Electronic Engineering

SEPTEMBER 1951

TWO SHILLINGS

CLASSIFIED ANNOUNCEMENTS

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OFFICIAL APPOINTMENTS

ADMIRALTY. Vacancies exist for Electrical and/or Mechanical Engineering Draughtsmen in Admiralty Research and Development Establishments located in the vicinity of Weymouth, Portsmouth, Teddington (Middlesex), and Baldock, Herts. Draughtsmen experienced in light current, electro-mechanical, precision mechanical and electronic equipment are particularly needed. Candidates must be British subjects of 21 years of age and upwards, who have had practical workshop experience (preferably an apprenticeship) together with Drawing Office experience. Appointments will be in an unestablished capacity but opportunities may occur for qualified staff to compete for established posts. The salaries offered, depending on age, experience, ability and place of duty, will be within the range £320—£560 p.a. Hostel accommodation is available at some Establishments. Applications stating age and details of technical qualifications, apprenticeship (or equivalents), Workshop and Drawing Office experience, should be sent to Admiralty (C.E.II, Room 88) Empire Hotel, Bath, quoting DM/R.D. Original testimonials should not be forwarded with application. Candidates required for interview (at London or Bath, whichever is nearer) will be advised within two weeks of receipt of application. W 2984

ADMIRALTY. Applications are invited from Engineering, Electrical and Ship Draughtsmen for temporary service in Admiralty Departments at Bath. Candidates must be British subjects of 21 years of age and upwards, who have had practical Workshop and Drawing Office experience. Salary will be assessed according to age, qualifications and experience within the range £320-£545 per annum. Applications giving age and details of technical qualifications, apprenticeship (or equivalents) Workshop and Drawing Office experience, should be sent to Admiralty (C.E.II, Room 88), Empire Hotel, Bath. Candidates required for interview will be advised within two weeks of receipt of application. W 137

APPLICATIONS are invited by the Ministry of Supply for the following unestablished appointments at the Royal Aircraft Establishment, Farnborough, Hants.:- Physicists or Mathematical Physicists. (1) Principal Scientific Officer. Candidates should have experience of Radar systems analysis and war-time operational research. A strong mathematical bias is desirable. Ref. A 133/51A/BE. (2) Senior Scientific Officer, for theoretical investigations. A knowledge of statistical methods is desirable. Ref. A 134/51A/BE. Aeronautical Engineer. (3) Senior Scientific Officer, with experience in planning and analysis of Flight trials and application of results to project design. A knowledge of servo mechanism theory and practice is required, experience of liaison with industrial firms an advantage. Ref. C 217/51A/BE. Physicists, Mathematicians or Engineers. (4) Senior Scientific Officer, with research experience involving arithmetical applications of mathematics in the analysis of physical data, and the formulation of problems for solution by automatic computing machinery. A knowledge of aerodynamics an advantage. Ref. A 135/51A/BE. (5) Senior Scientific Officer with wide experience of methods of measurement in physics or engineering research, experience and up-to-date knowledge of electronics. Ref. A 136/51A/BE. Candidates should have a first or second class Honours Degree in the appropriate subject and at least 3 years post-graduate research experience is necessary. For the P.S.O. post candidates must be at least 31 years of age, for the S.S.O. post at least 26 years. Salary will be determined on age and on an assessment of the successful candidates' qualifications and experience within the ranges :- Principal Scientific Officer—£960-£1,295. Senior Scientific Officer—£720-£910. Rates for women somewhat lower. Posts carry benefits of F.S.S.U. Application forms obtainable from Technical and Scientific Register (K), York House, Kingsway, W.C.2, quoting appropriate reference number. Closing date 22nd September 1951. W 2067

ASSISTANT (SCIENTIFIC) CLASS : The Civil Service Commissioners give notice that an Open Competition for pensionable appointment to the basic grade will be held during 1951. Interviews will be held throughout the year, but a closing date for the receipt of applications earlier than December, 1951, may eventually be announced either for the competition as a whole or in one or more subjects. Successful candidates may expect early appointments. Candidates must be at least 17½ and under 26 years of age on 1st January 1951, with extension for regular service in H.M. Forces, but other candidates over 26 with specialized experience may be admitted. All candidates must produce evidence of having reached a prescribed standard of education, particularly in a science subject and of thorough experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces, covering a minimum of two years in one of the following groups of scientific subjects:- (i) Engineering and Physical sciences. (ii) Chemistry, bio-chemistry and metallurgy. (iii) Biological Sciences. (iv) General (including geology, meteorology, general work ranging over two or more groups (i) and (iii) and highly skilled work in laboratory crafts such as glass-blowing). Salary according to age up to 25—Men £215 (at 18) to £330 (at 25)—£455; rather less in the provinces and for women. Opportunities for promotion. Further particulars and application forms from Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S 59/51. Completed application forms should be returned as soon as possible. W 2053

B.B.C. invites applications for post of Engineer, Planning and Installation Department, London. Good basic knowledge of electrical engineering and some knowledge of television are essential. University Degree is desirable though not essential. Preference to applicants with practical experience of cinematographic equipment used for sound and picture recording. Work is chiefly concerned with use of films for television purposes and duties will include assisting in preparation of specifications for supply and manufacture of television equipment, supervision of installation, acceptance trials at works and conduct of relevant correspondence. Salary £745 (possibly higher if qualifications exceptional) with 5 annual increments to maximum £965. Applications, stating age, qualifications and experience to reach Engineering Establishment Officer, Broadcasting House, London, W.1, within 7 days. W 2092

CROWN AGENTS FOR THE COLONIES. Assistant Engineer (Electronics) required for the London Office. Salary scale £475 a year rising to £750 a year. The £475 minimum is linked to entry age at 25, with the addition of £25 a year for each year above that age up to £600. Extra duty allowance of 8 per cent of annual salary also payable at present. Engagement will be on unestablished terms with a prospect, after satisfactory service and as vacancies occur of appointment to the established and pensionable staff and of promotion to a higher grade. Duties consist of the purchase of all types of telecommunications, broadcasting and public address equipment and advising Colonial Administrations on problems connected therewith. Candidates should be capable of preparing specifications in sufficient detail to enable tenders to be called for an adjudicated thereon when received. They should be between 25 and 35 years of age and preferably have a Degree in electrical engineering (telecommunications and electronics) or be corporate members of the Institution of Electrical Engineers or have equivalent qualification. Apply at once by letter stating age, full names in block letters and full particulars of qualifications and experience and mentioning this paper to the Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.28834.B on both letter and envelope. The Crown Agents cannot undertake to acknowledge all applications and will communicate only with applicants selected for further consideration. W 2097

ELECTRICAL ENGINEERS and Physicists are invited by the Ministry of Supply to apply for unestablished appointments in the grade of Senior Scientific Officer at the Royal Aircraft Establishment, Farnborough, Hants. Candidates should be at least 26 years of age and have a 1st or 2nd class Honours Degree in the appropriate subject and at least 3 years post-graduate research experience. They should also have a wide knowledge of communications work and H.F., V.H.F. or display techniques for research work associated with design and development of airborne and ground equipments. Salary will be determined on age and on an assessment of the successful candidate's qualifications and experience within the S.S.O. range £720-£910. Rates for women somewhat lower. Posts carry benefits of F.S.S.U. Application forms obtainable from Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, W.C.2, quoting D 159/51—A. Closing date 22nd September 1951. W 2065

ELECTRONIC ENGINEERS are invited to apply for appointments in the Ministry of Supply to work near London or at provincial stations on the development and design of electrically operated systems for a variety of applications including weapons, telecommunications and radar equipment. The responsibilities of the posts will vary according to the age, qualifications and experience of the selected candidates, and acceptable qualifications range from 1st or 2nd Class Honours Degree in physics or light electrical engineering or equivalent qualifications, Corporate Membership of the Institution of Electrical Engineers to Higher School Certificate, Higher National Certificate, etc. Grade and entering salary will be determined after interview on ranges up to approximately £1,000 a year. Some posts carry F.S.S.U. benefits, but all are unestablished. Application forms obtainable from M.L.N.S., Technical and Scientific Register (K), York House, Kingsway, W.C.2, quoting D 134/51A. Closing date 24th September, 1951. W 2089

ENGINEERS I required by Ministry of Supply establishment at Sevenoaks, Kent. Qualifications: British, of British parentage; engineering apprenticeship, corporate membership of Inst. of Civil, Mech., or Elec. Engrs. or exempting qualifications. Experience appropriate to one of the following: Duties: (1) Ref. (C461/51-A) Development of optical instruments (including optical processing) and of drives for Ultra high speed cameras. (2) Ref. D343-4/51-A. Development of radio communications and monitoring equipment. Planning systems. Salary range: £997-£1,192 p.a. Not established, periodical competitions for establishment. Application forms from Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, W.C.2, quoting appropriate reference number. Closing date, 14th September 1951. W 2074

MINISTRY OF SUPPLY requires Electronic Engineers for establishments in S. England. Duties include design of radio and/or radar components, equipment and installations (including aerials) and engineering of prototypes for production. Candidates must be British of British parentage, and should be normally either corporate members of one of the Institutions of Civil, Mechanical or Electrical Engineers, or have qualified for exemption from Sections A and B of the Assoc. Membership examinations, or hold equivalent qualifications. Salary according to age, qualifications and experience in the range £448 (may be slightly less below the age 25)-£1,192. The appointments will be unestablished, but opportunities to compete for establishment occur periodically. Write for application form, to Ministry of Labour and National Service, Technical and Scientific Register (K Section), York House, Kingsway, W.C.2, quoting reference (D.359/51A). Closing date 17th September 1951. W 2090

MINISTRY OF SUPPLY requires Instrument and Radio Production Engineers in London. Candidates should have extensive knowledge of the following:- Airborne radio equipment, radio navigational aids, test and measuring equipment, lightweight and miniaturised electronic airborne equipment (a knowledge of moulding technique would be an advantage), quartz crystals, engine flight and navigational instruments, gyroscopic instruments, electric lamps. Duties will be connected with the planning and

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progressing of production of these equipments. Candidates must be British of British parents, should be normally either corporate members of one of the Institutions of Civil, Mechanical or Electrical Engineers, or have qualified for exemption from Sections A and B of the Associate Membership examinations, or hold equivalent qualifications. Salary according to age, qualifications and experience in the range of £475 (at age 25—slightly less below age 25)-£1,000 p.a. The appointments will be unestablished, but opportunities to compete for establishment occur periodically. Write for application form to Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting reference (D338/51-A). Closing date 14th September 1951. W 2072

MINISTRY OF SUPPLY requires Technical Grades I, II and III on Electronic Work in London and S. England. Candidates must be British of British parentage, have served a recognised engineering apprenticeship or have had equivalent training, preferably hold an Ordinary or Higher National Certificate or equivalent and have experience of electronic equipment in one of the following fields: (a) Documentation—preparation of schedules, instruction books, parts lists, etc., examination of sources of supply, specifications, etc., for contact action. (b) Maintenance and Test—assembly, fault finding, maintenance, repairs, calibration, performance tests including climatic and vibration effects. Salaries according to age, qualifications, location and experience up to £825 p.a. Write for application form to Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, W.C.2, quoting reference (D345/51-A). Closing date 14th September, 1951. W 2075

PHYSICISTS and Mathematicians are invited by the Ministry of Supply to apply for the following unestablished appointments in the Scientific Officer Class at an Experimental Establishment in Essex for work connected with out-of-door instrumentation. Senior Scientific Officer (1) Physicists with some mathematical knowledge including statistics or a statastician with some interest in experimental procedure to be in charge of a team investigating the performance of weapons. Scientific Officers (1) Physicists, preferably with some knowledge of experimental range techniques and procedure. For some posts a knowledge of electronics is required. (2) Experimental physicist with experience of metallurgical techniques. (3) Mathematician with interest in experimental methods and some knowledge of hydrodynamics. Candidates must possess a 1st or 2nd class Honours Degree in appropriate subject, or equivalent qualification. For the senior grade candidates should be at least 26 years of age with a minimum of three years post-graduate research experience. Salary will be determined on age and on an assessment of the successful candidates qualifications and experience within the ranges: Senior Scientific Officer £720-£910. Scientific Officer £380-£620. Rates for women somewhat lower. Post carry benefits of F.S.S.U. Application forms obtainable from Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, W.C.2, quoting A.220/51/A. Closing date 24th September, 1951. W 2073

PROFESSIONAL ENGINEERS in Government Departments. The Civil Service Commissioners announce an Open Competition to be held during 1951, for permanent appointments in many Departments of the Civil Service for a wide variety of engineering duties. Applications will be accepted at any time but not later than 31st December, 1951, and selected candidates will be interviewed as soon as possible after the receipt of their Application Forms. Candidates are advised to apply as early as possible. Age Limits: Candidates must be under 35 on 30th November, 1951, with extension for regular service in H.M. Forces and for established Civil Service. For appointments in the Post Office they must be 21 or over, in the Ministry of Supply, 23, and in all other Departments 25 or over on that date. Minimum qualifications vary for different posts. Generally a University Degree in Engineering or Corporate Membership of the Institutions of Mechanical Engineers, Electrical Engineers or Civil Engineers, or passes in or exemption from Sections A and B of the corresponding Associate Membership examinations, or evidence of exceptionally high professional attainment are required. For certain posts, Corporate Membership of the Institute of Fuel by examination or the Institution of Chemical Engineers, or Graduate Membership of the Institution of Chemical Engineers or Associate Fellowship of the Royal Aeronautical Society or an Honours Degree in Physics will be accepted instead. The salary on appointment will be fixed according to age. The salary for men aged 26, in London, is £500, rising by annual increments of £25 to £750. Salaries for women and for posts outside London are lower. There are prospects of promotion to higher grades on scales for men in London of £750-£1,000, £1,050-£1,270, and above. These rates are at present under review. Further particulars and application forms from the Secretary, Civil Service Commission, Trinidad House, Old Burlington Street, London, W.1, quoting No. S85/51. W 2056

PROFESSIONAL ENGINEERS in Government Departments. The Civil Service Commissioners announce an Open Competition for permanent appointments of Professional Engineers, General Service Class (Main and Senior grades). The vacancies at present announced are in the Admiralty (about 8 in the Main Grade and at least one in the Senior Grade), and one (Main Grade) in the Prison Commission. The duties in the Admiralty cover the production of mechanical, electrical and electronic equipment for H.M. ships and include design for production, correlation of manufacturing requirements and capacity, advice on production methods, preparation of estimates and, in certain cases, material inspection and functional testing. The post in the Prison Commission calls for practical, rather than academic interests with experience mainly on mechanical, heating, ventilating, hot water and steam engineering, but a good working knowledge of electrical engineering, is also required. Candidates must be at least 30 years of age on 1st January, 1951. Minimum Qualifications. Generally Corporate Membership of the Institutions of Mechanical Engineers or Electrical Engineers or (for the Prison Commission post) of the Institution of Civil Engineers is required together with evidence of apprenticeship or pupilage and subsequent engineering experience. Exceptionally, candidates of high professional attainments without some or all of these qualifications may be admitted. Salary scales: London—Men. Main Grade, £750-£1,000; Senior Grade, £1,050-£1,270. Women. Main Grade, £650-£850; Senior Grade, £900-£1,100. Provinces—Men. Main Grade, £720-£960; Senior Grade, £997-£1,192. Women. Main Grade, £620-£810; Senior Grade, £860-£1,040. These rates are at present under review. Further particulars and application forms from Secretary, Civil Service Commission, Trinidad House, Old Burlington Street, London, W.1, quoting No S86/51. Applications will be accepted at any time, but not later than 1st October, 1951, and selected candidates will be interviewed as soon as possible after receipt of their application forms. Candidates are advised to apply as early as possible. W 2094

TELECOMMUNICATIONS ENGINEERS and Physicists are invited by the Ministry of Supply to apply for unestablished appointments in the grade of Principal Scientific Officer or Senior Scientific Officer at the Royal Aircraft Establishment, Farnborough, Hants. Candidates should have a 1st or 2nd class Honours Degree in physics or telecommunications and upwards of 5 years' experience of research and development in one of the following: R.F. techniques at centimetric wavelengths: centimetric radar, preferably for airborne application; servo systems or telecommunication networks and feedback amplifiers. For the P.S.O grade candidates must be at least 31 years of age and for the S.S.O. grade at least 26. Salary will be determined on age and on an assessment of the successful candidate's qualifications and experience within the ranges: Principal Scientific Officer £960-£1,295. Senior Scientific Officer £720-£910. Rates for women somewhat lower. Post carry benefits of F.S.S.U. Application forms obtainable from Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, W.C.2 quoting D 158/51A. Closing date 22nd September, 1951. W 2066

MECHANICAL ENGINEER, Internal Degree (or equivalent), workshop training, experienced in Applied Physics. Candidates should apply in writing, giving full details, to Consultant engineer, Ilford Limited, Romford Essex. W.2059

SITUATIONS VACANT

A HOUSE (married accommodation) is available for Senior Electronics or Radar Engineers required to organise a ground radar system including development of certain control and monitering and supervisory circuits and displays. Special circuit engineers already available. Location in special laboratory for important defence project within 30 miles of London. Salary up to £1,200 per annum for suitable candidate. Apply quoting ref. DEF to Box No. W 2007.

A LARGE ORGANISATION of international repute invites applications from Engineers and Scientists wishing to take up commercial work in the professional electronic field. For one such vacancy, at managerial level, candidates should be between the ages of 35 and 45, and now earning not less than £1,500 p.a. Vacancies also exist for less experienced men aged about 30 with qualities likely to fit them for promotion to senior executive and managerial appointments. All candidates must have:- 1. An Engineering or Science degree. 2. Technical experience, preferably in the electronic engineering or scientific field. 3. General education and personal qualities suited for commercial work. Successful candidates will have time to familiarise themselves with the Company's products, organisation and practices. They will probably be based in the London area with occasional overseas travel and the possibility, if desired of transfer to an Associated Company in the British Commonwealth. Good prospects in various branches of an expanding business. Salary according to experience. Applications will be treated as confidential and must include age, salary required, qualifications and chronological statement of experience and appointments held. Write to Box No. W 2006.

ALL GRADES of draughtsman are required at Chelmsford and in West London by Marconi's Wireless Telegraph Co. These are permanent positions on the design and development of radio and radar equipment. Applicants should write, giving full details, and quoting ref 142E to Central Personnel Services, English Electric Co. Ltd., 24-30 Gillingham Street, Westminster, S.W.1. W 2008

AMBASSADOR RADIO and Television require Assistant Development Engineers for electronic projects. Applicants should submit details of qualifications and experience addressed to Chief Engineer, Princess Works, Brighouse, Yorkshire. W 2088

A **NUMBER** of Senior and Junior vacancies for Radio, Radar, Electronic, Television, etc., Development, Service Engineers, Draughtsmen Wiremen, Testers, Inspectors, etc. Urgently required. 30 Television Service Engineers. Write in confidence: Technical Employment Agency, 179 Clapham Road, London, S.W.9. (BRIxton 3487.) W 113

ASSISTANTS of various grades for Research and Development work on Computers required by a large N. Kent Engineering firm. Qualifications: B.Sc., Higher National Certificate, Intermediate B.Sc. or equivalent. Salaries according to qualifications and experience. Write giving full particulars to Box No. W 2939.

A VACANCY exists in the Electronics Section of the Research Department for an Electronics Engineer, preferably with a Degree in mathematics, for the design of equipment for

CLASSIFIED ANNOUNCEMENTS
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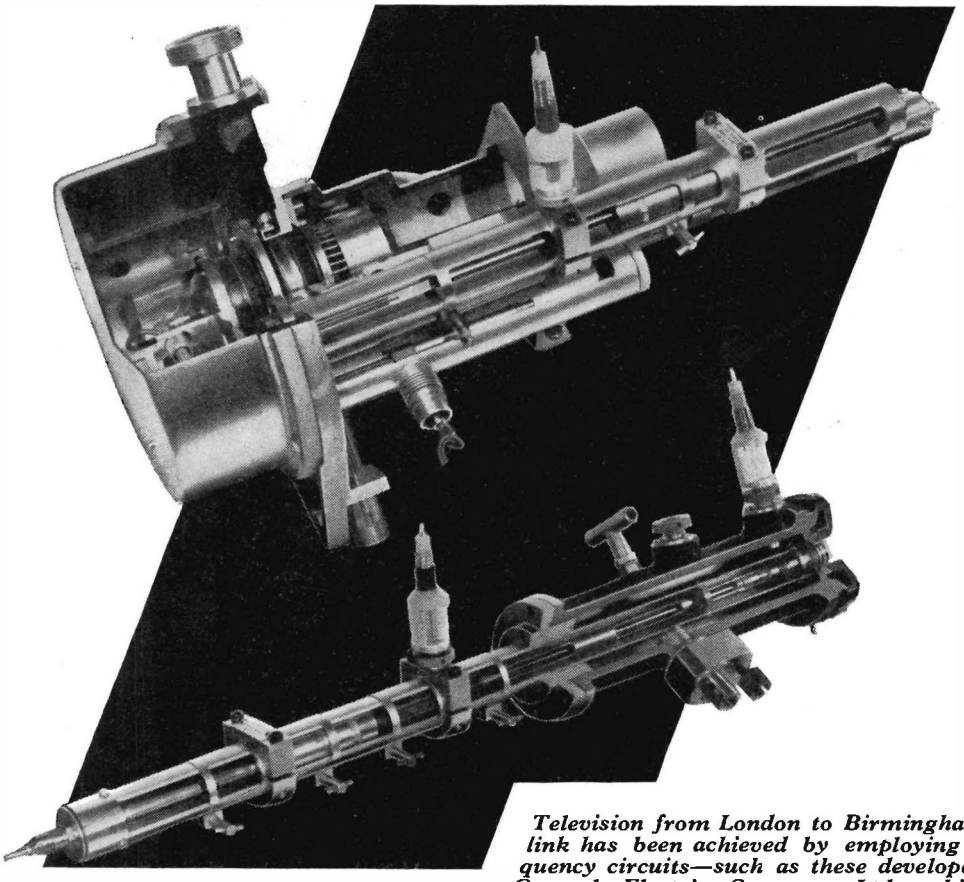
RHODIUM *for contact stability*



Television from London to Birmingham by radio link has been achieved by employing radio-frequency circuits—such as these developed by The General Electric Company, Ltd., which incorporate rhodium plated contact surfaces.

Electrodeposited rhodium, completely non-tarnishing and of great hardness, is an ideal protective finish and sliding contact surface for all radio- and audio-frequency applications. There is little or no loss through skin currents and the high surface finish of the deposit gives smooth operation without electrical noise due to variations in resistance.

One of the Specialised Services of

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The properties and applications of electrodeposited rhodium are fully discussed in data sheet 2053, available on request.

JOHNSON, MATTHEY & CO., LIMITED, HATTON GARDEN, LONDON, E.C.1

Telephone : HOlborn 9277 *Birmingham : Vittoria Street, Birmingham, 1.*

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electronic measurement of physical variables and associated problems. Applications, stating age, qualifications, experience and salary required, should be addressed to the Personnel Officer, Westland Aircraft, Limited, Yeovil, Somerset. W 1338

A VACANCY occurs for a technician of experience, qualified in the calculation and construction of lens and mirrors, for interesting work in optics. Must have a sound knowledge of filters, materials and technique. The position carries a salary of approximately £700 per annum. Degree standard is desirable, though not necessary, to applicants having the correct experience. Apply Box AC 64425. Samson Clarks, 57/61 Mortimer Street, W.1 W 2046

A VACANCY EXISTS for a Senior Wireless Engineer to control a team engaged on research, development and engineering of new low power equipments in the 400-600 megacycle band. Salaries up to £1,200 per annum offered to suitable candidates. Please write giving full details and quoting Ref. HHE to Box No. W 2030.

A WELL KNOWN COMPANY has the following vacancies in its Midland Industrial Electronics Department. 1. Estimator, experienced in estimating for electronic, light, medium and heavy equipment and able to estimate both piece part costs and assemblies. (Ref. 923). 2. Contracts Manager for Sales Section, experience in dealing with contracts, and the co-ordinating and estimating thereof for electronics and electrical equipment. (Ref. 827.) 3. Applications Engineers, experience in R.F. heating equipment. Metallurgy experience an advantage. (Ref. 357.) Please write giving full details and quoting appropriate reference to Box No. W 2084.

A WELL KNOWN COMPANY undertaking interesting radar development work in the London area has vacancies for the following: 1. Senior Electronic Engineer who must be fully experienced in the design of radar equipment. Degree desirable, salary about £800 p.a. (Ref. IBA.) 2. Mechanical Engineer conversant with Naval radar installation and control systems. Degree desirable, salary according to qualifications and experience. (Ref. IBB.) 3. Designer Draughtsmen, H.N.C. desirable, should be capable of working on own initiative and doing all necessary calculations and Draughtsmen with general electronic and/or mechanical experience. Salary according to qualifications and experience. (Ref. AEF.) Applicants should write quoting appropriate reference to Box No. W 2079.

BELLING & LEE LTD., Cambridge Arterial Road, Enfield, Middlesex, require research assistants in connexion with work on electronic components, fuses, interference suppressors and television aerials. Applicants must be graduates of the I.E.E. or possess equivalent qualifications together with similar laboratory experience. Salary will be commensurate with previous experience. Applications must be detailed and concise, and will be treated as confidential. W 138

CHIEF ELECTRONIC ENGINEER possessing electrical engineering degree, required for factory near Stockport. Duties will include design of precision production line test gear, supervision of test gear model shop and staff engaged on mechanical inspection and electronic test. Previous experience in similar post and of Ministry inspection methods desirable. Write in confidence stating age, experience and qualification to Box No. W 2055.

CHIEF OF SALES and Contracts Section required by the North Midland Industrial Electronics Department of a well known company. Commercial experience on contracts, sales statistics and correspondence and handling representatives essential. Experience in heavy or electrical engineering fields desirable. Technical knowledge, whilst an advantage, is not essential. Please write, giving full details, quoting Ref. HBG to Box No. W 2069.

DEVELOPMENT ENGINEER. A large engineering establishment in the N. Kent area requires the service of a Development Engineer with technical and practical experience in electronics. Preferred minimum qualifications the Higher National Certificate in Electrical Engineering. A knowledge of Servo Mechanisms would be an advantage. Reply, stating age and giving full particulars of experience and salary required to Box No. W 2938.

DEVELOPMENT ENGINEER required by Electrical Component Manufacturers situated in N.W. London. Applicants must be experienced in mechanical and electrical engineering, and it is desirable to have experience in model shop or design-development work. Minimum qualification Inter B.Sc., or equivalent. Write giving full details and stating salary required to Box No. W 2078.

DRAUGHTSMEN are invited to make an appointment with E.M.I. Engineering Development, Limited, to discuss the several vacancies available at their Hayes and Feltham branches. All grades of designers and draughtsmen are required for a wide range of engineering products for which their experience may be suited. Details will be sent by post on request, and/or strictly confidential interviews arranged without obligation. Posts available offer a maximum of interest, technical information and experimental facilities, and long term employment prospects with good salary to suitable applicants. Apply, giving fullest details of experience, qualifications, etc., to Personnel Department EB/A, E.M.I. Engineering Development Limited, Hayes, Middlesex. W 2071

E. K. COLE, LIMITED, have vacancies for testers at their Electronics Division. Experience in the testing of Radar, Communications or Electronics equipments to Ministry specifications, essential. Full details in writing to the Personnel Manager, Malmesbury, Wilts. W 2091

E. K. COLE LTD., have vacancies in their Electronic Division at Malmesbury, Wilts., for senior and Intermediate Draughtsmen in the Development Drawing Office, for work on Radar, Communications and Electronic Projects. Previous experience in this field desirable but not essential. Apply in writing to the Personnel Manager, Ekco Works, Malmesbury, Wilts. W 2934

E. K. COLE (Electronics Division) offers excellent opportunities for young Draughtsmen of Ordinary National Standard to gain experience in the Development of Radar, Communications and Nucleonic Equipments. Also a limited number of vacancies for Senior Draughtsmen with experience of this type of work. Apply giving details of experience to Personnel Manager, E. K. Cole Limited, Malmesbury, Wilts. W 2971

ELECTRICAL engineering graduate for the design and supervision of the construction of electronic test equipment. Interesting development work, offering full scope for initiative. Previous electronic design experience essential. Apply quoting Ref. "TE" state age and salary expected and give full details of training, qualifications and experience to the Personnel Officer, Ferranti, Ltd., Ferry Road, Edinburgh. W 2087

ELECTRONIC INSTRUMENT Manufacturers require Development Engineer for pressure pick-ups and electro-mechanical transducers. Candidates should have degree in mechanical or electrical engineering and an interest in both fields. Southern Instruments, Ltd., Fernhill, Hawley, Camberley, Surrey. W 1341

ELECTRONIC ENGINEERS—opportunities in Canada. The Canadian Westinghouse Company invites applications from experienced qualified Electronic Engineers for work on Radar Computors, Ultra Sonic devices (Asdic), Servo mechanisms, Microwave and Fire Control. Assistance will be given for transport to, and location suitable housing in Ontario. Interviews will be arranged in London. Write, giving full particulars as to education, experience and salary required to Box No. W 2080.

ELECTRONIC ENGINEERS required by large firm, S.E. London, for the development of Radio and radar equipment. Applicants should have had 2-3 years previous experience on similar work and qualifications either to degree or H.N.C. standard. The work is of high national importance. Apply, giving full details of previous experience to Box No. W 2042.

ELECTRONIC/ELECTRICAL ENGINEER required with degree in Physics or Telecommunication Engineering, and at least four years experience of Radar. Apply Employment Manager, Vickers-Armstrongs Ltd., (Aircraft Section), Weybridge. W 2942

ELECTRONIC/ELECTRICAL ENGINEERS required with Higher National Cert. (electrical) and at least four years experience of Radar. Apply Employment Manager, Vickers-Armstrongs Ltd., (Aircraft Section), Weybridge. W 2943

ELECTRONIC ENGINEER. Applications are invited for the post of development engineer (West London Area). Experience on Radar, Television or similar pulse techniques would be an advantage, and special consideration will be given to applicants with B.Sc. Degree or H.N.C. Salary would be determined by qualifications and experience. Apply to Chief Engineer Box No. W 2015.

ELECTRO-HYDRAULICS, LIMITED require a Chief Electrical Engineer to be responsible for the design and development of light electrical equipment for aircraft and other purposes. Applicants should have a first or second class Honours Degree, have served an apprenticeship, or had similar practical training and have had some experience of the control of design and development groups. Knowledge of servo systems and aircraft control gear would be an advantage. Apply: Chief Designer, Electro-Hydraulics, Limited, Warrington. W 1342

E.M.I. Engineering Development, Limited, require experienced electronic engineers, including team leaders, for the development and design of radar equipment. Applicants should have sound technical training with a degree or equivalent qualification and several years' experience in this field, a thorough knowledge of microwave technique and ability to originate circuitry is essential. The appointments are for permanent pensionable staff and carry good salary and excellent prospects. Applicants should write quoting ED/34 and give full details to Personnel Department, E.M.I. Engineering Development, Ltd., Hayes, Middlesex. W 2050

ENGINEER for transformer design work, used to small power audio and pulse transformer work, required by prominent aircraft firm in the London area. Highest technical ability and experience of miniaturisation required. Write full details, qualifications, experience, age, salary sought to Box AC 64420, Samson Clarks, 57/61 Mortimer Street, W.1. W 2045

ENGINEERS to initiate and supervise the layout, construction and test of prototypes (to Ministry standards) of special electronic circuits for production. Considerable experience of similar work is essential and familiarity with miniature practice is desirable. Experience of radar circuits and technique would be an advantage. Senior engineers salaries in range £800 per annum and Juniors £600 per annum. Location special laboratory in Bedfordshire. Write, giving full details and quoting ref. 907 to Central Personnel Services, English Electric Co. Ltd., 24-30 Gillingham Street, Westminster, S.W.1. W 2994

ENGINEERING establishment, West London area, require several first-class Project Design Engineers for work of an intricate mechanical and electro-mechanical nature. Only qualified men capable of undertaking complete design of projects, under guidance of Chief Engineer and Chief Design Engineer, will be considered. Experience in either of the following fields will be advantageous: Printing Machinery, Automatic Feeding Apparatus, Teleprinter principles and Electronic Controls. Write in first instance giving full experience and qualifications to Chief Engineer, Box No. W 136.

ENGLISH ELECTRIC require junior and senior engineers for radio, radar, servo-mechanisms and analogue computor design and development. Starting salaries up to £1,200 per annum, according to qualifications and experience. Location, Bedfordshire. Applications, giving full details of qualifications and experience, quoting Ref. S.A.7, should be addressed to Central Personnel Services, English Electric Co Limited, 24-30 Gillingham Street, London, S.W.1. W 2069

EXPERIENCED Electronic Wiremen required immediately for top priority Government Contracts. Excellent wages, working conditions and prospects for the right type of applicant. Apply: Peto Scott Electrical Instruments, Addlestone Road, Weybridge, Surrey. W 2058

EXPERIENCED ESTIMATORS are invited to apply for employment with a large Electro-Mechanical firm in the West Country. A knowledge of this type of work, including radio components, would be a great advantage though not necessarily essential. Good staff conditions operate and the post offers excellent prospects

CLASSIFIED ANNOUNCEMENTS
continued on page 6

of advancement. Full details of experience and qualifications should be sent to Box No. W 2061.

FERRANTI, LIMITED, Moston Works, Manchester, have staff vacancies in connexion with special electronic valve development and manufacture in association with an important Radio Tele-Control project. (1) Senior Valve Engineers to take charge of Research and development work. Qualifications include a good Degree in Physics or Electrical Engineering and extensive experience in charge of development work. Salary according to qualifications and experience in the range of £1,100-£1,600 per annum. Please quote Ref. S.V.E. The company has a Staff Pension Scheme, and will give housing assistance in special cases. Application forms from Mr. R. J. Hebbert, Staff Manager, Ferranti, Limited, Hollinwood, Lancs. W 2044

FERRANTI, LIMITED have vacancies for Engineers with experience or interest in work connected with Electro-Mechanical Gunnery Predictors, Gyroscopic Instruments and Allied Projects. Preference given to holders of degrees or equivalent qualifications, but aptitude and practical ability in light mechanical or electrical engineering is essential. Salary according to age and experience in the range of £350-£650 per annum. The company has a Staff Pension Scheme. Forms of application from Mr. R. J. Hebbert, Staff Manager, Ferranti, Limited, Hollinwood, Lancs. Please quote Ref. E.E.M. W 2049

FERRANTI LTD., Moston Works, Manchester, have staff vacancies in connexion with long term Development Work on an important Radio Tele-Control Project. (1) Senior Engineers or Scientists to take charge of research and development sections. Qualifications include a good degree in Physics or Electrical Engineering and extensive past experience in charge of development work. Salary according to qualifications and experience in the range of £1,000-£1,500 per annum. Please quote reference R.S.E. (II) Engineers and Scientists for research and development work in the following fields: Radar, radio and electronic circuits, micro waves, high power centrimetric valves, vacuum and/or high voltage techniques, servo control and electro-mechanical devices. Qualifications include a good degree in Physics or Electrical Engineering or Mechanical Science, or equivalent qualifications. Previous experience is an advantage but is not essential. Salary according to qualifications and experience in the range £420-£1,000 per annum. Please quote reference R.T.E. (III) Technical Assistants for experimental work in the fields listed in (II) above. Qualifications required: a Degree or Higher National Certificate in Electrical or Mechanical Engineering or equivalent qualifications. Salary in the range of £260-£550, according to age and experience. Please quote reference R.T.A. The Company has a Staff Pension scheme, and will give housing assistance in special cases. Application forms from Mr. R. J. Hebbert, Staff Manager, Ferranti Limited, Hollinwood, Lancs. W 2970

JUNIOR ENGINEERS to assist in the design, construction and test of laboratory models of special electronic circuits, with several years experience of similar work. A knowledge of radar circuit designs and operations would be an advantage. Salary in the range of £600 per annum. Location, special laboratory in Bedfordshire. Please write giving full details and quoting ref. 815B to Central Personnel Services, English Electric Co. Ltd., 24-30 Gillingham Street, Westminster, S.W.1. W 2989

JUNIOR DRAUGHTSMAN required for interesting work on electro-mechanical apparatus in connexion with radar and electronics, S.E. London area. Applicants are asked to state age and salary required and details of experience to Box No. W 2040.

JUNIOR ENGINEER required for Acoustics Laboratory of large telephone manufacturing company in S.E. London area, for work mainly on the development of telephone instruments and allied equipment. Degree or H.N.C. essential and preferably some industrial experience in electro-acoustic work. Salary in accordance with experience and qualifications. Write Box No. W 2062.

LABORATORY ASSISTANT for north east coast area for development work in connexion with the manufacture of radio resistors. Applicants should be at least Inter B.Sc. standard (electrical engineering or physics) and have some knowledge of electronics. Practical industrial experience would be an advantage but not essential. Box No. W 2085.

MARCONI'S WIRELESS TELEGRAPH Co., Limited, Chelmsford, has vacancies for several Technical Writers, men or women, to prepare hand books on operation and maintenance of radio equipment. Applicants should have sound technical training to Degree or H.N.C. standard and some practical experience in development of radio equipment is desirable. Experience of technical writing is essential. Good salaries will be offered depending upon the applicants qualifications and experience. A staff pension scheme is in operation. Please reply giving full details to Central Personnel Services, English Electric Co., Limited, 24-30 Gillingham Street, London, S.W.1, quoting Ref. 278A. W 2070

McMICHAEL RADIO LIMITED, require qualified draughtsman with experience in the mechanical design of radio and electronic instruments for the government services. Salary will be commensurate with ability. Write stating age, training, experience and salary required to the Chief Engineer, Equipment Division, McMichael Radio Limited, Slough, Bucks. W 2976

McMICHAEL RADIO LIMITED, require senior project engineers in their equipment division development laboratory at Slough. Training and experience in the field of applied electronics (including communications) and experience of working with government departments are the chief qualifications required. Salary will be commensurate with ability. Write stating age and full details of training, qualifications and experience to the Chief Engineer, Equipment Division, McMichael Radio Limited, Slough, Bucks. W 2977

MECHANICAL ENGINEER required. Good academic qualifications, recognised apprenticeship and some electrical knowledge essential. Experience in one or more of the following desirable:- Precision mechanical design, fire control mechanisms, servo theory, hydraulic and pneumatic servo systems, aerodynamics. Apply with full details of age, experience and salary required to the Personnel Manager, Sperry Gyroscope Company Limited, Great West Road, Brentford, Middlesex. W 2014

PHYSICISTS OR PHYSICAL CHEMISTS required for laboratory in Northamptonshire, to carry out varied and interesting work on new ceramic and metallic materials. Applicants should have a good science degree and be familiar with techniques for measuring magnetic and dielectric properties. Experience in designing radio and electronic components from these materials an advantage. Salary £450-£650 according to qualifications and experience. Box No. W 2051.

PHYSICIST REQUIRED to take responsible position in a team engaged upon new and important developments in Thermionic Values. Applicant must possess a good Degree in Physics and some experience in Research or Industry is desirable. Post offers excellent prospects for a man keen on Applied Research and possessing a quick brain and initiative. Salary in accordance with qualifications and experience. Write, in confidence, giving full details to the Personnel Officer, Standard Telephones and Cables, Ltd., Foots Cray, Sidcup, Kent. W 2077

PROMINENT AIRCRAFT firm in **Greater London area, commencing new project of great National importance, offers unique opportunity for advancement. High salaries with monthly staff status and Pension Scheme offered to suitably qualified applicants. Electronic Engineers with 1st Class Honours Degree in Mathematics or Engineering preferably with several years' practical experience, though not essential. Apply,** stating age, **nationality and experience to Box Ac.58212, Samson Clarks, 57-61, Mortimer Street, W.1.** W 131

REQUIRED by large radio manufacturer in London area: (1) Senior Draughtsman for communications section of the drawing office—applicants should have experience of communications equipment. (2) Draughtsman for test gear department—applicants should have experience in radio or light engineering. The positions are permanent and the company has a pension fund and life assurance scheme. Apply stating full particulars of experience with age and salary required to Box No. W 2025.

REQUIRED immediately by large firm in London Area. Senior and junior radio development engineer to work on long term projects of high priority. Applicants should have experience in the development and design of VHF communication equipment. For the junior posts, however, experience is not essential provided applicants have adequate grounding in basic electronic techniques. Posts permanent and pensionable. Apply quoting reference R.E.D. to Box No. W 2086.

RESEARCH AND DEVELOPMENT Engineers are required by British Telecommunications Research, Limited, a company associated with The Automatic Telephone and Electric Co., Limited, and British Insulated Callender's Cables, Limited, for work on long term development projects in the following fields: (a) Wide-band line communication. (b) V.H.F. and U.H.F. radio communication. (c) Electronic Switching and Computing. A number of posts with a salary in the range £500-£1,200 per annum are available for suitably qualified engineers or physicists with experience in any of the above or allied fields. Further posts are available for technical assistants with salary in the range £300-£600 according to qualifications and experience. Applications are also invited from Honours Graduates in physics or electrical engineering who are considering careers in the research and development side of the telecommunications industry. There is a superannuation scheme and the Company works a five-day week. The laboratories which are well equipped are situated in ideal country surroundings within easy reach of London. Applications, which will be treated in strictest confidence, should be made on forms obtainable from the Director of Research, British Telecommunications Research Limited, Taplow Court, Taplow, Bucks. W 2060

RESEARCH LABORATORIES of The General Electric Co., Limited, Wembley, Middlesex, have vacancies on a Major Guided Weapon Project at their Stanmore Laboratories for engineers and physicists with at least three and preferably five years' experience in the generation and handling of waveforms for radar computors or pulse multiplex systems. These openings will offer good prospects in experimental teams and attractive starting salaries will be paid. All applications should be sent to the Staff Manager (Ref. GBLC/766), stating age, qualifications and experience. W 2081

SENIOR AND JUNIOR Electronic Development Engineers required for work of high priority. Degree or inter-B.Sc. desirable. Salary £400-£750 p.a. according to qualification and experience. Write stating full details to Personnel Manager, The McMurdo Instrument Co., Ltd., Ashtead, Surrey. W 2907

SENIOR DESIGNER DRAUGHTSMAN required with experience of design and development of Radar and Electronic apparatus to Service requirements, S.E. London Area. Applicants are asked to state age and salary required and details of experience to Box No. W 2039.

SENIOR DRAUGHTSMAN required for interesting work on electronic equipment, design and small quantity production. Experience an advantage, also ability to work on own initiative. Good prospects and five day week. Apply Personnel Manager, Dynatron Radio Limited, Ray Lea Road, Maidenhead, Berks. W 2929

SENIOR ELECTRONIC ENGINEER required by large firm in S.E. London, for development work in connexion with Radio and Radar equipment, a good knowledge of pulse and C.R.T. display technique is essential. This work is of particular interest as it deals with research and production aspects, and is of high national importance. Apply, giving full details of previous experience, qualifications and salary expected to Box No. W 2041.

STANDARD TELEPHONES & CABLES Limited, have vacancies in their Line Transmission Division at North Woolwich, London, E.16, open to qualified Engineers and Physicists for the Development of Multi-Channel Carrier Systems and Micro-wave Radio Link Equipment. Salary in accordance with qualifications and experience. Graduates without experience will be considered. Apply Personnel Manager, Standard Telephones & Cables Limited, North Woolwich, E.16. W 2095

TECHNICAL ASSISTANT for vibration research on Aero Engines. Specific experience of this work not essential if well qualified to undertake experimental investigations. Write, stating age, qualifications and previous experience to: The Personnel Officer, The de Havilland Engine Co., Ltd., Stag Lane, Edgware, Middlesex. W 2010.

CLASSIFIED ANNOUNCEMENTS
continued on page 8

SITUATIONS VACANT (Cont'd.)

TECHNICAL ASSISTANT required to take charge of small scale production of electronic valves for specialized equipment. Previous experience desirable and education up to inter B.Sc. advantageous. Apply giving age, details of education and experience together with salary required, to Personnel Department (CRT), E.M.I. Factories, Limited, Hayes, Middlesex. W 2054

TECHNICAL DEVELOPMENT ENGINEERS required, Senior, Intermediate and Junior, for interesting work in electronics, including defence contracts. Excellent salaries for suitable applicants. Apply to Technical Director All-Power Transformers, Ltd., Chertsey Road, Byfleet, Surrey. W 2048

TECHNICAL SALES ASSISTANTS required by Company specializing in equipment for high vacuum work. Applicants 25/30 of good personality and appearance and high integrity, should have suitable training, e.g. physics, electrical or chemical engineering, electronics to Inter B.Sc./Graduate standard. Technical and commercial training will be given for subsequent service in Sales Office or travelling at home and abroad as positions arise. A real enthusiasm and flair for sales work is essential. Progressive and superannuated posts. Apply with full details to Box No. W 2096.

TELEVISION ENGINEER with original ideas wanted for novel application in important defence project in special laboratory within 40 miles of London. Starting salary £700-£1,000 p.a. according to qualifications. Write quoting Ref. IAH to Box No. W 2063.

TESTING PERSONNEL required by large firm S.E. London, for work on Radio and Radar equipment, should be capable of fault finding and dealing with both transmitter and display equipment. Applicants should have had 2-3 years previous experience on this type of work. Apply stating age, previous experience and salary expected to Box No. W 2043.

THE ENGLISH ELECTRIC Co. Ltd., offers unusual opportunities for young Engineers in the Design and Application of electrical instruments and protective relays, with the assurance of stability of employment and exceptionally good working conditions. Applicants should write giving full particulars and quoting Ref. 406E to Central Personnel Services, English Electric Co. Ltd., 24/30 Gillingham Street, London, S.W.1. W 2098

THE GENERAL ELECTRIC CO., LTD., Radio and Television Works, Coventry, have vacancies for Development Engineers, Senior Development Engineers, Mechanical and Electronic, for their Development Laboratories on commercial and Government work of national importance. Fields include Microwave and Pulse Applications. Salary range £400-£1,250 per annum. Vacancies also exist for Specialist Engineers in Component design, valve applications, electro-mechanical devices and small mechanisms. The Company's Laboratories provide excellent working conditions with Social and Welfare facilities. Superannuation Scheme. Assistance with housing in special cases. Apply by letter stating age and experience to the Personnel Manager (Ref. CHC.) W 2999

THE PLESSEY COMPANY, Limited, Ilford, requires the following staff: Test Gear Design and Development Engineers, with sound theoretical knowledge and experience in the development of test gear for radio, television or other electronic equipment. First Class Estimator/Ratefixer with preproduction planning experience of communications and radar equipment—early promotion to production engineer is envisaged for successful applicant. Senior Draughtsman for communications section of the drawing offices with experience of communications equipment. Draughtsman for test gear department with experience of radio or light electrical engineering. Radio Mechanics with experience of installation and maintenance of test gear—service or civilian. All positions carry the right to participate in the pension fund and life assurance scheme after the usual trial period. State full particulars to the Personnel Manager. W 2076

THE SUPERMARINE WORKS of Vickers-Armstrongs Ltd., at their Winchester Design Offices require Instrumentation Engineers for interesting work on high speed aeroplanes. Qualifications preferred:- Engineering Degree with knowledge of Electronics, and practical workshop experience. Apply Personnel Department, Hursley Park, Near Winchester. W 2031

THERE ARE a number of vacancies suitable for Honours Graduates in physics, electrical or mechanical engineering or mathematics or a good general Degree covering two or more of these subjects, for both research and development work in the following fields: Radio and Line Communications, Radar, Electronic Instrumentation, Microwaves, Ultrasonics, Vacuum Techniques and Electromechanical Devices. Salary according to qualifications and experience consistent with general present-day levels. There are vacancies for which considerable post-graduate experience is required and others for which previous experience is not necessary. Consideration will be given to students taking finals during the current academic year. Prospects of promotion are good and the posts all fall within the Mullard Company's Superannuation Scheme. Apply Personnel Officer, Mullard Electronic Research Laboratory, Salfords, Nr. Redhill, Surrey. W 2896

X-RAY. Foremost apparatus manufacturer offers an interesting overseas post for a technical representative with commercial ability and sound electrical engineering background. Successful applicant would receive intensive training. Apply in writing to Box No. W 2047.

YOUNG ELECTRICAL ENGINEER required, S.E. London area, to assist Chief Engineer, some knowledge of chemistry, high vacuum processes, and transformers preferable. Able to drive. All relevant details and salary required to Box No. W 2082.

SITUATIONS WANTED

E.E G. male Technician/Recordist experienced Ediswan six channel recording and maintenance, desires change, preferably Southern England. Box No. W 1347.

LABORATORY ENGINEER (electronics, experience, high power audio amplification, vibration technique, supervise construction specialised laboratory gear, London, Home Counties preferred. Box No. W 1346.

FOR SALE

AMERICA'S famous magazine Audio Engineering, 1 year subscription 28s. 6d.; specimen copies 3s. each. Send for our free booklet quoting all others; Radio Electronics, Radio and Tele. News, etc. Willen Limited (Dept. 9), 101 Fleet Street, London, E.C.4. W 108

ELECTRIC BULBS and lamps for all purposes; neon and discharge lamps; U.S. radio accessories, switches, (Ceramic) condensers, etc. Telephone headsets, breast and headsets, lamps, lamp caps, jacks, plugs, Fullerphones, etc. Suplex Lamps Limited, 239 High Holborn, London, W.C.1. W 1344

GLASS-TO-METAL SEALS and **High Vacuum** by Hall, Drysdale & Co. Ltd., of 58 Commerce Road, Wood Green, London, N.22. 'Phone: BOWes Park 7221. W 117

MAGSLIPS—For use as flexible shaft or synchronous link, for remote indication, computation or for servo-control, Applications. Many types available. Linear Ipots and Ball and Plate Integrators for computation. Selsyns—For remote torque transmission (45lb. in). Servotronic Sales invite inquiries for the above and all types of servo-control Electronic and Electrical equipment. Write for brochure "Synchros" and price list to Servotronic Sales, Abbey Road, Belvedere, Kent. W 1348

MAGSLIPS at 1/10th to 1/20th of **list prices. Huge stocks. Please state requirements. K. Logan, Westalley, Hitchin, Herts.** W 116

MERCURY SWITCHES are made by **Hall** Drysdale & Co. Ltd., of 58 Commerce Road, Wood Green, London, N.22. Phone BOWes Park 7221-2. W 107

WEBB'S 1948 Radio Map of World, **new** multi-colour printing with up-to-date call signs and fresh information; on heavy art paper, 4s. 6d., post 6d. On linen on rollers, 11s. 6d., post 9d. W 102

TOROIDAL COILS, manually wound to one per cent. Bel Sound Products Co., Marlborough Yard, Archway, N.19. ARC. 5078. W 139

WANTED

WANTED 328A and 394A Western Electric Valves—in quantity. Terry, 50 Westcliffe Road, Bournemouth. W 1330

EDUCATIONAL

BOROUGH POLYTECHNIC, Borough Road, S.E.1. A course of 14 lectures by specialist lecturers on "Application of Electronic Instruments to Engineering Problems and Measurement," to be held on Monday evenings at 7 p.m., will begin on Monday, 1st October, 1951. Further particulars and forms of application for enrolment may be obtained from the Secretary. W 2987

CITY AND GUILDS, (Electrical, etc.) on 'No Pass—No Fee' terms. Over 95 per cent Successes. For full details of modern courses in all branches of Electrical Technology, send for our 144-page handbook—Free and post free. B.I.E.T. (Dept. 337c), 17 Stratford Place, London, W.1. W 123

MIDDLESEX COUNTY COUNCIL. Education Committee, Southall Technical College, Beaconsfield Road, Southall. Special courses each of 20 weeks duration will be held in Pulse Technique (Thursdays, 7-9 p.m., commencing on 11th October) and Electro-Acoustical Transducers (Mondays, 7-9 p.m., commencing on 8th October). Intending students, who should possess a Higher National Certificate or an equivalent qualification, should enrol before 1st October. The fee is £1 for each course. T. B. Wheeler. Chief Education Officer. W 2057

NORWOOD TECHNICAL COLLEGE, W. Norwood, London, S.E.27. Full-time, part-time day and evening courses in Radio and Television (Technology and Servicing), Radar and Line. Preparation for following examinations: C. & G. Full Technological, R.T.E.B., Amateur Transmitting Licence, P.M.G. Free Telecom. Prospectus (D) from the Secretary. (170.) W 2775

THE POLYTECHNIC, 309 Regent Street, W.1. A course of six lectures on "Radio Wave Propagation and the Ionosphere," will be given by Mr. L. Prechner (engineering division, B.B.C.), on Tuesday evenings from 6.30 to 8 p.m. commencing 16th October; 1951. A detailed syllabus is available. Application to attend this course should be made as soon as possible to the Head of the Department of Mathematics and Physics. W 2064

BUSINESS OPPORTUNITIES

SOUTH AFRICAN company director now in England wishes to contact British and Continental manufacturers of Radar and Marine Radio and Electronic Equipment with a view to arranging service and sales facilities in South and East Africa. Box No. W 1343.

PATENT

IT IS DESIRED to secure the full commercial development in the United Kingdom of British Patent No. 605,621, which relates to "Electronic Transmitters for Electrical Measuring Devices," either by way of the grant of licences or otherwise on terms acceptable to the Patentee. Interested parties desiring copies of the patent specifications should apply to Stevens, Langner, Parry and Rollinson, 5-9 Quality Court, Chancery Lane, London, W.C.2. W 2083

SERVICE

GLASSBLOWING, repetition and scientific, by Hall Drysdale & Co. Ltd., of 58 Commerce Road, Wood Green, London, N.22. Phone BOWes Park 7221-2. W 109

METALWORK. All types cabinets, chassis, racks, etc., to your own specifications. Write Dept. "T," Philpott's Metal Works, Ltd., Chapman Street, Loughborough. W 2731

VALVE-MAINTAINED TUNING FORKS

THE valve-maintained tuning fork is recommended for use wherever an audio frequency standard of high accuracy is required. Various models are available covering a frequency range of 40 c/s to 4,000 c/s, with a frequency stability of 0.005% or better. All models are a.c. mains operated, and may be supplied either for rack mounting or bench use.

TEMPERATURE-CONTROLLED FORK TYPE A-339

To enable the highest stability to be obtained this instrument incorporates a thermostatically-controlled oven to maintain the fork unit at a constant temperature. A frequency stability of ±0.001% or better is obtained. The output is 1 watt into 600 ohms. Standard frequencies: 500, 1,000, 1020, 2,000, 3,000 and 4,000 c/s.

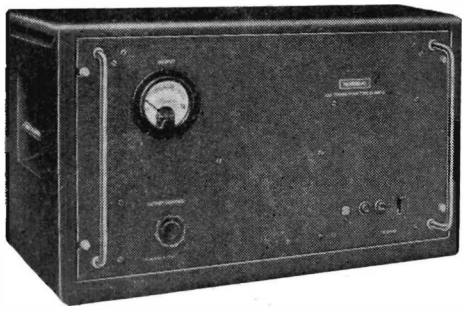
Write for Bulletin B-522

VALVE-MAINTAINED FORK TYPE D-20

This simple unit is capable of delivering an output of 5 volts into 600 ohms, with a frequency stability of ±0.0025%. Standard frequencies: 1,000, 1,020, 2,000, 3,000 and 4,000 c/s.

Write for Bulletin B-597

LOW FREQUENCY FORK TYPE D-418



This instrument employs a resiliently mounted fork unit to absorb the anti-nodal vibrations which are inevitable with low frequency forks. The frequency stability is ±0.005% and the output is 3 watts at 200 volts; this is sufficient to drive a mains clock. Standard frequencies: 50, 100, 150 and 200 c/s.

Write for Bulletin B-617

Multiple Metal-Glass Seals

Most metals and glasses vary widely in their expansion characteristics, attempts to join them inevitably resulting in very highly stressed and unreliable joints.

Satisfactory joints can result only from very careful selection of special metalloys and laboratory control of the characteristics of both metal and glass, together with the most modern techniques.

These conditions are satisfied by all Ediswan metal-glass seals which can be produced in an infinite variety of types to meet designers' requirements.

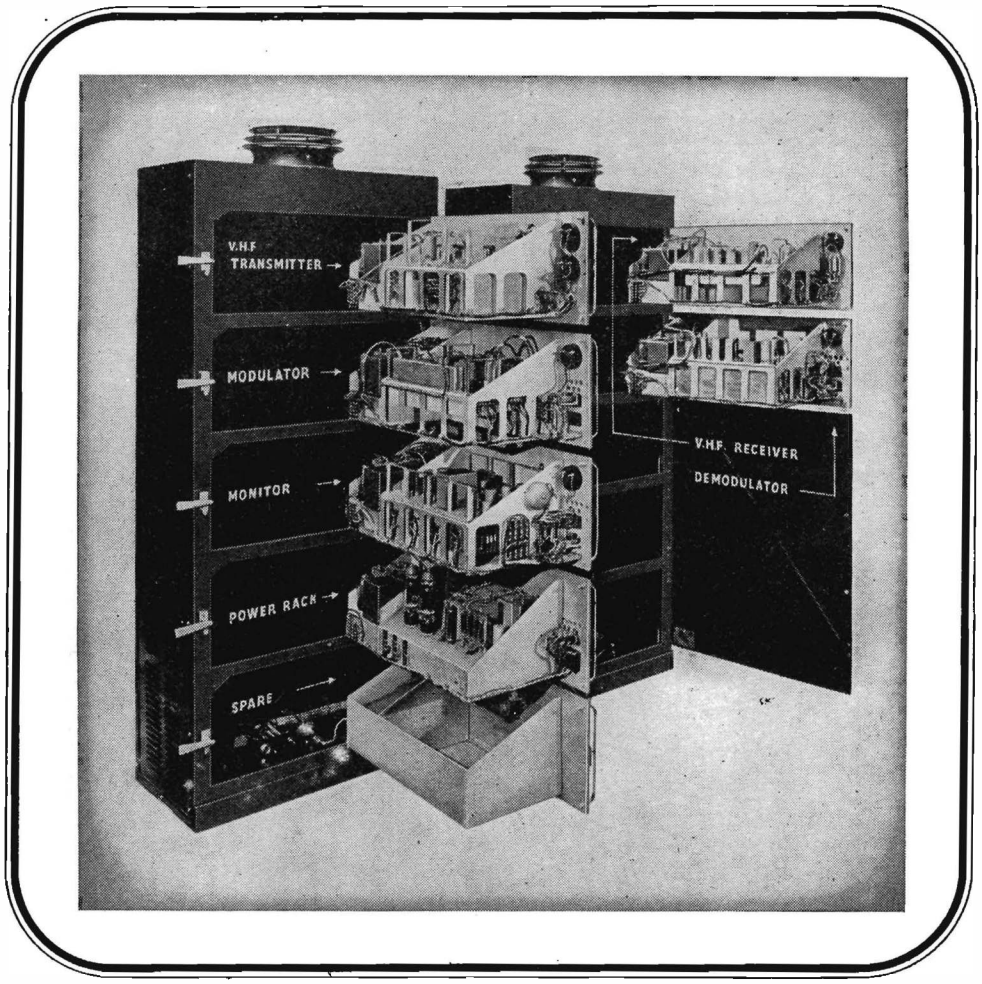
Our engineers will be pleased to advise regarding your sealing problem.

EDISWAN

THE EDISON SWAN ELECTRIC CO. LTD., 155 CHARING CROSS ROAD, LONDON, W.C.2

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

SP61



RADIO TRANSMISSION

OF INTERNATIONAL 12 CHANNEL CARRIER GROUPS

Where telephone lines cannot be built or are too costly, this V.H.F. FM radio system will give C.C.I.F. transmission standards for 12 channel telephone groups over a single link up to 40-50 miles long. Radio relay stations are available to extend links up to several hundred miles. Each main unit comprises a number of sub-units which are quickly replaced by spare sub-units when faults occur. The frequency ranges are from 40-90 Mc/s or 150-200 Mc/s.

AUTOMATIC TELEPHONE & ELECTRIC CO. LTD.

(Radio and Transmission Division)

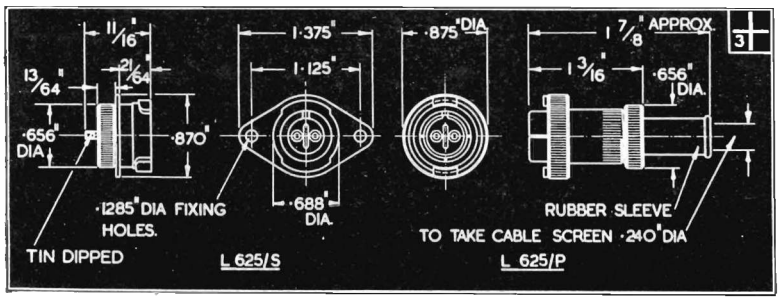
STROWGER HOUSE · ARUNDEL STREET · LONDON · W.C.2

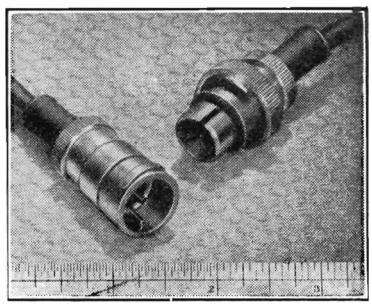
Telephone: TEMple Bar 9262

Cablegrams: Strowgerex, London

A14161/B107

The "Belling-Lee" page for Engineers



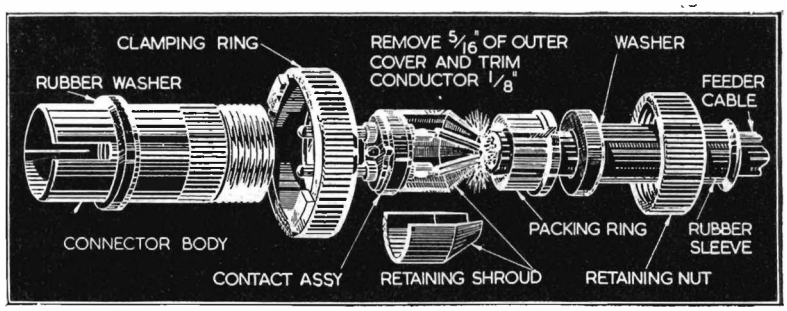


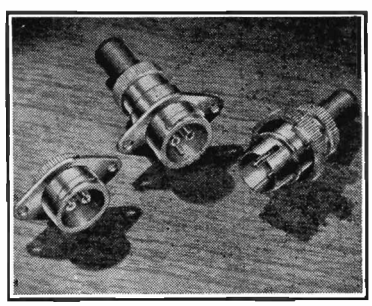
"SCREENECTORS"

This new range of screened connectors in light alloy is based upon the draft R.E.C.M.F. specification for a non-reversible screened plug and socket to load cables up to 0.24 in. diameter over the braid.

Single or multi-pole contacts may be assembled into the common housings which are designed so that various applications may be employed—e.g., line connector, flex plug and chassis socket and vice versa, through chassis (bulkhead) connector, each part interchangeable in its appropriate position in the assembly.

METHOD OF LOADING IS SHOWN BELOW





Assembly	Coaxial	2-pole	3-pole
Flex plug	L722/P	L625/P	L715/P
Chassis socket	L722/S	L625/S	L715/S
Through chassis socket	L723	L689	L716
Flex socket	L724	L690	L717

Type	Characteristic Impedance ohms ★	Contact Resistance	Capacitance ★ Conductor/conductor	Capacitance ★ Conductor/screen
Coaxial	75	Less than 5 milliohms each	—	—
2-pole	100		1 pF	2.5 pF
3-pole	—		—	—

★ At 1 Mc/s

Other design features include: (1) High grade bakelite insulators. (2) Simple assembly and loading. (3) Positive quick-action locking device. (4) Machined light alloy screened housing finished for instrument panel requirements.

The characteristics of these connectors are shown opposite.

We invite you to inspect our Stand No. 64 at the National Radio Exhibition, Earls Court, August 28th — September 8th, 1951.

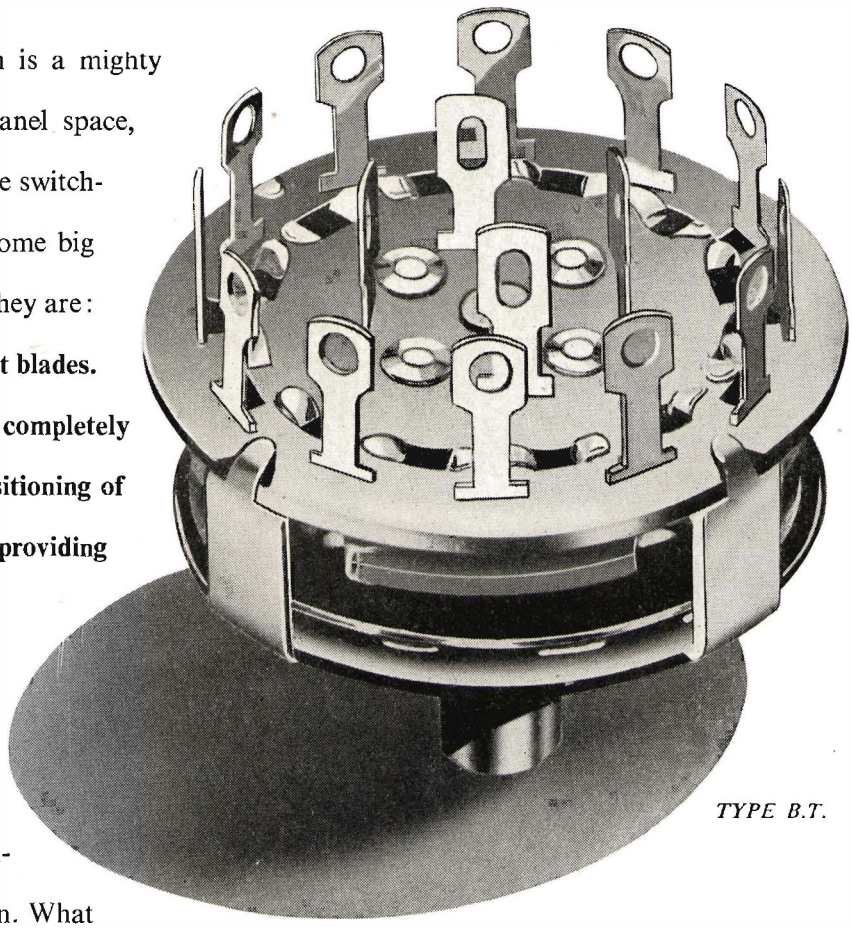
BELLING & LEE LTD
CAMBRIDGE ARTERIAL RD., ENFIELD, MIDDX., ENGLAND

a better baby . . .

The Walter Type B.T. Switch is a mighty midget. It takes up small panel space, and is just the switch for simple switching. Recently we have made some big improvements in it too. Here they are:

A new method of fixing contact blades. This ensures that they are completely rigid all the time. Definite positioning of the drive spindle in the wafer, providing double bearing.

There are other improvements as well—positive contact and steady contact resistance, better insulation between contacts, and a self-cleaning action. What does all that add up to? A sensible, reliable and lasting switch, which we feel will give you first class service and complete satisfaction.



TYPE B.T.

Walter Instruments LIMITED

WALTER SWITCHES

MADE FOR LIFE

GARTH ROAD, LOWER MORDEN, SURREY. TELEPHONE: DERWENT 4421-2-3

CRC 48

Standard radio frequency

push button ATTENUATOR

for true V.H.F. loss measurement

Available in two ranges, one giving 0—9 db in 1 db steps and the other 0—90 db in 10 db steps. Attenuators have been specially designed for building into your own equipment. They may be used in tandem.

ACCURACY OF D.C. ADJUSTMENT

0—9 db model—The insertion loss error will not exceed ±0·05 db for any setting.
0—90 db model—The insertion loss error for the 90 db setting will not exceed ±0·3 db. For other settings this limit falls linearly to a value of ±0·06 db at the 10 db setting.

HIGH FREQUENCY PERFORMANCE

0—9 db model—At 50 megacycles, the insertion loss error for the 9 db setting will not exceed ±0·15 db. For other settings this limit falls linearly to a value of ±0·05 db for the 1 db setting.
0—90 db model—At 50 megacycles, the insertion loss error will not exceed ±0·1 db per step.

N.B. All insertion loss errors are relative to zero db setting.

MODELS AVAILABLE

Type 74600-A : 0—9 db in 1 db steps
Type 74600-B : 0—90 db in 10 db steps
Both the above models have a characteristic impedence of 75 ohms and will handle inputs up to 0·25 watts. Two further models will shortly become available having a characteristic impedence of 50 ohms with comparable performance.

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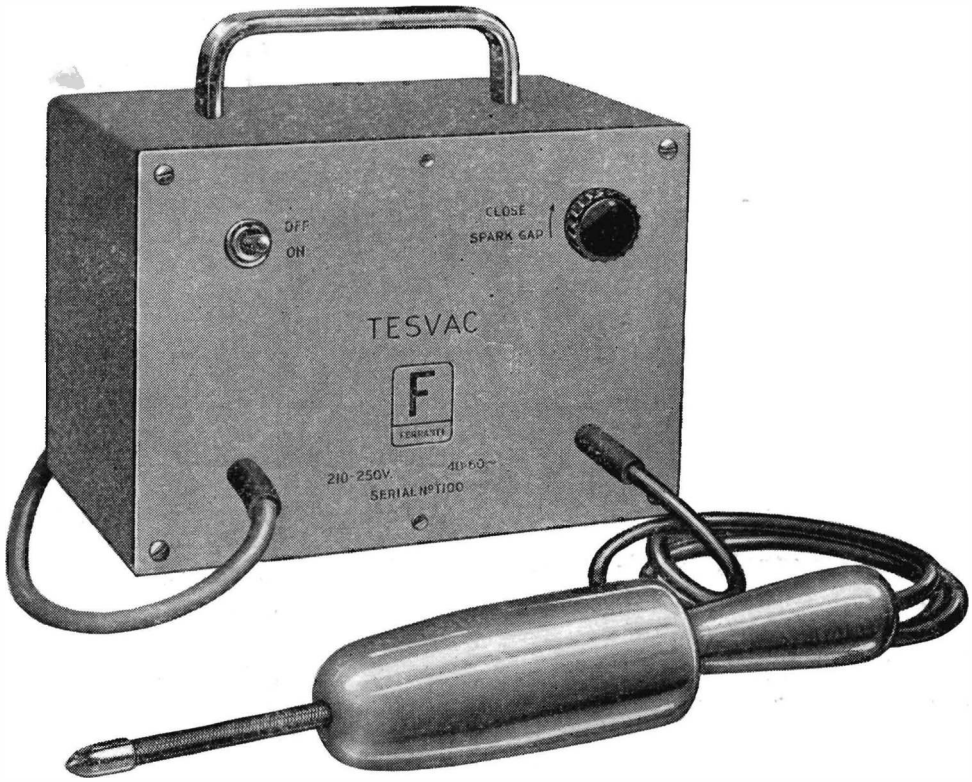

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Electronic Engineering

Incorporating
ELECTRONICS, TELEVISION and SHORT WAVE WORLD

Managing Editor, H. G. Foster, M.Sc., M.I.E.E.

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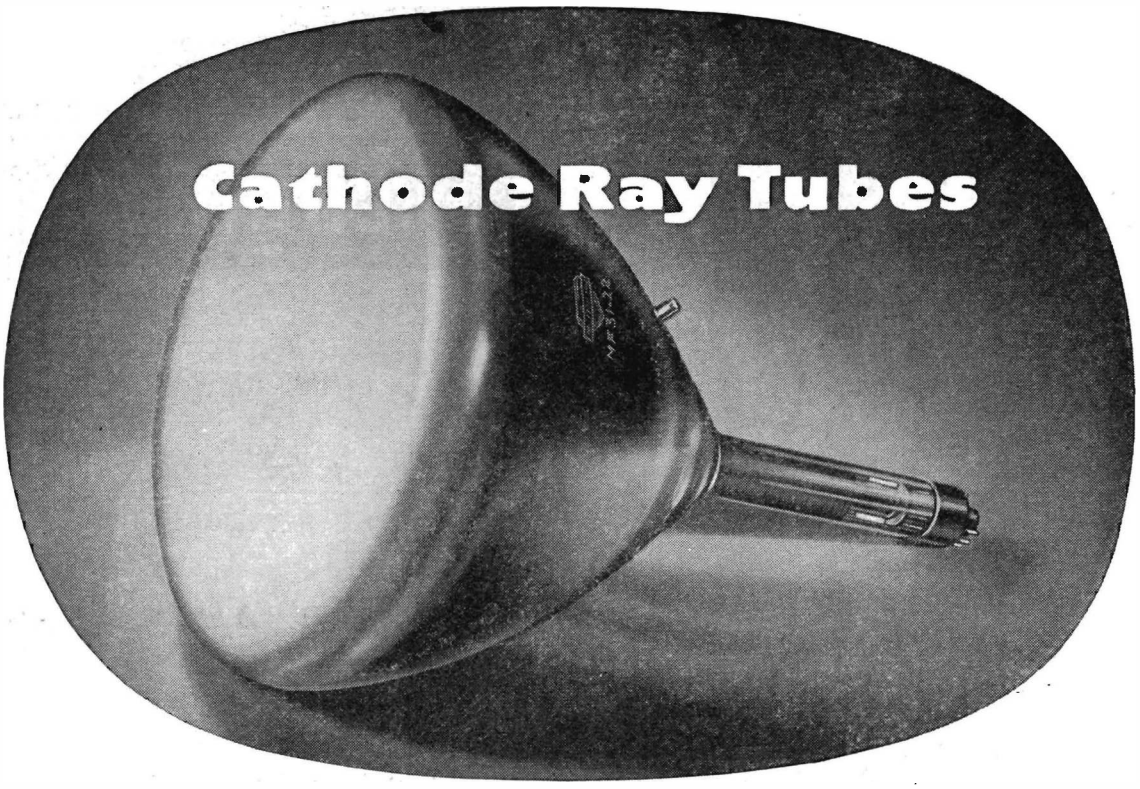

for Radar, Research and Industrial Applications

The cathode ray tube is now accepted as an essential component in all electronic equipments where it is required to obtain a rapid indication or display of physical phenomena. As such it forms the basis of oscilloscopes, test apparatus, monitors, flaw detectors and numerous other research, industrial and communications equipments. The Mullard range of cathode ray tubes has now been extended to meet all these applications.

TUBES FOR RADAR DISPLAYS.

Of particular importance among this range are the Mullard C.R. Tubes MF31-22 (12-in.) and MF13-1 (5-in.) both of which are designed to meet the continuous operation and arduous conditions of service encountered in marine radar applications. Having long-persistence aluminised fluoride screens, these tubes are suitable for use in P.P.I. systems.

SMALL TUBES FOR INSTRUMENTS

A variety of $1\frac{3}{4}$-in. and $2\frac{3}{4}$-in. electrostatic C.R. Tubes with green, blue or persistent screens are also available. These tubes are all characterised by low inter-plate capacitances and are designed for operation with voltages from between 800 and 1,000 volts. These features, coupled with the fact that the tubes are fitted with standard B9G bases and have a seated length of less than 6 ins., make them suitable for use in small, compact oscilloscopes, and in a variety of industrial, communications and research testing and measuring equipments. All these tubes can be obtained in versions suitable for either symmetrical or asymmetrical deflection.

For larger equipments, a high-grade electrostatic 5-in. tube is also available.

Abridged technical details on the tubes for radar displays are listed below. Full data on the complete range of cathode ray tubes is available on request.

Type	Description	Base	Max. Screen Diameter (mm.)	Max. Overall Length (mm.)	V_h (V)	I_h (A)	Va1 max. (V)	Va2 max. (KV)
MF13-1	5″ radar tube with metal-backed magnesium fluoride screen	Octal	127.5	292	6.3	0.3	450	11
MF31-22	12″ radar tube with metal-backed magnesium fluoride screen	B12A	308	471	6.3	0.3	400	11

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Electronic Engineering

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Commentary

THE 18th National Radio and Television Exhibition is being held at Earls Court between August 28 and September 8. In addition to being an important contribution to the Festival of Britain, the Exhibition is being held at a time when the industry is at an all time peak of production, the annual value of the equipment manufactured exceeding £85 million, including exports now running at the rate of £21 million a year. Although many factories have Service contracts, that has always been so, and the new re-armament programme has not yet interfered to any great extent with production for civilian needs, and not at all with exhibits in the show. In this connexion, it is interesting to note that the industry has sold well over a million television receivers since the end of the war.

August 28 will be an "invitation day" for overseas and other special visitors and, subject to his official engagements, Earl Mountbatten of Burma will open the Exhibition to the public on Wednesday, August 29.

As at the previous Radio Shows of recent years the greatest emphasis will be on television and this tendency will, no doubt, be accentuated this year as the Exhibition is being held almost on the eve of the opening of the new B.B.C. television transmitter at Holme Moss. This will be the most powerful television transmitter in the world and it will bring twelve million more people within range of the programmes. In addition to a large number of receivers that have been designed for this station, there will also be on view a number that have been designed for Kirk O' Shotts, the Scottish station, which is due to open in the spring of 1952. The manufacturers are confident that the demands of re-armament will not prevent them from supplying the necessary number of receivers to satisfy all immediate demands from the two new television areas.

On account of the present economic situation it might be thought that the manufacturers of radio and television receivers would be indulging in a price cutting campaign, together with the inevitable reduction in quality. On the contrary, however, the majority are concentrating on the provision of good and dependable performance. This is evidenced by the fact that the twelve inch cathode-ray tube is now almost standard, and more sets than ever are available with fifteen or sixteen inch tubes. In addition, nearly a dozen manufacturers have projection television receivers in production, while new circuit techniques, frequently involving more efficient valves and components, for both television and radio reception and audio reproduction have been fully utilized.

There will, as usual be a Television Avenue, in which receivers of the various manufacturers can be seen working side by side. This year the Avenue will be no less than two hundred and fifty feet long.

The supply and distribution of radio, television and audio signals for the demonstration of the various products is quite a considerable technical problem and one of the most interesting features is the microwave link, working on a frequency of 6,800Mc/s, which will be used to relay the television programmes from Alexandra Palace to Earls Court. The equipment used for distributing the demonstration signals will be on view through glass panels in the walls of the distribution rooms.

In addition to the broadcast and television receivers and audio reproducers there will also be on view a large range of industrial and scientific equipment including test gear, components, electro-medical equipment and other related products. The electronic divisions of eight Government Departments, including the three services, will also be exhibiting some of their latest equipment and techniques.

* * *

We will be pleased to welcome any of our readers on stand number 37 where, in addition to a large range of popular reprints and technical books we will be demonstrating the De Luxe version of the ELECTRONIC ENGINEERING Home Built Televisor. This De Luxe version incorporates, in addition to all the latest circuit techniques and refinements, a three waveband radio and a high quality record reproducing unit. The long awaited constructional manual for this comprehensive home entertainer will also be on sale at our stand.

Included in this issue there is a six page preview of the new electronic equipment that will be on view at the Exhibition, while on page 340 there is a short description of a few of the interesting technical details of the De Luxe Home Built Televisor.

Equipment for Acoustic Measurements

(Part 1)

A Portable General Purpose Microphone Amplifier Using Miniature Valves

By D. E. L. Shorter,* B.Sc.(Eng.), A.M.I.E.E., and D. G. Beadle,* B.Sc.(Eng.), A.C.G.I., A.M.I.E.E.

Research on the acoustics of rooms frequently involves the use of portable apparatus for making tests in studios and concert halls remote from the laboratory. The special equipment used in this work must be as compact and light as possible so that it can be handled easily by the engineers making the measurements. With these considerations in mind, apparatus for studio testing has been designed in the B.B.C. Research Department, using as far as possible, the types of miniature valves and other components which have become available since the war. The first of these, a general-purpose microphone amplifier, is the subject of the present article.

THE amplifier to be described has to operate in conjunction with the high quality microphones used in broadcasting equipment. The output from such microphones with weak sounds may be only 30db above the thermal agitation noise arising from the resistance of the microphone itself, while a full orchestra may produce an output some 50db higher. Special arrangements are therefore necessary in the amplifier to preserve the highest possible signal-to-noise ratio with minimum distortion.

The amplifier is required to work into a load having a nominal impedance of 600 ohms, and to present a substantially resistive output impedance of the same figure over the working frequency range. The maximum output required for the present purpose is + 20db relative to 1mW and it is desirable that the harmonic distortion of the system at this level should be below 0.5 per cent. In modern amplifiers using negative feedback, the distortion may be quite low even when the output is nearly equal to the maximum which the valves can deliver, but may increase rapidly with a slight rise in level. A percentage harmonic figure taken at a single output level may thus be misleading and it is therefore advisable to specify, in addition, the margin of safety between this level and the "ceiling" level at which actual clipping of the wave-form begins. In the present instance, a margin of at least 6db was called for, so that the output stage has to be capable of delivering at least 400mW (+26db) to the load.

In addition to the above requirements, an independent monitoring output is necessary to operate a loudspeaker for checking purposes, together with some visual indication of the outgoing level. The amplifier is required to transmit short-duration pulses and other rapidly fluctuating signals used in studio testing. A quick-acting indicator is therefore essential and since speech and music have also to be handled upon occasion, the standard B.B.C. peak programme metering circuit is used.

From the above, it will be seen that the new microphone amplifier fulfils the same functions as the portable apparatus used at outside broadcasts and is in fact similar in many respects to the existing equipment designed for that purpose in 1938.[1] However, by careful layout and the use of miniature components, the same facilities are provided by the present amplifier unit in a fraction of the space occupied by the earlier equipment. The new design has been in use in the Electro-Acoustics Group of the B.B.C. Engineering Research Department since 1947.

* *Research Department, B.B.C. Engineering Division.*

Circuit

The complete circuit of the amplifier is shown in Fig. 1. With the exception of the H.T. rectifier and the first amplifier stage, B7G based valves are used throughout. The circuit may be divided into the following parts:—

(a) a first stage, the gain of which is variable by altering negative feedback in two 10db steps.

(b) a continuously variable carbon track interstage attenuator of novel design, having a nearly uniform decibel scale over a large range.

(c) a three-valve line amplifier with push-pull output.

(d) a second circuit similar to amplifier (c) but having a low-impedance output for operation of a checking loudspeaker.

(e) a peak programme meter circuit operated from amplifier (d).

(f) a power supply unit using light-weight components.

These parts will now be described in more detail.

(a) First Stage (Valve V_1)

The circuit of the first stage is based on that of an existing single valve unit amplifier designed by H. D. Ellis of the B.B.C. Designs Department and used in the new B.B.C. studio equipment.[2] In this circuit, the requirements of low distortion with large input signals and maximum gain with small input signals are met by the use of negative feedback, variable in 10db steps. In the present instance, the steps are arranged to give a maximum overall gain of 70, 80 or 90db, the setting used being determined by the maximum input to be handled. It will be noted that the feedback is taken from the anode circuit of V_1 to the grid and thus lowers the input impedance to that stage. The constants of the circuit are so arranged that with the minimum degree of negative feedback, the value of the input impedance at the grid of V_1 is correct for the termination of the input transformer T_1. Series resistors are automatically switched into circuit to maintain the load

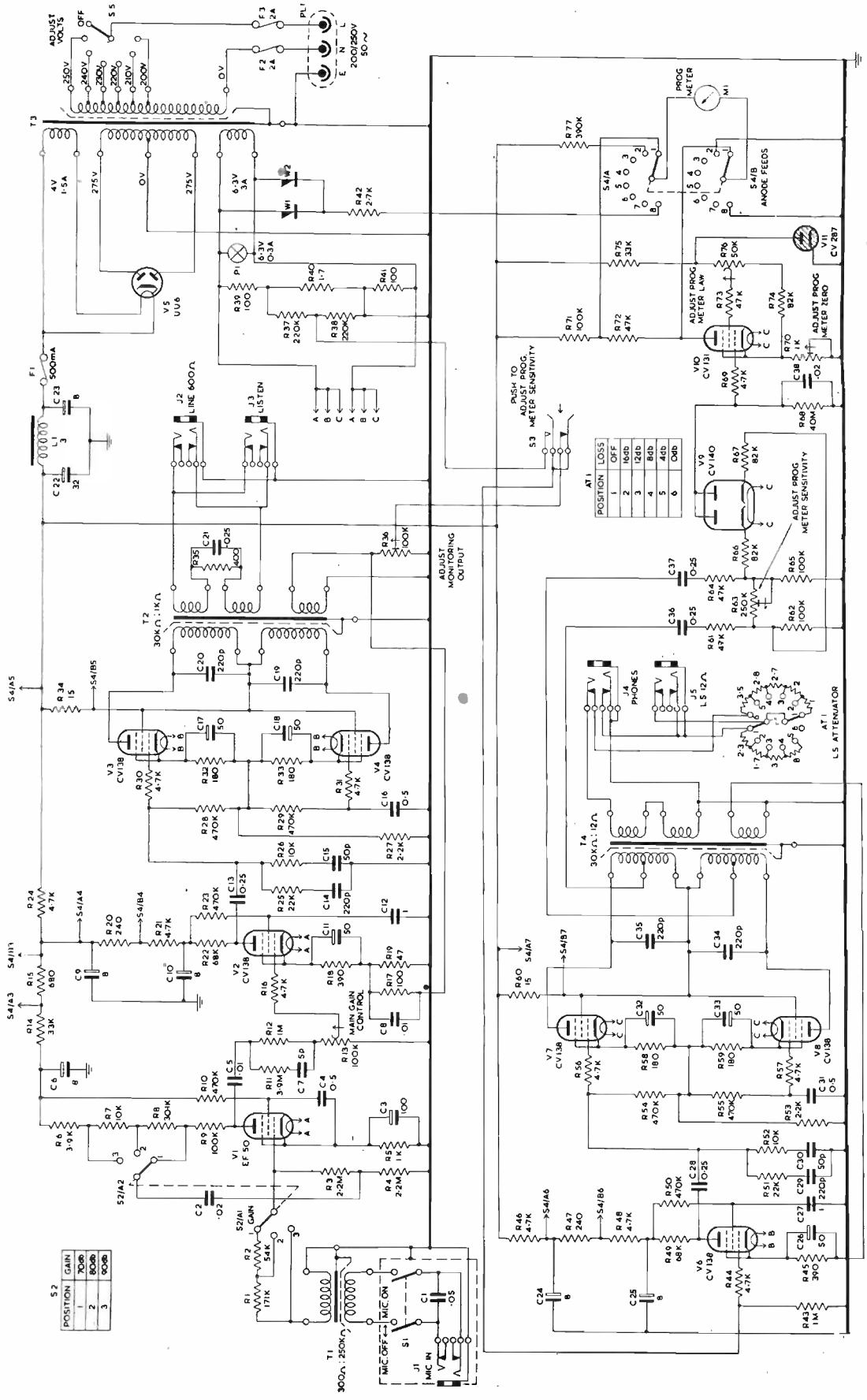


Fig. 1. The complete circuit diagram of the amplifier

on the transformer at the same value when the feedback is increased.

As in the earlier portable equipment,[1] T_1 is in effect, a filter circuit, a shunt capacitor C_1 being added on the primary side to complete the network formed by the leakage inductance, winding and circuit capacitances. This device makes it possible to use a relatively high step-up ratio—300 ohms : 250,000 ohms in the present instance—so that the signal level at the grid of V_1 is sufficient to allow A.C. to be used for the heater supply to this valve. Because of the high value of impedance at the grid of V_1, the secondary of T_1 must be so wound as to minimize the self-capacitance. Low-capacitance windings are necessarily wasteful of space and the result is thus a rather bulky transformer. Unfortunately, the size of T_1 cannot be reduced without also reducing the step-up and hence the signal-to-noise ratio. Therefore, when adapting the above circuit for the present purpose, T_1 was retained in its original form and, as will be seen later, the usual relative sizes of input and output transformer are actually reversed.

At the time when the amplifier was designed, miniature valves having a sufficiently low level of hum and microphony for first stage operation were not available. As a compromise, however, selected specimens of the EF50 are used.

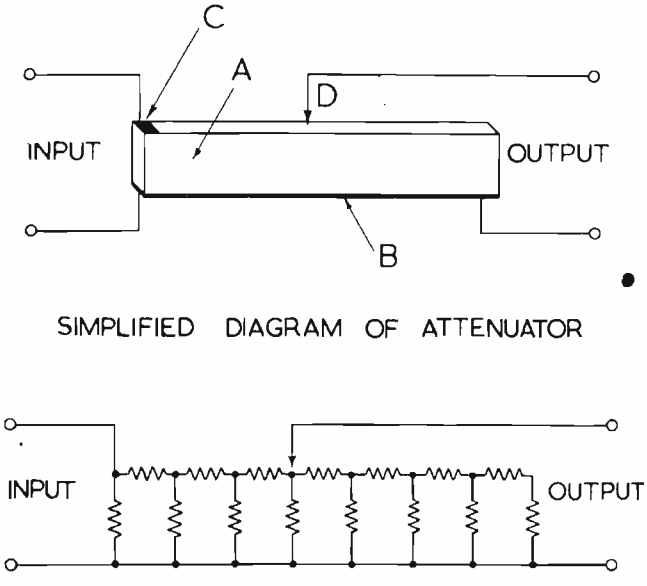


Fig. 2. The interstage attenuator

Even high-grade microphones may have slightly non-uniform frequency characteristics and it is convenient to compensate for these effects by equalization within the microphone amplifier. To this end, the circuit was designed with a certain amount of excess gain. Where no equalization is required, this extra gain is offset by the loss in a high series resistor R_{12} which is interposed in the input circuit of the second stage. The impedance of the circuit is high and a rise or fall in either high or low frequency response can therefore be brought about by the use of quite small series or shunt capacitors in conjunction with suitable values of resistors. Advantage has been taken of this arrangement to correct for a slight high frequency loss in the first amplifier stage by the addition of capacitor C_7 and resistor R_{11} shunted across R_{12}. The limit to the amount of equalization obtainable is set by the permissible variations in the load imposed on the anode of V_1, for any change in the voltage gain of that valve would affect the input impedance of the amplifier. Up to 10db of equalization can, however, be obtained without serious disturbance of the input impedance.

(b) MAIN GAIN CONTROL (R_{13})

A special type of carbon track attenuator provides a continuously variable gain control between the first and second stages. This attenuator was devised in 1946* in the B.B.C. Research Department by C. G. Mayo and R. H. Tanner. The principle of operation is illustrated by the simplified diagram of Fig. 2. The attenuator is formed by a block of resistance material A, of which the underside is covered with conducting material B. The input to the attenuator is applied between B and a fixed electrode C, while the output is taken between B and an electrode D which can be moved along the upper surface of A. The theory of this device is outside the scope of this article; a full mathematical treatment has recently been published in America.[3] As an approximation, the various series and shunt paths through the resistance material may be considered as roughly equivalent to the elements of a ladder network and the attenuation in decibels is proportional to the displacement of the slider D over a wide range. In the practical embodiment of this device as used in the the microphone amplifier, the block of resistance material is bent into a circular form and mounted in a $1\frac{1}{2}$in. diameter casing, similar to that of a conventional carbon track potentiometer. Fig. 3 shows an exploded view of an experimental model using a resistance element made

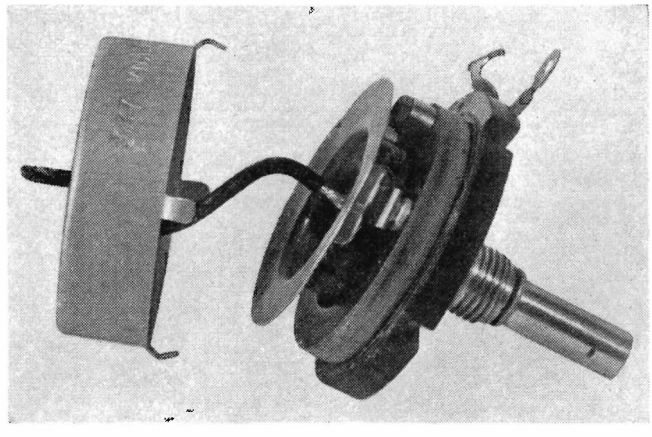


Fig. 3. The interstage attenuator showing dished screen around the output connexion

by the Morgan Crucible Co., Ltd. The output impedance of this attenuator, unlike that of a conventional potentiometer, does not become low when the attenuation is high. It is thus important to avoid stray capacity coupling between input and output, and the slider connexion is therefore carefully screened both inside the attenuator and in the external circuit. The useful range of the model illustrated is about 70db.

(c) LINE AMPLIFIER (VALVES V_2, V_3 AND V_4)

The line amplifier was designed as a standard unit for incorporation in this and other pieces of equipment.

The circuit involves no fundamentally new principle. A single-ended gain stage V_2 drives one valve, V_3, of a class-A push-pull pair of which the other valve, V_4, derives its signal from the voltage developed across the common cathode resistance R_{27}. Because of the high mutual conductance of the valves used, the degree of unbalance between the signal currents in the anodes of V_3 and V_4 is only of the order of 6 per cent. This method of obtaining a push-pull drive was originally described in an earlier publication.[1] Negative feedback is taken from a tertiary winding on the output transformer T_2 to the

* *Prov. Pat.* 963/47. *January* 10, 1947.

cathode of V_2, the loop gain in the audio-frequency band being 24db. With this degree of feedback, the impedance looking back into the secondary of T_2 is 200 ohms and a series resistance R_{35} is added to raise the output impedance of the amplifier to the required value of 600 ohms.

To reduce the voltage to be handled by the output transformer T_2, the anode load of V_3 and V_4 is made about 60 per cent of the optimum value, a compromise which makes it possible to keep the size of T_2 to $2^5/_{16}$in. by $1^9/_{16}$in. by $2^3/_{16}$in. high over tags and the weight to 7¼ozs. Although each winding on the transformer is divided into two by a central partition on the spool, the total number of sections is, in effect, only three, one primary and two secondaries. With this arrangement of windings, the leakage inductance is sufficient to cause a slight loss in the 10-15kc/s region. To reduce the loss by increasing the number of sections would be difficult in such a small transformer and would lead to considerable complication of the feedback windings. Instead, the leakage inductance is approximately compensated over the frequency range concerned by shunting R_{35} with a capacitor C_{21}. By this means, the amplifier as a whole is made to present an almost constant output impedance up to 15kc/s.

Because of the small number of sections used in the output transformer, extensive distribution of the feedback winding is unnecessary. Each half of the primary winding is split to allow half of the feedback winding to be interposed. As the feedback winding consists of only a few turns of fine wire spread out in a single layer, the capacitance to earth introduced at the junction of the two parts of each primary winding is not sufficient to cause serious internal phase shift. To give the form of loop characteristics required for stability, the forward gain of the system is progressively attenuated at high frequencies by step circuits R_{25}, C_{11} and R_{26}, C_{15}, while a slight rise in response with a corresponding phase lead is introduced into the feedback path above the audio-frequency band by R_{17}, C_8.

The overload point of this amplifier is at approximately 750mW, of which 300mW are dissipated in R_{28} and 450mW are delivered to the external load.

(d) MONITORING AMPLIFIER (VALVES, V_6, V_7 AND V_8)

For convenience, the input to the monitoring amplifier is taken from the feedback winding on the output transformer T_2 of the line amplifier. The circuit of the monitoring amplifier is basically the same as that of the line amplifier, but the output is designed to operate into a 12 ohm load. Since a low output impedance is desirable, the building-out resistance is omitted with a consequent gain in efficiency and the amplifier will thus deliver the full 0.75W to the load. With a modern high-efficiency loudspeaker, this power provides adequate sound level for checking purposes.

(e) PEAK PROGRAMME METER (VALVES V_9 AND V_{10})

This circuit is of the form standard in the B.B.C. Both halves of the signal wave are rectified by the double diode V_9 which charges capacitor C_{38} negatively. The voltage change across C_{38} is converted by the variable-μ valve V_{10} to a current change in the milliammeter M_1, which is made with a right-hand zero to avoid the necessity for a backing-off circuit. The operating characteristics of V_{10} are adjusted to give a roughly uniform decibel scale over a range of 20db.

The input to the double diode V_9 is taken from the output stage of the monitoring amplifier. The diodes necessarily impose on this stage a non-linear impedance load and to minimize the distortion thus introduced into the monitoring circuit, the programme meter input is tapped down on the primary of T_1 and further isolated by resistors R_{61}, R_{61} and R_{66}, R_{67}.

For many purposes, it is desirable that the reading of the programme meter should be proportional to the internal E.M.F. at the amplifier output and thus be independent of load impedance. Although the input to the monitoring amplifier and programme meter is derived, as already stated, from the feedback winding on T_2, the circuit constants are such that the above requirement is approximately met. Of the 600 ohms output impedance presented by the line amplifier, 400 ohms are provided by the resistance R_{35}, while the resistance of the transformer secondary winding accounts for another 130 ohms. The remaining 70 ohms represents the true output impedance of the stage and it is in effect the voltage across this impedance which is registered by the programme meter. It can readily be shown that if the programme meter is lined up to read correctly with the amplifier working into a 600 ohm resistive load, the maximum error involved in assuming the meter to read the true internal E.M.F. is $\pm\frac{1}{2}$db for any load condition from short circuit to open circuit.

Since the programme meter is fed from the monitoring amplifier, the gain of the latter must be kept constant. Control of the loudspeaker volume is, therefore, affected by an attenuator AT_1 following the output transformer. This attenuator provides four steps of approximately 4db each and is designed to keep the impedance presented to the loudspeaker as low as possible without presenting too low an impedance to the monitoring amplifier output. Because of the degree of negative feedback used in the loudspeaker amplifier, the variation in the loudspeaker impedance with frequency has only a slight effect on the programme meter frequency characteristic. The maximum deviation arising from this cause is $\pm\frac{1}{2}$db, and even this figure could be reduced, if necessary, by rough equalization of the loudspeaker impedance.

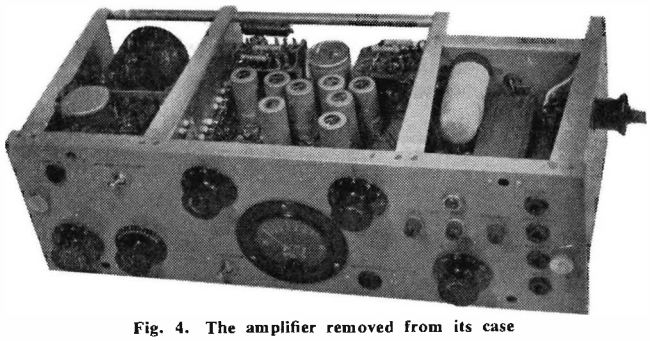


Fig. 4. The amplifier removed from its case

It might at first sight appear that the use of an attenuator between the monitoring amplifier and the loudspeaker would lead to overloading of the amplifier, but this is not the case in the present design. The adjustment of potentiometer R_{36} is pre-set so that the monitoring amplifier overloads at a programme meter reading corresponding to an output from the line amplifier 4db above the maximum rated level. Control of the main output thus automatically ensures sufficient margin of safety. The programme meter sensitivity is adjusted according to the output level required by potentiometer R_{63}, an internal calibrating voltage for this purpose being derived from the heater supply via resistors R_{37}-R_{41}. The heater voltage in turn is checked by the programme meter itself via the rectifiers W_1, W_2 and meter switch S_1, the mains tapping switch S_5 being adjusted as required to bring the reading to a fixed point on the scale.

(f) POWER SUPPLY (VALVE V_5)

The iron-cored components in the supply circuit are designed for minimum size and weight. The mains transformer on the prototype was wound on a stalloy core, 3½in. by 3¼in. by 3¾in. and weighed 4.3lb. It has been recently redesigned on a grain-oriented silicon iron core, the dimensions being reduced to 3¼in. by 3¼in. by 2¾ in. and the weight to 2.7lb. The smoothing choke is wound on

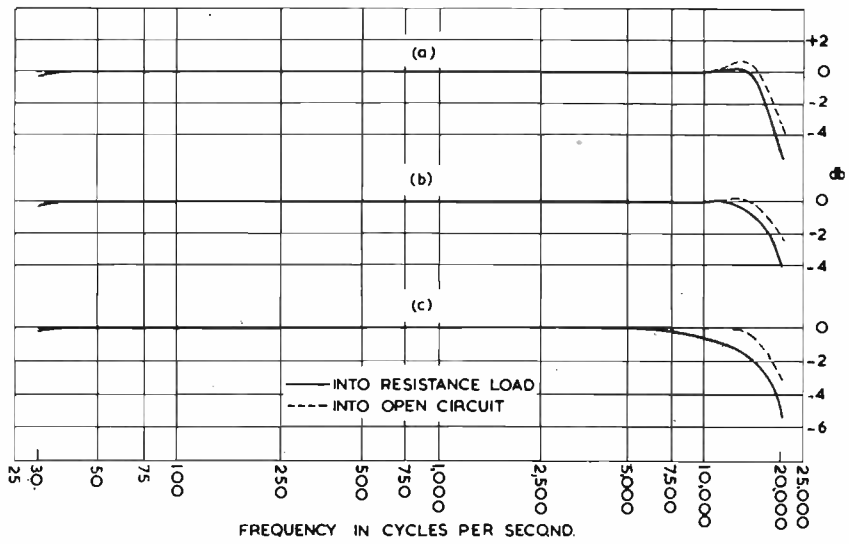


Fig. 5. Frequency response
(a) 600 ohm output, 70db gain setting
(b) 600 ohm output, 80db and 70db gain settings
(c) 12 ohm output, 70db gain setting

a radiometal core having a gapped centre limb. This form of stamping gives a small external field, an important point in compact equipment, while the sliding friction between laminations ensures a high degree of mechanical stability of the gap without the use of special core clamps. The choke is $1\frac{5}{8}$in. by $1\frac{1}{2}$in. by $1\frac{1}{8}$in. and weighs $4\frac{1}{2}$ ozs.

Metering of anode feeds is carried out on the meter M_1, the values of the shunts being so adjusted that the normal feeds of the various stages correspond to the same point on the meter scale.

The power consumption of the amplifier is 48W at 200/250V, 50c/s.

Mounting and Layout

The complete apparatus described above is accommodated in a carrying case 17in. by 10in. by 6in. To achieve such a degree of compactness while retaining reasonable accessibility to components, careful layout and screening are essential; the voltage gain per stage is high and the frequency response can be seriously affected by quite small stray capacity couplings.

Fig. 4 is a photograph of the assembly out of its case, showing the upper side of the chassis. It will be noted that T_1, V_1 and V_2 are carried on a rubber-mounted sub-chassis at one end of the amplifier while the power unit is housed in a separate compartment at the other end.

The weight of the complete assembly as originally designed was $19\frac{1}{4}$lb. and with the new power transformer, the figure is reduced to just under 18lb.

Performance

The following figures give the performance of a typical specimen of the amplifier described above.

Frequency Response

See Fig. 5. The constancy of the output impedance with frequency can be judged from the small difference between the frequency response in the on-load and open-circuit conditions. This difference can be made even smaller by adjusting the value of C_{21} to suit individual output transformers, the leakage reactance of which varies slightly according to the tension used in winding them. In the case of the 12 ohm output, there is no compensation for leakage inductance and the output impedance therefore rises slightly at high frequencies. However, the cone loudspeaker used presents an inductive load so that no loss occurs in practice from this cause.

Noise

With main gain control set at maximum

Gain	Noise output, relative to 1mW
90	−38db
80	−44db
70	−48db

For comparison it may be noted that the calculated out-

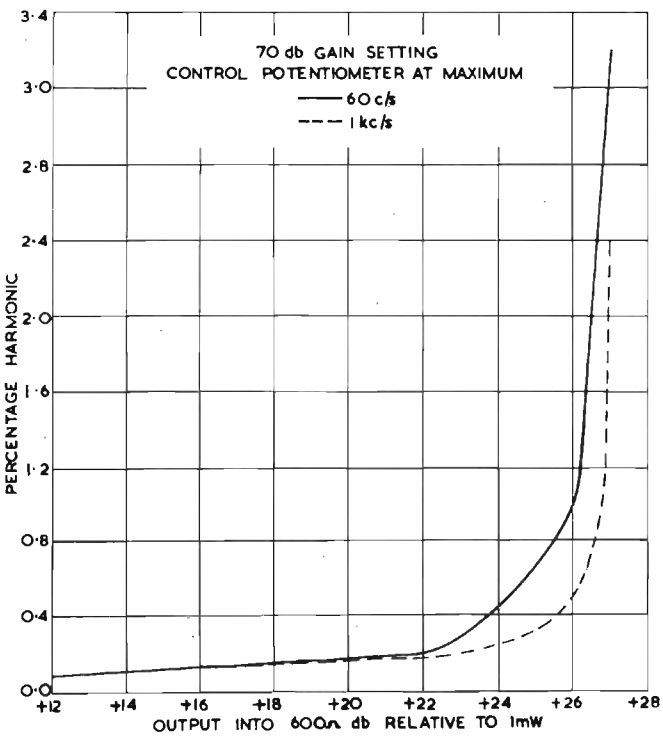
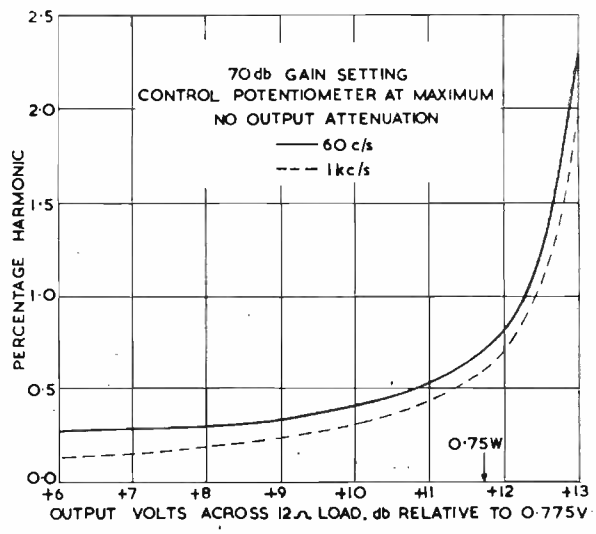


Fig. 6 (left). Overall distortion
Fig. 7 (below). Distortion of 12 ohm output stage



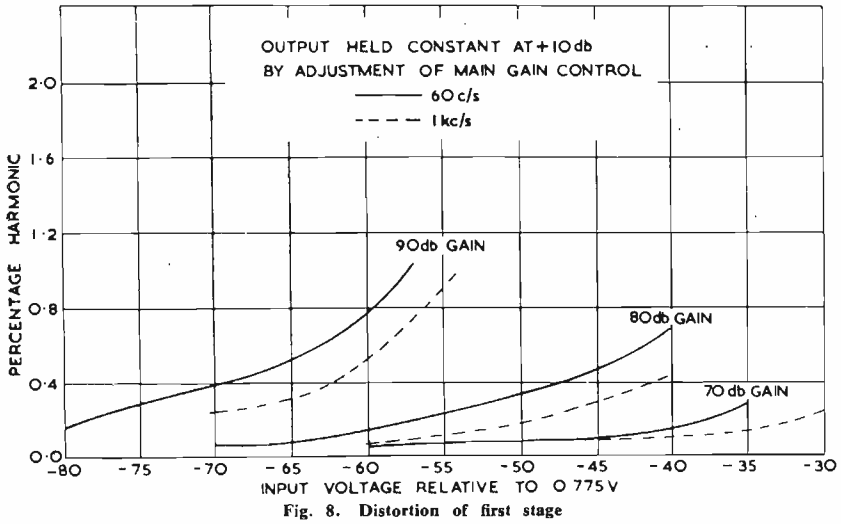


Fig. 8. Distortion of first stage

put from thermal agitation in the input circuit, including 300 ohms source, is −42db for a 15kc/s frequency band and 90db gain.

DISTORTION

To cover all possible gain settings, the circuit has been treated for the purpose of distortion measurement as two separate amplifiers in cascade.

All amplifier valves are operated under class-A conditions with sufficient negative feedback to keep the distortion small over the working range. In these circumstances, it is legitimate to take the total harmonic distortion as an indication of the degree of linearity of the system. An exception must be made in the case of the distortion introduced into the monitoring circuit by the rectifier of the peak programme meter. As this type of distortion is greatest immediately after the arrival of a signal, before the capacitor C_{38} has had time to charge, steady-state measurements are misleading and careful listening tests had to be carried out to check the performance of the amplifier in this respect.

Fig. 6 shows the overall distortion with the 70db gain setting and the control potentiometer at maximum. Here, the distortion is principally that of the line amplifier.

Fig. 7 shows the distortion of the 12 ohm output stage under the same conditions.

Fig. 8 shows the distortion introduced by the first stage, the output to line being restricted to a low value so as to keep other distortions small.

Acknowledgments

The authors wish to acknowledge the help received from their colleagues in the B.B.C. Engineering Research Department, and in particular, the technical assistance rendered by Mr. C. G. Mayo and the work of Mr. S. H. Holmes on the mechanical layout. They are indebted to the Chief Engineer of the B.B.C. for permission to publish this article.

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The Noise Limited Amplifier

By A. Q. Morton

THERE is present at the input of an amplifier a random noise voltage which is the sum of the Johnson noise in the resistive component of the input impedance and the valve noise. In a typical case for a 20kc/s bandwidth the noise across a 100 kilohm resistor will be about 5 microvolts and valve noise will be much less. Hum will be present but by selecting a suitable valve and paying attention to the layout of the input stage the hum can be reduced to within 6db of the Johnson noise and at this level the insensitivity of the ear at mains frequencies renders it inaudible while the smooth hiss of random noise is clearly heard.

If the signal is derived from a modern transducer it will be only a few hundred microvolts and at the output of the transformer or equalizer will probably not exceed 50 millivolts peak. This fixes the best possible ratio of wanted-unwanted output at about 70db. It is unlikely that the amplifier will not generate much more than that. If, however, negative feedback is applied from the output to the input it will reduce the distortion and by using part of the input signal to overcome the feedback voltage, it will degrade the signal-random noise ratio in the same measure. It is therefore practical to make an amplifier which is noise limited, that is one which has at the rated output noise and distortion equal. It cannot be bettered, for more feedback would reduce the distortion but it would then be masked by the noise, less would mean that a possible reduction has not been realized.

Given input and output signals and impedances it is possible to fix an absolute limit to the performance in terms of random noise, the nearest approach will be the noise limited condition. It is hoped shortly to describe an audio amplifier noise limited over the audible range in which noise and distortion are .03 per cent of the rated fifteen watts output—voltage of 15 volts.

The author has been denied the opportunity to extend the theory to the wide band amplifiers used in television, in that field the construction of a noise limited amplifier should be much simpler.

JOHNSON NOISE

The random noise in a resistance of R ohms is $\sqrt{4ktr\Delta f}$

Where k is Boltzmann's constant, 1.37×10^{-23}
t is the absolute temperature
Δf is the bandwidth in c.p.s. it can be taken as the half power points with negligible error.

VALVE NOISE

Valve noise is referred to an ohmic resistance which would give rise to the same noise by the Johnson effect.

For triodes it is $\frac{2.5}{g_m}$ Ω

For pentodes it is $\frac{I_a}{I_c}\left\{\frac{2.5}{g_m} + \frac{20\,I_a}{g_m^2}\right\}\Omega$

Microwave Rotating Joints

(Part 1)

By J. P. Grantham *

MICROWAVE aerials are frequently required to have very narrow beamwidths and also to cover a field of view much greater than a beamwidth. Continuous rotation is usually required in the horizontal plane and vertical movement is necessary in some cases. When a waveguide feed is used, one or more rotating joints will be required between the fixed waveguide and the feed attached to the aerial; it is not usually desirable to fix the whole of the microwave equipment to the aerial.

This paper describes most of the known forms of microwave rotating joints in such a manner that anyone requiring a rotating joint for a specific application may be able to decide which form is the best for that application. In cases where the author's work has added to the information already published, the results of this work are given in the text; in other cases, brief descriptions only are given and fuller details may be obtained by reference to the works listed in the bibliography. It is hoped that reference to this paper and to the appropriate works in the bibliography will help the reader to design the required form of rotating joint with the minimum experimental work. Curves of guide wavelength against free-space wavelength are given for the $H_{1\cdot1}$ and $E_{0\cdot1}$ modes in circular waveguides and there is a short appendix devoted to radial waveguides as applied to half-wave chokes.

The material in this paper is drawn from the author's original work and from general literature published in this country and the U.S.A. The author has been faced with various problems concerning rotating joints for broad-band *X*-band (3cm) applications. These problems led to investigations of the various rotating joints using circular waveguides carrying the $E_{0\cdot1}$ mode and to the abandonment of this form of joint in favour of the concentric-line type. In the course of these investigations, circular waveguide rotating joints, using the $E_{0\cdot1}$ mode, of the types referred to in the text, were designed on the lines indicated, using the original papers on the subjects. Although most of these papers are not generally available, and are, therefore, not listed in the bibliography, the more important parts of the work described in them appears in the literature in the bibliography. In general, the results given in these papers were confirmed and in this paper the author has laid stress on the disadvantages found to belong to these joints. These disadvantages led to a search for a different form of rotating joint and to the investigation of the concentric-line joint. The work on the concentric-line joint produced an improved form of doorknob coupling, which satisfied the author's requirements. The new type of doorknob concentric-line-to-waveguide coupling forms the basis of a broad-band rotating joint requiring no matching diaphragms. One of the problems encountered was the design of a two-channel rotating joint, whose characteristics did not vary on rotation and where one channel was to carry low power only; the concentric line joint was the only solution found to this problem; the low power channel was run down the centre of the high power line, the latter being designed for maximum power-capacity. The small size of the concentric-line joint was found to be an advantage in applications involving high rotation speeds. The slip-ring joint mentioned at the end of the paper was developed in the laboratory for a special application, but was never put into production. Sufficient work was done on this joint to show that the design is quite practical and it is deemed worthy of mention as it is one of the few joints that can be designed with a large diameter hole in the centre of the structure.

A suggestion for a new form of concentric-line-to-waveguide transformer is made later in this article. The idea is suggested by the bi-conical dipole, which is known to be a very broad band aerial. Unfortunately, it has not so far been possible to carry out any work on this subject. If the reader wishes to investigate this transformer, there are many papers available on bi-conical dipoles and the textbooks listed in the bibliography consider the concept of aerials in waveguides.

The text of the paper is divided into two main sections; Section 1 being concerned with Circular-Waveguide Rotating Joints and Section 2 with Concentric-Line Rotating Joints. There follows a short description of the slip-ring joint and an appendix on radial waveguides.

As the circular-waveguide rotating joint is commonly used at the present time, and was investigated by the author before any work was done on the concentric-line joint, it will be considered first.

Circular-Waveguide Rotating Joints

The form of rotating joint most widely used at the present time consists of a rectangular-waveguide-to-circular-waveguide transition, followed by a length of circular waveguide and completed by a second transition. The circular waveguide is broken at one point to permit rotation, some form of half-wave choke being used at the break.

In order to obtain the full 360° rotation, a circularly symmetrical field is required in the circular waveguide in the plane perpendicular to the axis. The five lowest modes (in order of cut-off wavelength) in circular waveguides are $H_{1\cdot1}$ ($\lambda_c = 3.41a$); $E_{0\cdot1}$ ($\lambda_c = 2.61a$); $H_{2\cdot1}$ ($\lambda_c = 2.06a$); $H_{0\cdot1}$ ($\lambda_c = 1.64a$); $E_{1\cdot1}$ ($\lambda_c = 1.64a$): where a = tube radius. It will be seen from Fig. 1 that the $E_{0\cdot1}$ mode is the lowest that is suitable.

The circular-waveguide-to-rectangular-waveguide transition should therefore excite the $E_{0\cdot1}$ mode in the tube with minimum reflexion and should, preferably, suppress the $H_{1\cdot1}$ mode. As the $H_{1\cdot1}$ mode may be suppressed elsewhere than in the transition, it is proposed to consider transitions first purely as $E_{0\cdot1}$ couplings and then to deal with the more difficult problem of $H_{1\cdot1}$ suppression.

Rectangular Waveguide to Circular Waveguide Transitions

Type 1. *Fig.* 2

The transformer is matched by the piston *P* and also with a diaphragm in the rectangular waveguide. This coupling is narrow-band and is not now in general use. It is convenient for spot-frequency use in the laboratory, when an adjustable piston can be incorporated in the equipment. A development of this transformer, in which the piston is inside the end of the tube, forming a flat step, (Fig. 3) is in use at *S*-band, but has not been adopted for *X*-band equipments on account of voltage-breakdown troubles.

* *Royal Naval Scientific Service.*

Type 2. *Fig.* 4

The transformer is matched by the half-wave stub, the stub length being made approximately half a guide-wavelength for the $E_{0\cdot1}$ mode. A bandwidth of about 5 per cent can be obtained, if a matching diaphragm is used in the rectangular waveguide. The match can be improved by choosing the optimum diameter for the stub, which will be less than the tube diameter.

Type 3. *Fig.* 5

The coupling is matched by a transformer at the end of the circular waveguide, the rectangular waveguide being fed into the transformer section. The diameter d is chosen to give the best match. A good broad-band transformer is obtained by adding a capacitive diaphragm in the circular waveguide and an inductive iris in the rectangular waveguide. It is claimed that such a transformer gives an input V.S.W.R. not less than 0.9 over a 12 per cent band.

The above remarks relate to a single transition. A complete rotating joint will consist of two transitions joined by a length of circular waveguide. The length (L) of the joint may be chosen so that the impedance changes with wavelength of the two transformers approximately cancel over a band. As this band becomes smaller as the length of the joint is increased, this method of improving the match is only effective with short joints; the phase change with wavelength increases as the length of the joint increases.

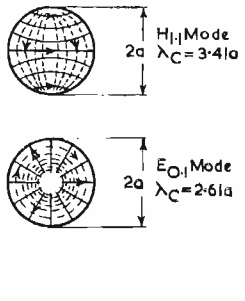

Fig. 1. E and H fields in circular waveguide

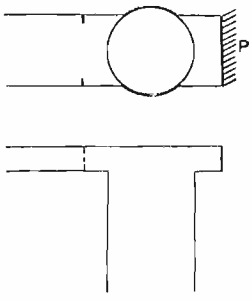

Fig. 2. Simple narrow band transition

The following results (taken by Preston at M.I.T.) will serve as an example. The two lengths chosen were adjacent worst and best lengths.

Wavelength (cm.)	V.S.W.R. (L=9.4cm.)	V.S.W.R. (L=7.5cm.)
3.170	0.89	0.96
3.185	0.94	0.95
3.200	0.95	0.95
3.215	0.89	0.95
3.230	0.83	0.93

THE SUPPRESSION OF THE $H_{1\cdot1}$ MODE IN CIRCULAR WAVEGUIDES

The presence of the $H_{1\cdot1}$ mode is most noticeable when the length of the tube approaches a multiple of half a guide-wavelength for the $H_{1\cdot1}$ mode. If the rotating joint is to be used over a narrow band, so that the length may be chosen to lie well clear of an $H_{1\cdot1}$ resonance, elaborate precautions for suppressing the $H_{1\cdot1}$ mode are not required.

In all the simpler methods to be described, suppression is not complete and resonance will occur as the effective length L of the tube approaches a multiple of half a guide-wavelength for the $H_{1\cdot1}$ mode. The input impedance varies over a wide range around such resonances. Since the $H_{1\cdot1}$ mode is not axially symmetrical, the effective length L will vary as one end of the joint is rotated relative to the other. This means that for each frequency over a band there will be an angular position at which resonance occurs. This is one limitation on the useful bandwidth of the joint.

It has been shown (Farr—M.I.T.) that at resonance for a first order mode:

$$L/\lambda_g = \tfrac{1}{2} + (\tfrac{1}{4}\pi)\cos^{-1}[\cos(\alpha + \beta)\cos^2\theta + \cos(\alpha - \beta)\sin^2\theta]$$

where θ is the angular position of one coupling relative to the other.

λ_g is the guide wavelength for the mode considered.

α and β are characteristcis of the couplings.

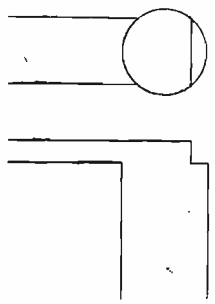

Fig. 3. Improved narrow band transition

Thus the requirements for a broad band between resonances are that α and β be small. However as the couplings must in the first place be designed for good $E_{0\cdot1}$-transformation and good $H_{1\cdot1}$ suppression it is not usually possible also to design for the smallest change of L on rotation.

There is another limitation on bandwidth between resonances, depending on the length of the joint. This may be shown as follows:

For a given L, let there be a resonance at λ_1. Calling the guide wavelength for the $H_{1\cdot1}$ mode $(\lambda_g)_1$ at a free space wavelength λ_1.

$$(n/2)\ (\lambda_g)_1 = L \quad \ldots\ldots\ldots\ldots\ (1.1)$$

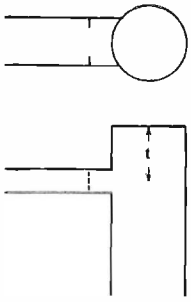

Fig. 4. Stub matched transition

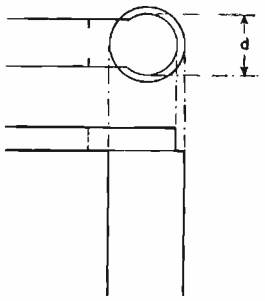

Fig. 5. Transformer matched transition

at another wavelength λ_2, calling the $H_{1\cdot1}$ guide wavelength $(\lambda_g)_2$ there will be a resonance when

$$[(n + 1)/2]\ (\lambda_g)_2 = L \quad \ldots\ldots\ldots\ldots\ (1.2)$$

Then

$$n/(n + 1) = (\lambda_g)_2/(\lambda_g)_1 \quad \ldots\ldots\ldots\ldots\ (1.3)$$

Now

$$\lambda = 1/\sqrt{(1/(\lambda_c)^2 + 1/(\lambda_g)^2)} \quad \ldots\ldots\ldots\ldots\ (1.4)$$

Therefore

$$(n/n+1)^2 = (1-\lambda_c^2/\lambda_1^2)/(1-\lambda_c^2/\lambda_2^2) \quad \ldots\ldots\ (1.5)$$

as n increases, the left-hand side of Equation (1.5) approaches unity, and λ_1 approaches λ_2. Therefore, the useful bandwidth of the joint decreases as the length of the joint is increased, until the bandwidth becomes zero.

Where Δf is the band over which resonance occurs on rotation, a representative figure for $\Delta f/f$ is 1 per cent. This must in practice be increased to about 2 per cent to allow for manufacturing tolerances.

Even at frequencies well clear of resonance the presence of the $H_{1\cdot1}$ mode will be noticed in a change of phase of the input match on rotation, which may in some cases cause pulling of the transmitter frequency.

There follow descriptions of three methods of suppressing the $H_{1\cdot1}$ mode. In general, the effect of rotation on the resonant frequency is greatest in rotating joints employing resonant rings in circular waveguides.

Method 1. *Fig.* 6

Two rings, resonant to the $H_{1\cdot1}$ mode, are placed in the circular waveguide perpendicular to the axis of the tube, one near each end of the tube. The exact position is chosen

to give the best match consistent with a small change in input match on rotation. The best position for the rings will be about half a wavelength (for the $H_{1,1}$ mode) from the ends of the circular waveguide. Some experimental results are given at the end of this sub-section showing the effect of ring position in an S-band joint. The amount of $H_{1,1}$ power transmitted by the ring increases as the polarization of the E vector approaches the direction of one of the arms supporting the ring. If the ring is mounted on metal arms, this variation is large and the amount of $H_{1,1}$ power transmitted in the worst position is large enough to make the mode suppression ineffective. A

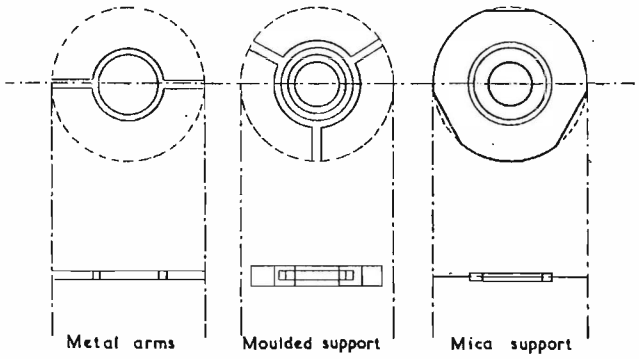

Fig. 6. Resonant ring for mode suppression

change has been quoted of 1 per cent to 50 per cent $H_{1,1}$ power transmitted by a ring with two metal supporting arms. It is usual, therefore, to mount the rings on insulating arms or supports. The material used must not distort at the temperature reached inside the waveguide, as even a small distortion will move the rings sufficiently to upset the match. If distrene is used there is a danger of the rings falling out altogether. Fluon (polytetrofluorethylene) would be more suitable, but is not very rigid. Ruby mica has proved satisfactory at *S*-band, but great care is needed when assembling the rotating joint if the mica is not to be damaged.

The bandwidth of the resonant rings themselves is adequate, as other factors limit the bandwidth of the joint to less than the ring bandwidth.

Voltage - breakdown problems are often encountered with $H_{1,1}$ resonant rings. While it is true that a polished ring with rounded edges will not cause breakdown below about 400kW at X-band, at atmospheric pressure, and with a V.S.W.R. of 0.5, this figure is greatly reduced in practice. A rough ring surface or the presence of small particles of foreign matter on the ring or ring supports (such as grease from the bearings) will reduce the safe operating power level. Unless a clean dry atmosphere is maintained inside the tube, this form of $H_{1,1}$ mode suppression is not satisfactory above 200kW to 250kW at X-band.

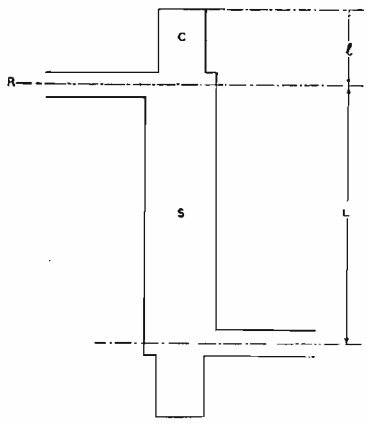

Fig. 7. Stubs for matching and mode suppression

The following results were obtained at a wavelength of 10cm on one coupling of a joint of the improved Type 1. The $H_{1,1}$ mode was suppressed with resonant rings, which were 4.9cm. apart. One end coupling was replaced by an extension of the circular waveguide, terminated by a matched load. The rings were kept 4.9cm apart, and the pair was moved towards the transformer in small steps. The input V.S.W.R. with the rings in the original (best) position was 0.92.

Movement of Rings	Input V.S.W.R.
From original position (cm.)	0.92
0.5	0.92
1.5	0.82
2.5	0.72
3.5	0.70
4.5	0.65
5.5	0.60

Method 2. *Fig.* 7

The rectangular waveguide R is fed into the side of the circular waveguide S and a circular cavity C is placed at the end of the circular waveguide. The length l of the cavity is measured to the centre line of the rectangular waveguide, and the length L of the tube is measured between waveguide centres.

The cavity C may be considered as a reactance in series with the input. For good $E_{0,1}$ transformation, a low series reactance is required and l should be half a wavelength for the $E_{0,1}$ mode. Excitation of the $H_{1,1}$ mode will be discouraged if the series reactance for this mode is high, that is if l is made an odd number of quarter wavelengths for this mode.

If l is made half a wavelength for the $E_{0,1}$ mode, the $E_{0,1}$ transformation will be good. An $H_{1,1}$ resonant ring may then be placed in the cavity a quarter guide-wavelength for $H_{1,1}$ from the input to the cavity. The cavity will still behave as an $E_{0,1}$ half-wave stub, but will also be an $H_{1,1}$ quarter-wave stub.

The objections to a resonant ring discussed above also apply in this case, but there is an alternative solution, which forms the basis of many rotating joints in use at the present time.

If l is made three-quarters of a guide-wavelength for the $H_{1,1}$ mode, a high series reactance will still exist for that mode. By choosing a suitable diameter for C, l can be made sufficiently equal to both three-quarters of a guide-wavelength for $H_{1,1}$ and half a guide-wavelength for $E_{0,1}$. The use of a three-quarter wave stub restricts the bandwidth to some extent, but a bandwidth of at least 5 per cent can be obtained with this transformer.

A good input match can be obtained under these conditions, but the cavity dimensions are very critical. It has been common practice to aim at an input V.S.W.R. of about 0.7 and to improve this with an inductive diaphragm in the rectangular waveguide. However, if care is taken to hold the cavity dimensions within close limits (± 0.001 inch), and to keep the cavity very clean, an acceptable match can be obtained without matching irises. This is important when the joint is to be used at high powers. It is not possible to increase the bandwidth by reducing the Q of the cavity, as the $H_{1,1}$ mode suppression then becomes ineffective.

Suppression of the $H_{1,1}$ mode is not complete, and a rotating joint of this form can only be used clear of $H_{1,1}$ resonances. Long joints have not proved satisfactory, as a reasonable bandwidth can only be obtained by holding the tolerances within very close limits; manufacture of the tube becomes difficult. At X-band, the useful limits of the joint are about 3in. for a 5 per cent to 7 per cent band and about 12in. for a 2 per cent band.

Method 3.

The $H_{1,1}$ resonances could be eliminated if nearly all the $H_{1,1}$ power in the circular waveguide was "coupled" out of the waveguide into absorbing loads. A method of achieving this has been developed and is normally used in

conjunction with one or other of the designs described above.

Narrow longitudinal slots in the circular waveguide will couple to the $H_{1,1}$ mode but not to the $E_{0,1}$. As any $H_{1,1}$ wave may be resolved into two $H_{1,1}$ waves with their polarizations at right angles, four slots spaced at 90° intervals round the tube will couple to any $H_{1,1}$ wave in the tube. These slots may conveniently couple into a cylindrical cavity where the $H_{1,1}$ power is absorbed in rings of resistive material. At X-band the slots will be rather less than one inch long, so the unit is quite compact. It is usual to place an absorbing cavity of this type near each transition, but in cases when the tube is broken near one end it is quite satisfactory to use only one cavity at the middle of the tube. When a single cavity is used, greater care is required in design and construction if all the $H_{1,1}$ power is to be absorbed. When a very long joint is required to operate over a broad band, it is recommended that two cavities be used.

Rotating joints of this form have been made as long as 3ft with bandwidths of 12 per cent at X-band. It is clear that when $H_{1,1}$ resonances can be neglected it is not necessary to maintain close tolerances on the tube diameter and a long joint becomes a practicable possibility. It is still necessary to maintain close tolerances at the end transitions if a good input match is required. If it is required to limit the change of phase of the input match on rotation, it is important that the circular waveguide be truly circular. A tolerance of ± 0.001in. is required on circularity, that is the difference between maximum and minimum diameters at a given cross section, for negligible change of phase on rotation in an X-band joint. A variation of diameter along the tube of 0.001in. to 0.002in. is acceptable.

The Effect of Cavity Variations on Input Match

The following effects were observed on a rotating joint of the type described under Method 2:

When the cavity surfaces were clean but not polished

Wavelength (cm.)	Input V.S.W.R.
3.03	0.80
3.08	0.78
3.1	0.71

When the cavity surfaces were polished

3.03	0.84
3.08	0.83
3.13	0.90

It is most important that there is good electrical contact between the end of the cavity and the walls. Indeed, the cavities should be made from solid castings; soldered end plugs have not proved satisfactory. The figures below relate to four production samples, A and B having cavities machined from solid castings, C and D having soldered end plugs.

Sample	Wavelength (cm.)	Input V.S.W.R.
A	3.03	0.93
B		0.94
C		0.79
D		0.85
A	3.08	0.99
B		0.99
C		0.73
D		0.88
A	3.13	0.97
B		0.93
C		0.67
D		0.99

The following measurements taken on a rotating joint of the type described under Method 2 show the effect of small changes in cavity dimensions. The circular waveguide diameter was 1.180in.; the length between the rectangular waveguide centres was 3.625in. No matching diaphragms were used. The cavity length was measured to the centre line of the rectangular waveguide.

Wavelength (cm.)	Input V.S.W.R. for various cavity lengths				
	1.065 in.	1.079 in.	1.109 in.	1.125 in.	1.140 in.
3.18	0.73	0.74	0.71	0.73	0.74
3.20	0.97	0.96	0.87	0.92	0.87
3.22	0.62	0.62	0.79	0.71	0.75

The cavity diameter was 1.030in. throughout.

Wavelength (cm.)	Input V.S.W.R. for various cavity diameters			
	1.030 in.	1.062 in.	1.078 in.	1.093 in.
3.18	0.71	0.60	0.58	0.57
3.20	0.87	0.61	0.57	0.54
3.22	0.79	0.71	0.67	0.57

The cavity length was 1.109in. throughout.

The following measurements were taken on a joint of similar type, with the circular waveguide diameter 1.187in. and length 16in; the cavity diameter was 1.030in.

Wavelength (cm.)	Input V.S.W.R. for various cavity lengths						
	1.250 in.	1.235 in.	1.221 in.	1.187 in.	1.156 in.	1.125 in.	1.095 in.
3.21	0.33	0.25	0.35	0.96	0.82	0.71	0.68
3.23	0.76	0.84	0.89	0.88	0.92	0.78	0.72
3.25	0.58	0.56	0.53	0.50	0.50	0.50	0.32
3.27	0.56	0.51	0.51	0.51	0.57	0.49	0.47

The cavity length was now fixed at 1.095in.; and the cavity diameter varied.

Wavelength (cm.)	Input V.S.W.R. for various cavity diameters							
	1.030 in.	1.043 in.	1.058 in.	1.062 in.	1.072 in.	1.082 in.	1.092 in.	1.102 in.
3.21	0.68	0.71	0.75	0.76	0.80	*	*	*
3.23	0.72	0.96	0.81	0.78	0.73	0.69	0.66	*
3.25	0.32	0.55	0.83	0.88	0.92	0.81	0.74	0.69
3.27	0.47	0.56	0.71	0.73	0.81	0.81	0.93	0.97

* Signifies the presence of $H_{1,1}$ resonance.

N.B.—The above examples are not intended to show the best rotating joints that can be designed, but to show the order of the effects of varying the cavity parameters.

Rotating Joint with Circular Polarization in the Tube

A rotating joint using rectangular-to-circular-waveguide transitions with circular polarization in the tube has been designed. This form of joint is seldom used, as resonance problems arise and can only be overcome by methods at least as complicated as those applied to the $E_{0,1}$ type of joint. A short description of this joint is given in "Microwave Transmission Circuits" (Vol. 9 of the Radiation Series.)

(To be continued)

Electro-Ceramics

with special reference to Pyrophyllite

By N. E. Hyde*

RAW materials for certain of the ceramics used by the electrical industries of this country are obtained from Bavaria, Italy, India and Egypt. As a result, supplies of these ceramics during and immediately after the recent war were seriously curtailed, and in order to avoid a recurrence of such a situation in any future emergency, a search for a more readily accessible substitute was instituted.

A ceramic-like mineral called pyrophyllite, which was alleged to have stable firing properties and extremely small shrinkage, was thought to be a likely and useful substitute ceramic and a preliminary survey confirmed this view.

The main conclusion drawn from this survey was a strong recommendation that a comprehensive investigation of pyrophyllite should be conducted. The report was distributed throughout the Service Establishments, and, in November, 1949, an Inter-Service Development Contract was placed with Messrs. Bullers, Ltd., of Stoke-on-Trent. The contract covered, firstly, full investigation into the physical and electrical properties appertaining to the unfired and the fired material; secondly, the initiation of experiments with various mixes in an endeavour to improve the H.F. properties should it be found necessary; and finally, investigation of the moulding properties of the powdered material with a view to large-scale production.

It is proposed in this article first to give a very brief account of the origin and history of ceramics, and the processes involved in their manufacture, and then to record the more important characteristics of the pyrophyllite ceramics evolved by Messrs. Bullers as a result of their investigation.[1]

The Origin of Ceramic Raw Material

There appears in nature a great number of rocks or earths which, when mixed with water, form a plastic body or clay capable of being moulded and formed into various shapes (called in the trade " green " ware) which, after the process of firing are termed " biscuit." At any stage in production the material can be called the " body."

These so-called pure clays used in the ceramic industry are said to be the result of decomposition under the influence of water or carbonic acid, of certain eruptive silico-aluminous rocks containing foreign matter. After decomposition there only remain soluble bases, a certain quantity of silica and the so-called pure clay $Al_2O_3.2SiO_2.2H_2O$ referred to above, although such chemical purity as the formula suggests is not found in nature.

Among the rocks which produce these clays the most important are the feldspathic rocks, granites, porphyry, gneiss and eurites. When these rocks contain lime, carbonate of lime is carried away by the rains and deposited as sedimentary beds. Nearly three-quarters of the known surface of the Earth is formed of gneiss and granite containing 60-90 per cent feldspar, a product of the decomposition, through the ages, of feldspathic or crystallised rock.

The clays used in the ceramic industry owe their properties chiefly to the hydrosilicate of alumina, designated kaolinite in mineralogy and pure clay in ceramic technique. The name kaolin is probably derived from the Chinese word " kao-ling " meaning " high ridge ": the ridge, one suspects, from which they obtained the clay for their famous pottery.

Brief History of Ceramic Ware

The Egyptians some 3,000 years ago were probably the first race to discover that mud became hard under the influence of the sun. This occurred where the Nile had overflowed its banks and receded. The fact that the clay could be made much harder by firing was probably discovered by accident, although archaeologists appear to have proof that fired clay vessels were used in various parts of the world at about the same period. There is little doubt, however, that the Egyptians were the first people to make pottery.[2]

In later years, various races carried the manufacture of ceramic articles to a high degree of perfection, but the art was lost during the great migration from Europe in the 4th, 5th and 6th centuries A.D.

Throughout the seventeenth century strenuous efforts were made in Europe to reproduce the remarkably translucent Chinese hard porcelain of the famous Sung Dynasty (A.D. 960-1290) but without success. This failure was due to the fact that nothing was then known by the European of kaolin, the very important constituent of the hard porcelain.

The first European hard ceramics were probably made at Meissen in Saxony in the year 1709 and, in spite of the most extraordinary means employed to guard the secret of manufacture, it leaked out and at about this time various factories sprung up in different parts of Europe. Later, kaolin beds were discovered near Yrieux, in France, and their use very quickly led to the complete abandonment of soft porcelain in that country. The vast Cornish beds were subsequently discovered in the year 1768.

This very brief summary brings us to the beginning of the nineteenth century, to the technicians of which belonged the task of uniting the different branches of the art; of substituting for tradition and the secrets of manufacture the principles of science; of transferring the craft into an industry and of placing the privilege of the few at the disposal of all.

Refractory ware is an invention of the nineteenth century, during which period scientific investigation of the properties of the raw materials and the accuracy of mixings, created an industry which has since rendered possible great progress in the electrical, metallurgical and chemical sciences, so that today their products constitute one of the most important exports.

Although the refractory industry originated in England, Germany was for many years mainly responsible for the chief researches into the properties of the high temperature ceramics; more recently, however, a vast amount of work has been carried on in this country, so that we are now in the forefront of the world's development.

Manufacturing Technique

The visitor to any of the well-known manufacturers of electrical and special porcelains in this country would find

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the production methods and machinery very similar in each case. As the techniques of manufacture may be of general interest, it is proposed to describe them briefly.

Plasticity of the Mix

The plasticity of the mix depends mainly upon the amount of water added and the physical properties of the clay substance itself (ball clay is more plastic than kaolin, for example, because of smaller particle size); if necessary a very little alkaline solution such as sodium carbonate or sodium silicate can be added to produce a "slip" of cream-like consistency. For hand work, more "water of formation" (as it is called) is required than for machining operations, while for pressure moulding the mix should be practically dry or it will adhere to the metal mould.

Preparation of the "Bodies"

Apart from weathering, i.e., exposure to sun, rain and frost, raw material is broken up by various kinds of mechanical crushers, stamp mills and ball mills. The ingredients thus ground are stored, suspended in water at a fixed density, in large containers from which they are passed, as required, to "Blungers" for mixing with more water before passing on to the various processes of cleaning, sieving or screening, and settling. Due mainly to the inadvertant inclusion of metal in the breaking-up stages, it is necessary for the "slip" (as it is now called) to be passed over a magnetic separator before being fed to the filter presses where it is received into large canvas bags which are screwed up tightly together to remove the water. The clay is finally delivered in large slabs or "filter cakes." This plastic "body" is then available for direct use or for "dry body" work.

Plastic "Bodies"

The filter cakes are thrown into mixers or "pug mills" and pass through in much the same way as meat through a housewife's mincing machine, being then fed into a second similar machine called a "vacuum pug." This removes the air from the material which is then extruded in square, round, tubular or other suitable section. In other cases, after the addition of a small amount of sodium silicate to give a creamy consistency,

Fig. 1. "Throwing"

the material passes on to the "slip casting" shop for pouring into moulds. In some factories this creamy slip is piped round in the same way as water in the home.

Dry Mixes

When very accurate mouldings are required, a dry mix becomes necessary. The filter cakes are dried, ground and sifted, and mixed in a special mill which is enclosed to prevent contamination of the air or injury to machinery. Water and oils are added and the mix is then ready for moulding.

"Throwing"

This is the well-known and ancient art of the potters wheel. (See Fig. 1.) A mass of clay from the vacuum pug mill is thrown on to an electrically-driven revolving table. The ancient "thrower" used to knead and reshape his "body" over and over again to extract the air. The vacuum pug mill takes the place of this operation and the body is extruded ready for immediate forming. A piece

Fig. 2. "Jollying"

may be taken, spread out into a pancake on a revolving table, picked up and thrown on to a revolving pattern and the shape of the article formed in a few seconds.

"Jollying"

In "jollying," the body (in a plastic state) is placed into or on a mould or pattern made of plaster of paris. (See Fig. 2.) The mould is fixed to a rotating wheel (jolly) and while the body rotates it is formed to shape by a profile tool. Automatic jollying machines have now been developed for production of plates, cups and saucers, etc. After jollying the body is removed and fired.

Turning

For turning, a dryer mix is used than for jollying and if the article is large a semi-fired body is necessary. This process is similar to wood or metal turning, and the final shape can be quickly obtained by bringing up a profile tool as a last operation.

Slip Casting

For simple shapes, for instance the house brick, a wooden frame or mould is sufficient, but for intricate shapes plaster of paris moulds are used. These are in two parts and after they are tied together the "slip" (which is now drawn from a tap) is poured in and left for a certain time dependent upon the thickness of walls required, after which time the surplus slip is poured away. The mould is left for a while, then opened up and the body is removed for firing. (See Fig. 3.)

Pressing or Moulding

Pressing in steel dies is used for mass production and is carried out with either a wet, semi-wet or dry body. The technique is very similar to ordinary engineering practice and need not be described here.

DRYING

After the " green " ware is completed by any of the above methods it must be dried; this process is carried out in heated rooms rather like components store-rooms and the " water of formation " is driven off. The time of drying is proportional to the thickness, or to the ratio of surface to volume for bodies of uniform thickness. Uniform thickness, symmetrical shape and no projections or sharp corners are advisable objects in design of ceramic bodies, otherwise cracking is likely to take place during either the drying or the firing process.

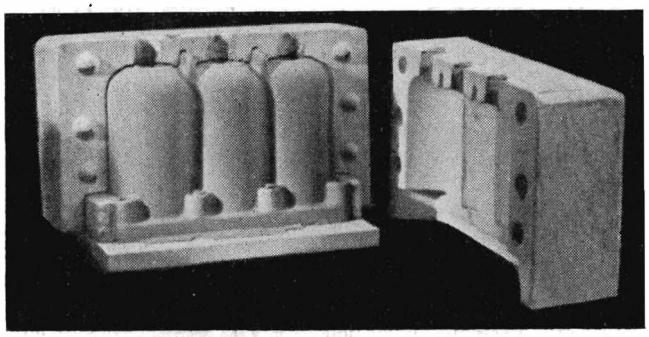

Fig. 3. Casting mould open showing cast article in one half

GLAZING

For obtaining water-repellant surfaces in electro-ceramics transparent glazes are usually employed. The glaze is applied either by dipping, pouring, sprinkling or spraying. Glazing is " fired on," and can be put on before or after colouring.

COLOUR

The artistic colouring of bodies is a most intricate and greatly varied technique, but as it is not directly associated with electro-ceramics it is necessary in this short article to pass it by.

FIRING—THE ACTION OF HEAT ON CERAMIC " BODIES "

Firing is carried out in some form of kiln, of which there are several types. As a result of heating, hygroscopic water is eliminated at about 100°C, then at between 350 and 400°C, which must be reached slowly in order to prevent distortion, the combined water is driven off. Both these stages are critical. The water is slowly liberated up to about 650-700°C during which time the clay begins to decompose. The hydrosilicate of alumina is completely destroyed, all the water removed, the carbon from organic matter burnt, and the material remaining is then composed of alumina and silica. If the temperature is raised still further the silica and alumina form a new anhydrous silicate of alumina, this combination commencing at about 700-800°C and being completed at about 1,100-1,200°C. Finally, at about 1,250-1,500°C, the mixture becomes vitrified. If the temperature is raised still further the mass grows soft and ends by losing shape and fusing. In general, ceramics vitrify between 1,100 and 1,700°C, the refractory materials such as alumina and corundum requiring the higher temperature.

Firing is the most important, and in manufacture, the most difficult operation. During the cycle of firing the evaporation of the moisture causes a diminution of the density and the volume slightly increases. When the silicates begin to be formed the body contracts and has a tendency to fill the empty spaces made by the evaporation of the water and contraction of the organic materials. This continues until vitrification, when the body becomes impermeable and the apparent density attains its greatest value.

TEMPERATURE CONTROL

Control of kilns is carried out by one or both of the following methods:—

1. Pyrometer control.
2. Direct observation.

The former needs no description but its disadvantage is that it gives no indication of the effect of temperature upon the body being fired. This may be ascertained in a variety of ways, the most well known being the use of Seger Cones. (See Fig. 4.) These cones are made of various ceramic mixes and the temperature at which they " squat " indicates the effect of the heat on the work done on the bodies. Seger Cones are calibrated and have " squatting " temperatures of 20-30°C between each cone number. These are passed through the kiln with the articles being fired.

Origin of Raw Materials for Ceramics used in the Electrical Industry

Ceramics used for insulation at low frequency are made from china clay (from Cornwall) ball clay (from Dorset and Devon), feldspar (from Norway, Sweden and Canada), and quartz (silica sand) which is found in England, although the best quartz sand beds are at Fontainbleu in France and in Belgium. For ceramics used as high-frequency insulators some of the above materials are employed together with fluxes, but the main constituent is steatite derived from Bavaria, Rumania, Italy, Spain, Egypt, India and Manchuria. Other ingredients are titanium oxide, barium and strontium sulphate fluxes, and calcium.

Origin of Raw Materials for Pyrophyllite Ceramics

Variations in the composition of various rocks, as well as in the circumstances of their decomposition, explain the formation of other hydrated silicates of alumina having

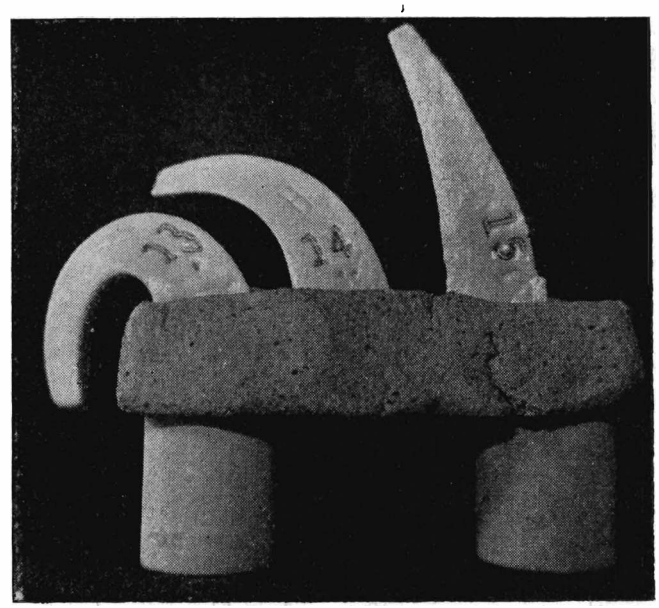

Fig. 4. Pyrometric cones

similar composition to kaolinite; among these is pyrophyllite. Some geologists suppose that some of these rocks may be distinct eruptive products. This especially appears to be the case with pyrophyllite which is a sedimentary and very finely grained compact rock of metamorphosed clay, probably derived from volcanic ash. It has exceptionally uniform texture and composition and is practically free from impurities.

Pyrophyllite, sometimes known as " G " stone, Koranna stone or Wonderstone, occurs in large quantities near the village of Ottosdall in the Lichtenburg district of the

Western Transvaal of the Union of South Africa. The main quarry is on a farm at Gestoptefontein where communication to Johannesburg (165 miles away) is good. On this farm alone the deposit is estimated to be about 600 feet in thickness. A hole bored 200 feet into a hill penetrated the mineral without encountering bands of rock. A conservative estimate gave about 60,000 cubic feet (or roughly 5 million tons) for the contents of this hill. In the whole of the region the quantity available must be enormous.

Pyrophyllite was introduced into the United Kingdom by the Minerals Research Laboratory of the Department of Mines of the Union of South Africa under the auspices of South Africa House, London, in the year 1937. Little was known concerning its physical and electrical properties as the majority of the tests which had been carried out were to what are now considered obsolete specifications. However, the use of the material for experimental and prototype work had been proved by several research laboratories in the United Kingdom, and in 1947 the Admiralty Signal and Radar Establishment used it for the first time in several experimental equipments where a ceramic body was required which could be machined, fired and ready for use in a few days.

At about this time some preliminary moulding indicated that by using a binding agent of either commercial sodium silicate, gum arabic or fire clay, dry pressings which well maintained their shape after firing, with good edges and a smooth surface, would become a practicable proposition. The sodium silicate mix gave the best results.

Properties of Pyrophyllite

CHEMICAL COMPOSITION

The bulk of pyrophyllite is made up of silica and alumina, as is shown by the following approximate analysis (by weight):—

	Surface	100 *ft. deep*	300 *ft. deep*
Silica (SiO_2)	56.29	56.08	54.38
Alumina (Al_2O_3)	33.18	33.37	33.88
Ferric Oxide (Fe_2O_3) ..	1.12	0.79	1.72
Titanium Oxide (TiO_2) ..	2.54	2.42	2.54
Lime (CaO)	0.32	0.29	0.22
Magnesia (MgO)	0.41	0.24	0.36

The small variation in chemical composition at various depths indicates that the rock is of fairly homogeneous character. Two interesting features are the relatively high titanium content and, at the greater depths, the decrease of silica content.

A molecular formula (calculated from the above data) of $3SiO_2.Al_2O_3.H_2O$ may be assigned to the mineral composing the rock. A mineral of this composition is pyrophyllite.

PHYSICAL PROPERTIES

Water Absorption

Despite statements to the contrary, pyrophyllite, even in the raw unfired state, only absorbs 0.25 per cent by weight after 24 hours immersion in water, and after firing to vitrification there is no measurable absorption. After dry pressing of a mix there is no absorption after firing at 1,300°C. This is comparable to the "radio frequency ceramics," and better than the pressed electrical porcelains used for low tension work.

Thermal Shock Resistance

An interesting feature is that when test specimens of 1in. diameter by 1in. long are heated and then plunged into cold water, cracking does not take place unless a temperature of 200-220°C has been reached. This is better than the refractory porcelain used for electric fires, etc.; when mixed with a small amount of sillimanite (an aluminium silicate obtained from India), even better resistance to thermal shock is attained.

Mechanical Strength

Natural pyrophyllite fired at 1,275°C has a tensile strength of 6,200lb/sq. inch, which is comparable with that of any other electrical porcelain. The bending strength is 1,400lb/sq. inch ("natural fired" at 1,435°C) and 6,500lb/sq. inch when moulded and fired. These figures are comparable with those for the pressed electrical porcelains. The impact strength of a moulded pyrophyllite mix fired at 1,275°C is much higher than that for the equivalent moulded electrical porcelain; when fired at 1,435°C it is more than twice as strong, having an impact figure of 0.230 inch lb.

Machinability

As will be seen from the illustrations in Fig. 5, pyrophyllite can be formed into many diverse shapes. Any wood or metal working tool can be used for this purpose and the raw material can be turned, milled, ground, drilled and tapped, or powdered and mixed with other ceramics and fluxes for moulding.

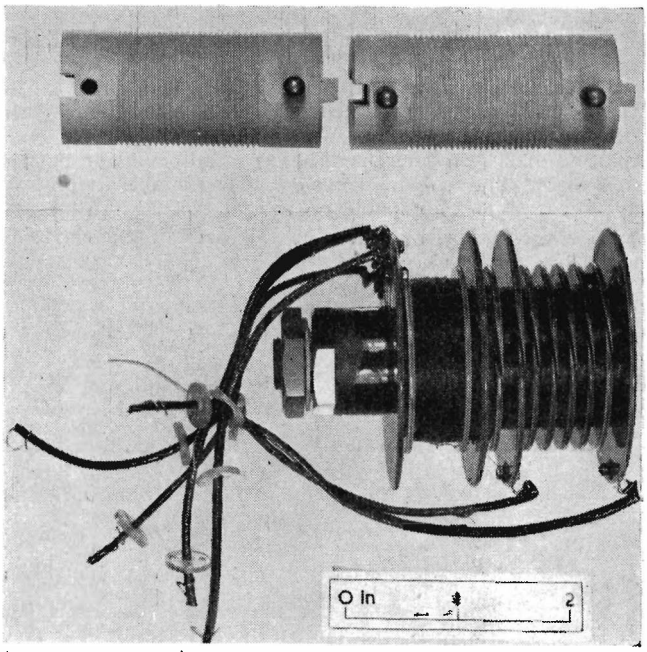

Fig. 5. Examples of Pyrophyllite components

(Top) Coil formers for a delay line in which 2-microsecond sections are interlocked as required

(Bottom) Coil assembly for 5kV R.F. power unit

The ease of machining immediately suggests use in laboratory engineering and experimentation; it may be found advisable, however, to employ dust extractors to remove the fine dust produced during cutting.

If the machined raw material is fired properly there is no measurable shrinkage, this is a property not shared with any other ceramic material.

ELECTRICAL PROPERTIES

The power factor at 1Mc/s for the natural material fired at 1,435°C is 0.007, and at 10Mc/s it is 0.0036. One mix has a power factor at 1Mc/s of 0.002. The permittivity is 5.2. Surface resistivity is of the order of 5×10^{10} ohms per unit square when enclosed at 100 per cent humidity for 24 hours, this property being similar to that of electrical and radio frequency ceramics. Volume resistivity is very high being of the order of 1.3×10^{15} ohms per cm cube at room temperature. The electrical strength is 500kV

(R.M.S.)/inch, which is comparable with other electrical ceramics. Surface breakdown voltage is of the order of 16kV across a 1 inch length between brass electrodes.

MOULDING

One of the main requirements in the contract with Messrs. Bullers, Ltd. was to confirm the "mouldability" of powdered pyrophyllite. A series of ceramic "bodies," based on pyrophyllite with the addition of ceramic plasticiser (bentonite) and various fluxes, was made with the object of finding a mixture which would vitrify at a firing temperature in the range 1,250-1,300°C, this being the temperature used for electrical porcelain.

By using two parts of bentonite to 100 parts of pyrophyllite powder satisfactory dry pressings which require a high firing temperature were obtained. It should here be mentioned that dry pressings are those containing a moisture content of 1 to 5 per cent and are used when minimum shrinkage is necessary to maintain close dimensional tolerances, whereas wet pressings are those containing a moisture content of up to 15 per cent. The plasticity of a wet "body" enables more complicated shapes to be produced using simpler dies than with the dry pressing technique.

Some "bodies" based on pyrophyllite but with additions of bentonite and various ceramic fluxes were tried out, and with nephylene syenite alone or with barium and strontium, a satisfactory vitrified body was produced at the normal firing temperature of 1,250-1,300°C. Such a body may be machined after firing. The addition of the barium and strontium enabled a lower percentage of nephylene syenite to be used and so improved the electrical properties.

The two mixes found satisfactory are:—

	Mix No. 1	*Mix No.* 2
Pyrophyllite	100	100
Barium Sulphate	—	5
Strontium Sulphate	—	5
Nephylene Syenite	20	10
Bentonite	2	2

Two satisfactory materials for producing good wet pressings with a firing temperature of approximately 1,300°C are:—

	Mix No. 3	*Mix No.* 4
Pyrophyllite	50	75
Marl (raw)	50	25
Steatite	15	15

Summary

It is established that pressing mixtures based on pyrophyllite can be made having mechanical and electrical characteristics similar to those of other pressed porcelains.

Pyrophyllite has a higher mechanical impact strength than any other electrical porcelain, and is therefore particularly suitable for use where sudden high mechanical strains are experienced. The material maintains a higher volume resistivity at high temperatures than other electrical porcelains, thus indicating an advantage in refractory ware.

The very small shrinkage of pyrophyllite mixes when fired (1.03-1.04) enables close tolerance pressings to be made, and where extremely accurate dimensions are a necessity the raw material can be machined first, and then fired at 1,435° C, when shrinkage is negligible.

The use of pyrophyllite for experimental and prototype work is already well established; the ease of machining the unfired material making it particularly suitable for the rapid construction of a wide range of shapes.

Finally, it is established that the material is a suitable substitute for many of the ceramic products now in use in the Services.

Acknowledgments

In concluding this survey the author wishes to record his indebtedness to Messrs. G. Perrins and W. G. Robinson, of Bullers, Ltd., for their co-operation and for the photographs concerning the manufacturing techniques used at their works at Milton, and to the Admiralty for permission to publish the article.

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[1] A full report by Messrs. Bullers was recently embodied in Central Radio Bureau Report. Reference 50/172. (Obtainable from the Central Radio Bureau, Thames House (South), Millbank, London, S.W.1.).

[2] Pottery and Ceramics, by Ernest Rosenthal.

The De Luxe Home Built Televisor

During the four years since the booklet describing the ELECTRONIC ENGINEERING Home Built Televisor was published, considerable progress has been made in television technique and, in the new booklet, "A De Luxe Home Built Televisor and Radiogram," a number of circuit improvements have been incorporated, together with a three waveband radiogramophone. The following are a few of the technical details of this new televisor.

Interlacing

The sync separator has been modified by the addition of a diode interlace filter which enables correct interlacing to be maintained without the necessity of critical adjustment of the frame frequency control.

Focus

To overcome defocusing due to the variation in resistance of the focus coils due to heat, two separate methods are employed. The first uses a modified focus coil connected in a constant current circuit, while the second method makes use of a permanent magnet.

Definition

In order to add to the already excellent definition a form of push-pull modulation of the C.R.T. is employed, in which both the grid and cathode of the tube are modulated. This helps in providing a picture of extremely good contrast but entirely free from harshness.

Ease of Adjustment and Control

In centring the picture by moving the focus coil, or magnet, the focus over the whole of the screen will suffer if the focus coil is tilted to such an extent that it is far from parallel with the screen of the C.R.T. To overcome this difficulty, and at the same time to make the operation easier, picture centring is carried out electronically by the adjustment of two shift controls.

E.H.T. Supply

In order to enable the use of modern aluminized C.R.T.s several methods of increasing the E.H.T. potential to the required level are described. These include voltage doubling, R.F. oscillator units and boost from the line flyback.

High Quality Amplifier

The television sound transmission is normally of a very high quality and to make full use of this a high quality amplifier has been included. This consists of a single output pentode and a triode pre-amplifier with negative feedback over two stages; the total distortion for three watts output being less than 0.5 per cent.

Radio Reception

A three waveband superhet tuning unit has been developed which, although having only three valves, has proved itself to be very reliable and of good quality. A fourth valve is included which acts as a tone corrector and amplifier for record reproduction.

An Electronic Digital Computor

Using Cold Cathode Counting Tubes for Storage

(Part 2)

By R. C. M. Barnes, B.Sc., E. H. Cooke-Yarborough, M.A., A.M.I.E.E., and D. G. A. Thomas, M.A. *

The relation between the state of the scale of two at the beginning of one round off operation and that at the beginning of the previous round off thus depends upon whether the number of pulses occurring in the intervening period is odd or even. These pulses are spaced a few milliseconds apart whereas the interval between successive round off operations is several (usually very many) seconds. The exact length of this interval is affected by many uncertainties, such as the operating times of the tape readers and printers and many relays. These may confidently be expected to produce unpredictable variations in the interval amounting to very many milliseconds.

Experiments so far carried out show no significant correlation between the zeros and ones produced by repeated round off operations.

The Translator Unit

The function of the translator unit is to convert the information obtained via a relay circuit from a punched paper tape into a form suitable for operating the transfer units in the computor and vice versa. The translator is brought into circuit in the same way as any storage address and no alteration is needed to the transfer unit to accommodate it.

The basis of the unit is a special Dekatron in which the cathodes are all brought out separately. For this purpose a 10-cathode tube would be suitable, but the tube available has 11 cathodes (GS11A) and this has been used.

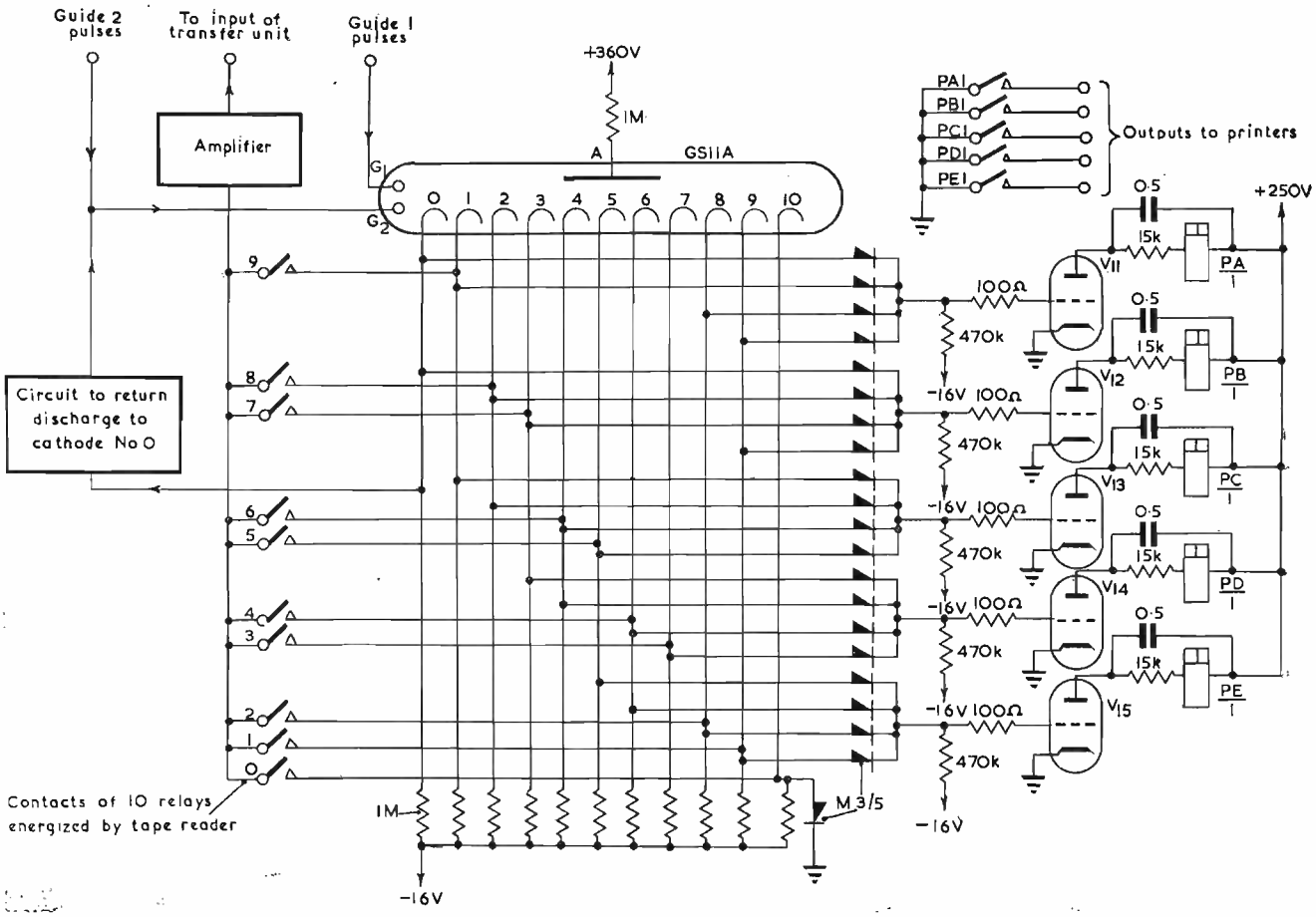

Fig. 8. Translator unit

The method of operation is shown in Fig. 8. If, for example, the numeral 3 is to be fed into the computor, one of the Dekatron cathodes, No. 7 in this case, is connected to the input of the transfer circuit by relays energized from the tape reader. When translation-in takes place, the discharge in the GS11A is stepped round by a train of 10 pulses to cathode No. 10. In passing the selected cathode, a pulse is fed to the input of the appropriate transfer unit. The transfer unit then functions in the normal way and if

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a positive number is being translated, the remaining pulses of the train of 10 (in the example, 3) are passed to the receiving store by the transfer unit. When translating in negative numbers the transfer unit is arranged to complement them. Since the translator deals with only one digit at a time the remaining transfer circuits are arranged to transfer zeros (or nines in the case of a complement). The translator is connected via the transfer circuits to each digit of the store in turn by the relay shift circuit.

When translating out (i.e., taking information from the computor) the GS11A tube again starts from cathode No. 0, but in this case it steps round by the number of pulses delivered to it by the transfer unit. The cathode on which the discharge is left rises in potential from −16V to something positive with respect to earth, causes the grid potential of two of the triodes V11 to V15 to rise, and so closes two of the relays *PA*/1, *PB*/1 - - - *PE*/1. The contacts of these relays operate the teleprinter or tape perforator. The metal rectifiers in the cathode circuits of the GS11A give an output in the appropriate code (i.e., the 10 combinations of 2 holes punched in two of five spaces) for this purpose.

After translation-in or -out a separate circuit returns the discharge in the GS11A to cathode No. 0 before the translator is again required for use.

Sequence Control

This part of the computor controls the tape readers and output organs, selects the Dekatron stores required for each arithmetical order and interprets these orders as a sequence of the basic functions of addition and subtraction. It is designed to operate as an asynchronous system in which each switching operation in the sequence is checked before the next is allowed to begin. This simplifies maintenance by eliminating critical relay timing and by stopping the computor immediately a circuit fault is detected.

The sequence of an arithmetical operation can be regarded as consisting of three parts:—

(1) Reading in the current order.
(2) Setting up the necessary connexions.
(3) The arithmetical operation itself.

Non-arithmetical orders are dealt with in a similar manner and the operation of the computor continues until a special order is reached which leads to the lighting of the "Finish" lamp and prevents any further operations.

READING IN THE CURRENT ORDER

Each order is transferred, digit by digit, from the perforated tape or Dekatron store into the relay order storage circuit and is then interpreted as a sequence of additions and subtractions. The address from which the order is obtained has been derived from an earlier order calling for a change of order source. This address is stored on a group of relays which mark out the two digits of the order source address. The "tens" digit energizes a relay connecting a group of ten addresses as the sending store and the "units" digit selects the individual store in this group. The reading-in sequence begins when it has been proved that the correct tens and units relays have operated. If the order source is a tape reader the sequence will consist of six cycles. The space or block-marking character is read during the first cycle and the order digits during the remaining five cycles. At the beginning of each cycle the appropriate relay storage group is connected to the five-wire output of the tape readers.

The contacts of each tape reader correspond with the pattern of holes on the tape, and they operate the equivalent combination of five relays in the storage group to which they have been connected. The relay storage group into which the space or block-marking character should be routed will only allow the next cycle to commence if it receives a particular combination of one hole out of five (the space combination) or any combination of three holes (the block-marking characters). The five storage groups into which the order digits are fed will only allow the next cycle to commence if each receives one of the ten combinations of two holes. If the tape reader moves the tape forward more than one row before reading the next character, or fails to move the tape, a digit storage group will be offered the space code or vice versa. Furthermore, any erratic operation of the reading contacts is unlikely to distort a two-hole code into another two-hole code, so that any faulty operation of the tape reader is almost certain to be detected.

SETTING UP THE CONNEXIONS

The source from which the current order has been read and the relay storage group are now disconnected, leaving the order stored on the relays. If this order requires an arithmetical operation the sending and receiving addresses are selected and connected to the input and output of the transfer system in the following way. The Dekatron stores are built in units each containing ten stores of eight digits and sign. These units are a convenient size and suit the decimal address code. Each group of ten stores has switching relays which connect it either to the input or the output of the transfer systems. These are the sending and receiving "tens" relays. When a "tens" relay is energized the Guide 2 electrodes of all the sign storage Dekatrons in the group are connected to the sign input or output lead of the transfer system, all the Guide 2 electrodes of the 1st digits to the 1st digit lead, and so on. The individual store in the group is selected by one of ten switching relays (the "units" relays) which connects Guide 1 pulses to all the Dekatrons of one address. Thus although all the 90 Dekatrons in the group of 10 addresses receive Guide 2 pulses, only those of the selected address receive pulses on both guides and the position of the discharge can change only in this one address.

The two sets of "tens" and "units" relays which bring the sending and receiving addresses into action are selected and checked by four groups of address storage relays. A fifth group stores the operation to be performed and, provided that the addresses selected are compatible with the operation demanded, sets up the arithmetic control relay circuits. As a further guard that the sending and receiving addresses are connected correctly the arithmetic sequence cannot start until the signs of both addresses and of the accumulator have been identified.

THE ARITHMETIC OPERATION

When the selection of function and addresses is complete the arithmetical sequence begins. It occupies a variable number of cycles, only one for addition or subtraction, nine for multiplication, ten for division, 11 for reading in a number from the tape and up to 19 for printing a number in a maximum length print layout. For addition or subtraction the single cycle has two steps: setting the shift circuit to the straight-through condition and carrying out a single transfer. For division of a positive dividend by a positive divisor each cycle has three steps: setting the shift to successive positions, carrying out a multiple subtraction until the sign of the accumulator changes, and carrying out a single addition. The completion of each step is checked before the next can begin.

When the arithmetic sequence has produced the full number of cycles required for the particular operation the address relays are released, the stored order is cleared down and the next order reading sequence begins.

PRINTING OUT

If the current order selects the printer as the receiving address the translator is connected to the output of the transfer system and the printer is connected to the five-wire output of the translator. A previous order will have specified the print layout which is to be adopted. Each cycle of the arithmetical sequence then consists of three

steps. The first sets the shift to route each digit in turn to the input of the translator (which accepts only one digit at a time). At the same time the translator is recycled to zero. During the first step there may alternatively be connected to the printer the contacts of one of a number of relays which mark out non-digital characters such as space, line feed and carriage return. The second step is a single addition or subtraction. If a non-digital character has been selected by the first step this transfer is not required. The teleprinter with page printing attachment has been modified so that five-wire signals operate magnets controlling the five combs of the combination head. The third step of each cycle sets the combination head of the teleprinter by operating these magnets from the output of the translator or a character relay, checks the position of the combs, and prints a character.

Conclusion

It is believed that the computor described above will meet a real need in the computing field. It is particularly suited for cases in which the same calculation must be performed many times on a variety of numerical data. Its use is expected to be an economical proposition in many cases when the cost of a large, fast computor would not be justified.

Acknowledgment

The authors have received much helpful advice from Dr. J. Howlett, and during the early stages of the work they benefited by a discussion with Professor D. R. Hartree. The work was carried out as part of the programme of the Electronics Division at A.E.R.E. and is published by permission of the Director, A.E.R.E.

A Time Selection Circuit for Frame Sync-Separation

By W. R. Luckett

TIME selection circuits for frame sync-separation in television receivers do not seem to have been widely used, although such circuits can give very satisfactory results.

Basically the principle is one of selecting those pulses which occur within a fixed period of time after a reference pulse.

The circuit to be described is designed around the Mazda 6F33 valve, which has a short cut-off suppressor grid characteristic.

The output from the picture sync-separator is fed via a differentiating network of $RC < 2$ microseconds to the control grid, G_1. The G_1 voltage waveform consists of negative and positive going pulses, but the cathode being 17V positive allows cathode current to flow only during the positive going pulses.

It is usual to employ the negative going pulses of the differentiated sync signal to start the flyback period of the line deflexion generator. The saw tooth output from this generator is fed to the suppressor grid, G_3, via a differentiating network which must allow G_3 to reach cathode potential in approximately 30 microseconds.

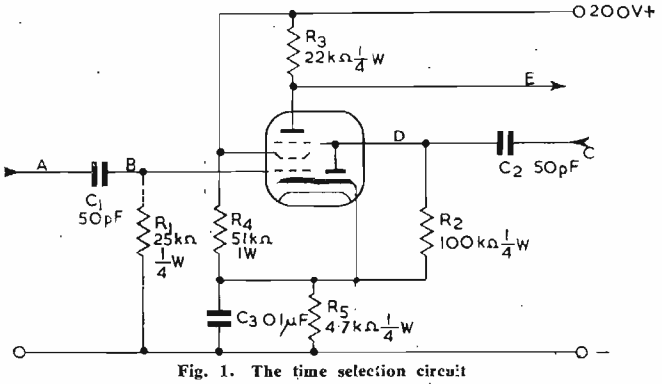


Fig. 1. The time selection circuit

The 6F33 has an internal diode connected between G_3 and cathode which clips the tops of the G_3 waveform.

As the G_3 base is about 9V, anode current is held off for about 20 microseconds after the start of the line flyback period. The result is that the positive going pulses of the differentiated line sync signal do not cause anode current to flow because G_3 is below cut-off. There are however small voltage pulses of approximately 1.5V (peak to peak) at the anode due to capacitive coupling in the valve.

The frame sync signal consists of inverted half line pulses. When these are differentiated they produce a waveform that consists of a positive going pulse followed by a negative going pulse.

It will be seen from the waveforms of Fig. 2 that the positive pulses occur during a period when G_3 is at cathode potential. The resulting flow of anode current produces negative going voltage pulses at the anode. These pulses are used to synchronize the frame deflexion generator.

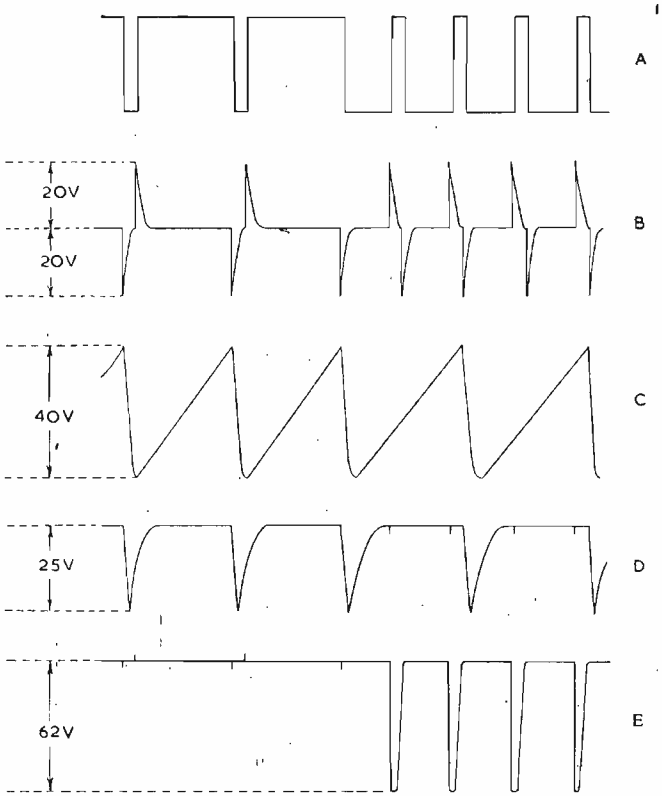


Fig. 2. The waveforms at :- (A) Output of picture/sync separator. (B) G_1. (C) Output of horizontal deflexion generator. (D) G_3. (E) Anode

It will be seen that the circuit cannot introduce any timing error, because the leading edges of the output pulses are coincident with the leading edges of the frame sync pulses.

This circuit is stable in operation and requires no critical adjustment of circuit values.

Nimrod

A Small Automatic Computor

By R. Stuart-Williams, B.Sc., A.M.I.E.E., M.I.R.E. *

THIS machine was built to display the principles of automatic computors at the Exhibition of Science of the Festival of Britain.

The design of the machine represented an experiment in engineering. The decision to build a machine for demonstration was made at the end of November, 1950, but the time table was a very tight one. Work on the design was commenced on 1 December, 1950. It was agreed that the machine would be shipped to the Festival on 12 April, 1951, which meant that it must be ready and tested by 4 April. The primary function of the machine is to display its method of operation and this made it necessary to use different circuit techniques from the Manchester machine. It was necessary therefore to produce a complete new design on paper, build it and test it in four months. The basic design work alone took six weeks as, in addition to the other difficulties, it was necessary that the machine should be very reliable. In order to complete it in time it was required to design a machine on paper without any experimental stage and without risk of mistakes. The machine was shipped on time and has proved reliable and, therefore, it is considered that the experiment has succeeded. This article deals with some of the methods adopted in the design.

Some Features of Nimrod

The machine is a special purpose computor designed to play variations of the game of NIM. It is a true digital computor and displays the three basic characteristics of such machines.

It calculates.
It remembers.
It makes decisions.

Nimrod uses rather more decisions than calculations and therefore can be considered as a thinking machine rather than as a calculating machine. The machine has three main displays, the centre one showing the state of the game, the two side ones being used to display the method of operation. The left-hand display shows the machine making decisions while the right-hand one displays memory and calculation.

Nimrod is a parallel machine, direct coupled throughout. It uses binary numbers for computation but the input and output are in decimal form. The circuits were designed for 50kc/s working but have not been tested above 10kc/s. From the latter frequency downwards the machine is aperiodic and can be operated over a wide range of rates of operation. Normally its complete operation time is from 5 to 15msec. When slowed down or operated in a step by step manner the side displays can be used to explain the exact method of operation of the machine.

The machine, when presented with a choice of moves, chooses one at random. This facility can be demonstrated by setting it to play against itself. The result is much more human in character than one would normally expect.

The physical shape of the machine has been dictated by exhibition conditions. The height and size of the Nimrod displays fixed the dimensions. In practice the computor occupies a little more than 1 per cent of the total volume, and could have been built inside the control desk. Advantage has been taken of this fact to provide space inside the machine for testing and for accommodating spares and test gear.

The control desk of Nimrod. *The players are studying the game by using matches in addition to the push-buttons and lights.*

The entire computation is electronic, 480 valves type 12AT7 being employed for the purpose. Apart from the 480 valves, 120 relays are used to control the display lighting. The power units are simple selenium rectifier, choke, electrolytic capacitor type, the only stabilization being provided by a moving coil regulator. This is also used to stabilize the filament supplies.

It was not considered that any form of connector was sufficiently reliable and therefore soldered connexions were used wherever possible. One immense disadvantage of this form of construction was the time taken in breaking and making connexions when the machine was shipped, but it did ensure reliability.

The computor consumes 2kW and the displays 4kW of power. The total weight is about four tons but the machine is designed to break down into suitable sections for manhandling.

The Game of NIM

This game, which is still played in some parts of the world, has been analysed in a logical form, and therefore it can be programmed for a computor.

The game is normally played with matches, which are arranged in a number of unequal rows between the two players. In the simple game each player in turn must take at least one match or as many as he chooses from any one row.

In the game known as NIM-K each player in turn may take matches from up to K rows at a time. It is clear that the simple game corresponds to $K = 1$.

There are two possible ways of ending the game.

In the NORMAL game the player tries to take the last match or group of matches himself.

In the REVERSE game he tries to force his opponent to take the last match.

In order to keep the display in reasonable proportion, Nimrod has been restricted to playing with not more than seven matches per row and not more than four rows. It can play any combination within this restriction for either the normal or reverse games, and with K values of 1, 2 or 3.

* *Computor Group, Ferranti, Ltd.*

In playing against Nimrod the opponent may decide whether or not the machine shall make the first move; given this choice, and provided he makes no mistakes, he will win. If we postulate an opponent playing at random then he has one chance in 10^4 of making the first three moves correctly, and one in 10^{10} of winning. These are approximate figures on the basis of the combination 7, 3, 6, 5, and assume that he is playing against a perfect player. So far no unskilled player has beaten this combination but several have made three moves correctly.

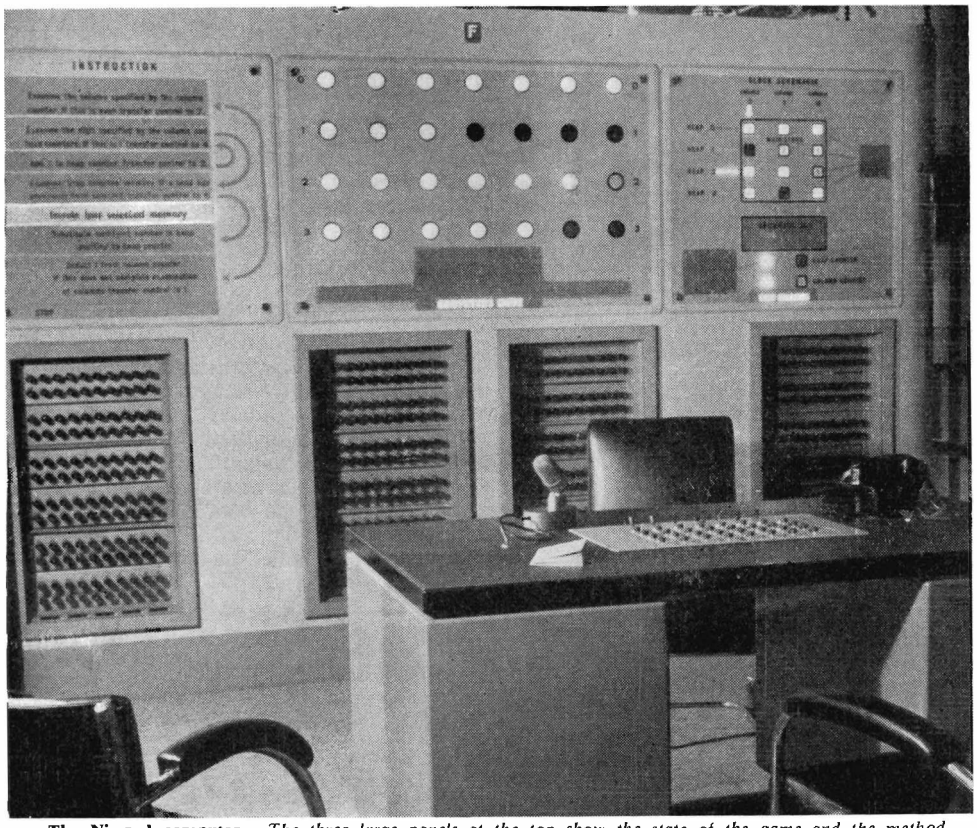
The Correct Method of Playing NIM

The first and most difficult process is that the number of matches in each row must be expressed as binary numbers. Nimrod carries out this conversion and the binary equivalents are displayed in terms of groups of 4, 2 and 1 on the right-hand display panel.

Next count the number of groups in each column starting at the 4's end. Test each sum and see if it is exactly divisible by $K + 1$ or not. If it is, then it is defined as SAFE ,and if it is not, as UNSAFE.

If, when commencing a game, all columns are safe, then if the opponent is to win the machine must be made to move first.

If one or more columns are unsafe then a correct move can be made. To make a correct move, matches are removed, within the restrictions of the game, to leave all columns safe. In the normal game by playing in this manner throughout the player will win. In the reverse game it is necessary to play as above until TRANSITION occurs. This can be recognized when during play there are K or less rows containing more than one match. One match only is left in each of 1 or $K + 2$ rows, whichever is possible.



The Nimrod computor. *The three large panels at the top show the state of the game and the method of operation of the machine. The doors at the bottom house the* 480 *miniature valves.*

For those unfamiliar with binary notation a table of equivalents is listed below for numbers up to seven.

Decimal Number	4 Groups	2 Groups	1 Group	Binary Number
0				0
1			1	1
2		2		10
3		2	1	11
4	4			100
5	4		1	101
6	4	2		110
7	4	2	1	111

Assuming that a game starts 7, 3, 6, 5 the table of equivalents is as shown below.

7	4	2	1	111
3		2	1	11
6	4	2		110
5	4		1	101

To decide in which row the move should be made, commence at the 4's end and check each column. The first unsafe column defines the row or rows for the correct move. A move can be made in any row containing a group in the first unsafe column.

The following is a record of an actual game of NIM played with $K = 1$ and reverse game.

The game starts with	7	3	6	5
The opponent moves first, and can leave 7, 3, 1, 5, 7, 3, 6, 2 or		3	6	5
Machine now leaves		3	3	5
Opponent leaves		3	3	
Machine leaves		3	1	
Transition has occurred and therefore opponent leaves			1	

The machine is forced to take the last match and the opponent wins.

Method of Play Employed by Nimrod

The machine first tests for transition and if it has occurred stores the information.

It then moves to the 4's column and tests for safety. It displays this as *even*, meaning safe, or *odd*, meaning unsafe. This is done because the display is primarily intended for displaying the $K = 1$ game. If the column is safe it moves to the 2's column.

If the column is unsafe it searches for a row having a 4 in it. This search is commenced from a row chosen at random and hence if there is more than one move available it will choose one of them.

Having found a row on which it can operate the

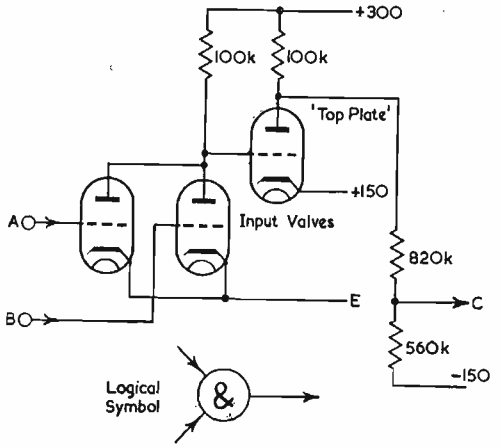


Fig. 1. AND gate

following information about the row is stored.

(1) The fact that a row has been fixed.
(2) The number or address of this row.
(3) The order in which the row was fixed.

The machine then replaces the contents of this row by the " modifying " number. In general this number is the greatest number, less than the existing number, in which the group at present being operated on, does not occur. Thus, for the 4's column this must be 3 or 011. This represents the minimum move that the machine can make that removes the offending group. If the machine is playing $K = 1$ it now goes to the next column, the 2's column. If it is not playing $K = 1$ then it retests for safety and if the column is still unsafe modifies again, repeating this until safety is achieved.

Similar processes take place for 2's and 1's columns until the machine has examined all columns. If the machine is playing a reverse game and transition has occurred then the conditions of safety are altered appropriately when the 1's column is attained.

If all columns are safe initially then the machine rapidly finds that it cannot make a correct move and a sequence is provided, using the random number generator, that causes the machine to take a random number from a random row. The number taken is one 80 per cent of the time, the remaining 20 per cent being 2, 3 or 4.

It is possible to play NIM oneself in this manner but although it will always give the right answer it does involve a rather difficult mental process.

Major Computing Elements that are Required in Order to Play NIM

(1) A device that will count either the number of groups in a column or the number of rows with more than one match.

(2) Given the number of rows, a device to test for K or less rows.

(3) Given the number of groups, a device to test for *safe* or *unsafe*.

(4) A device that will test a given group for *there* or *not there*.

(5) Sundry counters, storage elements, and logical elements.

LOGICAL ELEMENTS

All operations in Nimrod are confined to the use of one type of storage element and three types of logical elements. These circuits will be defined in electronic terms, and therefore it is necessary to define a " signal."

A zero signal or no signal is said to exist when the voltage on a signal line is at earth or positive to earth.

A " 1 " signal or a signal is represented by a voltage that is more negative than − 25 volts. This is usually standardized at − 50 volts.

AND

This circuit has several inputs and one output. When all input lines are energized an output signal is obtained.

OR

This circuit is similar in definition to the AND circuit but in this case if any of the input lines are energized an output signal is obtained.

NOT

This circuit has one input and one output. If a signal is present at the input then an output is not obtained, and conversely, if a signal is not present at the input an output is obtained.

STORAGE

This element will store either 0 or 1 as long as required.

Circuits and Symbols of Logical Elements

The minimum number of basic circuits consistent with reasonable economy of design have been used. The policy has two major advantages. Each circuit was designed mathematically to achieve the widest possible tolerance values, and secondly, each circuit has a single logical symbol, making it possible to test the machine by referring to the logical diagram alone. Some idea of the value of this second point can be appreciated when one realizes that a valve failure can be cleared in from five to ten minutes provided one is skilled in the logic of the machine.

AND

There are two types of circuit employed: true logical element, and a derived element for parallel operation.

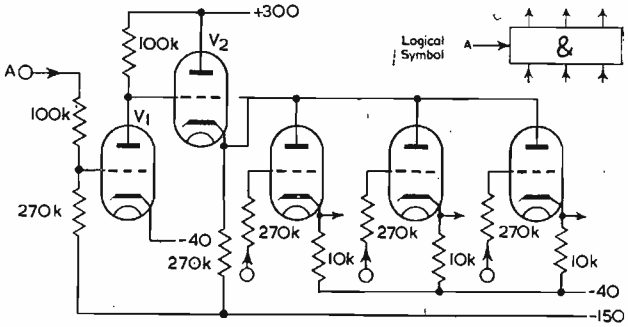


Fig. 2. Block AND gate

The normal circuit is illustrated in Fig. 1. Only when all the input triodes are cut off will an output be obtained.

The parallel AND or " block AND " is illustrated in Fig. 2. It is shown with only one control voltage (A) but quite obviously it is easily adapted for multiple control lines. When a signal arrives at A, V_1 is cut off, V_2 conducts, the remaining valves, or output valves, behaving rather like cathode followers, transmitting signals to the outputs. It is apparent that the normal state of the output is the " 1 " state but this does not introduce any difficulties.

The behaviour of the output valves is not quite that of a cathode follower. The large grid stoppers reduce the effect of the grid-cathode diode action when the anode is

low, but also isolate the grid from the capacitance of the input line. When the anode rises, under the action of V_2, the grid also rises as it represents the centre-point of the anode-grid, grid-cathode interelectrode capacitances. As the grid rises, the cathode follows it and a very fast rise time is obtained at the cathode. This rise time is almost independent of the characteristics of the output valves. If the rise is too fast it can be slowed down by introducing a small capacitor between the grid and the cathode. The value of this capacitance is not very critical, normal commercial values being quite suitable.

OR

The OR operation is usually obtained by connecting together the outputs of other logical circuits. For example it is frequently necessary to "OR" the outputs of AND gates. This can be done by using a common anode load for the "top" valves of the AND gates. A few germanium diode OR gates have been used and one of these is shown in Fig. 3.

NOT

If a NOT operation must be performed an invertor is employed but usually it can be obtained without adding valves. Storage elements are symmetrical and direct and inverse signals are almost always available. The "top" valve of an AND gate can be used as a cathode follower and this "NOT'S" the output of the gate.

STORAGE

The basic circuit employed for all storage and counter circuits is shown in Fig. 4. It is a D.C. coupled flip-flop, with anode triggering and cathode follower outputs. The output levels are crudely standardized by grid current in V_1 and by cut off in V_3.

In most cases the flip-flops are triggered either by a differentiated pulse or by the output of an AND gate. In Fig. 4 the differentiating circuits are shown connected to the grids of V_2 but if the AND gate is used then the V_2 triodes become the "top" valves of the AND gates.

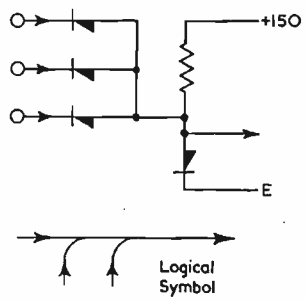


Fig. 3. OR gate

To counter connect the circuit, the grids of V_2 are joined together and small memory capacitors are placed in parallel with the 820kΩ resistors.

The flip-flop can trigger only as the result of positive drive to the correct grid of V_2. Drive on the other grid will have no effect at all. For this reason a simple differentiating circuit is sufficient and unwanted pulses cannot be obtained on the output waveforms.

The circuits that have been described in this section may be justly criticized in that most of them can be replaced by diode circuits. The chief value of using triode circuits is that a power gain takes place in each circuit and consequently they may be arranged in any manner without deterioration of signals.

Reliability and Circuit Design

The only valve type employed in Nimrod is the 12AT7, which is a high slope, short grid-base, pulse double triode. It was employed for two reasons. First, because circuits of this type are being considered for 100kc/s working and secondly, because the short grid base valve allows one to use very wide tolerance components. A similar valve with longer grid base, the 12AU7, might have been used and might have given even better reliability.

Any discussion of reliability of Nimrod must concern valve rather more than component reliability because the circuits employed use a minimum of components. In addition all components are run at a small fraction of their nominal rating.

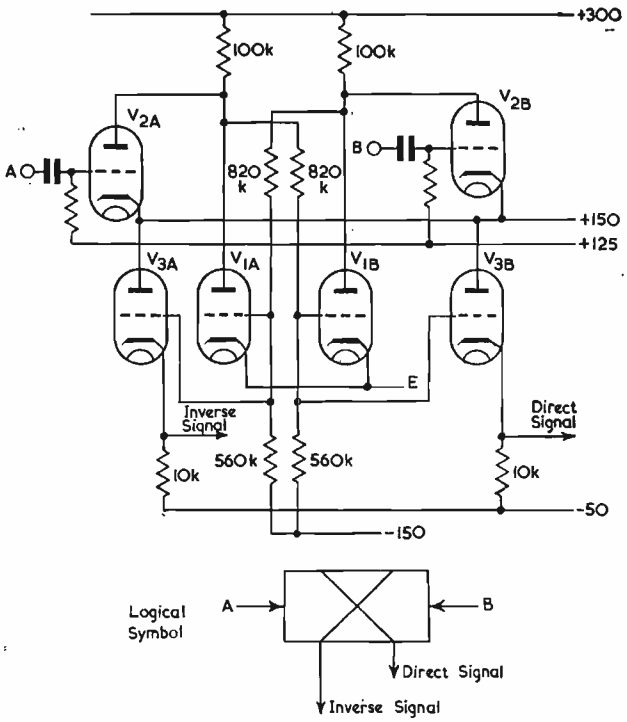


Fig. 4. Storage element

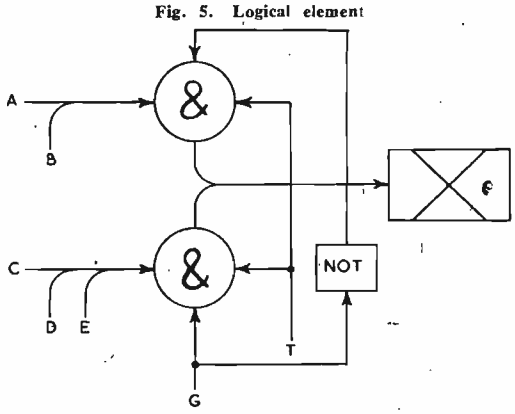
Valves are rated very carefully as they are rarely used at more than one fifth their total anode dissipation, or more than one hundredth their total emission. They are also used in an on-off manner, *off* being defined as −50 volts grid bias, and *on* as from one tenth to one milliamp grid current.

It has already been explained that short grid base valves allow large component tolerances. The flip-flop is the most critical element and it was calculated that the circuit would still operate if all components were varied 13 per cent, and the valve characteristics varied by a factor of 2 at the same time, the direction of variation in each case tending towards the maximum probability of failure. This means in practice that 20 per cent components can be used with a very low probability of failure. In the same manner variation of power supplies and ripple on power supplies of the order of 10 per cent is tolerable.

Synthesis of Computing Elements

Three examples are given of the types of circuit that can be built up using logical elements. The circuits shown are typical of special purpose but not of general purpose machines. In the latter the circuits are less complex and more fundamental.

Fig. 5. Logical element



Example 1. Fig. 5.

The logical meaning of this circuit is that the storage element will be operated at time T and

(1) if G is present and A or B is present.

or (2) if G is not present and C, D, or E is present.

Example 2. Fig. 6.

This circuit adds up the number of inputs present on lines A, B, C and D and gives the answer by energizing one of the lines 0, 1, 2, 3, or 4.

Gate 1 will give an output only if there are four inputs.

Gate system 2 will give an output if there are 3 or 4 inputs. The output from this gate is gated with NOT 4 in

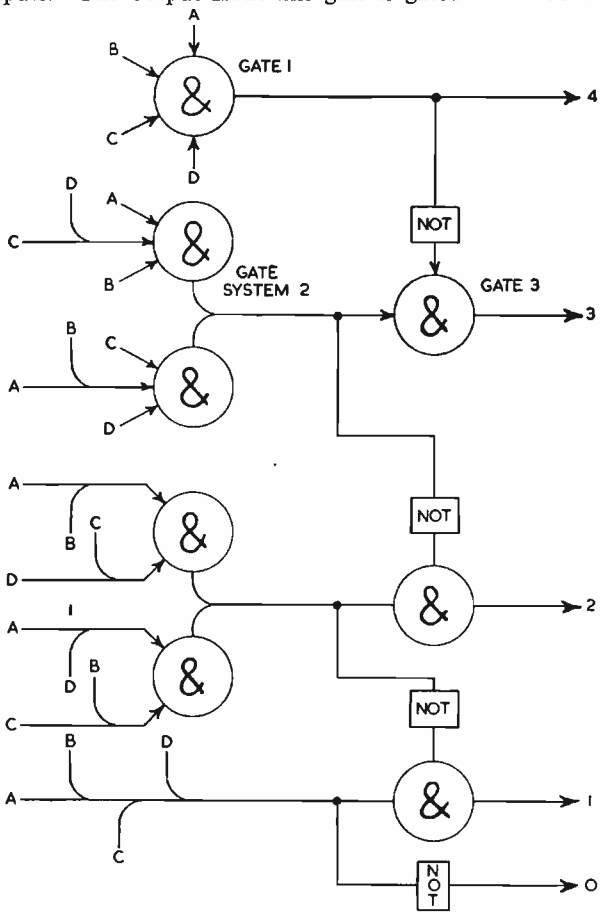


Fig. 6. Column adder

AND gate 3 to produce the 3 signal. Similar logic will explain the remaining elements. The circuit is used to add up the number of groups in a column and by switching the 4's and 2's column to the circuit simultaneously it adds up the number of rows containing more than one match.

Example 3. Fig. 7.

One of the first three AND gates is opened by $K = 1$, or 2 or 3, which are fed from the control desk. The signals 0, 1, 2, 3, are supplied by the circuit in Fig. 6. It will be seen that one of these gates will operate if the input to it is K or less than K i.e. transition has occurred. This is examined at time X to set storage element $TF1$. A similar but more complex circuit is used for the safety examination.

Reliability of the Machine

At the moment of writing the machine has completed 900 hours of intermittent service, being operated during the day and closed down at night.

The first hundred hours of life have not been counted for reliability purposes and the statements that are made refer to the last 800 hours only.

MISTAKES.

Mistakes as distinct from faults occurred on the machine mainly in its very early life and were traced to an incorrectly wired circuit. At this period mistakes occurred 2 to 3 times a day but during the last 500 hours no electronic mistakes have been detected.

Dirty contacts on push buttons, etc., occasionally cause errors of input or output but are usually seen immediately and do not cause errors in computation.

INTERMITTENT FAULTS.

Faults of this nature occurred during the first 200 hours due to dirty valve contacts or incipient valve failure and during the first 400 hours due to incipient resistor failure. No intermittent faults have occurred since that time.

COMPONENT FAILURE.

No capacitors have failed and resistor failures were confined to one type only which has since been replaced throughout the machine.

VALVE FAILURE.

The valve failure record is self-explanatory.

Type of failure	Date	Hours
Cathode-Filament short	May 4th	118
Soft Valve	May 5th	134
Soft Valve	May 7th	158
Soft Valve	May 10th	198
Open circuit filament	June 11th	551
Soft Valve	July 11th	779

Note: Hours are measured from the commencement of machine operation.

The interesting thing about the above table is that 4 of the 6 failures occurred shortly after the machine had been moved to London and therefore such failures were still within the period in which valves damaged in transit could cause trouble. It should also be noted that the valves are standard commercial valves and no special selection process has taken place.

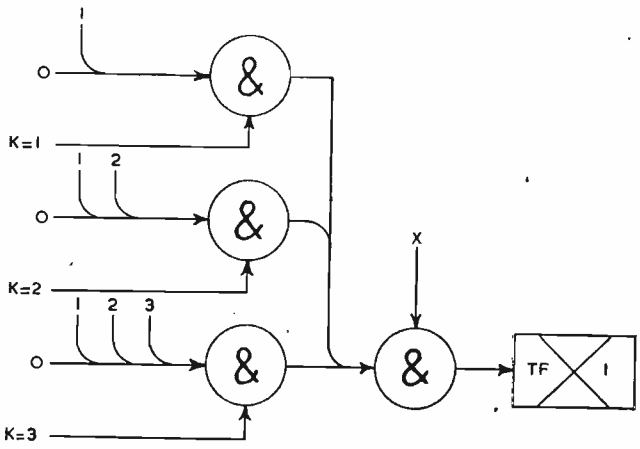


Fig. 7. Transition examination

TIME LOST DURING EXHIBITION.

Until the valve failure on July 11th only one hour twenty five minutes exhibition time had been lost due to failures. The machine is now staffed by University students, one of whom has been made responsible for maintenance. He had received only a few hours' training when the above fault occurred but even so he was able to locate the fault logically in half an hour. He had been instructed not to remove any valve until he was certain that it was defective, and not being familiar with the machine $1\frac{1}{2}$ hours elapsed before the offending valve was located with certainty. This not only reflects great credit on the student concerned but it also demonstrates that it is not necessary to employ experts to maintain computors.

A Single Valve Line Scan and E.H.T. Generator

By C. H. Banthorpe *

ONE of the many interesting problems met in television receiver design is that of line scanning, and it is also one which so far little has been published, with a few notable exceptions.[1-7] None of these writers, however, describes a single valve time base which will also provide E.H.T., but such a circuit is of great interest from the economy point of view. Self-drive circuits are not new and, in fact, were used in very early Baird television receivers. One of the troubles of such circuits is that generally speaking the valve has unusually high voltages on its electrode, −2kV on the grid during flyback was common, and some trouble was experienced due to flash-over across the pinch of the valve, valve holder, or base. Valves have become better and better, however, and it is extremely rare to have such troubles now, and in a modern design the grid voltage need not exceed −600 volts during flyback. Another inherent fault of single valve circuits is the interdependence of controls. Such interdependence has not been overcome to any extent so far, except amplitude control which can vary over a wide range without much

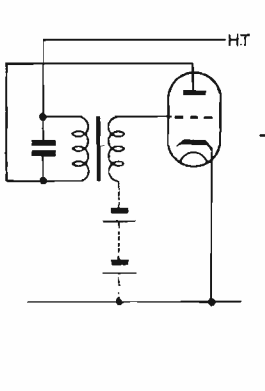


Fig. 1. The basis circuit

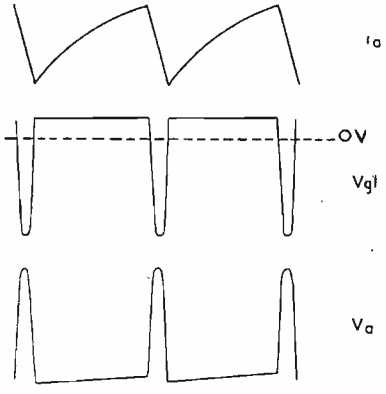


Fig. 2. Typical waveforms

change of frequency. It is also more difficult to obtain good linearity, and generally speaking they are not as linear as the best driven time bases. They are, however, extremely stable, remain in synchronism in the presence of a considerable amount of interference, are very economical in components and can be made to provide E.H.T. in a simple manner. The basic circuit is shown in Fig. 1; this has been described in some detail elsewhere.[1] Briefly, however, the circuit functions as follows:—

If the circuit has been oscillating and a magnetic field established by current through the windings of the transformer, the collapse of the field will generate a back E.M.F. which will drive the grid of the valve negative and hold the valve off. When the rate of change of current falls to zero the back E.M.F. will disappear, the valve will commence to take current and the grid will be driven positive. This current will increase at a more or less constant rate at first, but the rate will eventually decrease. As soon as the rate of change of current falls, the positive grid voltage will decrease and slow the rate of increase of anode current still more. The effect is cumulative and the valve will be rapidly driven to cut-off by the collapse of the magnetic field, which starts the cycle again. The action will consist, therefore, of two main states.

(i) a rapid change of current consisting of a part of a cycle of frequency given by $f = \frac{1}{2\pi\sqrt{(LC)}}$ (L and C being the effective inductance and capacitance of the transformer), followed by

(ii) a much longer time during which the current changes in the opposite direction and in a fairly linear manner.

The duration of the longer interval is determined by a number of factors, one of them being the bias on the valve.

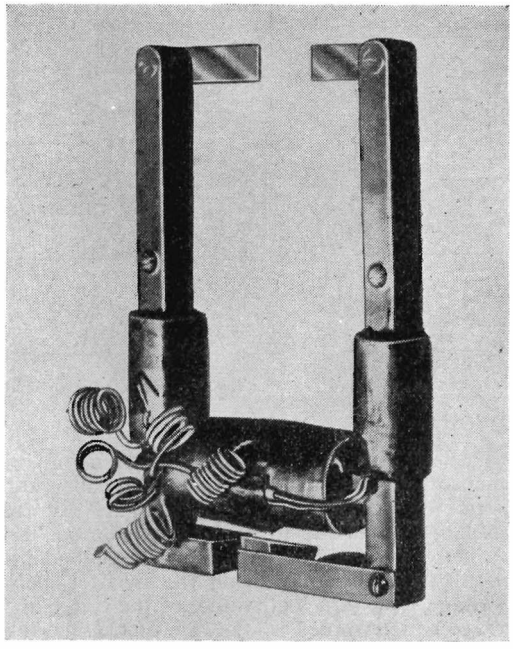


Fig. 3. The Plessey frame scan transformer

This provides a convenient method of frequency control. Typical waveforms, not to scale, are shown in Fig. 2.

The sawtooth current flowing in the anode circuit will be seen to increase exponentially, but the shape of the grid current waveform will be modified by the grid voltage-grid current characteristic of the valve. To make use of the sawtooth current in the grid circuit, some sort of magnetic circuit must be fitted to the C.R.T. and this can take several forms. The leakage flux itself may be used, and in fact has been so used in the frame circuit of Baird television receivers. A similar version was made by the Plessey Co., Ltd., Fig. 3. Alternatively normal scanning coils may be coupled to the grid circuit, and this is the usual method for line scanning. As there is D.C. in the transformer windings it is usual to feed the scanning coils through a capacitor of 25μF or more. This introduces distortion in the direction

* *Central Equipment, Ltd.*

where it already exists and the writer has found it possible to dispense with a capacitor, particularly if grid current can be kept small, and the slight picture shift corrected by moving the focus magnet, which is the usual method of picture centring in magnetically deflected tubes. It is not necessary to use a triode in this circuit, and in fact the pentode has several advantages, one being that a certain amount of linearity control is possible. The second advantage of using a pentode is that special valves exist for line output duty, which have high slope, high current, and can stand high anode and grid voltages. If a pentode is used, and G_2 is not decoupled it will be found that the voltage on G_2 will be of a sawtooth shape and will be positive-going. The mean potential of G_1 is negative and it is thus possible to bias G_3 using this negative supply, and feed the positive-going sawtooth voltage from G_2 onto G_3 and improve the linearity. This is used by at least one manufacturer and is shown in basic form in Fig. 4.

Another similar method is shown in Fig. 5, and the linearity, particularly the start of the trace, can also be improved by the usual C.R. damping. This is a popular method. The voltage at G_1 of the oscillator is approximately a square wave and it is this voltage which has to force current through the scanning coils. Other things being equal, therefore, the best linearity is obtained when the scanning coil circuit is purely inductive, the smaller the resistance the better. Tetrodes may also be used, and Messrs. Murphy Radio, Ltd., use one in the self-drive circuit of Fig. 6. In this arrangement the circuit oscillates between G_2 and anode and this has the advantage that G_1

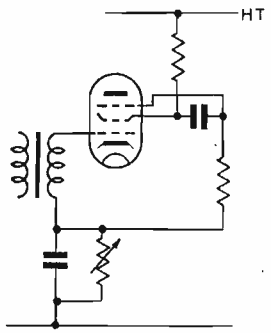


Fig. 4. Method of coupling scanning coils to grid circuit of pentode

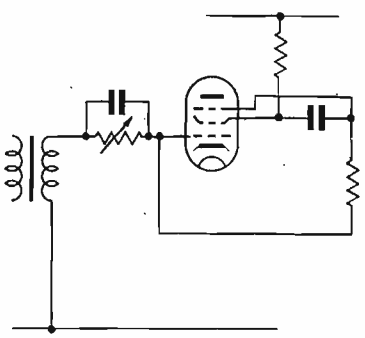


Fig. 5. An alternative method

is now free and can be used for synchronizing injection. The synchronizing voltage can thus be smaller and there is little kick-back into the synchronizing circuit from the time base, only that due to the capacitance between electrodes. This removes one of the causes of bad interlace.

In all of these circuits during the fly-back period the anode voltage rises to a high value, of the order of +3kV. The voltage is determined by the rate of change of current and the effective anode inductance L. It will be remembered that the fly-back is part of a cycle at a frequency determined by the resonance of the effective L and C of the transformer, and for a given L the flyback will be quicker if C is made smaller and the positive pulse at the anode will be bigger, that is to say the voltage is inversely proportional to $\sqrt{C}$. This pulse may be rectified and used for E.H.T., but it is too small for general use in television receivers. It may, however, be stepped up by means of another winding on the output transformer which, together with the primary, forms an auto transformer. If one of the low-wattage heater E.H.T. rectifiers is used, the heater may be fed from yet another winding and the circuit then becomes as Fig. 7; or a voltage doubling or trebling circuit may be used fed directly from the anode of the valve. If rectifying valves are used, their heaters may be fed from small windings as above, or metal rectifiers may be used. The basic circuit of doublers and treblers is given in Fig. 8, but a full description of their operation has been given elsewhere.[8] Metal rectifiers have the advantage that no heater supply is required, but are not quite so efficient as valves.

The amplitude of scan may be controlled in a number of ways, but as previously mentioned, circuit changes are

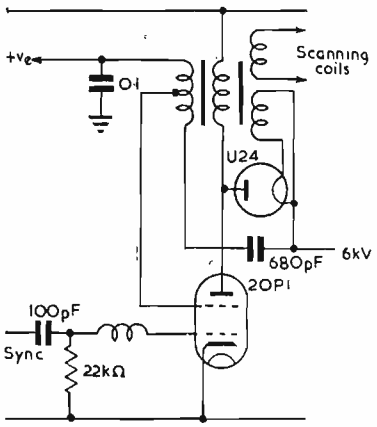


Fig. 6. The Murphy Radio self drive circuit

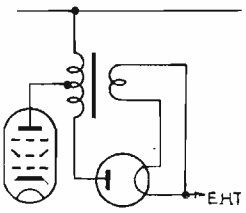


Fig. 7. The use of the primary as an auto-transformer

so interdependent that if, for instance, the H.T. is varied much for amplitude control, the frequency, E.H.T. and focus would change too. But the scan may be controlled by means of an inductor in series with the scanning coils and the inductance varied by means of an adjustable iron dust core. This is a great improvement, and for still greater independence a differential inductor may be used, the two coils being wound end to end with an adjustable core movable from one coil to the other, one coil being in series with the scanning coil, and the other in parallel with part of the transformer, Fig. 9. This circuit is used by The Plessey Co., Ltd., and is very successful, a change of width of scan over wide limits, causing almost no change of frequency or E.H.T. It is also possible to vary the scan width by changing the E.H.T. and this can be done by adding capacitance to the transformer. A compression type capacitor, made by Cyldon, has been used by the writer and gives satisfactory results if moderate control is sufficient. It has a maximum capacitance of 500pF and is rated at 1kV. Connected across the scanning coils it works at 600V peak only, and so should be quite safe. It is also compact, stable and cheap. Some manufacturers do not fit a width control as the circuit is slightly self adjusting, because if the scan tends to increase, the E.H.T.

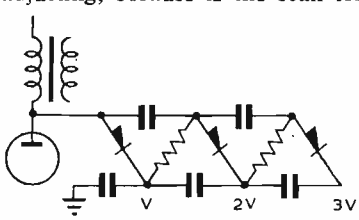


Fig. 8. Basic circuit of voltage trebler

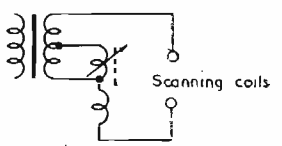


Fig. 9. Method of controlling amplitude of scan

rises and tends to reduce the scan. Frame scan and focus will change, however.

The design of the transformer for a single valve circuit as described above is not very straightforward, as many of the factors do not lend themselves to exact calculations, and others may be unknown until some experience has been obtained. In any case a certain amount of "hit and miss" seems inevitable and the writer thought that the description of a transformer that functions may be of interest to others on similar work. For a number of reasons it was decided that standard 6.5mH scanning coils

were to be used, and it was found by measurement that these needed approximately 40V across them to provide enough scan for a C.R.T. with 6.5kV on the final anode. The anode voltage of an EL38 should not be allowed to fall below about 80V for long or the wattage of G_2 may be exceeded, and as the H.T. supply was 250V the voltage available for the primary was 170V. The transformer ratio is therefore set at 170/40 or 4.25:1. To provide a slight margin for width control, 4.2:1 was finally used. If the sweep was linear during the scan stroke there would be a steady potential across the primary of 170V. As the sweep is not linear, however, but slows down somewhat as the scan progresses, the voltage drop becomes less and the anode volts rise. Because of this the transformer ratio may be somewhat higher and a ratio of up to 5.1:1 has been used.

During the flyback period the rate of change of current is much higher and is opposite in sign. The anode voltage therefore goes well above H.T. up to about 3kV. If 6.5kV is required then the extra winding for E.H.T. must contain rather more turns than the primary, but may be wound with smaller gauge wire as the current is very small. The winding must, however, be able to withstand the higher voltage. The writer has found that it is difficult to wind wire smaller than about 42 S.W.G. and therefore used this gauge, enamelled and silk covered. The primary should have a high inductance and a practical value is about 450mH, and this should be wound in a form to give low

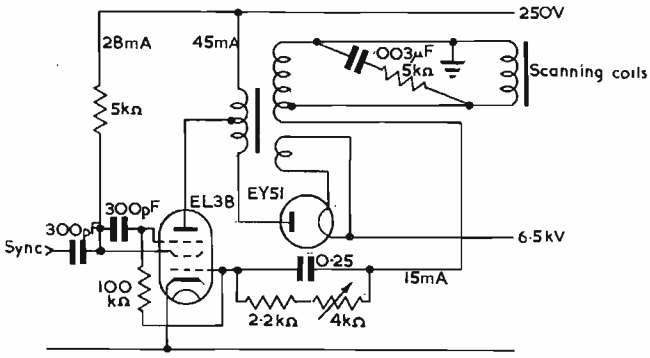


Fig. 10. The final circuit

self-capacitance. Some manufacturers wind the primary in sections or "pi's," and this keeps the capacitance down, but is somewhat difficult to wind as the coil-winding machine must be adjusted for each pi, and it is also difficult to get really close coupling between primary and secondary. If the number of pi's is reduced, the capacitance will go up, it is easier to wind, and there is more risk of voltage breakdown between turns. The primary may be layer wound, with each layer paperinterleaved and this method gives good coupling, but higher self capacitance. The writer uses a combination of both methods, a wave-wound coil consisting of a single pi with .003 in. paper interleaved every hundred turns. This is easy to wind, there is no trouble from end turns slipping out as in a layer wound coil, the capacitance is low and the coupling adequate.

The choice of core material and shape is very wide. There are the special cores such as "Caslam" manufactured by The Plessey Co., Ltd., and "Ferroxcube" by Mullard, Ltd., as well as the more usual alloys. The dust cores have the great advantage of low loss at line scanning frequencies, and the whistle emitted by them is considerably less than that from laminations. The permeability is, however, less than a Silicon alloy such as Silcor II and an increased number of turns must be used for the same inductance. The writer has also found it more difficult to get good linearity with dust cores and for these reasons uses .014 in. Silcor II laminations. As experience is gained, it is more than likely that special cores

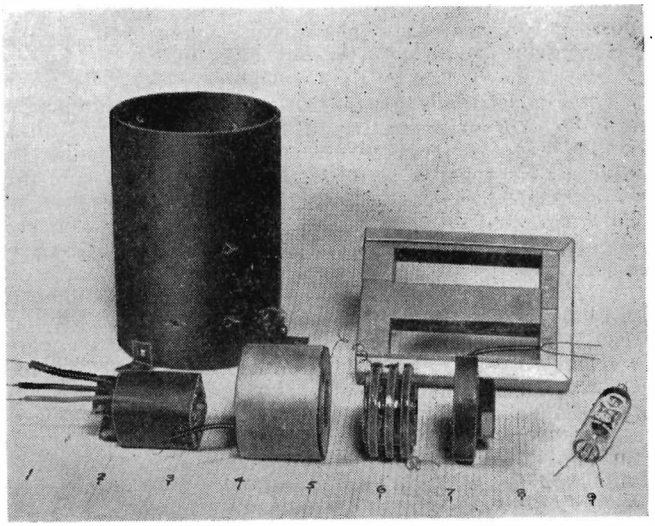


Fig. 11. An "exploded" view of the transformer

will be used much more in high-efficiency scanning components, including the scanning coils. It has been found that No. 84, Magnetic and Electrical Alloy, Ltd., laminations are quite big enough to contain all the windings required, and this, in a stack of 40 laminations, makes a compact assembly. On this stack the primary needs 970 turns to give the required inductance and the secondary, therefore, needs 970/4.2 = 230 turns. The thickness of the wire should be as great as possible to keep the resistance low, but of course the thicker it is the more space it occupies. A practical compromise has been found to be 28 S.W.G. for the secondary, and 36 S.W.G. for the primary, both enamelled.

The E.H.T. winding, as already stated, is wound with 42 S.W.G. enamelled and silk covered wire and is wound in 3 pi's $^3/_{16}$ in. wide. This form of winding not only reduces the self capacitance, but is also a satisfactory method of preventing breakdown due to the high voltage across the windings. It consists of a total of 1,500 turns. This number of turns may be tapered so that the winding withstanding the highest voltage has less turns than one with less voltage across it, but as there is plenty of clearance between the outside of the windings and the laminations the writer has not found it necessary. The former must be of good grade material or breakdown may occur between the inside of the coils and the core. The

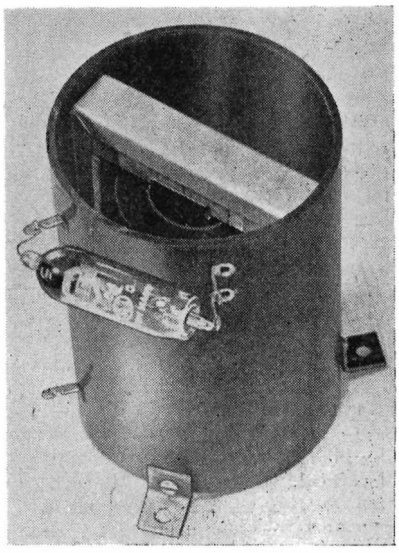


Fig. 12. The complete transformer

E.H.T. coils are doped with a mixture made by dissolving polystyrene in benzene. This dope dries qiuckly and makes an extremely rigid coil.

The heater supply for the E.H.T. rectifier, in this design an EY51, consists of another secondary containing 12 turns of 28 S.W.G. enamelled wire. This winding must be insulated for the full E.H.T. It is difficult to measure the voltage of the heater winding and the only simple way to find the number of turns required seems to be to compare the glow of the heater of the valve when supplied from a 50c/s supply, where it can easily be measured, with the same valve on the high frequency supply, adding a half turn at the time until the glow is the same. It has been found that it is not always satisfactory to compare a valve with 50c/s heating with another on H.F. as the heater glow of different valves may differ in appearance even if fed from the same supply. It may be said in passing that the valves are surprisingly tolerant towards abuse, and the writer has overrun them when making tests without any measurable damage occurring. A convenient method of housing the E.H.T. filament winding is to wind it in a P.V.C. grommet, afterwards melting over the outside with a warm soldering iron. This seals in the wire and provides very good insulation. At least one manufacturer has a special grommet made for such a purpose.

It has been found that better linearity can be obtained if the voltage on the secondary feeding the scanning coils is stepped up somewhat before being applied to the grid of the valve. A limit to the step-up is breakdown of the valve, and it is not advisable to let the voltage on the grid exceed -1kV, although voltages in excess of this have been tried. No trouble has been experienced with voltages less than -1kV and in the design discussed the voltage is only -600V. The grid, which is taking current during the scan, is better able to have effect on a higher impedance, and this seems to be the reason why a step-up is advantageous. In the transformer discussed the step-up is approximately 2:3, an extra 120 turns. The final circuit then becomes as Fig. 10 and this has been found to give satisfactory results. Figs 11 and 12 show photographs of an " exploded " and complete transformer respectively.

Fig. 11 shows the layer-wound secondary winding which is connected to the scanning coils and grid circuit, the primary into which it slides, the E.H.T. winding, and the P.V.C. grommet which contains the secondary to heat the EY51 and the wires brought out in a single piece of P.V.C. sleeving. It also shows the laminations in the simple clamp and the paxolin tube into which the assembled transformer is a push fit, as in Fig.12. The laminations are butt-assembled with a single layer of transparent tape to form a gap. This gap has little or no effect electrically, but reduces the whistle produced very greatly. The P.V.C. grommet is mounted on a short piece of former which has two sides extended. This holds the centre limb of the laminations in position and also reduces whistle. It will be seen that the valve works well within the manufacturer's rating. Many people have carried out a great amount of experimental work on similar circuits and transformers, particularly Messrs. Baird, Ltd., and The Plessey Co., Ltd., and none of the above is claimed as new, but it should assist those who would like to work on such lines and gives an economical design which performs satisfactorily.

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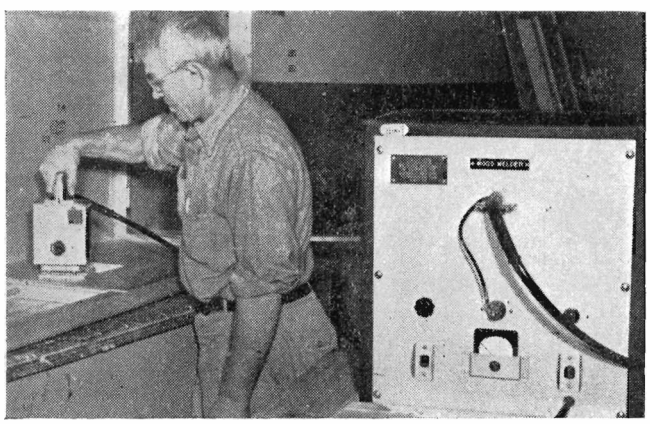
R.F. " Woodwelder " *

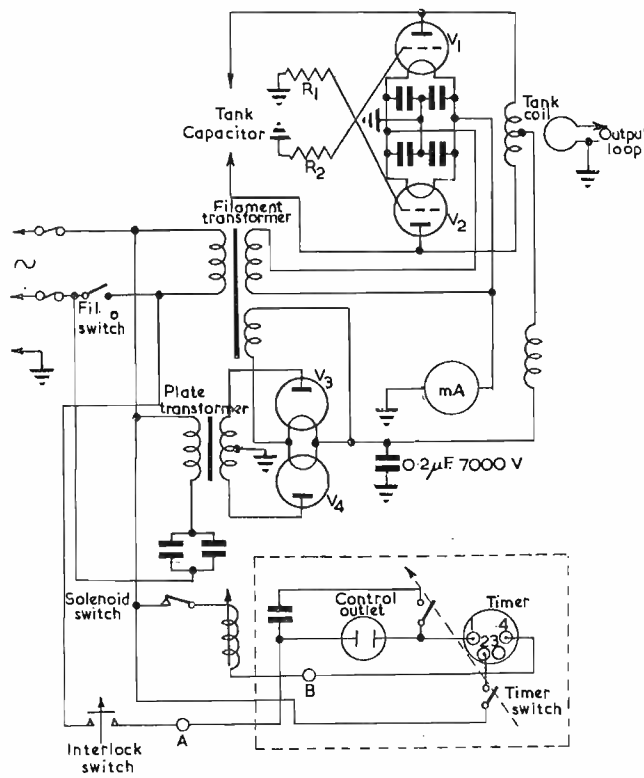


The accompanying illustrations show details of a rather unusual radio-frequency heating unit which was recently designed for Woodwelding Inc. at Burbank, California.

The oscillator valves have an anode potential of 12,000V and work at a frequency of 40Mc/s.

The unit is used for the dielectric heating of thermosetting adhesives on wood veneers which are thus formed into plywood.

The heating cycle is controlled by a Cramer time unit in conjunction with a trigger control on the manually operated " gun."



* Communication from S. M. Milanowski, California.

Crystal Transducer Response

A Description of the Development of a Simple Method for Obtaining the Response Characteristics of Crystal Microphones and Earpieces

By B. J. Shelley, M.I.R.E. *

THE method to be described is based upon the reciprocity properties of piezoelectric crystals. These properties may be stated as follows:

"Direct" effect: the voltage generated due to an applied mechanical force F is given by $E_g = kF$.

"Converse" effect: the mechanical force generated due to an applied voltage E is given by $F_g = k'E$, where k and k' are piezoelectric constants.

In acoustic applications there is an important difference in the way these two effects are manifested. This difference concerns the nature of the loading in the two cases. In the case of the direct effect E_g signifies the open-circuit voltage generated, i.e., an infinite loading impedance is assumed, and this voltage may be directly measured and used to depict the frequency response characteristic. In the case of the converse effect, however, the "open-circuit" mechanical force generated is not of corresponding significance since there is always a definite acoustic load and the response characteristic is depicted by the sound pressure generated in an air space. In the case where the crystal works into a small closed cavity with rigid walls this pressure is proportional to F_g and for the purpose of the present discussion such a condition will be assumed.

In general the dimensions and elastic constants of the crystal are such that the resonant frequency is very much higher than the highest audio-frequency to be accommodated and the mechanical impedance of the crystal is that of a compliance or mechanical capacitance throughout the audio range, just as in the case of a series resonant LC circuit the impedance is capacitative below the point of resonance. Thus, putting C_m for this mechanical capacitance we have, using the well-known properties of electromechanical equivalence, velocity, $v = \dfrac{\text{force}}{\text{impedance}} = F/Z_m = F\omega C_m$, where $\omega = 2\pi \times$ frequency; but under sinusoidal conditions $v = \omega x$, where x = displacement or amplitude, so that:

$$v = \omega x = F\omega C_m \text{ or } x = FC_m$$

Thus, the amplitude is independent of frequency, and since the output of the crystal is proportional to amplitude the response is flat over the audio range where the mechanical impedance is mainly a capacitive reactance. This means that the response of the crystal by itself is flat throughout the audio range. In practical transducers this flatness is modified by the mechanical constants of the diaphragm system and we may, therefore, represent the conditions in this case as $E_g = aF$ and $F_g = bE$, where a and b are functions of frequency and correspond to the frequency response characteristic in the two reciprocal modes of operation, i.e., as microphone and as receiver. In this practical case F is now the force acting on the diaphragm and F_g is the force developed within the cavity.

If the dimensions of the cavity fulfil certain conditions the ratio a/b will be constant and the relative frequency response becomes the same for both modes of operation. These conditions are:

(1) That the cavity shall have a resonant frequency above the audio range so that its impedance is capacitive.

(2) That the value of the mechanical impedance presented by the cavity shall be small compared with that of the crystal and diaphragm together.

This may be shown as follows. Working as microphone, we have $E_g = aF$, where F is the force applied to the system by the sound pressure. This force acts upon the impedance of the diaphragm Z_d in series with the impedance of the crystal Z_x, so that the fraction effective at the crystal is $F \cdot \left\{\dfrac{Z_x}{Z_x + Z_d}\right\}$ and the generated voltage is k times this force, k being the appropriate piezoelectric constant. Thus:

$$E_g = aF = kF \cdot \left\{\frac{Z_x}{Z_x + Z_d}\right\}, \text{ or } a = k \cdot \left\{\frac{Z_x}{Z_x + Z_d}\right\}$$

In the converse mode the force developed in the cavity is a fraction of the force generated by the crystal. The latter force is given by $k'E$, where E is the applied voltage and k' is the appropriate piezoelectric constant. This force acts upon Z_x in series with Z_d and the cavity impedance Z_c. The fraction effective in the cavity is, therefore,

$$k'E \times \left\{\frac{Z_c}{Z_x + Z_d + Z_c}\right\} = bE \text{ or } b = k \cdot \left\{\frac{Z_c}{Z_x + Z_d + Z_c}\right\}$$

When condition (2) above is fulfilled $Z_c \ll Z_x + Z_d$ and we may put $b = k\left\{\dfrac{Z_c}{Z_x + Z_d}\right\}$ so that $a/b = kZ_x/k'Z_c$. When condition (1) is fulfilled, i.e., Z_c is capacitive, then $a/b = kC_c/k'C_x$ where C_c and C_x and the compliances of the cavity and crystal, respectively. Thus under these two conditions the ratio a/b is constant.

These conditions are substantially fulfilled by the usual type of closed cavity of some 2 to 3cc employed in artificial ears. As an example of the magnitudes involved, the resonant frequency of a crystal bimorph of one square cm area and one mm thickness vibrating in flexural mode is in the region of 18kc/s and the mechanical compliance is of the order of 10^{-10}cm per dyne. A 2cc cavity of circular section of 1cm radius and 0.64cm length resonates at about 12kc/s and has an input compliance of about 2.5×10^{-7}cm per dyne, so that its impedance is several hundreds times smaller than that of the crystal.

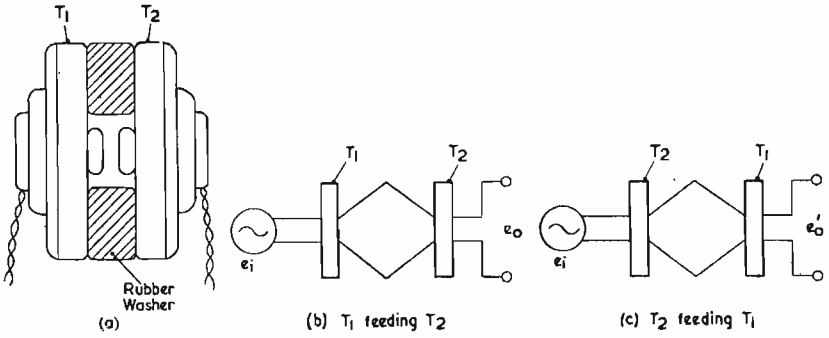


Fig. 1. Two crystal units in tandem.

The fact that under these conditions a transducer does have identical response curves in either direction of operation leads to a convenient technique for the measurement of frequency response.

The development of this technique has revealed an interesting property in connexion with the coupling of two crystal transducers by means of a small common cavity. Referring to Fig. 1, two similar (but not necessarily identical) crystal units (e.g., Brush type D270) are shown in "tandem" coupling by means of a small cavity. This cavity may be constituted by the hole of a $\frac{1}{4}$in. thick rubber washer which forms an effective seal between the two units. A voltage e_i is applied to unit T_1 and the out-

* E.R.D. Ltd., Twickenham Studios.

put e_o is plotted against frequency. When the conditions are reversed, e_i being applied to T_2 and the output taken from T_1, then the second curve plotted is found to be identical in form to the first. These over-all curves are, of course, the product of the separate responses of T_1 and T_2 for the given cavity; more conveniently, by using a decibel scale the over-all response becomes the sum of the two separate responses. This interesting property is

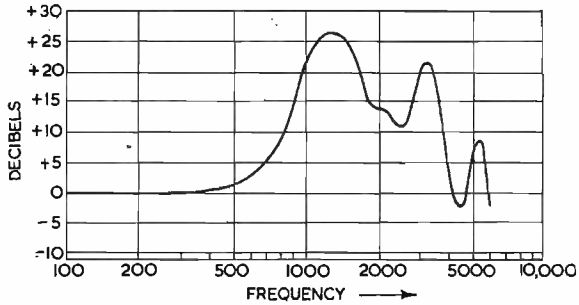
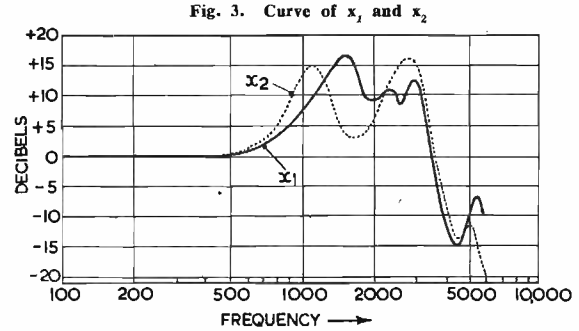


Fig. 2. Curve of $(y_1 + y_2)$.

Fig. 3. Curve of x_1 and x_2



shown to be quite expected from the theoretical analysis of the "tandem" system, and moreover the identity between the two curves for forward and reverse operation is independent of the nature of the cavity (See Appendix).

This coupling technique is, in fact, the basis of the present method. If the individual response curves are designated as y_1 and y_2 then the procedure outlined enables us to obtain the curve $(y_1 + y_2)$, the measurement being made in either direction. The next step is to obtain the curve for $(y_1 - y_2)$, for by so doing we shall have all the information necessary for obtaining the individual response of T_1 and T_2, since by adding $(y_1 + y_2)$ to $(y_1 - y_2)$ we obtain $2y_1$, and similarly by subtracting we obtain $2y_2$.

The procedure for obtaining the curve $(y_1 - y_2)$ is quite simple. Each of the two units T_1 and T_2 is coupled, in turn, to a moving coil earpiece acting as a reference pressure generator. Actually, any type of earpiece would do, although it is desirable that it should be free from sharp peaks or regions with steep variations. A constant voltage (or current) is applied to this earpiece and the output of each unit is plotted, in turn, so that two curves are obtained, x_1 and x_2. When x_2 is subtracted from x_1 the result $(x_1 - x_2)$ is equal to $(y_1 - y_2)$ since x_1 and x_2 show the difference in decibels at each frequency to the same applied pressure. The curves x_1 and x_2 each involve the constants of the reference earpiece, but on subtraction the earpiece constants are thereby eliminated. This is a useful dodge often resorted to in acoustic measurements.

An example of such a measurement is illustrated in the graphs of Figs. 2, 3, 4 and 5. Fig. 2 shows the combined over-all response of a pair of units type D270. In Fig. 3 is shown the response of each unit to the pressure developed by a moving coil earpiece. Fig. 4 gives the difference curve resulting from the subtraction of x_2 from x_1 of Fig. 3, and hence equivalent to $(y_1 - y_2)$. In Fig. 5 we have the result of performing the addition and subtraction indicated above, followed by halving in each case. The individual response characteristics of T_1 and T_2 are, therefore, both obtained at the same time and either one may constitute the unknown.

In order to ensure reproducible results the usual care is necessary to make airtight seals, and any clamping device should be such as not to vary the normal performance of the units.

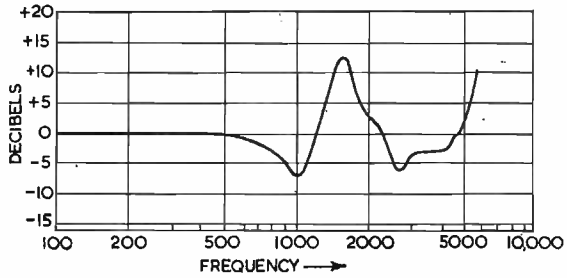
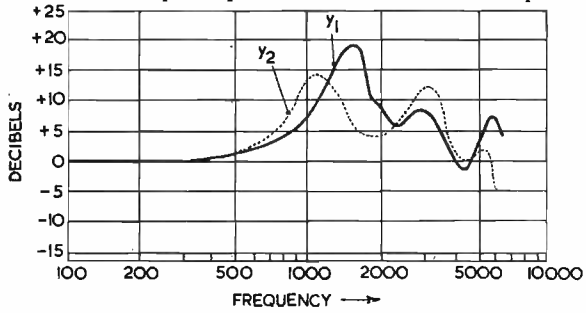


Fig. 4. Curve of $(x_1 - x_2) \equiv (y_1 - y_2)$.

Fig. 5. Curves of y_1 and y_2 showing individual response of T_1 and T_2.



Appendix

Fig. 6 shows the equivalent mechanical circuit for T_1 working into T_2 (Fig. 1(b)). Fig. 7 shows the corresponding equivalent for the reverse case (Fig. 1(c)). Z_{x1} and Z_{x2} are the impedances of the crystals, Z_{d1} and Z_{d2} those of the diaphragms, and Z_c is that of the common cavity.

Let k_1 and k_1' be the direct and converse piezoelectric constants for T_1 and similarly k_2 and k_2' be those for T_2. For T_1 working into T_2 we have (i) $F_1 = k_1' e_1$ and $e_o = k_2 F_2$
For the reverse condition (ii) $F_2' = k_2' e_1$ and $e_o' = k_1 F_1'$
Putting $Z_{x1} + Z_{d1} = Z_1$
and $Z_{x2} + Z_{d2} = Z_2$ and applying the usual analysis,

$$F_2 = F_1 \cdot Z_{x2}/Z_2 \cdot \frac{Z_c Z_2/(Z_c + Z_2)}{Z_1 + Z_c Z_2/(Z_c + Z_2)}$$

$$\text{and } F_1' = F_2' \cdot Z_{x1}/Z_1 \cdot \frac{Z_c Z_1/(Z_c + Z_1)}{Z_2 + Z_c Z_1/(Z_c + Z_1)}$$

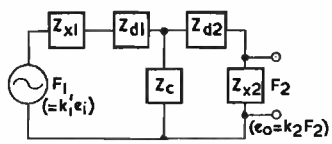


Fig. 6. T_1 feeding T_2.

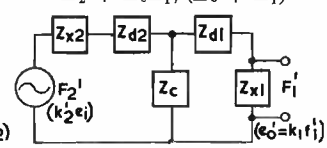


Fig. 7. T_2 feeding T_1.

These simplify to:

$$F_2 = F_1 \cdot Z_{x2}[Z_c/(Z_1Z_2 + Z_1Z_c + Z_2Z_c)]$$
$$F_1' = F_2' \cdot Z_{x1}[Z_c/(Z_1Z_2 + Z_1Z_c + Z_2Z_c)]$$

whence $F_2/F_1' = F_1 Z_{x2}/F_2' Z_{x1}$, and substituting for F_1, F_2, F_1' and F_2' from Equations (i) and (ii) then

$$\frac{e_o/k_2}{e_o'/k_1} = \frac{k_1' e_i Z_{x2}}{k_2' e_i Z_{x1}} \text{ or } e_o/e_o' = \beta \cdot Z_{x2}/Z_{x1} \text{ where } \beta = \frac{k_2 k_1'}{k_1 k_2'}$$

Now Z_{x1} and Z_{x2} are the crystal impedances reckoned as capacitive throughout the audio range, so we may put $e_o/e_o' = \beta Z_{x2}/Z_{x1} = \beta \cdot C_1/C_2$, i.e., e_o/e_o' is constant and therefore the combined characteristic is the same for both directions (neglecting absolute magnitudes) and also e_o/e_o' is independent of Z_c.

The 18th

NATIONAL RADIO EXHIBITION

EARLS COURT, AUGUST 28 to SEPTEMBER 8

1951

A description of selected exhibits compiled from information supplied by the manufacturers

(*Figures in parenthesis refer to Stand Numbers*)

The Royal Navy (231)

THE Royal Naval stand represents the bridge of a modern cruiser showing the operations centre. This consists of a display station, a control station and a plotting station. In the display station will be a panorama depicting an aerial view of the ship and her escorting destroyer which are being attacked by a formation of three enemy bombers.

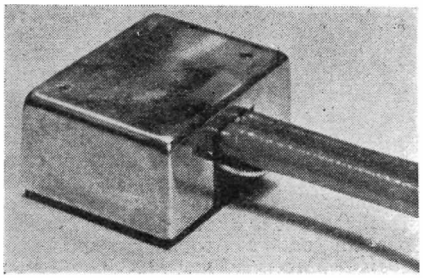
Also over the panorama will be a group of three friendly fighter aircraft whose task it is to destroy the bombers before they reach the ship. As the bombers fly in towards the ship and the fighters converge to intercept them a facsimile of the radar picture as would be seen by the aircraft warning radar is shown on a plan position indicator in front of the panorama in the display station. The same picture appears also on two plan position indicators in the control station. From this presentation a rating passes ranges and bearings of friendly and hostile aircraft to a plotter who plots their progress on the vertical perspex plotting screen. The interception and control of the fighter aircraft is made by the Direction Officer sitting at his desk in view of the plotting screen.

The plotting station will contain various items of navigational aids, for example "Loran" an echo sounding recorder, Decca Navigator, etc. The bridge wireless station will contain modern Naval M.F., H.F. and V.H.F. transmitting and receiving equipment and a working D.F. wireless equipment. This station will also be manned, and demonstrations given of the latest technique of taking down messages in morse directly by touch typing.

Also on the stand will be an outfit of transmitting and receiving equipment supplied gratuitously by the Admiralty to the members of the Royal Naval Volunteer Wireless Reserve for their individual training in their own homes.

It is expected that this equipment will be manned by members of the R.N.V.(W.)R. during the evenings at the Exhibition, when they will be in communication with the Naval Rating in the bridge wireless station Two models on the stand will show respectively a modern destroyer with all its radar and wireless aerials, and the wireless transmitting aerial equipment as fitted in a modern cruiser.

The Admiralty,
London, S.W.1.



Aerialite, Ltd. (47)

ILLUSTRATED above is a new lightning arrestor which has been designed to provide positive protection for radio and television installations, static charges being automatically discharged to earth. It is of small size, and fully water-proofed for outdoor mounting. The device incorporates a gas filled element which ensures a low voltage flash-over to earth. Both conductors of the television downlead are protected.

Another new product is the indoor flexible loft or attic aerial, consisting of 3-elements of 300 ohm twin feeder with a neat connector box and spring tension for the upright element. It is effective for ranges up to 15-20 miles from the transmitter, and models are available for all channels.

Also of recent design is the Aerialite car aerial model 17, which is for header bar mounting, and is adjustable from a knob inside the car. The aerial can be moved to four positions and can be extended to a height of 35in. It requires single hole mounting, and is easily fitted to most types of cars. The aerial is supplied with low loss co-axial cable for connexion to the receiver.

Aerialite, Ltd.,
Castle Works,
Stalybridge, Cheshire.

Royal Air Force (232)

THE Royal Air Force exhibits this year consist of five pieces of radio and radar equipment and scale models of R.A.F. aircraft. These will provide visitors with an idea of the wide range and variety of radio and radar equipment in use today. The exhibits are an A.I. Mk. 10, a Trainer Type 102, a T.R.1936, a Rebecca Mk. 4, and a Gee Mk. 3.

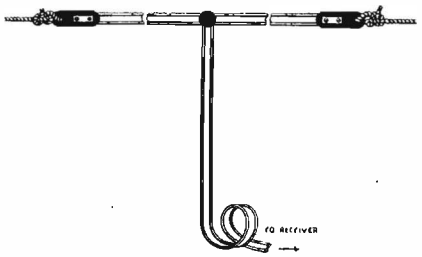
The A.1. Mk. 10 is the most up-to-date type of radar equipment used for "air interception" in the latest night fighter, the Gloster Meteor M.F. Mk. 11. The one on show is a synthetic training device which enables visitors to see how the presence of hostile aircraft is indicated on the screen to the airborne radar observer in the night fighter.

Trainer Type 102 is used for training aircrews on the ground. It simulates the responses received in aircraft fitted with H.2Z Mk. 4a which is a radar device carried by Bomber Command such as the Lincoln. Radar impulses are sent vertically downwards from the aircraft to the ground which on "bouncing back" like the echo, reveals to the radar observer the nature of the terrain below, i.e., the shape of a coast-line, presence of rivers and towns. By correlation with a map of the area, this enables a position to be checked in any weather or a target to be sighted and bombed through cloud.

The T.R.1936 is a new type of High Frequency transmitter/receiver set, now standardized for fighter and bomber aircraft alike in the Royal Air Force.

The Rebecca Mk. 4 and the Gee Mk. 3 are the latest blind-landing and navigation aids in use in all types of R.A.F. aircraft which carry a navigator—including the latest night fighters.

The Air Ministry,
Parliament Square House,
Parliament Street,
London, S.W.1



Antiference, Ltd. (94)

(Illustrated above)

THE "Arnine" aerial is suitable for shortwave reception and transmission, and consists of two flexible spans calibrated in metres and megacycles, together with a downlead. The whole forms a folded dipole with all connexions sealed.

The aerial is available in two models, one for 7Mc/s upwards and the other for 14Mc/s upwards.

Antiference, Ltd.,
67 Bryanston Street,
London, W.1.

Avimo of Taunton (10)

THE Avimo "Hiperspeed" continuous film recording camera has been designed for high-speed continuous film recording with standard oscilloscope equipment; it can also be used on multiple-tube work to suit specific requirements.

The camera is contained in a single case and houses a film transit mechanism, spools and cassettes; the film sprocket, guide rollers, and automatic film tension governor; the driving mechanism, high and low speed gear train, clutch and three-speed gearbox, etc.

The camera has film speeds ranging from 2.5 to 300in./sec. The 200ft daylight-loading cassettes take 70mm standard perforated film. The lens fitted is a 2½in., f/1.9 anastigmat, and adjustments permits of object to image reduction in the order of 15 : 1 to 1 : 1. A reflex viewfinder is fitted, which allows the lining-up of traces after loading, and viewing during actual exposure.

Automatic presetting enables any desired length of film to be exposed, following which the camera ceases to operate. A clutch allows the film to be set in motion and reach the desired speed with a minimum of waste, while an isolator prevents actual photography before this speed has been attained. On completion of the exposure a rewind mechanism resets the film, for each subsequent exposure.

Avimo of Taunton,
Taunton,
Somerset.

The B.B.C. (237)

THERE will be an exhibit at this stand which illustrates the work of a B.B.C. mobile recording unit in sound broadcasting. Visitors will be able to make a recording and then have it played back to them. There will also be a 1:7 scale model of the feeder switching towers used at the B.B.C.'s short-wave stations for connecting the transmitters to any of the numerous aerial arrays. This will be a working model, and visitors will be able to select an aerial and then watch the switch operate.

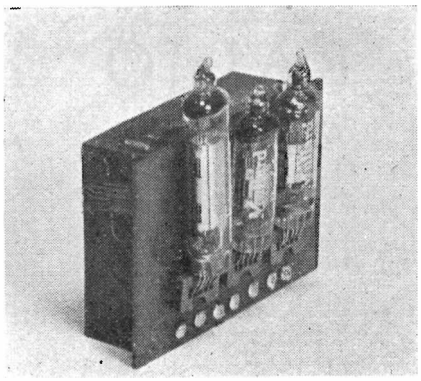
The B.B.C.,
Broadcasting House,
London, W.1.

John Bell and Croyden (22)

THIS firm is showing a new sub-miniature packaged amplifier, illustrated top centre, which is available in one, two or three stages. The amplifier is a moulded unit with valve holders for Mullard sub-miniature valves, and can have either a high or low impedance output. It has a very low battery consumption and a low noise level. The compression strength of the block exceeds 250lb. The components are completely sealed to prevent air inhibition.

The weight of the 3-stage amplifier with valves and transformer is 3oz., a 2-stage with valves ¼oz., and 1-stage ½oz.

The main characteristics of a typical 2-stage amplifier are: a gain of 60db level 10c/s to 50c/s; an input impedance of 10MΩ; an output impedance of 1MΩ; V_{in}max. of 1.6mV, and V_{out}max. of 1.5V.

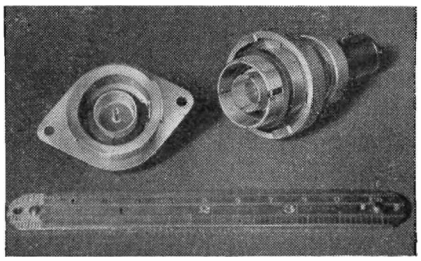


Another new item on this stand will be the portable miniature oscilloscope, which is designed for television servicing, laboratory work and for radio servicemen. The dimensions of the case are 9½in. by 3½in. by 5in.

The cathode-ray tube has the following sensitivity: X — 24V R.M.S. per cm, and Y — 15V R.M.S. per cm. The Y amplifier has an input impedance of 1MΩ, a sensitivity of 50-100mV R.M.S. per cm, and a frequency response of 10c/s — 3Mc/s. The time base has a frequency of 10-50,000 sweeps per second in six ranges, and provision is made for synchronizing. The time base output is available for use with a "wobbulator."

The oscilloscope has A.C. coupling to one Y plate, direct coupling to at least one of both X and Y plates, and possible coupling to a tube modulator.

John Bell and Croyden,
117 High Street,
Oxford.



Belling and Lee, Ltd. (64)
(Illustrated above)

THE Belling and Lee Connector is designed for use with coaxial cable with an additional screen, and will accept cable up to ⅛in. overall diameter. The dielectric between the inner conductor and braid is polythene, and that between braids, nylon filled bakelite. The characteristic impedance of the centre conductor is 80Ω. The outer braid is directly connected to the chassis, but the inner braid can carry R.F. or D.C. up to 250V, or can be earthed separately.

One type of plug is available for connexion to the cable, but there are alternative sockets as follows: L.764/CS, a standard chassis socket with two hole fixing, with solder connexions for centre conductor and inner braid; or L764/BS, in which the connexion to the centre conductor and inner braid terminate in a standard coaxial socket to accept coaxial plug L.734/P. The plug is fitted with a quick action retaining ring, which ensures positive, vibration proof locking.

The solder connexion can be made with the metal parts removed from the insulation so that there is no danger of damage to the dielectric by heat.

The outer housing is sturdily constructed in light alloy, and is splash proof but not sealed. The electrical performance is well within the requirements (where applicable) of specifications RCS/322 and RIC/322.

Belling and Lee, Ltd.,
Cambridge Arterial Road,
Enfield, Middx.

A. F. Bulgin and Co., Ltd. (2)

THE new Bulgin mains voltage signal lamp, taking standard "15W Pigmy Sign" or "Switchboard Indicator" lamps, with B.C. (BS.52) Caps, for direct use upon all usual mains-supply voltages, will be exhibited. This model has a thermosetting-heat-resisting front moulded bezel and glass lenses in a wide variety of colours. The lamp-holder itself is all-insulated, and the aluminium casing may be earthed. Lamp-replacement is from either front or rear, and it is suitable for panel-thickness of from 18 S.W.G. upwards. The aluminium casing is louvred for ventilation, with light-trapping so that a plurality of these fittings may be mounted adjacently, without stray light giving false or unwanted signalling or indication.

All Bulgin signal lamps are standard with plastic lenses, for use at up to 70°C., but all models can now be had with glass lenses. Models are being introduced to cover continental lamps and American lamps, with candelabra or E.12 screw-cap.

Among the large range of Bulgin plugs and sockets, there have been further improvements to cover improved cable-gripping and reinforced strength against crushing or fracture due to collision of apparatus or equipment, while a new form of safety mains connector, suitable for all-insulated apparatus will be shown. With this model, removal of the cabinet back or opening of the cabinet door not only breaks both poles in the briefest possible movement, but inadvertent or even wilful contact with live parts is prevented, and temporarily re-connecting of the connector members is also impossible, although service-engineers on the other hand, may easily establish the mains connexions for their purposes. This component is adaptable to all kinds of radio and electronic equipment and appliance, to give compliance with safety requirements. As soon as the cabinet back or door is unlatched or unscrewed, the connector itself promotes the disconnexion of both poles of the mains.

The new Bulgin low-current Fuse-links, low current sensitive fuses operating upon currents as low as 10mA, carrying and 20mA blowing, are reasonably robust. They are precise to rating and are designed to protect expensive but low-rated or overload-factor instruments in equipment. Like all Bulgin Fuse-links, replacements are easily fitted, by the Cartridge form of construction, fitting into standard holders. These fuses are being made in the well known ¼in.

diameter styles, in lengths of ⅝in., 1in. and 1¼in., with a number of useful ratings up to the 60 or 100mA (carrying) figures of the lower-end of the existing ranges.

New models in the Bulgin range include biased or non-biased ("non-locking" and "locking") types with longer fixing bushes, in toggle (lever) and semi-rotary types, and new side types, all with positive Q.M.B. action and with new overload-withstanding features, widening the scope of their application to inductive circuits giving high back E.M.F. upon breaking circuit. All models have new and improved internal action, to meet difficult conditions of usage.

A. F. Bulgin and Co., Ltd.,
Bye Pass Road,
Barking, Essex.

Burndept Ltd. (40)

BURNDEPT Ltd. will exhibit a new range of V.H.F. communications equipment. Some of the more interesting types are briefly mentioned below.

The BE201 is a transmitter/receiver of 5 watts, having a frequency range of 100-125Mc/s in one band. The BE202 and BE203 are lightweight V.H.F. dry battery operated transmitter-receivers of the walkie-talkie type. BE202 has a frequency range of 95-100Mc/s. Three transmitter/receivers having a power of 50 watts are the BE206, 207 and 208, which have a frequency range of 66-100Mc/s, 100-156Mc/s and 156-184Mc/s respectively. These three models can be used in association with a remote control unit BE210, which is designed for ease of maintenance and simplicity of operation, either in cabinet or rack mounted form. Type BE211-A is a 10 watt V.H.F. transmitter, as designed and produced for the Ministry of Civil Aviation. It has a frequency range of 117-133Mc/s for use as an airport control station. A three channel 60-93Mc/s transmitter/receiver, with a vibrator power pack is BE209, which is a portable field equipment of special design which gives a high quality performance.

Burndept, Ltd.,
West Street,
Erith,
Kent.

A. C. Cossor, Ltd. (86)

AN interesting item on this stand will be the Model 1314 Electro-Cardiograph, which is a direct-writing instrument containing an electronic amplifier of special design and a two-speed recorder unit giving an instantaneous recording of the heart waveform. The instrument is for use on 50 cycle A.C. mains or with a convertor from batteries. Normal sensitivity is the internationally accepted standard of 1cm/mV and suitably calibrated recording paper is supplied in rolls giving 30 minutes continuous recording. The calibration signal or any of the standard lead connexions may be selected on a single front panel control. The whole instrument is precision engineered throughout, and is completely portable.

A. C. Cossor, Ltd.,
Instrument Division, Cossor House,
Highbury Grove, London, N.5.

Dept. of Scientific and Industrial Research (235)

THE D.S.I.R. stand at the Radio Show will show the use of ionospheric recording in short wave communications. From information obtained by recording stations all over the world, the best frequencies for transmitters to use are forecast six months before. Radio receivers tuned in to the same broadcast on different frequencies will prove how accurate these forecasts are.

D.S.I.R.,
Charles House,
5-11 Regent Street,
London, S.W.1

Dubilier Condenser Co. (1925), Ltd. (45)

ILLUSTRATED bottom left are the insulated wire-wound resistors type BWF, which are completely insulated wire-wound components available in two wattage ratings of ½W and 1W at 71°C. The shaped connecting wires are crimped to the ends of the resistance element assuring definite contact. The whole resistor assembly is moulded in selected phenolic resin, to make it completely insulated and adequately sealed. The resistors are available in the range of 1.0Ω to 1,000Ω for the ½W rating, and 1.0Ω to 4,700Ω for the 1W rating.

The high stability resistor, illustrated bottom centre, consists of a hard crystalline or pyrolitic carbon element which is formed and deposited upon the surface of a specially selected ceramic rod at high temperature. These resistors have: high intrinsic stability of resistance value; a temperature coefficient of −0.02 per cent to −0.06 per cent per °C, dependent upon resistance value; negligible voltage coefficient; low noise level and negligible inductive phase angle. The resistors have rigid metal end-cap contacts with integral connexion wires, and are available in two types—normal and insulated with neoprene sleeve, suppliable in preferred values.

Shown bottom right are the type C potentiometers. These are made up of a moulded phenolic resin base to which is riveted a resistance element. This element has a suitably graded resistance coating, permanently bonded to high-grade laminate of the required shape, and is processed and seasoned at a high temperature to ensure a durable and stable element.

The contact brush is carried on, but insulated from a ¼in. diameter spindle rotating in a ⅜in. diameter, 32 T.P.I. brass bearing bush. The brush is of a multi-finger type with each of the fingers contacting the resistance element independently.

The resistance value is from 5,000Ω to 10,000Ω semi-log, and from 25,000Ω to 5.0MΩ log.

There is a tropicalized form of the Type C control, called Type Z, which is identical internally.

Dubilier Condenser Co. (1925), Ltd.,
Ducon Works, Victoria Road,
North Acton, London, W.3.

Edison Swan Electric Co., Ltd. (63)

OF considerable interest to the non-technical visitor will be the Ediswan "talking" television set. This is a special display unit which has been developed as a method of teaching in non-technical language the importance of the valves and cathode-ray tube in a television receiver.

It takes the form of a "ghosted" receiver in which each group of valves will be illuminated in turn and the receiver will explain their function so that the method by which the signal is taken from the aerial and used to produce a picture on the cathode-ray tube can be understood.

In accordance with the expressed desire of the Radio Industry Council Ediswan are showing a number of items of electronic and electro-medical equipment. Prominent among these is a demonstration of a new low priced highly stabilized power supply unit. This unit has been designed to power electronic equipment in research and development undertakings and for the testing and calibration of instruments.

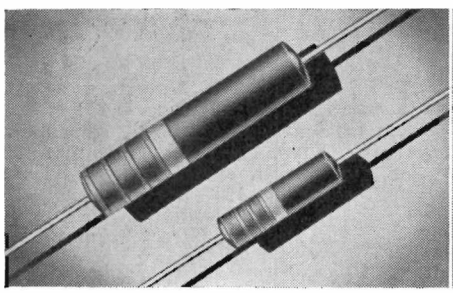
It operates on 200-250 volts, 40-100 cycles A.C. and provides an adjustable 120-250 volts D.C. highly stabilized supply at 0-50mA.

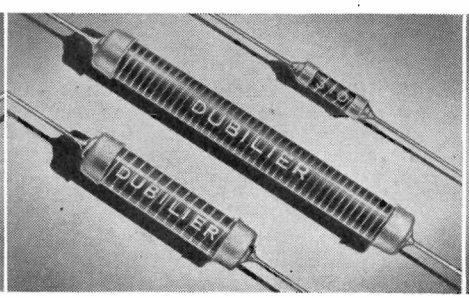
The Edison Swan Electric Co., Ltd.,
155 Charing Cross Road,
London, W.C.2.

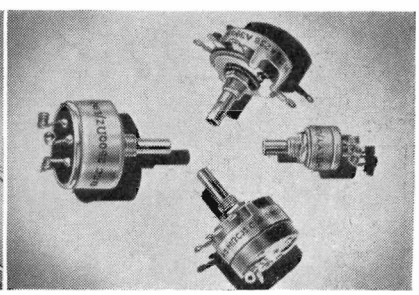
The Garrard Engineering and Manufacturing Co., Ltd. (68)

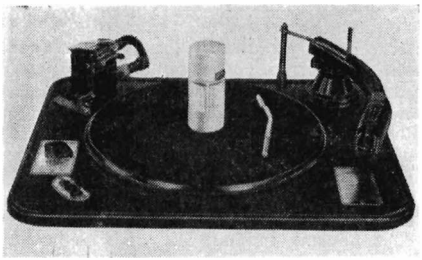
THE Garrard exhibit will include two automatic record changers, the RC80 and the RC72A.

The model CR80, which is illustrated









above, is made only for export, and will play up to ten records, 7in., 10in., and 12in. not mixed at 33⅓, 45 or 78 R.P.M. It has two record spindles, one for the large hole 45 R.P.M. records, and a stepped sloping spindle for all other types. It is fitted with a pick-up muting switch and automatically stops when the last record has played.

The model RC72A will play any number up to eight records of 10in. or 12in. not mixed, at 33⅓ or 78 R.P.M. 7in. 45 R.P.M. records can be played singly using centre hole adaptors. It also stops automatically when the last record has played.

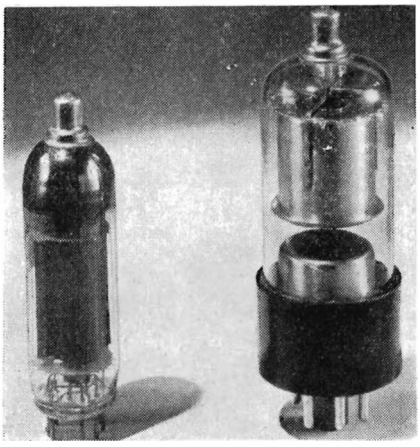
The Garrard Engg. and Mfg. Co., Ltd., Swindon, Wilts.

The General Electric Co., Ltd. (51, 23, 211)

THE Osram valve and electronic stand will display a complete range of current Osram receiving valves, particularly the miniature button seal types, in both 7 pin (B7G) and 9 pin (B9A Noval) bases. These valves include six types for 1.4 volt dry battery sets or mains-battery receivers, including a new shortwave frequency changer, the X18. There will also be a range of 6.3 volt indirectly-heated miniatures including the new X79 triode hexode frequency changer, and high slope output pentode N78; a range of 100 mA A.C./D.C. valves with comparable characteristics to their A.C. counterparts. For television receivers, the well known Z77 high gain R.F. pentode will be shown in the range of miniatures, and four new "Noval-based" valves to replace octal types hitherto used. These are Osram N339, a line scan pentode, which is illustrated below left, U319 and U309 mains rectifier and booster diode respectively; and the LN309, a triode-pentode multiple miniature with various applications.

The sub miniature E.H.T. rectifier for fly-back circuits, U37, which is illustrated with the pentode, will also be exhibited.

The General Electric Co., Ltd., Magnet House, Kingsway. London, W.C.2.



The General Post Office (233)

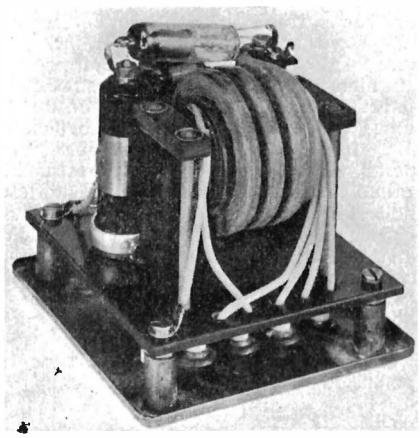
A MODEL of a microwave Rhombic aerial will be on view. This type of aerial is widely used in the Post Office Overseas Radio Telephone and Telegraph services, and the model is similar to that used in planning transmitting and receiving stations. Congestion of aerials, aerial supports or buildings at a station may adversely affect the efficiency of the station, and models are used to assess the effects of obstructions without the expense of full scale trials.

Radio and coaxial cable links for B.B.C. television stations are supplied by the Post Office and how this is done will be seen in a pictorial representation.

There will be displayed various electronic devices including a reaction timer used to demonstrate the speed of human reaction, and a telegraphy code convertor which automatically translates five-unit code into morse.

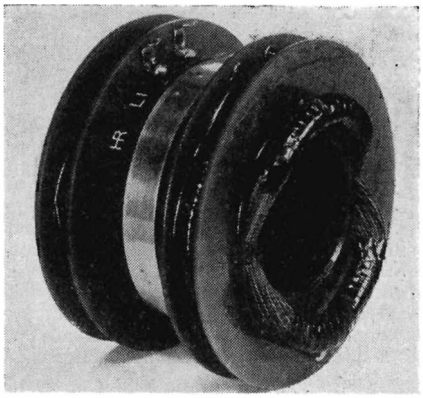
The Telegraph Automatic Switching scheme is represented on the stand. This scheme is a revolutionary development in telegraph technique designed to speed up transmission of telegrams. It is now being put into operation in this country in four stages and is expected to be completed at the end of 1952. The exhibit will show how an operator in one telegraph office can dial and obtain direct connexion to any other office in the scheme without the intervention of an intermediate office.

The General Post Office, London, E.C.1.



Haynes Radio, Ltd. (6)

THE line output transformer, illustrated above with its cover removed, is totally sealed in a copper container. It consists of: a ferroceramic core, and an extended winding for H.T. boost with an external valve rectifier; two enclosed E.H.T. rectifying valves, and other circuit components including E.H.T. capacitors for delivering 10-12kV, together with width controlled line scan when connected in the anode circuit of an EL (PL) 38, taking 60/70mA from a 300/330V H.T. supply.



The transformer is for use with 35 or 38mm (wide angle) cathode-ray tubes.

Shown above is a scanning coil unit for 38mm wide angle round or square faced cathode ray tubes. The scanning coil is provided with a ferroceramic (Ferroxcube) ring core.

Haynes Radio, Ltd., Queensway, Enfield, Middx.

A. H. Hunt, Ltd. (95)

(Mark 51 capacitor illustrated)

THE original Hunt-Ingram capacitor was limited in its usefulness by its relatively high power factor of 0.2 per cent. compared with that of the standard oil-filled capacitor with 0.05 per cent, but in the new Mark 51 development the power factor has been reduced to a limit of 0.1 per cent, with the result that the permissible loading of the capacitor is increased by approximately 100 per cent. The capacitors are particularly useful in high voltage and power R.F. equipment.

There are three ratings available of 140kVA, 70kVA, and 35kVA, with a capacitance of 1,000pF-0.01μF, 500pF-2.000pF and 150pF to 500pF, respectively.

A. H. Hunt, Ltd., Bendon Valley, Garratt Lane, London, S.W.18

Lee Products (Great Britain), Ltd. (16)

LEE PRODUCTS will show a new car radio aerial, type CA/8, which will have a wing scuttle fitting, and be similar to type CA/7. It will be made up of four sections extending to 40 inches, but measuring 13½ inches in its telescopically closed position.

Lee Products (Great Britain), Ltd., 90 Great Eastern Street, London, E.C.2.

Metro Pex, Ltd. (31)

METRO PEX. LTD., have introduced the Magnavista filtachromatic lens, which is available in a number of different models. The filter is actually contained inside the lens to afford "daylight" viewing without having to increase the brilliance.

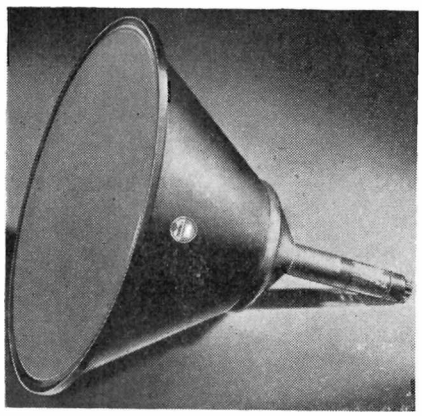
Metro Pex, Ltd.,
42a Denmark Hill,
London, S.E.5.

Ministry of Civil Aviation (236)

THE main feature of the Ministry of Civil Aviation exhibit in the Radio Show will be a 15ft by 8ft model, built to a scale of 1:1250, of London Airport as it will appear in the future.

The model will be flanked on its four sides by photographic and diagrammatic information on many aspects of London Airport activity. Subjects dealt with include present amenities, British aircraft, radio and radar aids, air traffic control, lighting, architectural design and statistics showing the increase in aircraft passenger and freight movements in the London area to date.

Ministry of Civil Aviation,
Ariel House,
Theobalds Road,
London, W.C.1.



Mullard Ltd. (75)

THE new Mullard 16-in. Television Picture Tube Type MW41-1 will be shown for the first time on the Setmaker's Section of the Mullard Stand, and is illustrated above.

The new tube, which incorporates a magnetic ion-trap, has a useful screen diameter of approximately 14½in. This enables a picture with rounded corners of approximately 130 sq. in. or 13in. × 10in. to be obtained.

A feature of the tube which should prove of particular interest to set designers is its short neck measurement, which is, in fact, no greater than that of the standard 12-in. type of tube. This means that it is possible to design larger-screen television receivers without any appreciable increase in the size of the cabinet.

The tube consists of an almost flat glass viewing screen, a metal cone envelope, and a glass neck containing the electron gun. It can be operated from power supplies normally used in television receivers, and sufficient light is produced for the picture to be viewed under average conditions of ambient light in the home.

The MW41-1 tube has a heater with a voltage of 6.3V and a current of 0.3 amp (series operation), which is suitable for series or parallel operation A.C. or D.C. The fluorescent screen material is an efficient emitter of white light providing high definition pictures of good contrast. The tube has a deflexion angle of approximately 70°, with a recommended anode voltage of 9-12kV, although the maximum value is 14kV. The anode connector is a metal-cone lip, and the base is a Duodecal B12A.

The tube has on overall diameter of 15.9in. and a maximum overall length of 18in. It weighs about 11½lb.

Mullard Ltd.
Century House,
Shaftesbury Avenue,
London, W.C.2.

Ossicaide, Ltd. (32)

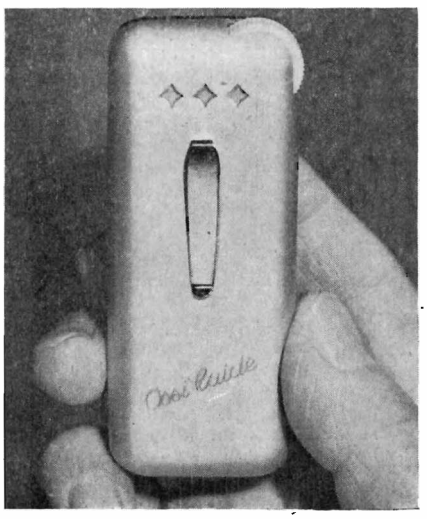
(R17 illustrated below)

THE Ossicaide stand will be exclusively devoted to hearing aids. The three main models will be the "Osray" RP15, RP16 and RP17, the last named being claimed as the smallest aid in the world, since it weighs only 3oz., complete with all batteries. At the same time it is sufficiently powerful for most deaf people.

The model R17 incorporates a crystal microphone, a three valve amplifier volume control, the output being via an output transformer to either a Miniature Earpiece or Bone Conductor having an impedance of approximately 90 ohms. The overall gain is not less than 45db operating on 15V high tension lasting approximately 150 hours, and a 1.4V low tension giving approximately 25 hours use.

The R.P.15 is a deluxe instrument incorporating magnetic pick-up unit, automatic volume control and straight high quality reception.

This device is particularly useful for listening to the radio, television, telephone, cinema and in similar circumstances, and relies for its operation upon the small magnetic field which is thrown out when a loop of wire is run from the output terminals of a suitable amplifier, and in the case of the telephone, on the leakage from the transformer contained in the base.



These three aids are constructed on the same lines, using a Berryllium copper strip circuit, which gives the advantage of a small aid, while being very durable. Air or bone conduction may be used on all these instruments, the earpiece (air conductor) being only the size of a sixpence.

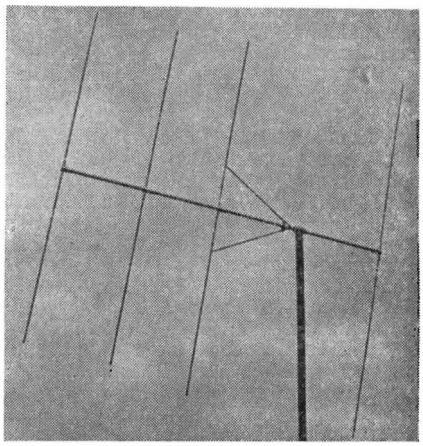
Ossicaide, Ltd.,
Suffolk Hall,
1 Upper Richmond Road,
London, S.W.15.

Standard Telephones and Cables, Ltd. (87)

BRIMAR are now producing a limited range of valves having a higher expectation of life than ordinary types. The range comprises 14 types, 13 of which have miniature or Noval bases, the other being of the GT type. They have been specially developed for aircraft control apparatus, transmitters and receivers to withstand the shock of battle conditions in tanks or battleships, to meet the stringent requirements of industry—in fact, wherever conditions are tough and reliability is of the utmost importance.

The S.T.C. rectangular wide angle deflexion tube is another development. Although much smaller in length and volume, this tube gives a bigger picture than the round version and is much easier to handle. Brimar rectangular tubes are all aluminized, thus giving added brightness, improved contrast and daylight viewing.

Standard Telephones & Cables, Ltd.
Footscray,
Sidcup, Kent.



Telerection, Ltd. (27)

(Illustration above)

TELERECTION, LTD. have introduced a new principle of impedance matching, in a new aerial—the "Multimus." Designed for use in fringe and ultra fringe areas, Delta matching is utilized in T.V. and F.M. aerials.

By use of this new matching device, any receiver with an impedance cable may be used. At the same time it gives maximum gain from a 4-element array, since the Delta matching device allows negligible losses. Being fully adjustable, accurate matching may be obtained, and

by the design. of the aerial, maximum bandwidth, consistent with interference suppression properties, is obtained.

It is more than essential that in matching an aerial to a set there is a maximum transfer of energy. By using the Delta Match system the standing wave ratio on the transmission line is unity, and there is consequent elimination of interference pick-up on the feeder.

The manufacturers claim that the "Multimus" has a maximum gain of 3db above any other four element aerial. It has a bandwidth of 4.25 megacycles, a front/back ratio of 40db, and an acceptance angle of 60°.

Telerection, Ltd.,
12 Suffolk Parade,
Cheltenham, Glos.

Valradio Ltd. (21)

ON the stand will be shown a full range of A.C./D.C. vibrator convertors, including new heavy-duty vibrator power units for operating mobile transmitters from 6 and 12 volt batteries. These units are capable of supplying outputs up to 150 watts, which is sufficient for most mobile transmitter requirements; the efficiency of these units is over 70 per cent.

A popular unit of this type provides 500V at 250mA; 6.3V at 6 amp from a standard 12V car battery. The vibrator used utilizes a total of 20 contacts.

Valradio Ltd.,
New Chapel Road,
High Street,
Feltham, Middlesex.

The Regular Army (284)

REPRESENTING the Regular Army this year are the Royal Corps of Signals and the Corps of Royal Electrical and Mechanical Engineers. To a large extent each of these Corps is dependent on the other, and it is symbolic of their mutual assistance that their separate displays are blended into one combined stand.

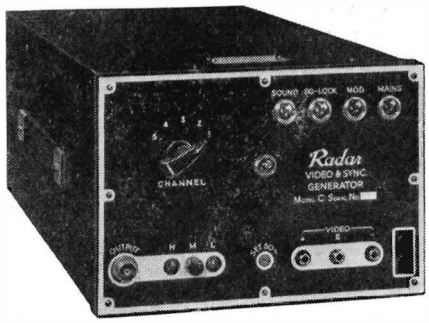
The main exhibit for the Royal Corps of Signals will be an interesting tableau showing the various phases through which military signalling has passed since the Greeks first used a water telegraph system in 150 B.C. Electricity first came to the aid of the Army communications in the Crimean War and the tableaux will show some of the equipment used in those early days.

The centrepiece of the R.E.M.E. display will be a working model anti-aircraft gunsite, including the radar equipment. Other electronic equipment shown will include: a high speed oscilloscope; a superheterodyne demonstration rack; a graphoscope; an electronic valve characteristic plotter, and an electronic polar diagram plotter.

The War Office,
London, S.W.1.

Waveforms Ltd. (34)

THE Radar 5-Channel Video and Sync Generator, illustrated top centre. has been introduced to meet the requirements of service engineers called upon to check and adjust television receivers in more than one reception area. It produces a complete test pattern with line and frame synchronizing pulses for injection into the aerial socket of

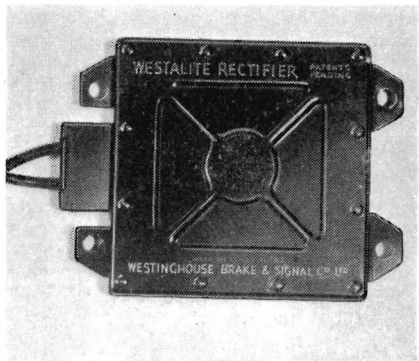


a receiver. Simultaneous sound is provided. A single control selects the required sound and vision channel and a three-position attenuator provides an R.F. output (peak video) of 10mV; 1mV; and 100 microvolts corresponding to varying signal conditions.

The pattern consists of horizontal and vertical bars which are graded from black (30 per cent mod.) to full white (100 per cent mod.). The modulation can be switched off leaving a blank synchronized raster, and the frame synchronizing frequency which is normally locked to the mains, may be unlocked to enable hum to be more readily observed. The complete video waveform with sync is available for injection into the V.F. stage of a receiver for checking sync separator and time base faults. This video output is approximately 6V peak and positive or negative modulation is provided.

The generator is primarily intended for checking and adjusting line hold and width, frame hold and height line and frame linearity, brightness and contrast, interlacing, sound on vision interference, etc., in the absence of a transmission. The instrument is portable, and weighs 15lb, and is for use on 200/250 volts A.C. mains.

Waveforms Limited,
26 Oakleigh Road,
New Southgate,
London, N.11



Westinghouse Brake and Signal Co., Ltd. (43)

THE Westinghouse "Westalite" rectifier Code No: 2L985, illustrated above, is an hermetically-sealed biscuit shaped unit, designed primarily for unobtrusive housing on lightweight motorcycles and with an 8 amp output for battery charging from fly wheel dynamos. Incorporating selenium-compound elements, the unit is centre-tapped; the case being positive and the two leads negative.

Westinghouse Brake and Signal Co., Ltd.,
82 York Way, King's Cross,
London, N.1.

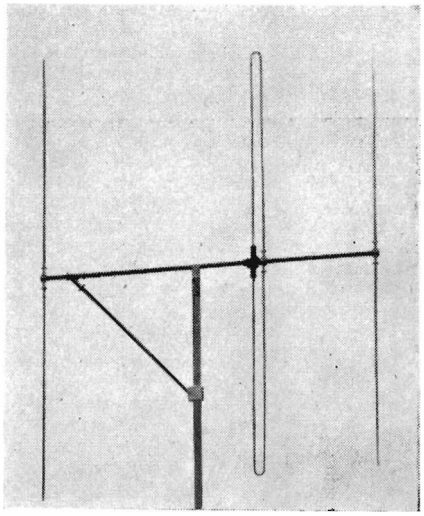
Wolsey Television, Ltd. (5)

THE Wolsey F3E aerial, illustrated below, consists of a folded dipole with a director and reflector. This aerial has been designed to meet the requirements of reception at extreme range or with severe interference.

The gain is 7.5db over a single dipole, and has an acceptance angle of 65°, with a front to back ratio of 30db. The use of a folded dipole ensures an impedance match with 70 ohms feeder, and the aerial has a bandwidth of 3.5Mc/s.

The aerial weighs 7½lb, and is available for the following channels: London, Birmingham, Huddersfield and Scotland.

Wolsey Television, Ltd.,
75 Gresham Road,
Brixton, London, S.W.9.



Wright and Weaire, Ltd. (112)

THIS stand will be so arranged as to exhibit the two main interests of the company, viz., radio and electronic components and magnetic tape recorders.

The central portion of the stand consists of a sound proof room where continuous demonstrations of magnetic recording will be taking place. These demonstrations will feature "live" recording by members of the public of speech, song and pianoforte playing, simultaneous dual-track recording and replaying, speech recording at tape speeds of 3¾in. and 1⅞in. per second, continuous loop recorders, remote control and voice/signal operation.

Typical Ferrograph recorders tape-decks and rack-mounted assemblies will be on view at one open end of the stand while the other will comprise a comprehensive display of Wearite components.

Wright and Weaire, Ltd.,
138 Sloane Street,
London, S.W.1.

NOTES FROM THE INDUSTRY

The 1951 Audio Frequency Engineering and Acoustics Convention of the Brit. I.R.E. will be held at the Richmond Hall, Earls' Court, London, S.W.5, on September 4th, 5th and 6th, and is concurrent with the National Radio Exhibition held at Earls Court.

A large range of subjects concerned with audio frequency engineering will be covered by 15 lectures, with titles such as "The Royal Festival Hall: Acoustic Design and Testing," "Problems in Magnetic Recording with particular reference to Film Production," "The Mechanics of Hearing," "Electrophonic Organs" and "Piezo-Electric Crystal Transducers."

Admission to the lectures is by ticket only, for which application must be made to the Secretary, the British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. The registration fee of 10s. 6d. should be enclosed. Further details of the convention can also be had from the same address.

New Examination of Graduateship of the Institute of Physics. In September, 1949, the Institute of Physics instituted a new grade of membership—Graduateship (Grad.Inst.P.)—for those holding a recognized degree or other qualification in physics but not having the necessary period of professional experience required for Associateship of the Institute. By July, 1951, more than 400 applicants had been elected to the new grade.

The Board of the Institute now announces the establishment of an examination by which those not holding a recognized university degree may satisfy the academic requirements for election to Graduateship and, subsequently, when the necessary approved experience has been acquired, for the acquisition of professional status as a physicist by transfer to the corporate grade of Associate of the Institute.

Candidates for the examination will normally be required to have followed a suitable course of study at a college or other institution recognized for this purpose by the Institute. The subjects of the examination are physics (three papers and a practical examination), mathematics (two papers) and a third subject (one paper) chosen by the candidate from (a) applied physics, (b) more advanced physics, (c) mathematical physics and (d) statistics. Those choosing applied physics will be required to offer only one of the sections (i) electronics, (ii) high vacuum technology, (iii) acoustics, (iv) spectroscopy, (v) X-rays or (vi) temperature measurement.

Direct election to Graduateship without examinations will be still open to holders of recognized university degrees in physics. Certain other degrees or other qualifications such as the Higher National Certificate in Applied Physics will entitle the holders to exemption from up to four of the six papers of the examination.

The first examination will be held in 1952.

Copies of a booklet containing the full regulations and syllabuses of the Graduateship examination may be obtained free, on request, from the Institute of Physics, 47 Belgrave Square, London, S.W.1.

The Polytechnic Evening Courses, in Telecommunications, which includes television and radio servicing, are due to start on September 24, for the session 1951-1952. These courses provide a thorough training in the principles and technique of the subjects they cover.

The Telecommunications courses are approved for the award of the "Ordinary" and "Higher" National Certificates granted by the Institution of Electrical Engineers in conjunction with the Ministry of Education, and are also recognized by the City and Guilds of London Institute as preparing for their examinations.

The courses in Radio and Television Service Work prepare for the Radio and Television Servicing Certificates awarded jointly by the City and Guilds and the Radio Trades Examination Board.

The radio, television and measurements laboratories are well equipped with modern apparatus, most of which has been specially designed for advanced experimental work. These laboratories are available for those wishing to prepare theses for the higher university degrees, or to pursue an advanced study of a particular subject.

A copy of the syllabus, together with further details, may be obtained from the Secretary, The Polytechnic, Electrical Engineering Department, 309 Regent Street, London, W.1.

Wireless Interference from Ignition Systems.—The Postmaster General's Advisory Committee on Wireless Interference from Ignition Systems which was appointed to sit under the chairmanship of Sir Stanley Angwin has now presented its report.

The Committee devoted its attention in the main to the abatement of interference with the television services of the B.B.C. from ignition systems, including those used in motor vehicles, motor boats, fixed or portable stationary engines, motor mowers, tractors, etc.

The Committee's recommendations are based on the assumption that all reasonable measures will be taken to reduce the susceptibility to interference of receiving installations. They recommend that ignition equipment when tested as installed in the vehicle or stationary engine with which it is used should not radiate an interference-producing field which exceeds 50 microvolts per metre for frequencies in the 40-70 megacycle per second frequency band, measured on specified equipment at a point not less than 10 metres distant from the vehicle or engine.

The Committee advise that suppression to this limit can be achieved with negligible effect on the mechanical performance of the engines. In the case of about 60 per cent of existing motor cars the Committee think that the required degree of suppression can be achieved by fitting a single resistor costing about 2s. 6d.

The Committee recommend that at least six months should elapse between the making of any regulation prescribing requirements to be complied with for the prevention of undue interference and the time of its coming into force. As regards the application of regulations to users (as distinct from manufacturers) they say that the efficacy of such a measure will depend mainly upon the co-operation of the public and adequate publicity for the simple remedial measures which users can take.

British Radio Exports in the first six months of 1951 were valued at £10,195,333, 39.4 per cent more than the figure for the same period last year, an all-time record and five times the value of a whole year's exports before the war.

These figures, based on Customs returns and issued by the Radio Industry Council recently, show that the biggest increase was in the export of radio receivers which rose by 74 per cent to £2,110,824. Receiver manufacturers were able to expand their markets in almost all countries.

Loose components were exported to the value of £3,387,892, approximately 10 per cent going to the U.S.A. and Canada. Exports of valves rose by 54 per cent to £1,817,171 and of capital equipment (broadcast transmitters, communications equipment, navigational aids, etc., not including that installed in ships and aircraft) by 12.6 per cent to £2,646,618.

The British Commonwealth took about 40 per cent of the total radio exports which now form the highest single group among exports of the British electrical industry.

The R.S.C.B. Amateur Radio Call Book is being published for the first time, and is available price 3s. 6d., by post 3s. 9d., from the Radio Society of Great Britain, New Ruskin House, Little Russell Street, W.C.1.

This new venture of the R.S.G.B. contains up-to-date names and addresses of some 6,000 licensed amateur transmitting stations in the British Isles and Irish Republic, and it is believed to be as accurate a record of amateur activity in these Isles as has yet been produced. Copies may be obtained in the Irish Republic from the Honorary Secretary of the Irish Radio Transmitters' Society —Captain A. C. Woods, 17 Butterfield Crescent, Rathfarnham, Dublin. If a call sign does not appear in the book the licensee should notify the Call Book Editor: Mr. J. P. P. Tyndall, G2QI, 174 The Drive, Ilford, Essex.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

A D.C.-A.C. Amplifier for Use in Physiology

DEAR SIR,—We have read with interest the paper by Mr. H. Asher published in the May edition of ELECTRONIC ENGINEERING entitled "A D.C.-A.C. Amplifier for use in Physiology." In his paper Mr. Asher suggests that this amplifier may have a wide range of applications—presumably in physiology—and we should therefore appreciate the opportunity of commenting on his circuitry.

The following remarks are confined to the input and first amplifying stages, it being generally agreed that these are the most important in the design of an amplifier for electrophysiological investigations.[1,2]

Considering first the input stage, Mr. Asher states that this is used to provide the grid current for the succeeding pair of valves, but he does not appear to utilize the other advantages offered by cathode followers as input valves. While agreeing that with biological preparations presenting a source impedance of several megohms[3,4] a considerably more complex input stage, such as that of Bishop[5] is necessary, it does appear that the present circuit is unsuitable to deal with a group of biological techniques where the source impedance may reach 100KΩ. (Assuming that the "thin braided screened cable" mentioned is similar to that examined by us, the input impedance of Mr. Asher's circuit appears to be 2MΩ shunted by 180pF, which when fed from 100KΩ source gives a voltage loss of 4db at 5kc/s). The versatility of the amplifier could be increased by improving the input impedance, this being accomplished by placing the cathode followers close to the biological preparation, thereby minimizing the length of screened lead, and increasing the value of the grid resistors from 1MΩ to 5-10MΩ. The latter change is compatible with stability, as has been shown by Crawford[6] though a limiting value is set by grid current. The alteration will also increase the open circuit noise of the stage, partly by virtue of increased Johnson noise but more importantly from current and frequency dependant grid shot noise[7,8]. These two factors, together with the desirability of minimizing possible injury to the tissue under examination, may call for the selection of a low grid current 6SN7, possibly working under reduced potentials.

In passing it may be noted that when the 1μF grid blocking capacitors are in circuit they form frequency dependant potential dividers with the grid leaks. Mismatch of the components on the two sides can thus adversely affect the discrimination of in-phase/out of phase signals. For example, with the values indicated, allowing standard 20 per cent tolerances, discrimination at 50 c/s may be reduced to less than 400:1. This means that an out of phase signal of 50μV will produce the same beam deflexion as an in phase signal of approximately 20mV. This ratio may not be high enough for certain types of isolated preparation without additional screening. The substitution of higher value grid leaks diminishes the possible error, simultaneously increasing the time constant of the coupling without increased risk of blocking.

Computation indicates that the gain of the stage is 0.7. This loss of signal amplitude is unnecessary, and the gain of the stage could be made to approach unity by increasing the cathode loads (a negative H.T. supply is available in the circuit if necessary). This alteration would simultaneously provide the other advantages enumerated by Bishop[5]. An increase of 10 times in the value of the resistors would only increase the output impedance of the stage by 20 per cent.

So far opportunity has been taken solely to suggest alterations which might improve the overall performance of the input stage, and thereby increase the range of usefulness of the amplifier. From the point of view of the present investigations (the study of electro-retinograms), these changes may be considered unnecessary or undesirable by Mr. Asher. If this is so the question presents itself as to whether the desired end result could be obtained by an alternative method. If the cathode followers are doing nothing save providing the grid current for the first amplifying stage would it not be advantageous to dispense with the present input stage, and substitute a low grid current valve type in place of the 1st stage of VR65s?

The E.F. series of valves merit consideration. They have an anti-microphonic construction which would eliminate the selection of VR65s mentioned by Mr. Asher, and working under reduced operating potentials, such as shown for the first amplifying stage, low values for grid current.[6] Mullard can now supply a selected EF37 (designated ME1400) with grid current less than 10^{-11} A. This alteration would dispense with the cathode follower stage altogether, reduce the overall noise level of the amplifier, while leaving the input impedance virtually unaltered, since the Miller effect would be negligible compared with capacitance of the screened lead.

Two criticisms may be levelled against this suggestion. In the first place Mr. Asher has stressed the fact that the majority of the components used in his circuit, including all the valves, are available from Government surplus. The EF37 series are not so available. However as these valves are not suggested as mere replacements for the VR65s, but are considered more suitable in this particular case, one's decision must not be too heavily influenced by minor financial considerations.

Secondly, working under the conditions specified for the first amplifying stage the VR65 has an amplification somewhat higher than the EF37. However removal of the cathode followers (Gain 0.7) and if necessary, utilization of some of the additional gain available by using a higher value amplitude control should remedy this.

Finally, could Mr. Asher provide more performance data for his amplifier? For example, figures for the in phase/out of phase discrimination ratio, frequency response (stating source impedance), noise level under capacitor-coupled conditions (stating whether R.M.S. or peak to peak) and total noise under D.C. conditions, including "drift" as suggested by Harris and Bishop,[8] taken over a period of half an hour or so, enable one to form a more accurate idea of the suitability of an instrument for a specific investigation. As stressed by Bishop and Harris[8] it is desirable to have an amplifier that is stable within defined limits over a period of time which is long compared with the the period under investigation. Comparatively few physiological experiments are completed in a time which is short compared with one minute (the period quoted for "drift" by Mr. Asher). Indeed, Fig. 4 reproduces a trace taken over approximately one sixth of a minute. It may be noted that at the right hand side of the trace the two recordings are separated by a distance which is in excess of the separation at the left hand side by an amount equivalent to a signal of approximately 100μV. Is this due to a prolonged after-potential following the initial "Light on" response (in which case the complete response lasting until the trace has returned to the base line must take considerably longer than one sixth of a minute) or is it due to drift in the preparation (in which case it must be troublesome to separate this effect from distortion due to A.C. coupling, etc)?

Yours faithfully.

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Sherrington School of Physiology,
and
P. STYLES,
Department of Physical Medicine,
St. Thomas's Hospital, S.E.1.

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DEAR SIR,—As is well known, directly coupled amplifiers may behave very erratically. It would therefore, require a large number of observations on a large number of amplifiers to be able to say with reasonable certainty what precautions are necessary to ensure a desired stability. The data in the literature is not sufficient for this to be done. It might, therefore, be valuable to collect the results of those workers whose main interests are other than electronic, who

would not normally publish their findings.

These remarks are suggested by the article by Mr. Asher[1] which recently appeared in this journal, particularly because his experience has been different from mine. I have used two battery operated amplifiers, one of which resembled Mr. Asher's, but despite perserverance, neither had the stability he reports. On the other hand since changing to mains operation and adopting some of the recent refinements of technique I have obtained a useful improvement in performance.

The use of a pentode as cathode load in the first stage was particularly beneficial; with a 12SH7 instead of a 50kΩ resistor in the cathode of a 12SC7, the immunity to heater temperature changes was about as great as could easily be obtained with Miller's[3] critically adjusted circuit. Furthermore, series-heater operation from a regulated high voltage supply as practiced by Miller and others, was found to be very satisfactory, and more reliable than accumulators.

The amplifier recently built here for the recording of thermocouple voltages consists of a 12SC7 (having its own supplies) followed by two stages of 10FI's. The 12SC7 has a subsidiary regulator similar to that described by Bishop and Harris,[2] but there is no mean level feedback (see also Johnston[4]). The stability is probably not far short of the highest yet reported; drift is commonly between 70 and 300 microvolts in thirty minutes and the warming up period is short enough to allow switching off at night. It should be mentioned that, since the bandwidth is several times greater than is used in physiological work, a gain greater than 10^5 times is not normally used.

Yours faithfully,
R. A. W. HILL.

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The author replies:—

DEAR SIR,—The amplifier which was completed early in 1947 when materials were short, could certainly be improved, The present VR65's give a noise value of 8 micro-volts "peak to peak" as measured with a ruler on the tube face, with the frequency response 3db down at 3kc/s, there being much cable on the output. Test voltage from a source of 2 ohms output impedance. EF37's would certainly give less noise, but the type of valve more often recommended for direct coupled amplifiers is one with a single cathode shared between two assemblies, such as a 6J6, AU55, 6SC7, or 12SC7.

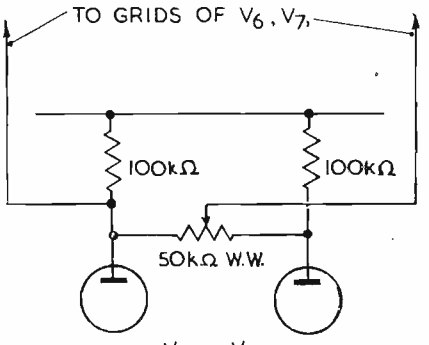
The mention of the long input leads and cathode followers mounted inside the amplifier was meant to indicate an absence of precautions. Naturally this arrangement is not suitable for a source impedance of 100kΩ at 5kc/s, and two references dealing with just this point were given. Where to put the cathode followers? When taking my own electro-retinogram I prefer not to wear cathode followers on my head, though it could be done, so they go in the box. In other cases they are better placed by the preparation. Concerning the cathode loads Messrs. Buller and Styles are quite correct, and they should in fact be larger.

Longer time constant. When switching from direct to capacitor input time has to be allowed for the input capacitor to charge through the grid leaks to the steady potential of the source before the trace is again steady. This delay, already irritating, would be made 5 to 10 times worse by the suggested change. However, were the longer time constant desirable the circuit could be modified to maintain the charge on the capacitor in the manner indicated for the later capacitor couplings. In practice the value that has been found most convenient is one second, and in general time constant values are best chosen to suit individual needs.

Hum. This has often been picked up. In my experience when hum occurs, shorting the two input leads together at the preparation end *always* reduces it very greatly or eliminates it. Thus, though in-phase hum may be present, greater trouble is caused by out-of-phase hum, and the remedy is therefore screening or suppressing it at the source, not balancing it out. For this reason no presets for the elimination of in-phase hum were included. Without these presets balancing the input circuits by increasing the time constant would not be useful. However, because of the question I have tried a 50kΩ preset resistor to adjust the anode loads of the first amplifier stage. By adjusting this and the shift control alternately it was possible to secure almost complete cancellation of the in-phase voltages for direct input. Then using capacitor input the values of the grid leaks were adjusted to balance the input circuits without altering the time constant. This gives an in/out ratio of 1500 to 1 when newly set.

Drift. Since this depends on the balance of two valves it would be expected to vary considerably with the specimens used. The figure quoted, 30 microvolts per minute or less, refers to this one amplifier and its batteries. It was taken as the mean of three seven-minute runs, and has since been confirmed over two periods, one of sixty and one of ninety minutes' duration.

Light affects VR65's considerably and should be excluded. Soldering the heater leads on to the valve pins is important, and I think it is best to have no ventilation. The drift rate is far higher than the figure of the order of 100 microvolts in half an hour for the amplifier of Bishop and Harris, or 70-300 micro-volts in half an hour in Mr. Hill's amplifier. In these amplifiers every possible precaution seems to have been taken. Changes much more rapid than the drift rate, such as the 100 micro-volts in 6 seconds noted by your correspondents may be safely attributed to the preparation or the electrodes. The correct attack on drift is I feel along the lines of the highly ingenious correcting circuit used by Southern Instruments, Ltd. "The correcting circuit thus provides a form of negative feed back which, while never completely cancelling the drift, reduces it by a factor approximately equal to the gain of the pentode amplifier, which is 100 times." (Quotation from catalogue.)



Volume control. An alternative arrangement, which is more linear, is shown in the figure above.

Yours faithfully,
H. ASHER,
Physiology Dept.,
Birmingham, University.

Maximum Bandwidth

DEAR SIR,—The attainment of maximum bandwidth in a television receiver depends largely on the sharpness of response which can be obtained in the rejector coils for the associated sound channel. The effective Q of a coil when used for reception purposes may be increased by the introduction of a controlled amount of negative resistance. It does not seem to have been discussed whether this will not increase its effectiveness as a rejector circuit also. Some experiments with a superheterodyne vision receiver tend to show that it will.

In this receiver the sound is picked out in the conventional manner from a point in the vision receiver I.F. circuits. The sound receiver consists of one stage of I.F. amplification followed by detector and two A.F. stages; the input tuned circuit acting, in the normal way, as the first sound channel rejector. This receiver originally showed a tendency to oscillate which was overcome by connecting a damping resistor across the I.F. anode coil. Three effects were noticed:

(1) Sound rejection was critically affected by variation of the *anode*, as well as the grid, tuning.

(2) Increasing the value of the anode damping resistor, i.e., permitting a greater degree of feedback, increased the effectiveness of the sound channel rejection.

(3) Rendering the I.F. amplifier inoperative by cutting off the H.T. supply caused severe sound break-through in the picture circuits which could only be partially removed by readjusting the sound input tuned circuit.

The bandwidth of the vision receiver is over 3Mc/s. It is probable that many owners of superhet television receivers may already have the benefits of such reactive rejector circuits without knowing it, inasmuch as some degree of feedback in the "peaked" circuits of the sound receiver is usually unavoidable.

Yours faithfully,
E. G. HARRISON, M.Sc.

BOOK REVIEWS

How to Write Technical Books

By John Gloag. 159 pp. Allen & Unwin. 1950. Price 12s.

THE title of this book explains its purpose. The author sets out to pass on the benefit of his own experience to others and most of the advice he gives is sound and practical. In effect, he takes the reader on a journey, in clearly defined, if somewhat illogical steps, from the moment a book or article is conceived to the day of its publication, and after; he warns against pitfalls and points out the stepping stones.

The first chapter is merely a preface with the appropriate heading "They don't want to read it"; this heading is a clue to the style used in the rest of the book.

The second chapter tells the reader how to plan a technical book and gives examples from the author's files. It is in this chapter, however, that the reader begins to ask himself "What sort of technical books is this author thinking of?" The answer is given on page 11 where he speaks of technical books for popular consumption. This explains the strange statement that "even a technical book may be influenced by the religious, political or economic faith of the author." It also explains why the author recommends the would-be writer of a technical book to estimate the total number of words as the first step in planning. This would preclude the introduction of new ideas which inevitably occur as such a work proceeds. It is a doubtful assumption that an author can estimate the number of words in the planning stage just as an architect can estimate the number of bricks for a building. For the rest, this chapter gives valuable advice, and who could quarrel with the exhortation to refrain from using words where illustrations can do a better job?

The third chapter, entitled "Say what you mean" is instructive and entertaining. It is modelled on Sir Ernest Gower's "Plain Words"; it ends with the slogan "They don't want to read it." Well, why do readers buy technical books?

Chapter Four is a diversion and explains relationships between publisher and author. This chapter opens in a light vein, with amusing pen sketches of what each thinks the other looks like; the latter part contains useful information about contracts with publishers.

In Chapter Five the author brings the reader back to the main road, and really gets down to the business of explaining the mechanics of writing: size of paper, margins, footnotes, illustrations and preliminary pages. The author quite rightly discourages footnotes; his arrangement of references, however, departs from accepted modern standards in that he quotes the title before the author.

In Chapter Six we are turned into the by-road of book production. Emphasis is on type faces and the effect of different founts on layout of the printed page.

Chapter Seven is also concerned with production, with bias on illustrations and the various ways of reproducing them. The examples shown are praiseworthy works of art, but bear little relation to illustrations normally associated with technical books and journals.

In Chapter Eight we are on the highway again and near the end of the journey; the heading is "The Proofs and the Index" and the space devoted to these subjects is well used. A helpful chapter.

Writers of technical articles, papers or reports will find much to interest them in Chapter Nine. Briefly, the formula is Introduction, Factual Material, Conclusion. Obvious, but how few writers can apply it. This is the best chapter in the book. Budding authors would do well to read it twice.

Chapter Ten is just a sidetrack signposted the "Reform of Forms." Colour brightens the author's suggestions for improved forms, but he doesn't explain how Government departments would justify the doubled cost of their production.

The book is not a complete reference handbook for technical writers; it contains no tables, sub-headings (and in fact, discourages them); it give no guidance in the preparation of mathematical formulæ for the Press.

A popular book by a popular author. Easy to read and understand, and delightfully produced. An asset to those who write, or aspire to write, for the popular Press.

J. W. GODFREY

Quartz Vibrators and their Application

By P. Vigoureux and C. F. Booth. Pp. 371, 186 figs. H.M. Stationery Office. 1950. Price 30s.

IT would be misleading to quote the preface of this book and describe it as a revision of the earlier edition, "Quartz Oscillators and Resonators," published in 1939. The immense wartime demand for quartz crystals for radio frequency control has led to very considerable advances in this subject since 1939. As a result, the scope of the present volume has been so enlarged and modified that it may be correctly regarded as a new and valuable addition to the comparatively few books on piezo-electricity.

The presentation is mainly made from a technological standpoint and as such the contents will be especially useful to the electronic engineer who is concerned with the use of quartz crystals for frequency generation and in selective networks. In addition, the several chapters on the properties and processing of quartz crystals will be appreciated by those actually engaged on their production.

Adequate attention has been given to the fundamental principles of piezo-electric phenomena without attempting to reproduce the completeness of treatment given by Prof. Cady in his standard work on "Piezo-electricity." In view of this abbreviated treatment, it is perhaps unavoidable that the piezo-electric notations used are not always precisely defined and that there is some confusion betwen matrix and tensor notations.

The various types and modes of vibration of quartz crystals are fully described and the range of their application is indicated. There are useful chapters on drive circuits for crystal oscillators and on the specification and testing of the quartz elements.

The importance of quartz vibrators in frequency standardization and for filter circuits in multi-channel carrier telephone systems is correctly emphasized and there is an interesting chapter on the employment of piezo-electric elements for ultrasonics. There is a concluding chapter which brings the book up to date on current developments.

Numerous diagrams and illustrations are included, and the photographic plates are particularly good, although a few are more decorative than informative. The important crystal parameters are given in a number of tables, and some of the more specialized aspects of the subject are dealt with in five appendices.

The importance of the subject covered and the general style and presentation of this volume make it an extremely valuable book, bearing in mind particularly the price at which it is offered.

L. A. THOMAS

Transmission Lines and Filter Networks

By J. J. Karakash. Pp. 413, 377 diagrams, 13 tables. 1st Edition. Macmillan & Co., New York. 1950. Price 45s.

THE book is divided into four main sections covering Transmission Lines, Transmission Networks, Elementary Filter Theory and Appendices.

In the first section the Transmission Line equations are derived and developed along orthodox lines, involving only propagation constant and characteristic impedance.

After a brief discussion of the primary line constants, short lossless lines are considered in the non-resonant and resonant condition. Impedance transformation by means of lines and the uses of single and double stubs serve as an introduction to the use of the well-known Smith Chart.

The general treatment is at a level intended for senior students, and the presentation is simple and clear.

It is interesting to see the increasing use by American writers of the matrix method of analysis of four terminal networks. The method is introduced on page 66, developed further on page 119 in connexion with composite transmission systems, and in Section 2 of the book it is used fairly consistently in dealing with transmission networks.

In view of the fact that most of the material, in particular Tables 1, 2 and 3, has been taken direct from the original papers by the Germans, Strecker and Feldtkeller, it seems a little ungenerous that the reference to their work is so brief. Apart from this omission the

second section is comprehensive and well presented.

Section 3 of the book is rather disappointing in that it deals with orthodox filter networks very thoroughly, including constant, *k*, *m* derived and double *m* derived sections; but has little to say on the design methods of Cauer and Bode and nothing to say on the more recent method of synthesis due to Darlington. This is to be regretted since Darlington's work has been a great stimulus to network designers; apart from synthesizing insertion loss characteristics, this method has now been adapted to allow synthesis of phase characteristics and impedance characteristics.

The book gives numerous problems which should be very valuable to students, and apart from the few omissions mentioned it is a book which can be heartily recommended for the student and the communication engineer.

L. I. FARREN

Electromagnetic Waves and Radiating Systems

By E. C. Jordan. Pp. 710 + X. Constable & Co., Ltd. 1951. Price 32s. 6d.

THE general impression is that this is not so much a book as a course of instruction. The reason is, perhaps, that Professor Jordan has covered such an extended field—from the elementary equations of electromagnetism in M.K.S. units, through electromagnetic waves in a homogeneous medium, wave guides, radiated power, aerial impedance calculations, the characteristics of practical aerials of many kinds for all frequencies, ground-wave propagation and the ionosphere to the mathematical analysis of the propagation of electromagnetic waves in an ionized medium situated in a magnetic field—that a lesser author might well have filled at least three books with it. Yet at every point the author "knows all the answers," as exemplified by the note on p. 123 pointing out that in radio the "plane of polarization" is that containing the electric vector but in optics it is the plane of the magnetic vector, and the appendix distinguishing phase, group and signal velocities. In reading the latter part of the book, from Chapter 13 onwards, the reader who is familiar with the subject is constantly meeting old friends: Bennett, Coleman and Meier on broad-band aerial matching techniques; Schelkunoff's treatment of bi-conical and cylindrical aerials from transmission-line theory; and Norton's classic work on propagation over the earth's surface. (It may still be necessary to consult Norton's original paper because the data charts have been much reduced in size in reproduction.) But the fact that the latter part of the book is based on papers which have been published over the last 10 years is an indication of the real need which it meets: these are old friends to the experienced engineer, but it will be of great value to the student to have the information collected together.

There are, however, a few minor criticisms. Its outlook is notably American in stressing the economic importance of the broadcast antenna (purely a product of U.S. broadcasting policy and F.C.C. regulations) and reproducing a map of soil conditions within the U.S.A. There are also some blemishes in presentation. From an American author we must accept the statement that "The unit of length is the *meter*," but there is less excuse for referring to A. A. Pistolkors (whose aerial work was published in America) as "Pisolkors" both in text and index, and for writing *nabala* instead of *nabla* for one of the names of the vector operator ∇. Finally the author follows a certain school of American radiation works in writing "H=curl A" whereas "B=curl A" has the authority of Jeans, Moullin, Mason and Weaver, and Harnwell, among authorities on electromagnetism, and King and Aharoni among aerial experts. In M.K.S. units the two statements are completely irreconcilable.

None the less, this book contains a vast amount of information which is presented with meticulous accuracy and without shirking the mathematics of radiation and propagation problems.

D. A. BELL

Radio Technology

By B. F. Weller. Pp. 413. 122 figs. 3rd Edition. Chapman & Hall, London. 1951. Price 30s.

THE author of this book explains in his preface to the first edition (1943) that he is hoping to fill the gap in the literature of radio between the "popular" non-mathematical books and the more advanced and specialized treatises, a laudable objective but one which presents great difficulties. The greatest of these are to decide on how large a field is to be covered, and how the emphasis is to be shared between fundamental principles and practical applications. The author presumably has in mind the type of reader who will study the work conscientiously but not have much experience in the theory of the subject, and one quality that is specially essential in such a book is accuracy. This is the third edition of a book first published "some seven years" ago, but even so it still contains a large number of inaccuracies and confused statements.

The ground covered includes some circuit theory, valves, detectors, oscillators, voltage and power amplifiers, transmitters for telegraphy and telephony, microphones, receivers, an enlarged chapter on aerials and radiation and a new one on ultra-high frequency technique. It is doubtful whether a student of the standard considered can form a clear over-all picture in his mind of such a wide range of subjects, and the author's style makes his task even more difficult. He spends over-much time on spark transmitters and crystal receivers, repeats statements which have already been made, or even appears to contradict himself. A catalogue of these confusions and errors would be tedious, but a few examples will show the general standard of the book.

Fig. 14a is a "Typical Circuit" of a "Diode as Signal Rectifier," but nearly 200 pages later the student is told that this "original circuit is rarely employed today" (p. 259).

On the ether (p. 329) we find "There is no direct physical evidence for the

BOOK REVIEWS (Continued)

existence of ether, but it is unreasonable to suppose that wave motion can exist without some medium capable of vibration. Many theories have been put forward assuming various properties for the ether of space, but so far it remains purely hypothetical, and, in fact, most modern physicists deny its existence."

Chapters III and IV deal with diode, triode, screen-grid and pentode valves, but it is not till the last paragraph of Chapter V on "Power Amplifiers" that the "Beam Tetrode" appears. A paragraph on page 214, dealing with directional properties of microphones, can at best be described as misleading.

On more specific points, "Kirchhoff's First Law is concerned with parallel circuits, and' states—" and "Kirchhoff's Second Law is for series circuits, and may be stated—" (p. 2) suggest an unnecessary restriction on their application.

In Fig. 79c, "Envelopes of Modulated Waves," that shown for 100 per cent modulation looks like the beat of two equal-amplitude waves, and is not the condition for 100 per cent modulation by a pure tone, as is implied by the text.

On the subject of band-pass filters, the student will almost certainly get the impression that any pair of identical coupled circuits gives a double-humped frequency response, while in the explanation of wave-guides we find (p. 403) ". . . as we have seen, the phase difference between the currents in a reflector and in an aerial always corresponds to the physical spacing between the elements."

If space permitted this catalogue of short-comings could be extended, and when to these are added sundry misprints it is seen that this is a book to be avoided by any inexperienced student who has not a tutor to guide him, though with such assistance the numerous practical illustrations could be valuable.

The printing and binding are to Messrs. Chapman & Hall's usual high standard.

C. R. G. REED

Survey of Modern Electronics

By Paul G. Andres. Pp. 522. 1st Edition. John Wiley & Sons, Inc., New York, and Chapman & Hall, Ltd., London. 1950. Price 46s.

THE author of this—yet another—book on electronics claims to have written a text book for a short course for mechanical, chemical and industrial engineers. The treatment is mainly descriptive and the principles of operation of the various types of tube are dealt with in a popular and elementary manner. A quick survey of the chapter headings shows a conventional order; the eleven chapters are devoted to basic principles, diode, triode, multigrid tubes, special tubes, gas tubes, phototubes, instrumentation, communication, controls and high frequency heating. Closer examination of the subject matter shows that the main characteristic of the book is the constant interjection of practical applications among the principles. For example, the first chapter deals with Basic Concepts and Current Conduction; yet it contains a section on germicidal lamps, including four photographs of micro-organisms, illustrating the effect of treatment with a "Sterilamp." The same chapter gives particulars of several single and three phase rectifier circuits, and, among other things, discusses cathodic protection, galvanized iron and the atomic bomb. All this is, of course, deliberate and occurs throughout the whole book. The author claims thereby to arouse and maintain reader interest, and at the same time to indicate some of the capabilities of electronics. The claim is no doubt justified. Stimulation of interest in electronics is relatively easy; inculcation of sound basic principles is much more difficult. If the constant emphasis on practical illustrations does achieve a better understanding of principles, then this book should be successful. On the other hand, some readers may find the sudden changes disconcerting; certain sections read almost like a dictionary, without the advantage of alphabetical arrangement.

The book is profusely illustrated with line diagrams and half-tone photographs. Each chapter has a collection of exercises and a list of references to American publications.

M. R. GAVIN

The Quarterly Journal of Mechanics and Applied Mathematics

Volume III, No. 4. (December 1950.) Oxford University Press. Price 12s. 6d.

THIS issue contains a complete solution by Prof. A. T. Price of the theory of the induction and free decay of electric currents in a semi-infinite conductor with a plane boundary. There are two types of elementary solution, one where there is a magnetic field outside a conductor, the other where there is no field outside. An interesting point in connexion with the first type is that the induced currents in the conductor are always everywhere parallel to its surface. Many examples are given to illustrate the application of the general solution. Another paper by D. S. Jones is concerned with the singularities of current and charge at an edge caused by the diffraction of light by edge.

G. J. KYNCH

The Quarterly Journal of Mechanics and Applied Mathematics

Volume IV, Part I. (March 1951.) Oxford University Press. Price 12s. 6d.

APART from some developments of the theory of induced currents, which was mentioned in the review of the previous issue of the journal, the only paper on electrical theory is one on the resistance of a rectangular plate with an internal electrode, the other electrode being the boundary. A paper of an intriguing type is an application of the principle of virtual work. If a bridge or other structures is repeatedly subject to heavy loads causing plastic deformation, the regions of plastic flow may increase in size until the whole thing breaks up. It is intriguing to learn that it can be proved that if it does not crack up under a particularly devised load which result in one set of residual moments, then it will never break up under any other loads which leave a different set!

G. J. KYNCH

Practical Wireless Encyclopaedia

By F. J. Camm. 12th Edition. 360 pp., 554 diagrams. George Newnes Ltd. 1951. Price 21s.

THE twelfth edition of the "Practical Wireless Encyclopaedia" incorporates recent developments in the field of radio, and obsolete matter published in eleventh edition has been deleted.

New sections deal with the following: radar, television, remote control, oscillators, Kirchoff's laws, photo-electric cells, a new series of modern circuits for receivers and amplifiers, automatic station selection, car radio, electron multipliers, quartz crystals, amateur transmission, fault finding, building a television receiver, new colour codes, aerials, meters, table of short wave stations, new valves and the officially approved service terms.

The book has been re-set and re-illustrated throughout.

The Radio Amateurs' Handbook

608 pp. 28th Edition. American Radio Relay League. 1951. Price $3.00 in U.K.

THE 28th Edition of this handbook is very similar to those of previous years; it has, however, been revised and the technical information has been brought up to date.

Two new chapters have been added. The first of these deals with the design and construction of single-sideband suppressed carrier radiotelephone transmitters, while the second deals with mobile techniques, with special reference to shortwave convertors for use with standard car radios.

The section dealing with valves, has also been revised, and data is given on most of the valves at present in production in the U.S.A. up to an anode dissipation of 500 watts. Details of klystrons and cavity magnetrons are also included.

A Magnetic Tape Recorder

By K. A. Cheeseman. 63 pp. Bernards (Publishers) Ltd. 1951. Price 3s. 6d.

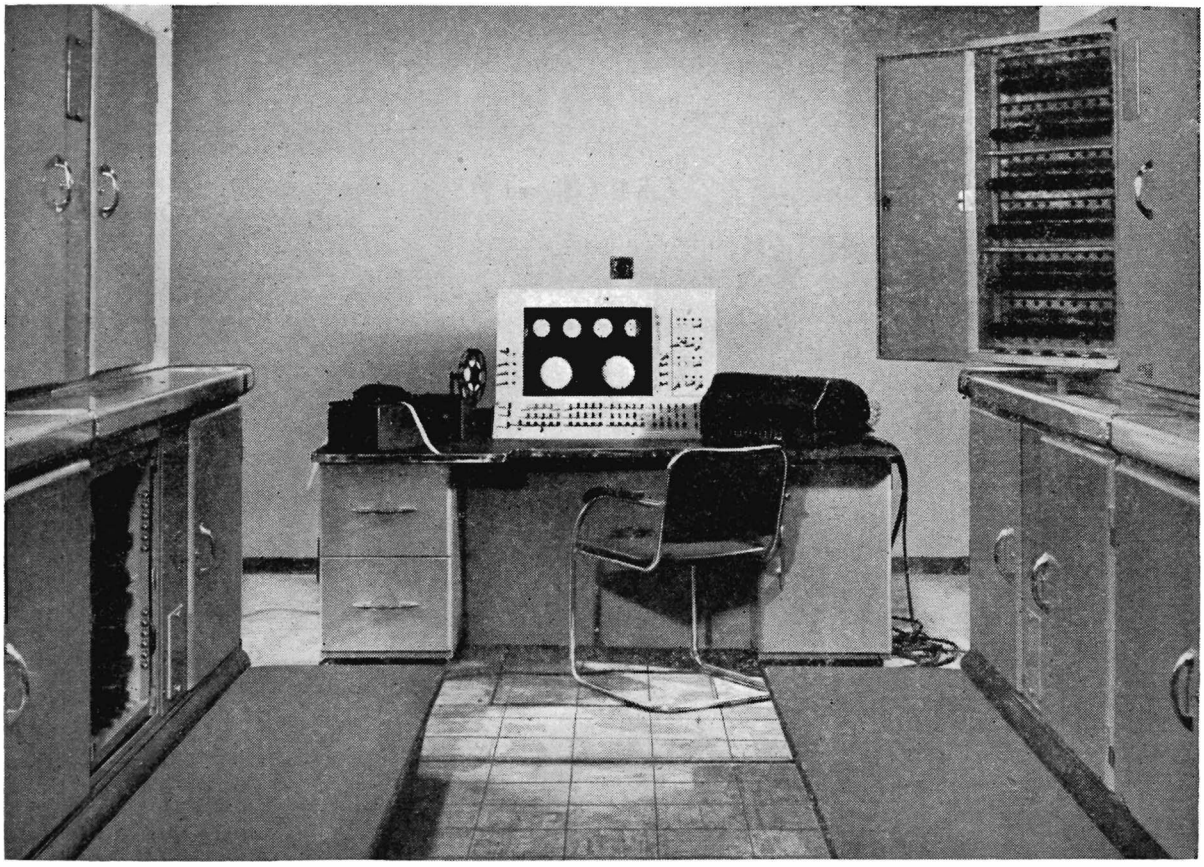
MAGNETIC recording has now come within the scope of the home constructor, and this small book has been written for his benefit, covering principles, design and construction.

The recorder described in this book was designed under home workshop conditions, so that all parts, with one exception, were made without any specialized tools. The prototype is described in detail, but the author gives sufficient information for modifications to be made for individual requirements.

The book is carefully written, and contains clear diagrams to help the constructor.

THE MANCHESTER UNIVERSITY

High speed Electronic Digital Computer



Made by Ferranti Ltd. for the University of Manchester
(Inaugurated July 9, 1951)

This machine will add up a column of 1000 numbers, each of the order of 10^{13} in one second, and will multiply two such numbers in 2.6 milliseconds. It accepts input on teleprinter tape at the rate of 200 characters a second, and prints out its results on a teleprinter. It has a main memory for 150,000 binary digits on a magnetic drum, which will ultimately hold 600,000 binary digits, and has a high speed memory on cathode ray tubes which hold 10,000 digits. (This is a William Tube Memory.)

Ferranti Ltd. are now in a position to discuss future applications of these machines.

Ferranti Ltd

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FERRANTI

NATIONAL PHYSICAL LABORATORY REPORT

ON TESTS OF TRANSFORMER (Marked: Lab: Output, Series II)

Tested for : Vortexion Ltd., 257 263 The Broadway, London, S.W.19.

The series resistance and inductance of the primary winding, with the secondary winding open-circuited, was measured at 50 cycles per second with 5 and 20 volts applied. The room temperature was 19°C. The results are given in Table I.

TABLE I

Primary Resistance and Inductance at 50 c/s

Voltage	Resistance: Ohms	Inductance: Henries
5	4 700	95
20	7 900	142

The series resistance and inductance of the primary winding with the secondary winding short-circuited, and of half the primary winding with the other half short-circuited were measured at 1,000 cycles per second. About 10 volts were applied. The results are given in Table II.

TABLE II

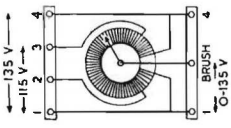
Resistance and Inductance at 1,000 c/s

Connections	Resistance: Ohms	Inductance: mH.
Primary. Secondary shorted.	495	5.3
Half Primary. Half Primary shorted	222	5.3

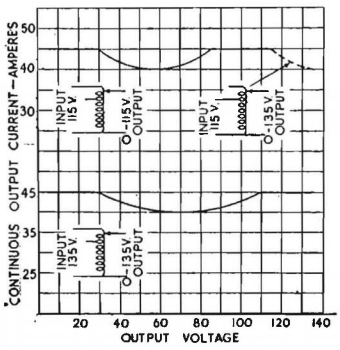
Date : 2nd June, 1951. *Reference :* E.475.100.

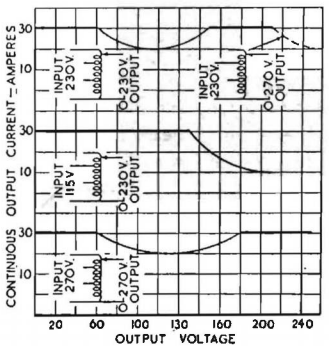
*VARIAC voltage-regulating infinitely variable transformer

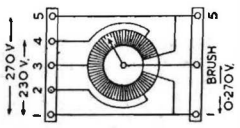
* *Registered Trademark*



OUTPUT CURRENT CHARACTERISTIC AND TERMINAL ARRANGEMENT FOR TYPE 50-A TRANSFORMER







OUTPUT CURRENT CHARACTERISTIC AND TERMINAL ARRANGEMENT FOR TYPE 50-B TRANSFORMER

SPECIFICATIONS							
TYPE	LOAD RATING	INPUT VOLTAGE	CURRENT		OUTPUT VOLTAGE	NO-LOAD LOSS	NET PRICE £ s. d. *
			RATED	MAXIMUM			
50-A	5 kva.	115 v.	40 a.	45 a.	0-135 v.	65 watts	44 18 6
50-B	7 kva.	230/115 v.	20 a.	31 a.	0-270 v.	90 watts	44 18 6

* *All "VARIAC" prices Plus 10% as from 1st JUNE 1951.*

SERIES 50 "VARIAC" TRANSFORMERS

With a "VARIAC," voltages are instantly and minutely adjustable from O-Line Voltage. On some patterns, such as 50-B, there is even an "over-voltage" feature. This can provide over line voltage or compensate for low lines. See curves and input and output connections, shown above. A very special application for this large transformer is operating them in 3-gang assembly on 3-phase work. A 3-gang 50-B will control 21 Kva. Many other suggestions on the use of "VARIAC" Transformers are contained in Catalogue V549 which will gladly be sent on request.

TYPE 50-B

C.L.4.

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...reduced power factor by 50%

...increased R.F. loading 100%

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5000-10000 pf. 10 kV. Pk. Wkg.
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TYPE M10 6½″ x 6½″ R.F. loading 70 kVA.
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TYPE M5 6½″ x 3¼″ R.F. loading 35 kVA.
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R.F. loading ratings are at room temperature (15-20°C.)

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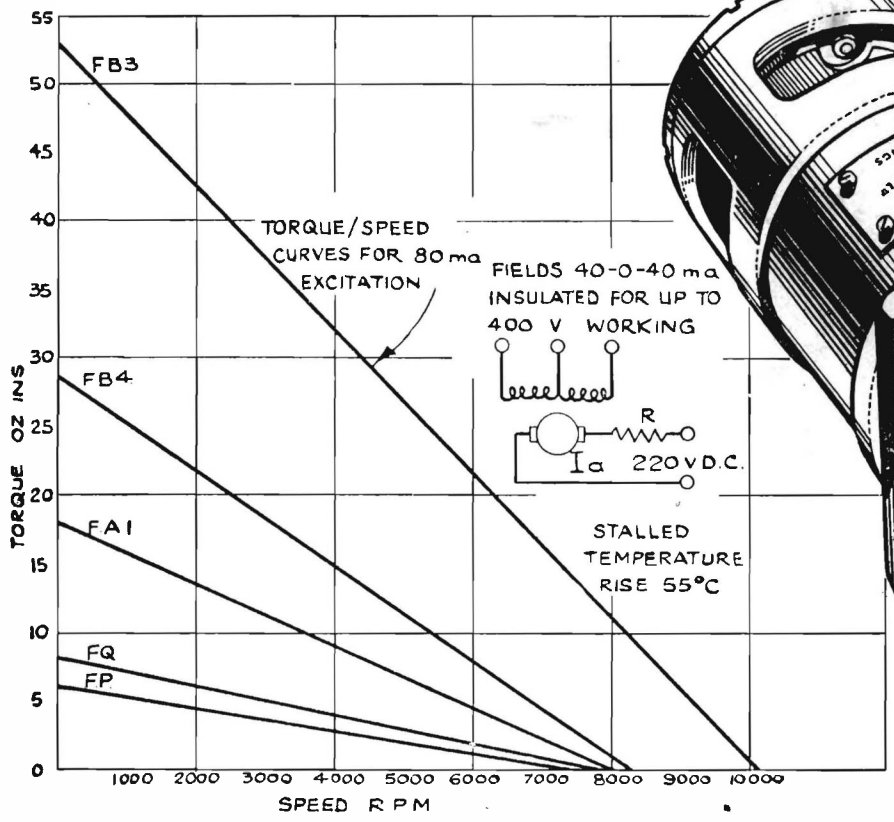
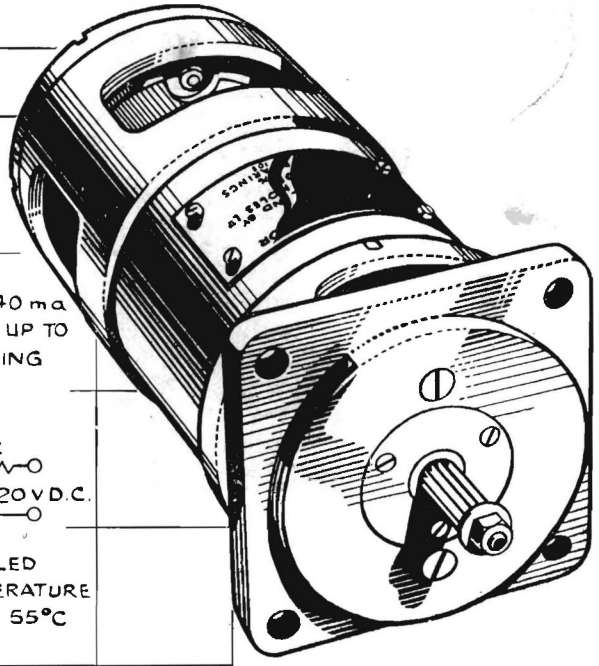
TYPICAL D.C. SERVO MOTORS FOR ELECTRONIC CONTROL





FRAME SIZE	MOMENT OF INERTIA OZ. INS²	BRUSH & BEARING FRICTION OZ. INS.	Ia AMPS
F.P.	0.5	0.5	0.25
F.Q.	0.75	0.5	0.33
F.A.1	1.8	0.5	0.75
F.B.4	2.2	1.0	1.5
F.B.3	2.2	1.0	3.0

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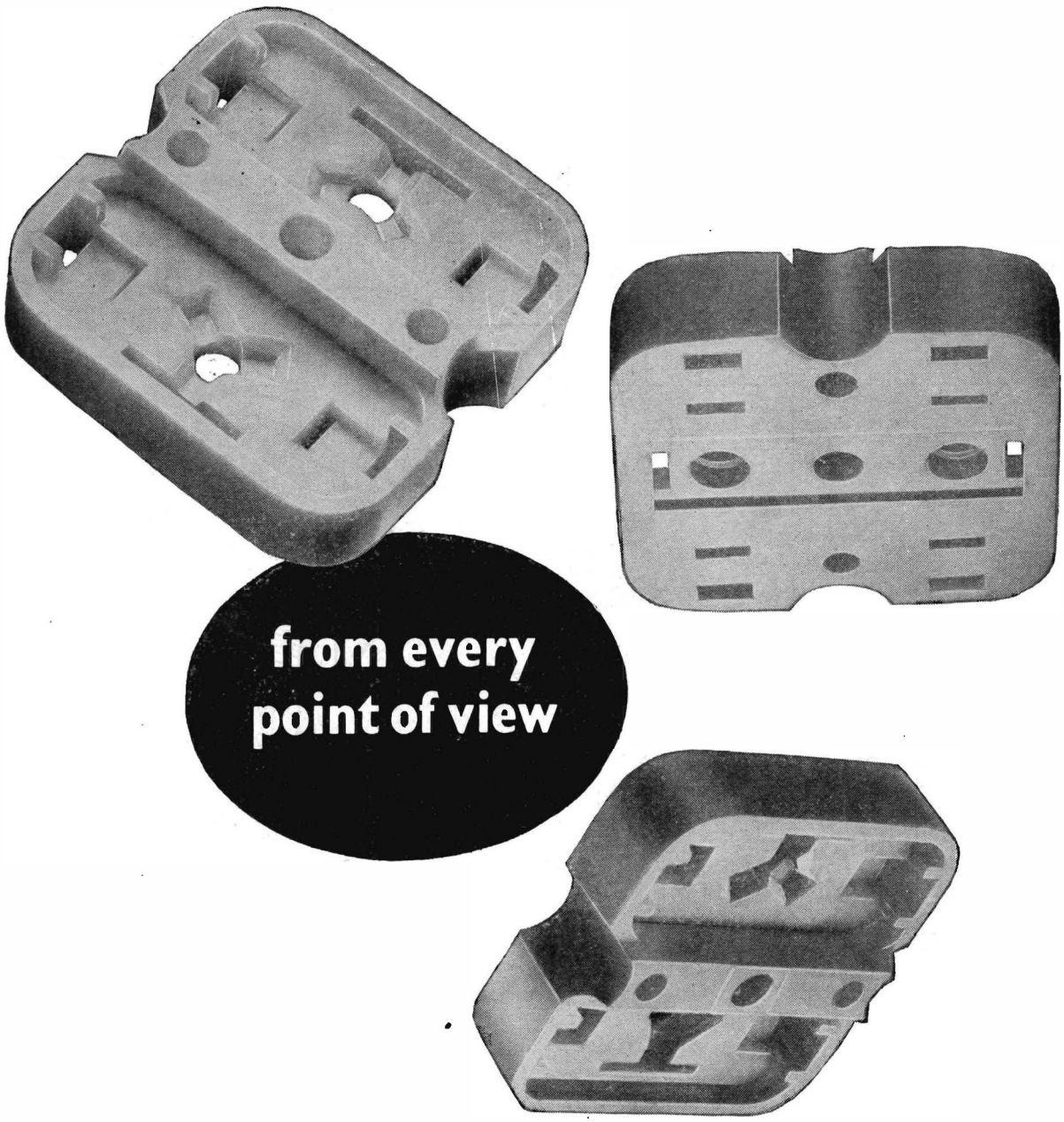

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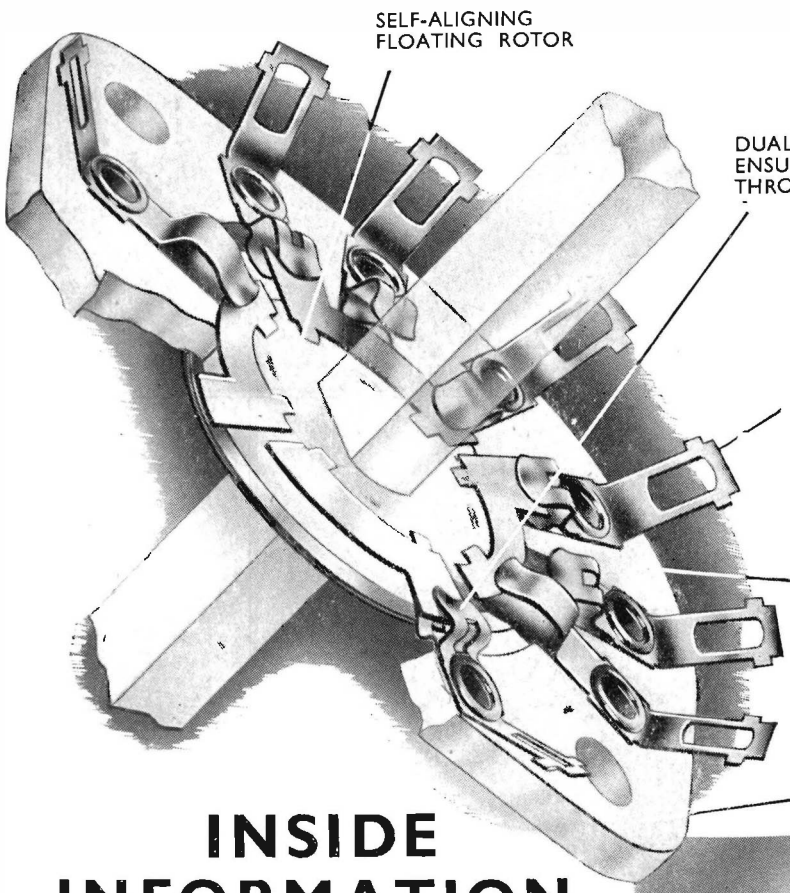

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—about the switch that is superior

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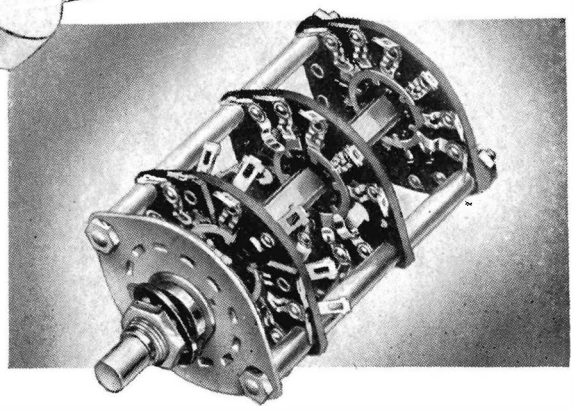

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NSF **OAK SWITCHES**

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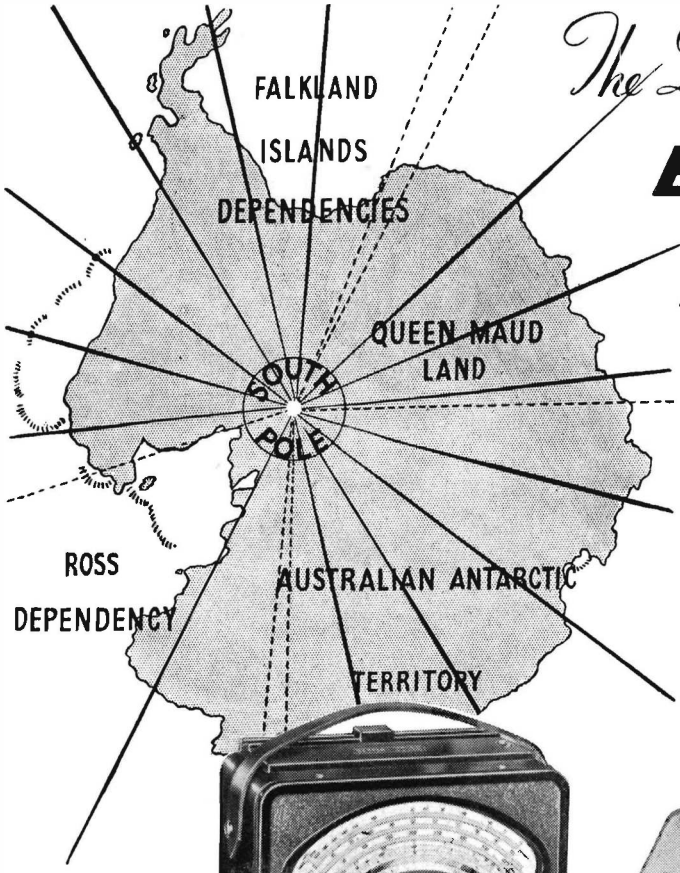

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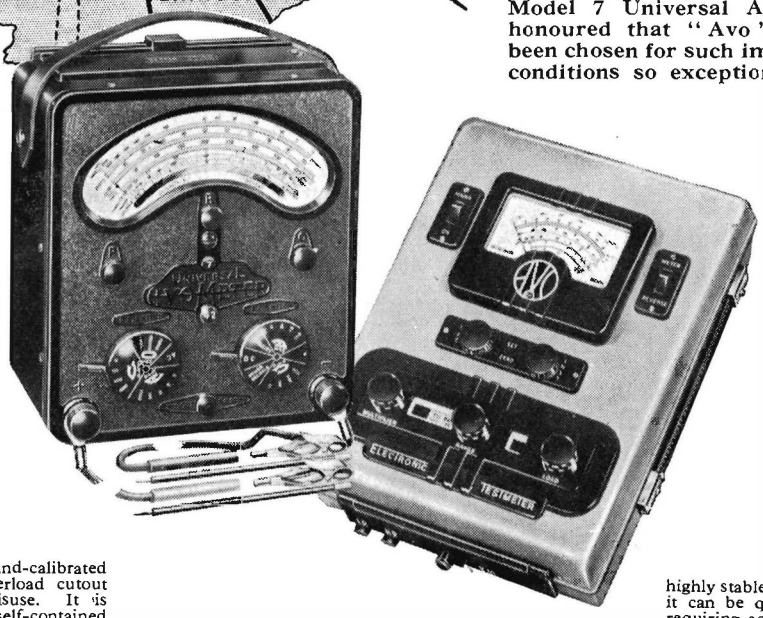

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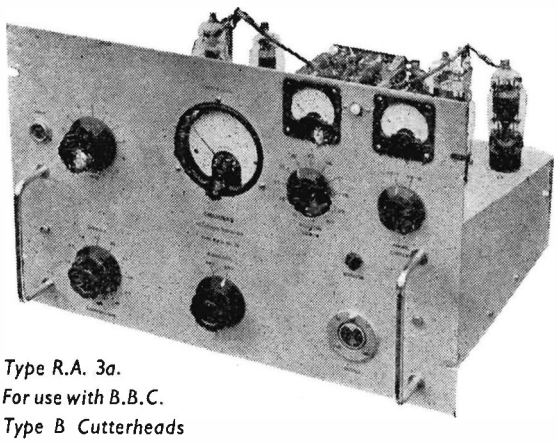

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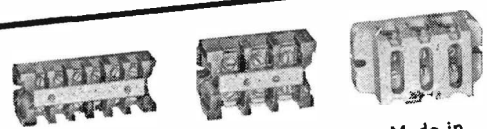

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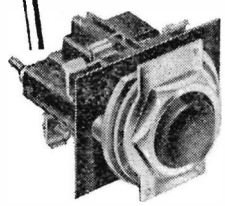

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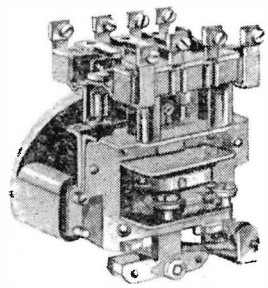

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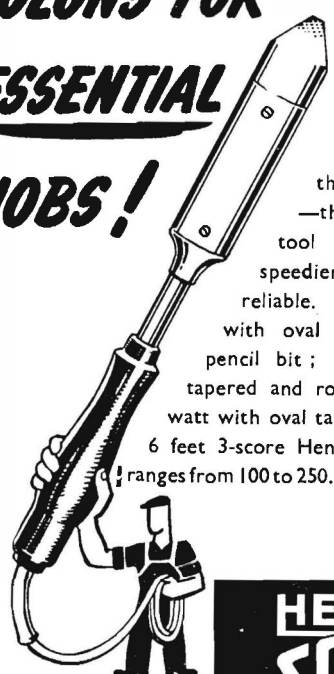

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