ex-19 set	39/6
500 Microamp.	D.C. M/C	2in.	Flush circular	12/6
500-0-500 Micro amp.	D.C. M/C	2½in.	Flush circular, scaled 100-0-100 V.	25/-
1 Milliamp.	D.C. M/C	2in.	Flush square, Fe/NFe	22/6
150 Milliamp.	D.C. M/C	2in.	Flush square	7/6
200 Milliamp.	D.C. M/C	2½in.	Flush circular	10/6
1 Amp. Thermo-couple		2½in.	Projecting circular	6/9
4 Amp. Thermo-couple		2in.	Flush square	6/9
15 Volts	AC. M/I	2½in.	Flush circular	8/6

METER RECTIFIERS. Full wave bridge. Brand new, Salford 1 mA. 3/6. 5 mA., 6/6. STC 3 mA., 5/6.

FLUXMETERS. Fitted with Ernest Turner 3½in. mirror-scale meter and contained in polished wooden instrument case with carrying handle and hinged lid. Size 13 x 9 x 6in. Brand new condition. SNIP, only 49/6.
AMERICAN METERS. Brand new Westinghouse flush, panel mounting, circular 2in. scale, 0-5 milliamps, with blank black scale. Boxed. 8/6, post 1/-.
AMERICAN MICROPHONES AND HEADSETS. Consist of carbon microphone with press-to-talk button, and two 300 ohm earpieces in series, connected with 7ft. cord. Phones are lightweight, and have rubber ear-cushions. As used with TBY-8 equipment, and should be very handy. BRAND NEW. A real SNIP at 15/-, post 2/-.

WIRELESS SET No. 19, Mk. 2.
Two Transmitter-Receivers and an Intercom Amplifier combined. "A" Set covers 2-8 Mc/s (37.5-150 metres), phone and CW. "B" Set freq. 235 Mc/s (1.25 metres), phone only. Complete with 15 valves, 6 of 6K7G, 2 of 6K8G, 2 of 6V6G, 1 of 6B8G, 807, EF50, EB34, E1148, and 500 microamp check and tuning meter, instruction booklet, and circuit. ALL BRAND NEW, air-tested. American made, 65/-. British made 50/-. OR, complete with 12 v. Dynamotor, American, 90/-. British 75/-. Carriage, set 10/-, both 15/-. Send S.A.E. for full details and price list of all 19 set equipment.

ADMIRALTY POWER UNITS. Equivalent to AM 234. Input 200-250 v 50 c/s. A.C. mains. Outputs 240 v. D.C. 125 m/Amps., and 6.3 v. A.C. 6 amps. Dual purpose 2½in. panel mounted 300 v. meter reads input and H.T. volts. Double smoothing with paper capacitors. Standard 19in. rack mounting. **BRAND NEW.** 79/6. Carr. 7/6.
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MARCONI LOOP AERIAL type 696. A small, compact, enclosed loop. On swivel mount with degree scale. Brand new, 69/6, post 2/6.

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12in. T.V. TUBES, £6. 3 months' guarantee on all round tubes. Ins., carr., 15/6.

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Single earphone and headband. C-LR. Ideal for crystal sets, extension on radio, etc. P. & P. 1/3.

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Superhet. Octal valves: 12K8, 12K7, 12Q7, 35L6 & 35Z4. 5in. speaker included. 2 wavebands (L. & M.) 3 control knobs. 100–240 volts. Universal supply. Wooden cabinet, size 17 × 8½ × 6in Ins., carr., 3/6.

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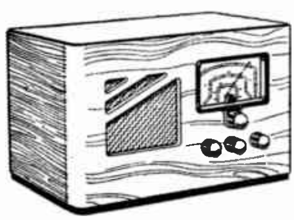
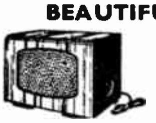
5 valve (octal) s/het. 3 w/band receiver. A.C. gram. P.U. sockets. In wooden cabinet 18½ × 11½ × 8½in. Ins., carr., 7/6.



BEAUTIFUL EXTENSION SPEAKER, 29/9



Complete. Fitted with 8in. P.M. speaker, "W.B." or "Goodmans" of the highest quality. Standard matching to any receiver. 2–5 ohms. Flex and switch included. Unrepeatable at this price. Money back guarantee if not completely satisfied. Ins., carr., 3/6.

8in. P.M. SPEAKERS, 8/9. Let the lady of the house listen to music while she works in the kitchen. Complete with O.P. trans., 10/-. P. & P. 2/9.

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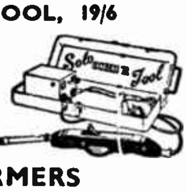
6–12 volt, 100–125 volt. Made for the American market. Car battery or mains. Export quality. Complete in light carrying case. Reel of solder and spare parts. P. & P. 2/9.

A few of the above in 6–12 volt, 200–240 volt. 35/6. Export enquiries invited.



MAINS TRANSFORMERS

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280–0–280 v. 80 ma. 6 v. 2 a., 4 v. 2 a., 4 v 2 a., 200–250 v. primary. Drop-through half shrouded 5/9
(All above 2/6 post.)
425–0–425 v. at 250 ma., 5 v at 6 a., 6.3 v. at 12 a., 6.3 v. at 6 a., 200–250 v. screened primary (P. & P. 3/9) 17/6
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O.P. TRANSFORMERS, 1/3. Standard size 2–5 ohms. Post 1/3. 20 for £1. P. & P. on 20, 5/6.

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"B"-type battery 22½ v. No. B155. Ideal for midget or personal radio, hearing aid or photography flash. Size ½ × 2in. Post 3d. 6 for 7/-, post 6d. 12 for 12/-, post 9d.

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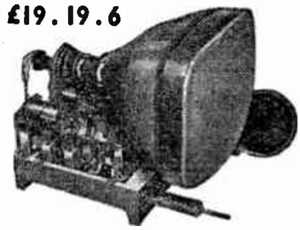
Complete with valves. Telescopic aerial Instruction booklet FREE with each order Ideal for Walkie-Talkie conversion. Test set 172A. Ex-W.D. P. & P. 4/6

17" T.V. CHASSIS £19.19.6

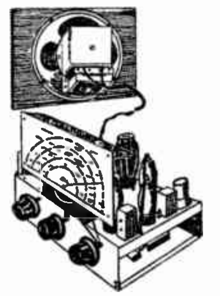


Latest Improved circuits. Higher E.H.T. (brilliant picture). Improved sensitivity (for greater range). Chassis easily adapted to any cabinet, 17in. rectangular tube on adapted chassis. All channels. TURRET TUNER, 50/- extra. Less valves. With 5 valves, £21/19/6. With all valves, £25/19/6. Valve line-up (5 valves): 2–6D2s, 6SN7G, 6P25, EL38. Others: 7–6F1s, EL33, 6L18.

12 months' guarantee on tube. 3 months' guarantee on valves and chassis. Ins., carr., 25/- (incl tube). State B.B.C. channel and I.T.A. if turret required.

14" T.V. CHASSIS, TUBE AND SPEAKER £13.19.6

As above with 14in. round tube. Less valves. Guaranteed 3 months. With 5 valves, £15/19/6. With all valves, £19/19/6. TURRET TUNER, 50/- extra. Ins., carr., 25/- incl. tube.



DENCO RADIOGRAM CHASSIS 97/6

3 and 4 waveband turret tuned. S/het. A.C./D.C. chassis with 6in or 8in. speaker. Size: 8½ × 10 × 12in. Valve line-up: CCH35, EF39, EBC33, CL33 & CY31. (C1C or dropper.) Ins., carr., 7/6.

SUPER CHASSIS, 99/6

5-valve superhet chassis including an 8in. speaker. 4 control knobs (Tone, Volume, Tuning), W.C. switch; 4 waveband with position for gram. P.U. for extension speaker. A.C./D.C. P. & P. 5/6.

ELECTRIC CONVECTOR HEATER, 99/6

Cleaner, cheaper, safer than paraffin. A.C./D.C. Switched for 1 or 2 k/watts. Illuminated grille. Ins., carr., 10/6.

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R.F. EHT COIL, 30/-. 6–10 k/volt. Drawing and data FREE with each order. Post free.

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POWER PACK AND AMPLIFIER, 19/6. O.P. stage 6V6 with O.P. trans. Smoothed H.T. 350 v. 250 ma., 6.3 v. 5 a., 22 v. 3a., 6.3 v. 4 a., 4 v. centre tapped. Less valves. FREE drawing. Carr 5/6

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T.V. CHASSIS TO CLEAR, 59/6. Complete chassis by famous manufacturer. R.F. EHT unit included. Drawing 2/6 or FREE with order Chassis in three separate units (power, s/vision, timebase interconnected). These chassis can easily be fitted into existing console cabinets. Less valves and tube. Channels 1–2, 3–5. Easily converted to I.T.A. Ins., carr., 10/6.

RADIOGRAM CHASSIS, 39/9. 3 waveband and gram. superhet, 5-valve (octal). Ideal for table gram., giving high quality output. 4-knob control. 8in P.M. speaker, 7/9, with order. Set of knobs 2/- chassis 12 × 6 × 7½in. Ins., carr., 4/6.

CHASSIS, 1/- each, 6 or 8 valve. Latest type midget valve design for A.M. and F.M. New cadmium-plated on s.w.g. steel. 12½ × 7½ × 2½in. P. & P 1/6. Post on 4, 3/-. 12 for 10/-. Carr. 5/-

Boxed VALVES — *3 MONTHS' GUARANTEE*

1A5	2/9	6H6M	1/9	12BE6	6/9	ECH42	8/9	EF50	2/9
1S5	4/9	6K7	3/9	12SG7	1/9	EF39	6/9	EL32	6/9
3A8	3/9	6N7GT	4/9	12SJ7	1/9	EF41	8/9	EL91	3/9
4D1	2/9	6SG7	3/9	CV18	3/9	EBC41	8/9	EZ40	8/9
6B8	3/9	77	3/9	EAF42	8/9	EF91	7/9	PEN45	6/9
6F12	7/9	8D2	3/9	EB34	1/9	EF37A	4/9	TT11	6/9
6D2	6/9	8D3	7/9	EB91	6/9	EF37	4/9	X66	8/9
		12AU7	5/9	ECC81	8/9			Z77	7/9

American Types UX. All at 3/9 each.

18	75	80	6D6	6A7
42	78	1D5	25RE	6C6

Barrettors 301 and 302 also at 3/9 each.

CAR AERIALS, 6/9. Whip antennae, 50in. long, collapsing to 11in. one-hole fixing Post 1/-.

Send for free 1958 Catalogue

DUKE & CO. (Dept. C) 621/3 Romford Road, Manor Park, E.12 TEL.: ILF. 6001-3

Liverpool Street to Manor Park Stn.—10 mins.

BATTERY CHARGING EQUIPMENT

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

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	
6/12 v. 1 a. ..	4/11
6/12 v. 2 a. ..	8/9
6/12 v. 3 a. ..	11/9
6/12 v. 4 a. ..	14/9
6/12 v. 6 a. ..	19/9
6/12 v. 10 a.	25/9
H.T. Type H.W.	
120 v. 40 mA.	3/9
250 v. 50 mA.	5/9
250 v. 80 mA.	7/9
250 v. 150 mA.	9/9
300 v. 250 mA.	12/11

ASSEMBLED CHARGERS

6 v. 1 a.	19/9
6/12 v. 1 a.	27/9
6 v. 2 a.	29/9
6/12 v. 2 a.	38/9
6/12 v. 4 a.	56/9

Above ready for use with mains and output leads. Cases well ventilated and finished in stoved blue hammer. Carr. and packing 3/6.

BATTERY CHARGER KITS

Consisting of Mains Transformer F.W. Bridge. Metal Rectifier, well ventilated steel case. Fuses, Fuse-holders, Grommets, panels and circuit. Carr. 2/6 extra.

6 v. or 12 v. 1 amp. ..	22/9
6 v. 2 amps.	25/9
6 v. or 12 v. 2 amps.	31/6
6 v. or 12 v. 4 amps.	53/9

BATTERY CHARGER KIT Consisting of F.W. Bridge Rectifier 6/12 v. 5 a. Mains Trans., 0-9-15 v. 6 a. output, and ammeter. Only 49/9. Post 3/-.

ASSEMBLED CHARGER 6 v. or 12 v. 2 amps.

Fitted Ammeter and selector plug for 6 v. or 12 v. Louvred metal case, finished attractive hammer blue. Ready for use with mains and output leads. Double Fused. Only **49/9** Carr. 3/6.

Assembled 6v. or 12v. 4 amps.

Fitted Ammeter and variable charge selector. Also selector plug for 6 v. or 12 v. charging. Double fused. Well ventilated steel case with blue hammer finish. Ready for use with mains and output leads. **75/-** Carr. 3/9. Or Deposit 30/- and four monthly payments 13/-.

AM/FM RADIOGRAM CHASSIS. HIGH QUALITY. PUSH PULL. 6-8 WATTS OUTPUT

Current manufacture. 12 months' guarantee. For 200-250 v. mains. Covers L and M. Wavebands plus F.M. Includes 8 latest type miniature B.V.A. valves. Only 22 gns. plus 7/6 carr. Or deposit £2/12/- and 9 monthly payments of £2/12/-. Guaranteed 12 months.

CO-AXIAL CABLE. 75 ohms. ¼in., 8d. yard. Twin screened feeder 11d. yard.

ELECTROLYTICS (current production) Not Ex-Govt.

Tubular Types		Can Types	
8 mfd. 450 v.	1/9	16μF 450 v.	2/9
8 mfd. 500 v.	2/6	16 mfd. 500 v.	3/9
16μF 350 v.	1/11	32μF 350 v.	2/11
16μF 450 v.	2/9	32 mfd. 450 v.	4/9
16μF 500 v.	3/9	100 mfd. 450 v.	4/9
8-16μF 500 v.	4/11	8-8μF 450 v.	2/11
25μF 25 v.	1/3	8-16μF 450 v.	3/11
50μF 12 v.	1/3	16-16μF 450 v.	3/11
50 mfd. 25 v.	1/9	32-32μF 350 v.	4/9
50μF 50 v.	1/9	32-32μF 450 v.	5/9
100 mfd. 12 v.	1/9	100-100 mfd. 350 v.	5/9
100 mfd. 25 v.	2/3	64-120 mfd. 350 v.	7/6
3,000 mfd. 6 v.	3/9	100-200 mfd. 275 v.	6/11
6,000 mfd. 6 v.	3/11		

Many others in stock.

VOLUME CONTROLS with long spindles, all values, less switch, 2/9; with S.P. switch, 3/9.

EX GOVT. STEP UP/STEP DOWN TRANSFORMERS. Double wound 80/100 watts. 10-0-100-200-220-240 v. to 5-0-75-115-125-135 v. or Reverse. Only 11/9, plus 2/9 post. 10-0-100-200-220-240 v. to 9-0-110-122-136-148 v. or Reverse. 200 watts, 35/9, plus 7/6 carr.

EX GOVT. METAL BLOCK PAPER CONDENSERS

4 mfd. 500 v.	2/3	8 mfd. 500 v.	4/6
4 mfd. 1,000 v.	3/9	10 mfd. 500 v.	3/9

THE SKY FOUR T.R.F. RECEIVER

A design of a 3 valve 200-250 v. A.C. Mains L. & M. wave T.R.F. receiver with selenium rectifier. For inclusion in cabinet illustrated or walnut veneered type. It employs valves 6K7, SP61, 6F6G, and is specially designed for simplicity in wiring. Sensitivity and quality is well up to standard. Point-to-point wiring diagrams, instructions and parts list, 1/9. This receiver can be built for a maximum of £4/19/6 including cabinet. Available in brown or cream bakelite, or veneered walnut.

EX GOVT. VIBRATOR UNITS. 12 v. input 280 v. output. Suitable for car radio, etc., 16/6.

VIBRATORS. Oak and Wearite. Synchronous 7 pin 2 v. 7/9, 6 v. 8/9.

EX. GOVT. 50 WATT AMPLIFIERS. Brand new. For normal 200-250 v. 50 c.p.s. A.C. mains. Designed for speech only but with suitable pre-amp. could be used with Gram. or Radio. Valves included. Four 6L6s used for output. Complete with hand microphone with good length of lead. Unused in original transit cases. Only 9gns. Ready for use. Carr. 15/-.

RE-ENTRANT SPEAKERS, 8 watt, 7.5 ohms suitable for above, 25/- each.

5 CORE FLEX. Henleys circular rubber 14/36. Each lead colour coded. 1/6 yard.

EX GOVT. MAINS TRANSFORMERS

All 200-250 v. 50 c/s input.

120-0-120 v. 40 mA.	5/9
250-0-250 v. 60 mA., 6.3 v. 3 a., 6.3 v. 1 a. Potted 4½-3½-3in.	11/9
Pr. 0-110-200-230-250 v., 275-0-275 v. 100 mA., 6.3 v. 7 a., 5 v. 3 a.	18/9
230-0-230 v. 80 mA., 12.6 v. 1.5 a. 5 v. 2 a.	11/9
400-0-400 v. 250 mA. 5 v. 2 a., 5 v. 2 a...	18/9
12.5 v. 3 a., 5 v. 3 a.	12/9

MANUFACTURERS: SURPLUS TRANSFORMERS. Primary 200-240-250 v. Drop through type 250-0-250 v. 70 mA. 6.3 v. 3 a., 11/9. Postage 2/9.

EX GOVT. SMOOTHING CHOKES

300 mA., 20 H. 150 ohms	19/6
250 mA., 5 H., 50 ohms	12/9
150 mA., 10 H., 50 ohms	10/11
100 mA., 10 H., 100 ohms	6/9
100 mA., 5 H., 100 ohms, tropicalised	3/11
80 mA., 10 H., 350 ohms., tropicalised	3/11
50 mA., 50 H., 1,000 ohms	6/9

EX GOVT. CASES. Well ventilated, black crackle finished, undrilled cover. Size 14 × 10 × 8½in. high. IDEAL FOR BATTERY CHARGER OR INSTRUMENT CASE. COVER COULD BE USED FOR AMPLIFIER. Only 9/9, plus 2/9 post. Size 13½in. × 8in. × 6½in. with undrilled perforated cover finished in stoved grey enamel, 7/9, plus 2/9 post.

SPECIAL OFFERS. Small 2 gangs .0005 mfd., 4/9. Electrolytics 32-32-32 mfd. 250 v., 2/9 each or in lots of six, 2/3 each.

R.S.C. BATTERY TO MAINS CONVERSION UNITS

Type BM1. An all dry battery eliminator Size 5½ × 4½ × 2in approx. Completely replaces batteries supplying 1.4 v. and 90 v. where A.C. mains 200-250 v. 50 c/s. is available. **Suitable for all battery portable receivers requiring 1.4 v. and 90 v.** This includes latest low consumption types. Complete kit with diagram. 39/9 or ready for use 46/9.

Type BM2. Size 8 × 5½ × 2½in. Supplies 120 v., 90 v., and 60 v., 40 mA. and 2 v. 0.4 a. to 1 amp. fully smoothed **THEREBY COMPLETELY REPLACING BOTH H.T. BATTERIES AND L.T. 2v. ACCUMULATORS** when connected to A.C. mains supply 200-250 v. 50 c/s. SUITABLE FOR ALL BATTERY RECEIVERS normally using 2 v. accumulator. Complete kit with diagrams and instructions, 49/9, or ready for use, 59/6.

JUNCTION TRANSISTORS For R.F. 17/6.

MINIATURE MOTORS. 24/28 v. D.C. or A.C. Size only 2½ × 1¼in. Spindle 1½in. long, ⅛in. diam. Made by Hoover Ltd., Canada. Price only 9/9.

M.E. SPEAKERS. 2-3 ohms R.A. 8in. Field 600 ohms., 11/9.

R.S.C. TRANSFORMERS

FULLY GUARANTEED. INTERLEAVED AND IMPREGNATED.

MAINS TRANSFORMERS

Primaries 200-230-250 v. 50 c/s.

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250 v. 60 mA., 6.3 v. 2 a., 5 v. 2 a.	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 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/-
200-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
300-0-300 v. 130 mA., 6.3 v. 4 a., c.t., 6.3 v. 1 a., suitable for Mullard 510 Amplifier	33/9
375-0-375 v. 150 mA., 6.3 v. 4 a., 5 v. 2 a.	29/9
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

TOP SHROUDED DROP-THROUGH TYPE

260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.	16/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.	18/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	22/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	29/9

ELIMINATOR TRANSFORMERS

Primaries 200-230 v. 50 c/s.

120 v. 40 mA., 5-0-5 v. 1 a.	14/9
90 v. 15 mA., 6-0-6 v. 250 mA.	9/11

FILAMENT TRANSFORMERS

Primaries 200-250 v. 50 c/s.

6.3 v. 1.5 a. ..	5/9	6.3 v. 3 a. ..	8/11
6.3 v. 2 a.	7/6	6.3 v. 6 a. ..	17/6
0-4-6.3 v. 2 a.	7/9	12 v. 3 a. or	
12 v. 1 a.	7/9	25 v. 1.5 a.	17/6

CHARGER TRANSFORMERS

All with 200-230-250 v. 50 c/s. Primaries: 0-9-15 v. 1½ a., 11/9; 0-9-15 v. 3 a., 16/9; 0-3.5-9-17 v. 3 a., 17/9; 0-9-15 v. 5 a., 19/9; 0-9-15 v. 6 a., 23/9.

OUTPUT TRANSFORMERS

Midget Battery Pentode 66:1 for 3S4, etc.	3/6
Small Pentode 5,000Ω to 3Ω	3/9
Standard Pentode, 5,000Ω to 3Ω	4/9
Standard Pentode, 8,000Ω to 3Ω	4/9
Push-pull 8 watts 6V6 to 5 ohms	8/9
Push-pull 10-12 watts 6V6 to 3Ω or 15Ω	15/9
Push-pull 10-12 watts to match 6V6 to 3-5-8 or 15Ω	16/9
Push-pull EL84 to 3 or 15 ohms	16/9
Push-pull 15-18 watts, sectionally wound, 6L6, KT66, etc., to 3 or 15 ohms....	21/9
Push-pull 20 watt high-quality sectionally wound, 6L6, KT65, etc.. to 3 or 15Ω	47/9

SMOOTHING CHOKES

250 mA., 5 H., 100 ohms	11/9
150 mA., 7-10 H., 250 ohms	11/9
100 mA., 10 H., 200 ohms	8/9
80 mA., 10 H., 350 ohms	5/6
60 mA., 10 H., 400 ohms	4/11
1 amp. 0.5 ohm. L.T. type	6/6

G.W. SMITH & CO (RADIO) LIMITED

Phone: GERRARD 8204/9155
Cables: SMITHEX LESQUARE
3-34 LISLE STREET, LONDON, W.C.2

JOHNSON TX. CONDENSERS Brand new and boxed, 500pf. variables, 15/6. P/P. 1/-. Also new, boxed 2¼in. variable inductances by Johnson, 22/6. P/P. 2/6.

HIGH RESISTANCE HEADPHONES. Brand new, boxed. S.G. Brown's, (ex-gov.) 4,000 ohms, 12/6 pr. P/P. 1/6.

MUIRHEAD VERNIER DRIVES. Brand new, 7/6. P/P. 1/-.

R.1155 COMMUNICATION RECEIVERS. New issue, in new condition fitted with super slow motion drive. Supplied thoroughly checked and reception tested, £8/19/6 each. P/P. 6/-.

HEAVY DUTY "C" CORE TRANSFORMERS. Input 230 volts. Outputs 510/0/510v. 300ma., 375/0/375v. 100ma. 6.3v. 9a., 2X6.3v. 2a., 2X6.3v. 1a., 6.3v. 1.5a., 6.3v., .5a. 5v. 3a. Brand new, 82/6. P/P. 5/-.

AR.88 WAVECHANGE SWITCHES. Spare for Model D. Ceramic, 8 bank, 6 pos. complete with all screens. Brand new, 17/6 each. P/P. 2/6.

FURZEHILL CRYSTAL CALIBRATORS. Circuit incorporates 6 valves and 1mc/s. crystal, giving pips at 10,100 and 1,000kc/s. Built-in modulator, battery operated, 2v. and 120v. Supplied brand new and boxed, 59/6. P/P. 3/6.

TAPPED L.T. TRANSFORMER. Input 200/250 volts. Output tapped, 3, 6, 9, 12, 24 or 36 volts 5 amps, 35/- each. P/P. 3/-.

WELDING TRANSFORMER. Input 230 volts. Output 17.5 volts 35 amps. New, 72/6 each. P/P. 5/-.

L.T. TRANSFORMER BARGAIN. Input 200/250 volts. Output 12 volts 5 amps. New, 12/6 each. P/P. 2/-.

MUIRHEAD STUD SWITCHES. Brand new and boxed. 4 banks, each bank 24 position. Heavy duty contacts. Only 17/6 each. P/P. 1/6.

R.1155 SUPER SLOW MOTION DRIVES. Improved version as fitted to models L and N. Suitable for Model A etc. Brand new, 12/6 each. P/P. 1/-.

AVO MODEL 7 MULTIPLIERS. Extended 1000 volt range to 4000 volts new and boxed 5/6. P/P. 1/-.

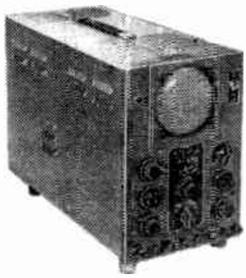
W.1191 WAVEMETERS. Portable battery operated frequency check meters, frequency coverage 100kc/s to 20mc/s] in 8 switched bands, directly calibrated on vernier scale. Circuit incorporates a 1mc/s. crystal. Supplied in first class condition, £5/19/6 each. P/P 6/-.

ROTARY CONVERTORS. Input 24 volts D.C. Output 230 volts A.C. 50 cycles, 100 watts. Supplied unused, 92/6 each. P/P. 5/-.

CRYSTAL MICROPHONE INSERTS

Sensitive, ideal for tape recorders, amplifiers, etc., 4/6 each. P/P. 6d.

COSSOR DOUBLE BEAM OSCILLOSCOPE TYPE 339



Operation 110/200/250 volts A.C. 120 watts. Time Base 10 positions. 6 cps. to 250,000 cps. Amplifier 10 cps. to 2,000,000 cps. Sensitivity, Y1.Y2.3.1 v. D.C. 1.1 v. rms. X. 2.25 v. D.C. .8v. rms.

Supplied in good working order, £27/10/- each. P/P. £1.

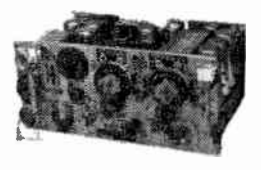
MARCONI TF-643 U.H.F. WAVEMETERS. Frequency coverage 20 to 300mc/s. in 4 bands. Accuracy 1% up to 150mc/s. and 2% above. Supplied in perfect condition with all coils and calibration charts, £19/10/- each. P/P. 6/-.

RCA. ET.4336. PLATE TRANSFORMERS. Special release, brand new in original makers' transit cases. Primary tapped 200 to 250 volts 50 cycles. Secondary 2000/0/2000 volts 400ma., tapped 1500/0/1500 volts. Price £12/10/- each. P/P. £1.

AUDIO BEAT FREQUENCY OSCILLATORS. Frequency coverage 0 to 10kc/s. with separate 50 cycle check point. Output impedance 10 or 600 ohms. Built-in monitoring voltmeter. Operation 110/200/250 volt A.C. Not new but supplied in good working order, £9/19/6 each. P/P. 10/-.

SPECIAL OFFER

BRAND NEW AMERICAN/CANADIAN No. 19 Mk. II TRANSMITTER-RECEIVERS.



Complete with all valves. Frequency coverage 2 to 8 mc's, 65/- ea. P/P. 10/-. *Limited number only available.*

HEAVY DUTY MAINS ISOLATING TRANSFORMERS. Specifications:—Primary 230 volts 3 amps. Secondary 230 volts 3 amps. (service rating, OK 5 amps.). Ideal for laboratory or workshop use. Supplied brand new in original transit cases. £6/10/- each. P/P. 10/-.

MAINS VOLTAGE REGULATOR TRANSFORMERS. For A.C. mains 50 cycles. Will give a variable output from 185 volts to 250 volts at 24 amps, £15 each. P/P. 10/-. Smaller type available 200/240 volts 7.5 amps, 87/6 each. P/P. 5/-.

EDDYSTONE MAINS POWER PACKS

Supplied brand new and unused. Mains input 200/250 volts. Output 175 volts 60ma. and 12 v. 2.5a Double choke and condenser smoothed. 5Z4 rectifier. Housed in grey metal case. Only 32/6 each. P/P. 3/6.

EX-NAVY SOUND-POWERED TELEPHONES. This type requires no batteries to operate and can be fitted in moments to give complete inter-communication between two points. Hand generator calling. Only 45/- each. P/P. 4/6.

"C" CORE E.H.T. TRANSFORMERS. All new and unused. Input 230 volts. Type 1. Output 3850v. 5ma. 4v. 2.5a. 4v. 1a., 52/6. P/P. 3/-. Type 2, 1250/0/1250v. 5.5ma. 6.3v. 1a. 6.3v. 1a. 4v. 1a., 42/6. P/P. 2/6.

6 VOLT VIBRATOR PACKS. Output 120 volts 30ma. Fully smoothed, uses standard Mallory 4-pin vibrator, new and boxed, 12/6 each. P/P. 2/6.

MIDGET RECORDER MOTORS. Size 1¼ x 1 x 2¼in. Operates from 4.5 to 24v. D.C. Fitted with reduction gear. New and boxed, 12/6 each. P/P. 1/-.

12 VOLT MIDGET ROTARY TRANSFORMERS. Type H.T.11., size 4¼ x 2¼in. Output 310/360 volts 30ma. New and boxed, 22/6. P/P. 1/6.

FERRANTI POTTED FILAMENT TRANSFORMERS. Hermetically sealed, ceramic terminations. All new and boxed. Type 1, 200/250v. input. Output 6.3v. CT. 5.6a., tapped 5v. 6.3v. CT. 4.8a. tapped 4v. 6.3v. CT. 1a. tapped 4v., 19/6 each. Type 2. Input 200/250v. Outputs, 6.3v. CT. 3.3a. tapped 5v. 6.3v. CT. 1a. tapped 4v. 6.3v. C.T. .9a. 6.3v. CT. .6a, 15/6 each. P/P. 2/- each type.

300FT. COPPER AERIAL WIRE. Ex-U.S.A. dinghy aerial, 3/6. P/P. 1/-.

RCA. OUTPUT TRANSFORMERS. Completely potted. Centre-tapped primary, 8000 ohms. Secondary tapped, 3, 7.5, 15 or 600 ohms. Separate feedback winding. 15 watts rating. Suitable for 6L6, EL84 etc., unused, 27/6 each. P/P. 2/-.

P/O JUMPER LEADS. 4ft. twin screened lead fitted with 2 standard P/O jack plugs, 3/-. P/P. 6d. Panel jacks to suit, 9d.

12 VOLT D.C. MOBILE AMPLIFIERS. Ex-Admiralty. Separate mic. or gram inputs. Output 10 watts, matched to 3, 15 or 600 ohms. Supplied in good working order, £8/19/6 each. P/P. 5/-.

AMERICAN SUPER LIGHTWEIGHT HEADPHONES. Res. 50 ohms. Fitted with rubber earmoulds to fit inside the ear. Extremely good quality, ideal for communication receivers, etc. New and boxed, 15/- pair. P/P. 1/-.

HEAVY DUTY SLIDER RESISTANCE. 1 ohm 12 amp, 6/6. P/P. 1/-.

MINIATURE H.T. TRANSFORMER. Input 220/240v. Output 220v. 25ma. 6.3v. 1a. new, 10/6 each. P/P. 1/-. Midget contact rectifier to match, 7/6.

AMERICAN ROTARY TRANSFORMERS. Models available for either 6 or 12 volt D.C. input. Output 250 volts 80ma. Ideal for car radios or razors etc., new and unused, 22/6 each. P/P. 3/-.

AMERICAN GEARED MOTORS

American 24 volt D.C. motor with built-in precision gearbox giving twin outputs 20 r.p.m. and 6 r.p.m. Will also operate on 12 v. giving reduced outputs. Size 7in. x 1¼in. Shaft dia. ¼in. Supplied brand new only. P/P. 3/-. **19/6** each.

SPECIAL OFFER OF MULTI-RANGE TESTMETERS

THE WESTON 772 A.C./D.C. TESTMETER. Sensitivity 1,000 ohms per volt, basic movement 50 microamps. 5 resistance ranges 100 ohms to 10 megohms. 5 A.C. or D.C. volt ranges, 2.5 to 1,000 volts. 5 D.C. current ranges 1,000 microamps to 500 ma. 3 A.C. current ranges, .5 to 5 amps. Supplied in perfect working order in rexine-covered carrying case, £10/10/-. P/P 4/-.

THE FAMOUS AVO MODEL "D" TESTMETER. Another of the large series AVO meters. Incorporates 2 resistance ranges, 1k. and 10k. ohms. (can be extended by using external batteries). 5 D.C. volt ranges, .15 to 1,500 volts. 4 A.C. volt ranges, 7.5 to 1,500 volts, 4 D.C. current ranges, .015 amp. to 30 amps., 3 A.C. current ranges .075 amp. to 15 amps. Supplied in perfect working order, £8/19/6 each. P/P 4/-.

THE POPULAR UNIVERSAL AVOMINOR TESTMETER. A small and compact highly accurate instrument. Resistance measurements from 0 to 20k. ohms. D.C. voltage 0 to 500 volts. A.C. voltage 0 to 500 volts. D.C. current 0 to 500 ma. Supplied in perfect working order. Complete with leather carrying case and leads, £5/10/- each. P/P. 2/6.

SMOOTHING CHOKE BARGAINS. 10H. 60ma., 4/6; 15H. 60ma., 5/6; 8H. 100ma., 8/6; 9H. 100ma., 7/6; 10H. 100ma., 8/6; 5H. 200ma., 5/6; 20H. 120ma., 10/6; 50H. 120ma., 15/6; Swinging choke 3.6-4.2H. 250ma., 10/6. P/P. 1/- to 2/6.

CHEAP LOUDSPEAKERS. All new and unused, 3 ohm coils. Plessey, 2½in., 16/-; Elac, 6½in., 17/6; Elac, 5in., 17/6; Goodmans 3½in., 17/6; Elac, 8in., 19/6; Elac, 10in., 27/6; Plessey 12in., 32/6; Elac, 7 x 4 elliptical, 18/6; Plessey, 10 x 6in. elliptical, 27/6; Postage 1/6.

MODULATOR 67

A wonderful complete A.C. mains power pack containing the following components. Transformer 350/0/350 v. 200 ma. 6.3 v. 6 a. 5 v. 3 a. Input 230 v. 200 ma. choke, 5Z4 rectifier. Paper and electrolytic smoothing condensers. 11 other useful valves. Hundreds of components including switches, pots, condensers, resistors, etc. Supplied brand new with covers.

SPECIAL REDUCED PRICE 39/6 each P/P. 7/6

"C" CORE H.T. TRANSFORMERS. Input 230 volts. Output 450/0/450 v. 220 m/a., 6.3 v. 6 a., 6.3 v. 3 a., 5 v. 3 a., 59/6 each. P/P. 4/-.

CAMBRIDGE INSTRUMENTS CURRENT TRANSFORMERS. Input 50 cycles, 300, 150 or 75 amps. Output 15 amps. Brand new and boxed, £4/19/6 each. P/P. 4/-.

MAINS NEON PANEL INDICATORS. 200/250v Chrome escutcheon. Red amber green or clear, 3/9 each. P/P. 3d.

DYNAMO EXPLODER UNITS. Used for detonating explosive charges. Operation is by hand generator, giving 1,800 volts across output terminals. Ideal also as photo flash. Brand new, only 29/6 each. P/P. 3/-.

EDDYSTONE MAINS POWER PACKS S.441B. Supplied brand new and unused. Input 200/250 volts Output 300 volts 200ma. and 12 volts 3 amps Double choke and condenser smoothed, 5U4 rectifier Housed in grey metal case, fully fused, indicator etc. Only 49/6 each. P/P. 6/-.

AMERICAN MINE DETECTORS. Type SCR-625c. Battery operated, portable and complete with instruction book. Ideal for detecting all types of metals. £12/10/- each. P/P. 10/-.

G.E.C. SELECTEST MULTI-RANGE METERS. Basic movement 1 ma., ohms 0-1 megohm. D.C. volts .15 to 1,500 volts. A.C. volts 7.5 to 1,500 volts. A.C. current 75 ma. to 15 amp. D.C. current 1.5 ma. to 30 amp. Supplied in good working order. £9/19/6 each. P/P. 4/-

AMERICAN BEACON TRANSMITTER/RECEIVERS

RT 37/PPN-2. Brand new and boxed, complete with instruction book. Equipment comprises transmitter/receiver with 9 valves (5 3A5, 3 1S5 and 1 1R5), with built-in 2 v. vibrator power pack, spare vibrator, head-set connector leads and 10ft. collapsible aerial. Frequency coverage 214/238 Mc/s. Price 72/6 each. P/P 6/-.

MINIATURE SLOW MOTION DRIVES. Dia 1¾in. 180deg. scale calibrated 0-100. For ¼in. spindles. New and boxed 7/6 each. P/P. 1/-. Larger type available, 7/6 each.

CHEAP PLASTIC RECORDING TAPE. 1,200 ft. by famous manufacturer on 7in. universal spool, only 19/6 each. Brand new and boxed. P/P. 1/6.

METER BARGAINS

50 microamp 2½in. FM. M.C.	59/6
50 microamp 2½in. Pj. M.C.	49/6
100 microamp 2½in. FM. M.C.	39/6
200 m/amps. 2½in. FM. M.C.	9/6
1 amp. RF. 2½in. Pj.T.C.	5/-
300 volt A.C. 2½in. FM. M.I.	25/-
1.5 amp. A.C./D.C. 2in. FM. M.I.	6/6
2 m/a. meter rectifier, STC	5/6

EDDYSTONE SPEAKER UNITS

Wonderful offer. All brand new and boxed 6½in. speaker fitted in grey metal case. Standard 3 ohm coil, built-in volume control and matching transformer for 600 ohm line. Ideal for all type receivers. Only 27/6 each. P/P. 2/6.

INSTRUMENT POTENTIOMETERS. Brand new Colvern type. 100,000 ohms, 10 watts, 3½in. dia. Ideal for bridges, etc., 10/6 each. P/P 1/-.

ADVANCE CONSTANT VOLTAGE TRANSFORMERS. Input 190 to 260 volts, A.C. 500 cycles. Output constant at 230 volts. Max. rating 150 watts. Supplied brand new in original crates, £8/10/- each. P/P. 5/-.

CHARGING AND MODEL TRANSFORMERS.
1. Pri. 200/250 v. Sec. 3.5, 9 or 17 v. 1 amp., 9/9.
2. Pri. 200/250 v. Sec. 3.5, 9 or 17 v. 2 amp., 14/3.
3. Pri. 200/250 v. Sec. 3.5, 9 or 17 v. 4 amp., 16/6.
4. Pri. 200/250 v. Sec. 6.3 v. 3 amp., 8 v. 1.5 amp., 9/6.
5. Pri. 200/250 v. Sec. tapped, 3, 4, 5, 6, 8, 10, 12, 15, 18, 20, 24 or 30 volt 2 amp., 18/6. Postage 1/6 all types.

L.T. METAL RECTIFIERS. Full wave and bridged. 12 v. 1 amp., 6/3; 12 v. 2 amp., 9/3; 12 v. 4 amp., 13/9; 24 v. 1 amp., 12/6; 24 v. 4 amp. 22/6; 36 v. 4 amp., 27/6. P/P 1/- all types

BARGAIN GRAM MOTORS. Garrard centre-drive motors complete with turntables. 200/250 volt A.C. Adjustable mechanically from 0 to 45 r.p.m. Only 22/6 each. P/P. 3/-.

MARCONI SIGNAL GENERATOR TF144G

The famous laboratory standard. Frequency coverage 85kc/s. to 25mc/s. Output voltage from 1 microvolt to 1 volt. Operation 200/250 volts A.C. Offered reconditioned as new and guaranteed to be within original makers' specification, a certificate issued with each individual instrument. Price only £65 each. Carriage £1.

0-1 MA. METERS

Brand new moving coil meters, round flush mounting with 2½in. scale calibrated 0/300 volts. Resistance 100 ohms. Supplied complete with rectifier, 25/- each. P/P. 1/-

PORTABLE PRECISION VOLTMETERS

Brand new and boxed instruments by famous manufacturer housed in polished teak case. Moving iron movement reading A.C. or D.C. volts on 2 ranges. 0-160 and 0-320 volts. 8in. mirror scale. Accuracy within 2%. Supplied at a fraction of original cost, only £5/19/6 each. P/P. 4/6.

HEAVY "C" CORE H.T. TRANSFORMERS.
Type 1 Input 230 volts Output 360/0/360 volts, 200 m/a. 360/0/360 volts 65 m/a. 6.3 v. ct. 5 a., 6.3 v. ct 2 a., 6.3 v. 5 a., 5 v 4a., 5v. 3 a. 65/- each P/P. 4/6.
Type 2. Input 230 volts. Output 350/0/350 volts, 400 m/a., 25 v. 1 a., 21 v. 5 a., 6.3 v. 5a., 6.3v. 1a., 5 v. 4 a., 75/- each. P/P 4/6
Type 3. Input 23 volts Output 450/0/450 volts 250 m/a., 2 x 6.3 v. 5 a., 2 x 6.3 v. 1 a., 5 v. 4 a., 69/6 each. P/P. 4/6.

BENDIX COMMAND TRANSMITTERS. Complete with all valves and crystal. Frequency coverage 2.1 to 3 mc/s. Only 22/6 each. P/P. 3/-.

SPECIAL OFFER OF MARCONI SIGNAL GENERATORS TF517. Frequency coverage 16 to 58 mc/s. and 130 to 260 mc/s. Operation 200/250 volts A.C. Supplied in perfect condition at the ridiculous price of £12/10/- each. Carriage £1.

G.W. SMITH & CO (RADIO) LIMITED
Phone: GERRARD 8204/9155
Cables: SMITHEX LESQUARE
3-34 LISLE STREET, LONDON, W.C.2

WESTINGHOUSE RECTIFIERS

16RC.1-1-16-1	9/- each
18RA.1-1-16-1	6/6 each
18RA.1-1-8-1	4/- each
14RA 1-2-8-3	25/- each
14A.86	13/9 each
14A.97	13/6 each
14A.100	15/- each
14A.124	27/6 each
14B.130	31/6 each
LW7	23/9 each
WX6	3/6 each

CYLDON "TELETUNER." All types available. Stations of your choice. Fit this Converter and your troubles are over. £7/7/- each.
Aerial and Oscillator Coils (All channels)—all frequencies 7/6 pair.
Also available from stock, complete range of spares.

CONTROL KNOBS
Long necked knobs for T.V Receivers in walnut black and cream .... 1/- each

SUPPRESSORS
Dubilier kits of condensers and chokes for Interference Suppression.
1 amp. kits 5/6. 2 amp kits 6/-. 3 amp. kits 6/6.

REVISED SECOND EDITION "POINTS ON PICK UPS"
A Replacement Guide to pick up heads cartridges, style. Over 193 illustrations. 5/- each

Osmor coils for Collaro Type Deck Transcriptor.
QT6 Bias Filter coil .... 7/6 each
QT7 Treble Boost coil in Mu Metal can £1/7/6 each
QT9 Bias Osc. coil .... 7/6 each

Osmor Coils for the Beginners Shortwave Receiver. Radio Constructor Aug. 1957.
SW Q1 31/11 Mc/s. .... 6/- each
SW Q2 12 4.5 Mc/s. .... 6/- each

SCRATCHOFF
Removes scratches from Radio and T.V Cabinets. In Polythene Dispenser Tubes. 3/- each

All Components in Stock for BBC Television Studio "E" Building your own Radio Set. Complete Kit including Headphones, etc. 45/-

MAINS DROPPING RESISTORS

Manufacturers Surplus Types.	each
945 ohms Zenith with taps	1/-
650 ohms tap at 375 ohms, 500 ohms, 5 ohms, 30 ohms	2/6
Erie 1.490 ohms with Taps	1/-
Norman .2 amp. 1,000 ohms with sliders	4/6
Norman .3 amp. 1,000 ohms with sliders	4/6
Zenith Mains Dropper 910 ohms	2/-
Dubilier Type HY tapped 200-210, 220-230, 240-250 ohms	1/9
Erie Two Section Dropper, 150 ohms and 1,340 ohms, with two taps	1/9
Bulgin Dropper with voltage taps	3/9

REPANCO COILS

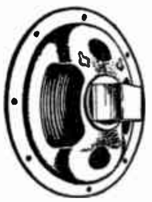
TRANSISTOR COILS AND COMPONENTS

	Each
Type OT1 combined 1ST IFT (315 Kc/s) and OSC Coil Medium and Pre-Set Long Wave	11/6
Type TT2 2nd if transferable 315 Kc/s	5/-
Type TT3 3rd if transferable 315 Kc/s	5/-
Type TT4 Push Pull interstage Transformer	8/6
Type TT5 Push Pull Output Transformer	8/-
Type DRX1 High Gain Dual Range Crystal Set Coil	2/6
Type DRR2 Dual Range High Gain Coil	4/-

All are complete with circuits.

IMPLOSION GUARDS. For 17in. tube Outside dimensions. 17¼in. × 12¾in. Brown/Fawn Escutcheon. Price 7/6 each. Post 2/6.

LOUDSPEAKER UNITS



Make	Type	Size	Price
Elac	Square	3½in.	19/6 each
Lectrona, Plessey	Round	5in.	17/6 each
Goodmans, Plessey	Round	6½in.	18/6 each
Goodmans, R. & A.	Round	8in.	19/6 each
Plessey, R. & A., Elac	Round	10in.	25/6 each
Plessey	Round	12in.	35/- each
Elac	Elliptical	7in. × 4in.	19/6 each
Elac	Elliptical	10in. × 4in.	25/6 each

All the above are PM units with 2 to 3 ohm speech coils.

RTC 12in. heavy duty 20 watts model 15in. ohms Speech Coil £5 5 0
5in. Mains Energised Speaker £1 0 0
6½in. Mains Energised Speaker 17 6
8in. Mains Energised Speaker £1 1 0
All have field coils of approx. 600 ohms.

SPECIAL OFFER
Just a few 8in. units by Goodmans and Lectrona fitted with standard output transformer .... £1 1 6 each

SCOTCH BOY RECORDING TAPES, ETC.

SCOTCH BOY TYPE 150-9 "EXTRA PLAY" RECORDING.
900ft. on 5in. diameter spool, per reel, 28/- each.
1,800ft. on 7in. diameter spool, per reel, 50/- each. Immediate delivery from stock
SCOTCH BOY TYPE III STANDARD RECORDING TAPE.
600ft. on 5in. plastic spool, per reel, 16/- each.
1,200ft. on 7in. plastic spool, per reel, 27/- each.
Spare Spools: 5in. diameter, 3/6 each. 7in. diameter. 4/3 each

WB EASY TO ASSEMBLE CABINETS

JUNIOR BASS REFLEX CORNER CONSOLE. A new contemporary-style cabinet, specially designed to give maximum reproduction quality from Stentorian 8in. or 10in. units, with provision for Tweeter Unit, if required. Measures 33in. × 22½in. × 18½in. Price £9/9/-.

SENIOR BASS REFLEX CORNER CONSOLE. Carefully designed to ensure superb quality of reproduction when used in conjunction with Stentorian 10in. or 12in. units. Provision is also made for Tweeter Unit, if required
Measures (approx.) 35in. × 30in. × 19in. Price £11/11/-.

PUBLICATIONS

No. 134 F.M. TUNER CONSTRUCTION by W. J. May. ★ Easy to Build ★ Point-to-Point Wiring ★ Super High Fidelity Response ★ 32 pages ★ All components for this Circuit available, ex stock. each 2/6

No. 138. HOW TO MAKE AERIALS FOR TV (Band 1 and 3) and V.H.F. (Band 2). Data for all Channels. Ten different designs for local and fringe areas. each. 2/6.

No. 128. PRACTICAL TRANSISTORS AND TRANSISTOR CIRCUITS ★ How To Make Your Own Transistors ★ 48 pages, each 3/6

No 140. TELEVISION SERVICING FOR BEGINNERS. ★ 40 pages of information each 4/6

No 142. MODERN TV CIRCUITS AND FAULT FINDING GUIDE. ★ Many interesting Circuits included, each 4/6

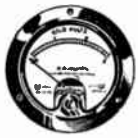
MULLARD. HIGH QUALITY SOUND REPRODUCTION Includes 20 watt Amplifier. F.M. Tuner. Pre-Amplifiers, etc..each 3/6

Reprint No. 5. TV FAULT FINDING. Profusely illustrated with Photographs taken from a Televisor Screen, each 5/-

LOUDSPEAKERS by G. A. BRIGGS. The Why and How of Good Reproduction. "Sound" information for the layman and the enthusiast, each 7/6
Wearite Manual of the Tape Deck, each 3/-

Postage 4d. each on all the above.

METERS



Instrument Meter Moving Coil, ex-Ministry 0-3kV. Round Panel mounting. Brand new 7/6 each.
Instrument Meter 0-100 m/A. Square type. Panel Mounting. Ex-R.A.F Equipment 7/6 each.
2 Range Pocket Voltmeter. Ex-Ministry Brand New. 0-15 volts, 0-250 volts, moving coil 345 ohms per volt, complete with leads. 16/- each.

HENLEY-SOLON ELECTRIC SOLDERING IRONS

INSTRUMENT MODELS 25 WATTS

Weight 3½ oz. (excluding flex) Length 9 in.
Now available in a wide range of voltages as under:

IRONS	Voltage	List No.	Price
25 watt INSTRUMENT MODEL fitted with straight bit	12	618	26/-
	24	619	26/-
	50	620	20/-
	100/110	621	24/-
	120/130	623	24/-
	200/220	624	24/-
	220/240	625	24/-

RECORD PLAYER UNITS

B-S-R. MONARCH
Four speed automatic record change unit. Plays 7in., 10in. and 12in. records automatically with "MAGIDISK" Selector Turn-over Pick-up. Unit plate 13¾ × 10¾in. £8/15/-. Postage, etc., 4/6.

COLLARO
Model 3/544. Three speed single player. Automatic stop. fitted with "Studio T" pick-up. Cream finish £6/19/6. Postage, etc., 4/6.

COLLARO
Four speed automatic record change unit. A fully mixing automatic changer with many advanced features. Unit plate 12in. × 13½in. £8/15/-. Postage, etc., 4/6.

MISCELLANEOUS COMPONENTS

TV SLIDER PANEL. Welwyn panel of 3 resistors, values 1 Meg. ohms, 150K ohms, 250K ohms, with black screw type locking knobs. Total size: 3½in. × 3in. Price 1/9. each

RUBBER GROMETS. Mixed sizes, 6d. doz.

GRID CAPS. 1. Octal Push-on type, 6d. doz. British Screened type. 3d. each.

ARMOUR PLATED GLASS. Size 13in. × 10½in., rounded corners, 3/6 each.
2 Pin Mains Plug and Socket, 2/6 each. **Pliers Side Cutters,** 2/9 pair. **Line Cord.** .3 amp., 3 core, 1/9 yd. **Line Cord.** .2 amp., 3 core, 1/9 yard. **Electric Buzzers** in Bakelite case. Loud tone, 2/6 each. **Epicyclic Friction Drive with Brass Drum.** For use with Steel Dial Drive Wire, 1/6 each.

AMERICAN RELAY. 45 ohms Impedance with lead No. AZ0545, 1/9 each.

IRON LEADS. Black and white flat iron leads, bonded ends, 1/3 each.

POTENTIOMETER PANEL. Four Potentiometers on Panel 50K ohms SP8; 750 ohms W/W; 25K ohms Carbon; 5K ohms W/W. All with long spindle, with leads of different colours terminating in an 11 pin plug, 7/6 each. **Wavox choke,** max. current 100 m/a. D.C., resistance 125 ohms, 6/- each. **Westinghouse 1 m/a. Rectifier** wire ends, 9d. each. **6 volt Vibrator Pack,** complete with Vibrator, 17/6 each. **Morphy Richards Type Replacement Iron Elements,** 3/9 each.

INDICATOR LAMPS. Spring fixing type, 9d. each. **"Aerovox" Condenser Clips,** 1d. each. **Pencil Rectifiers,** Type J10. 2/- each. **Amplion Volume Controls,** 2 meg. S.P.S., 3/6 each. **Extension Speaker Volume Controls** 1/3 each **Vibrator Clips** (Standard). 5d. each

NINE-INCH TUBE MASKS. White (Soiled Condition), 4/9 each. **Tri-Sol 3-Core Solder.** Nett weight 1lb 16 S.W.G 60/40 alloy, per carton, 6/6.

SURPLUS GEAR PARCELS. We have found, from time to time, stocks of components stripped from ex-Government equipment, along with discontinued lines. etc. These are in small quantities and therefore unprofitable to advertise. To make room for new items we offer at less than cost parcels of these components at 10/- each.

JUNCTION BOXES. Type 5X/2234, 20 way 1/6 each.

TELETRON transistor superhet coils set of IF and oscillator coils with Ferrite Rod 36/- per set (circuit included).
Long Wave Loading Coil to match 4/6 each.

RECORDING TAPE, 1,200 feet "Puretone," 12/6 each.

NEEDLE CUPS. For Gram. Needles (Bakelite), 1d each.

CRYSTAL DIODES. Wire Ends plastic case. 1/- each. **Bulgin 7-pin Plug and Socket,** 1/6 each. **Insulated Coupler,** 2in. dia., for standard ¼in. spindles, ceramic insulation. 9d. each. **Pairs of Instrument Handles.** 5½in. between centres, 1½in. back to front, 1/3 pair. **Speaker Cones,** 6A8P is 8in., cone with 1in. cone piece, 4/6 each. 6A6P is 6½in. cone with 1in. pole piece, 4/6 each. **A Low-High Impedance Matching Unit** for Headphones to be inserted in the cord, 3/9 each. **Mains Transformer, Standard Type** Primary Windings with a Secondary 325-0-325 20 m/a. 6.3 v. .3 amp., 11/6 each. **Bulgin Indicator Lamp,** single hold fixing for standard MES bulb, red lens, 3/3 each. **Tubular Condenser** (Metal Boss) Sprague 4 mfd 600 v., 4/- each. **Sprague Block Condenser,** 2 × 1. mfd. 2,000 volts, 3/- each. **Paper Block Condenser,** 2 mfd. 250 volts, 9d. each. **Kettle Elements.** 1,000 watts for 200/210 volts or 230/250 volts, 17/6 each. **Relay Valve** CV271, in Holder, 3/9 each.

BELL TRANSFORMER "CONCORDIA." 3 v., 5 v., 8 v., 1 amp. fused. In bakelite case 8/6 each.

SELF TAPPING SCREWS (PK). No.4, ½in. long, 3/d. os.

"CLEM" TRAVELLING IRON with **ASBESTOS STAND.** Size: 4in. × 2in. × 2½in., including handle, complete with lead and switch to enable it to be used on any voltage between 110 and 250 v. A.B.C. adaptor is fitted on the lead (Colour as available: Blue, Green, etc.), 21/- each. **FUSES:** ½, 1, 1½, 2, 3, 5 amp., 1¼in. Standard Cartridge Fuses, 3d. each.

CARRYING CASE. Suitable for use as a projector or recording case, size 15in. × 9½in. × 13in. Internal dimensions: 14in. long, 11½in. deep, 5½in. front H.T., 8½in. rear H.T. With black rexine finish. Weight 8½lb. 13/6 each. Post and Packing 2/6.

B7G MINIATURE VALVE PIN STRAIGHTENER. This is an American manufactured tool at a price every one can afford. Complete with plug. 2/6 each.

ACOS MICROPHONES

MIC. 36 SERIES
A good quality omni-directional microphone with flat response from 30 to 7,000 c.p.s.
MIC. 36—3 Table Model without switch.
MIC. 36—4 Table Model with switch.
MIC. 36—5 Without switch; with adaptor for a floor stand.
MIC. 36—6 With switch and adaptor for a floor stand.
The adaptor incorporates both a ⅜in. and a ½in. 26T.P.I. thread.
Without Switch — £3/3/-. With switch £3/8/-.

MIC. 33—1 without switch
A crystal hand or desk microphone designed for the high quality public address and tape recording field, incorporating a specially designed acoustic filter giving a response flat from 30 to 7,000 c.p.s. With microphone is omni-directional and is housed in an attractive plastic case. Without Switch — £2/10/-.
MIC. 33—2 with switch £2/15/-.

MIC. 35—1.
A general purpose hand microphone of robust construction with substantially flat response from 50 to 5,000 c.p.s. Suitable for use in recording apparatus. Public Address equipment. etc. £1/5/-

MIC. 35—2
The same as the MIC 35—1 but fitted with a small desk stand. £1/8/6

ALPHA RADIO SUPPLY CO., 103 LEEDS TERRACE, WINTOUN ST., LEEDS, 7

RADIO TRADERS LTD.

23 WARDOUR ST., LONDON, W.1. (Coventry Street end)
Phone: No. GERrard 3977/8 *Grams: "Radiotrade"*

SPECIAL OFFER OF CURRENT MANUFACTURE ELECTROLYTIC CONDENSERS
8 mfd. 450 v. 2/6 each; 16 mfd. 450 v. 3/-; 32 mfd. 450 v. 4/-; 8 x 8mfd. 450 v. 3/9; 8 x 16 mfd. 450 v. 4/-; 16 x 16 mfd. 450 v. 4/6; 32 x 32mfd. 350 v. 5/-. Bias Condensers: 25 mfd. 25 v. 1/6; 50 mfd. 50 v. 1/9. Please note we can offer special discounts for quantities.

W.W. RESISTORS. 5 watt 1/6; 10 watt 2/6; 15 watt 3/-; 20 watt 3/6. We carry stocks of resistors from 2 watt to 150 watt W.W. Your enquiries invited.

HIGH STABILITY RESISTORS. ½ watt 5% 6d.; ¼ watt 5% 9d.; 1 watt 5% 1/-. A few values in 1% and 2% still available.
ALL ORDERS FOR RESISTORS C.O.D. PLEASE, AS WE CANNOT GUARANTEE TO STOCK ALL VALUES.

ELECTROLYTIC CONDENSERS. Manufacturers' Surplus, in perfect condition. 100 mfd. x 200 mfd. 350 v. surge 5/6 each; 100 mfd. x 100 mfd. 425 v. surge 5/6 each; 150 mfd. 450 v. wkg. 5/6 each.

BIAS CONDENSERS. 3,000 mfd. 6 v. 3/6 each; 2,500 mfd. 3 v. 3/6 each; 1,000 mfd. 12 v. 1/6; 25 mfd. 25 v. 1/3; 50 mfd. 12 v. 1/-.

TRANSISTORS: Junction type Red Spot by well-known manufacturers 10/- each.
TRANSISTOR CONDENSERS: Miniature Electrolytic Capacitors 32 mfd. 3 v., 25 mfd. 25 v., 25 mfd. 6 v., 16 mfd. 12 v., 8 mfd. 6 v., 5 mfd. 12 v., 2.5 mfd. 25 v., 1.6 mfd. 6 v., 1 mfd. 12 v. All these types of condensers are 3/6 each. SPECIAL DISCOUNTS FOR QUANTITIES.

AIR-SPACED TRIMMERS, 5, 10, 15, 20, 25, 50; and 75 of pre-set and spindle types 2/- each .... doz. 21/-

PYE PLUGS AND SOCKETS 1/6 per pair "T" pieced ... each 1/9

GROMMETS, 1 grs. assorted grommets, ¼in. to 1in. .... gross 8/6

WESTECTORS. WX6, WX12, W4 1/- each .... doz. 9/-

SIGNAL LAMP HOLDERS. Panel mounting, complete with adjusting lampholder 2/- each .... doz. 21/-

BELLING-LEE PLUGS AND SOCKETS, 5 pin 1/9; 7 pin 2/-; 10in. .... each 2/6

MANUFACTURERS PLEASE NOTE. We hold large stocks of Nitrogol, Visconol and other block-type Condensers, your enquiries are invited.

0-100 amps. 50 c.p.s. 4½in. METERS £2/10/-; 0-50 amp. Moving Iron 6in. Meters, £3/10/- each. All brand new and boxed.

MIDGET MICA CONDENSERS. .0001, .0002, .0003, .0004, .0005 5/- per dozen.
200 Assorted Moulded Mica Condensers, popular value £2 10 0
200 Assorted Silver Mica Condensers, popular values £2 10 0
200 Assorted Carbon Resistors, ½, ¼ and 1 watt. Good selection £1 10 0

PAXOLIN SHEET. 18 x 4½ x 1/16in. 1/6; 10 x 10 x 1/32in. 1/6; 20 x 10 x 1/32in. 3/-; 10 x 10 x 1/16in. 2/-; 20 x 10 x 1/16in. 4/-. Minimum P. & Pkg. 1/6.

BARGAIN OFFER OF BATTERIES

4½ v. Heavy Duty Bell Battery. Size 6½ x 4½ x 2½in.	2/6
72 v. H.T. 1.5 v. L.P. Size 6 x 5 x 1¾in.	2/6
150 v. H.T. Size 2¾ x 5½ x 1¾in.	5/6
67½ v. Size 2¾ x 3¾ x 2¾in.	6/6
60 v. H.T. 1.5 v. L.T. 3½ x 3¾ x 1½in.	4/6

All batteries sealed and unused. All plus 1/6 post and pkg. Special reduction for quantities.

4-way Push Button Units 2/6 each. Knobs for same 3/- per doz.

WEARITE COILS. PA4, PO4, PA5, PO5, 1/3 each. .... doz. 12/-

VALVE HOLDERS. Moulded B9A 7/6; B7G 6/-; Int. Oct. 9/-; Eng. Oct. .... doz. 4/6

VALVE HOLDER FITTED WITH LOWER CAN 1/6 per doz. extra. Screening cans for B7G and B9A .... doz. 6/-

JONES PLUGS AND SOCKETS. 4 pin 2/6 per pair; 6 pin 3/6 per pair; 8 pin 4/6 per pair; 12 pin 6/6 per pair. If cover required send 1/6 extra per cover.

POINTER KNOBS. Small black with white line, standard ¼in. spindle .... doz. 7/6

WANDER PLUGS. Red and black .... doz. 2/-

PHILIPS TRIMMER TOOLS 1/- each .... doz. 10/6

CASH WITH ORDER OR C.O.D. ALL ORDERS DEPT. W.1.

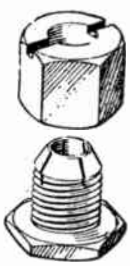
ALL ORDERS FOR LESS THAN £2 ADD POSTAGE.

● *We invite your enquiries for items not listed*

Trade Counter open 9 to 6 Monday to Friday.
Also 9 to 1 Saturdays. Callers welcomed.
WHOLESALE MANUFACTURERS AND EXPORT ENQUIRIES INVITED

PRE-SET CONTROL LOCK

Designed to lock the spindles of pre-set potentiometers or trimmers without rotational or lateral displacement of shaft.



Will accept wide range of panel thicknesses.

TYPE P **TYPE C**

Very attractive appearance for panel mounting

Send for leaflet A.1

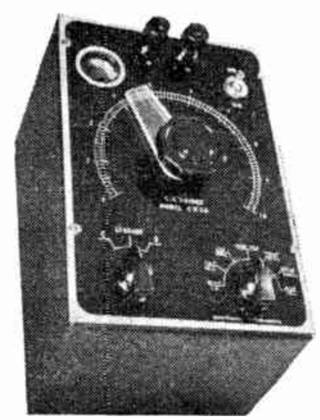
"KNOB LOCK"

The ideal method of locking panel mounted controls. Positive guard against vibration, etc.

This development of our popular pre-set control lock is finished in black plastic and embodies control knob and instantaneous finger-tip locking knob.

Send for List No. A.6

SUTTON COLDFIELD ELECTRICAL ENGINEERS
Reddicap Trading Estate, Sutton Coldfield. 'phone SUT 3038 & 5885



CR50 BRIDGE measures from 10pFd to 100mFd and from 1 ohm to 10 Megohms in fourteen ranges, having a total scale length of over 120 inches. Leakage test for condensers. Indication of balance is given by a magic eye fed from a high gain pentode. Internal standards of "Constants" 1% resistors. Robustly constructed for bench use, complete and ready for use from A.C. mains. £8/2/6 plus 4/6 carr./packing.

SG50 SIGNAL GENERATOR covers 100kc/s to 80Mc/s in six ranges on fundamentals (not harmonics) either modulated 400 cps or CW. Frequency accuracy 2%. Uses 6AG5, 6C4 and RM1 with double wound mains transformer. A de luxe instrument housed in grey hammer finished case size 9 x 13 x 4in., with engraved Perspex scale. £9 plus 6/- carr./packing.

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See us for your requirements or send for out latest list.

COLLARO 4-SPEED MIXER AUTO-CHANGER

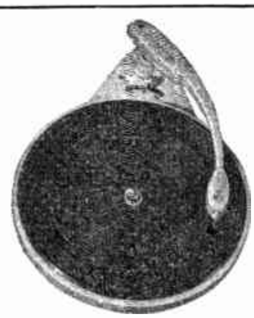
Latest model RC 456 incorporating auto and manual control enabling records to be played singly or automatically. Complete with Studio crystal pick-up and sapphire stylus. List £13/17/-. LASKY'S PRICE **£8.19.6** Post 5/-

SPECIAL OFFER!

COLLARO "JUNIOR" 4-SPEED MOTOR AND PICK-UP

Collaro "Junior" 4-speed motor and pick-up with HGP59 cartridge. Post 5/-. **£4.12.6**

Motor only, 59/6, post 2/6.
Pick-up only, 33/6, post 2/6.



Collaro 4/564 4-speed Single Player with Studio T p.u. crystal cartridge and styli. Automatic stop. LASKY'S PRICE **£7.7.0** Carr. 5/-

COLLARO 4-speed Transcription Turntable

4T200/PX, £19/10/0. Less pick-up £14/18/-. Carr. 7/6

BUILD YOURSELF A HIGH GRADE RECORD PLAYER!

We have the biggest selection of Auto-Changers, Single Players, Amplifiers and Cases, and you can make your own Record Player for as low as **£10** Come and see us.

TRANSISTORS AT A REASONABLE PRICE

R.F. P.N.P. Junction type, suitable for medium and low frequency oscillators, frequency changers and I.F. amplifiers 1.5 to 8 Mc/s (double spot—yellow & red) **21/-**

AUDIO P.N.P. Junction type, suitable for high gain and low frequency amplifiers, and for output stages up to 250 milliwatts. (double spot—yellow and green). Post Free. **10/-**

★ TESTED AND GUARANTEED EFFICIENT
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Full operating data and circuit diagrams for a simple receiver superhet, T.R.F., multi-vibrator, relaxation oscillator, audio amplifier, oscillators, signal tracers, etc., supplied with each Transistor.

MULLARD TRANSISTORS
OC70 or OC71 21/- OC72 30/- OC16 60/-

BRIMAR TRANSISTORS
TS1 12/6. TS2 12/6. TS3 15/-. TS4 27/6. TP1 or TP2 40/-.

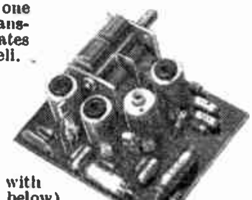
Season's Greetings
to the thousands of customers we have served in person or by post

LASKY'S TRANSISTOR SUPERHET TUNER FOR HOME CONSTRUCTION ON PRINTED CIRCUIT

Uses three R.F. Transistors and one Germanium Diode, three I.F. transformers. Ferrite rod aerial. Operates on one 6 v. battery and one 1.5 v. cell. Printed Circuit, 3¼in. × 3¼in.

CAN BE BUILT FOR. Post 3/6. **£5.12.9**

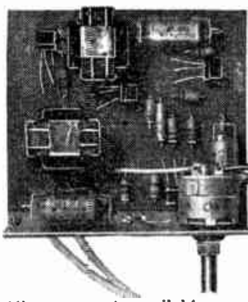
Full details and illustrations post free on request.
Demonstrations at both addresses.



NOTE:—This Tuner in conjunction with our Transistor Amplifier (see below) makes an excellent Transistorised radio. Cabinets available.

LASKY'S TRANSISTOR AMPLIFIER KIT

(200 milliwatts) For construction on a Printed Circuit



All components available separately

Size: 3¼in. × 3¼in. Height can be under 1in. Uses our new hermetically sealed Transistors and operates from 6-volt battery. Output impedance 3 ohms.

FULL DETAILS, CIRCUIT DIAGRAM AND SHOPPING LIST 1/- post free.

COMPLETE KIT including 4 Transistors, all brand new components, latest T.C.C. miniature condensers, printed circuit and full instructions. **79/6** Post 3/6.

DEMONSTRATIONS AT EITHER OF OUR ADDRESSES

SUB-MIN. TRANSISTOR TRANSFORMERS 45-1 ratio each. **4/6** Post 1/-

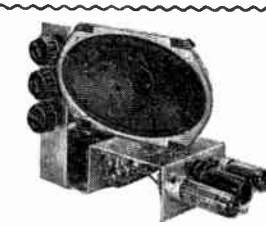
ALL TRANSISTOR COMPONENTS. Trans., midget, min. and sub-min. Coils, Ferrite Rods, sub-min. Condensers, etc.

PICK-UP BARGAIN
"RONETTE" Lightweight Crystal Pick-up with 2 cartridges. LASKY'S PRICE **45/-** Post 2/6

CARTRIDGES
ACOS HGP37 p.u. Cartridges. l.p. and standard, complete with styli. List 41/7. LASKY'S PRICE **18/-** Post 1/-

Teletron "Companion"

3-TRANSISTOR POCKET RADIO. T.R.F. circuit covering medium and long waves, with balanced armature output. Ferrite aerial. Note small size: 4¼ × 3 × 1in. You can build this novel transistorised pocket receiver for only **89/6** Full instructions and price list, 6d. post free. All components available separately.



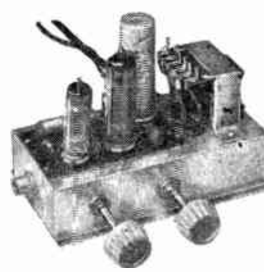
LASKY'S 4-WATT PORTABLE GRAM AMPLIFIER

Will suit any type of crystal or magnetic pick-up. Uses 3 valves: EL84 output, L63 and EZ80 rect. Speaker and controls are completely separate and can be mounted as shown or on anywhere in cabinet where most suitable.

COMPLETE with 3 valves and knobs, less Speaker. Carr. 5/-. **79/6**

7in. × 4in. Elliptical Speaker, if required, 19/6 extra.

Details and circuit diagram post free on request.



LASKY'S PORTABLE GRAM AMPLIFIER KIT

2 watts. Note small dimensions, approx. 6¾in. × 3⅞in. max., height 5in. Uses EL84 output and 6X4 rectifier, double-wound transformer, tone control, output transformer, etc. Built on a T.C.C. PRINTED CIRCUIT which greatly simplifies construction and eliminates wiring errors.

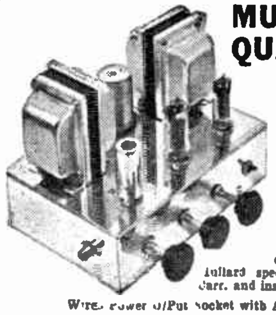
COMPLETE KIT, including valves, printed circuit, full instructions, less Speaker. Carr. 2/6 **58/-**

7in. × 4in. Elliptical Speaker, if required, 19/6 extra.

★ H.P. TERMS and CREDIT SALES available on certain items.

MORE MONEY-SAVING LASKY BARGAINS ON NEXT PAGE

MULLARD "3—3" QUALITY AMPLIFIER



An ideal companion unit to the JASON Tuner. A really first-class 3-valve 3-watt Amplifier giving Hi-Fi quality at a reasonable cost. Mullard's latest circuit. Valve line up: EF86, EL84, EZ80. H/duty mains trans. giving extra HT and LT for Tuner Unit addition.

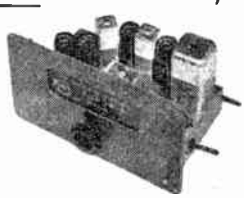
Variable treble cut and bass boost controls. Sensitivity 100 MV for 3-watt output. Frequency response + or — 1db. 40 c/s to 25 kc/s.

Complete amplifier wired and tested with quality sectionalised output transformer to Mullard specification (less speaker) **£8 . 8 . 0** Carr. and ins. 4/6.

Wired Power O/Put Socket with Additional Smoothing 10/6 extra.

JASON F.M. TUNER UNIT 87-105 mc/s

F.M. TUNER-UNIT (87 mc/s—105 mc/s) by Jason. As described in Radio Constructor. Designer Approved Kit of parts to build this modern highly successful unit, drilled chassis and superior type dial as illustrated coils, can, and all quality components, etc., for only 5 gns., post free. Set of 4 spec. EF91 or equiv valves 30/- post free. Illustrated handbook with full details 2/-, post free. Free with Kit. 48-hr Alignment Service. 7/6 and 2/- p.&p.



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100/250 v.....	1/9	8-16/500 v...	5/6
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8/500 v.	2/9	16+16/500 v.	6/-
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8+16/450 v...	5/-	32+32/350 v.	5/6
16/450 v. ..	3/6	32+32/275 v.	4/6
16-16/450 v.	5/6	50+50/350 v.	6/6
32/350 v. ..	4/-	60/350 v.	6/6
32/500 v. ..	5/-	60+250/275 v.	12/6
32-32/350 v.	5/6	64-120/275 v.	11/6
32+32/450 v.	6/6	100+200/275 v.	12/6
		100/270 v. ..	6/6

MIDGET TRANSISTOR TYPES. 2μF, 4μF 8μF 6V 3/6; 6μF 10μF 16μF 3V. 3/6: 32μF 1½V. 3/6.

CONDENSERS.—Mica, Silver Mica. All pref values, 3 pf. to 1,000. pf. 6d. each. Ditto ceramics 9d. each. Tubulars, 450 v. Hunts and T.C.C. .001 mfd.-.01 and .1/350 v. 9d. each. .02-1/500 v.. 1/- each, .25 Hunts, 1/6. .5 Hunts, 1/9. .001 mfd. 6k.. 5/6. 001 mfd. 20kv. 9/6.

CLOSE TOLERANCE CONDENSERS S/Mica. 10% Type, 5 pf.—500 pf., each 1/-; 600 pf — 5,000 pf. each 1/3. 1% Type 1.5 pf.—50 pf. (Tol. 1 pf.), 1/9; 56 pf.—500 pf. each 1/9: 575 pf.—5,000 pf. each 2/-.

RESISTORS.—Pref. val. 10 ohms 10M ohms.

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20% Type, ¼ w.. 3d.; ½ w. 5d.; 1 w.. 6d.; 2 w., 9d.
10% Type ½ w. 9d.; 5% Type, ¼ w 1/-; 1% Hi-Stab. ½w. 2/-

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3 w. / 10 w / 15 w.	25 ohms—10 000 ohms	1/3, 1/6, 2/-
5 w. / 10 w.	15,000—33 000 ohms	1/9, 2/3

WIRE-WOUND POTS Pre-Set Min. T.V. Type Knurled Slotted Knob. All values 25 ohms to 30 K., 3/- ea. 50 K. 4/-. Ditto, Carbon Track 50 K. to 2 Meg. 3/-.

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SENTERCEL RECTIFIERS. E.H.T. Type, Fly-Back Voltages. K3/25 2 kV., 5/-; K3/40 3.2 kV. 6/9; K3/45 3.6 kV. 7/3; K3/50 4 kV., 7/9; K3/100 8 kV. 13/6. etc MAINS TYPES.—RM1 125 v. 60 mA. 4/9; RM2 125 v. 100 mA 5/6; RM3 125 v. 120 mA.. 7/6; RM4 250 v 250 mA. 16/-; RM4B type 270 mA. 17/6. RM5 250 v 300 mA 21/-.

SPEAKER FRET.—Expanded Bronze anodised metal 8 x 8in., 2/3; 12 x 8in. 3/-; 12 x 12in. 4/6; 12 x 16in., 6/-; 24 x 12in. 9/-, etc. Any preferred size cut.

TYGAN FRET (Murphy pattern) 12in. x 12in. 2/-; 12 x 18in. 3/-; 12 x 24in.. 4/-.etc.

NEW BOXED **VALVES** ALL GUARANTEED

1R5,1T4	7/6	EABC80	9/6	EZ80	8/6
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3S4 3V4	8/-	EBC41	9/6	PCC84	10/6
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6SN7	8/6	ECH81	10/6	PY80	9/6
6V6	7/6	ECL80	10/6	PY81	9/6
6X4	7/6	EF41	10/6	PY82	8/6
6X5	7/6	EF80	10/6	PY83	10/6
7C5	9/-	EF86	12/6	U22	8/6
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DAF96	9/-	EM85	11/3	UCH42	10/6
DF96	9/-	EL41	10/6	UF41	10/-
DK96	9/-	EL84	11/6	UL41	10/6
DL96	9/-	EY51	10/6	UY41	8/6
35L6	10/6	EZ40	8/6		

SPECIAL PRICE PER SET
1R5, 1T4, 1S5 1S4, or 3S4, or 3V4 27/6
DK96. DF96 DAF96. DL96.... 35/-
6K8 6K7 6Q7. 6V6 5Z4 or 6X5 35/-

TRANSISTORS. Mfrs. surplus PNP Junction type. Audio Type. 800 kc/s 250 mW 9/6; R.F. and L.O. Mixer Type, 2.5 Mc/s. 19/6. All tested and guaranteed.

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Log. ratios, 10,000 ohms—2 Megohms. Long spindles, 1 yr. guarantee. Midget Ediswan type. No Sw. 3/-; S.P. Sw., 4/- D.P. Sw. 4/9. Linear Ratio. 10,000 ohms—2 Megohms. Less switch. 3/ each. Coax plugs 1/2. Coax sockets. 1/- Couplers 1/3. Outlet boxes 4/6.

80 ohm CABLE COAX

STANDARD ¼in. diam. Polythene insulated GRADE "A" ONLY. **8d. yd.**

SPECIAL—Semi-air spaced polythene. 80 ohm Coax ¼in. diam. Standard core. Losses cut 50%. **9d. yd.** IDEAL BAND 3.

TRIMMERS, Ceramic, 4 pf.—70 pf., 9d.: 100 pf., 150 pf., 1/3; 250 pf.. 1/6; 600 pf.. 1/9. PHILIPS Beehive Type—2 to 8 pf. or 3 to 30 pf.. 1/- each.

LOUDSPEAKER.—PM. 3 ohm. 2½in. Elac. 17/6; 3½in. Goodmans 18/6; 5in. Rola 16/6; 6in. Elac. 18/6; 7 x 4in. Goodmans Elliptical 18/6; 8in.. Rola 20/-; 10in. R. and A., 25/-; 10in WB-HF1012, 99/9; 12in. Plessey 15 ohm with 6 x 4in. Tweeter and Cross Over Filter 97/-.

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TRANSFORMER & COIL/WINDING CAPACITY AVAILABLE FOR PROTOTYPES & SMALL RUNS.

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EDDY'S (NOTTM) LTD (DEPT WW)

THIS MONTH'S SPECIAL OFFERS

TRIPLETONE AMPLIFIERS. List price £6/19/6. Our price £5/19/6 plus 2/6 postage, etc. 200-250 v. A.C. 4 watts matched output for 2-3 ohms. Size only 8 x 4 x 4½in. high. **VALVES**—6SJ7GT, 6V6GT, 6X5GT.

Special Feature of Treble, Middle and Bass Controls.

ALL NEW & GUARANTEED

SINGLE-PIECE THROAT MIKES. 1/- each. Post etc. 3d. each. Could be used for electrifying musical instruments.

MIDGET BATTERY ELIMINATORS. To convert all low consumption Portables for Mains operation. Mains input 200/240 v. A.C. H.T. output 85 v. 10 mA, L.T. output 1.3 v. 125 mA. Size 3.7 x 2.5in. Actually smaller than H.T. battery alone! SPECIAL PRICE OF 55/- plus 2/6 post, etc.

NEW & GUARANTEED

ANY PARCEL INSURED AGAINST DAMAGE IN TRANSIT 6d. extra.

SURPLUS, NEW & GUARANTEED **VALVES** ALL TESTED BEFORE DESPATCH.

Post, etc. 6d. per valve extra over £2 free.

DAF93	9/8	PCL83	13/11	6B8G	3/11
DF96	9/6	PY80	8/3	6BA6	6/6
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DM70	7/11	PZ30	15/11	6F15	14/9
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EABC80	7/6	UF41	8/-	6K7G	2/11
EB91	6/6	UL41	9/11	6L6G	7/11
ECC83	8/6	UCH42	8/-	6Q7G	8/3
ECC84	10/-	UL84	11/6	6Q7GT	8/11
ECC85	9/6	U25	13/6	6V6GT	5/11
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EF41	9/-	W76	7/6	12AH7	7/6
EF80	8/3	1A7G	12/6	12K7G	7/6
EF86	12/6	1C5G	10/6	12Q7G	7/6
EF89	9/11	1H5G	10/6	1487	13/6
EF91	6/11	1N5G	10/6	25L6GT	9/-
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EY51	11/6	1T4	7/-	35W4	7/6
EZ80	8/-	3Q4	9/-	35Z4G	7/11
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GZ34	13/11	3V4	8/-	955	3/11
MU14	8/11	5Y3GT	7/6	956	2/6
PCC84	8/-	5Z4G	9/6	958	3/11

172, ALFRETON RD., NOTTINGHAM

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LARGE STOCKS OF VALVES and C.R.T.s. METERS, Avo, Advance, Taylor, and Cossor Oscilloscopes in stock. AMPLIFIERS, Leak, Trix & Quad. GRAM UNITS, Garrard & Collaro. Collaro TRANSCRIPTION UNIT 2010PX.

LOUDSPEAKERS, Goodmans, Wharfedale, WB Tannoy and leading makes. PICK-UPS and STYLI of most makes. TAPE RECORDERS, Grundig, Philips, Truvox, Playtime & Ferrograph.

LATEST VALVE MANUALS

Mullard, 10/6; Osram & Brimar No. 6, 5/- each; Osram Part 2, 10/-.

Postage 9d. each extra.

PARTICULARS ON REQUEST

Terms C.O.D. OR CASH with order.

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IT'S MUCH BETTER

MODERNISE YOUR OLD RADIOGRAM

IT'S MUCH CHEAPER

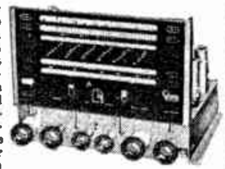
THE NEW ARMSTRONG P.B.409 AM/FM RADIOGRAM CHASSIS

PRICE **£29.8.0** (Plus 7/6 carr. and ins.).

TERMS: Credit Deposit £7/7/- and 9 monthly payments of £2/14/-. H.P. Dep. £14/14/- and 12 monthly payments of £1/7/3.

BRIEF SPECIFICATION:—
A 9 valve line up employing the latest MULLARD preferred-type valves. ● Provides complete coverage of the VHF/FM Transmissions, plus the SHORT, MEDIUM and LONG waves. ● Has Push-Pull output, with negative feedback, for 6 watts Peak output ● Quick action "Piano Key" Selectors and separate Bass and Treble Controls. ● Has "Magic Eye" Tuning Indicator. ● Dimensions 13in. × 9½in. × 8in. high. Dial size 11¼in. × 5½in.

THE ARMSTRONG MODEL A.F. 105 AM/FM RADIOGRAM CHASSIS
A Genuinely Hand Made Chassis



Developed to meet the needs of those who require really high quality radio and record reproduction but who, for reasons of expense or lack of room in existing or proposed cabinets, cannot consider the normal high-fidelity system. The A.F.105 is as good as, or better than, many of the high quality amplifiers, and Associated units. Independent and continuously variable Bass and Treble controls give a wide range of control. SEND S.A.E. FOR DETAILS.

PRICE **£37** (Plus 7/6 carr. and ins.).

CREDIT SALE TERMS: Deposit £9/5/- and 9 monthly payments of £3/7/10.
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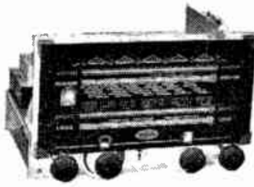
THE DULCI MODEL H.4
COMBINED AM/FM RADIOGRAM CHASSIS



A 4 Waveband Receiver designed for first-rate reproduction of Radio and Gram.

PRICE **£24.6.6** (Plus 7/6 carr. & ins.).

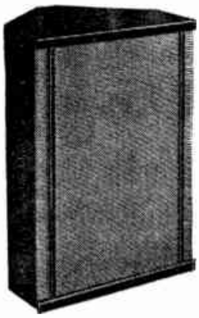
CREDIT TERMS: Deposit £6/2/- and 9 monthly payments of £2/4/7. H.P. TERMS: Deposit £12/3/3 and 12 monthly payments of £1/2/7.

BRIEF SPECIFICATION:—
- Covers Short, Medium, Long and F.M. Wavebands
- Employs full A.V.C.
- The Latest 7-valve line-up
- For 3 or 15 ohm P.M. Speakers.
- "Magic Eye" Tuning Indicator.
- **Excellent Tone range up to 4 watts output.**
- Internal aerial for local stations.
- Overall size 12in. × 8¼in. × 7¾in. high.

A good Quality Chassis and Well Recommended.

HOME CONSTRUCTORS ! !
BUILD YOUR OWN "Hi-Fi" LOUDSPEAKER SYSTEM

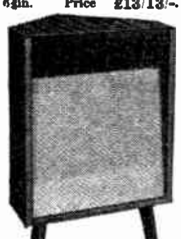
WITH W-B's WELL KNOWN RANGE OF READY-TO-ASSEMBLE CABINETS. ALL ARE BEAUTIFULLY MADE AND FINISHED AND VERY EASILY ASSEMBLED. ONLY A SCREWDRIVER IS REQUIRED. THEY ARE PACKED FLAT IN CARTONS AND COMPLETE WITH SCREWS.
WE SHOW A FEW HERE BUT OTHERS ARE AVAILABLE. SEND S.A.E. FOR LEAFLET.
CALL IN AND LISTEN TO THEM.



THE JUNIOR BASS REFLEX CORNER CONSOLE

A new contemporary-style cabinet, specially designed to give maximum reproduction quality from Stentorian 8in. or 10in. units, with provision for Tweeter Unit, if required. Measures 33in. × 22½in. × 18½in. Price £9/9/- or with the 8in. Stentorian Speaker £13/12/6 or with 10in. Stentorian Speaker £14/8/6.

The "PRELUDE" Hi Fi CONSOLE CABINET



Takes any make of tape-deck or record player amplifier, pre-amplifier control unit, and radio tuner. Size 33in. × 19in. × 19½in. Height above baseboard is 6¾in. Price £13/13/-.

THE "PRELUDE" BASS REFLEX CORNER CONSOLE

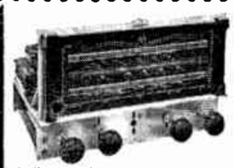
This most attractive cabinet has been specially designed to utilise the natural acoustic properties of the walls, and is also obviously suitable for use where space-saving is a consideration. It is sturdily constructed to take every advantage of Stentorian 8in. or 10in. units, with provision for Tweeter Unit. Size 33in. × 21in. × 17in. Price £10/10/0 or with the 8in. Stentorian Speaker £14/13/6 or with the 10in Stentorian £15/9/6.

The 'PRELUDE' Hi Fi TABLE CABINET

Designed to take any make of Tape Deck or Single Record Player (not Auto-changers) Amplifier, Pre-amplifier Control Unit, and Radio Tuner. Price £9/19/6. Size 19½in. × 19in. × 19½in

HIRE PURCHASE and CREDIT SALE TERMS ARE AVAILABLE . . . SEND S.A.E. for details.
WE ALSO HAVE THE GOODMANS SHERWOOD ENCLOSED IN STOCK.

THE DULCI MODEL H3.
COMBINED AM/FM RADIOGRAM CHASSIS



This model is very similar to the model H.4 described above but covers 3 WAVEBANDS instead of 4 (omitting the Short Band) and is for 3 ohm Speakers only. Overall size is as for the H.4.

PRICE **£20.17.0** (Plus 7/6 carr. and ins.).

CREDIT TERMS: Deposit £5/4/3 and 9 monthly payments of £1/18/4. H.P. TERMS: Deposit £10/8/6 and 12 monthly payments of 19/4.

THE DULCI MODEL H.4T
Combined AM/FM Tuning Unit incorporating own Power Supply.

MODEL H.4T. This model is the "TUNER UNIT VERSION" of the H.4 Radiogram Chassis illustrated and described above. It has the same coverage of A.M. and F.M. Wavebands (4 altogether) and precisely the same in size and appearance, except that it has three Controls only, being: TUNING, WAVECHANGE and Volume On/Off, mounted centrally on the chassis. A self-contained Tuner incorporating own Power Supply.

PRICE **£20.17.0** (plus 7/6 carr. & ins.)

CREDIT TERMS: Deposit £5/4/3 and 9 monthly payments of £1/18/4. H.P. TERMS: Deposit £10/8/6 and 12 monthly payments of 19/4.

Stern's "fidelity" F.M. TUNING UNIT

A 5-Valve Tuner incorporating the latest Mullard Permeability Tuned Unit. Price assembled less Power Supply:

£14.10.0 (Plus 7/6 carr. and ins.).

TERMS: (a) H.P. Deposit £7/5/- and 9 monthly payments of 18/4:
(b) Credit Deposit £3/12/6 and 9 monthly payments of £1/6/7. Provides "Hi-Fi" reproduction with any make of Amplifier and many Radio Receivers. It incorporates: ● The latest Valve line-up—ECC85, 2 type EF85, EF91 and EM80. ● A "Magic Eye" Indicator. ● Power consumption is 1.7 amps at 6.3 volts and 25 m/a. at 250 volts.

STERN'S "fidelity" COMBINED A.M. and F.M. TUNING UNIT

This is IDENTICAL to the Stern's F.M. Tuner illustrated above, but in addition incorporates the MEDIUM WAVEBAND and thereby also provides a selection of foreign stations. PRICE **£18.18.0** (Plus 7/6 carr and ins.).

TERMS:—(a) H.P. Deposit £9/9/- and 10 monthly payments of £1/1/-; (b) Credit Deposit £4/15/- and 9 monthly payments of £1/14/7. Send S.A.E. if further data required.

HOME CONSTRUCTORS . . . You can build

(a) The "fidelity" F.M. TUNING UNIT FOR **£10.0.0**

(b) The "fidelity" AM/FM TUNING UNIT for **£13.0.0**

The COMPLETE ASSEMBLY DIAGRAMS and INSTRUCTIONS CAN BE OBTAINED FOR 1/6 each

STERN'S POWER SUPPLY UNITS

Fully smoothed with all output connections terminated to connecting Blocks, thereby enabling ease of connecting to a Radio Tuner Unit or Amplifier, etc. (the Compact 5 Amplifiers are immediately connected in this way). Overall size of Units is 9½in. × 3½in. × 4½in. high TWO MODELS ARE AVAILABLE. Type "A" Unit provides 250-300 volts at up to 70 m/a. and 6.3 volts at 3½ amps.

PRICE **£2.17.6** (Plus 2/- carr. and ins.)

Type "B" Unit provides 250-300 volts at up to 100 m/a and 6.3 volts at 3½ amps.

PRICE **£3.3.0** (Plus 2/- carr. and ins.).

WE ALSO SUPPLY THESE UNITS AS COMPLETE KITS OF PARTS

A detailed wiring-up leaflet is supplied (this is available separately for 9d.), and they are very quickly and easily assembled.
Type "A" Unit Complete Kit PRICE £2/9/6.
Type "B" Unit Complete Kit. PRICE £2/15/-.
(Carriage and insurance is 2/- extra.)

"FRUSTRATED EXPORT ORDER"

The Cossor Model 527/X 4 Valve "All-dry" Battery Portable.

Offered For **£6.15.0**

Plus 5/- carr. & ins.

Consists of a 4 valve Superhet Receiver covering Medium Waveband 187-575 metres, and two Short Wavebands 13.6 to 136 metres. The new low consumption valves are incorporated and the whole is accommodated in an attractive robustly made case. Battery required is 90 volts and 1.4 volts (price 19/6) and is external to case.

RECORD PLAYERS
THE VERY LATEST MODELS ARE IN STOCK
MANY AT REDUCED PRICES ! ! !

TRANSCRIPTION UNITS—AUTOCHANGERS
SINGLE RECORD PLAYERS
Send S.A.E. for ILLUSTRATED STOCK LIST

CASH ONLY OFFER ! ! !

This latest Brand New B.S.R. MONARCH 4-SPEED AUTOCHANGER **£8.7.6** (Plus 5/- carr. and ins.).

● Minimum baseboard size required 14in. × 12½in., with height above 5½in., & height below baseboard 2½in.

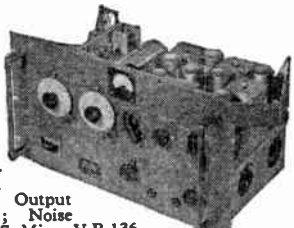
WE ALSO HAVE A FEW ONLY

COLLARO MODEL 456 4-Speed "Mixer" Autochangers. The Units are BRAND NEW and incorporate the STUDIO "O" Pick-up. PRICE **£8.19.6** (Plus 5/- carr. and ins.).

Open Monday to Friday 9 a.m.—6 p.m.
Saturday 9 a.m.—1 p.m.

STERN RADIO LTD.

RECEIVER TYPE R.1392

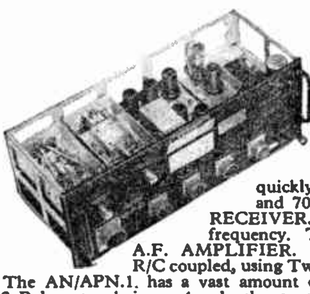


Frequency 95-150 Mc/s (2-3 Metres). Air Tested 15 Valve Superhet. Valve Line-up: 1st and 2nd R.F. Amp. VR.136 (EF54); 1st Local. Oscillator V.R.65 (SP61); 2 Oscillator Multipliers V.R.136 (EF54); 3 I.F. Amp. V.R.53 (E.F.39); AGC. 6Q.7. Output 6J5; Muting V.R.92 (EA.50); Noise Limiter V.R.92 (EA.50); B.F.O. 6J7; Mixer V.R.136 (EF.54); De Mod. 6Q7. Normally Crystal Controlled but can be tuned over 95 to 150 Mc/s. Power supply required: 240-250 volts at 80 mA. 6.3 volts at 4 amps. Size 19 × 10in. × 10in. Standard Rack Mounting.
Complete with valves and circuit diagram **£6.19.6**
Packing and Carriage 10/- extra.

TRANSMITTER/RECEIVER No. 19. Mk. II

Frequency coverage 2 to 8 mc/s. for R/T. MCW. CW. Superhet Receiver 465 kc/s. I.F.'s BFO etc. Receiver line-up: 6K7 RF; 6K8 Mixer; Two 6K7 I.F.'s; 6B8 Det. Transmitter line-up: 6K8 Mixer; VFO EF50 buffer; ADC EB34; 807 P/A. This unit incorporates a TX/RX 229 ot 241 mc/s. with a local range of 1 mile.
Valve line up: CV6. Two 6K7's and 6V6. Also intercom. set two valve AF amplifier 6K7 and 6V6.
As new condition and American manufacture.
Fully valved. **£3.5.0**
Plus 10/- Packing and Postage

AN/APN.1. TRANSMITTER/RECEIVER

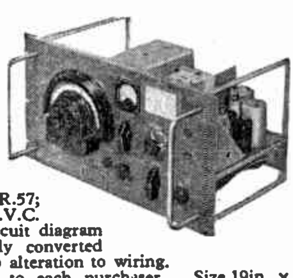


Frequency approx. 400-485 mc/s.
R.F. TRANSMITTER. Operating 67.42 cm. (445 mc/s) with a band width of 40 mc/s. Modulation of its carrier is by means of a moving coil Transducer.
Two 955 (VT.121) valves; quickly converted for Radio control and 70 cm.
RECEIVER. Tuned to the Transmitting frequency. Two 9004 valves.
A.F. AMPLIFIER. An audio frequency amplifier R/C coupled, using Two 12SH7's and One 12SJ7 valves.
The AN/APN.1. has a vast amount of useful components including: 3 Relays one being a 4 pole change over type (3 off 1 megohm. 1 per cent Resistors (wire wound), Potentiometers and the following valves; 3 12SH7's; 1 12SJ7; 1 VR. 150/30 (OD.3) and 2 12H6's making a total of 14 valves in all.
Brand new **£1.10.0**
Plus 7/6 Packing and Carriage.

WALKIE TALKIE TRANSMITTER/ RECEIVER TYPE 38

Frequency 7.4 to 9 mc/s, valved with four VP.23's and one ATP.4. Brand new and complete with two pairs of earphones two throat microphones, whip aerial, junction box and canvas satchel. **£3.5.0**
Plus 5/- Packing and Postage.

RECEIVER TYPE R.1132

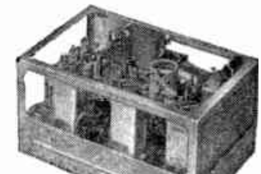


Frequency 95-126 mc/s. 11 Valve Superhet. Valve line-up: RF. Amp. VR.65; Frequency Changer VR.65; Local Oscillator VR.66; Stabilizer VS.70; I.F. Amplifiers V.R.53's; B.F.O. V.R.53; Detector V.R.54; A.F. Amplifier V.R.57; Output V.R.37 (6J5). Switchable A.V.C. and A.G.C. Variable B.F.O. Circuit diagram supplied with each unit. Easily converted to receive Wrotham band with no alteration to wiring. Conversion instructions available to each purchaser. Size 19in. × 10in. × 10in. Standard Rack Mounting. **£3.7.6**
Packing and Carriage 10/- extra

All these fine offers
PROOPS

Shop and Head Office: *Telephone:* **LANgham 0141**
Mail order enquiries: *Telephone:* **EUSton 8812**
Carriage prices quoted apply only to England and Wales.

RECEIVER UNIT EX. 1143a

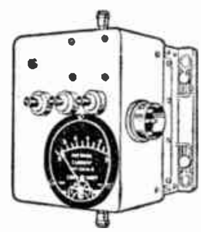


Suitable for conversion to 2 Metres or FM Wrotham transmissions. Valve line-up: Four EF.50's; One EL.32; Two EF.39's; One EBC.33; One EA.50.
Circuit diagram supplied with each unit. Fully valved. **£1.5.0**
Plus 3/6 Postage

DESYNN TYPE ANTENNA

or Beam position indication system

This comprises a transmitter unit and Indicator which will operate on 12 or 24 volts D.C. and will indicate with instantaneous and smooth pointer movement. The Transmitter is a specially designed potentiometer and will operate the receiver on a simple three-wire system and the receiver in this instance is calibrated in gallons but dial could be easily altered to indicate a 360 deg. sweep. Transmitter and receiver with full instructions. **12s. 6d.**
Plus 2/- Packing and Carriage



ANTENNA RELAY UNIT

U.S. manufacture, containing change-over relay, 2½in. panel mounting meter (measuring aerial current) with separate thermocouple. Meter movement 2 mA. basic contained in metal case 3¼ × 4¼ × 3½in. with ceramic stand off terminals.
12s. 6d.
Post paid

AN/APN.1 TRANSDUCER

This unit consists of Magnet and Coil which is attached to an aluminium diaphragm suspended freely and perforated to prevent air damping. Mounted on a Ceramic cover which sits over the diaphragm in a form of 2-gang capacitor which has a swing from 10-50 pF.
The above unit is used as part of Wobbulator described on page 252 of the June, 1956, *Wireless World*.
Price **7s. 6d.**
Post paid

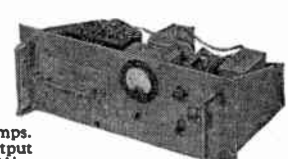
GYRO UNIT AND INVERTER

Inverter: 12 volt d.c. input 3-phase 190 cycle output. (These inverters can be used successfully as 12 volt d.c. Motors for Models).
Gyro Unit: Operates on 3-phase output from Inverter. Peak speed 11,400 r.p.m. Caged. Precision made equipment.
These units are ideal for experimenting and demonstration purposes.
Size: Inverter 4 × 4 × 3in.; Gyro 4in. dia. incl. cage. Price **12s. 6d.** per pair
Plus 3/- p.p.

NEW TANNOY SPEAKERS

External 8 watt unit 7½ ohm impedance complete with matching transformer.
£1.0.0 each
Plus 3/6 Packing and Postage

MAINS POWER UNITS. TYPE 234

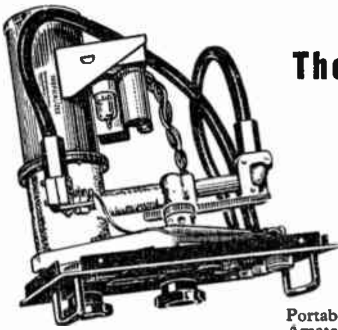


Double smoothed 200 to 250 v. 50 cycle input. Output: 200 or 250 volts at 100 m/A 6.3 volts at 6 amps. Voltmeter reading input and output voltages. Size: 19in. × 10in. × 6½in. Standard Rack Mounting. **£4.10.0**
Plus 10/- Packing and Carriage

are on display at

BROS Ltd. DEPT. 'W'

52 TOTTENHAM COURT ROAD, LONDON, W.1.
Shop hours 9 a.m to 6 p.m.—Thurs.: 9 a.m. to 1 p.m.
OPEN ALL DAY SATURDAY.



The TS184 A/AP

Real 70 cm. Test Gear, brand new in carrying case for only

£5.10.0

Carriage Paid

Portable Precision for Mobile Hams, Amateur T.V. Telearchics (with acknowledgements to Free Grid) and those monitoring the latest U.H.F. allocations.

RESONANT CAVITY WAVEMETER, calibrated 400-430 mc/s. Tuning stops adjustable to any 30 mc/s band within the 400 to 470 mc/s coverage. Calibrated scale rack and pinion drive piston input attenuator—and alternative fixed coupling loop input provides facilities for use as a signal generator. Plug-in "Telescopic Probe Antenna" 6J6 detector and Monitor amplifier, 2-600 ohm phone jacks for modulated signals. Panel output terminals for metering 6J6 output current. Power required 6 volt at 300 m/A and 30 volts at 0.5 m/A.

24-page booklet supplied with each unit giving comprehensive circuit descriptions, diagrams and suggested modifications Etc.

SIGNAL GENERATOR TYPE 52A

Frequency 6 to 52 mc/s. Internal mains power pack. **£10.0.0**
Plus 10/- Carriage

SIGNAL GENERATOR AND WAVEMETER

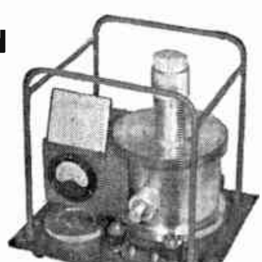
Type W.1649. Frequency of signal generator: 140 to 240 Mc/s. Accuracy ±0.5 Mc/s. Frequency of Heterodyne Wavemeter: 155 to 255 Mc/s. Accuracy ±0.2 Mc/s. Containing VR.135 and 4-VR.91. 5 meg. crystal. Retractable aerial. Power requirements: 6.3 volts and 120 volts. Unit housed in copper lined wooden case. Size: 15½in. × 13in. × 14½in. In good used condition.

£2.10.0
Plus 10/- Packing and Carriage

G.93 WAVEMETER

£12.0.0
Post paid

'S' BAND PRECISION WAVEMETER



2900 to 3150 Mc/s. TEST SET 288 A.M. Ref. 10SB/6161.
Comprising exceptionally rugged silver-plated Wavemeter Type 1665, resiliently mounted and directly tuned by 7½in. dia. calibrated micrometer with 6¾in. thimble scale. Temperature correction for micrometer attached. Resonance indicated on 100 microamp meter. Equally suitable for laboratory using milliwatt powers or, with loose coupling, for high powers. UR21 connecting cable and coupling probe supplied. Brand new in robust moisture-proof case with jacking-off screws and tool.

£15.0.0
Plus £1 Packing and Carriage

AMPLIDYNE MOTOR GENERATOR

Type 74. Brand new. **£1.15.0**
Post paid

ELECTRIC TIME SWITCH

Beautifully made clockwork mechanism automatically wound by 6 volt Solenoid. The time switch can be set for any period between 30 minutes and 44 days This robust unit is housed in strong Bakelite case 4in. in diameter.

12s. 6d.
Post Paid

BENDIX DYNAMOTORS

24 volts input 235 volts at 100 mA. D.C. **9s. 0d.** each
Post paid

BINOCULAR TYPE INFRA RED VIEWING EQUIPMENT

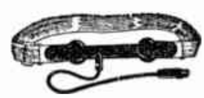
Complete with EHT supply operating from 6 or 12 volt D.C. Originally designed for night driving. Complete with cleaning fluids and canvas carrying cases. Packed in transit cases.

£3.10.0
Carriage 7/6

PETROL ELECTRIC CHARGING SET

12/18 volts, 80 watt. Ideal battery charging unit or for Field Days. Size: 14½in. × 7½in. Weight 46lbs.
Brand New, with complete set of running spares and Canvas cover.

£11.10.0
Plus 10/- Packing and Carriage



THROAT MICROPHONES TS.30.

Including socket. **3s. 0d.**
Post paid

CRYSTAL MIKE INSERTS

4s. 6d. each
Post paid

HIGH RESISTANCE EARPHONES

2,000 ohms, single units **3s. 6d.**
Post 1/-

AMERICAN TANK PERISCOPES

7s. 6d.
Post paid

STANDARDISE YOUR RIG

With British to American or American to British Co-axial adaptors. Plug or Socket fittings.

1s. 6d.
Post paid

TRANSFORMERS

HEATER TRANSFORMERS
6.3 volt, 1½ amps.; brand new, 6/6, plus 1/- p.p.

SMALL MAINS TRANSFORMERS
Input 230 volt 50 cycles, output 250 volt 40 mA., 6.3 volt 1.5 amp. Size 3.9in. × 2.4in. × 2in. Ideal for TV converters. Price 12/6 each, plus 1/- p.p.

CHARGER TRANSFORMERS
For 6 or 12 volt; 230 volt 50 cycles input, 9 and 17 volt 3 amp. output. Price 15/6 each, plus 1/- p.p.

MAINS CHANGING TRANSFORMER

(Admiralty Pattern) 230/100-110 130 V. Separate primary and secondary with earthed screen winding between. Totally enclosed in 7in. × 6in. × 8in. black steel case with detachable lid exposing terminal block and tapping link. Secondary very conservatively rated at 0.44 amps. (core size 3 sq. in.), tested to 2,000 V. Weight 19lb.

£1.0.0
Including Packing and Postage

TEST METERS & EQUIPMENT

EVERSHED & VIGNOLES WEE MEGGER 250v.

New and unused. Only £10/10 P. & P. 3/-.

★

THE NEW AVO "MULTI MINOR" will test 1,000 v. D.C. or A.C. Sensitivity 10,000 M/V D.C. or 1,000 M/V D.C. This 19 range all-purpose pocket size tester is for ohms, volts and milli-amps. Complete with instructions, test leads, etc. £9/10/-.

AVO VALVE TESTER. Complete with Rotary Panel in good order. £7/19/6, carr. 7/6.

WAVEMETER TYPE W 1310 (Marconi ex Govt.), coverage 155-230 Mc/s continuous. Complete with chart and test prods. As new for 200–250 v. A.C. mains operation. £4/15/-, carr. 10/-.

VALVE TESTER (by Radio City Products, U.S.A.), model 314, brand new, unused with instruction manual. 110–220 v. A.C. 50 c/s. Will test most American valves from 1.1 v. tp 200 v. £10, carr. 5/-.

TEST SET. TS-26/TSM. This volt ohmmeter is the correct tester for EE8 telephones and all standard telephone equipment. Brand new and boxed, with full technical data. £7/10/-.

METERS. 0–1 m/a 2in. circular F/M 17/6. Ditto, 2½in., 25/-. 0–50 microamps, D.C. m/c., projecting 2½in. round, 49/6. 0–10 mA. A.C. m/c., rectifiers, flush 3½in., round, 49/6. 0–300 v. A.C. 2½in. flush mounting, 25/-. 0–200 v. A.C. 3½in. flush mounting, 25/-. 0–300 v. A.C. 3½in. flush mounting, 25/- each.

★

AVO TEST BRIDGE. A.C. mains operated from 200–250 v. Will test resistance from 5 ohms to 50 megohms and capacity from .00001 to 50 mfds. A most useful instrument for everyday uses. Our price ONLY £7/19/6. P. & P. 3/6.

★

TEST METER. Model 420 S.P. (by Radio City Products, U.S.A.). 1,000 ohms per volt for both A.C. and D.C. tests. As previously advertised. £5/19/6 only, carr., etc., 7/6.

EVERSHED & VIGNOLES MEGGER CIRCUIT TESTER (low reading ohm meter). The perfect meter for continuity and polarity testing. Complete with test leads and ready to use. Brand new. Only £4/17/6. P. & P. 3/-.

S. METERS. 2in. circular calibrated in decibels 5 mA. FSD, 25/- each. All brand new and boxed. P. & P. 1/- each.

WAVEMETER CLASS D. Freq. range 1,900 kc/s. to 8,000 kc/s. (158–37.5 metres) in two ranges. Supply 6 v. D.C. input. New with instruction manual, spare vibrator and frequency changer. Complete in maker's transit case. £5/19/6. Carr. 5/-.

MARCONI CRYSTAL CALIBRATOR. Frequency coverage 170–250 Mc/s. Directly calibrated, accuracy .001%. Operation 200/250 volts A.C. Supplied complete with 5 Mc/s crystal and spare set of 5 valves, in original transit case, brand new with instructions. £4/15/6 each, carr. 10/-.

ACCUMULATORS. Bakelite cased 2 v. 100 ampere, 75 actual. Ex Govt. New and unused. Complete with carrying handle. Ideal for coupling 6 or 12 v. storage batteries. Size 6½in. x 6½in. x 3½in., 15/- each. Carr. 3/6. 3 sent for 50/- or 6 for £5 carr. paid. Ditto, 14 A.H. less handle, 5/6, post 2/-.

CATHODE RAY TUBES. VCR 139A 2½in., 30/-; 3BP1, 3in., 30/-; 5FP7, 5in., 35/-; VCR97, 6in., 20/-. All new and unused. P. & P. 3/- each.

GRAMOPHONE PLAYER AND AMPLIFIER CABINET. Finished in blue rexine. Complete with hinges and handle which are unassembled. New and unused. Overall size 12¾in. x 19½in. x 7½in. SPECIAL PRICE 32/6. P. & P. 3/6.

TRANSFORMERS

RCA OUTPUT TRANSFORMERS. 20 watts, for 5, 7.5, 15 and 500-600 ohms impedance. Primary for a pair of 6L6's in push-pull. (Connection details supplied.) This specially designed first-quality output transformer is the best that money can buy! **OUR PRICE** 27/6 each. P. & P. 2/-.

L.T. TRANSFORMERS. Pri. 200–250 v. 50 cycles A.C., Sec. 17.5 v. at 35 amps. £4/15/-, carr. 10/-.

TRANSFORMER (FERRANTI). Potted for 0–250 v. 50 cycles tapped primary, sec. 1,250 v., 15 mA. Ideal for oscilloscopes, etc. Size 3¾ x 3¾ x 4½in. ONLY 35/-. P. & P. 2/6.

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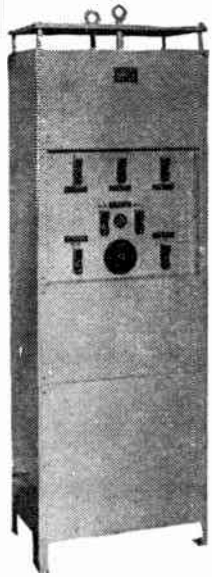

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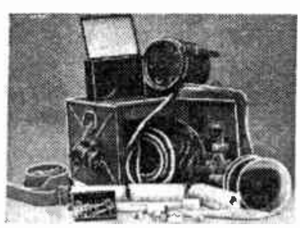

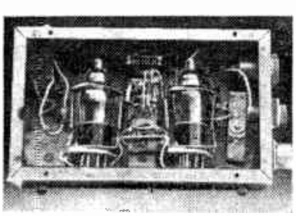

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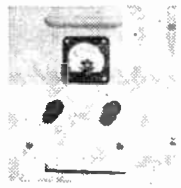

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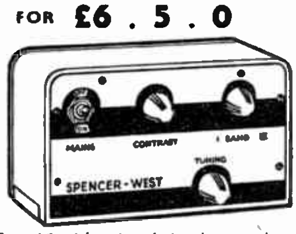

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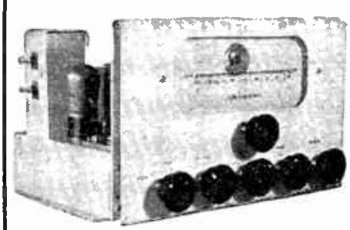

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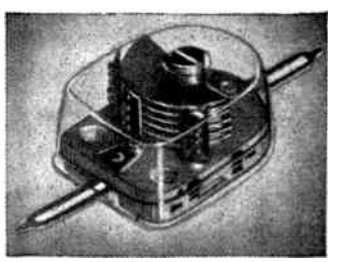

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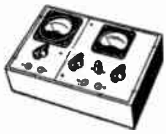

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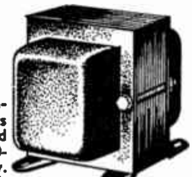

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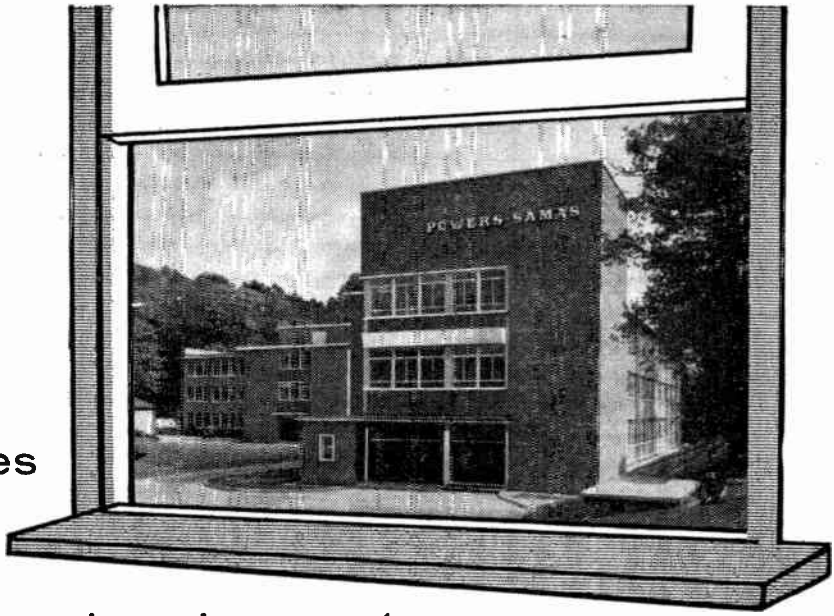

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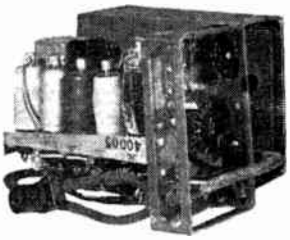

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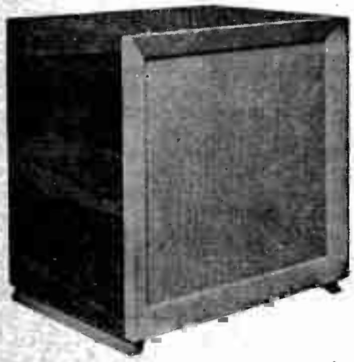

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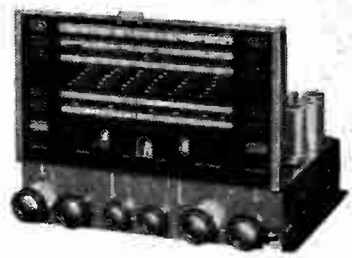

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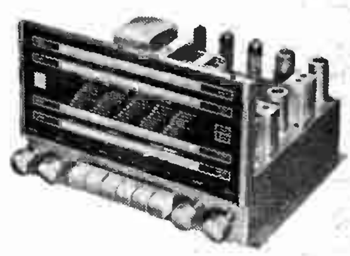

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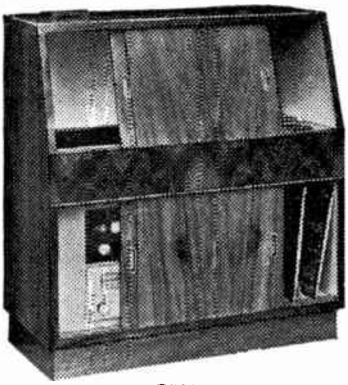

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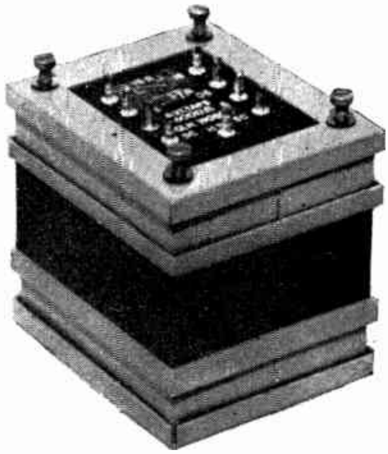

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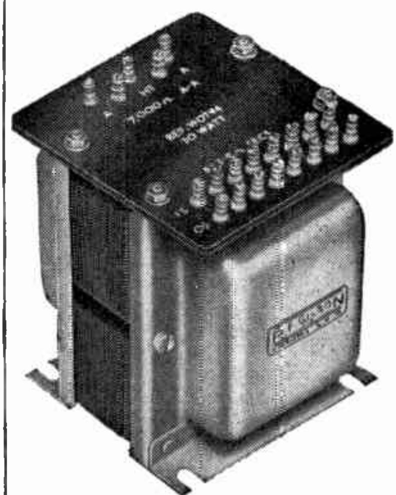

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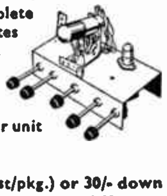

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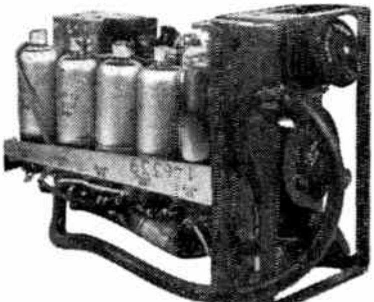

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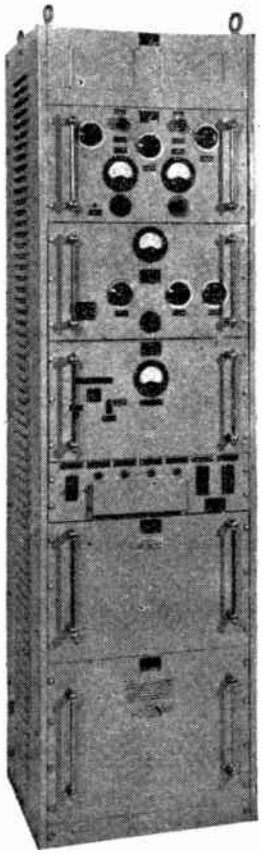

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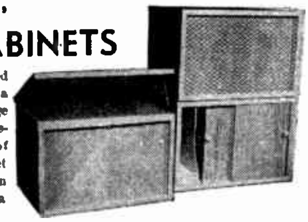

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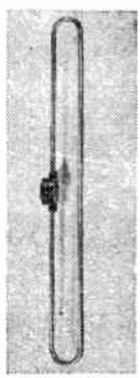

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INDEX TO ADVERTISERS

Page
A.A. Tools 156
Acoustical Mfg. Co., Ltd. 51
Adcola Products, Ltd. 52
A.D.S. Relays, Ltd. 128
Advance Components, Ltd. 19, 41
Airmec, Ltd. 6
Alpha Radio Supply Co., The 136, 137
Altobass, Ltd. 89
Amphenol, Ltd. 121
Amplex Appliances (Kent), Ltd. 173
Andec, Ltd. 90
Anders Electronics, Ltd. 50
Anglin, John 155
Antex, Ltd. 81
Antiference, Ltd. 37
Appointments Vacant 157, 158, 159, 160, 161, 172, 173
Arcolectric Switches, Ltd. 64
Ariel Pressings, Ltd. 53
Armstrong Wireless & Television Co. Ltd. 54, 165
Aspden, W. 172
Aviation Traders, Ltd. 171
Avinash & Co. 157
Avo, Ltd. 1

B. & K. Laboratories, Ltd. 67, 73
Beamish, V. W. 152
Belling & Lee, Ltd. 101
Benson, W. A. 168
Berry's (Short Wave), Ltd. 84
Bird, S. S. & Sons, Ltd. 25
Birmingham Sound Reproducers, Ltd. 96
Blickvac Eng., Ltd. 116
Bradmatic, Ltd. 166
Britain, Chas. (Radio), Ltd. 124, 125
British Institute of Engineering Technology 154, 170
British Insulated Callender's Cables, Ltd Cover ii
British National Radio School 116
British Thomson-Houston Co., Ltd. 128
Brookes Crystals, Ltd. 84
Bulgin, A. F., & Co., Ltd. Edit. 49
Bull, J. & Sons 112

C. & G. Kits 120
Candler System Co. 150
Capitol Radio Engineering Institute 65
Carr Fastener Co., Ltd. 21
Cementation (Muffelite), Ltd. 20
Champion Products 154
Chapman, C. T. (Reproducers), Ltd. 126
Cinema Television, Ltd. 5, 75, 173
City Sale & Exchange, Ltd. 48
Clyne Radio, Ltd. 130, 131
Cosmocord, Ltd. 100
Cossor Instruments, Ltd. 108
Coventry Radio 168

Daly (Condensers), Ltd. 42
Davies, A., & Co. 157
Davis, Jack (Relays), Ltd. 92
Denco (Clacton), Ltd. 56
Dependable Relay Co. 153
Direct T.V. Replacements 119
Dixon, L., & Co. 154
Duke & Co. 129
Dulci Co., Ltd., The 53, 72
Duode Natural Reproducers 166
Dynatron Radio, Ltd. 73, 119

Eddy's (N'tham), Ltd. 142
Egen Electric, Ltd. 46
E.I.R. Instruments, Ltd. 168
Electro-Acoustic Developments 154
Electro-Acoustic Industries, Ltd. 15
Electro-Methods, Ltd. 26
Electronic Precision Equipment 114, 115
Electronic Tubes, Ltd. 28
Electro-Winds, Ltd. 120
E.M.I. Electronics, Ltd. 103, 160
E.M.I. Institutes 102, 110, 157, 160, 168
English Electric Co., Ltd. 161
English Electric Valve Co., Ltd. 16A
English Electric Valve Co., Ltd. 59
Enthoven Solders, Ltd. 63
Eta Tool Co. (Leicester), Ltd. 80
E.V., Ltd. 83

Felgate Radio, Ltd. 152
Ferranti, Ltd. 45, 160, 161
Fibreform, Ltd. 119
Filmer, J. T. 166
Finsbury Trading Co. 169
Foyle, W. & G., Ltd. 120
Fringevision, Ltd. 173
Frith Radiocraft, Ltd. 152

Garrard Eng. & Mfg. Co., Ltd., The 23
Gee Bros., Radio, Ltd 151
General Electric Co., Ltd. 36, 47
Gilfillan R., & Co., Ltd. 156
Gilson, R F., Ltd. 167
Gladstone Radio 156
Glaser, L. & Co. 150
Goldring Manufacturing (Gt. Britain), Ltd 34
Goodmans Industries, Ltd. 116
Govt H.Q., Cheltenham 158
Grampian Reproducers, Ltd. 82
Gray, Arthur, Ltd. 142
Grayshaw Instruments 138
Grundig (Gt. Britain), Ltd. 12

Page
Hall Electric, Ltd. 87
Hanney, L. F. 154
Harding Electronics 152
Harris Electronics (London), Ltd. 122, 123
Harris, P. 164
Hatter & Davis, Ltd. 172
Henley's, W. T. Telegraph Works Co., Ltd. 164
Henry's (Radio), Ltd. 149
Hivac, Ltd. 16D
Hivac, Ltd. 62
Home Radio Ltd. 152
H.P. Radio Services, Ltd. 80
Hunton, Ltd. 82

Iliffe & Sons, Ltd. 49
Imhof, Alfred, Ltd. 7
Industrial Electronics 80
Instrument Electrical Co. 157
International Correspondence Schools 122

Jason Motor & Electronic Co. 150
Jeffery Transformer Co. 173
Jones, J. A. 152

Kenroy, Ltd. 166
Keyswitch Co., The 88

Lasky's Radio, Ltd. 139, 140, 141
Leak, H. J., & Co., Ltd. 111
Leevers-Rich Equipment, Ltd. 54
Lewis Radio Co. 90
Light Soldering Developments, Ltd. 173
Linear Products Ltd. 50
Lionnet, J., & Co. 165
Lockwood & Co. (Woodworkers), Ltd. 170
London Central Radio Stores 166
Long Playing Record Library 85
L. R. Supply Co. Ltd. 112
Lyons Radio, Ltd 166

McMurdo Instruments Co., Ltd. 66, 86, 88, 91
Magnetic Devices, Ltd. 69
Mail Order Supply Co. 86
Marconi Instruments, Ltd. 16B
Marconi Instruments, Ltd. 22, 157, 158, 160
Marconi's Wireless Telegraph Co., Ltd. 39, 105
Martin, J. H. 160
Mayco Electric Co. 150
Measuring Instruments (Pullin), Ltd. 74
Mercia Enterprises, Ltd. 84
Midland Instrument Co. 150
Mills, W. 155
Ministry of Transport 160
Modern Book Co. 168
Modern Electrics, Ltd 68
Modern Techniques 122
M.O. Valve Co., Ltd. 160
M R Supplies, Ltd. 78
Mullard, Ltd. 48A
Mullard, Ltd. 3, 31, 35, 38, 55, 98
Multicore Solders, Ltd. Cover iv
Multitone Electric Co., Ltd. 13, 160

Nagard, Ltd. 60
N.A.R Agencies, Ltd. 173
National Plastics (Sales), Ltd. 78
Newmarket Transistors, Ltd. 79
Newnes, George, Ltd. 32A, 32B
Northern Radio Services 16

Oddie Bradbury & Cull, Ltd. 170
Osmor Radio Products, Ltd. 120
Oxley Developments Co. 155

Painton & Co., Ltd. 43
Palmer, G. A. Stanley, Ltd. 118
Partridge Transformers, Ltd. 163
P.C.A Radio Ltd. 92
P.C.D., Ltd. 46
P.C. Radio 92
Pearce, T W. 154
Pearson M. & J. 155
Philips Electrical, Ltd. 48
Phillips & Bonson, Ltd. 29
Pitman, Sir Isaac, & Son, Ltd. 154
Planet Instrument Co. 152
Plessey Co., Ltd., The 104
Post Radio Supplies 172, 173
Power Controls, Ltd. 33
Powers-Samas Accounting Machines, Ltd. 159
Premier Radio Co 93, 94, 95
Preston A., & Sons 153
Proops Bros., Ltd. 146, 147
Pye, Ltd. 14
Pye Telecommunications, Ltd. 11, 66

Page
Quality Mart 120
Quartz Crystal Co., Ltd. 170

Racal Engineering, Ltd. 71
Radio & T.V. Components (Acton), Ltd. 128
Radio Component Specialists 148
Radio Corporation of America 117
Radio Exchange Co., The 156
Radio Resistor, Ltd. 52
Radio Servicing Co. 85
Radiospares, Ltd. 82
Radio Supply Co. (Leeds), Ltd. 132, 133
Radio Telephone Aerial Systems, Ltd. 70
Radio Traders, Ltd. 138
RCA, Great Britain, Ltd. 76
Relda Radio, Ltd. 127
Rogers Development (Electronics), Ltd. 70
Rola-Celestion, Ltd. 32
Rollet, H., & Co., Ltd. 170
Runbaken, Ltd. 126

Salford Electrical Instruments, Ltd. 10
Samsons Surplus Stores 153
Savage Transformers, Ltd. 171
Semiconductors, Ltd. 77
Service Trading Co. 113
Servo-Electronics 156
Sherwood Instruments 152
Siemens & Halske 4
Siemens Edison-Swan, Ltd. 107
Simmonds, L. E., Ltd. 58
Smith, G. W. (Radio), Ltd. 134, 135
Smith, H. L., & Co., Ltd. 169
Smith, W. H., & Son, Ltd. 78
Solartron Electronic Group, Ltd. 2
Sonomag, Ltd. 153
Southern Radio Supply, Ltd. 164
Southern Technical Supplies 157
Sowter, E. A. 172
Specialised Electrical Components 158
Specialist Switches 118
Specto, Ltd. 74
Spencer-West, Ltd. 154
Staar Electronics, Ltd. 44
Stamford, A. L. 167
Standard Telephones & Cables, Ltd. 48C
Standard Telephone & Cables, Ltd 99, 106
Stern Radio, Ltd. 143, 144, 145
Stewart Transformers, Ltd. 112
Sugden, A. R., & Co. (Engineers), Ltd. 48D
Sugden, A. R., & Co. (Engineers), Ltd. 42
Sutton Coldfield Electrical Engineers 138

Tannoy Products, Ltd. 60
Taylor Tunnicliff (Refractories), Ltd. 9
Technical Ceramics, Ltd. 40
Technical Trading Co. 121
Tektronix Inc. 30
Telefusion Eng., Ltd. 64
Telegraph Condenser Co., Ltd. Cover iii
Telegraph Construction & Maintenance, Co., Ltd. 8
Tele-Radio (1943), Ltd. 68, 152
Telctron Co., The 150
Test Equipment Repair 126
Thomas, Richard & Baldwins, Ltd. 16C
Thorn Electrical Industries, Ltd. 24
Trianon-Electric, Ltd. 88
Trix Electrical Co., Ltd. Edit. 47
T.R.S. Radio 142
Tutor Tape Co. 90

Universal Book Co. 157
Universal Electronics 72

Valradio, Ltd. 86
Verdik Sales, Ltd. 170
V.E.S. Wholesale Services, Ltd. 173
Vitavox, Ltd. 17
Vortexion, Ltd. 109
V.Z Electrical Service 154

Walmore Electronics, Ltd. 118
Watt, Radio 124
Watts, Cecil E. 168
Wayne Kerr Laboratories, Ltd., The 27, 161
Webber, R. A., Ltd. 124
Westwood, L. 124
Weymouth Radio Mfg. Co., Ltd. The 93
Wharfedale Wireless Works 58
White, S. S., Co. of Great Britain, Ltd., The 62, 91
Whiteley Electrical Radio Co., Ltd 57
Wilkinson, L. (Croydon), Ltd. 126
Wilson, Ronald, & Co. 157
Woden Transformers Co., Ltd. 18
Wright & Weaire, Ltd. 61

Young, C. H. 121

Z. & I. Aero Services, Ltd. 162

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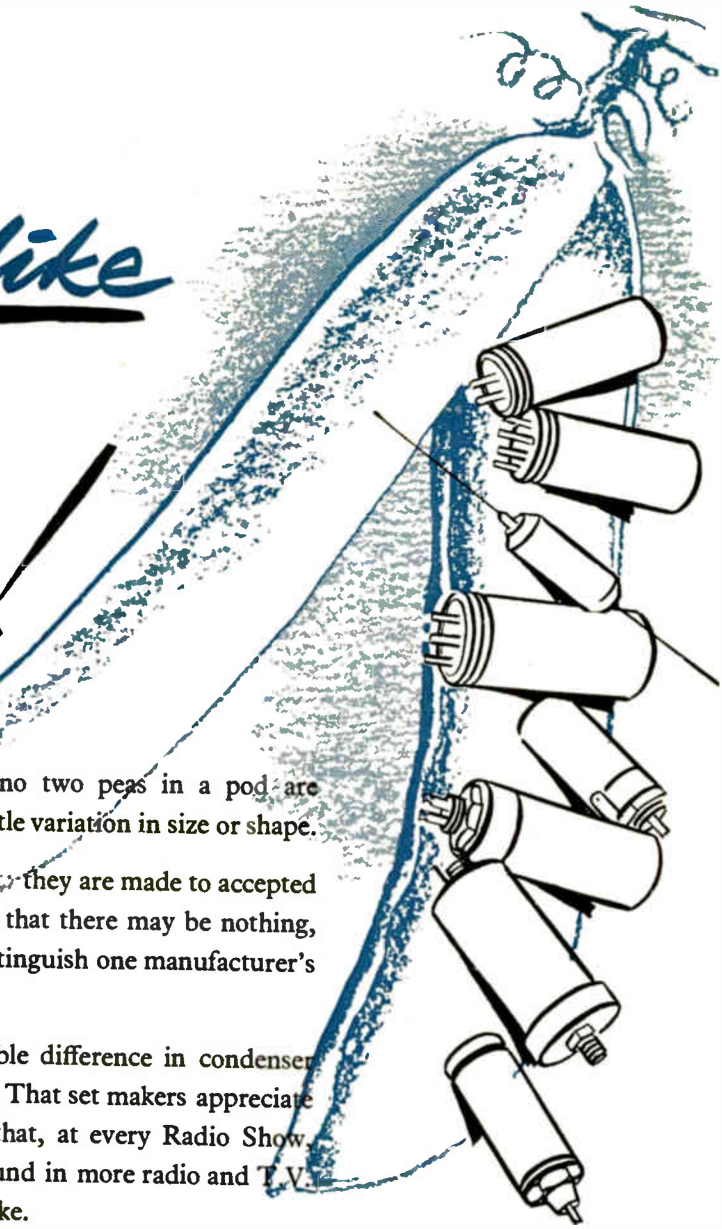

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