Electronic Engineering

APRIL 1951

TWO SHILLINGS

CLASSIFIED ANNOUNCEMENTS

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OFFICIAL APPOINTMENTS

PROFESSIONAL ENGINEERS are urgently needed by the Ministry of Supply for work of great National importance. The Civil Service Commissioners invite applications for permanent appointments of Professional Engineers (Higher Departmental Grades) in the Ministry of Supply. Applications will be accepted at any time before 30th June, 1951, but a closing date for the receipt of applications earlier than 30th June, 1951, may eventually be announced. 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. Candidates must be at least 30 years of age on 1st January, 1951. Candidates must (1) be Corporate Members of one of the Institutions of Civil, Mechanical or Electrical Engineers, or Associate Fellows of the Royal Aeronautical Society, or (2) have served an engineering apprenticeship or pupilage including a minimum period of two years in the workshops of a reputable establishment, and either hold a University Degree in Engineering, or a Higher National Certificate in mechanical or electrical engineering with the endorsements necessary to secure exemption from the whole of the Associate Membership examination of one of the above named professional Institutions, or have passed any other examinations recognised by one of the above-named Institutions as granting exemption from the whole of its Associate Membership examination or by the Royal Aeronautical Society as exempting from its Associate Fellowship examination. Candidates will be required to undertake the more responsible duties in a wide variety of professional engineering work. Preference will be given to those candidates with experience in (a) The design and construction of large factories and the necessary plant and services, (b) the design of radio and radar equipment, (c) the design and development of very high precision medium and light mechanical devices, (d) the production of aircraft engines or electric cables, (e) the installation and maintenance of plant, gas, electrical water and steam services in large factories, (f) production management in a large factory filling ammunition. In some cases houses will be available at moderate rents for successful candidates. London Salary Scales:—Men—Main Grade £750-£1,000; Senior Grade £1,050-£1,270. Women—Main Grade £650-£850: Senior Grade £900-£1,100. Further particulars and application forms from the Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S87/51. Completed application forms should be returned as soon as possible. W 2815

RESEARCH FELLOWSHIPS. Applications are invited for a limited number of Senior and Junior Research Fellowships, tenable for three years at the Telecommunications Research Establishment, Malvern, Worcestershire, commencing in Autumn 1951. Fellows will be expected to carry out fundamental research in experimental or theoretical physics or electronics. A wide range of subjects will be available within fields of interest to the Establishment. Candidates for Junior Fellowships should normally have had at least two years post-graduate research experience and should preferably be aged 23-26; for Senior Fellowships they should have had at least three years post-graduate experience and should preferably be aged 26-30. Candidates must be British subjects. Remuneration will depend on individual merit and will be between £650-£750 for Senior Fellows and £475-£575 for Junior Fellows. Both carry F.S.S.U. benefits. At the expiry of a Fellowship the holder may be considered for a permanent post at the Establishment if he so desires. Applicants should write to the Chief Superintendent, Telecommunications Research Establishment, Malvern, Worcestershire, for application form which must be returned to that address by 1st May, 1951, accompanied by suitable testimonials regarding research ability, and, where possible, copies of published papers. W 2829

PHYSICISTS and Electrical Engineers are invited by the Ministry of Supply to apply for the following unestablished appointments at Experimental and Development Establishments for work on out-door instrumentation. Senior Scientific Officer. Candidates should be at least 26 years of age and possess a 1st or 2nd class Honours Degree in Physics and have had at least 3 years post-graduate research or other approved experience in electronics. Some knowledge of experimental range technique and procedure, particularly technical photography, is desirable. Experimental Officer Class. Candidates must possess a minimum qualification of Higher School Certificate with Physics as a main subject but other qualifications, e.g., Higher National Certificate in Electrical Engineering would be acceptable. Experience in design of electronic apparatus and interest in technical photography is desirable. Starting salary will be determined on age and an assessment of the successful candidates' qualifications and experience within the ranges:—Senior Scientific Officer (minimum age 26) £670-£860 Provinces. This post carries F.S.S.U. benefits. Senior Experimental Officer (minimum age 35), £705-£895 Provinces. Experimental Officer (minimum age 28) £495-£644 Provinces. Assistant Experimental Officer £230-£490—London, £220-£460—Provinces. Rates for women somewhat lower. Application forms obtainable from Ministry of Labour and National Service Technical and Scientific Register (K). York House, Kingsway, W.C.2, quoting A95/51A. Closing date 23rd April, 1951. W 2806

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 £283-£510 p.a. Exceptionally well qualified candidates may be considered for appointment in a higher grade within the salary range £470-£610 p.a. Hostel accommodation is available at some Establishments. Applications, stating age and details of technical qualifications and apprenticeship (or equivalents) and Workshop and Drawing Office experience, should be sent to Admiralty (C.E.11, Room 88) Empire Hotel, Bath. 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 2780

BBC invites applications for two posts in the Radio Section of Planning and Installation Department, London. The duties of the posts include the preparation of specifications for radio and video frequency transmitters, supervision of installation and acceptance trials and conduct of necessary correspondence. Applicants should have a University Degree in Electrical Engineering or equivalent qualifications and a thorough basic knowledge of power and radio engineering is essential. Experience in planning and installation of short-wave and V.H.F. transmitters and associated equipment desirable. Knowledge of television theory and practice and/or transmission line and aerial technique advantageous. Starting salary £745 p.a. (may be higher if qualifications and experience are exceptional) rising by annual increments on a 5-year progression to £965 p.a. The successful applicants will become eligible for consideration for appointment to established staff (contributory pension scheme) after two years' qualifying period. Applications, stating age, qualifications and experience to reach Engineering Establishment Officer, Broadcasting House, London, W.1, within 7 days. W 2805

THE CIVIL SERVICE Commissioners give notice that an Open Competition for pensionable appointment to the Assistant (Scientific) Class (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, biochemistry and metallurgy. (iii) Biological sciences. (iv) General (including geology, meteorology, general work ranging over two or more groups (i) to (iii) and highly skilled work in laboratory crafts such as glass-blowing). 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 2833

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 £900 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 May, 1951. W 2834

MINISTRY OF SUPPLY require Production Officers and Assistant Production Officers in London for technical work on planning and production of equipments in one or more of the following:—Radio; Line Telecomm. Army Radar; Electronic Instruments; Primary and Secondary Batteries; also provision of associated spares. Applicants must be British of British parentage, have served recognised engineering apprenticeship and preferably hold Higher National Certificate or equivalent. Good general knowledge and experience of one or more of above equipments essential. Salary Range: P.O. £625-750 p.a., A/P.O., £500 (if age 30, less below 30)-£625 p.a. Appointments are unestablished but opportunities for establishment may arise later. Write for application form which should be returned completed by 16th April, 1951, to Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting (D95/51A). W 2788

RADAR AND ELECTRICAL Control Equipment Technicians wanted for work of National Importance. Vacancies exist in various locations in the London and Home Counties area. Good prospects exist of advancement. Salary Scale £400 p.a. rising to £525 p.a. Apply with full details of qualification, experience and area preferred to 1 A.A. Group Workshops, Shrapnel Barracks, Woolwich, S.E.18. W 2826

ROYAL AIR FORCE—Education Branch Permanent and Short Service Commissions. Applications are invited for Permanent Commissions (age limit 23-33 years) or for Short Service Commissions for 3, 4 or 5 years (minimum age 21 years). University graduates in Physics, Engineering (Mechanical, Aeronautical, Electrical, Electronic or Radio) or Mathematics are mainly required. Candidates for Permanent Commissions should ordinarily be first or second class honours graduates in one of these subjects. Pay on appointment depends on qualifications, experience and war service. Thus a first class honours graduate aged 25 may receive pay of £529 a year and, if married, marriage allowance of £338. Single officers receive free furnished accommodation. All officers draw rations in kind, or a tax-free allowance of £60 a year in lieu. There is time promotion to Squadron Leader, in which rank pay and marriage allowance rise to £1,232 a year (plus rations or ration allowance). Promotion to Wing Commander and higher rank is by selection. Retired pay for Permanent officers varies with rank (e.g. £625 for Wing Commander, £825 for Group Captain). Some Short Service officers will be selected annually for permanent commissions. Those not so selected receive a gratuity on completion of service. Short Service in the Education Branch can be treated as contributory for teachers' superannuation purposes. Women's Royal Air Force. Vacancies exist for Education Officers on Permanent and Short Service Commissions. Qualifications and conditions as for men except that pay rates are about three-quarters and retired pay rates about two-thirds of those for men. Free furnished accommodation and rations are provided. Full details and application forms for all the above appointments from Air Ministry A.R.1, Kingsway, London, W.C.2. W 2772

SITUATIONS VACANT

ELECTRO-MECHANICAL ENGINEER required Good academic qualifications and recognised apprenticeship desirable. Experience in electrical and electro-mechanical methods of computation ; servo theory, and instrument design preferred. Apply with full details of experience and salary required to the Personnel Manager, Sperry Gyroscope Co., Ltd., Great West Road, Brentford, Middlesex. W 125

MECHANICAL ENGINEER required. Good academic qualifications and recognised apprenticeship desirable. Preferably experienced in one or more of the following : Precision mechanical design ; hydraulics or pneumatic servo systems ; servo theory ; aerodynamics. Apply, with full details of experience and salary required to the Personnel Manager, Sperry Gyroscope Co., Ltd., Great West Road, Brentford, Middlesex. W 129

ELECTRONIC ENGINEER required. Good academic qualifications and recognised apprenticeship desirable. Required for development work on control systems. Experience of D.C. amplifiers and computing devices an advantage. Apply with full details of experience and salary required to the Personnel Manager, Sperry Gyroscope Co., Ltd., Great West Road, Brentford, Middlesex. W 127

MARCONI'S WIRELESS TELEGRAPH Co. Ltd. invite applications from persons interested in joining teams which will spend a considerable time in various parts of the world carrying out wave propagation experiments leading to the selection of sites for the erection of wireless stations. Preferably applicants should possess a University Degree, but consideration will be given to those possessing other qualifications. Selected applicants will be trained under expert guidance in this country before taking up duties, and will be employed in the laboratory during intervals of home service. In addition to normal home pay, successful applicants will receive an overseas allowance and liberal expenses whilst abroad. The Company operates a Staff Pension Scheme. Apply, quoting Ref. 833, to Central Personnel Services, English Electric Co. Ltd., 24-30, Gillingham Street, London, S.W.1. W 2672

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

FERRANTI LIMITED, 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. (2) Engineers and Scientists for research and development work in the following fields :—Radar, radio and electronic circuits, microwaves, high-power centimetric 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. (3) Technical Assistants for experimental work in the fields listed in (2) 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 2764

ELECTRONIC TESTERS required for firm manufacturing instruments and servo mechanisms in West Country. Housing available. Interviews in London area. Box No. W 1278.

A SALES OFFICE Administrative Assistant is required for the Electronic Control Equipment Department of a large Midlands firm. Applicants should be experienced in dealing with Representatives and with customers' enquiries, and have some knowledge of organised sales promotion and selective circularisation. Preference will be given to those who have light current technical training or practical background. Write, giving details of experience and mentioning Ref. HBG, to Box No. W 2822.

UNIVERSITY COLLEGE, LONDON (Gower Street, W.C.1), requires Glassblower experienced in using glassblowing lathe, in constructing vacuum equipment and simple electrode systems, and in making common types of glass to metal seals. Scale £7 10s. to £9 5s. according to qualifications. Family Allowance Scheme and four weeks' annual holiday. Applications forms from Secretary. W 2828

ELECTRONIC MECHANIC required by Oil Refinery for maintenance work on Process Controllers. Applicants must have experience of automatic electronic control. Industrial experience preferable but not essential. Apply Box No. W 1283.

PROMINENT AIRCRAFT FIRM in Greater London area commencing new project of National importance offers unique opportunity for advancement. High salaries with monthly status and pension scheme offered to suitably qualified applicants. Engineers required with good theoretical and practical experience in design and research in any of the following specialist groups:—(a) Radar, Marine or Aircraft, (b) U.H.F. Radio, (c) Low Frequency Amplifiers, (d) Electro-mechanical measurement techniques. City & Guilds qualification or University Degree desirable though not essential. Apply stating age, nationality and experience to Box AC60194, Samson Clark & Co., Ltd., 57-61 Mortimer Street, London, W.1. W 2790

THE G.E.C. is re-organising and expanding its radio engineering development and production units, both for its peacetime needs and for Government Contract work. It requires additional men of calibre and experience in its Coventry group of factories for work of considerable importance. Suitable Engineers, Physicists, Designers, Draughtsmen, Testers and Production Engineers, with experience of electronics, telecommunications and radio are offered an unusual opportunity of joining this developing side of the Company's business. Good conditions, excellent social facilities, interesting work, pension scheme. Considerable scope exists for men with energy and determination to overcome day to day difficulties. Write, giving precis of training, experience, etc., and salary required. Interview either Coventry or London, to : The General Electric Co., Ltd., Radio and Television Works, Spon Street, Coventry. W 2773

RADIO ENGINEER required for Test Instrument Laboratory, with experience of design and manufacture of test apparatus. One without experience but having good qualifications and an interest in the subject would be considered. Write, giving full particulars, age and salary required, to Personnel Department, Murphy Radio Ltd., Welwyn Garden City, Herts. W 2735

ASSISTANT wanted on staff of Research Department in Midlands, for work on special valves and radar. State experience and qualifications to Box No. 837, T. & G., 101, St. Martin's Lane, W.C.2. W 2757

DIGITAL COMPUTERS: Ferranti Limited, Moston, Manchester, are engaged upon the long term development and exploitation of digital computers. This interesting work covers vacuum physics, the electronic and electrical properties of materials, computing and pulse circuit techniques, electrical and mechanical recording, electromechanical mechanisms, precision mechanical engineering and power supply equipment. In the course of this work there are occasional vacancies for senior engineers with wide experience from whom enquiries will be welcomed at any time. There are immediate vacancies for: (1) Engineers and Scientists for research and development work in the above fields. Qualifications include a good Honours Degree in Physics or Engineering, or equivalent experience. Salary according to qualifications and experience in the range £450 to £1,000 per annum. Please quote Ref. D.C.E. (2) Technical Assistants for experimental work in the above fields. Qualifications are a Degree or Higher National Certificate in Engineering, or equivalent. Salary according to age and experience in the range £350 to £650 per annum. Please quote Ref. D.C.A. The Company has a Staff Pension Scheme and will give housing assistance in special cases. Application forms from the Staff Manager, Ferranti Limited, Hollinwood, Lancs. W 2825

CLASSIFIED ANNOUNCEMENTS
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CLASSIFIED ANNOUNCEMENTS (Cont'd.)

NATIONAL COLLEGE of Horology & Instrument Technology. The Minister of Education, in consultation with the Board of Governors, proposes to appoint from 1st September, 1951, a Head of the National College of Horology & Instrument Technology. The College is accommodated at the Northampton Polytechnic, St. John Street, London, E.C.1. The College provides for technical education and research to the highest levels in connexion with the horological and the instrument making industries. The curriculum is being developed, but is at present confined to a three-year General Course in Horology. Candidates for the post must have good academic qualifications and industrial experience. Salary scale not less than £1,100 by increments of £50 a year to £1,250 p.a. The post is recognised for pension purposes under the Teachers' Superannuation Acts. A letter of application to include particulars of age, academic qualifications, industrial experience, and the names of three persons to whom reference may be made, should be sent to the Secretary, National College of Horology & Instrument Technology, Northampton Polytechnic, St. John Street, London, E.C.1, within three weeks of the appearance of this advertisement. W 1276

A FUNDAMENTAL Physical problem of great importance and interest awaits solution by a Research Team now being built up. Candidates qualified by Honours Degrees and with experience in Physical problems, who are prepared for hard and interesting work, and who seek a permanent pensionable post, with good prospects, are invited to send full personal particulars to the Plessey Company Limited, Ilford, quoting Ref. A.A. They should be between the ages of 25 and 35, and British born. W 2827

PHYSICIST. Interesting vacancy occurs in the Research and Development Section of a large Engineering Company situated in Wiltshire. Applicants should possess a good Degree, and have had at least two years' industrial experience. A knowledge of Radio Components and/or moulding technique an advantage, but not essential. The appointment is of a permanent nature, pension scheme in operation. Write stating full details of experience to Box No. W 2819.

ESTIMATING ENGINEER required in the Telecommunications Division of large light engineering Company in the Eastern suburbs of London. Experience must cover detailed estimating for both low frequency and high frequency communications equipment. Applicants should have practical experience and adequate technical knowledge. This is a Senior appointment with commensurate salary. Kindly state full details to Box No. W 2830.

ELECTRONIC DEVELOPMENT ENGINEERS. Vacancies exist for: (1) Senior Development Engineer to be responsible under Technical Director for the development and design of a wide range of CRO and associated electronic equipment. Applicants must have an Honours Degree in Physics or Electrical Engineering (Telecommunications) and some industrial experience. First class opportunity for a man with original ideas and a keen interest in the subject. (2) Development Engineer for work on interesting development projects. A Degree in Physics or Electrical Engineering is essential and some industrial or research experience desirable. Salaries according to age and qualifications. Apply with full details to Southern Instruments Ltd., Fernhill, Hawley, Camberley, Surrey. W 1281

SENIOR DESIGN ENGINEER required to undertake original work on Electronic Test Equipment and Iron Cored Components. Qualifications required include Degree or equivalent and the ability to initiate and develop new projects to the production stage. Apply in writing, giving full details of experience, to Advance Components Limited, Back Road, Shernhall Street, Walthamstow, London, E.17. W 1279

ASSISTANT ENGINEER required by large Engineering Organization in East London area for Capacitors Design and development. 21/25 years of age, good opportunities for advancement. Degree or Higher National Certificate—Electrical. Write stating age and qualifications to Box No. W 2812.

ELECTRONICS : Senior Engineer required with mature experience in design and manufacture of modern and advanced apparatus. Send fullest details of education and experience with salary required to Box No. W 1275.

E.M.I. Engineering Development, Limited, require experienced electronic engineers, including team leaders, for the development and design of radar equipment. Applicants should have a 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 a good salary and excellent prospects. Applicants should write quoting ED/34 and give full details to Personnel Department, E.M.I. Engineering Development, Limited, Blyth Road, Hayes, Middlesex. W 2776

TECHNICAL WRITERS (Male or Female) required to prepare and edit reports and handbooks for publication. Qualifications:—A good general training in electronics with practical experience of electronic equipment desirable; marked critical faculty and ability to write clear English. Applicants should write giving full details and quoting ED/19, to Personnel Department, E.M.I., Ltd., Blyth Road, Hayes, Middx. W 2777

E.M.I. Engineering Development, Limited, have a number of vacancies for engineers and senior engineers on interesting development work in various electronic engineering projects. The posts are for permanent pensionable staff and offer good prospects. Qualifications: a Degree in Physics or Engineering or equivalent, together with several years design or specialised experience in the following fields:—(a) L.F. Equipment. (b) Television Equipment. (c) Microwave Techniques. (d) Pulse Techniques. (e) Servo Mechanisms. (f) Test Gear Design. (g) Inspection. Applicants should write giving full details of experience and type of work required, and quote ED/33, to Personnel Department, E.M.I. Engineering Development, Limited, Blyth Road, Hayes, Middx. W 2778

ELECTRONIC ENGINEER REQUIRED to handle 250 Kilowatt high frequency Induction Heater. Knowledge of Metallurgy and familiarity with high power Radio components essential. Please write stating age, experience and salary sought to Personnel Manager, De Havilland Propellers, Ltd., Manor Road, Hatfield, Herts. W 2789

UNIVERSITY COLLEGE, LONDON (Gower Street, W.C.1), requires Grade I Technician in Department of Psychology. Experience in construction and maintenance of electronic and electrical apparatus essential, with ability to develop electronic apparatus on own initiative. Minimum qualifications—Higher National Certificate in Electronics or City and Guilds Telecom. with Radio III. Salary £390 × £13 to £481, depending on experience. Family Allowance Scheme. Application forms from the Secretary, quoting Psychology/2. W 2821

INSTRUMENT SALES ENGINEER required with modern industrial instrumentation and sound knowledge of electronics. Position entails travelling the U.K. with headquarters in London. Minimum technical qualifications Higher National Certificate or equivalent. Preference given to candidates with commercial experience. Candidates 28/33 years of age should send full particulars of education, training, career, salary expected, enclosing, if possible, a photograph, which will be returned, to Reference S, Box No. W 2824.

REQUIRED by leading manufacturers of High Frequency Equipment, Sales Engineer with electronic experience, preferably with experience of production of automobile or machine tool parts. Minimum standard, Higher National Certificate or equivalent. Engineer will operate from Headquarters in London. Excellent prospects for active, well-qualified engineer, 25/33 years of age, who will be given every encouragement. Candidates should write giving details of education, training, experience, salary expected, enclosing photograph, if possible, which will be returned, to Reference Z, Box No. W 2823.

ROWETT RESEARCH INSTITUTE, Bucksburn, Aberdeen. Technician required with training and experience in electronics or electrical engineering, to operate and maintain physical instruments used for chemical analysis. The appointment will be in the Experimental Officer Grade for which candidates must be at least 26 years of age. A superannuation scheme is in force. Salary scale (Provincial) £495 × £20—£645. Applications, stating date of birth, qualifications and experience, should be addressed to The Secretary, Rowett Research Institute, Bucksburn, Aberdeen. W 1282

SEVERAL FIRST CLASS project Design Engineers required for work of an intricate mechanical and electromechanical 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 2832.

WE ARE LOOKING for a man with drive, ambition, and a power of leadership with unimpeachable technical qualifications and experience in the design of light mechanisms for quantity production. He will be required to lead a development team on a new, long-term, important project which will provide him with an absorbing interest. Applicants who are able to earn a four-figure salary, and who have experience in the design of light electromechanical systems are invited to apply to S.M. Box No. W 2811.

ATTRACTIVE and interesting opportunities are available in an independent research group located in West London on important radar projects. Applications are invited from experienced Physicists or Electronic Engineers. Give full particulars of age, education, qualifications, experience and salary required to Box A.E. 283, Central News Ltd., 17 Moorgate, E.C.2. W 2783

DESIGN ENGINEER required by unit of English Electric Co. Ltd., working on important defence project, to undertake detailed design and layout of electromechanical analogue computing devices. Degree or H.N.C. essential and experience of Anti-Aircraft predictors. Magslip applications or the like desirable. Write giving full details and quoting Ref. 862 to Central Personnel Services, English Electric Co. Ltd., 24-30 Gillingham Street, London, S.W.1. W 2793

SENIOR DEVELOPMENT ENGINEER. A large Engineering establishment in the North Kent area are requiring the services of Senior Development Engineers with technical and practical experience in electronics. Applicants should possess a good Degree, the minimum qualifications being the Higher National Certificate in Electrical Engineering. A good knowledge of Servo Mechanisms would be an advantage. Reply, stating age and giving full particulars of experience and salary required to Box No. W 2785.

YOUNG ENGINEER, with experience in underground and internal cabling and small generating sets and prime movers, required for installation design section, responsible for planning radio and similar stations. Write giving full details, quoting Ref. HEG, to Box No. W 2787.

TELECOMMUNICATIONS Research and Development Engineers are required by British Telecommunications Research Ltd., a Company associated with The Automatic Telephone & Electric Co. Ltd., and British Insulated Callenders Cables Ltd., for work on long term development projects. Applicants should preferably have a good University Degree in physics or light electrical engineering and have had experience of some aspect of development work in any of the following fields: (a) Wide-band line transmission systems and apparatus, or (b) V.H.F. and U.H.F. radio communication systems and apparatus, or (c) Electronic switching computing and control systems and apparatus. Applications for a number of more junior posts are also invited from Hons. Graduates in physics or electrical engineering who have an interest in the above fields. Salaries in accordance with experience and qualifications. Successful candidates will be required to join the B.I.C.C. superannuation scheme after an initial probationary period of 3 months. Application forms obtained from the Director of Research, British Telecommunications Research Ltd., Taplow Court, Taplow, Buckinghamshire. W 2795

THE I.S.C. LTD. requires a physicist, holding a first or second-class Honours Degree for work involving the development of spectrographic methods of analysis and the use of an electron microscope. Experience with X-ray, spectroscopy and electron microscopy would be a distinct advantage, but a recent graduate having specialist knowledge would be considered for the post. Written applications giving brief details of age, training and experience, should be sent in confidence to the Personnel Manager, I.S.C. Ltd., Avonmouth, Bristol. Please quote the reference EE/P. W 2803

DESIGNER DRAUGHTSMAN aged 28/35. Sound knowledge light electromechanical apparatus. Used to handling detailing draughtsmen. Education at least H.N.C. standard. Old established and highly reputed firm of instrument and telegraph engineers. S.E. area. Applications with full particulars of age, experience and salary required to Box No. W 2786.

THE FOLLOWING VACANCIES for Electrical Engineers with experience of the design of electronic equipment for production exist in a large industrial Research Laboratory in the vicinity of London: (1) Senior Engineer, age 35-45, starting salary £1,000-£1,500, according to qualifications and experience. (2) Engineers, age 27-35, starting salary £600-£1.000, according to age and experience. (3) Junior Engineers, age 23-27, starting salary £400-£600, according to age and experience. Candidates for posts (1) and (2) should have had development experience on medium to large scale projects, but for post (3) candidates will be considered who have only small experience in the electronic industry. All posts will be permanent and a superannuation scheme to which the firm contributes will be available to those successful candidates who wish to join. Applications must be made in writing by April 30th, 1951. Before appointment, candidates will be expected to attend an interview in the vicinity of London. Reasonable travelling expenses will be paid. Please reply to Box No. W 2813.

BELLING & LEE LTD., 540 Cambridge Arterial Road, Enfield, Middlesex, wish to engage a specialist to conduct aerial research and development, particularly at television frequencies. Applicants must possess scientific qualifications together with considerable experience in the field; must be imaginative and original, and able to work with minimum supervision. Excellent research facilities are available and an attractive salary will be offered to the right applicant. W 134

MIDDLESEX HOSPITAL Medical School. Department of Physics Applied to Medicine. Workshop technician required in the research laboratories of the above Department. Experience in the construction of electronic equipment essential. Salary on the scale £370 to £435 p.a., plus London weighting, superannuation and family allowance. Applications not later than 7th April, 1951, to the Secretary, Barnato Joel Laboratories, The Middlesex Hospital, London, W.1. W 1273

SENIOR DESIGN DRAUGHTSMEN. Highly reputed Company situated in Western area. An extensive experience of design of light electromechanical mechanisms is essential. Educated to H.N.C. Standard. The appointments are for permanent pensionable staff and carry a good salary. Write stating age and experience to Box No. W 2818.

ELECTRONICS SECTION of the Motor Industry Research Association requires for construction and development of electronic instruments, Laboratory Assistant of Ordinary National standard. Age about 25; salary according to age and experience. Reply giving age, experience, qualifications and salary required, to Motor Industry Research Association, Great West Road, Brentford, Middlesex. W 2816

RESEARCH MEN required by Marconi's Wireless Telegraph Co. Ltd., Chelmsford, for work on problems connected with frequency measurements and stability up to microwave frequencies. Vacancies exist both for highly qualified engineers or physicists with good experience in this field as well as for a number of Juniors with H.N.C. or similar qualifications. Salaries offered will be by arrangement and will depend upon the qualifications and experience of the applicant. Pension Scheme. Please write giving full particulars and quoting Ref. 863, to Central Personnel Services, English Electric Co. Ltd., 24-30 Gillingham Street, London, S.W.1. W 2820

ELECTRONIC ENGINEERS. Well established Company situated in Wiltshire. Applicants should have educational qualifications to H.N.C. standard and have served a recognised Engineering apprenticeship. A sound experience of design and development of light electronic components is essential. Permanent appointments, pension scheme. Write stating qualifications to Box No. W 2817.

DEVELOPMENT ENGINEER. Applications are invited from Graduates with experience in radio and television. Salary depending on qualifications and experience but not less than £500 per annum. Write giving details of age, experience, etc., to Personnel Officer, Mitcham Works, Limited, New Road, Mitcham Junction, Surrey. W 2802

ELECTRONIC ENGINEER required for constructional design of industrial installations and Laboratory equipment, and to assist in running small production unit. Drawing Office experience in this work would be considerable advantage. Progressive and responsible post. Excellent working conditions. 41-hr. week. Canteen. Write stating age, experience and salary required to Director of Research, G.K.N. Research Laboratories, Manor Works, Ettingshall, Wolverhampton. W 2796

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 2797.

McMICHAEL RADIO, LTD., require Senior Project Engineers in their Equipment Division Laboratory at Slough. Training and experience in the field of Applied Electronics (including Communications) and experience of working with Government Departments are the chief qualifications required. 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 2799

E. K. COLE, LTD. (Malmesbury Division), invite applications from Electronic Engineers for permanent posts in Development Laboratories engaged on long-term projects involving the following techniques:—(1) Pulse Generation and Transmission. (2) Servo Mechanisms. (3) Centimetric and V.H.F. Systems. (4) Video and Feedback Amplifiers. (5) V.H.F. Transmission and Reception. (6) Electronics as applied to Atomic Physics. There are vacancies in the Senior Engineer, Engineers and Junior Grades. Candidates should have had at least 3 years industrial experience in the above types of work, together with educational qualifications equivalent to A.M.I.E.E. examination standard. Commencing salary and status will be commensurate with qualifications and experience. Excellent opportunities for advancement are offered with entry into a Pension Scheme after a period of service. Forms of application may be obtained from Personnel Manager, Ekco Works, Malmesbury, Wilts. W 2800

VACANCIES exist for two experienced Electronic Testers in modern factory near Watford. Interesting and varied work. Five day, 44 hour week. Canteen. Remuneration according to ability. Write stating age, experience and salary required. Box No. W 2804.

EDITORIAL ASSISTANT—A vacancy will shortly occur on the staff of ELECTRONIC ENGINEERING for an Editorial Assistant. He should have a sound knowledge of electronic and general scientific subjects and be able to write good technical English. Knowledge of make-up, proof correcting, etc., desirable. Age 25 to 35. Salary according to age and experience. Applications with full details of education, training and experience to: Staff Director, Morgan Brothers (Publishers), Ltd., 28 Essex Street, Strand, London, W.C.2. W 2814

NORTHAMPTON POLYTECHNIC, St. John Street, London, E.C.1. Lecturer-in-charge of instruction in Instrument Making. Applications are invited for appointment as lecturer-in-charge of Instrument Making at the Polytechnic, to date if possible from 1st May, 1951. Candidates should have a thorough knowledge of the theory and design of scientific and industrial control instruments and wide manufacturing experience. An academic standard of Degree or Associate Membership of the Institution of Electrical Engineers or the Institution of Mechanical Engineers will be expected. Teaching experience in a part-time or full time capacity is desirable. Salary will be under the Burnham Technical Report. This scale is at present under revision, but subject to approval of the Ministry of Education the post is expected to attract not less that £936 p.a. by increments of £25 to £1,048 p.a. Particulars and application forms obtainable from the Secretary at the above address. J. E. Richardson, Ph.D., B.Eng., M.I.E.E., A.M.I.Mech.E., Principal. W 2801

NELSON RESEARCH LABORATORIES, English Electric Co., Ltd., Stafford, have a vacancy for a Senior Electronic Engineer for work on high speed automatic electronic digital computers. Applicants should have Honours Degrees in Physics or Engineering, with a sound knowledge of the principles of circuit design and have had three or four years experience in radar or electronic development. The appointment will be in the London area for an initial period of at least one year and then at Stafford. Apply giving full details and quoting Ref. 305C to Central Personnel Services, English Electric Co., Ltd., 24/30, Gillingham Street, London, S.W.1. W 2781

ELECTRONIC ENGINEER required, with Physics Degree or good experience of same, by well established electronic component manufacturer, for research and development. Applicants must have the following qualifications:—Present salary at least £750 per annum. Be above average intelligence. Live and of proven ability. Able to work on own initiative and get results. Position offered is a first-class one with scope for advancement. Write fullest details in confidence, stating age, salary required, and experience in full, including length of service in each position held, together with salary received. Our own staff are aware of this advertisement. Box No. W 2782.

MARCONI'S WIRELESS TELEGRAPH CO., LTD., Chelmsford, have staff vacancies for Technical Assistants in their Test Division to work in all branches of electronic engineering. Candidates with suitable qualifications and good electronic experience will be considered. Good salaries paid to suitable applicants. The company operates a Pension Scheme. Please apply quoting reference 809 and giving full details to Central Personnel Services, English Electric Co., Ltd., 24-30 Gillingham Street, London, S.W.1. W 2779

THE RESEARCH LABORATORIES of The General Electric Co., Ltd., East Lane, North Wembley, Middx., have a vacancy for an engineer for field trials on a development project. Experience with electronic equipment and organizing ability are essential. An ex-service radar or signals officer would be suitable. This position will involve considerable periods spent away from the Laboratories but continual travelling will not be involved. Applications in writing should be sent to the Personnel Officer (Ref. GBLC/996) and should give details of age, qualifications and experience. W 2810

CLASSIFIED ANNOUNCEMENTS
continued on Page 6

DEVELOPMENT ENGINEER required with Degree or equivalent in Telecommunications, Electrical Engineering or Physics and experience in design of Andis and carrier frequency measuring instruments. Knowledge of design of Noise Measuring Apparatus and/or Bridges an advantage. Salary according to qualifications and experience. Write giving full details to Personnel Manager, Standard Telephones and Cables, Limited, Newport, Mon. W 2798

UNIVERSITY OF LEEDS. Technician wanted in May or earlier by arrangement in the Plant Biophysics Research Laboratory to service and maintain X-ray Generators, electronmicroscope and other instruments involving electronic apparatus. Previous experience in electronics essential; experience in high vacuum technique desirable but not essential, and supplementary training will be given. Age preferably between 28 and 35; salary according to age and experience. Applications, giving the names of two referees should be sent to Dr. R. D. Preston, Biophysics subdepartment, Botany Department, not later than 13th April. W 1265

LABORATORY ASSISTANT (Female). At least Matriculation standard including Electricity and Magnetism. To work on quality control of radio receiving valves. Hours 7.30 a.m. to 5.15 p.m. Five day week. Age 20 to 30 years. Salary according to age and experience. Chances of finding local accommodation remote. Apply in Writing to Miss M. B. Little, Women's Personnel Officer, Mullard Radio Valve Co., Ltd., New Road, Mitcham Junction, Surrey. W 2809

PADDINGTON GROUP HOSPITAL Management Committee. Applications are invited for the post of Junior Technician (Recordist) in the Department of Electro-Encephalography of the West-End Hospital for Nervous Diseases, 73 Welbeck Street, W.1. The salary is £300 to £350 per annum according to experience. Applications stating age, qualifications, experience together with the names and addresses of two referees, to be forwarded to the Administrative Officer immediately. W 2831

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 2808

CAMBRIDGE INSTRUMENT COMPANY invite applications for the post of Assistant Physicist in the Research Department at Cambridge. The work covers a wide range of subjects and calls for a young man interested in the practical development of electronic instruments and electro-mechanical devices. Applicants should preferably possess a University Degree or equivalent qualification but ability and originality are the main considerations. Apply in writing stating salary required. W 2807

SENIOR AND JUNIOR Mechanical Development Engineers required for interesting long term projects by a light engineering company. Age range 25-35. Candidates who must be British born should have a Degree or equivalent qualifications in Mechanical Engineering, and some knowledge of light Electro-Mechanical systems would be an advantage. Ability to design for quantity production is essential. The posts are permanent and pensionable. Candidates for the Senior posts must be able to show several years experience in an equivalent design capacity in a light electrical or mechanical engineering firm of repute. Apply in confidence to the Plessey Company, Limited, Ilford, quoting reference S.M. W 2784

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

ASSISTANT ENGINEER, age 22-30, with Degree or Higher National Certificate in Electrical Engineering, required for development work in laboratories in the Guildford area. Some experience in light current engineering is desirable, together with an interest in electronics or servo systems. Write, giving details of qualifications, experience and salary required, to Box No. W 2758.

WELL-KNOWN firm of Precision Engineers and Scientific Instrument Makers requires Research Physicists and Engineers for the Electronic and Computing Divisions of their Research Laboratories situated on the northern outskirts of London. Vacancies exist for: (1) A Senior Research Engineer age 30-40, starting salary £1,000 to £1,500 per annum according to qualifications and experience. (2) Research Engineers and Research Physicists age 25-30, to take charge of small research groups, starting salary £700 to £1,000 according to age and experience. (3) Junior Research Physicists and Engineers age 21 to 26, starting salary £350 to £700 according to age and experience. Candidates for posts (1) and (2) are expected to have an Honours Degree in Physics or Engineering and to have had research experience. For post (1), experience of research in advanced circuit techniques is required; candidates for posts under (2) are expected to have experience of research in advanced circuit techniques or in servomechanisms Candidates for posts under (3) are expected to have an Honours Degree or research experience. All posts will be permanent and a superannuation scheme to which the firm contributes will be available to those successful candidates who wish to join. Applications must be made in writing by 30th April, 1951. Before appointment, candidates will be expected to attend an interview in the vicinity of London. Reasonable travelling expenses will be paid. Apply Box No. W 2836.

THE GENERAL ELECTRIC CO. LTD. have vacancies for technical laboratory assistants at the Research Laboratories, North Wembley, Middlesex. Candidates should have qualifications to about Higher Schools Certificate or equivalent standard and preferably some experience in a laboratory or workshop. Applications in writing should be sent to the Personnel Officer (Ref. GBLC/101) giving age and record. W 2839

FIRST CLASS opportunities for graduate engineers and physicists with good Honours Degrees are available at the Research Laboratories of The General Electric Co. Ltd., North Wembley, Middlesex. All vacancies will be for experimental or design work mainly in the fields of electronic and mechanical engineering. A limited number will be concerned primarily with vacuum physics. Openings will occur in three grades as follows: (a) Section Leaders—first class experience is essential. Only men aged 27 or over, with proved ability to lead research teams, will be considered. (b) Post Graduate Research Physicists and Engineers who are completing their theses for advanced Degrees this summer and who are seeking interesting experimental work in an industrial research laboratory. (c) University students who will be sitting for Finals in physics or engineering during the next three months. Starting salaries will be dependent on academic qualifications, age and experience, and prospects of advancement will be exceptionally good. Further particulars will be sent to all applicants who forward details of their record to the Personnel Officer (Ref. GBLC/101). Interviews will be arranged during the next few weeks for graduates available between April and the end of September. W 2837.

THE CAMBRIDGE INSTRUMENT Co. Ltd., Sydney Road, N.10, have vacancies for development engineers for work on electrical and pneumatic instruments. Some knowledge of automatic control would be desirable. Please write giving full details of experience and salary required. W 2835

ENGLISH ELECTRIC, Stafford, invite applications from young Engineers who are interested in relay and meter design. Previous experience desirable but not essential. Qualifications: Degree in Electrical Engineering with bias towards mathematical aspect. Facilities exist for giving successful applicants a thorough education in the design and development of meters and relays. Apply, giving full details and quoting Ref.444B. Central Personnel Services, English Electric Co., Ltd., 24-30, Gillingham Street, London, S.W.1. W 2769

ELECTRONIC RESEARCH and Development, There are vacancies for Honours Graduates for work in the following fields: (1) Measurement technique on V.H.F. and microwaves. (2) High power R.F. generation. (3) Carrier telephony. (4) General scientific instruments and high-grade components. Some of these posts require a thorough experience in one of the fields and there are others for recent graduates. Apply to Personnel Officer, Mullard Research Laboratories, Salfords, nr. Redhill, Surrey. W 2765

DRAUGHTSMEN required to asist Designers. Capable of producing detail drawings from layouts and sketches to standards suitable for quantity production of radio and radar equipment. Apply, giving full details, to Personnel Department, Murphy Radio Ltd., Welwyn Garden City, Herts. W 2749

RADIO ENGINEER required for Factory Laboratory, with experience of technical problems associated with the manufacture of radio and television receivers. An engineer with some design experience, wishing to apply his knowledge in the factory, would be considered. Write, giving full particulars, age and salary required, to Personnel Department, Murphy Radio Ltd., Welwyn Garden City, Herts. W 2736

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LABORATORY TECHNICIAN. Layout and construction valve operated equipment from theoretical diagram, without supervision. Carry out designers ideas. London or Home Counties preferred. Box No. W 1252

YOUNG MAN of culture and initiative, with wide experience of electronics and light electrical engineering, accustomed to accepting responsibility, seeks new position. W 1280

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SELENIUM RECTIFIERS. FW, 12V, 1A, 5s. 6d. 4A, 14s. HW 250V, 70 MA, 4s. Sliding resistances, 1 ohm 12A, 4 ohm 6A, 6s. Fixed 1 ohm 12A, 3s. 6d. Vitreous, 800, 30W, tapped 2s. 2,000 30W, 1s 3d. 1,500 15W, 10d. 50 200 5W, 5d. 25, 1,000, 1,500, 3W, 4d. 45, 100, 1,200 2W, 3d. Tone controls 15,000, 6d. Voltmeters AC/DC 0-15, 5s. Motors squirrel cage, 24V, 3ph, 5s. Reduction quantities. Letters answered: Parker, 3, Longdene Road, Haslemere, Surrey. W 1271

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

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AMERICAN MAGAZINES. One year post free. "Radio Electronics," 32s. 3d.; "Audio Engineering," 28s. 9d.; "Radio and Television News," 36s.; "Popular Science," 28s. 6d. S.A.E. for full list from Willen Ltd., (Dept. 9), 101 Fleet Street, London, E.C.4. W 108

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FIRST BOOK about transmitters "Radio Communication Transmitters" by J. J. Hupert, Prof. de Paul University, Chicago, USA, published by ATA Scientific Progress Ltd., 19, Effra Road, S.W.2, price, 24s. W 133

PURE BERYLLIUM FOIL, 0.005 in. thick, for X-Ray Tube Windows. Elgar Trading Limited, 240 High Street, London, N.W.10. W 132

RF COILS, 10kc/s to 100Mc/s, Singly or Quantity. Bel Sound Products Co., Marlborough Yard, Archway, N.19. ARC. 5078. W 2794

VALVES. SP.41, VR.78, HL.2, EB.34, 1s. 6d. each. VU.111, 215.SG, Pen.220a, VR.116, 2s. 6d. each. EL.32, 6B8G, EF.36, 4s. each. Carriage extra. Condensers. 0.02uf at 8kV, 2s. each. .04 at 4kV, 1s. 6d. each. Post and packing 6d. IFF. Motors. Suitable for conversion to A.C./D.C mains, complete with gearbox—a motor with 100 uses, 12s. 6d. each. Post and packing 1s. 6d. D.C. only Type identical to above but with P.M. Field, 7s. Post and packing 1s. 6d. Quotations for quantity. Headphones. Type 7 Moving Coil Head Set and Mic., complete, 6s. Post, etc., 9d. J. H. Dakin, 13 Church Road, Birmingham, 15. W 1277

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THE COLLEGE OF AERONAUTICS, Cranfield. Two-Year Course in Aircraft Electrical Engineering and Electronics. Applications are invited for admission to the above course which starts in October 1951. The course, which leads to the Diploma of the College, provides a good grounding in Aeronautical Engineering in general, together with the opportunity of specialization in the aeronautical applications of Electrical Engineering, including Electronics. Subjects covered include the application of electronic techniques in measurement and control; airborne radio and radar devices; servo-mechanisms; aircraft electrical power systems; and aircraft aerials. In the second year students have the opportunity to participate in research work to form the subject of a thesis. Applicants should have a University Degree or Higher National Certificate, with some previous knowledge of Electrical Engineering, but the College may, after interview, admit candidates without these qualifications who are of an equivalent educational standard. Further information and forms of application may be obtained from the Registrar, The College of Aeronautics, Cranfield, Bletchley, Bucks. W 2838

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 Te'ecom. Prospectus (A) from the Secretary. (170). W 2775

ONE YEAR Advanced Course in Electronics. A few vacancies exist on course commencing April 17. Prospective students should possess a sound knowledge of Radio and Telecommunications fundamentals, and a knowledge of Maths between Intermediate and Degree standards. Full details from E.M.I. Institutes, Dept. EE.17, Pembridge Square, London, W.2. Bayswater 5131/2. W 2792

E.M.I. gave the world electronic television. E.M.I. is now giving the finest home study Television courses. Moderate terms—facilities for easy payment. Free brochure giving full details on application to the Registrar, Dept. EE.7, E.M.I. Institutes, 10 Pembridge Square, London, W.1. Bayswater 5131/2. W 2791

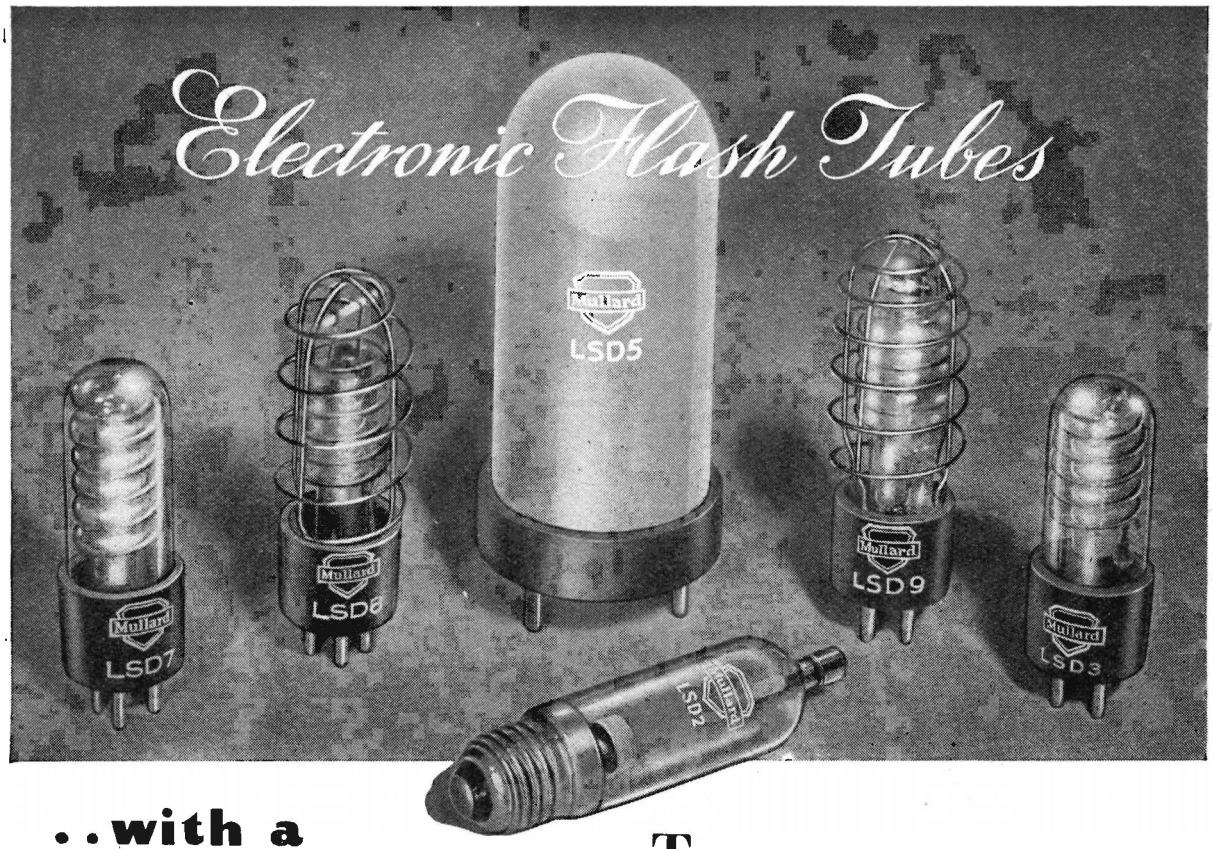
UNIVERSITY COLLEGE, Southampton. Department of Electronics. The Department of Electronics (Professor E. E. Zepler) gives an advanced course at Honours Degree standard in Electronics. The course is full-time for one academic year and the College grants a Diploma by examination to students who successfully complete the course. Entry qualification is a University Degree in Physics or Electrical Engineering, or its equivalent. The fifth of these courses will commence in October 1951, and application for admission should be made now to the Academic Registrar, from whom further details may be obtained. W 1250

WANTED

WANTED FOR BINDING, "Electronic Engineering," January and March 1949. State price. Dawe Instruments Limited, 130 Uxbridge Road, Hanwell, London, W.7. W 1285

PATENTS

THE PROPRIETORS of British Patent No. 564,382, relating to Electronic Translating Devices are desirous of entering into arrangements by way of Licence or otherwise on reasonable terms for the purpose of exploiting the same and ensuring its full development and practical working in this country. Interested parties who desire a copy of the Patent Specification and further particulars should apply to: S. E. Matthews, Esq., 14/18 Holborn, London, E.C.1. W 1274



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The Mullard range of electronic flash tubes is finding increasing use in industrial photography and in problems involving the analysis of motion in production processes.

On account of their high luminous efficiency, low-triggering voltage, daylight colour quality, and short-flash duration, the Mullard flash tubes at present available offer wide possibilities in equipments used for applications varying from the motion-study of workers to the examination of high-speed machinery in operation.

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LSD7	For higher power portable equipments	200	2.7
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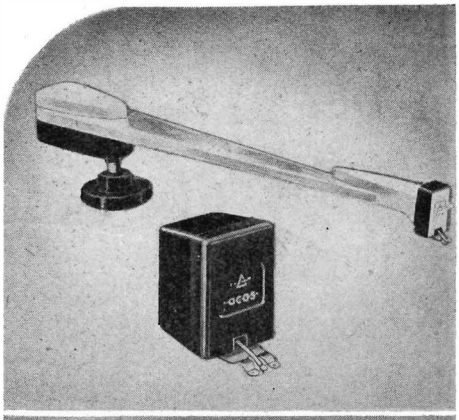

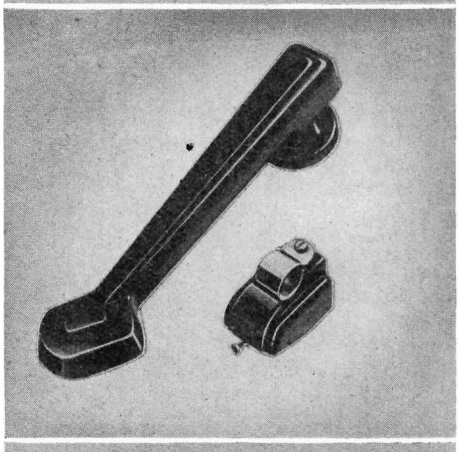

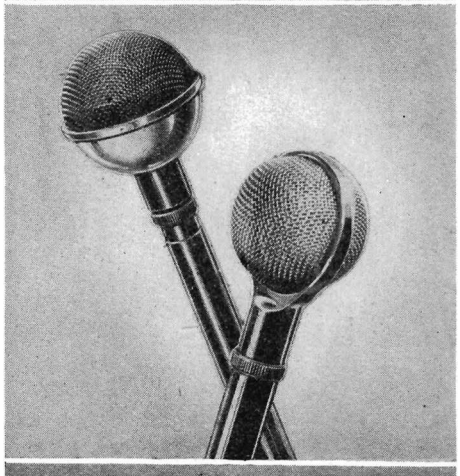

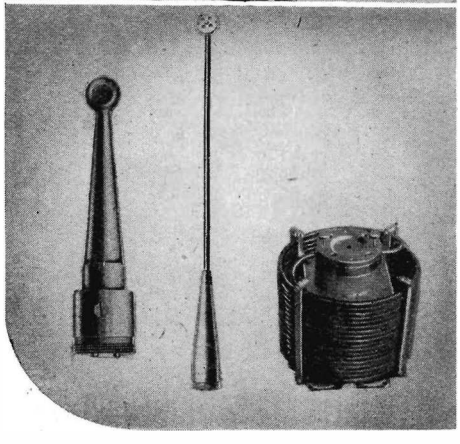

PRODUCTS AND SERVICE

Acos research and service is devoted to the practical application of piezo-electric phenomena to all forms of acoustic, ultrasonic and vibration problems.

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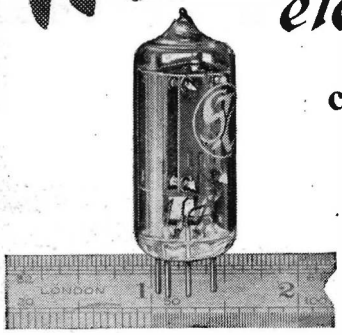

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count up to 20,000 digits per second

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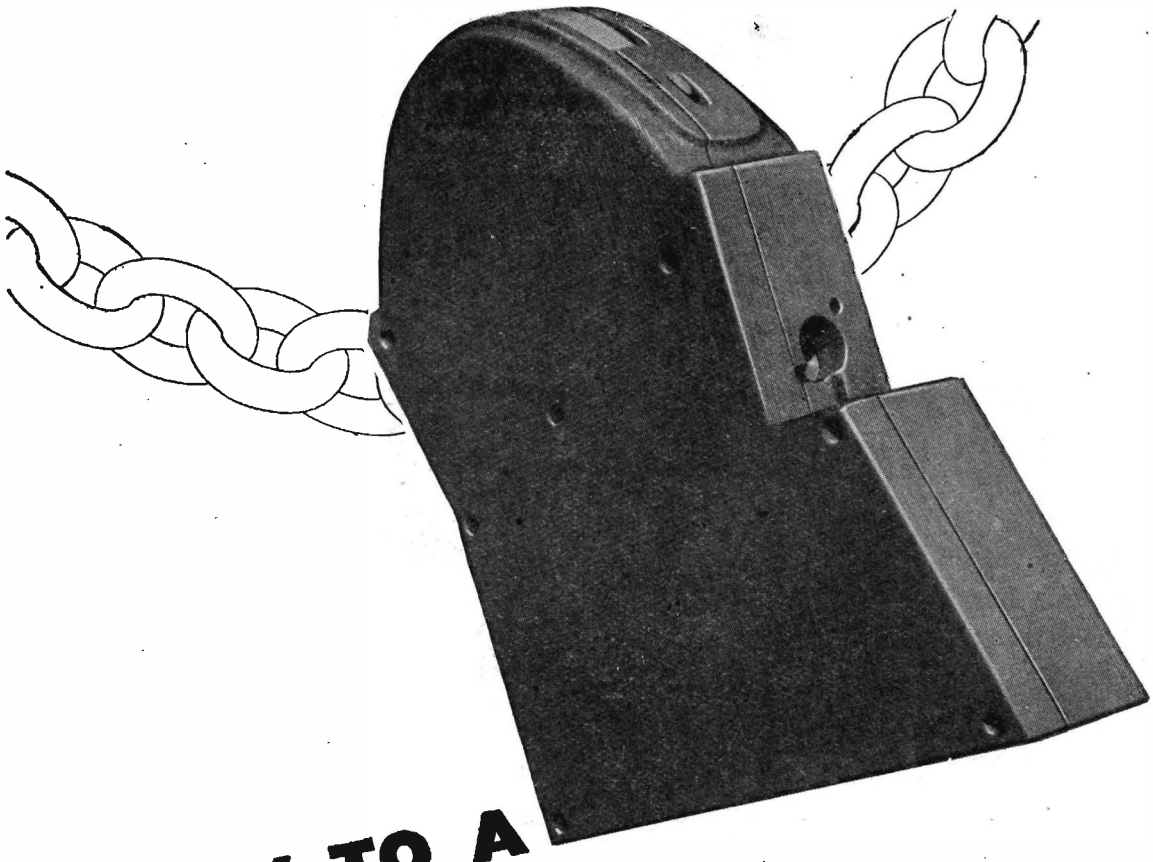

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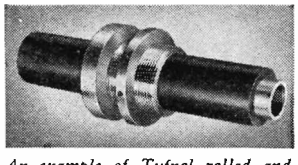

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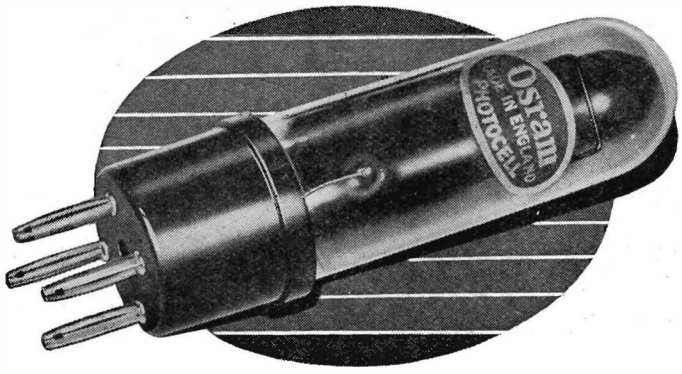

Dimensions: 92 mm seated length, 28 mm diameter and mounted on a four-pin British base.

Osram caesium antimony cells, vacuum and gasfilled, have a higher sensitivity level to artificial light than the cells of the caesium silver oxide type, and for most purposes are, therefore, preferable.

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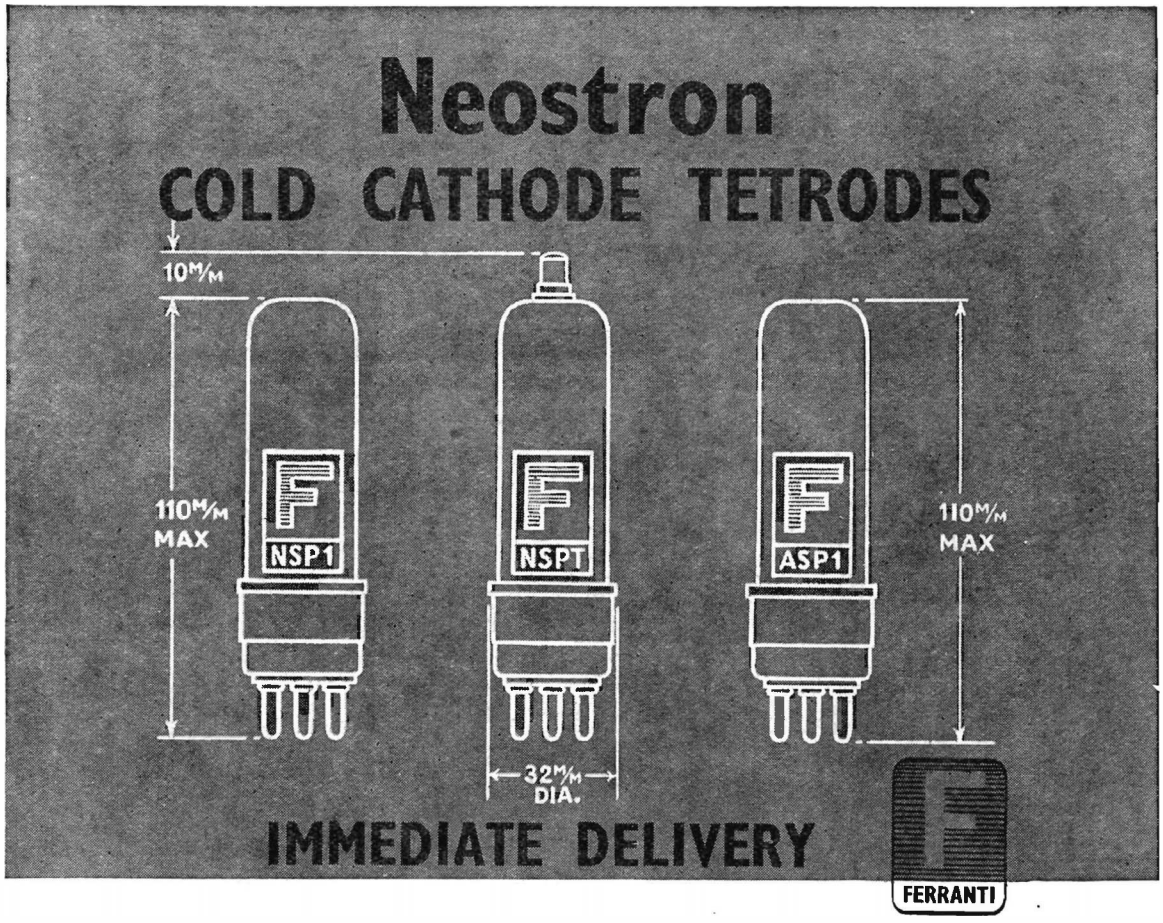

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Normal Anode Voltage	300	600	300
Mean Anode Current	40-100* mA	40-100* mA	40-100* mA
Peak Anode Current	250 Amps.	250 Amps.	250 Amps.
Max. Operating Frequency	250 c.p.s.	250 c.p.s.	300 c.p.s.
Anode Connection	in base	Top cap	in base
Gas Filling	Neon	Neon	Argon

**Dependent upon frequency of operation*

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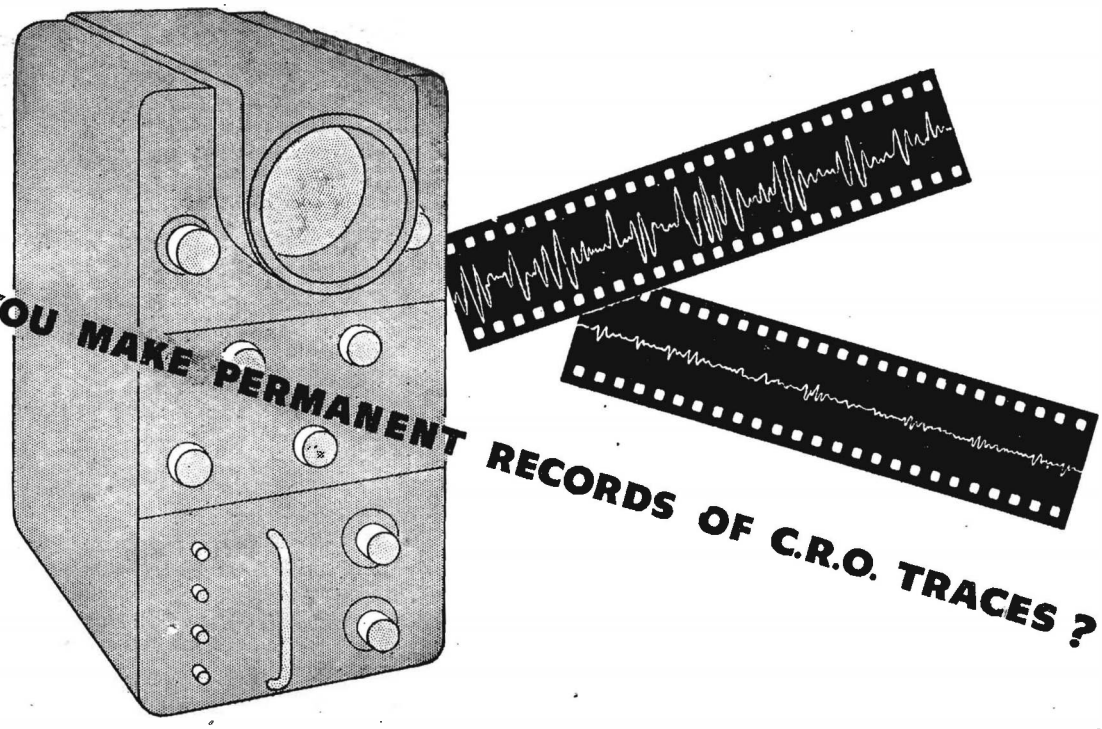

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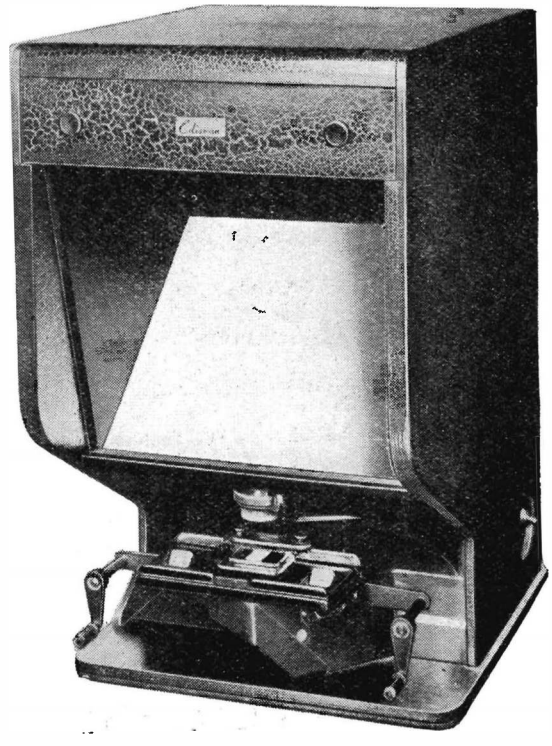

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Electronic Engineering

Vol. XXIII. APRIL 1951 No. 278.

Commentary

CONSIDERABLE disappointment will be felt by a large number of potential viewers with the announcement last week by Mr. C. R. Hobson (Assistant Postmaster General) in the House of Commons that the provision of the five low power Television transmitters has been indefinitely postponed.

It will be recalled that these five transmitters were part of the B.B.C.'s plan for a national television network, details of which were announced by the Postmaster General as far back as November 1949. After the three remaining high power transmitters had been completed at Holme Moss, Kirk O'Shotts and Wenvoe by the middle of 1952, it was intended that five low power transmitters at Newcastle, Southampton, Aberdeen, Belfast and Plymouth would be installed by the end of 1954, so completing the Five-Year Plan by means of which some 80 per cent of the population would be within service.

The main reason given for the postponement is on the grounds of the rearmament programme, although it has been stated that the Postmaster now considers that these transmitters are unnecessary as the range of the high power transmitters is much higher than originally predicted.

We venture to suggest, however, that this statement is in direct contradiction to the information provided by the B.B.C. and published in the recent Beveridge report. The service areas covered by the various transmitters were prepared from actual measurements made on existing transmitters or derived from site tests and a study of the map given in the report (which we reproduced on p. 80 of the March issue of ELECTRONIC ENGINEERING) shows no overlap of the service areas.

Unless the raw materials position is very much worse than we are led to believe it is equally difficult to understand why the rearmament programme should cause this postponement, and to us the action is one of panic. We understand that the transmitters in question are nearing completion and will, in fact, be used at the main sites for testing purposes until the high power transmitters are available so that the saving in raw material must be very small.

Mr. Strauss, the Minister of Supply, in addressing The Radio Industries Club towards the end of last month, emphasized the importance of the part the radio industry would play in the defence programme, and said that where necessary it should sacrifice alternative markets. To us it appears that the Government have already indicated what these sacrifices are to be, for the postponement of the television programme was made, as far as we can gather, without any prior consultation with the industry, and the impression left on the industry is one of disappointment and frustration.

* * *

IT is well over a hundred years ago since Charles Babbage—a mathematician of considerable repute—obtained a grant from the Government of the day to construct a calculating machine or engine to perform simple mathematical sequences. That he was unsuccessful in completing his project was due solely to the limitations of his day. It was not until the 1930's that mechanical devices for computing were developed to any great extent, but the real impetus arrived with the first Electronic Numerical Integrator and Calculator (ENIAC) built by the University of Pennsylvania in 1942. This was the first of the so-called "Electronic brains" and it was followed in this country by the Electronic Delay Storage Automatic Calculator (EDSAC). These machines were digital computers and performed calculations with prodigious speed and accuracy, but an interesting extension of these machines was towards the solution of problems in mathematical logic.

As the authors of the present article say, much of the reasoning in the process of human thought involves merely the elimination of situations which conflict with clearly definable rules, and such problems of elimination can be expressed mathematically and may thus be brought within the scope of digital computers.

Here again the foundations were laid down by another Englishman, G. Boole, who in 1847 produced his "Mathematical Analysis of Logic", but the first apparatus equipped with mechanized reasoning was the Logical Truth Calculator developed by Kalin and Burkhart at Harvard University in 1947.

It should not be imagined that such machines are made purely for the amusement of the designers. The purposes for which these logical computers are required are very real, and the problems they are capable of solving are by no means trivial.

* * *

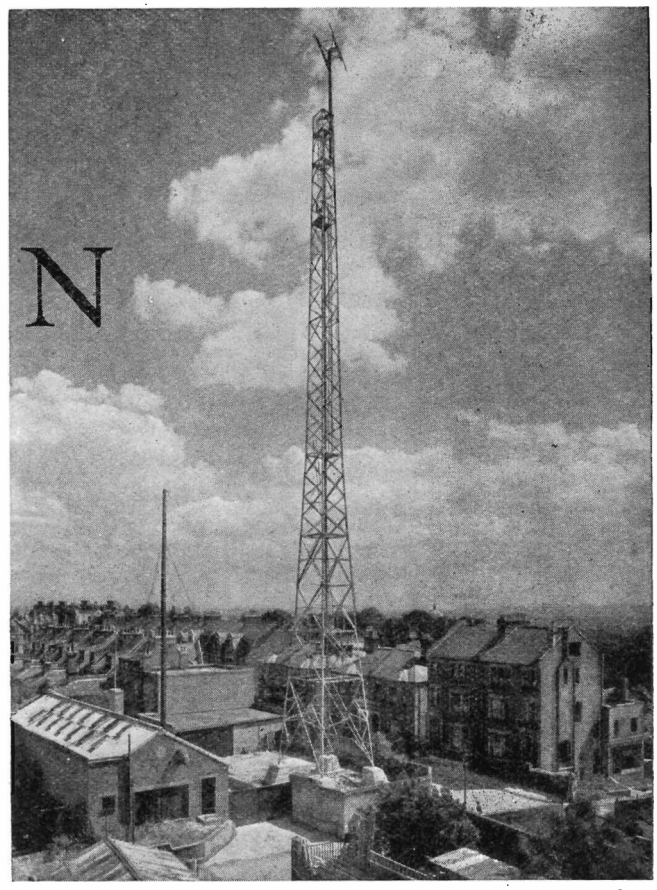
THIS month sees two Exhibitions of importance running concurrently in London. The first is the thirty-fifth annual Exhibition of the Physical Society to be held at Imperial College, South Kensington, from April 6th to April 10th, and the second is the annual Exhibition of The Radio and Electronic Component Manufacturers' Federation at Grosvenor House from April 10th to April 12th.

In this month's issue is included a preview of the R.E.C.M.F. Exhibition, and we hope to give fuller details of both Exhibitions in the May issue.

B·B·C· TELEVISION

Radio and Cable Links for Outside Broadcasts

By T. H. Bridgewater, A.M.I.E.E.*



Courtesy J. L. Eve Construction Co.

EVER since the first television outside broadcast, namely, that of the Derby in 1931, the problem of temporary links to carry television signals from the pick-up point to the main broadcasting centre has exercised communication engineers. The Derby broadcast was, of course, by the 30-line system and the already crude pictures at the sending end were certainly not enhanced by their journey along the hired telephone line between Epsom and London. Since then considerable progress has been made, dating particularly from the inception of the high-definition television service in 1936, and Television Outside Broadcasts have brought some 900 different events to the homes of the public. The purpose of this article is to trace the growth of the principal methods and operational techniques used in the conveyance of vision signals between their point of origin at the venue of an outside broadcast and the main distribution centre at Alexandra Palace.

In the main, the events have all taken place within a 30 mile radius of North London, though latterly it has become possible greatly to exceed this distance—for example, to Birmingham, Nottingham and Calais—by the use of new equipment and techniques now becoming available and already in service on an experimental basis. These new developments, involving, in particular, the use of centimetre-wave radio transmissions, will form the subject of a later article, our present attention being confined to the normal methods which have been used up to now. Space will not permit any detailed reference to the transmission of the accompanying sound, but this is almost invariably passed over ordinary telephone lines irrespective of the method of vision transmission and involves no novel techniques other than those already developed in connexion with the B.B.C's widespread Sound O.B. service.

Birth of the O.B. Service

As soon as the high definition service opened in London in 1936 the potentiality of television for bringing actualities direct into the home soon became evident, and the importance of developing mobile camera equipment and suitable methods of transmission led the B.B.C., the Post Office and the radio industry to give their close attention to this. As a target there was looming ahead the big public event of the Coronation, due in May 1937, and it was decided that by one means or another this would be televised and broadcast to viewers. As will be obvious, the transmission of vision and sound signals from the O.B. site, which in the present instance was to be at Hyde Park Corner, could be done by one of two methods, that is by wire or radio. It was decided to prepare for both. At this point it may be convenient to divide this discussion, not only from the point of view of the Coronation O.B. but of the subsequent service in general, into two main sections, namely, cable links and radio links. It is convenient to deal with the former first.

O.B. Section, B.B.C. Television Service

Cable Links

About 1936 the E.M.I. Company developed a special low-capacitance balanced pair cable which was demonstrated and shown to be capable of transmitting high-definition television signals, with a frequency characteristic substantially flat up to 2½Mc/s, over a distance of some 7 miles, at which point the insertion of a suitable repeater would then permit another similar distance to be covered, and so on. The performance of this cable appeared so promising that it was decided to use it firstly for interconnecting Alexandra Palace and Broadcasting House, and secondly for serving a large number of strategic points in Central, West and South-West London. Repeaters would be needed both at Broadcasting House and Alexandra Palace, the latter for equalizing and amplifying the signals from Broadcasting House and the former for similarly treating signals arriving from O.B. points.

The routeing of this cable was carefully chosen to pass as many potential O.B. locations as possible. For example, one branch passed Marble Arch and Hyde Park Corner and continued westwards along Hyde Park to Olympia and Earls Court; another came from the Strand through Piccadilly, Cambridge Circus, Trafalgar Square, thence to the Whitehall Exchange and on to Broadcasting House via the Gerrard Exchange; another, also coming in to

Whitehall, covered Victoria, the Mall and Buckingham Palace, while a separate extension ran to the Houses of Parliament and Westminster Abbey. Since the war there have been further extensions, such as from Olympia to Riverside Exchange, and Lime Grove to the same exchange.

As far, therefore, as the Coronation was concerned, the main problem became that of installing this cable and its associated equipment in time for the event: this was successfully achieved. After the Coronation this cable proved of great value for transmission of the Cenotaph Ceremony, the Television Studio at Radiolympia, arrivals of celebrities at Victoria Station, West End theatres, etc. To this day the same cable is in regular use, although now supplemented by some other types.

Apart from O.B's it is also used for conveying the vision signals from the Lime Grove Studios to Broadcasting House en route to Alexandra Palace.

During the pre-war years it was soon found, however, that potential O.B's had a way of occurring at locations not coinciding with the cable route. This, of course, had been anticipated and a general solution provided in the form of a mobile radio transmitter, to be discussed in a later part of this article. Some of these locations, however, though not coincident with the cable, might well be quite close to it, varying from a few hundred yards to a few miles. In the more congested parts of London it was often found highly inconvenient to erect a radio aerial and to accommodate all the additional vehicles. It was, therefore, a most welcome development when the B.B.C. showed that it was possible to transmit vision signals over ordinary telephone lines as well as over the special cable already referred to. This represented a revolutionary advance which was to do much to widen the scope of Television O.B's. The principal difference between the two methods was that the simple telephone line required "repeatering" as closer intervals, of the order of one mile instead of seven, but in other respects the quality of signal transmitted by this line was most satisfactory. As will be realized, the Post Office have such a vast network of telephone circuits that one could almost always count on being able to hire a line from the proposed O.B. site to the nearest convenient point of access on the special cable; this might be either some manhole in the street or, more probably, in one of the telephone exchanges through which it passed. The first O.B. to use this new technique, that is, the combination of telephone line and special cable, was in 1938 from the British Movietone News headquarters in Soho Square, W.1. The ordinary telephone line, consisting of 1 pair, 20lbs per mile copper wire, took the signals into the Gerrard Exchange where they joined the balanced cable to Broadcasting House and Alexandra Palace.

This was the beginning of a new and valuable technique which, with further development by the G.P.O. since the war, has done much to widen the field of cable-linked outside broadcasts. A good example was the Boat Race O.B. in 1950, for which temporary telephone lines brought to a central switching point at the Riverside Exchange the video signals from the cameras at three different shore positions, namely, Harrods, Metropolitan Water Board (Hammersmith) and Chiswick Wharf. The method is in regular use and has proved particularly valuable in the Birmingham area where, as yet, no special television cables have been laid other than the main London-Sutton Coldfield circuit forming part of the developing national network linking the B.B.C.'s television centres and transmitters. For example, nearly 5 miles of this cable and three repeaters were used for bringing the signals from the Radio Exhibition at Castle Bromwich to the centre of Birmingham, whence they joined the network and were passed on to Sutton Coldfield and London.

During the post war years the problems of television transmission by cable have been further studied by the G.P.O., particularly in relation to coaxial cables, the development of which for telephone purposes using multiplex carrier systems had become very extensive. This type of cable and the carrier transmission system associated with it were thought to offer equal advantages to television, in particular economy in copper and improved efficiency of transmission.

Thus, when it appeared desirable to extend the special cable service to additional locations now regularly visited by the B.B.C., e.g., the Oval, Lords, Wembley Stadium, the Post Office connected them to Broadcasting House by the coaxial type of cable. Coaxial cables have also been used to increase the number of permanent vision circuits between Alexandra Palace and Broadcasting House, these being necessitated not only by the increase in the number of outside broadcasts but also by the advent of the Lime Grove Studios and the Midlands transmitter.

Fig. 1. Graphs showing typical performances of cable and radio links

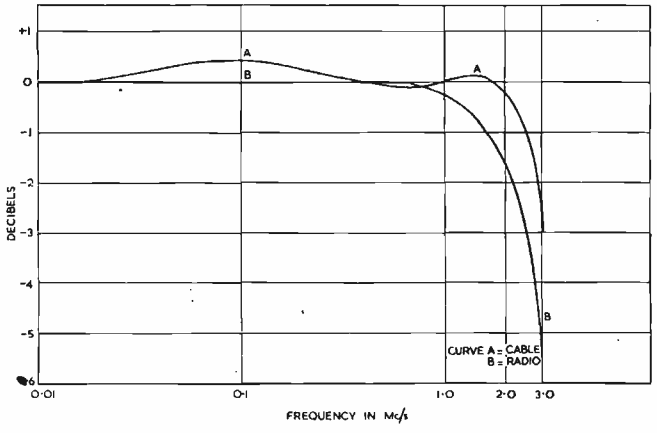
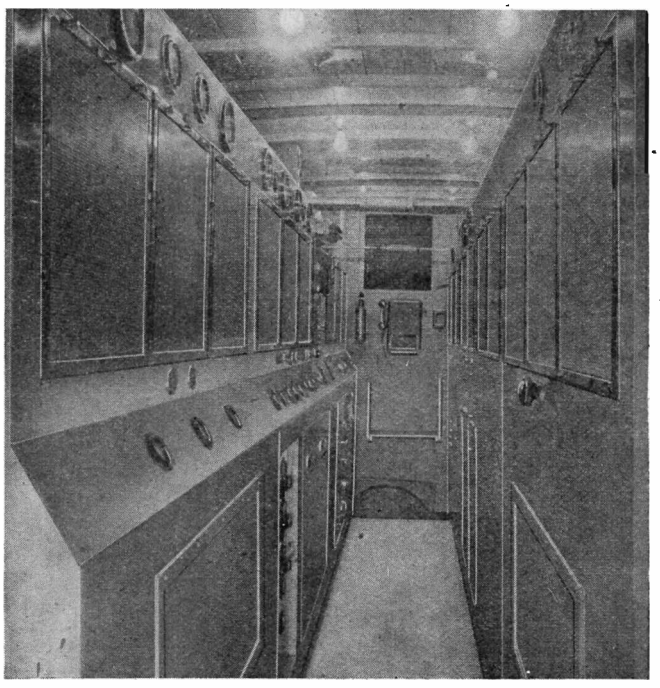


Fig. 2. Mobile Transmitter

Interior of vehicle showing, on the left, R.F. and Modulator Sections and, on right, rectifiers and power supplies.



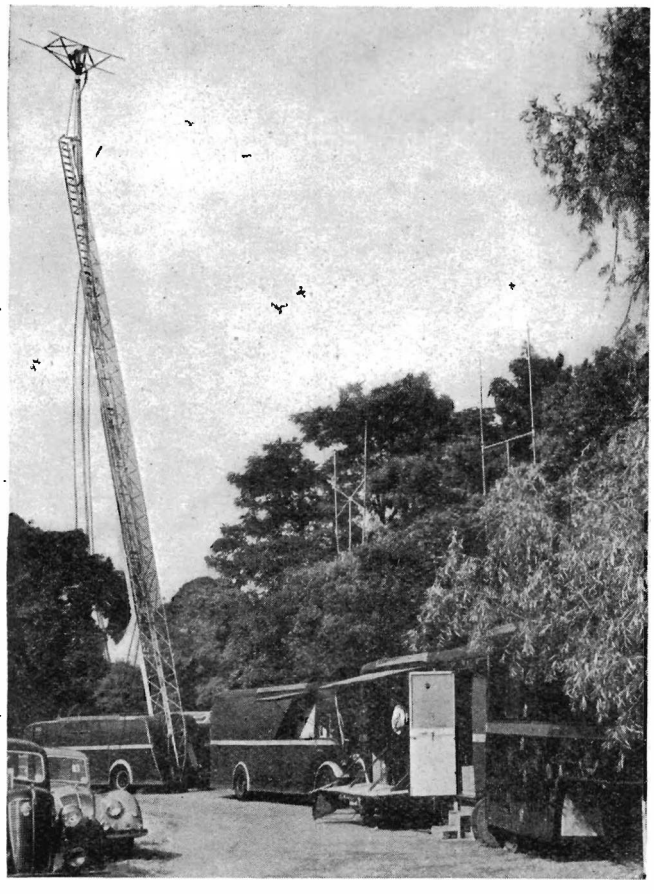
The frequency of the carrier used on the coaxial cable is 6.12Mc/s so that with an asymmetric sideband type of transmission the range of frequencies transmitted lies between 3 and 7Mc/s approximately. It will be appreciated that the system requires the use of a modulator and a demodulator at either end of a circuit, so that when such cable terminates at the O.B. point itself (e.g. Wembley Stadium), it is necessary for the extra equipment —at this end the modulator—to be carried in the O.B. Mobile Control Room, or, as is sometimes the case, in a small Post Office van which will park alongside. The performance of cable circuits used for O.B.'s will vary to some extent according to circumstances, but the graph of Fig. 1 shows the measured characteristic of a typical circuit between the O.B. point and Broadcasting House. The example refers to the O.B. from Hammersmith Palais last Christmas and the circuit included all three types of cable described (see also Fig. 8).

RADIO LINKS

As mentioned earlier, the B.B.C. had by 1937 acquired mobile radio transmitting equipment so that Television O.B's. could roam at will within the transmitter's range and be independent of the necessarily restricted cable routes. The first equipment of this kind was available and installed in Hyde Park for the Coronation O.B. and used as a standby in case of any failure of the then untried cable circuit. Happily no such failure occurred and so this radio equipment did not make its first bow to the public until a few weeks later, when Wimbledon tennis was televised. This equipment consisted essentially of a transmitter, installed in a rather large van (see Fig. 2), and a receiver, the latter being based originally at Alexandra Palace. A receiving aerial (with vertical polarization) was erected at the summit of the main tower. The corresponding transmitting aerial consisted of a directional array suspended between two portable masts. This latter arrangement proved cumbersome, and some time later the B.B.C. acquired an old fire-escape ladder. This proved an eminently satisfactory way of raising the aerial, which was attached to the end of the top section. By this means the aerial could be quickly elevated to a good height—over 80 ft.—without any of the complications caused by the guy ropes of an ordinary mast, the only requirement being sufficient area of ground to stand the vehicle. So effective was this arrangement that the B.B.C. quickly acquired another similar "mast," built by Messrs. Merryweather specially for the purpose (see Fig. 3), while since the war two more of these were ordered and are now coming into service. The use of the original fire-escape had to be discontinued after the war on account of its age. The aerials and their feeders, particularly at the transmitting end, went through successive stages of development up to the outbreak of war; but since the service re-opened a standard design has been in regular use consisting of two half-wave elements, centre fed, with a passive reflector approximately one quarter of a wavelength behind, the whole mounted horizontally. This arrangement gives a polar diagram roughly of the form illustrated in Fig. 4.

Fig. 3. A complete O.B. Unit on "location" at Wimbledon

Left to right, collapsible aerial mast and its vehicle, transmitter, power unit, and (trailer-type vehicle) control room. The H-aerials seen among the trees are for receiving Alexandra Palace for cueing and monitoring purposes.



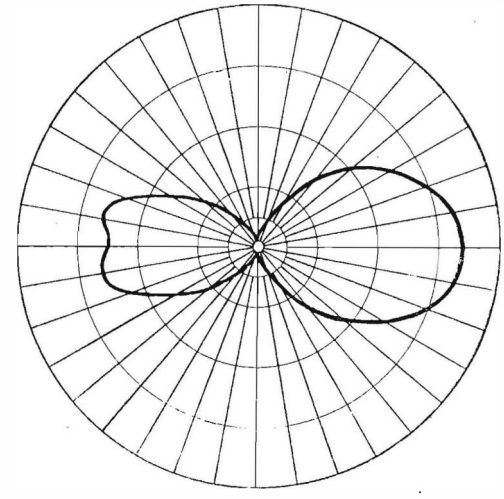


Fig. 4. Approximate horizontal polar diagram of transmitting and receiving aerials used for television O.B. radio links (frequency approx. 65Mc/s)

The directional properties are helpful in increasing power and reducing interference, but, of course, they demand the correct orientation of the aerial at either end of the path according to the bearing of each individual O.B. with respect to the receiving point. This would be done with the aid of map and compass. At either end the aerial is joined to the apparatus by means of a solid dielectric cable which, in the case of the transmitter, requires an internal diameter of $\frac{3}{4}$in. in order to withstand the high voltages applied.

Transmitter

The original transmitter supplied by Messrs. Marconi-E.M.I. delivered a peak carrier of 1kW, requiring a power input of about 18kW 3-phase 50c/s. The design of the R.F. portion followed fairly conventional lines, though the carrier frequency, approximately 65Mc/s, was in those days higher than had been used for broadcasting, or even communications except at much lower power. A Franklin master oscillator was followed by two frequency-doubling stages and five amplifiers, the final amplifier being grid-

modulated by the output of the modulator. The latter delivered a "video" output of some 700 volts. The successive stages of amplification between the input and output of the modulator maintained a frequency characteristic substantially flat to 3Mc/s and followed, in "stream-lined" form, the general principles embodied in the design of the main transmitter at Alexandra Palace. The considerable amount of input power required by this transmitter made it inadvisable to depend on the availability of mains supplies at O.B. locations and the B.B.C. acquired a 25kW petrol-electric generator mounted in a separate van; this could be used as a power supply not only for the transmitter but, if necessary, for the Mobile Control Room. Thus, the first O.B. Fleet consisted of four vehicles; control room, transmitter, aerial and power, (Fig. 3). It will be seen that the use of a radio link involved the addition of at least two and possibly three vehicles to the O.B. "set-up" and this is one of the reasons why, as mentioned earlier, the cable link has been preferred in congested areas. However, the use of radio transmission had many unique applications and in 1938, to meet the demands created by the growing popularity of the O.B. programmes, the B.B.C. bought a second transmitter and second mobile power unit. The new transmitter followed broadly the design of the older one, except for the modulator, the output stage of which incorporated a "distributed" amplifier. These two transmitters have continued in regular service up to the present day and at the time of writing are being used to as great an extent as ever. It is probable that in the next year or so they will be replaced by transmitters of shorter wavelength and much more compact design, but meanwhile, and certainly throughout this coming summer, they will be in considerable demand.

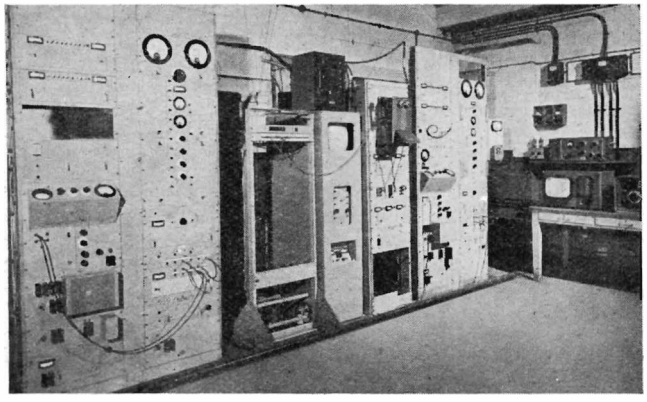


Fig. 5. The O.B. radio receiving station at Highgate

The duplicate receivers are seen, each occupying two bays at opposite ends of the row. Other equipment includes vision monitors, signal generator, field-strength measuring set. The small bracket on the right of the far receiver holds the remote control buttons for the aerial turning, and the bearing indicator.

Receiver

The original receiver for use with the radio vision link was of the superheterodyne type, but embodied many special features, including a complex filter network between the feeder and input in order to reject the powerful local field from the main transmitters operating on 45 and 41.5Mc/s. The frequency conversion was carried out in the first stage and then followed by ten stages of I.F. After demodulation the black level was "clamped" and a video amplifier supplied an output signal of some 10 volts. Later a second receiver of the tuned R.F. type was supplied. The performance of each was similar and, with one standing-by for the other, they, like the transmitters, are still in regular service, (Fig. 5).

Radio Reception Point

Although the radio reception point was originally at Alexandra Palace it soon became evident that this arrangement was not entirely satisfactory. Curious "splashes" of intermittent interference frequently appeared during the reception of O.B's. and these, although they conformed with no recognizable pattern, were found to be associated with the operation of the main vision and sound transmitters whose aerials, of course, shared the same mast. The interference was spasmodic and sometimes absent altogether; it seemed to depend on weather conditions and could usually be expected on occasions of high wind. This led to the theory that currents induced from the main transmitters were being rectified by the varying contact potentials between the steel members of the mast, as their joints strained under the wind force, thus giving rise to fitful bursts of re-radiation which were picked up by the O.B. receiving aerial. Whatever might have been the precise explanation there seemed no ready cure available and so it was decided to re-site the receiver at Highgate Village, situated on rather higher ground some two miles to the south-west of Alexandra Palace. Suitable premises were found and acquired and a 150ft. tower erected to support the aerial. This original tower, of wood, was unfortunately blown down during the war, but has since been replaced by one of steel. The buildings and the 150ft. steel mast are shown in the photograph on page 120. The aerial system (two half-wave elements and reflector) is mounted on a spar which can be rotated by remote control. As mentioned earlier, the aerial would need swivelling to the appropriate bearing to suit each O.B. A man had to ascend the tower for this purpose, but since the war an electrically driven rotating gear, remotely controlled from the receiver room, has been provided. This incorporates Selsyn motors to enable the bearing of the aerial to be indicated continually. The signals from the receiver were passed on to Alexandra Palace by means of the special balanced cable from Broadcasting House which fortunately passed through Highgate on its way and could therefore be readily intercepted.

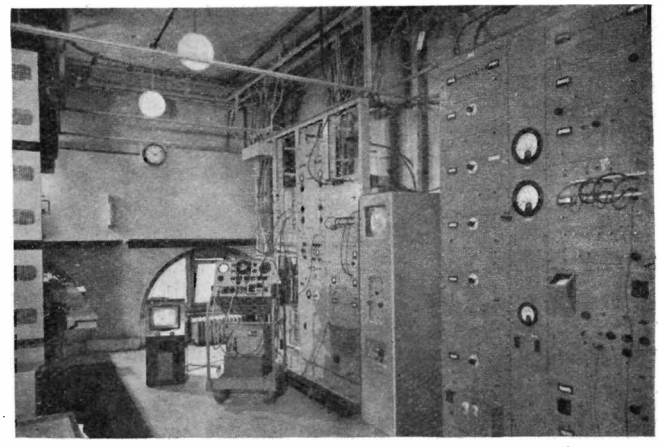


Fig. 6. The Lines Termination Room at Alexandra Palace

(a) The equalizer-amplifier equipment used in conjunction with the wide-band balanced-pair cable occupies the two bays on the extreme right. Other equipment on that side includes waveform and picture monitors, signal generators and distribution amplifiers. On the left (just in picture) are the modulators and de-modulators associated with the outgoing and incoming coaxial cables.

The performance of the radio vision link for O.B's. has varied according to the direction and distance from the receiving point. In most directions the land around Highgate falls away rapidly, but to the west some higher land at Hampstead intrudes and propagation is weakened accordingly. Generally speaking, however, ranges of

Fig. 7. The Central Control Room at Alexandra Palace

Signals from all programme sources are assembled and selected here. The Sound and Vision control panels are in the front row, left and right respectively. Standing on the vision control desk is a high-grade waveform-monitor. Staff in the back row are, left to right, Continuity Secretary, Presentation Assistant and Senior Engineer.

15-20 miles can usually be obtained in almost any direction, while on favourable bearings and at reasonably well elevated transmitting points the range can be increased to between 25 and 30 miles. For example, very fair signals are obtainable from Ascot Race Course some 26 miles from Highgate. As far as the frequency response is concerned the overall performance is typified by the graph of Fig. 1 which includes the complete chain between the input to the O.B. transmitter and the input of the main transmitter at Alexandra Palace. It will be seen that very little distortion is introduced.

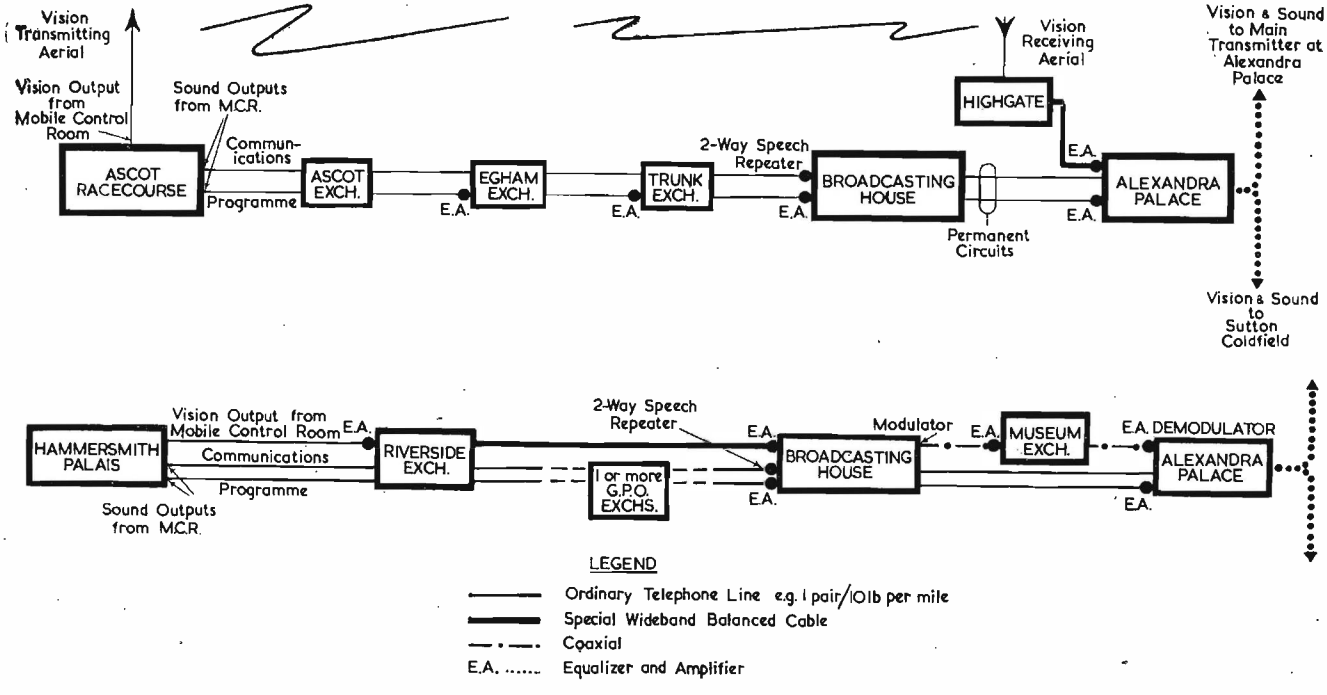
Arrangements at Alexandra Palace

The internal arrangement at Alexandra Palace for the acceptance and retransmission of outside broadcast signals may now be briefly reviewed. It will have been seen that, irrespective of whether the main vision link has employed radio or cable, the final signal will enter Alexandra Palace on the cable, that is from Highgate or Broadcasting House respectively. This cable is brought into the Lines Termination Room, a centralized point for all incoming and outgoing lines, both vision and sound, and their associated equalizing and amplifying equipment, (Fig. 6). Here the signals are monitored and tested. In this room at the same time there may well be passing through signals incoming from Lime Grove and outgoing to Sutton Coldfield. Before the broadcast is due to begin the O.B. vision signals are passed on from the Lines Termination Room to the final distributing centre in Alexandra Palace, known as the Central Control Room. This is where all incoming programme sources, both vision and sound, are finally selected and switched directly to the main transmitter. It is possible to accept up to five vision sources and it is not unusual to have this number incoming and awaiting transmission in turn, e.g. Lime Grove, Studios A and B (both these at Alexandra Palace), Telecine and an O.B. Two vision screens are provided, one to show whichever picture is being broadcast, the other for previewing at will any of the waiting sources. If the O.B. is the source next due to go on the air then it will be customary to monitor it on the preview screen so that one can be sure of its readiness as soon as required and also watch for any technical defects. This Central Control Room acts as a focal point in the handling and control of incoming programmes, and senior Engineering and Programme personnel are there to supervise. In the case of an O.B., telephone communication on a private line would be available for the purposes of engineering control and programme arrangements (see Fig. 8).

The O.B. End

At the distant end the O.B. signals originating in the Mobile Control Room will be connected by flexible cable to the input of the vision link. When the latter is by radio this cable can, if necessary, be several thousand feet in length. This is convenient when, as often occurs, it is desired to park the Transmitter some distance from the Control Room in order either to secure a situation better for propagation or to avoid congestion of vehicles close

Fig. 8. Schematics of typical O.B. links. (a) Vision by radio, sound by cable. (b) Vision by cable, sound by cable



to the event. It carries a video signal of 1 volt to the radio transmitter. In the case of a cable link it will be usual for the Post Office to have made a temporary extension to terminals conveniently close to the control point.

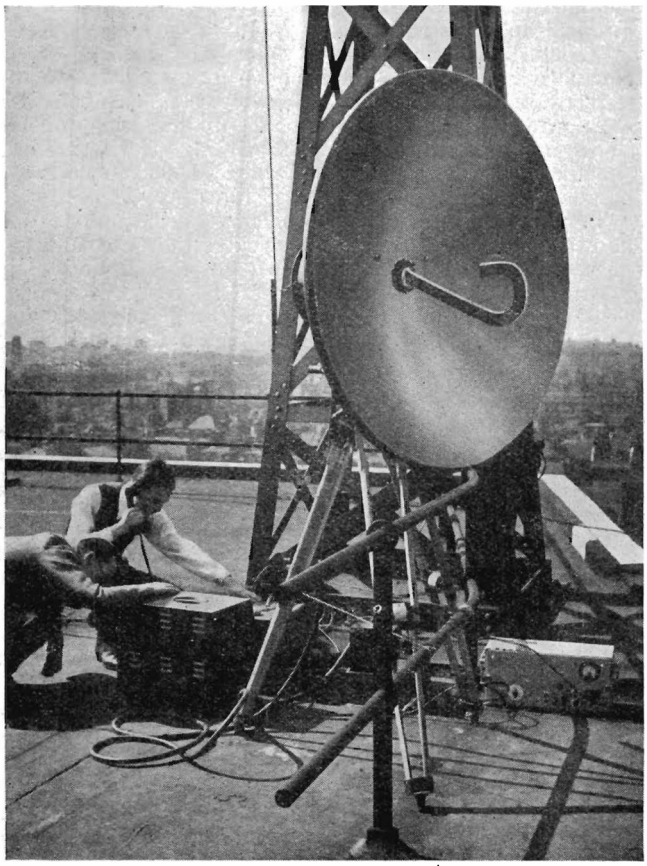
The block schematics in Fig. 8 show the routeing of vision, sound and communications circuits for two typical outside broadcasts.

Advance Planning

In order that O.B's. can be carried out efficiently it is usually necessary to make careful preparations in advance. For cable-linked O.B's. the Post Office must be notified of requirements, including the precise point where the Mobile Control Room will be located, it then being left to the Post Office to work out their own proposals as to the types of cable and routes to be adopted in order to convey the signals to Broadcasting House for onward transmission by the permanent circuit to Alexandra Palace. The Post Office may have to arrange for portable repeater equipment at appropriate points and in all cases will ensure the necessary setting-up of circuits with staff standing by at the appropriate times, the B.B.C. being responsible for operating the equipment at Broadcasting House and, of course, at Alexandra Palace. In addition to providing a through circuit for the period of the O.B. it is usual to conduct preliminary tests some hours beforehand, while in the case of new and untried routes the performance may well be proved some weeks in advance—indeed, the decision on the possibility or otherwise of carrying out a particular broadcast may well depend on the outcome of these circuit tests.

Fig. 9. One of the new portable radio links, using a centimetric wavelength and a very narrow beam

(Equipment supplied by Marconi's Wireless Telegraph Co., Ltd.)



Whereas an O.B. by cable throws a greater burden of responsibility on to the Post Office, a radio O.B. will be entirely in the hands of the B.B.C., whose O.B. Department are responsible for selection of site and for all preliminary testing, in co-operation with the receiving end, which is operated and supervised from Alexandra Palace. It is not always possible to predict the efficiency of a radio path, and before acceptance of a proposed programme involving radio from a hitherto untried location it is common practice to send out the mobile transmitter and aerial some weeks in advance to establish the circuit. Such tests will confirm not only the signal level at the receiver but also the presence of unwanted reflexions. If the transmitter or receiver is close to tall obstructions, such as towers, gasholders, radio masts, etc., it is not uncommon for a second image to appear beside the main one as a result of multi-path transmission due to reflexions. In such cases improvements or a cure may sometimes be made by re-orientating the aerials with the hope of reducing the relative power radiated in the direction of the reflecting obstruction.

It is the responsibility of the B.B.C's Outside Broadcast Department, from its headquarters at the Palace of Arts, Wembley, to deal with these advance preparations as well as with the operation and maintenance of the equipment. Other details associated with the vision link and which usually need catering for in advance, include, for a radio-linked O.B., the power supply for the transmitter (when this can be derived from the mains), parking positions and permissions for the vehicles, and the laying and routeing of cables from the Mobile Control Room.

Future Developments

As mentioned earlier, we are now on the threshhold of developments which will greatly extend the scope of television outside broadcasts. The main developments are (a) the G.P.O's national vision network, consisting of the cable and radio circuits linking London, Birmingham, Bristol, Manchester and beyond, and (b) the use of compact portable transmitters and receivers on metric or centimetric wavelengths, facilitating long distance connexion by means of "multi-hop," or tandem, working. An instance of this was the relay from Calais when four, and on the second occasion five, separate links formed the chain to London. The national network has already reached Birmingham and, although primarily laid down by the Post Office to distribute vision to the provincial transmitting stations, will have a duplicate channel for sending signals in the reverse direction. The combination of these permanent "main lines" with temporary branch circuits (which could consist either of radio links of the kind just referred to or of telephone lines for short distances) opens the way to television O.B. coverage of a very large part of the British Isles. Already programmes from Nottingham, Leicester and Birmingham have been successfully transmitted by these microwave links (Fig. 9).

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MECHANIZED REASONING

Logical Computors and Their Design

By D. M. McCallum, B.Sc., A.M.I.E.E. and J. B. Smith, M.A., B.Sc., A.M.I.E.E., A.Inst.P.*

THE prominent part played by intuition and flashes of inspiration in the process of human thought obscures the fact that much reasoning involves merely the elimination of situations which conflict with clearly definable rules.

Such problems of elimination may be expressed mathematically and may thus be brought within the scope of modern high-speed digital computors. These computors are however generally designed to deal with great precision with numerical problems; on this account they tend to be large and complex. It is not generally realized that the logical problems involved are essentially very simple and may therefore be solved by relatively simple mechanical means.

The present article describes a "slow-motion" demonstration model built from a small number of readily obtainable components, but nevertheless able to solve logical problems which are not entirely trivial. There are in the internal circuits of the instrument only 17 relays and one stepping switch. Compared with the human brain with its 10^{10} cells the "level of intelligence" of the machine is thus extremely low, and the remarkable results obtained from it are due to the extremely specialized function of the elements and their connective units. Some indications are given later in the article of possible developments which lead to more sophisticated structures of greater "intelligence" and correspondingly greater economy of design.

Symbolic Logic

A mathematical treatment of logic has been described by Boole[1] and other writers. The method of treatment employs ideas such as the following: suppose A is a concept which is either true or not true. We denote A and "not A" by A, $\not A$ respectively. Then if B is another concept, various multiple concepts may be defined, for example:—

A and B	representing the combination AB
A or B	representing the combinations AB, A$\not B$, $\not A$B.
A or else B	representing the combinations A$\not B$, $\not A$B.
A if and only if B	representing the combinations AB, $\not A\not B$.
If A, then B and so on.	representing the combinations AB, $\not A$B, $\not A\not B$.

As an example of the use of such symbols the following regulation may be considered. "Only members or their guests may play over the Blankshire Golf Club's course." This is evidently equivalent to

A if and only if (B or C).

where

A denotes eligibility to play over the course.
B denotes membership of the club.
C denotes the status of member's guest.

Now this multiple concept, by the above definitions, represents the combination AD, $\not A$D, where D is "B or C". Also by the above definitions, D represents the combinations BC, B$\not C$, $\not B$C, and hence $\not D$ represents the remaining combination $\not B\not C$. Combining the two results, the multiple concept represents ABC, AB$\not C$, A$\not B$C, $\not A\not B\not C$. Hence the classes of persons consistent with the regulation are as follows:

(i) ABC. Eligible persons who are both members and members' guests.
(ii) AB$\not C$. Eligible persons who are members.
(iii) A$\not B$C. Eligible persons who are members' guests.
(iv) $\not A\not B\not C$. Non-eligible persons who are neither members nor guests.

Any other combination must involve a logical contradiction, e.g., $\not A$B$\not C$. Members not eligible to play over the course, and so on.

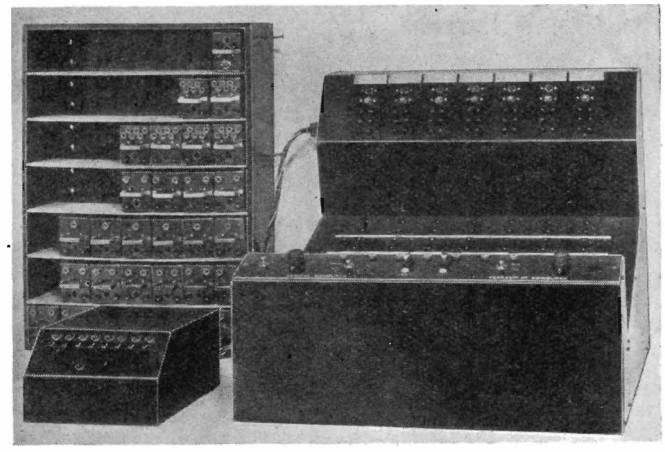
Application of Systematic Logical Method

A logical problem may in general be solved by techniques similar to the above provided that it is capable of being reduced to a form which consists of one or more "rules" (the regulation in the above example) connecting a number of "variables" (which have only two possible states, as A, B, C in the example) by standard logical relations. The number of possible relations is not large; the definition of those which shall be regarded as "standard" is a matter of convenience; three are sufficient (e.g. "not," "and," "or") while the use of more than about eight tends to be confusing. The reduction of the problem to the desired form is not always easy, but is in general much less difficult than solving the problem completely. Once the problem has been reduced to the standard form, it may be "solved" by a machine. The solution will in general consist of the finding of all possible "answers," that is to say, combinations of the variables which are consistent with *all* the rules. The example above has one rule, three variables and four answers.

A machine dealing with problems of this nature and known as the Kalin-Burkhart Logical Truth Calculator has been constructed,[2] but is known to the authors only by name.

Fig. 1. General view of the Logical Computor

The main computor is on the right, while on the left is the rack with the connective boxes. In front of the rack is the counting unit



* Ferranti, Ltd., Edinburgh.

The Ferranti Logical Computor

The computor has been built from war surplus relays and components which were readily available. No attempt has been made to produce a highly refined circuit, and improvements may be apparent to the reader.

The general appearance of the machine is apparent from Fig. 1, in which there will be seen seven pairs of signal lamps at the top of the rear panel of the computor; each pair represents one of the variables. The upper lamp of each pair is green in colour and lights when the variable is in the "affirmative" state; the lower (red) lamp indicates the "negative" state. These lamps permit of the reading of the combination of the variables which is being dealt with at any instant; for example, if the lamps show the sequence (reading from left to right) red-red-green-green-red-green-red, then the combination set up in the machine, using the previous notation, is $\bar{A}BCDE\bar{F}\bar{G}$.

When the first variable is in the state A the six paralleled output sockets beneath the indicating lamps for that variable are "live" (this term will be used throughout to denote direct connexion to the +24 volt supply) and when it is in the state $\bar{A}$ the sockets are connected to earth, and similarly with B, C, D, E, F and G. When the machine runs through a problem, every combination of the seven variables is set up in a prearranged sequence. There are 128 such combinations.

The middle area of the machine is for the insertion of the rule boxes required for the particular problem. These boxes may be seen in the rack on the left of Fig. 1; a number of them are shown plugged into the computor in Fig. 7. Each box contains a Siemens high speed relay and picks up the supply voltage from a pair of sockets into which it is plugged. These rule or connective boxes are all so designed that when the variables connected to the input terminals satisfy a certain logical relation, a green signal lamp on the box lights and the relay makes the output terminals of the box live; when, on the other hand, the required relation is not satisfied, the output terminals are earthed and the lamp does not light. The six types of connective box used on the machine are NOT, AND, OR, OR ELSE, IF AND ONLY IF, IF THEN.

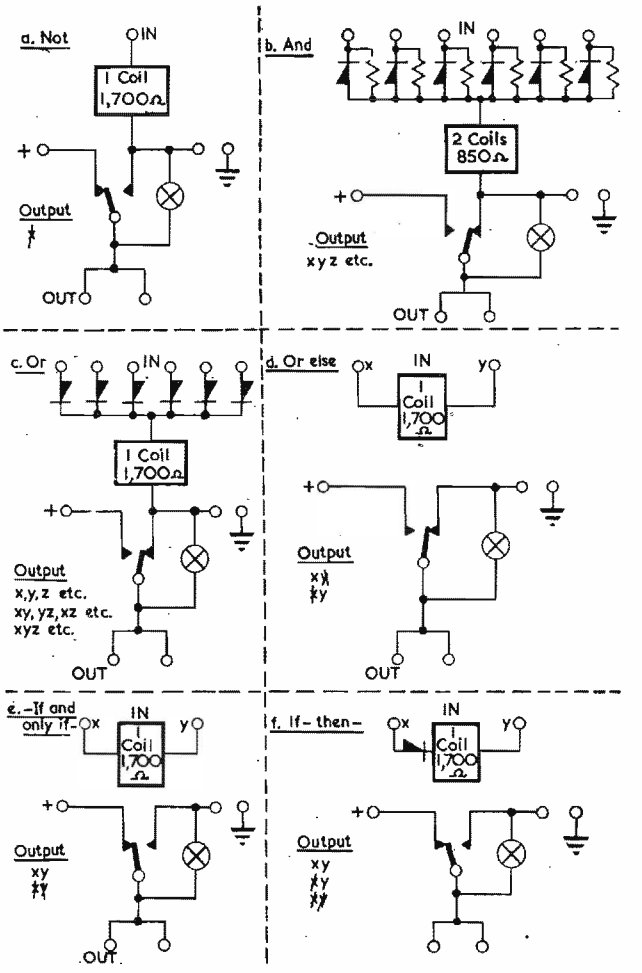


Fig. 2. Connective boxes for the Logical Computor

Connective Boxes

The operation of these boxes is described by denoting the inputs to them as x, y, z, where each of these letters may denote any one of the variables A, B, C, D, E, F, G, or may denote the output of a preceding box. In every case x will denote the variable in its affirmative state and will thus correspond to a live lead; $\bar{x}$ will conversely correspond to an earthed lead.

Reference should be made to the diagrams of Fig. 2 for details of the circuits used to perform the functions indicated below.

(a) NOT This box has a single input. If this input is earthed (i.e. in the negative state), the condition NOT is *satisfied* and the relay makes the output sockets *live* and lights the green lamp on the box. Conversely, if the input is live, the condition NOT is *unsatisfied* and the relay connects the output sockets to *earth* and extinguishes the lamp.

This may be expressed briefly by saying that this condition is satisfied by $\bar{x}$.

(b) AND This box may have any number of inputs up to six. The condition to be satisfied is that *all* inputs must be in the affirmative state; if there are three inputs, the condition is satisfied by xyz only.

This is brought about by the circuit shown, the inputs being connected through selenium rectifiers shunted by 1.5kΩ resistors; the cathodes of the rectifiers are connected to the input terminals. When any input is earthed, the resistance to earth in parallel with the relay is so low that even if all the others are live they are unable to develop sufficient voltage across the relay to operate it. Input sockets not required need not be connected.

(c) OR This box may also have any number of inputs up to six and the required condition is that at least one input must be in the affirmative state. Here the anodes of the rectifiers are connected to the input terminals and any one live input generates a sufficiently large potential difference across the relay to operate it. With three inputs the condition is satisfied by any one of xyz, $xy\bar{z}$, $x\bar{y}z$, $\bar{x}yz$, $x\bar{y}\bar{z}$, $\bar{x}y\bar{z}$, $\bar{x}\bar{y}z$.

(d) OR ELSE This box has two inputs and the condition is that they shall be in opposite states. The relay operates and makes the output live when one or other of the inputs is live and the other earthed. To operate this box both input terminals must be connected. The condition is satisfied by $x\bar{y}$ or $\bar{x}y$.

(e) IF AND ONLY IF This box has two inputs and requires for satisfaction of the condition that both inputs shall be in the same state (i.e. both affirmative or both negative). The relay bobbin is connected between the input terminals as in the OR ELSE box, but the output is live when the relay is not operated i.e. when the inputs are either both live or both earthed. The condition is satisfied by xy or $\bar{x}\bar{y}$.

(f) IF—THEN This box has two inputs which correspond to the relation "if x, then y"; it is to be noted that this differs from "if y, then x" so that the order of the input sockets is important. The condition is satisfied by xy, $\bar{x}$y, $\bar{x}\bar{y}$ but not by x$\bar{y}$. The circuit is similar to that for "IF AND ONLY IF" with an additional rectifier which prevents the relay from operating when the inputs are of the form $\bar{x}$y.

CONTROL PANEL

The front section of the machine carries the controlling switches and the lamps which indicate in what state the machine is. There are three such states.—

(1) RESET This is the condition of the computor when ready to start scanning. When switched on, the machine rapidly sets itself in this condition. At any time on pressing the RESET button the machine will return to this condition as it also does on completing a scanning cycle of the 128 combinations.

(2) SCANNING When a problem has been set up the machine is started searching for an answer by pressing the THINK button. If the AUTO-MANUAL switch is at AUTO the machine scans the combinations under the control of the self-oscillating timing relay.

(3) ANSWER On reaching an answer the machine stops; the answer may be read from the lamps showing the states of the variables. After the answer has been noted the machine is started scanning again by pressing the THINK button.

To operate the answer mechanism the outputs of the rules in use are plugged into the sockets at the front of the machine. These go to an AND box which operates the answer relay and lights two large signal lamps when a combination of variables consistent with the rules is found. The machine may also be made to find combinations inconsistent with the rules by switching the CON-INCON switch to INCON. This converts the final AND box into a NOT AND box.

MECHANISM OF COMPUTOR

The arrangement for setting the 128 combinations of the 7 variables consists of 7 relays, one for each variable, a uniselector which opens and closes them in a pre-arranged sequence, and auxiliary relays. The sequence in which the variables are altered is that known as binary cyclic permuting code in which only one change is made from one combination to the next. For the first four variables a complete sequence is :—

Combination	*Changes*	*Combination*	*Changes*
ABCD	mA	AB$\bar{C}\bar{D}$	mA
$\bar{A}$BCD	mB	$\bar{A}$B$\bar{C}\bar{D}$	mB
$\bar{A}\bar{B}$CD	bA	$\bar{A}\bar{B}\bar{C}\bar{D}$	bA
A$\bar{B}$CD	mC	A$\bar{B}\bar{C}\bar{D}$	bC
A$\bar{B}\bar{C}$D	mA	A$\bar{B}$CD	mA
$\bar{A}\bar{B}\bar{C}$D	bB	$\bar{A}\bar{B}$CD	bB
$\bar{A}$B$\bar{C}$D	bA	$\bar{A}$BCD	bA
AB$\bar{C}$D	mD	ABCD	bD

(mA denotes "A relay makes," bC denotes "C relay breaks" etc.)

and this may readily be extended to seven digits. Using this arrangement the seven relays are operated or released on the pattern shown in the change column of the table. The circuit shown in Fig. 4 is used for the relays. When a relay is to be made the "m" line is earthed and when it is to be released the "b" line is earthed.

A four bank uniselector is used with 50 contacts on each bank. This gives 200 positions of which only 32 on each bank are used for changing the variable relays. The uniselector is stepped round by a timing relay circuit at about 3 steps per second. After 32 contacts on a bank have been used it steps rapidly over the remaining 18 changing the α or β relays (Fig. 4) which switch the circuit through the four banks in sequence.

The complete circuit for the computor is shown in Fig. 4. The other relays perform functions connected with starting, finding an answer and resetting.

COUNTING UNIT

As an additional facility a box is provided to count the number of the seven variables which are in the states A, B, etc. (i.e., having outputs live, as opposed to $\bar{A}$, $\bar{B}$, etc. which have outputs earthed). This is done by a digital method using relay switches to transfer the input from one line to the next (Fig. 3). The box can be seen in Figs. 1 and 7 next to the main computor; it has a row of 8 lamps numbered 0 to 7, and lights the lamp corresponding to the number to be indicated. Each lamp has a push-button which when depressed makes the output socket of the box live whenever the lamp lights; one or more of these

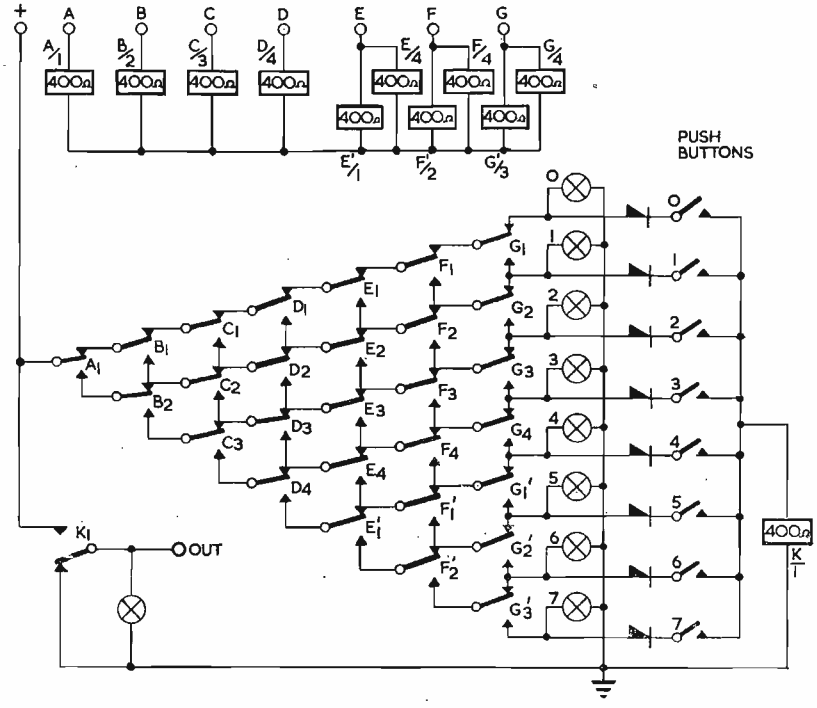


Fig. 3. Digital Relay Counter

buttons may be depressed at any time. This enables the box to be used to impose a numerical condition which may be plugged into the output stage of the main computor in addition to the other rules. This use is illustrated in Problem II of the examples which follow.

Examples of the Use of the Computor

Problem I

Find the classes of persons conforming to the rule: Only members or their guests may play over the Blankshire Golf Club's course.

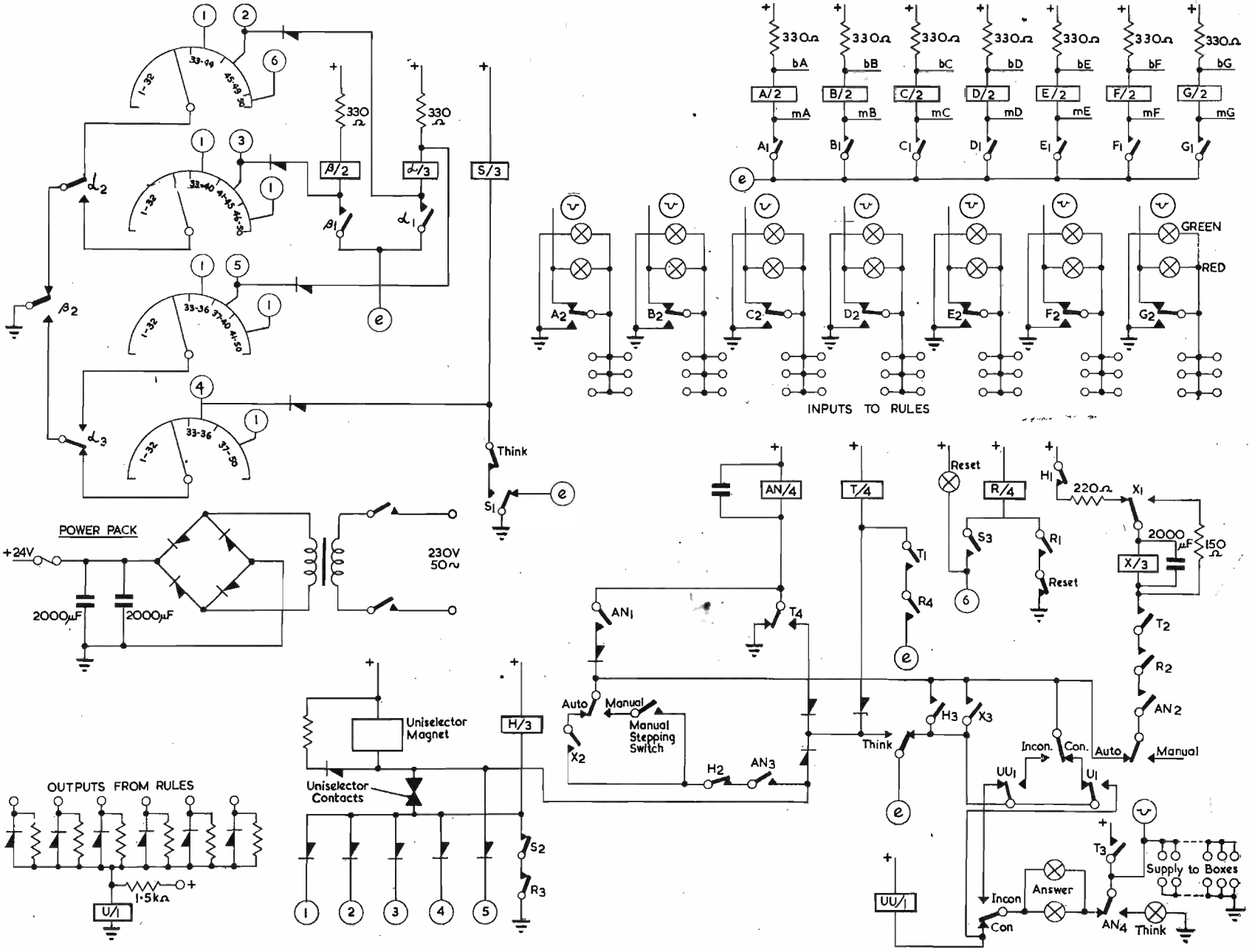


Fig. 4. General Circuit Diagram of the Logical Computor

This problem was explained earlier. The connexions required to set it up in the machine are shown in Fig. 5 and the machine will find the four solutions in succession.

Problem II

I am going to University and have to choose what subjects I will do in my final year at school. The subjects I can choose are Maths, History, Science, English, Latin, German and French.

English is compulsory and I may choose up to five other subjects. If I take Science I must take Maths. If I take Latin then I cannot take German as the timetable clashes. I do not want to take History. For entrance to the course at the University I need to have Science and French. How many ways may I choose the subjects?

The connexions required to set this problem up are shown in Fig. 6(a). There are only two solutions.

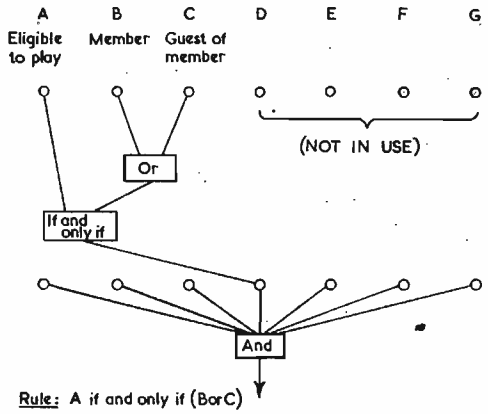


Fig. 5. (Above). Setting up problem with a single rule

Fig. 6. (Right) (a)

Rules (i) Not History.
(ii) If Science, then Maths.
(iii) If Latin, then not German.
(iv) Science and French.
(v) 5 or 6 subjects.
(vi) English.

(b) See text for explanation of rules

Problem III

It is known that salesmen always tell the truth and engineers always tell lies.

B and E are salesmen. C states that D is an engineer. A declares that B affirms that C asserts that D says that E insists that F denies that G is a salesman.

If A is an engineer, how many engineers are there?

This problem is set up by taking A and $\not A$ to represent "A is an engineer" and "A is a salesman (i.e. not an engineer)" respectively, and similarly for the other variables. The connexions then required are shown in Fig. 6(b). It is not immediately obvious how these are deduced from the problem. The basic guide is that if "A states X," this is equivalent to "A is an engineer *or else* X is true"; repeated application of this formula is *all* that is necessary for setting up the two rather involved rules. It is to be noted, therefore, that the operator does not have to grasp the implications of either of these rules *as a whole*, so that the difficulty of setting up the machine is very much less than the difficulty of solving the problem without the machine.

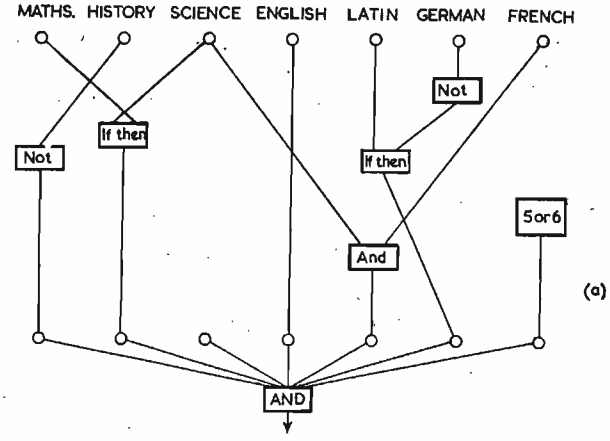
There are four solutions (AB$\not C$DF$\not E$G, AB$\not C$DE$\not F\not G$, A$\not B$CDF$\not E$G, A$\not B$CDE$\not F\not G$), and inspection shows that in every case the number of engineers is three.

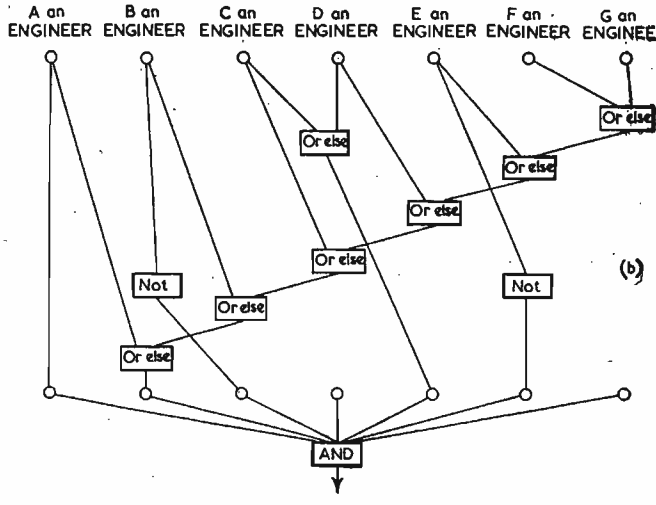
The appearance of the computor with a problem set up is shown in Fig. 7.

Possible Extension of a Computor of this Type

The reader who has followed thus far may be inclined to question the usefulness of a computor of this type. The demonstration model described is of course severely limited in scope, but it is possible to envisage elaborations of it which would greatly increase its usefulness without adding to its complexity. These will be considered under three headings

(i) Use of the present Computor as control mechanism for a numerical calculating machine.
(ii) Design of a Computor on the same principles as the present one, but of greater capacity.
(iii) Design of a Computor on the same principles as the present one and of greater capacity, but incorporating more advanced ideas in order to reduce greatly the solution time for problems of a certain class.





A Logical Computor as Control Mechanism for Numerical Calculations

This use may best be described by means of an example of the type of problem which may be attacked:

What is the probability of throwing at least two heads when tossing four coins, of which two are normal, and two biased, one in such a way as to throw tails twice as often as heads and the other in such a way as to throw tails nine time out of ten?

This problem is mathematically equivalent to obtaining from the expansion of $(\frac{1}{2}H + \frac{1}{2}T)^2$ $(\frac{1}{3}H + \frac{2}{3}T)$ $(1/10H + 9/10T)$ the sum of the numerical coefficients

of all terms for which the index of H is equal to or greater than 2. There are therefore two distinct steps in obtaining the result, namely, selection of terms and operation upon the coefficients of selected terms. A Logical Computor is ideally suited to perform the first step and may therefore be used to control a numerical computor performing the second.

The selection process is done thus: suppose that each coin is represented by a "variable" of the Logical Computor so that A, B, C, D represent "heads" and Ⱥ, Ɓ, Ȼ, Ð, "tails." Then the condition requiring two or more heads is evidently represented by the single rule:

-(A and B) or (A and C) or (A and D) or (B and C) or (B and D) or (C and D) which may be set up directly in a manner analogous to that described for previous problems, and will cause the instrument to signal an "answer" whenever a combination is set up which includes two or more "heads".

If now the Logical Computor performs its usual routine of scanning sequentially the possible combinations (sixteen in all) of "heads" and "tails", it is obviously a simple matter to arrange that for each combination set up, four and only four factors are fed into a multiplier, these factors being as follows:—

First factor	$\frac{1}{2}$	if	the	combination	contains	A
	$\frac{1}{2}$	,,	,,	,,	,,	Ⱥ
Second factor	$\frac{1}{2}$	,,	,,	,,	,,	B
	$\frac{1}{2}$	,,	,,	,,	,,	Ɓ
Third factor	$\frac{1}{3}$	,,	,,	,,	,,	C
	$\frac{2}{3}$	,,	,,	,,	,,	Ȼ
Fourth factor	$\frac{1}{10}$	,,	,,	,,	,,	D
	$\frac{9}{10}$	,,	,,	,,	,,	Ð

The relation of these factors to the problem will be evident; to solve the problem it is only necessary to run through the sixteen combinations and to add the outputs given by the multiplier for *all combinations indicated by the Logical Computor to be "answers,"* and for no others. The routine therefore proceeds thus:

Combination set up by Logical Computor	Factors fed into Multiplier	Product	Conditional Control (Arrow denotes answer)	Running Total
	1 1 1 1	1		1
ABCD	— . — . — . —	——	——→	——
	2 2 3 10	120		120
ⱭBCD	1 . 1 . 1 . 1*	1	——→	2
ⱭɃCD	1 . 1 . 1 . 1	1	——→	3
AɃCD	1 . 1 . 1 . 1	1	——→	4
AɃȻD	1 . 1 . 2 . 1	2	——→	6
ⱭɃȻD	1 . 1 . 2 . 1	2		
ⱭBȻD	1 . 1 . 2 . 1	2	——→	8
ABȻD	1 . 1 . 2 . 1	2	——→	10
ABȻÐ	1 . 1 . 2 . 9	18	——→	28
ⱭBȻÐ	1 . 1 . 2 . 9	18		
ⱭɃȻÐ	1 . 1 . 2 . 9	18		
AɃȻÐ	1 . 1 . 2 . 9	18		
AɃCÐ	1 . 1 . 1 . 9	9	——→	37
ⱭBCÐ	1 . 1 . 1 . 9	9		
ⱭɃCÐ	1 . 1 . 1 . 9	9	——→	46
ABCÐ	1 . 1 . 1 . 9	9	——→	55

(* Denominators of all fractions remain constant and are omitted from this point onwards)

The required probability is thus 55/120. Although the description appears complex, the design of the numerical computor is not difficult, and the authors have been able to design a simple relay computor (using about 20 relays only) which could be controlled by the Logical Computor described and which would perform the above calculation with probabilities chosen from the discrete values 0, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, $\frac{7}{8}$, 1, for any number of variables up to seven, displaying the final result as an exact vulgar fraction.

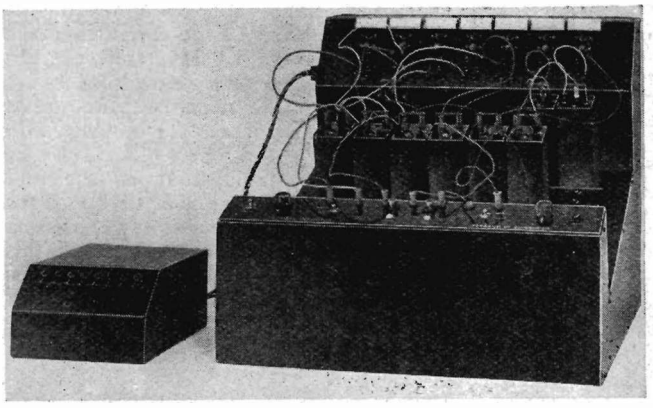


Fig. 7. View of Computor set up for Problem III

Leads come from the variables to the connective boxes and from the outputs of the connective boxes to the sockets in the control panel, the latter sockets being the inputs of the "AND" box which detects answers.

A Logical Computor of Greater Capacity

The desirability of increasing the capacity of the present Computor is evident. There is no difficulty in increasing the capacity by a factor of about 2 or 3, since it is possible to use an identical system with valves replacing the relays. This enables the "scanning" of possible solutions to be done at a much greater rate; a thousand times faster would seem not unduly difficult and since $1000 = 2^{10}$ approximately, this would enable the possible combinations of 17 variables to be scanned in the same time at present used for 7.

Since with a larger capacity the number of "answers" found will tend to be larger, it would be desirable to provide for the machine to record answers automatically and not, as in the case of the present machine, to stop on finding an answer. This presents no technical difficulty.

It is clear, however, that the doubling of the length of the operating cycle which accompanies each increase of the capacity by a single variable will ultimately set a limit to the capacity of such a machine and that a machine to deal with say, 50 variables would be impracticable.

This difficulty is a fundamental one, and can only be resolved by a new approach to the problem. A possible method of attack is described in the next section.

A Logical Computor involving more Advanced Principles

Let it be supposed for the present that the problem consists not of finding *all* "answers" to a logical problem, but only *one*. For definiteness, consider the problem of which the "rules" are

If B, then C.
A If and only if D.
A or else B.

The reader should attempt to obtain mentally a single "answer" to this problem. (There are, in fact three, namely AɃCD, AɃȻD, ⱭBCÐ). He should then consider the mental process by which he arrived at the solution; he will probably find it to be roughly that of *assuming a trial solution* and *modifying it to remove features inconsistent with the rules.*

It was suggested to the authors by Mr. M. K. Taylor that a logical computor might be made to operate on this principle, and they have, in fact, been able to give a simple demonstration of this technique using special "sensitive variable" units in conjunction with the normal connective boxes of the basic Logical Computor. The "sensitive variable" units have the following properties:—

(a) Each possesses a number of output sockets and a number of input sockets (known as "feedback" sockets for a reason to be explained later).

(b) Each has two basic states, corresponding to the affirmative and negative states of the variables of the original Computor. In the affirmative state a green lamp upon the unit is lit, and the output sockets are connected to +24 V; in the negative state a red lamp is lit and the output sockets are connected to earth.

(c) Either state is normally stable; that is, the unit remains in whatever state it happens to be. An exception to this rule is that *when any feedback socket of the variable unit is connected to earth,* this has the effect of making the unit "hunt" between its two basic states, changing its state about twice per second.

Each sensitive variable unit contains only a single relay; the circuit is shown in Fig. 8.

Referring now to our problem, suppose the problem is set up as in Fig. 9(a) with these sensitive variable units linked by connective boxes of the type previously described in accordance with the given rules. The configuration of the variable units will then be an "answer" if and only if all three rules are satisfied, i.e., if the leads marked 1, 2, 3 are all live. If it is not an anwer, one or other of the leads 1, 2, 3 will be connected to earth.

Now let additional connexions be made as in Fig. 9(b) where the dotted lines represent connexions from the leads 1, 2, 3 to the feedback sockets of the variable units made on the principle that *each rule is "fed back" to all variables in it,* i.e., "A or else B" is connected back to A and B, and so on. This gives rise to a network which has the following desirable properties.

(a) If the configuration set up on the variable units is an "answer" then the network is stable and remains in that configuration.

(b) If the configuration set up is not an answer, the network changes its configuration.

(c) The change in configuration occurs only in those parts of the configuration which violate the rules.

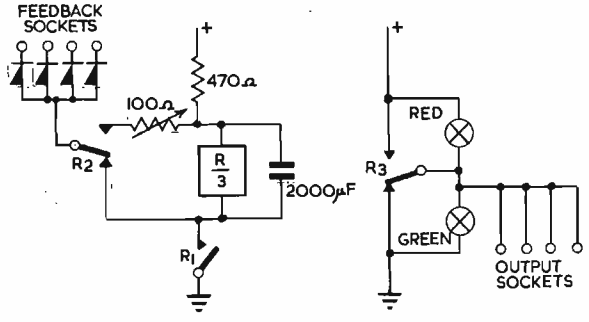


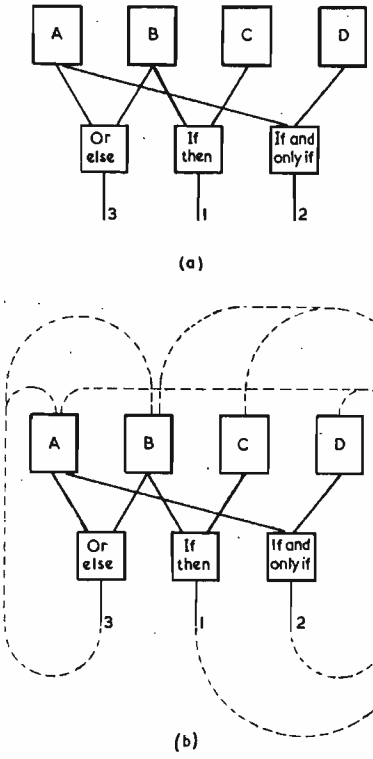
Fig. 8. (Above). Circuit diagram of sensitive variable unit
Fig. 9. (Right). Feedback connexion principle

Referring again to the example and to Fig. 9, suppose the initial configuration is $A\bar{B}\bar{C}\bar{D}$. Then the first rule (if B, then C) is satisfied, so point 1 is live; the second rule (A if and only if D) is satisfied, so point 2 is live; but the third rule (A or else B) is unsatisfied, so point 3 is connected to earth. This places an earth on the feedback sockets of variables A and B, which begin to hunt. Suppose A changes first, giving $AB\bar{C}\bar{D}$. This satisfies rule 3, so the earth on point 3 disappears; but at the same time an earth appears at point 2, since rule 2 is not now satisfied; A and D now begin to hunt. Suppose D changes first, giving $AB\bar{C}D$. This satisfies all the rules, so points 1, 2, 3 are all live and no further change takes place.

It is seen that this type of system may give a rapid convergence towards a solution however many variables are involved. There are, however, certain basic difficulties which arise, which will be briefly outlined.

The first is concerned with the general stability of the network set up; as would be imagined, the introduction of a large number of feedback loops brings with it the possability of continued oscillations of a *periodic* type which represents a process of "arguing in a circle." To illustrate this, reference is again made to the above example; suppose that the sensitive variable A always hunts more rapidly than the others. Then as before $A\bar{B}\bar{C}\bar{D}$ will require that A and B hunt; A, being the more rapid, will change first, giving $\bar{A}\bar{B}\bar{C}\bar{D}$; this will require that A and D hunt; but this time, A being the more rapid, will change again, restoring $A\bar{B}\bar{C}\bar{D}$; this cycle will repeat indefinitely.

It might appear that this type of instability could be avoided by making the hunting rates of all variables equal, but this is not so; referring again to the example, $A\bar{B}\bar{C}\bar{D}$ would change to $AB\bar{C}\bar{D}$ (A and B changing simultaneously); this latter combination violates all three rules, and all variables would change, giving $\bar{A}\bar{B}CD$, which violates rules 2 and 3. This in turn would give $ABC\bar{D}$, which still violates the same rules, causing a return to $A\bar{B}CD$, and the latter two configurations would alternate indefinitely. In practice it is found that even if the hunting rates are only approximately equal when measured independently, there will be a tendency when they are coupled into a network for "pulling in" to occur so that all variables hunt at a common frequency.



The complete solution of this problem is outside the scope of this article, but it consists in brief of introducing "random" disturbances which momentarily "clamp" one variable (i.e., remove from it all feedback connexions) and thus effectively break up any periodic oscillation.

A computor of this type will in general tend to find an "answer" which differs as little as possible from the initial configuration set up. If all answers are required, it is necessary that all initial configurations be set up, and this type of computor reduces to the simple type considered earlier. It is however possible in general to select from the set of all configurations a subset of any given length which has the property that any configuration lies tolerably

close to one member of the subset. (The property is more accurately expressed geometrically; the n variables, regarded as numbers which may have the value 0 or 1, are the vertices of an "n-dimensional cube" in n-dimensional space; the required subset is a group of approximately equidistant vertices of this figure). For example, with four variables, every configuration lies within one change from at least one member of the subset $\bar{A}B\bar{C}\bar{D}$, $AB\bar{C}D$, $ABC\bar{D}$, $\bar{A}BCD$, but the members of the subset all differ by at least two changes. Hence, if these be used as initial configurations in four trials with a computor of the feedback type, the probability of obtaining several *different* answers is much enhanced. The operations of recording the answer found and setting up a new initial configuration may, of course, be made automatic in cases where a large number of variables are used.

The properties of such a feedback computor may therefore be summarized thus:

(i) The time taken to obtain a single "answer" is much reduced.

(ii) If the number of "answers" is small and the "answers" are isolated (i.e., all differ appreciably) then steps may be taken to increase the chance of obtaining *all* answers early in the operating cycle. This is a particularly useful feature if the number of answers is known.

(iii) In general, if *all* answers are required, every initial configuration must be set up; in this case there is no advantage to be gained from the feedback method.

Conclusion

The authors feel that the possibilities of small specialized computors of this type are tending to be overlooked and that intensive investigation of their capabilities should be made. It is hoped that this note may stimulate further work in this direction.

The authors wish to thank Messrs. Ferranti, Ltd., for permission to publish this note and to acknowledge the numerous valuable suggestions made by Mr. M. K. Taylor, Chief Research Engineer, in connexion with the work therein.

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A Three State Flip-Flop

By Andrew D. Booth and J. Ringrose *

DURING investigations into the design of shifting register units[1] for an electronic computing machine a certain instability of operation led to the suspicion that the flip-flop units[2] were behaving in an unusual manner. A closer examination showed that for the circuit constants in use the only tenable explanation was that the circuit had three stable states. A drawing of the circuit is given below, and it was found that when the valve in use was a 6J6 the three stable state conditions could be reliably obtained for values of the cathode resistor R varying from $R = 3.8k\Omega$ to $4.2k\Omega$ and for a 6SN7 from $R = 3.0k\Omega$ to $4.0k\Omega$. A large number of valves of those types were found to exhibit the effect with complete uniformity.

It will be noticed (Fig. 1) that no anode-grid storage capacitors are present, so that the circuit, as it stands, will not act as a counter. However, if the circuit is rendered as symmetrical by inserting a capacitance of from 15 to 50pF in *one* of the anode to grid circuits as shown in Fig. 2, the circuit can be made to count reliably in scale of three when positive or negative pulses are applied to the common cathode resistor as shown.

The normal explanation of the action of flip-flop circuits[2] does not predict the existence of the third stable equilibrium state and measurements were made to clear up the matter. It appears that in the symmetrical case both sections of the valve conduct in such a manner as to produce a common cathode potential slightly in *excess* of the common grid potential (0.15V). This means that the circuit behaves as an amplifier with positive feedback, and the output/input voltage relationship is given by:

$$E_o = \mu E_i / 1 - \beta\mu$$

E_o and E_i being the output and input voltages respectively, μ being the effective amplification of the system and β the feed-back factor.

Since no reactive elements (to a first approximation) are present in the circuit, it follows that the vector $\beta\mu$ is frequency invarient and real, and hence Nyquist's criterion[3] shows the system to be stable. For large signal inputs, however, discontinuities are reached when grid current is drawn by one valve and also when a valve cuts off, this causes a change in the vector $\beta\mu$ which moves through the value 1, the circuit becomes unstable, and transition to one of the normal states occurs. In support of this mechanism, it may be mentioned that if cross coupling capacitances are introduced between *both* anodes and grids the circuit no longer has the third stable state which is in accord with the detailed predictions of Nyquist's theory.

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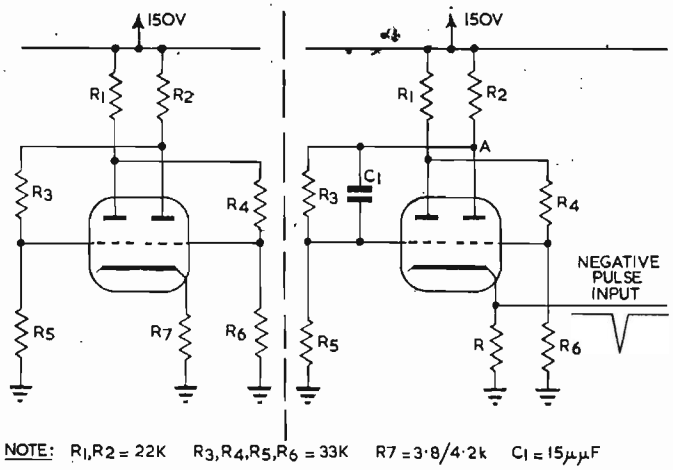


NOTE: R1,R2 = 22K R3,R4,R5,R6 = 33K R7 = 3·8/4·2k C1 = 15μμF

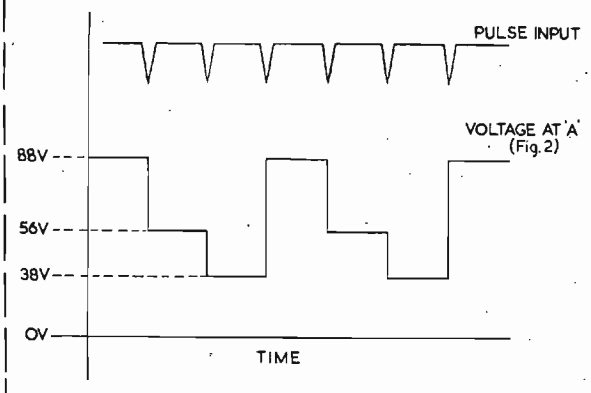


Fig. 1 (left); Fig. 2 (centre); Fig. 3 (above)

Piezo-electric Crystal Devices (Part 2)

By S. Kelly *

Bender Bimorphs

The behaviour of a bimorph made up of simple expander elements is illustrated in Fig. 6. (a) shows two identical expander elements oppositely oriented, (b) shows the motions of the individual elements under an applied voltage when they are not cemented together, and (c) shows the motion of the bimorph when the elements are cemented together. To the right of each of the figures, end views of the elements are shown. These clearly indicate the presence and effect of stresses and motions in the width as well as the length directions of the elements. It is obvious that the thinner the elements are made the greater will be the mechanical amplification and the lower the mechanical impedance. This fact of being able to vary the mechanical impedance of the bimorph enables the designer to "match" the various mechanical impedances in the system and thus obtain optimum power transfer in much

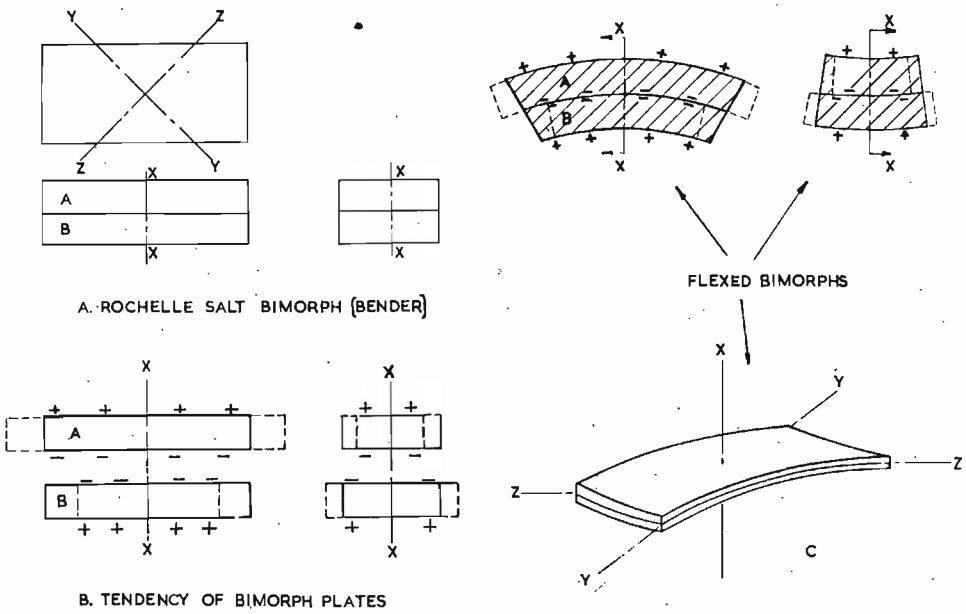


Fig. 6. Derivation of "Bender Bimorph"

the same way as the communications engineer "matches" his electrical circuits (say output valve and load). As a matter of fact, the chief limit to the amplification which can be achieved in a bimorph is set by practical limitations in cutting thin slabs of crystal, and the final mechanical strength of the assembly.

Thus a bimorph can be used to advantage to secure much larger voltage outputs when driven by sources of low mechanical impedance than would be developed by simple piezo-electric elements alone. In this application it functions as a "step-down" lever, which changes large motions with small force into large force with small motion. An analogy from basic electrical theory will show that when the source of mechanical energy from which a piezo-electric element is to be driven is capable of relatively large motions (current), but with little force (voltage), a bimorph will yield a much higher output than a simple element because of better impedance matching. When the mechanical impedance of the driving source is relatively high, however, as in the case of vibrations transmitted in a liquid, there is little advantage in using a bimorph element in a microphone and it is more usual in such applications to use a simple element such as an expander.

Torque Bimorphs

In addition to the bender bimorphs described above, it is possible to make "Twister" or "Torque" bimorphs by suitably cementing two shear plates together. The basic detail of a torque bimorph is illustrated in Figure 7. (a) shows two shear plates deformed by the application of a voltage. It is seen that the plates are so oriented that the stresses produced by the applied voltage are in opposite directions. (b) and (c) show these two plates placed one over the other and again deformed by the application of an applied voltage.

If these two plates are cemented together the stresses in each individual plate can no longer act freely since the reaction of the plates upon each other prevents them from deforming in shear. As a result, a couple which tends to twist the element with a resulting deformation as shown in (d) is caused by the oppositely directed shearing stresses in the two plates.

If the polarity of the applied voltage were reversed, the element would twist in the opposite direction, since the direction of the shearing stresses in the two plates would be reversed.

As with bender bimorphs, many different types of mountings are used in application of torque elements. There are, however, two methods of mounting which are especially common. These are the edge and the three-corner mounting. In the edge mounting, usually used with long narrow elements, one edge of the element is held by connecting it to a rigid support. With this type of mounting, the mechanical load (or drive) is normally applied across the edge opposite the support and a rotation about

* Chief Engineer, Cosmocord, Ltd.

the longitudinal axis of the element results from the torque.

Alternatively, in applications where a reciprocating motion is desired, a three-corner mounting may be used in which three corners of the element (usually square) are cemented to compliant plastic pads, and the mechanical load (or drive) connected to the fourth corner of the element. The motion is, of course, perpendicular to the major faces.

There are many variations of these basic mountings which find application for special purposes, but it is not feasible to discuss them in the present article.

Like bender bimorphs, torque bimorphs, because of their lever action, present a low mechanical impedance at their drive points and they offer the same advantages as benders in the form of high voltage output for low driving force.

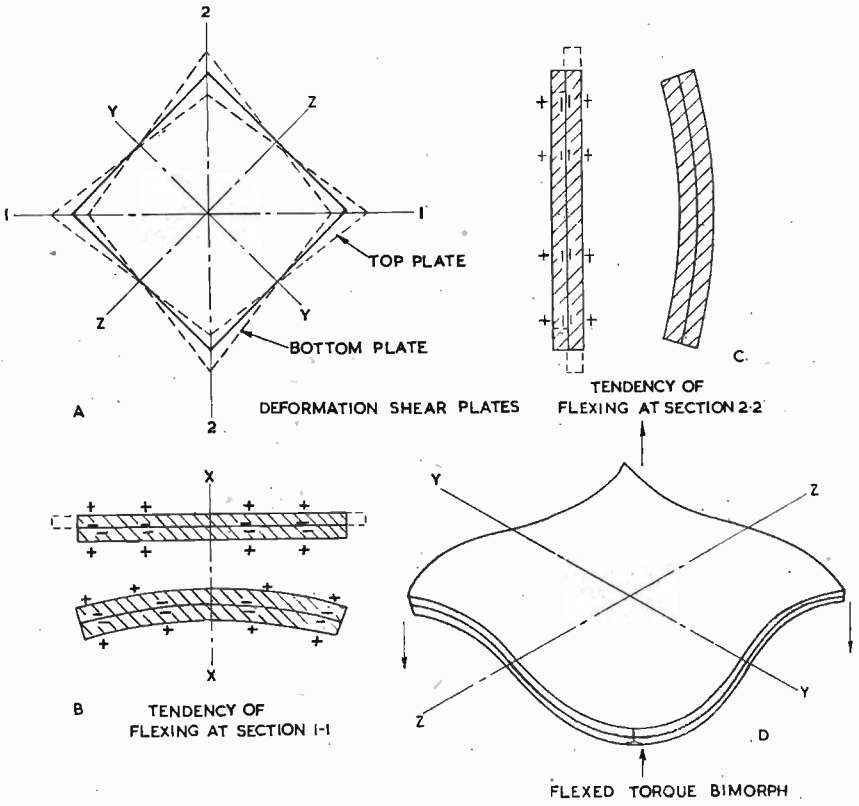


Fig. 7. Derivation of "Torque Bimorph"

Electrode Connexion of Bimorphs

The elements which comprise a bimorph can be connected in two ways, depending on their orientation with respect to each other. The connexion may be "parallel" by connecting the electrical capacitances of the two units in parallel. By turning one element over, the polarity of the elements is "series aiding" and the result is a bimorph which requires no centre electrode, but has only one-fourth the electrical capacitance of the parallel connected bimorph. This method of connexion is known as the "series" connexion. Assuming that the capacitances of the component elements are equal, it is seen that only half the applied voltage will appear across each element instead of the entire voltage as in the parallel connected bimorphs.

When used as a generator, as in pick-ups or microphones, the series connexion gives twice the output of the parallel connexion, although the source impedance is, of course, quadrupled and the corresponding circuit elements (load, resistances, etc.) must be likewise increased. It therefore follows that a given applied voltage will produce only half the motion in a series connected bimorph as would be produced in a parallel connected bimorph, using the same circuit element. It is common practice to use parallel elements in telephone receivers or microphones and pick-ups feeding into relatively low impedance circuits, and series elements for hearing-aid microphones and other units feeding directly into grid circuits of vacuum tube amplifiers. In the case of wide range microphones, where the signal-to-noise ratio is important, the parallel connexions are invariably used because the small size of the elements results in a very low capacitance per unit plate, usually of the order of 10-30pF and if, say, four plates are used, the final series capacitance would be 2.5-7.5pF against 40-120pF for the parallel combination.

Equivalent Circuit Data

One of the most useful concepts in modern engineering practice is the equivalent electro-mechanical circuit, in which mechanical elements can be shown as their equivalent electrical ones, and standard electrical circuit theory may then be applied to the solution of mechanical problems. This method can be applied with advantage to the solution of piezo-electric transducer problems.

The equivalent circuit is made up in exactly the same

TABLE 1

CORRESPONDING UNITS C.G.S. SYSTEM

ELECTRICAL			MECHANICAL			ACOUSTIC		
Quantity	**Unit**	**Symbol**	**Quantity**	**Unit**	**Symbol**	**Quantity**	**Unit**	**Symbol**
Voltage	Volts $\times 10^8$	E	Force	Dynes	P	Pressure	Dynes/sq.cm	P_A
Charge	Coulomb/10	Q	Displacement	Cm	x	Volume Displacement	cu. cm.	X
Current	Amperes/10	I	Velocity	Cm/sec.	v	Volume current	cu. cm.	U_A
Resistance	Ohms $\times 10^9$	R	Friction	Mech.ohms	r_m	Resistance	Acoustic ohms	R_A
Inductance	Henrys $\times 10^9$	L	Mass	Grams	m	Inertance	Mass/(area)^2	M
Capacitance	Farads $\times 10^9$	C	Compliance	Cm/dyne	c_m	Capacitance	cu. cm.	C_A

manner as the familiar electrical circuit diagrams of radio and electrical components with mechanical elements shown as their electrical analogue. The electrical and mechanical parts of the circuit are connected together by an ideal transducer. The ideal transducer performs in exactly the same manner as an electrical transformer except that it transforms electrical into mechanical energy with no loss, and vice versa. It also transforms electrical impedance into mechanical impedance, and vice versa, and the ratio of these impedances is the square of the "turns" ratio of the transducer. The "turns" ratio has no physical reality and is defined as the ratio of output voltage to input force, or vice versa.

As stated above, the electrical elements of the circuit are given their usual symbols, and Table 1 gives the corresponding mechanical and acoustical quantities; thus mass is equivalent to inductance, compliance to capacitance, friction to resistance, etc. Fig. 8 shows the representative piezo-electric transducer, comprising the electrical capacitance, *Ce* the transducer, with a "step-up" ratio of $N:1$ the mass and compliance of the element shown as

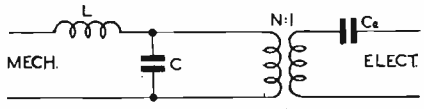


Fig. 8. Equivalent circuit of crystal transducer

the inductance *M;* and the capacitance *Cm*, together with two mechanical terminals to which the mechanical load (or drive) is connected. The correctness of this equivalent circuit has been experimentally verified and is a very good approximation of the actual elements up to about the first resonant frequency of the system.

It will be appreciated that in crystal devices, which have various independent piezo-electric and elastic constants, these will be coupled and the system will oscillate at a number of different frequencies. For the majority of

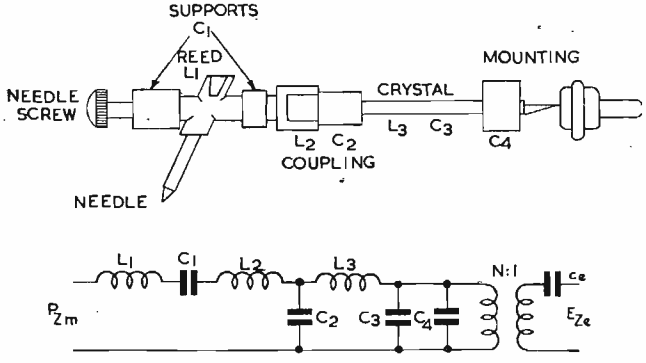


Fig. 9. Mechanical and electrical constants of general purpose gramophone pick-up

transducer problems, however, the system is operated either below or at the first resonant frequency and the fabrication of the crystal elements is usually arranged to attenuate the effect of the other resonances as much as possible. Referring back to Fig. 8, and remembering that it is useful to think of force as equivalent to voltage, velocity to current, and displacement to charge, intuition indicates that if the mechanical terminals are open circuited, the velocity at these terminals will be zero and this will correspond to the driving point of the transducer being rigidly clamped. In the same way, if the mechanical terminals in the equivalent circuit are short circuited, this will correspond to a condition of no restraint at the driving point of the transducer and consequently the velocity will be at maximum. In practice, the operating conditions of the transducer are somewhere between these two extremes and the mechanical load connected across the output of the transducer will be a network of more or less complexity such as a mass in series with a compliance in parallel with a resistance, etc. For the purpose of circuit analysis, the transducer element may be removed and either the mechanical or electrical constants multiplied by N^2 (or $1/N^2$) and referred to the other side of the transformer. Supposing, for the sake of argument, that the transformer ratio is unity and the mechanical terminals are short-circuited, referring to the electrical terminals it will be seen that the element behaves as a resonant circuit with a frequency of maximum impedance and a frequency of minimum impedance, the following deductions may be made: —

1. The parallel resonance of *M* and *Cm* will appear on the electrical side as a high impedance. This frequency corresponds to the electrical anti-resonance frequency of the actual piezo-electric transducer. Thus a load across the electrical terminals will affect the resonant frequency of the system because of the high electro-mechanical coupling factor.
2. At some frequency below this anti-resonant frequency, the inductive component of *M* and *Cm* will series resonate with the electrical capacitance *Ce*. This frequency corresponds to the electrical resonant frequency of the piezo-electric crystal. Any mechanical loading connected to the crystal which will alter the effective mass and compliance will alter the two resonant frequencies indicated above. Looking into the mechanical terminals of the transducer, similar deductions may be obtained.

The ratio $N:1$ of the ideal transducer expresses the ratio in which the conversion is made from mechanical to electrical constants, and is usually expressed in units of voltage over units of force, or alternatively, in units of displacement over units of charge. Providing that no electrical load is connected across the electrical terminals to the transducer, the frequency of resonances is determined solely by the mechanical constants, and for this reason

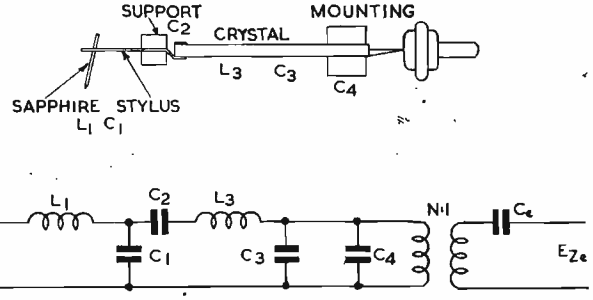


Fig. 10. Mechanical and electrical constants of high fidelity gramophone pick-up

where crystals are used for the precise control frequency, it is important that the electrical loading should be as small as possible and that the ancillary mechanical elements connected to the transducer should be invariable and placed at the points of minimum motion.

Pick-ups

The development of the equivalent circuit of Fig. 8 in the design of various systems is indicated below. In order to avoid unnecessary complication certain simplifications will be introduced. For example, each component part of the system will usually possess mass, compliance and resistance, but where possible only the predominant component will be used. In stating the electrical equivalent circuits, the intention is not to obtain an extremely accurate estimate of the device's performances, but to get some idea of the variation of response with frequency, the number

and location of resonances and the overall efficacy of the system. Again, the effect of resistance is usually to affect the amplitude of the resonances and it is therefore omitted, but the engineer can usually form a good idea of where and how resistance should be inserted.

Fig. 9 shows the mechanical layout of a simple type of gramophone pick-up and its electro-mechanical equivalent circuit. The stylus is rigidly connected to the needle chuck and thence by some compliant member to the crystal. Additionally, the bearings and mountings will also have an effective mass and compliance and it is the aim of the engineer to choose these values so that their natural frequency is well above the frequency range of the pick-up. Under these circumstances, they will always then behave as pure compliances within the designed range of the instrument.

A rather more complicated type of pick-up is illustrated in Fig. 10. Here, the stylus is connected through a long

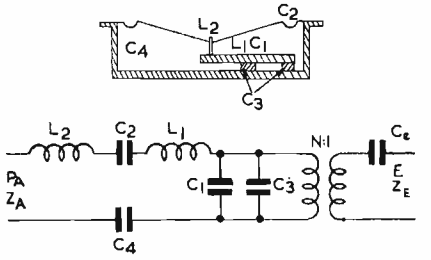


Fig. 11. Simple diaphragm operated pressure microphone

thin member to the crystal; the purpose of this coupling unit is to isolate the two resonances as much as possible and also to decrease the needle tip impedance while still using a fairly stiff crystal. This system is much in use in America at present for micro-groove reproducers, and while having the advantage of good tracking with very low needle pressure, it has the disadvantage of an uneven frequency response caused by resonances within the frequency band. These resonances must be reduced by the application of damping material to the stylus and the crystal.

In the two above illustrations, a perfect tone arm has been assumed, but in a practical case, the tone arm will be represented as a mass in parallel with the effective system compliance. At low frequencies, the impedance of $L1$, $L2$, and $L3$ is so small that it can be neglected, and the various compliances are then effectively in parallel and resonate with the tone arm mass. At medium and high frequencies, the tone arm is sufficiently high to be neglected, although in a badly designed tone arm where torsional resonance occurs, this can be represented as an additional circuit across the main tone arm mass.

In modern high fidelity pick-ups, the mass of the needle chuck and coupling is much too great, and the losses of the system shown in Fig. 10 result in a very inefficient pick-up. To extend the frequency range and improve the efficiency, it is necessary to obtain a better power match between the needle tip and the crystal. One such system is to suspend the whole crystal in a viscous gel. This has the effect of making the crystal mass, $L3$, and its compliance, $C3$, together with the compliance of the mounting $C4$, approximate to a smoothly loaded mechanical transmission line. If sufficient viscous damping is introduced into the compliances (represented as a conductance across $C4$) the crystal system will become aperiodic and no resonances will be apparent in the upper register. The parallel resonances of the tone arm mass and the compliance will not be completely eradicated, although the effect will be considerably reduced.

Microphones

The treatment of microphones is exactly the same and the simplest form of diaphragm-operated crystal microphone is shown in Fig. 11. It is seen that this consists of a simple single resonant circuit. Fig. 12 shows the effect of drilling a hole in the case in order that the mass of air, $L2$, will resonate with the acoustic capacitance, $C2$, behind the diaphragm. These resonances are usually arranged to occur at the low frequency end of the spectrum, causing a sharp reduction in response at frequencies lower than the resonance. This case will be immediately seen to be analogous to the reflex type of loud speaker cabinet.

If some acoustically resistive material (say fine silk fabric, rigidly supported) is placed in front of the diaphragm, this would have the effect of adding resistance to the circuit, and if correctly applied can reduce the high frequency resonance from, say 20db to 2 or 3db. It can be shown from the basic case that where tight coupling exists (between the needle and the crystal in the case of a pick-up, or the diaphragm and the crystal in the case of a microphone) there is only one resonance. In the case where the crystal and driving member are not rigidly connected, they are usually capacitively coupled and the

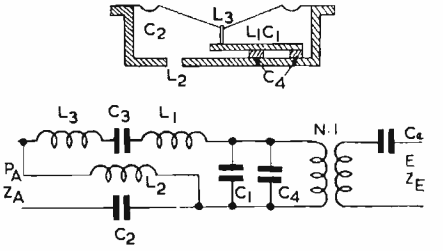


Fig. 12. As Fig. 11 but with cavity resonance $L_2 C_2$

system will show two resonances, the frequency of these resonances being influenced by the coefficient of coupling between the crystal and its driving force.

In all the above cases, the diaphragm is assumed to be a simple mass compliance system moving as a piston. On small type hearing-aid microphones, this assumption is correct below the lowest resonant frequency of the diaphragm and the cavity behind it. At higher frequencies, the diaphragm must be represented by a number of coupled mass compliance systems and the correct interpretation becomes very difficult.

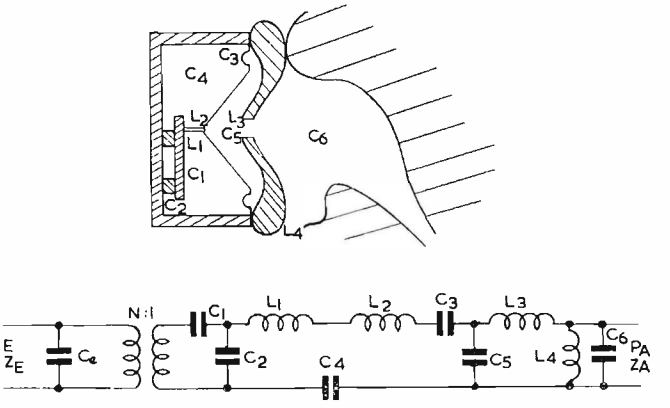


Fig. 13. Telephone receiver on real ear

As a final example, Fig. 13 shows a crystal telephone receiver. Here, not only is the receiver assembly more complicated than in the case of a microphone, but the acoustic impedance that it works into is considerably more complex. The question of successfully representing the acoustic impedance of the human ear will be dealt with later.

(To be continued)

A New Colour-coded Wiring System

By N. G. Partridge *

The study and maintenance of complex electronic equipment is dependent on the ease with which the wiring can be identified and traced.

It is usually necessary to split the equipment into several chassis, each of which performs a particular circuit function. The separate chassis may, or may not, be mounted in the same rack or cabinet and cableforms will be used to link separate chassis, racks and bays.

This article describes a new and improved method of coding which reduces errors and is applicable to a very wide range of equipment.

THE necessity for splitting a large equipment into separate units results in inter-connexions which are necessarily complex and it has not, in the past, been easy to indicate these connexions in a clear manner. Fault finding requires a detailed knowledge of the internal wiring of each chassis and of the routeing of external wires. In order to be familiar with an equipment it is necessary to know the final destination of each wire leaving a chassis and this information is usually supplied in a handbook associated with the equipment. If a fault develops in a cable-form joining two chassis, it is usually difficult to locate the trouble with the existing cable schedule systems since they do not normally describe the routeing of the cable, but only its end connexions.

The existing method of coding wires in cable-forms usually bears no relationship to the circuit function performed by each wire. It merely serves to identify "the other end" of a wire in a cableform provided its destination, i.e., the chassis to which it goes, is known. Thus, an engineer, having discovered a disconnexion in a circuit for which, say, a red and white wire is used in the cableform, must endeavour to find a similarly marked wire at the other end of cableform. If the cableform branches into many arms, each of which passes to a separate chassis, it becomes a difficult matter to locate the correct chassis since a red and white wire may appear in other arms of the cableform. If the wire is difficult to trace, then the cableform lacing must be undone.

There is also the added complication of "special cableforms', i.e., cableforms made to suit a particular application and containing wires of different types. For example, co-axial, rubber covered and braided leads may be employed, each particular type of cable having its individual maker's identification markings and probably having to be used more than once in a single cableform or cableform arm.

The existing method of coding the individual leads inside the chassis is also subject to criticism especially in the case of a chassis whose circuit involves a large number of valves and other components. It is usually necessary to start from a known point, e.g., on a valve holder it is often necessary to count the pins, beginning with pin No. 1, before a particular lead can be identified. Coding of the leads is sometimes generalized to specify the functions, e.g., Red for H.T. leads and Black for earth leads, etc. This system is unsatisfactory in operation, for the following reasons:

(a) The number of functions to be indicated in complex apparatus is very large and an adequate number of colour combinations does not exist. On the other hand, a simplified system is liable to cause confusion.

(b) Detailed examination of the wiring of a chassis requires a schedule of all the connexions in order to avoid duplication or omission of a wire and generalized coding does not permit such a schedule to be made.

(c) In production, the specified colours are occasionally out of stock, or not available from the suppliers. Alternative colours are essential for continuity of production and the use of these alternatives increases the confusion.

Any system which is designed to overcome these difficulties should (a) permit the identification of the wiring to follow a standard procedure, (b) be adaptable to the most complex equipment and (c) be capable of accommodating circuit changes brought about by design modification without interference with the remaining circuit coding.

The New System

The new coding method is based upon the consecutive numbering of all the items involved, whether wires, cables, chassis, drawers, cabinets, or bays, together with the use of the International Colour Code system to enable the allotted number to be carried by the item in the form of coloured bands or labels.

This procedure enables each wire associated with the equipment to be precisely and quickly identified. It provides a quick and easy method of wire tracing, even if the main diagrams appropriate to the equipment have been lost or destroyed. The scheme, although comprehensive, is simple in application and capable of adaptation to various types of equipment.

As an illustration, the application of the colour coding principle and the preparation of schedules will be described in more detailed terms.

Application of Colour Coding

The International Colour Code and the numbers corresponding to a given colour are given below:

Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet	7
Orange	3	Grey	8
Yellow	4	White	9

When the colour code is applied to resistors, for example, the third colour band indicates the number of noughts following the first two digits. This is convenient when applied to resistors since the number of colours is reduced to a maximum of three, though it does not permit a consecutive number series beyond "100".

The Coding of Wires

For the identification of wires and cables each digit in a number group is important and the colour code is therefore used in the following manner. Each colour represents a digit and is read directly, for example, the number "21" is shown as a red band followed by a brown band, i.e., two colours only. The number "216" is shown as a red band, a brown band and a blue band, i.e., a total of three colours. Thus, four colour bands, green, blue, black and orange define the number "5603".

The method of applying the code to a single wire is as follows:

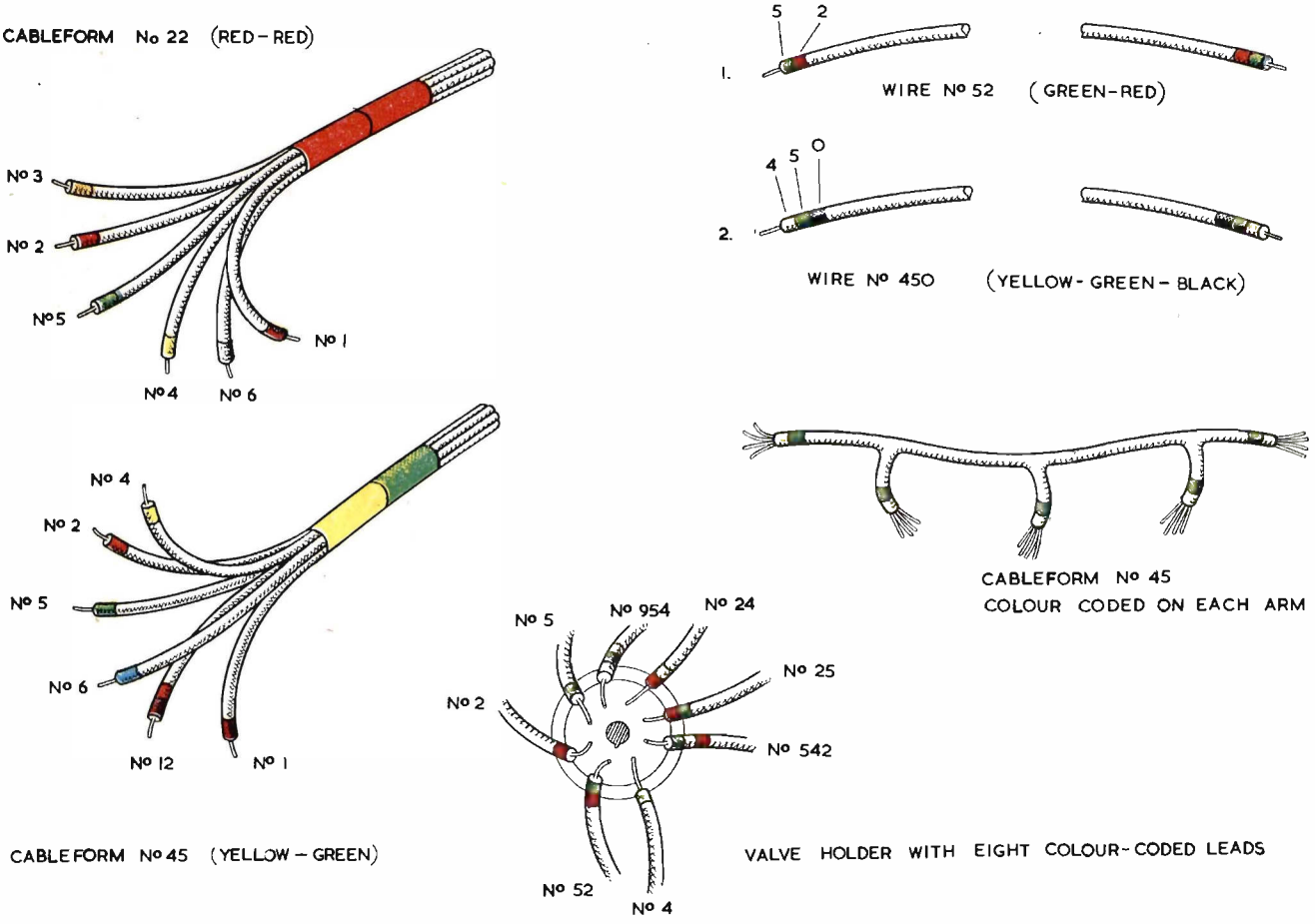
The colour bands are read starting from the *solder*

* *E.M.I. Engineering Development Ltd.*

joint or *free end* of the wire and the wire is similarly coded at *each* end.

It is considered that there will be no confusion between the colour bands and the colour of the actual wire, but possible objections can be obviated in any one of three ways:

(a) The wire covering can be neutrally coloured where the colour bands will be placed.



Examples of colour coded wires and cableforms

(b) A body colour which is not used in the International Colour Code can be employed.

(c) Colour combinations involving the colour of the wire covering can be avoided by omitting certain numbers, e.g., all numbers containing "9" might be omitted.

The Coding of Cableforms

The method of applying the code to a cableform is as follows:

In addition to the colour of each wire, the cable form has its own colour code. In general, not more than two colours are required, since this number permits the provision of 99 cableforms. Each arm of a cableform should be similarly coded and the coding is read from the free end of the cableform.

Coding of Chassis and Racks

Each chassis has a colour code to identify its position in the cabinet or rack. There are usually two colours, of which the first indicates the rack in which it resides, and the second indicates its position in the rack, numbered from the top downwards.

Each rack also has its own colour code, but if the whole equipment is finished in a colour which is normally used in the International Colour Code, that colour is omitted from the scheme. Thus, if the equipment is blue, the individual chassis and racks are numbered 1, 2, 3, 4, 5, 7, etc. Black (0) is not normally used for coding either chassis or racks, unless there are ten or more racks or chassis in any one rack.

Rack Cableforms

Some of the cableforms in a rack may not leave the rack since they may be required only to join the chassis located in the same rack. At least one cableform must, however, leave the rack.

Cableforms can be made to carry various types of circuits but in a complex system it is convenient and desirable to group the separate functions into individual cableforms, e.g. one cableform may carry only power circuits, another may carry only co-axial circuits, and so on.

Preparation of Schedules

As soon as a method of positive identification of each wire in an equipment has been adopted, it becomes possible to prepare schedules which group the wires in a logical manner. These schedules then supplement the information contained in the circuit diagrams and, with the latter, enable rapid servicing of complex apparatus to be carried out.

If it is necessary to modify the wiring of an equipment in such a way as to add wires, additional numbers are allotted and the functions and locations are entered on the appropriate schedule. Certain groups of numbers can, of course, be reserved for future modifications when the code numbers are originally allotted to the individual chassis.

Visual Presentation of Binary Numbers

By E. H. Lenaerts

SEVERAL electronic digital computors have recently been built, or are still being built throughout the country. In most cases it has been found convenient to design the machine to handle numbers in the binary system, since binary numbers can be conveniently represented in electronic circuits either by a train of pulses (a pulse representing "1" and no pulse "0") or by the condition of a valve (conducting or not conducting). The conversion of numbers from the decimal to binary form and the reverse operation is made part of the Input or Output process.

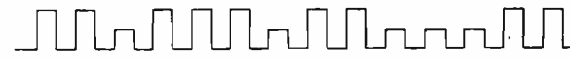
Most machines print the results of computations at the will of the programmer by means of some electromechanical device such as a teleprinter, although some users read the results directly from a cathode ray oscilloscope in binary form. In all cases, however, during the construction and maintenance of such a machine it is necessary to be able to examine the binary numbers while they are still in its store or in its other registers. If the numbers are represented by repeated trains of pulses, they may be inspected on an oscilloscope.

The mercury delay line used in the EDSAC[1,2] is a typical storage system. Here numbers are stored one at a time in registers consisting of short ultrasonic delay lines, or, in the main store in a series of long delay lines each capable of holding thirty two 17-digit binary numbers. Unfortunately the standard laboratory oscilloscope with a single or double trace cannot give a satisfactory representation of more than a few numbers at a time, so that a device is needed which will enable all the information held in one long delay line of this type of store to be displayed at one time.

In the use of a raster time base the pulses representing a number may be displayed as vertical deflexions of the trace. Alternatively, in order that information on one line of the raster shall not confuse that displayed on another, the units may be represented by a pattern of bright dots on a background of fainter dots representing the zeros.

A better method which has been used by the writer combines both of these forms, and results in a visual representation of the binary numbers, which is less confusing and more easily appreciated by the layman. This is an advantage when a rather bewildering amount of equipment is being demonstrated to people who may be interested only in what the machine can do with numbers.

In the method to be described the pulse train to be displayed is superimposed upon the frame deflexion of the time base, while the brightness of the cathode ray tube is modulated by clock pulses, which are timed to occur in all positions where a pulse is possible, applied to its grid. By adjusting the phase of the clock pulses one can arrange that only the back edges of the pulses are visible, while where there is no pulse the zero is represented by a spot of light. Thus the number 1101110110011 which is represented by the waveform:—



appears on the screen of the cathode ray tube as:—

Figure 1 is a photograph of the contents of a single ultrasonic delay line store containing sixteen numbers each having 35 possible digit positions displayed in this way. Figure 2 is a photograph of the same waveform without the brightening clock pulses (the brightness control of the tube has been advanced to produce a picture which would otherwise be invisible). Both signal and clock pulses used in the machine being built are approximately one microsecond wide with an interval of two microseconds.

There is little unusual in the circuits used to produce such a picture. It is important that the focus should be good over the whole face of the tube, and the time bases should have good linearity consistent with short fly-back time. In the circuit used, balanced deflexion in both line and frame direction ensures good focus. Both time base circuits are fundamentally Transitron-Miller valves (Fig. 3) with diodes to prevent "suppressor sticking." A rapid fly-back is achieved by introducing a cathode follower $V2$ which enables C to be discharged more quickly. By this means a fly-back time of less than three microseconds is achieved both in line and frame, which in the case of the frame is a sweep/fly-back ratio of nearly 400-1.

The clock pulses are delayed rather less than a microsecond by means of an LC delay line, to bring them to

Fig. 1. Representation of sixteen thirty-five digit numbers in Ultrasonic Delay Line Store

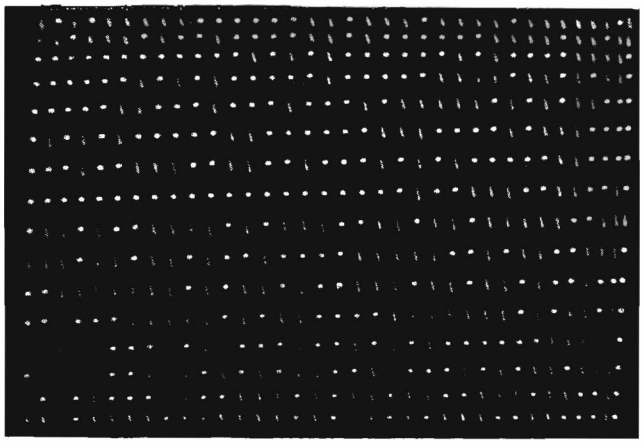


Fig. 2. As Fig. 1, but without beam modulation

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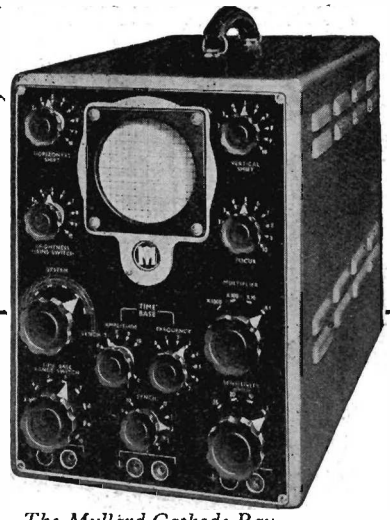

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Amplifier. Gain 1,400 or 5 mV rms/cm. Frequency range 2 c/s-2 mc/s. 3 dB loss.

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Time Base. 5 c/s-150 Kc/s in 10 steps with continuous variation between steps.

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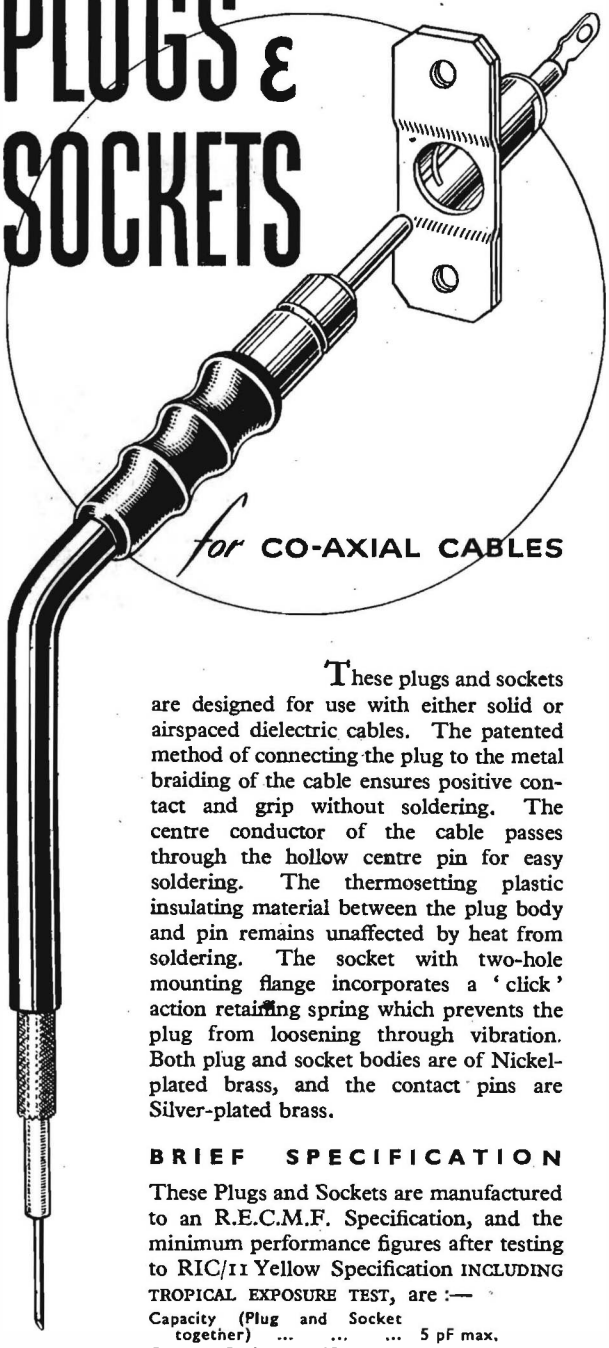
PLUGS & SOCKETS



for CO-AXIAL CABLES

These plugs and sockets are designed for use with either solid or airspaced dielectric cables. The patented method of connecting the plug to the metal braiding of the cable ensures positive contact and grip without soldering. The centre conductor of the cable passes through the hollow centre pin for easy soldering. The thermosetting plastic insulating material between the plug body and pin remains unaffected by heat from soldering. The socket with two-hole mounting flange incorporates a 'click' action retaining spring which prevents the plug from loosening through vibration. Both plug and socket bodies are of Nickel-plated brass, and the contact pins are Silver-plated brass.

BRIEF SPECIFICATION

These Plugs and Sockets are manufactured to an R.E.C.M.F. Specification, and the minimum performance figures after testing to RIC/11 Yellow Specification INCLUDING TROPICAL EXPOSURE TEST, are :—

Capacity (Plug and Socket together)	5 pF max.
Contact Resistance (Outer Contacts)	10 milliohms max.
Contact Resistance (Pin Contacts)	10 milliohms max.
Leakage Resistance	10 Megohms min.
Steady withdrawal force ...	6/16 lb.

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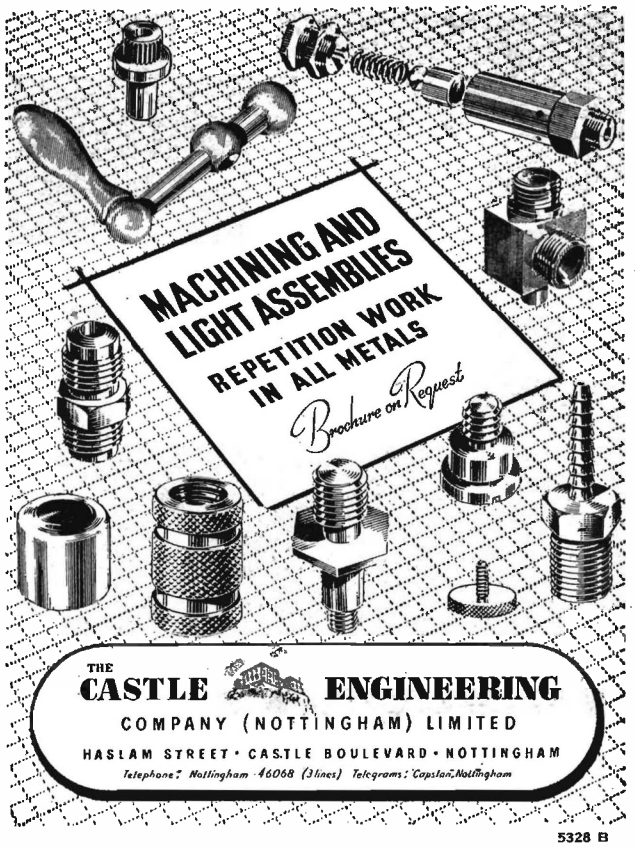

5328 B

Quantity production of small automatically made pieces in Steatite, Porcelain, and Rutile materials for electric cooking and heating equipment, and telecommunication apparatus.

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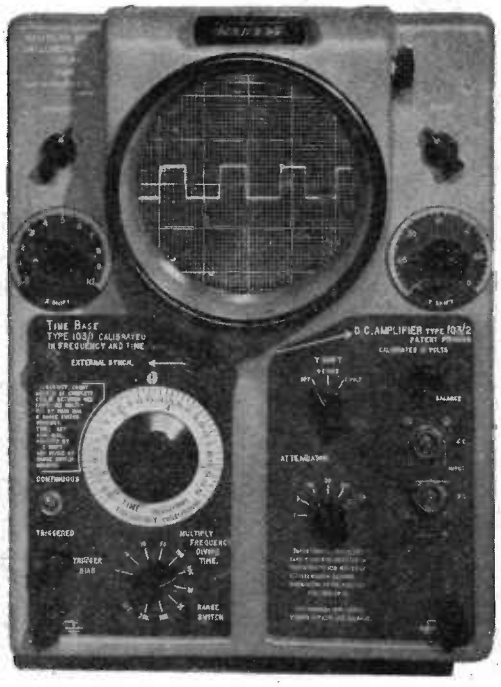
Tel.: 20981/8. *Grams.:* "Bray, Leeds 2"

WIDE RANGE NAGARD TYPE 103 OSCILLOSCOPE

6" C.R.T.

CALIBRATED IN TIME, FREQUENCY AND VOLTAGES



CALIBRATED OSCILLOGRAMS

The illuminated graticule and single shot camera attachment gives clear records and accurate measurements.

STABLE TRACES

The exceptional synchronising properties of the Time Base, and stability of the D.C. Amplifiers aids measurement and photography.

TIME BASE RANGES

Calibrated sweep velocities from 2 in. per sec. to 2 in. per u sec. Triggered or continuously running.

D.C. AMPLIFIERS

Voltage calibrated and fully stable Response, Maximum Gain and Sensitivity

0-20 K/cs.	0-2 Mc/s	0-10 Mc/s
100,000	20,000	300
0.12mV/inch	0.60mV/inch	40mV/inch

Phase to frequency ratio constant. Perfect square wave definition within the limitations of each frequency range.

These are available as self contained units with power supply and stabiliser for use apart from the oscilloscope.

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SEE TRULY

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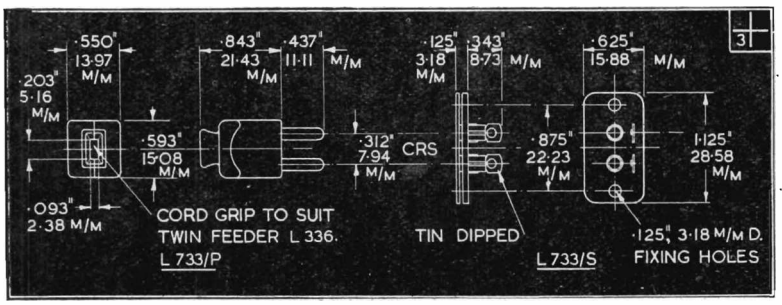
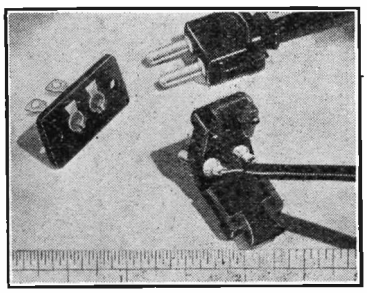
The "Belling-Lee" page of New Lines





OTHER NEW LINES AT THE R.E.C.M.F. STAND No.12

Heavy Duty Windscreen Wiper Suppressor L740

Coaxial Padder Box L725/P & L725/T

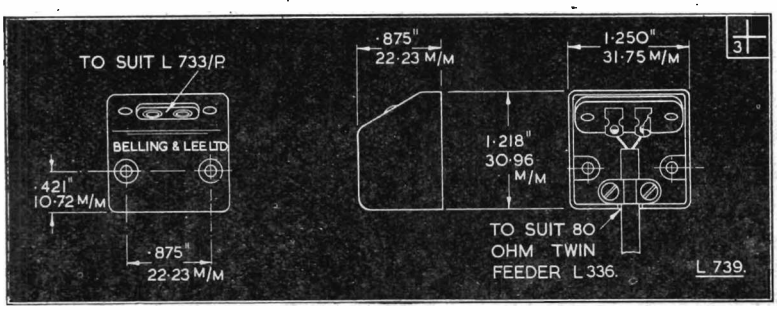
" Screenector " Cover Complete Regd. **with chain attachment L625/C Unitors. Miniature inter-unit connectors**

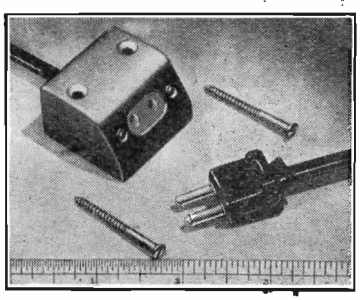
TWIN FEEDER PLUG L733/P

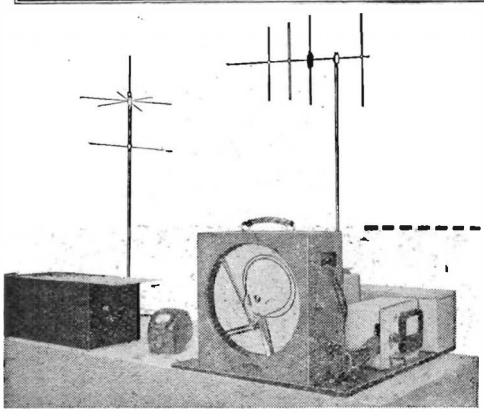
This new inexpensive " Belling-Lee " plug list No. L.733/P is specifically designed for unscreened balanced twin feeder as used with television or short wave reception.

It fits the appropriate chassis mounting socket L.733/S or skirting board outlet L.739.

The twin feeder (" Belling-Lee " L. 336) is loaded simply by pinching the wires in the spills provided, the ingeniously designed black polythene moulding then folds into shape, where it is held together by means of the two moulded ball-headed studs.







TWIN FEEDER OUTLET BOX L739

Designed for use with L. 733/P and as a skirting board termination for unscreened balanced twin aerial feeder. This outlet box will be found suitable for many purposes *i.e.*, amateur short wave aerial installations ; loudspeaker and earphone extensions, etc.

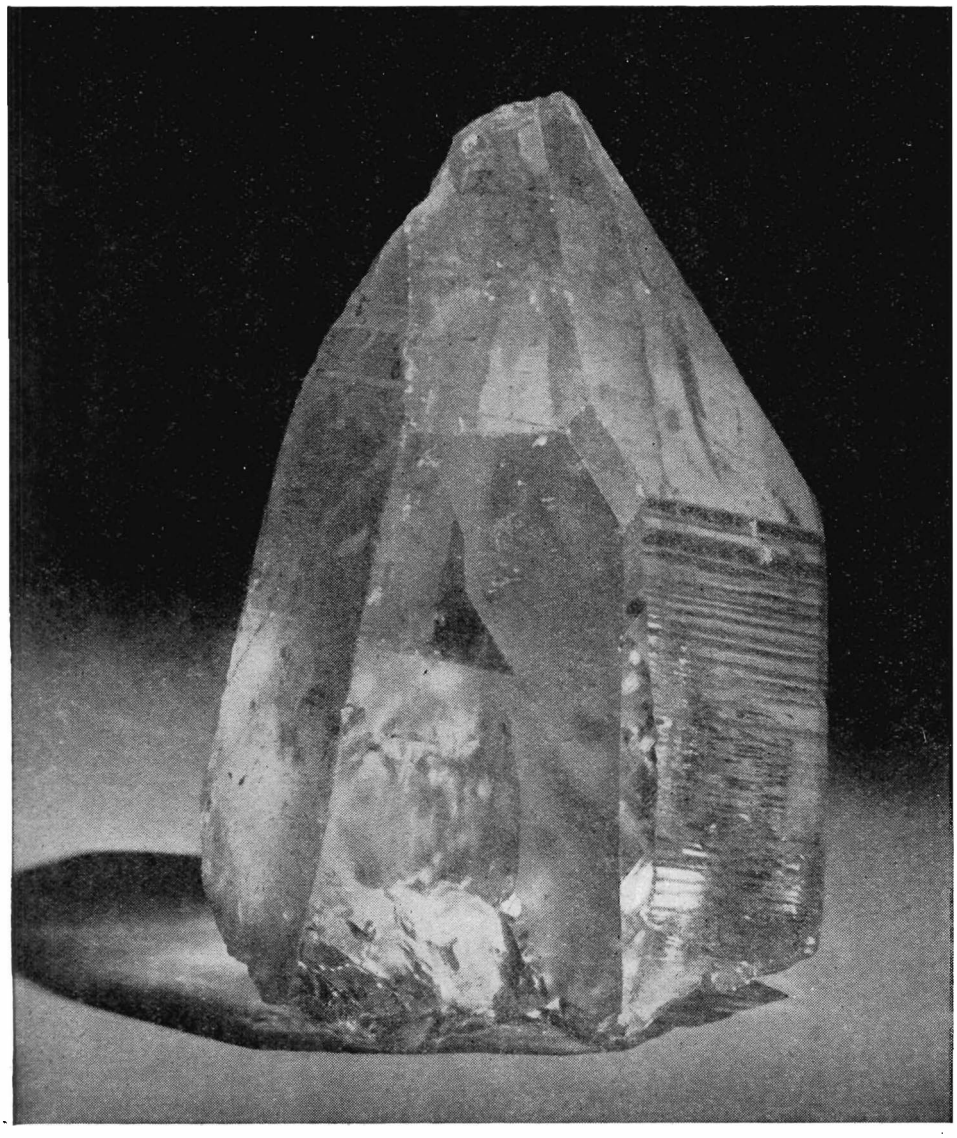
L. 733/S forms the outlet socket and a cable clamp is incorporated. Leads may be looped in.

AUTOMATIC POLAR DIAGRAM PLOTTER

Also on view is a very interesting working exhibit of an automatic polar diagram plotter. This apparatus was developed by " Belling-Lee " to speed up the development of television receiving aerials.

This apparatus is based upon a modification of the well known Servograph developed and manufactured by Fieldon (Electronics) Ltd., Wythenshawe, near Manchester.

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



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MEETINGS THIS MONTH

INSTITUTION OF ELECTRICAL ENGINEERS

Unless otherwise stated, all London meetings are held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2, at 5.30 p.m.

Measurements Section

Date: April 3.
Lecture: An Electronic Process-Controller.
By: J. R. Boundy, B.Sc., and S. A. Bergen, M.B.E.
Date: April 17.
Discussion: Humidity Measurement and Control.
Opened by: L. Hartshorn, D.Sc., and Professor H. S. Gregory, Ph.D.

Radio Section

Date: April 11.
Lecture: A V.H.F. Field-Strength Survey on 90Mc/s.
By: H. L. Kirke, C.B.E., R. A. Rowden, B.Sc.(Eng.), and G. I. Ross.
Lecture: The Propagation of Metre Radio Waves beyond the Normal Horizon—Part I: Some Theoretical Considerations, with particular reference to Propagation over Land.
By: J. A. Saxton, Ph.D., B.Sc.
Lecture: The Propagation of Metre Radio waves beyond the Normal Horizon—Part II: Experimental Investigations at Frequencies of 90 and 45Mc/s.
By: J. A. Saxton, Ph.D., B.Sc., G. W. Luscombe, B.Sc., and G. H. Bazzard, B.Sc.

Date: April 2.
Lecture: The Automatic Monitoring of Broadcast Programmes.
By: H. B. Rantzen, B.Sc.(Eng.), F. A. Peachey, and C. Gunn-Russell, M.A.

Date: April 23.
Discussion: The Trend of Design of Television Receivers.
Opened by: A. J. Biggs, Ph.D., B.Sc.

District Meetings

Date: April 2. Time: 7.30 p.m.
Held at: The New Inn, Sandling Road, Maidstone.
Lecture: Fifty Years' Development in Telephone and Telegraph Transmission in Relation to the Work of Oliver Heaviside.
By: W. G. Radley, C.B.E., Ph.D.(Eng.).

North-Eastern Centre

Date: April 24. Time: 7 p.m.
Held at: The City Hall, Newcastle-on-Tyne.
Lecture: Faraday Lecture on Lamps and Lighting—A Record of Industrial Research.
By: L. J. Davies, M.A., B.Sc.

North-Western Centre

Date: April 10. Time: 6.15 p.m.
Held at: The Engineers' Club, Albert Square, Manchester.
Lecture: The London-Birmingham Television Radio-Relay Link.
By: R. J. Clayton, M.A., D. C. Espley, O.B.E., D.Eng., G. W. S. Griffiths and J. M. C. Pinkham, M.A.

North-Western Radio Group

Date: April 4. Time: 6.30 p.m.
Held at: The Engineers' Club, Albert Square, Manchester.
Discussion: Electronic Computors.
Opened by: Professor F. C. Williams, O.B.E., D.Sc., D.Phil.

Northern Ireland Centre

Date: April 10. Time: 6.45 p.m.
Held at: Queen's University, Belfast.
Lecture: Modulation.
By: T. P. Allen, M.Sc.

Scottish Centre

Date: April 27.
Held at: Central Halls, Edinburgh.
Lecture: Faraday Lecture on Lamps and Lighting—A Record of Industrial Research.
By: L. J. Davies, M.A., B.Sc.

South Midland Centre

Date: April 2. Time: 6 p.m.
Held at: James Watt Memorial Institute, Great Charles Street, Birmingham.
Lecture: The Determination of Time and Frequency.
By: H. M. Smith, B.Sc.
Date: April 3. Time: 7 p.m.
Held at: The Winter Gardens, Malvern.
Discussion: The Trend of Design of Television Receivers.
Opened by: A. J. Biggs, Ph.D., B.Sc.
Joint Meeting with South Midland Radio Group.

SECRETARIES OF ASSOCIATIONS

INSTITUTION OF ELECTRICAL ENGINEERS

The Secretary, Institution of Electrical Engineers, Savoy Place, W.C.2.

Cambridge Radio Group

G. E. Middleton, M.A. University Engineering Laboratory, Cambridge.

North-Eastern Radio and Measurements Group

G. A. Kysh (Asst. Sec.), Carliol House, Newcastle-on-Tyne, 1.

North-Western Radio Group

A. L. Green (Asst. Sec.), 244 Brantingham Road, Chorlton-cum-Hardy, Manchester, 21.

South Midland Radio Group

W. H. Brent, B.Sc., Regional Director's Office, Midlands Region (G.P.O.), Civic House, Great Charles Street, Birmingham, 3.

BRITISH INSTITUTION OF RADIO ENGINEERS

The General Secretary, 9 Bedford Square, London, W.C.1.

West Midlands Section

R. A. Lampitt, A.M.Brit.I.R.E., 20 Northfield Grove, Merry Hill, Wolverhampton.

INC. RADIO SOCIETY OF GREAT BRITAIN

General Secretary, New Ruskin House, Little Russell Street, W.C.1.

BRITISH SOUND RECORDING ASSOCIATION

Richard W. Lowden, "Wayford," Napoleon Avenue, Farnborough, Hants.

TELEVISION SOCIETY

Lecture Secretary: T. M. Lance, 180 Bromley Road, Beckenham, Kent.

Engineering Group

G. T. Clack, 10 Tantallon Road, Balham, London, S.W.12.

RADAR ASSOCIATION

The Secretary, 83 Portland Place, London, W.1.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

W. H. Fox, A.M.I.E.E., Engineer-in-Chief's Office (T. P. Branch), Alder House, E.C.1.

INSTITUTION OF ELECTRONICS

Lecture Sec.: W. Summer, 31 Beech Road, Bournville, Birmingham, 30.

North-West Branch

W. Birtwistle, 17 Blackwater Street, Rochdale, Lancs.

SOCIETY OF RELAY ENGINEERS

T. H. Hall, M.Brit.I.R.E., 23 Dalkeith Place, Kettering, Northants.

SOCIETY OF INSTRUMENT TECHNOLOGY

L. B. Lambert, 55 Tudor Gardens, London, W.3.

Southern Centre

Date: April 4. Time: 6.30 p.m.
Held at: The Technical College, Weymouth.
Lecture: Crystal Diodes.
By: R. W. Douglas, B.Sc., and E. G. James, Ph.D.
Lecture: Crystal Triodes.
By: T. R. Scott, D.F.C., B.Sc.

BRITISH SOUND RECORDING ASSOCIATION

Date: April 20. Time: 7 p.m.
Held at: Institution of Electrical Engineers, Savoy Place, W.C.2.
Lecture: The Design of Magnetic and Dynamic Pick-Ups.
By: H. J. Leak, M.Brit.I.R.E.

RADIO SOCIETY OF GREAT BRITAIN

Date: April 27. Time: 6.30 p.m.
Held at: Institution of Electrical Engineers, Savoy Place, W.C.2.
Lecture: Low Power Portable Equipment.
By: A. O. Milne.

SOCIETY OF RELAY ENGINEERS

Date: April 24. Time: 2.30 p.m.
Held at: The Gaumont British Large Theatre, Film House, Wardour Street, London, W.1.
Lecture: The Savage Automatic Monitoring System, including the Telemonitor for Fault Signalling, Remote Listening, Programme Restoration and Telephone Facilities.
By: P. Taylor.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Date: April 18. Time: 5 p.m.
Held at: The Conference Room, 4th Floor, Waterloo Bridge House, S.E.1.
Lecture: Training for Management.
By: D. G. Dafforn, B.Sc., A.M.I.E.E.

SOCIETY OF INSTRUMENT TECHNOLOGY

Date: April 24. Time: 7 p.m.
Held at: Manson House, Portland Place, London, W.1.
Lecture: Human Control Systems.
By: Sir Frederic Bartlett.

North-West Section

Date: April 11.
Lecture: The Measurement of *p*H.
By: A. D. E. Lauchlan, M.A.

INSTITUTION OF ELECTRONICS

Midlands Branch

Date: April 3.
Held at: The Warwick Room, Imperial Hotel, Temple Street, Birmingham 2.
Lecture: F.M. Measuring Equipment.
By: E. D. Hart, M.A. and A. G. Wray, M.A.

Southern Branch

Date: April 4. Time: 7.30 p.m.
Held at: Signal School, Royal Marine Barracks, Eastney, Portsmouth.
Lecture: Some Applications of Infra-red Radiations.
By: R. A. M. Bound, Ph.D., B.Sc., A.Inst.P.

TELEVISION SOCIETY

Engineering Group

Date: April 12. Time: 7 p.m.
Held at: C.E.A., 164 Shaftesbury Avenue, W.C.2.
Lecture: Ferguson Television Receivers.
By: R. E. Norman, M.A.

Main Group

Date: April 27. Time: 7 p.m.
Held at: C.E.A., 164 Shaftesbury Avenue, W.C.2.
Lecture: Time Bases.
By: J. E. Rhys-Jones.

BRITISH INSTITUTION OF RADIO ENGINEERS

Date: April 26. Time: 6.30 p.m.
Held at: School of Hygiene and Tropical Medicine, Keppell Street, W.C.1.
Lecture: An 8-Channel Transmitter for an Experimental Carrier Wire-Broadcasting System.
By: R. G. Kitchenn, B.Sc.(Eng.).

North Western Section

Date: April 11.
Held at: College of Technology, Manchester.
Lecture: Frequency Modulation and F.M. Measuring Equipment.
By: E. D. Hart, M.A. and A. G. Wray, M.A.

Notes from the Industry

An Atomic Energy School to teach workers in industrial and medical laboratories how to use radioactive materials is to be set up at the Atomic Energy Research Establishment at Harwell.

The first course, lasting six weeks, begins on April 2, and will be in charge of Dr. J. E. Johnston, of Harwell's Isotope Division.

The school has been set up, states the Ministry of Supply, because the rapid increase in the use of British radio-isotopes has led to a widespread demand for further education in their applications.

It will give students of graduate level detailed instruction in the fundamental, practical and theoretical problems encountered, when radio-active materials are used in the quantities employed in a normal laboratory.

They will learn methods of handling radio-active materials as they are received from Harwell, and also the difference between isotopes of various substances. This will help to guard against the ordering of unsuitable substances by industrial and medical users.

The students will be taught how to measure radio-activity with a geiger counter and scaler, and how to use scintillation counters, ionization chambers and photographic methods for radiography and radioautography. The experiments they will carry out will give them ample experience of the methods of radiochemistry.

There will be from 12 to 18 lectures in the course, each given by a specialist from Harwell. The syllabus will be varied slightly to meet the needs of the majority of students present.

Fees for the course will be £40. Laboratory coats, protective shoes and notebooks will be provided. The school will be held in a building outside the security fence at Harwell, and no special security restrictions will be necessary.

Living accommodation at one of the A.E.R.E. hostels for senior staff will be available. The charge for this will be £5 5s. 0d. per week.

Further particulars of the school are available from Dr. J. E. Johnston, Isotope Division, A.E.R.E., Harwell, Berks.

Holme Moss Television Station.—The B.B.C. had hoped that the new television station at Holme Moss would be opened by the middle of 1951. However, it was always realized that this would depend to a large extent on the weather and on the prompt delivery of materials and equipment. Work on the 750-foot mast, which is on a very exposed site over 1,700 feet above sea level, has in fact been delayed by the weather and difficulties are occurring in the delivery of equipment. Subject to there being no further unavoidable delays it is hoped to start preliminary transmissions on medium power in July. These medium-power transmissions will not, of course, give the full coverage which will later be obtained on full power, and reception will be more susceptible to interference.

It is hoped that transmission of normal programmes on full power will begin towards the end of September, but this must depend on completion dates being fulfilled by the contractors concerned.

A Convention on Television.—The Council of The Institution of Electrical Engineers has agreed that a Convention to be known as "The British Contribution to Television" should be held at the end of April, 1952.

This date has been chosen to give authors ample time in which to prepare their papers, and to avoid following too closely on the Joint Engineering Conference (June 4-15, 1951), one session of which will be devoted to a survey paper on television.

The organization of the Convention is being undertaken by the Committee of the Radio Section, who have appointed a Convention Sub-Committee.

It is intended that the Convention shall consist of the reading and discussion of a number of papers, supported by demonstrations, together with visits of inspection to appropriate organizations. The Convention will probably last five days.

B.R.E.M.A. Annual Meeting.—At the Annual General Meeting on Friday, February 23, Mr. P. H. Spagnoletti was elected Chairman of the British Radio Equipment Manufacturers' Association in succession to Mr. M. M. Macqueen, who has been ill. Mr. E. K. Balcombe was elected vice-chairman.

Council members elected were: A. J. Balcome, Ltd.; Bush Radio, Ltd.; E. K. Cole, Ltd.; A. C. Cossor, Ltd.; English Electric, Ltd.; General Elecric Co., Ltd.; Gramophone Co., Ltd.; Kolster-Brandes, Ltd.; McMichael Radio, Ltd.; Philips Electrical, Ltd.; Pilot Radio, Ltd., and Ultra Electric, Ltd.

May, 1951, Brit. I.R.E. Graduateship Examination.—The next Graduateship Examination will be held on Wednesday, Thursday and Friday, May 16, 17 and 18, 1951, at 38 centres throughout the world. Entries from home candidates must be lodged with the Institution by April 1, 1951.

Arrangements have already been made for 234 overseas candidates at centres in Australia, Canada, Guatemala, India, Malaya, New Zealand, Pakistan and South Africa.

Further details and specimen examination papers may be obtained on application to the Secretary, 9 Bedford Square, London, W.C.1.

Aspects in the Design and Manufacture of Planar Grids for Triodes at U.H.F. The author has drawn our attention to a mistake which occurred in Equation 8 on page 96 of the March, 1951 issue. It should read:

$$D_2 = D_1 \sqrt{\left\{ \frac{d_2 K_2 Y_1 a_1}{d_1 K_1 Y_2 a_2} \left[\frac{\tau_2 + \epsilon_2}{\tau_1 + \epsilon_1} \right] \right\}} \quad \ldots(8)$$

PUBLICATIONS RECEIVED

BRITISH STANDARD FOR ELECTROPLATED COATINGS OF NICKEL AND CHROMIUM ON STEEL AND BRASS (B.S. 1224:1945). A memorandum has been added to this standard so that manufacturers can make the best use of nickel, which is now in very short supply. Attention is drawn to the Note on page 7, relating the standard classifications, according to which the minimum deposit thickness may be a composite deposit of nickel and copper. The British Standards Institution, 24/28 Victoria Street, S.W.1.

EDISWAN MAZDA VALVES 1949-50. This booklet is a condensed version of the Ediswan loose-leaf valve manual containing that part of the manual which has been added between February 1949 and February 1950. It is obtainable from the Radio Division, The Edison Swan Electric Co. Ltd., 155 Charing Cross Road, W.C.2.

ELECTRICAL AND MUSICAL INDUSTRIES LTD. NINETEENTH ANNUAL GENERAL MEETING. This well produced brochure gives an account of the nineteenth annual general meeting of the Company, and includes the address by Sir Alexander Aikman; C.I.E. Electrical and Musical Industries, Ltd., Hayes, Middlesex.

DIESEL ENGINE STARTING BATTERIES is the new illustrated catalogue dealing with Exide batteries for diesel engine starting, and can be obtained from Chloride Batteries Ltd., of Clifton Junction, near Manchester.

ANNEALING OF WHITEHEART MALLEABLE CASTINGS: SOME ASPECTS OF THE GASEOUS PROCESS is a booklet by Dr. F. Schulte, of Birlec Ltd. It has been previously printed in the Journal of Research and Development of the British Cast Iron Research Association. Birlec Ltd., Erdington, Birmingham 24.

MONEL, NICKEL AND INCONEL. In continuation of their policy of issuing practical instructions for the fabrication of high nickel alloys, Messrs. Henry Wiggin and Co. Ltd., of Wiggin Street, Birmingham 16, have just published a comprehensive handbook dealing with the hot-working, annealing and pickling of nickel, monel and inconel.

LOW CURRENT TUBULAR RECTIFIERS. This is a well illustrated and produced catalogue describing the Sentercel low current tubular rectifiers manufactured by Standard Telephones and Cables Ltd., of Connaught House, Aldwych, London, W.C.2.

DC 200 FLUIDS is a booklet describing only the liquid methyl silicones of the D.C. 200 range. Several other D.C. silicone fluids are described in detail in separate publications. Midland Silicones Ltd., 49 Park Lane, London, W.1.

CLIX RADIO, TELEVISION AND ELECTRONIC COMPONENTS. This well produced catalogue covers the range of Clix components from radio plugs to pin protectors for valves, and is profusely illustrated. The material is presented clearly, and copies of the catalogue will be available at the R.E.C.M.F. Exhibition from the stand of British Mechanical Productions Ltd., 21 Bruton Street, London, W.1.

TELEVISION FEEDER CABLE. Folder 474, published by W. T. Henley's Telegraph Works Co. Ltd., 95 Aldwych, W.C.2, describes their television feeder cables. In addition it gives some brief notes on choosing the most suitable type of cable for local and fringe areas.

VACUUM is a new journal reviewing developments in vacuum research and engineering. The articles, news and practical columns, together with the international literature abstracts, which are classified and printed for detached filing, provide information for scientists and industrialists on this subject. The Editor is H. L. J. Burgess, and the journal is published by W. Edwards & Co. (London) Ltd., Worsley Bridge Road, Lower Sydenham, London, S.E.26, to whom further enquiries should be addressed.

CORRECTION—RADIO MATERIALS CATALOGUE. This catalogue, mentioned in last month's column, was originally published in April, 1950, and Messrs. B.I. Callender's Cables Ltd. now inform us that it is out of print.

BOOK REVIEWS (Continued)

ception rather than the rule, and the book does form an excellent text for the study of "Basic Television." If the treatment is not deep it is intelligible, usually accurate, and extensive. The beginner cannot fail to benefit from reading this book, a remark which your reviewer would hesitate to make about some less worthy texts, but he will see the subject solely through the eyes of an American.

EMLYN JONES

Testing Radio Sets

By J. H. Reyner. 215 pages. Chapman and Hall Ltd. 5th (revised) Edition. 1950. Price 22s. 6d.

HOW easy would be the book reviewer's lot if all books he encountered had the finished polish of one by J. H. Reyner! In this case, of course, it is made doubly easy because the volume itself is sufficiently well known to need no introduction to the majority.

The author says: "I have therefore endeavoured to present the fundamental principles of set testing, including a certain amount of design information to assist the reader's understanding and so help him in the exercise of deductive reasoning, which is the basis of servicing."

So if your business or pleasure is radio servicing and you prefer the use of deductive reasoning to the good-swift-kick method of fault clearing, this book is for you.

Electromagnetic Fields: Theory and Applications. Volume I—Mapping of Fields

By Ernst Weber. 590 pps. 1st Edition. Chapman and Hall Ltd., 1950. Price 80s.

THIS book by the Professor of Electrical Engineering at Brooklyn Polytechnic Institute, deals primarily with electrostatic and magnetostatic fields, but many of the results may be readily applied to other types of potential field. The most important chapters are those devoted to the analytical solutions of two and three dimensional field problems and comprehensive accounts of the various available methods are given. The claim on the dust cover that the coverage of conformal mapping is equalled by no other book is certainly justified. The emphasis in the chapter on three dimensional solutions is on the separation of Laplace's equation in orthogonal coordinates.

Although the book is mostly devoted to theory there is a chapter on experimental methods for investigating field patterns and this includes a useful section on the electrolytic tank, which is now being used in several fields. Despite the large number of analytic solutions available there are still only too frequently problems which can only be solved by numerical methods: a chapter on these deals both with graphical methods for obtaining an approximate picture of the distribution and with more elaborate methods such as the relaxation technique.

The professed object of this book is to provide a comprehensive treatise suitable for study by a graduate class. The author has succeeded in his aim, but has included much material which is already freely available elsewhere. In particular the bulk of the material in the chapter on the fields of simple geometries should already be familiar to the class of reader for which the book is intended.

This is definitely not a book for someone approaching the subject for the first time but will be a valuable reference work for the research worker. It is supplied not only with an extensive bibliography but with innumerable footnote references to original papers. It is well illustrated with sketches of the field patterns discussed.

J. BROWN

Radar Simply Explained

By R. W. Hallows. 190 pp. 2nd Edition. Chapman and Hall Ltd., 1950. Price 10s. 6d.

THE second edition of Major Hallow's book "Radar Simply Explained" incorporates some applications of radar which have come off the secret list since the first edition was published.

Details are given of the method of measuring range with a high degree of accuracy, and the application of radar to navigation. Three chapters have been largely re-written and illustrations of the latest radar equipment are shown.

The success of this book is evident in the fact that it has been translated into German, Czech, Danish, Norwegian, French and Polish.

TV Installation Techniques

By Samuel L. Marshall. 330 pages. John F. Rider, Publisher, Inc. 1950. Price $3.60.

THIS most comprehensive work covers the field indicated by its title right from "The Nature of Television" to Chapter 41½ of the City Code Ordinance of Greensboro, North Carolina, in the municipal building codes section. Unfortunately most of the material is of interest only to American readers, as the systems and techniques described have little in common with those in use in this country.

Many clear diagrams and photographs are included, those showing the effect on the test picture of incorrect positioning of controls being especially helpful.

After reading this book the mystery of "large circle" television receivers is a mystery no longer. Apparently the sets are maladjusted to give an aspect ratio of 1:1, and the fact that the test circle and the picture generally become elongated is thought not to be terribly important!

The Quarterly Journal of Mechanics and Applied Mathematics

Volume 3, Part 1 (March, 1950). Oxford University Press. Price 12s. 6d.

IF a uniform circular disk is placed perpendicular to a varying magnetic field, currents are induced in it whose distribution over the disk can be found. In this issue, Mr. Ashour solves this problem and applies the results to find the currents induced in a large area of sea water. This is of interest when sorting out the origins of the variations of the earth's magnetic field. The conductance is very low and the results are not necessarily valid for a disk of much greater conductance. He finds that the current oscillates with the frequency of the applied field (once per day!) and its amplitude is almost proportional to the distance from the centre. The phase is approximately the same everywhere, and is in advance of the field by 70°. A further problem considered is the decay of currents when the excitation is removed.

Also of some general interest in this journal are two papers on the evaporation of lakes by wind.

G. J. KYNCH.

The Quarterly Journal of Mechanics and Applied Mathematics

Volume 3, Parts 2 and 3. (June and September, 1950.) Oxford University Press. Price 12s. 6d. each.

I HAVE mentioned previously that this journal contains mainly papers on hydrodynamics and elastic problems. A discussion of these is not of great interest to many readers of electronics but it may be of general interest to indicate the purpose of many papers which have recently appeared.

It is well known that saturation problems in electrical circuits and machines are difficult to handle mathematically. The reason is that the equations for the current or flux are then of the non-linear type, which are far more difficult to solve than linear ones. Exactly the same difficulties arise in the hydrodynamical theory of supersonic flow. For the flow past the almost flat surface of aeroplane wings, however, the overall flow is only altered slightly by the surface, and the non-linear equations can be replaced by linear equations as a first approximation. The results obtained this way agree very well with more exact calculations when these are available. Often the point at which the approximations break down can be estimated.

Such an advantage has to be pressed home in every conceivable way, and the papers under discussion have been doing this not only by solving particular problems using this method, but by producing as many general theorems as possible.

G. J. KYNCH.

Television Receiving Equipment

By W. T. Cocking. 375 pp. 284 diagrams. 3rd Edition. Iliffe and Sons Ltd., 1950. Price 18s.

THE third edition of this book has been brought up to date by its author, and is a useful guide to modern British practice in television engineerng.

The text is largely non-mathematical in treatment, but mathematical matter of particular value to the designer has been collated and appears in appendices.

Apart from the thorough and clear description of each stage of the normal television receiver, details of special circuits are included, and there are additional chapters devoted to faults and their remedies and to servicing modern sets. Another chapter of interest discusses the problem of obtaining selectivity.

cation are considered quite clearly in these two chapters.

Chapter six, on installation, subdivides into: determination of acoustic power required; practical details of installation of various items of equipment, microphone, amplifiers, loudspeakers and wiring. Several typical installations are described in detail to illustrate requirements in auditoria, restaurants, night clubs, churches and outdoors. Consideration is also given to features desirable in a mobile system. This chapter goes as far as possible by reading only toward giving a novice the benefit of extensive experience.

Chapter seven, on servicing, details the equipment required by an engineer, how to localize a fault and to effect the necessary repairs with a minimum interruption of service, according to the type of fault. A number of oscillograph waveforms are given to illustrate the output waveform produced by various faults, but it is felt that the utility of the information given could be increased by a little more explanation showing how the results of different tests can be used to avoid ambiguity in diagnosis and deduce the exact fault without loss of time. While treated generally, this could be more closely linked with the practical waveforms shown.

The book presents a comprehensive survey of most of the facts pertinent to the installation and servicing of public address equipment in a form that is definitely more helpful to the engineer engaged on this type of work than previous publications on the subject.

N. H. CROWHURST

Basic Television

By Bernard Grob. 596 pages. McGraw-Hill, 1949. Price 55s. 6d.

THIS book is described as a "comprehensive course in television receivers and transmitters for radio servicemen and technicians and is designed to bridge the gap between engineering texts and simplified books." Arithmetic and simple algebra are the only mathematics needed. It is the first volume of a recently inaugurated McGraw-Hill "Television Series," and its author is an instructor at R.C.A. Institutes Inc.

There are 25 chapters and 3 appendices. The first 7 chapters deal with various aspects of the television system as a whole. Then chapters 8 to 22 describe the operation of the receiver itself, taking it section by section and explaining the action of each circuit, including aerials and servicing. Chapter 23 is on television broadcasting, chapter 24 on colour television, and chapter 25 on light. The book is profusely illustrated—there must be about an illustration per page—and the circuits given are drawn from current receiver practice.

Mr. Grob's style is careful and unambiguous. He obviously is an experienced teacher. With the mathematical limitations he has set himself it is quite impossible to deal fully with his circuits, yet there are surprisingly few misleading or obscure statements in the book; on the contrary the treatment is in general admirably clear. One notable exception is his treatment of D.C. restoration which is exceedingly laboured.

In scope the book is very wide; it deals with almost every possible topic, and many which might be classed as general communication engineering training. Thus we have a whole chapter on the principles of frequency modulation, and another covering elementary optics. Every chapter is followed by a list of questions, and the three appendices cover the F.C.C. "Standards of good engineering practice," classification of T.V. stations, and a table of frequency allocations from 25 to 30,000Mc/s.

The wideness of scope has to be paid for by a shallowness of treatment in the case of the more difficult parts of the subject. As an example we read on p. 333 "The vertical output transformer matches the impedance of the vertical deflection coils to the impedance of the 6K6GT." While no-one could say this statement is wrong, it gives no clue to the special problems and niceties of design involved in the choice of ratio, and choice of inductance.

Of course, for the purpose of British engineers, there is the usual difficulty that American text-books concern themselves solely with American standards, channels, and methods. While it is an easy matter for the professional engineer to adapt the material to British practice such a course will be difficult, or impossible for the beginner. Thus on p.127 we learn that the superheterodyne type of circuit is always employed, and a study of the two sets of transmission standards will show no reason why this should not apply equally in either system. In fact, however, it is not at all true in this country because we have only one programme available and tuning need only be done once on installation, whereas the American user has a choice of alternative programmes.

The book contains a few errors, for example on p. 42 Fig. 3-6(b) we have a gross misrepresentation of the path of an electron beam undergoing magnetic focusing. We learn on p.152 that tubes with a deflexion angle of 50° are called "wide angle" tubes, whereas this is generally reserved for 70° tubes. In the high voltage source of Fig. 10-10 the grid winding is coupled to the primary winding. Although this is not an error it is bad practice because it results in two possible modes of oscillation. It is better to couple the grid winding to the secondary only. In section 12-14 it is stated that the video amplifier must have a uniform response down to 30c/s. Now either there is D.C. restoration or there is not. If there is not, the video amplifier must have a uniform response down to zero frequency. If there is, then the response must be such that the sag in the transient response to a unit step is small during a line period which need only imply a good response down to about 500c/s. So either way the statement is wrong. Page 224 paragraph 2 implies a similarity between a cathode-follower and a transformer in matching a high-impedance source to a low-impedance load. The analogy is superficial and dangerous. We find on p.354 that the extremely wide band of the vision I.F. is easier to get at a high I.F. than at a low one. This is untrue.

Nevertheless, such errors are the ex-

BOOK REVIEWS

A Short History of Radio-Activity

By T. W. Chalmers. 78 pp., with 34 illustrations. "The Engineer," London, 1951. Price 8s. 6d.

THIS book gives a comprehensive survey of the development and the present state of our knowledge of radioactivity. The therapeutical uses of radium fall outside its scope. Radioactive tracer elements and their ever-increasing importance in medical science and in industry are only briefly dealt with.

The first two chapters deal with the history of uranium and thorium and their compounds, especially also with those used in the manufacture of incandescent gas mantles.

The next two chapters tell the thrilling story of the "Becquerel rays," this discovery of radioactivity and that of the new elements polonium, radium and actinium by the Curies. The vast amount of patient and exhausting work is described, which had to be carried out after a suitable method for measuring radioactivity by the ionization chamber had been developed.

Chapters V-VII deal with the α-, β- and γ-rays and tell how it was found that only the γ-rays are undulatory and resemble the X-rays while the α- and β-rays are corpuscular and are caused by the emission of doubly ionized helium atoms and electrons respectively. A brief explanation of the Geiger counter is contained in Chapted VII.

In Chapters VIII and IX the atomic disintegration theory and the emanations are dealt with and an estimate is made of the amount of emanation in the earth's atmosphere.

Chapters X and XI, dealing with the active deposits of thorium, actinium and radium, contain a brief account of P. Curie's work of excited activity which forms the basis of the present-day tracer technique. Rutherford's qualitative explanation for the different behaviour of excited activity with different lengths of exposure is given. As is shown, three isotopes of lead are the stable end-products of the disintegration of radium, thorium and actinium respectively.

In Chapters XII and XIII the gradual development of the uranium-238 series and the actinium and thorium series is discussed and the modern series are given with the atomic weights and half-lives of the respective elements. Finally, the new elements neptunium and plutonium are mentioned as the outcome of the work done for developing the atomic bomb.

The last chapter is perhaps the most original one. Here, for those possessing only little mathematical knowledge, the theory of spontaneous atomic disintegration is made plausible by some simple financial analogies and thus e.g. a confirmation is expounded for Rutherford's explanation mentioned above.

The book forms a sequel to the author's "Historic Researches," reviewed in the February 1950 issue of "Electronic Engineering," and is characterized by the same lucidity of style and well-chosen illustrations.

R. NEUMANN

Installation and Servicing of Low Power Public Address Systems

By John F. Rider. 208 pp., 103 figs. John F. Rider Publisher, Inc. Price $1.89.

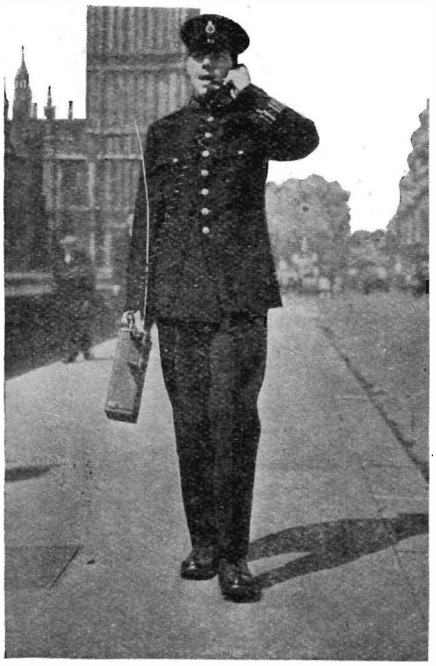
MR. RIDER has collected much information together in this book that will be of use to firms or individuals engaged in public address installations and servicing. The first five chapters deal with principles in a practical way, showing how to interpret manufacturers' specifications in relation to the needs of a particular application, while the last two chapters give typical examples of actual installations and servicing faults encountered.

Chapter one is an introduction to the fundamental quantities used in sound measurement, and the factors entering into the problems of the P.A. engineer. In considering attenuation with distance, however, the author does not make the distinction clear between reduction in level due to application of the inverse square law, and that due to absorption of energy by the medium. In view of the detail given in other respects, it is felt that this should have been clarified. An error that is repeated is that of expressing a pressure ratio of 3.10^6, or a power ratio of 10^{13} as equivalent to 120db.

Chapter two describes different types of microphone, pick-up and radio tuner, together with typical specifications for each type, instructions and examples on methods of connexion and use, cable requirements and effects upon performance. While it is agreed that under certain circumstances the phase angle of impedances is unimportant in P.A. work, it is unfortunate that the author takes examples to illustrate calculations in which the effect of phase completely invalidates the figures he obtains—a figure quoted as 0.424db should be of the order of 0.01, and a value given as 1,938db is actually 0.263, when the correct formula is used. The information on the moving coil pick-up is rather short, and it is felt the intermodulation should have received mention along with the other forms of distortion for which pick-ups are responsible.

Chapter three gives simple methods of calculating the matching arrangements for loudspeaker circuits, so as to distribute the power according to any desired requirements, using either high or low impedance distribution. While it is not technically accurate to refer to optimum load impedance in the plate circuit of the output stage as source impedance, it may avoid confusion for the purposes of this book. However, it is wondered whether the effect of the true source impedance upon resultant quality is not of sufficient importance to receive attention, as the treatment is otherwise very comprehensive.

The next two chapters deal with amplifier specifications and types of loudspeakers and their applications respectively. General characteristics of various types, and the features to look for in choosing components for any given appli-



can be screened, wound into a close coiled formation which extends up to 600 per cent of its normal length and is self-retracting.

Reliance Electrical Wire Co., Ltd.,
Fingal Works,
Staffa Road,
Leyton, London, E.10.

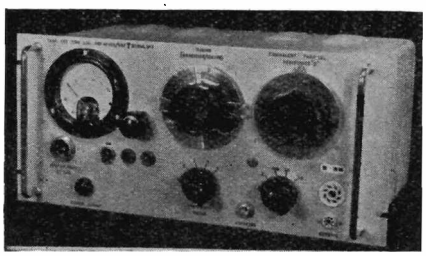
Quartz Crystal Activity Test Set

(Illustrated below)

THE G.E.C. Quartz Crystal Test Set is designed to permit the equivalent parallel resistance to be measured directly at input circuit capacitances of 20pF, 30pF or 50pF. The accuracy is better than 5 per cent for crystals having frequencies in the range 3Mc/s to 10Mc/s, and it can be used for crystals between 1Mc/s and 20Mc/s at slightly lower accuracy.

The test set can also be used to measure the dynamic resistance of parallel tuned circuits having resonant frequencies in the range 1Mc/s to 20Mc/s. It can therefore be used for many of the measurements normally made by a Q meter, and since it reads dynamic resistance directly without calculation its use frequently simplifies testing.

The range of activity measurement is 4kΩ to 130kΩ. The accuracy of loss dial calibration is ±2 per cent, with an accuracy of loss measurement of ±5 per cent for frequencies in the range 3Mc/s to 10Mc/s, and ±7 per cent for frequencies in the range of 1Mc/s to 20Mc/s.



Salford Electrical Instruments, Ltd.,
Silk Street,
Salford, 3, Lancs.

Television E.H.T. Voltmeter

(Illustrated top right)

SANGAMO WESTERN, LTD., have produced a new E.H.T. voltmeter, which is not yet fully in production.

The voltmeter is of the moving coil type, with a 2.8in. boldly figured scale to facilitate reading under difficult conditions. The sensitivity of 20,000 ohms per volt means that the current drain is approximately the same as a cathode ray tube, and readings should be taken with the tube disconnected to approximate normal working conditions.

It is magnetically and electrically shielded, and has a range of 0-7,500 volts D.C. Its leads are made of ignition type cable, and permanently connected to the instrument. The positive lead has a shrouded prod and the negative lead has a clip

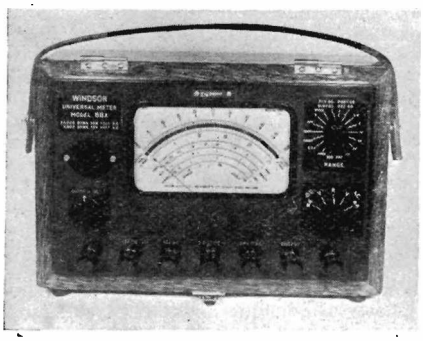
Sangamo Weston, Ltd.
Great Cambridge Road,
Enfield, Middx.

Windsor Universal Meter Model 88A

ILLUSTRATED below is the Windsor Universal Meter Model 88A which features a single mirrored 4in. linear scale for all ranges and overload protection.

The instrument has the following accuracy ranges: 2 per cent of full scale except for 5kV for D.C.; 4 per cent of full scale for A.C., and 6 per cent of the full scale for 5kV. It has a sensitivity of 20,000 ohms per volt D.C. and 2,000 ohms per volt A.C. It has 85 ranges including four ohms ranges varying from 1 to 5 megohms and a buzzer for continuity tests.

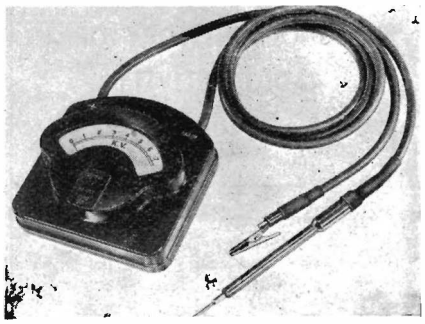
Taylor Electrical Instruments, Ltd.,
419/424 Montrose Avenue,
Slough, Bucks.



R.F. Cables

IN addition to the present range of television down lead cables, Telcon will be exhibiting both solid and air spaced low loss cables and accessories suitable for operation at frequencies as high as 10,000Mc/s per second.

The latest type of air spaced coaxial cable has as a spacer a helical membrane of Telcothene applied edge-on around the inner conductor. The outer conductor is



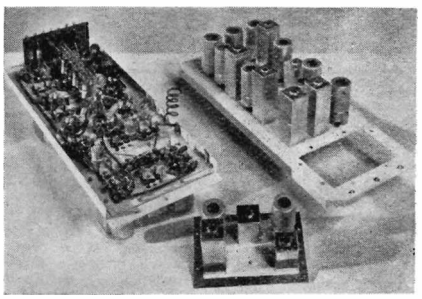
a seamless aluminium tube cold drawn down on to the helix and provides very adequate screening and waterproof protection. An effective dielectric constant of 1.08 is thus obtained in a robust and special construction with a high degree of uniformity.

Another Telcon new development is a mumetal powder for cores for operation at carrier frequencies particularly in the telecommunication field.

The Telegraph Construction & Maintenance Co., Ltd.,
Telcon Works, London, S.E.10.

Television R.F. Strip

AMONG the newly introduced components to be exhibited is the Television R.F. Strip manufactured by the Weymouth Radio Manufacturing Co., Ltd.



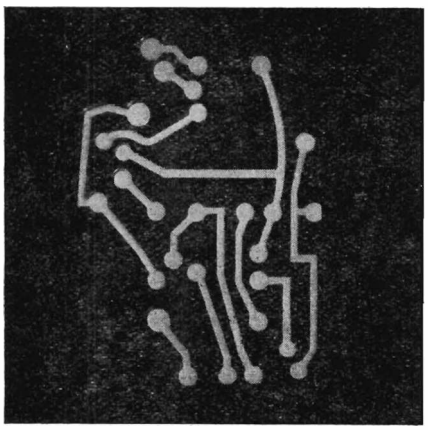
From a technical view-point the television unit has several interesting features. It is a complete vestigial sideband superhet unit of high performance using standard type B.7.G valves. The layout comprises two R.F. stages, oscillator/mixer, one common I.F.—two sound I.F's., sound detector, and noise limiter—two vision I.F's., Video detector, spot limiter, Video amplifier and Sync. separator. The R.F. and oscillator stages are mounted on a rapidly interchangeable sub-chassis which enables maximum performance to be achieved on all channels.

The receiver has an overall vision response better than 3Mc/s and the sound I.F. bandwidth is approximately 200kc/s. The sensitivity for 1 volt D.C. at the Video amplifier grid is 10 microvolts when aligned for fringe area use (it is normally in excess of this on the lower frequency channels). Two stages of sound rejection are employed giving −40db to −50db, dependent on I.F. bandwidth required.

Weymouth Radio Manufacturing Co., Ltd.,
Crescent Works,
Weymouth, Dorset.

"Helvin" is more economical, and the components are also tropicalized.

Hellerman Electric, Ltd.,
Tinsley Lane,
Crawley,
Sussex.



Printed Circuits

(Illustrated above)

A. H. HUNT, LTD., in conjunction with Ward, Blenkinsop & Co., Ltd., the well-known industrial chemists, have made further developments in the technique of printed circuits on plastic bases.

Improvements in the process have resulted in a definite adhesion of the metallic elements to the plastic material and have made the process of soldering connexions to it much less critical, although, as with all printed circuits on plastic, some care is needed in order to prevent damage to the plastic base. It is recommended that low wattage soldering irons, preferably of the pencil type, be used in conjunction with 60/40 solder.

One of the advantages of the process is that the equipment necessary for producing the circuit does not involve heavy tooling charges. Experimental and production tooling costs can be met at the expense of a few pounds.

The primary development has been with the use of high grade phenolic laminated sheet, but the process has been applied successfully to other plastic materials, and it will be seen that the possible applications are widespread. Further development to make full use of the process is well in hand.

Further information is available on request to Hunts.

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

Rubber Mouldings and Components

HIGH quality mouldings and components in rubber are to be exhibited by Long and Hambly, Ltd., together with a comprehensive range of masks for television tubes. The latter are now being finished with a Latex based lacquer, which, besides possessing a matt finish, has adhesive properties.

Long and Hambly, Ltd.,
Slater Street,
High Wycombe,
Bucks.

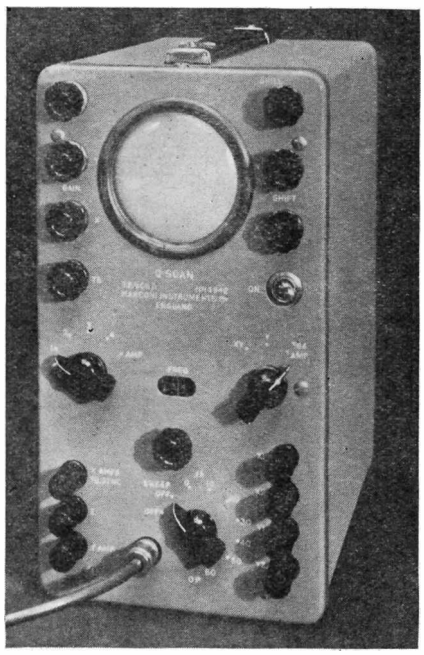
Q Scan Portable Alignment Oscilloscope

(Illustrated below)

THE Q scan type TF 966/1 is a portable alignment oscilloscope for the visual checking and lining up of television receivers; it also includes all the normal oscilloscope facilities required for laboratory and test room use.

The main components of the X-amplifier are rearranged by switching to form a time-base of variable frequency. The time-base output is used to frequency-modulate a R.F. sweep generator, the mean carrier frequency of which is variable over a range embracing the R.F. and I.F. frequencies of normal television receivers. The unit is housed, complete with its A.C. power pack, in a metal case of notably small dimensions, fitted with a convenient carrying handle.

Marconi Instruments, Ltd.,
St. Albans,
Herts.



Morganite Type "F" Switch

MORGANITE Resistors introduce this year a miniature model type "F" to their well-known range of potentiometer switches. This will be available as an alternative to the type "V" switch fitted to the type "A" potentiometer. It is only 19/32 in. deep by 29/32 in. maximum diameter so that the type "A" potentiometer with this switch can be used when there is only 17/32 in. depth behind the panel. It is available as a double or single pole switch. As compared with the type "V" switch which was designed for the stringent Scandinavian insulation requirements, it has smaller insulation clearances in line with American practice, but in reliability and current carrying capacity it stands up excellently on test. It is rated at 1 amp, 250 volts or 3 amps, 10 volts.

All electrical switching points are heavily silver plated and terminal tags are provided with auxiliary locating holes to ensure absence of rotation and consequent deterioration of the electrical contacts. Extremely rapid fly-over of the switch ensures a quick make and break of the electrical circuits and minimizes arcing.

Morganite Resistors, Ltd.,
Bede Trading Estate,
Jarrow,
Co. Durham.

Mullard Projection Television and "World Series" Valves

A WIDE range of picture sizes is made possible by the projection television components also exhibited on the Mullard components stand. In normal cabinet receivers the smallest size is 12¼ in. by 9⅛ in., and the largest 18 in. by 13-7/16 in. Cine-screen pictures can go up to 48 in. by 36 in. Set manufacturers are thus able to meet the now established demand for bigger pictures which can be viewed under normal lighting conditions. The Mullard projection television system comprises an optical unit, a Mullard 2½ in. cathode ray tube MW6-2 with deflexion and focusing coils, and an E.H.T. unit providing a 25kV supply to the cathode ray tube.

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

Zirconium Metal

THE production of Zirconium metal on a commercial scale has recently been initiated by Murex, Ltd. Previously, only very limited supplies of this metal were available in England and even now full production has not yet been attained.

Zirconium will be available in the form of rod, sheet and wire. Apart from its use in the chemical industry on account of its excellent corrosion resistance, and to a certain extent also in surgery for the same reason, Zirconium will be of considerable interest to electronics engineers. It has excellent getter properties which make it of value for all types of vacuum work. It has a high melting point and under the right conditions, can be readily formed. Zirconium is used for grid emission inhibitors and can, in many cases replace tantalum or molybdenum.

This company will also be exhibiting Tantalum metal which was shown for the first time at the 1950 exhibition. In the last year, considerable progress has been made in the production of sheet and wire; sheet can now be rolled down to .004 in. and can be supplied in lengths up to 2ft.

Murex, Ltd.,
Rainham,
Essex.

Extensible Coiled Cords

THE illustration at the top of the next column, first published in ELECTRONIC ENGINEERING, August, 1950. shows the extensible coiled cords, manufactured by the Reliance Electrical Wire Co., Ltd., in use. The cord is used mainly with communications equipment or mains operated apparatus where trailing cables are undesirable, or where storage space is limited.

The cords consist of a length of rubber sheathed flexible with any given number of conductors which, if so desired,

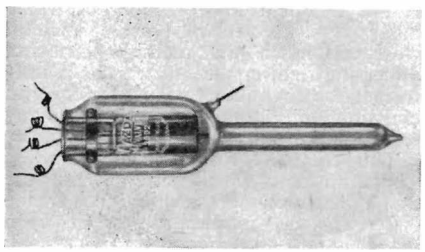
Ediswan Electric Welding Torch

(Illustrated above)

THE Ediswan Electric Welding Torch provides a means of welding materials like polythene and solid P.V.C. without involving complicated and expensive plant. It is portable and requires only to be fed from a compressed air source, or gas cylinder, and connected to a mains supply.

The gas jet temperature, the value of which depends on the material and its gauge, is regulated by means of a valve which is included in the handle of the torch. Earthing of metal parts complies with the standard regulations for portable apparatus.

The approximate temperature of the jet is 250 to 400°C (480 and 750°F). The consumption is 140 watts, with a gas flow of 30-50 cubic feet per hour. The minimum gas pressure is 1 lb. per square inch, and the maximum 10 lb. per square inch. The torch weighs about 1½ lb.



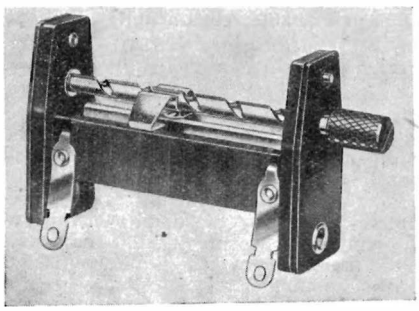
Also illustrated is Valve 29D2 which is a new ionization gauge for measurement and vacuum.

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

Egen Midget Pre-set Variable Resistor

(Illustrated top centre)

EGEN ELECTRIC, LTD., are exhibiting an improved midget pre-set variable resistor. Designed for panel or chassis mounting, it measures 2in. by 1⅛in. by ⅝in. It incorporates a newly designed double slider, actuated by a worm screw, a ratchet action preventing overwinding. The wirewound element is rated for 2½ watts and the solder tags are silver plated. It is available in any value from 10 ohms to 25,000 ohms.



There is also a range of carbon potentiometers which have been developed. Improved stability is claimed for them due to a specialized method of carbon deposition.

Egen Electric, Ltd.,
Charfleet Industrial Estate,
Canvey Island,
Essex.

New Erie Capacitors

THE Erie type 325 stand-off ceramicon is made for high frequency decoupling, and one of its uses is for by-pass application to avoid radiation in television and V.H.F. equipment.

A push-on clip facilitates high speed assembly, or the shell may be soldered directly into a hole in the chassis, and the post terminal provides a sturdy tie-point for several connexions at the terminal height of the average valve holder.

It has a capacitance of 1,500pF ±20 per cent, with a power factor of 2.5 per cent maximum at 1kc/s, and 5V R.M.S. maximum. Its capacitance will not change from its value at 25°C more than +10 per cent or −20 per cent as temperature is varied from −40°C to +85°C.

The Erie type 811 teledisc is a ceramicon offering a maximum capacitance of .01μF on a compact disk only 19/32 in. in diameter, and by virtue of its very small size and shape is easy to install in small spaces, and simplifies and speeds up soldering and wiring operations.

It consists of a flat ceramic dielectric disk with silver plates fired on by Erie's usual method. It is fitted with 0.020 (25 gauge) tinned copper wires firmly soldered to the silver plates, and is coated with the same low loss phenolic as this firm's general purpose ceramicons.

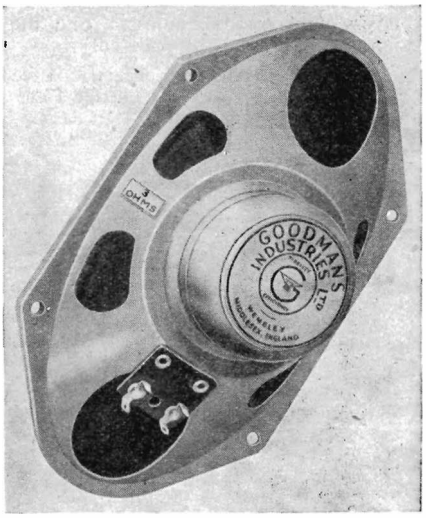
Its standard values are .003μF and .005μF with a k of 3,800 and 0.01μF with a k of 7 800.

Erie Resistor, Ltd.,
Millora Works,
Beevor Road, South Denes,
Great Yarmouth.

Elliptical Speaker Model T22/470

(Illustrated top right)

APART from Goodman's normal range of speakers from 2½in. to 18in., a new introduction is the Elliptical unit model T22/470. This loudspeaker makes it possible to obtain the bass response of a much larger unit, coupled with a more uniform spacing distribution of the higher frequency sound. Its shape makes it particularly adaptable to the more economical cabinet design. Like all Goodman speakers, it is fitted with a specially treated non-hygroscopic diaphragm.



It has a flux density of 7,000 gauss, with a power handling capacity of 2½ watts at peak A.C. The voice coil diameter is ⅞in., and it has an impedance of 3 ohms. It is available with single or multi-ratio output transformer ready mounted.

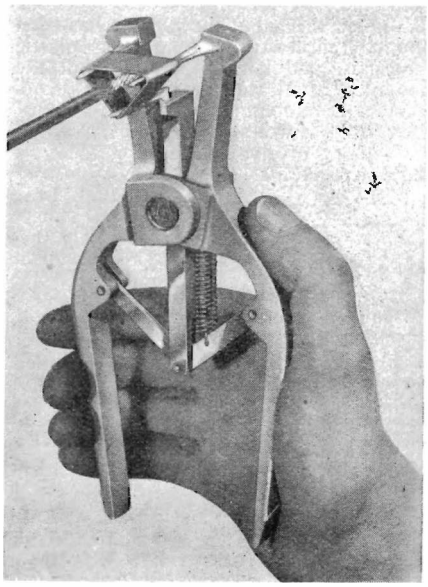
Goodmans Industries, Ltd.,
Lancelot Road,
Wembley, Middx.

Hellermann Tools

(Illustrated below)

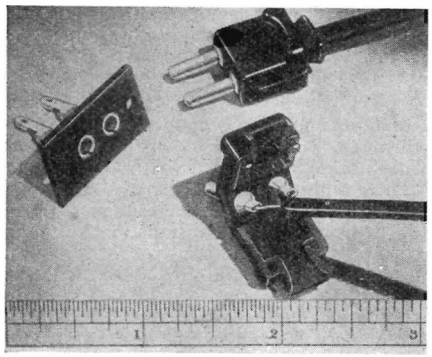
THE Hellermann tool illustrated below is designed for fitting Hellerman P.V.C. and Twinlay sleeves and cable markers. But where large quantities of sleeves or cable markers are being fitted the use of a foot operated tool is recommended.

"Helvin," this firm's elastic type plastic is also available. It is used for insulating shrouds for the anode connexions to C.R.T.s, for shrouding the valve base for insulating valve caps or flexibly mounting tubes and, of course, grommets which previously would have been made from rubber, but the use of



R.E.C.M.F. Exhibition

A selective preview of new components to be shown at the exhibition of the Radio and Electronic Component Manufacturers Federation at Grosvenor House, London, W.1, on April 10—12.



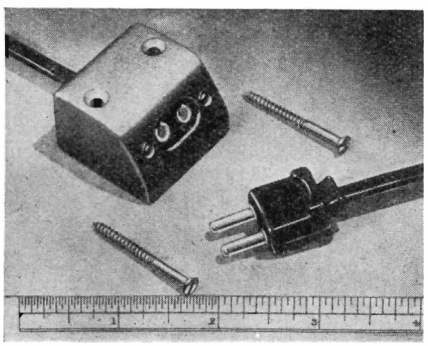
Belling and Lee New Components

THE new Belling and Lee plug, List No. 1.733/P, is specifically designed for unscreened balanced twin feeder as used with television or short wave reception. It fits the appropriate chassis mounting socket L.733/S or skirting board outlet L.739. These are shown above.

The twin feeder is loaded simply by pinching the wires in the spills provided and the ingenious black polythene moulding folds into shape where it is held together by means of the two ball headed studs.

The L.739 Outlet Box, illustrated below, is designed for use with 1.733/P plug and as a skirting board termination for unscreened balanced twin aerial feeder.

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



Bray Electro-Ceramic Insulators

GEO. BRAY & CO., LTD., are exhibiting a very varied selection of their precision made ceramic insulators, made in various bodies for different applications, i.e., some for temperatures up to 1,600°C, others for capacitor dielectrics and in low loss material, as well as the ordinary standard porcelain and steatite. The illustration right shows some typical Bray electro-ceramic insulators.

Geo. Bray & Co., Ltd.,
Leicester Place,
Blackman Lane,
Leeds, 2.

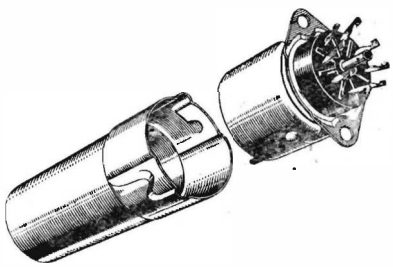
Nylon-Loaded Moulded Valveholders

(Illustrated centre)

CONFORMING to the requirements of R.C.S. Specification 251 for Grade II valveholders, the range of B7G and B9A nylon-loaded moulded valveholders has a wide application in service for high grade commercial equipment.

The combination of "Clix" patented Beryllium Copper Contacts and a nylon-loaded phenolic body moulding ensures good performance under Grade II conditions.

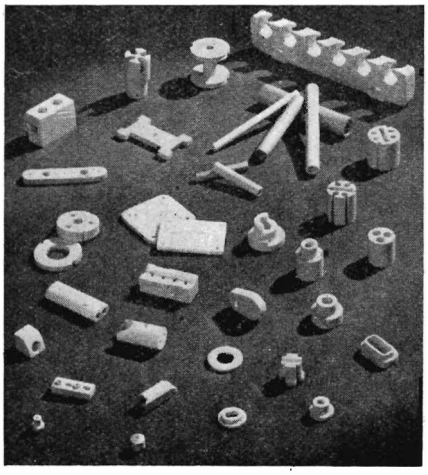
The nylon-phenolic body has low moisture absorption, high surface and volume resistivity, low permittivity and low power losses, while silver plated Beryllium Copper sockets provide good contact with hard or soft valve pins.



The makers claim that the contact resistance and noise level are of the lowest achievable order, and the specified limit figures for insertion and withdrawal forces are attained with a wide margin.

The Grade II range is mechanically interchangeable with, and available in the same variations of socket orientation, skirt, saddle and screen cans as the "Clix-Fluon" Grade I range.

British Mechanical Productions, Ltd.,
in association with
The General Accessories Co., Ltd.,
21 Bruton Street,
London, W.1.



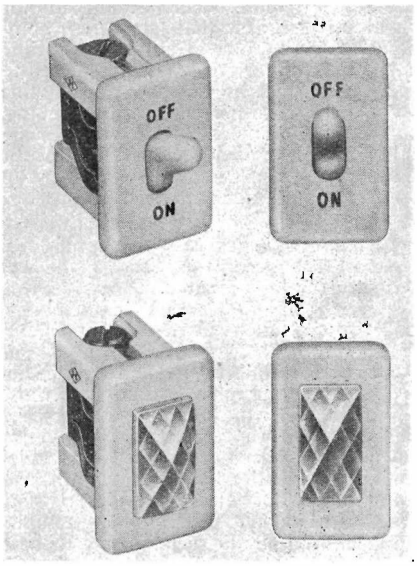
Bulgin New Components

AMONG the Bulgin components to be exhibited will be the following new lines: control knobs, appliance knobs, signal/indicator lamp fittings and fuse-links.

Many new types of Bulgin control knobs are being shown for the first time, including a triple-matching range of new instrument-dial knobs, moulded in the highest grade highly polished thermo-setting bakelite material.

A new set of Bulgin appliance knobs includes small lever and dial types, suitable for wide uses in electrical fields.

New kinds of Bulgin signal- or indicator-lamp fittings are forthcoming, including extensions to existing ranges of models which are well known and well tried, giving a bigger variety of acceptance of different lamp caps.



New Bulgin fuse-links include low-current sensitive fuses operating upon currents as low as 10mA carrying and 20mA blowing. Reasonably robust and comparatively inexpensive, these are precise to rating to an extreme degree, and can be relied upon to protect expensive but sensitive and low-rated or overload-factor instruments in equipment.

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

Toggle Switch and Neon Unit

(Illustrated above)

TWO newcomers to the "Diamond H" range of toggle switches are a small snap-in toggle switch and a neon indicator completely matching in appearance. The toggle switch is a single pole on/off type, and has a rating of 12 amps. 250 VOLTS A.C.

Diamond H Switches, Ltd.,
Gunnersbury Avenue,
London, W.4.

Letters to the Editor

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

Television for Radiomen

DEAR SIR,—In your issue for January, 1951, there appeared a criticism of a book "Television for Radiomen" by Edward M. Noll published by McMillan of New York. The criticism was written by Mr. Emlyn Jones and contained certain statements which I find most disturbing. If they are true, then I have wasted much time and mental energy in attempting to understand electrical vibrations.

I quote from the criticism—"Much more serious, however, are some of the misconceptions such as that on pp. 190 and 193 'The low order and high order harmonics are vested in the leading and trailing edges and flat top of the pulse' and 'The leading edges of a pulse are made up of high frequency components.' Now, in fact, all the components of a periodic waveform are present all the time and contribute to every part of the waveform; they merely happen to pass through zero together at the instants when the sharp fronts occur. The author apparently thinks that the H.F. components come along in bursts every time a sharp front arrives and this leads to such statements as that on p. 255, line 16. 'During the intervals that the H.F. components of the deflexion voltages are felt across the deflecting circuit the deflexion system is resistive . . .' Of course it is resistive all the time." Here the quotation ceases.

Mr. Jones writes of "the component parts of a waveform" as though he was writing of a bag of salted peanuts. From the point of view of a mathematical analysis his statements are perfectly correct, and the separate drawings of sine waves of harmonically related frequencies followed by a graphical addition of those waves to show the method of synthesizing any given waveform from an addition of pure sine waves of various frequencies and phase relations must be familiar to any student of electronics. To state categorically that this is what actually happens in a circuit seems to me to be a little odd, though, to say the least of it.

Mr. Jones, I think, mixes up physical phenomena with the theoretical tools used for understanding those phenomena. He seems to be unaware that Fourier's Analysis, though very clever on M. Fourier's part and certainly very useful, is yet no more than a mathematical trick.

Now it may be that my conceptions of "harmonics" are wrong and Mr. Jones' are right, in which case I owe him an apology. If I am right, however, you will appreciate that my faith in your book reviews will be a little strained. Which is faintly irritating, for I rely upon your book reviews to guide my reading. That is the reason for my writing this letter, for I see no mention of the matter in your issue for February. If you are already the recipient of a spate of letters on this subject then I apologize for flinging yet another on the pile.

Yours faithfully,

P. TURNER,
Mansfield, Notts.

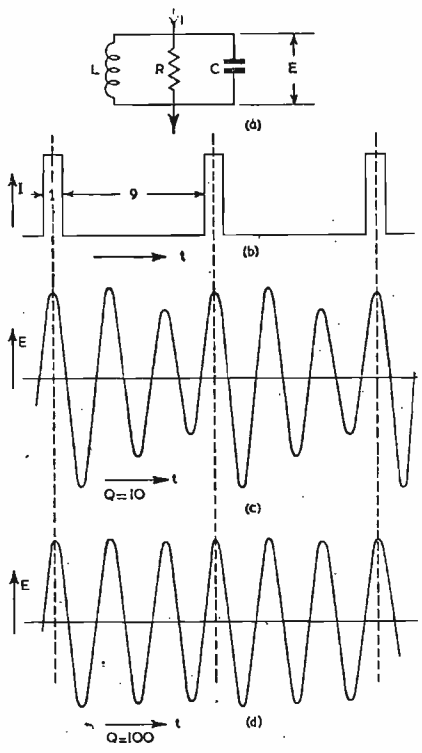


Fig. 1

Mr. Jones replies:

DEAR SIR,—Mr. Turner's letter pleased me greatly, for it showed that the review had served its purpose, and had brought to light misconceptions not only in the mind of Mr. Noll, but also in the mind of at least one reader of ELECTRONIC ENGINEERING. Mr. Turner agrees that "from the mathematical point of view his (my) statements are perfectly correct" but says that "to state that this is what happens seems to me to be a little odd, though, to say the least of it."

From this I deduce that he supports the view that "the H.F. components come along in bursts every time a sharp front arrives," which is the viewpoint to which I took exception in Mr. Noll's book.

If this is, indeed, what Mr. Turner means, then the best reply is to show how my contention agrees both with mathematical and physical fact, whereas his only appears to agree with physical fact.

Suppose we have a succession of sharp current pulses applied to a single-tuned circuit, as shown in Fig. 1(a) where the current waveform is drawn at 1(b). The pulse repetition rate is taken as 1,000c/s and harmonics will exist at multiples of 1,000c/s. If the circuit is tuned to one of these harmonics, say 3000c/s, an oscillograph will show a waveform of the type drawn in (c) where we see the amplitude increasing as each pulse arrives. One may therefore appear justified in saying "The H.F. components come along in bursts, and we can see the circuit responding to each burst in turn."

If the response of the circuit of Fig. 1(a) is plotted, it will (being a real circuit and not a mathematical fiction!) have a finite response at all frequencies from 0 to infinity, and will therefore respond slightly to *all* the components of the applied waveform.

Each frequency component of the waveform (b) is assumed to be of constant amplitude and phase with respect to time—nothing resembling a "burst of R.F." The component response it produces is therefore constant. Although each component response is of constant amplitude the total response will be found to be precisely the waveform shown at (c), the rise and fall in amplitude *being formed by the beating together of the component responses.*

To test this viewpoint one might attempt to make the circuit perfectly selective, so as to respond to a single component. The variations in amplitude should then cease, since there will now be no other component to beat with. Since, again, we have a real circuit, we know this is impossible in practice, but we can make our circuit more selective and see if the trend is in the right direction. If we do this we find that the variations do, in fact, diminish, for increased selectivity is just another aspect of reduced decrement, which implies that the decay of the circuit after each shock is slower (Fig. 1 (d)). Incidentally, the amplitude will be greater also. Now let us postulate a circuit of infinite Q, perfect selectivity, zero decrement. We are now in the realm of the impossible, so we expect an impossible answer. Well, first the circuit would take an infinite time to build up, but it could have had an infinite time to do it—we have not specified a beginning to the waveform (b). The amplitude would be infinite, the decrement zero, *and the per cent variation nil.*

The quantity which really does arrive in bursts is the total energy drawn from the source. The energy carried by the steady components sums to zero during the intervals between the pulses.

You will see that all this is perfectly in agreement with my statement, and the mathematical conception is entirely in agreement with the physical facts.

Now I have a great deal of sympathy with Mr. Turner, although in this instance he is wrong, because the fault lies not with him, but with the extremely loose way in which many authors treat this subject. It was because of this that I felt so strongly about Mr. Noll's book. Students rightly treat their textbooks as authoritative, and irreparable harm can be done to their progress by the implantation of faulty ideas. It is the attempt to picture discontinuous phenomena in terms of continuous concepts that lies at the root of this sort of misconception.

Yours faithfully,

EMLYN JONES,
Salfords, Surrey.

can be eliminated by adjusting the crystal against a frequency standard in the oven in which it is to work, after allowing the temperature to stabilize.

(c) As mentioned previously, the maximum total excursion in the oven temperature is 1.7°, which for the sake of simplicity (and a margin of safety) we will call ±1°. With the crystals used this effect will produce a frequency variation of ±1 part in 10^6.

(d) For a mains voltage change from −20 per cent to +20 per cent on the nominal voltage the crystal frequency varies between +1 part in 10^6 and −1 part in 10^6 relative to the frequency at the nominal voltage.

(e) Due to the use of a plated crystal in a well designed mounting and to the low excitation provided by the circuit used, frequency variations due to these effects do not contribute a significant quantity to the total variation from other causes.

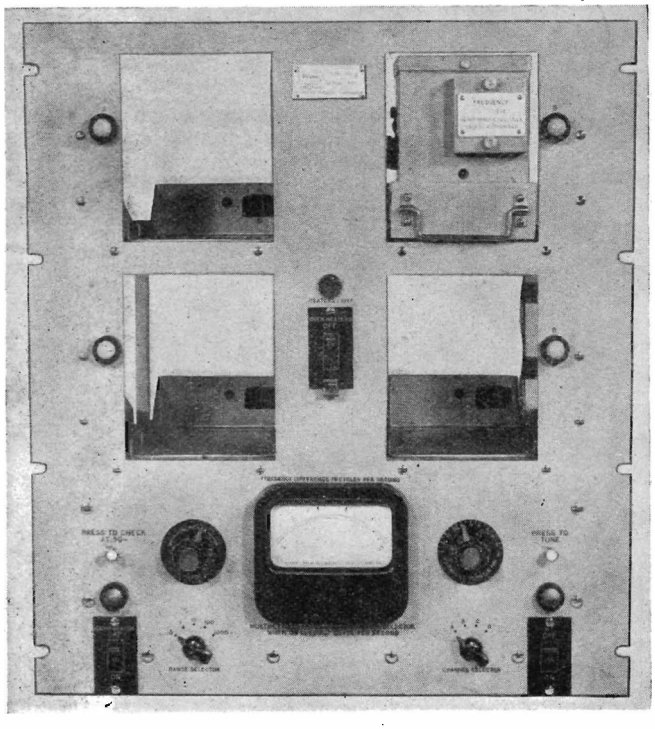
There is also another effect which will only be apparent if there are wide variations in the ambient temperature. This effect is a tendency (probably due to imperfect lagging and small thermal capacity of the oven) for the crystal average frequency to change slightly with ambient temperature. This effect causes a variation of just under 1 part in 10^6 for an ambient temperature change of 0° to 30°C.

It will be seen from the foregoing data, which in all cases represents maximum deviations observed on a number of units, that the requirements should readily be achieved. In practice when the equipment is run continuously in conditions of reasonably steady ambient temperature the required performance is exceeded.

The Stand-by Rack and Comparator

As spare drive units as well as transmitters are required to be always ready for operation a rack taking four drive units and having the necessary power supplies is provided at each station. This is illustrated in Fig. 3.

Fig. 3. The stand-by rack



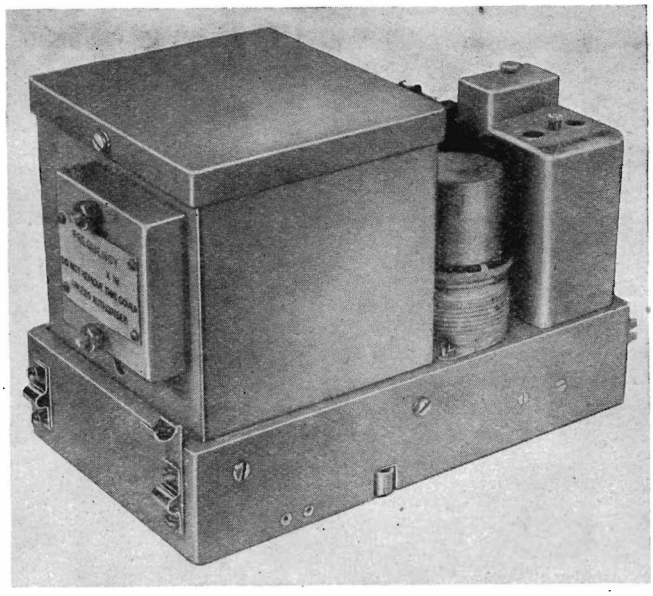


Fig. 4. The oscillator unit

In order to provide on-site a reasonably reliable check on the operation of the crystals without the use of expensive measuring gear this rack also includes a means for comparing the frequencies of any three crystals on the same channel. This device is carried in the lower part of the unit and consists essentially of a tuned circuit and detector which enables the R.F. signal from any of the four stand-by drive units to be mixed with the signal from the pick-up point in the corresponding transmitter (working or stand-by). This produces an audio signal whose frequency is then measured by a simple electronic frequency meter circuit and the result displayed as a direct reading in cycles per second difference on the meter. The meter has four ranges, 0-10, 0-100, 0-1,000, 0-10,000 cycles, and will read quite steadily down to two or three cycles on the 0-10 range. If it is desired to check frequencies below this figure, the range switch is tuned to a further position which enables the meter to indicate the actual beats, which can then be counted.

On the frequency meter ranges the device is accurate enough to provide a useful check on the crystal frequency and, by pressing a button, A.C. from the mains can be injected into the circuit to enable it to be set against the mains frequency by a control provided. A control is also provided to adjust the detector-tuned circuit to the appropriate channel frequency, and a further button enables the meter to be used as a tuning indicator for this purpose.

The system of operation is to note the frequency differences between the three drives and in the event of one showing a large difference from the other two it may reasonably be assumed that this one is in error and it can be withdrawn from service for checking.

The multiplication in the T1131 is 18 times, which gives a maximum deviation at crystal frequency in the region of 25 cycles before the carrier tolerance of ±500 cycles is exceeded. In practice it has been found that the drives will stay well within this figure. It would thus seem that the 0-1,000 and 0-10,000 ranges are unnecessary, but they were included because they involve little extra expense and would be useful in checking the deviation of drives which are grossly off frequency or in making alterations to the nominal channel frequencies which might possibly be required for operational reasons.

The writer is indebted to the Ministry of Civil Aviation and the Plessey Company for permission to publish this article and to Plessey Company also for the provision of the illustrations.

oven heater supply as there is no A.C. power supply on the panel capable of supplying the oven load.

The High Stability Oscillator Unit

The high stability unit consists of a small chassis bearing on its top the oven, heater transformer, oscillator valve and tuned circuit, and the thermostatic relay. The whole unit slides into the fitting in the driver panel and picks up its supplies and R.F. output connexion automatically. A trimmer for the fine-frequency control is provided in parallel with the crystal and is accessible from the rear of the oven.

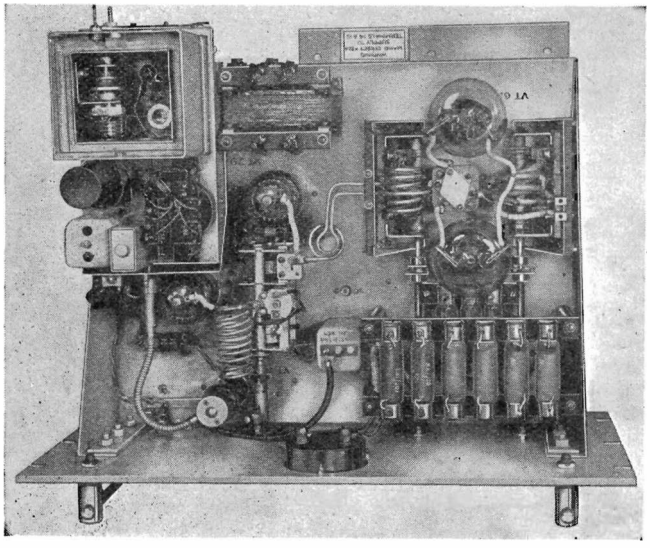


Fig. 1. The unit in place in the 1131 driver panel

The oven consists of a small double copper box, the volume of the inner chamber being about 30 cu. in. Round the inner box is the heater which consists of a number of turns of insulated wire in close thermal contact with the box. This winding is supplied with A.C. at a voltage of about 35 volts from the transformer mentioned above, which also supplies the thermostat relay at 6 volts. Within the inner chamber are the crystal, thermostat and the variable capacitor for fine control of frequency. The thermostat is a gas-filled type of a variety readily obtainable commercially and controls the heater through a relay. This method has been found to improve the action of the thermostat considerably, reducing backlash and giving greater certainty of operation, by diverting the comparatively heavy oven current from the thermostat contacts. A further improvement in the thermostatic control is provided by introducing a measure of "anticipation" into the action of the thermostat by connecting the inner shell of the oven, which carries the heater winding, to the envelope of the thermostat by means of a heavy copper braid and a sleeve which embraces the glass envelope. This device has been found to reduce the backlash in the thermostat operation by quite a significant amount. The nominal oven temperature is 70°C which is held to within a maximum total excursion of 1.7°. This figure, while not outstanding, is quite adequate to give the frequency stability required. The variation of the actual thermostat datum temperature between units is ±2°C. The oven will hold its temperature satisfactorily when fitted in a transmitter which is either in the operating or stand-by condition over a range of ambient temperatures of 0° to +30°C.

The crystal is of the glass-enclosed type in a B7G based valve envelope and has a substantially zero temperature co-efficient (±1 part in 10^6 per 1°C) in the immediate vicinity of the nominal oven temperature. As it is desired to reduce the initial errors in carrier frequency to the lowest possible degree, the crystals are so adjusted (in an oscillator circuit of the same type as that used in the equipment) that, by using the trimmer capacitor, their frequencies can be adjusted exactly to the nominal figure when fitted in the oscillator units.

The oscillator is an EF55 valve run at low dissipation as a Pierce oscillator with a low Q anode circuit tuned well below the lowest crystal frequency. This method enables a reasonably constant output to be obtained from crystals of between 5,500 and 8,111kc/s. The original oscillator valve in the driver panel is now used as a buffer and is biased to operate at low grid current to reduce loading of the oscillator and consequent deterioration of stability.

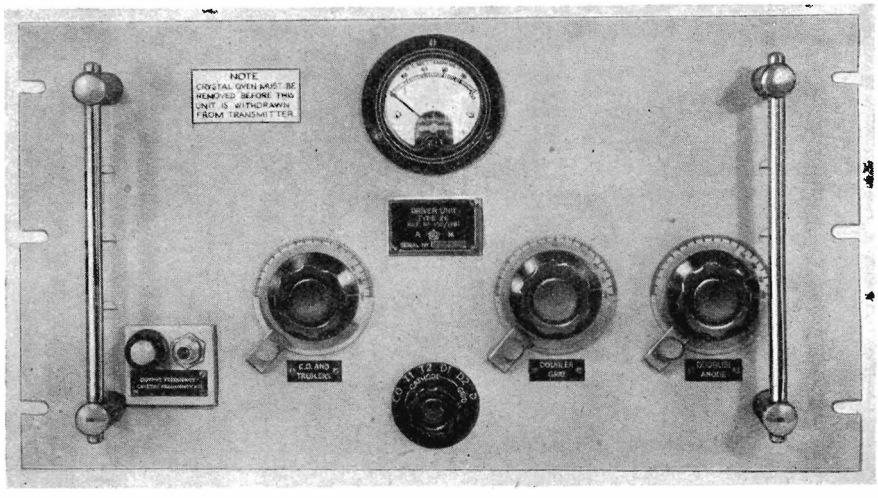
The Performance of the Oscillator Unit

The new oscillator was designed to give a carrier frequency stability of ±500 cycles, which at the mean frequency of 125Mc/s corresponds to ±3.2 parts in a million. This accuracy is required to hold for mains supply voltage variations of ±20 per cent and for ambient temperatures between 0°C and +30°C with the unit out of the transmitter or in the transmitter under any conditions of operation. The requirements for stability can be met provided the cumulative effect of the sources of error shown below is reduced to a sufficiently low figure.

(a) Error in cutting (deviation from nominal frequency).
(b) Error in oven average temperature (deviation from nominal temperatures at which crystals are cut to operate).
(c) Maximum deviation of oven temperature from average.
(d) Voltage co-efficient of crystal oscillator (variation of frequency of oscillator with supply voltage).
(e) A number of second-order effects due to such factors as vibration co-efficient of the crystal, drift due to crystal heating and crystal ageing.

(a) (b) Due to the high cutting accuracy of these crystals, which enables them to be trimmed exactly to the nominal frequency, errors due to these effects

Fig. 2. Front view of drive panel



that five or six pairs of headphones are comfortably fed. The amplifier is a simple device and incorporates a certain degree of limiting, but no expansion.

Transmit/Receive Station

Signals, comprising both speech and tone, are delivered from the Post Office pairs at a level of about −10dbm, and are applied to the input of a filter unit comprising band-stop and band-pass networks with suitable matching transformers. The speech output, less a gap about 50c/s wide around 2,460c/s, is then taken to a channel amplifier (XMT), which, apart from its output impedance (600Ω) is identical with the one on the receiving side at the control centre. The output of the amplifier goes direct to the input of the modulator unit on the transmitter 1131A.

The 2,460c/s tone filtered from the incoming signal is applied to the input terminals of a tone switching amplifier, in which it is amplified and rectified. By a combination of A.C. and D.C. positive feedback, the anode current of the last valve is made to rise suddenly when a certain level of input is reached.

In practice the amplifiers are arranged not to operate at an input level of −50db and to operate at −40db. The relay contacts are connected to the H.T. switching circuits of the transmitter, so that the transmitter becomes operative on receipt at the station of a 2,460c/s tone. Operate and release delays are kept to a minimum of a few milliseconds.

On the receiving side, the output from the receiver room is connected direct to the Post Office pairs without further amplification.

Ancillary Apparatus

It is obviously necessary to monitor the operation of the apparatus continuously, and facilities are therefore provided. Every incoming or outgoing pair at either TX/RX or control centre is taken to a break jack, whose inner springs are connected to the corresponding springs of another break jack connected to the apparatus. By this means either the line or the apparatus may be seized by a plug inserted into the appropriate jack. A number of sets of three jacks with their respective springs commoned is provided. By plugging in two patch cords to these jacks and then plugging the other ends of the patch cords into the desired pair of packs, the circuit will remain uninterrupted, but can be bridged by a third patch cord in the third commoning jack. By this means the monitor amplifier, of 10,000 ohms input impedance, can be bridged across any circuit at will, and the attendant can listen to the traffic on the station loudspeaker.

At the control centre a complete set of transmission measuring equipment is provided, comprising a variable-frequency oscillator, attenuator and level measuring set capable of measuring through or terminated levels from −50dbm to +20dbm. At transmit-receive stations a simple decibelmeter is provided.

The tone switching oscillators and the variable oscillator are of the R-C type and made under licence from Muirhead & Co. Ltd. In order to ensure continuity of tone supply, in case of failure of one oscillator, a second is provided. The outputs from both are connected to an oscillator changeover unit in which a relay is held up by the tone, and on release lights an alarm lamp, rings a bell and connects the spare oscillator to the apparatus. A manually operated changeover switch is then thrown to make the former spare oscillator the working one and *vice versa*, thus cancelling the alarm.

D.C. supply at the control centre is provided at 50V by a simple rectifier, without batteries. This rectifier is in duplicate and a changeover unit similar to that connected with the oscillators is provided.

Flexibility is provided in the distribution cabinet. Every controller's position, monitor operator's position, and set of channel apparatus is connected to a separate connexion strip, and by means of jumpers rove through jumper rings any change in arrangements may be made without disturbing the permanent cabling.

The M.C.A. - V.H.F. Area Coverage Network
Provision of Transmitting Station Equipment

By D. H. C. Scholes *

The use of the T.1131 Transmitter for the Area Coverage network, discussed in last month's issue; necessitated a considerable improvement in its frequency stability. In its standard form, the T.1131 depends on a 10X type of crystal without temperature control.

To achieve this improvement it was decided to introduce a new crystal oscillator stage having a crystal of improved type working in a temperature controlled oven, and it is this modification, together with the simple means evolved for routine frequency checking, which is described.

The Modification to the Transmitter

IN order to provide the maximum flexibility it was decided to make the new oscillator a completely separate unit which could be inserted in the T.1131 by means of automatic plug and socket connexions. There was little difficulty in finding a suitable location for the new unit inside the driver panel, as there is adequate space at the right-hand side of the chassis adjacent to the original drive stage. In this position a small rack is fixed, into which the unit can slide, making all its connexions on fixed sockets at the front end of the rack. It was found necessary to move a bank of resistors normally mounted just below the space occupied by the new unit as they caused a local hot spot which impaired the oven temperature control during the initial tests.

The original crystal oscillator valve in the 1131 is now used as a buffer, but otherwise there are no circuit modifications. The place normally occupied by the crystal on the front of the driver panel is now taken up by a small assembly bearing a lamp to monitor the action of the oven thermostat, and a co-axial socket to provide an output point for a signal for frequency checking, which process will be described later.

Anode and heater supplies for the crystal oscillator are obtained from the driver panel, but it was found necessary to run a mains-voltage A.C. line into the panel for the

* *Chief Engineer, Radio Engineering Department, The Plessey Company, Limited, Ilford.*

is apparent, but all connexions can be reached by opening the rear doors.

The microphone amplifier is normal in construction, and accepts signals round about −50dbm. Both expansion and compression is employed; expansion to decrease the gain at low levels and prevent background noise being amplified by a live but unused microphone, and compression to limit the output power of the amplifier, notwithstanding variations of input. In the ideal case, the amplifier would be inoperative until a certain input level were attained, after which any further increase in input level would have no effect on the output level. This ideal condition is indicated by the full lines in Fig. 3. The dotted lines indicate the degree of expansion and compression actually attained.

The signal from the microphone amplifier is about +24dbm and is fed into the local switching unit mentioned above. This piece of apparatus is special to the scheme and perform the following duties:—

(1) It contains the three switching relays and two call registers.

(2) It mixes the switching tone with the speech ready for transmission to the TX/RX stations.

(3) It acts as a central connecting point for all the apparatus in each channel.

The relays perform the following functions: Relay "A" is operated by an earth from either press-to-talk key, and connects the switching tone to the line by means of a resistive bridge which will be described below. Relay "B" connects microphone to headphones as described above when inter-communication between controller and monitor operator is desired. Relay "C" is merely a locking relay for the controller's intercommunication call lamp. It operates in parallel with the controller's buzzer and locks up to an earth via a normally made contact on the controller's intercommunication key. When this key is thrown to "Speak" the relay releases and the call lamp is extinguished. Apart from the above functions the local switching unit contains little of interest.

The outgoing signal is next distributed to all the transmitting stations from which it is to be radiated. This could simply be achieved by bunching all the pairs and connecting them to the output of the channel apparatus. If this were done, however, each of the outgoing pairs would be terminated not by its characteristic impedance, but by a fraction of it, determined by the number of pairs and the output impedance of the amplifier. The correct termination could, of course, be achieved by a system of transformers, but even then there would remain the further disadvantage that a noise or possible short circuit on one pair would effect every other and put the whole channel out of service. In fact, the distribution is performed by a passive resistive network resembling the Wheatstone Bridge. In Fig. 4 (a) is shown a bridge with six equal resistors. As is well known, any current flowing in arm *e* due to E.M.F. *E* will cause E.M.F. of $E/2$ to appear in each of the arms *a*, *b*, *c* and *d*, and no E.M.F. will appear across *f*. Hence *e* and *f* are completely decoupled and the loss between *e* and, say *d* is 6db. By symmetry, a similar current in *f* produces no E.M.F. across *e* and $E/2$ across *d*.

If now the circuit is redrawn as in 4(b) the resistors *d*, *e*, *f* may be considered as the characteristic impedances of the three transducers, e.g., an amplifier and two transmission pairs, and resistors, *a*, *b* and *c* are fixed equal non-reactive resistors.

As described, the device acts as a mixer, signals in *e* and *f* appearing in *d* with a loss of 6db. Clearly it must also act in the same way in the opposite direction, and a signal in *d* will appear in two parts, each $\frac{1}{4}$ of the power of the original in *e* and *f*, the remaining half of the power being dissipated in the resistors, *a*, *b* and *c*.

Turning to Fig. 4 (a), it is also well known that if a signal is applied across *e*, and *f* is short circuited, or disconnected, there is no re-arrangement of the currents in the rest of the bridge. The effects of this in Fig. 4(b) are seen to be that no matter what happens to one of the pairs the other is not affected.

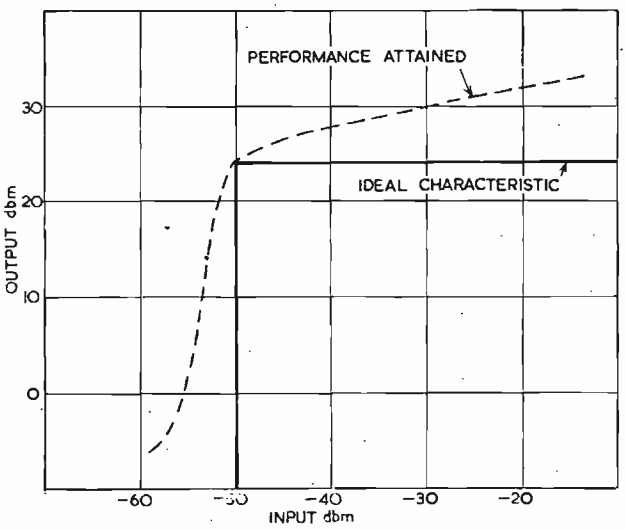


Fig. 3. Microphone amplifier: input-output characteristics

In the present application, more than two outlets are required for each channel, and so the signal is split three times in succession, giving a total of eight stations to which the signal may be distributed. The loss in the whole device is 18db.

While any cross-talk between lines connecting one channel to a number of transmit/receive stations would not be noticed, since all lines are carrying the same signal, cross-talk between channels would be most objectionable.

It was laid down in the specification that one (duplicated) Tone Switching oscillator was to feed to channels up to a maximum of eight. The output of the oscillator is therefore a bunching point between channels, and special arrangements had to be made to feed tone to all channels in parallel without mixing the speech. This was achieved

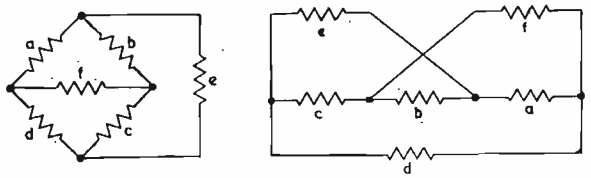


Fig. 4. Splitter and combiner

by an arrangement similar to that described above in the distribution network.

Three resistors and the input of the distribution network are arranged as the diamond mesh of a Wheatstone bridge, and the speech input and tone input as the diagonals. Providing the impedances of the mesh are equal, there can be no cross-talk between the diagonals. Hence, all the tone input connexions can be bunched and connected to a low impedance bus-line fed from the oscillator.

Receiving Circuits

The signal from the transmit/receive stations appears at the control centre on post office pairs at a level of about −10dbm. Each circuit passes via the pair of relay contacts mentioned in connexion with the monitor operator's apparatus to a mixer unit exactly as described above for the splitter unit. In fact, both mixer and splitter are accommodated in the same panel unit. The signal is then amplified in the channel amplifier (RCV) to such a level

The M.C.A. - V.H.F. Area Coverage Network

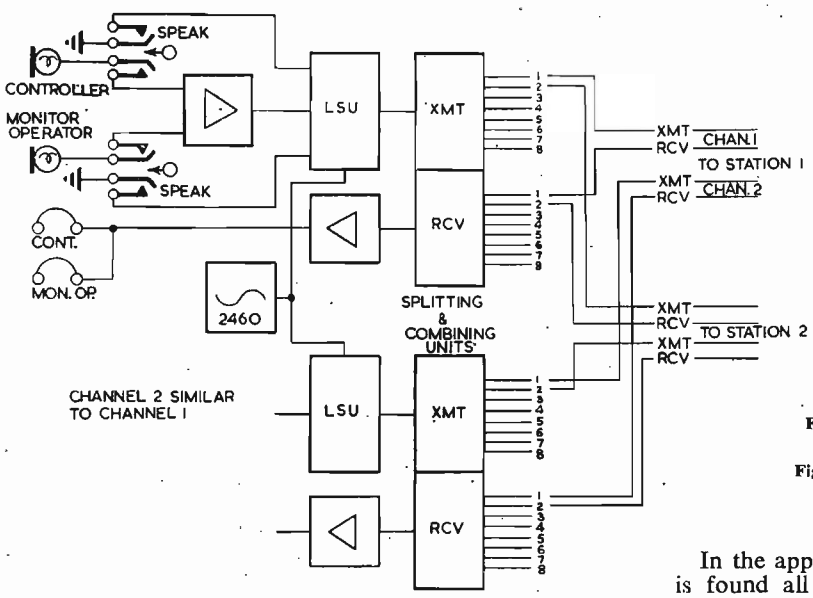
Audio Frequency Distribution

By J. L. French *

The following article describes the audio frequency equipment required for the M.C.A.-V.H.F. area coverage network (see "Electronic Engineering," March 1951)

THE main problem is to put the controller for each channel on the air at a number of stations simultaneously. With all his other duties to be considered, it was obviously impossible to expect him to operate more than one key and the apparatus on his key panel was therefore limited to a press-to-talk key of the locking type, an intercommunication key by which he can talk to the monitor operator, and a buzzer and lamp by which he can be called, together with a pair of potentiometers for adjusting the volume in his (duplicated) headphone to a level to suit local conditions. The potentiometers cannot be turned to zero, hence the receive side of the channel cannot be cut off deliberately or inadvertently.

The monitor operator maintains a continuous watch on each channel and relieves the controller of a certain amount of routine work. His apparatus includes a press-to-talk key in parallel with that on the controller's key panel, an intercommunication key and volume controls



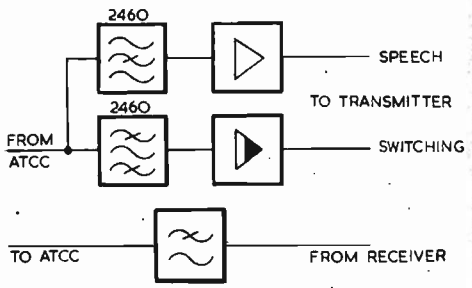


Fig. 1 (left). Block diagram ATC Centre

Fig. 2 (above). Block diagram TX/RX Station

for the duplicated headsets. In addition there is a push-button, a row of keys and meters (one set for each transmit—receive station connected to the channel).

It was considered advisable to include a semi-automatic register of the number of calls transmitted and received. The press-to-talk key operates by a spare contact a meter (Post Office No. 100) in the local switching unit in the apparatus racks, thereby registering the number of calls originated from the ground. A similar meter is energized by the monitor operator's push-button, which should be pressed every time an incoming call is received.

Intercommunication between controller and monitor operator, when the channel is otherwise disengaged, is provided by connecting the output of the microphone amplifier (to the input of which both controller's and monitor operator's microphones are connected) back to the headphones, all of which are in parallel, through a suitable fixed attenuator. The intercommunication keys do not energize the transmitters, so the conversation is not radiated, but incoming signals are unaffected, so that the channel is never left unserviceable. Signalling by buzzer is effected between monitor operator and controller by throwing the intercommunication key upwards. In addition there is a lamp on the controller's key panel which glows until cancelled by operation of his intercommunication key in the "Speak" direction.

Every incoming speech pair on the channel has, as described above, a VU meter permanently across it. It will be realized that when a number of circuits are bunched, any one which is noisy may obliterate the signal on the others. Any line on which the signal, as observed on the appropriate VU meter, exhibits unusual phenomena, can be instantly disconnected by pressing the key associated with the meter. This extends an earth to the line cut-off relay in the apparatus room and disconnects the offending line.

In the apparatus room at the Air Traffic Control Centre is found all the rest of the apparatus shown in Fig. 1. Each unit is self contained and supplied with 230V 50c/s A.C. from a fuse panel at the bottom of the rack. All connexions are taken into or out of the apparatus units by multi-pin plugs and sockets, except where the unit is passive and has too many connexions for plugs.

As mentioned in the original article by D. P. Taylor, switching of transmitters is effected remotely by a tone of 2,460c/s carried to the transmitter stations over the speech pairs. Oscillators for this purpose are provided in duplicate, and are switched to line by the operation of the press-to-talk keys as will presently be described.

All the apparatus is mounted in cabinets which are drilled on their front members to take international standard 19in. panels. In order to conserve panel space sub-panels are mounted between side members fixed to the front panel, and the heavier units are arranged to slide on runners, thus taking the strain off the panel fixing screws and making easier the operation of removing or replacing a unit. The rear of each cabinet is enclosed by a pair of doors, and all cabinets of a suite are bolted together, forming a cable runway at top and bottom. No external wiring

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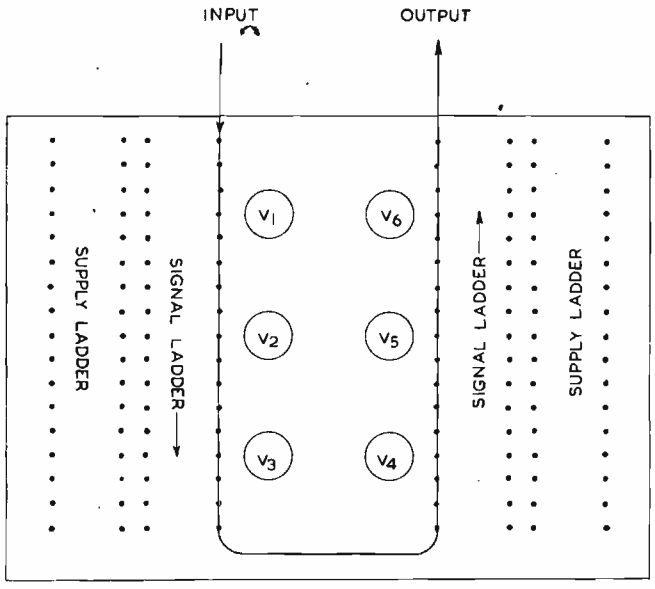

Fig. 4. Typical chassis layout suitable for method of component grouping shown in Fig. 3

of drawings, one of circuit diagrams and the other of the component layout, together with data on waveforms, etc. It is believed that circuit tracing would be considerably facilitated, with a corresponding increase of speed in phase (ii), if circuit diagrams and actual wiring developments were correlated in pattern.

The general problem is to find a suitable method of arranging and connecting the actual components ("wiring development") which can be readily correlated with the circuit diagram, preferably using existing forms of assembly and without seriously deviating from conventional forms of circuit diagram. In this process the signal path should, in both cases, be rendered as direct, distinct and accessible as possible.

Principles of Proposed Method of Correlation

One solution is based on the following principles:—

(i) The circuit components are divided into two sets (cf. Figs. 1, 2).

(a) Those directly associated with the signal path, e.g., anode loads, coupling devices, grid leaks, etc.

(b) Those concerned with establishing the required mean operating potentials for the valves, with decoupling of adjacent stages, etc.

(ii) In the circuit diagram each group may be arranged as a uniform ladder structure with the signal ladder running horizontally above the supply ladder. The actual signal path nodes extend along the upper side of the signal ladder, while the two ladders will in most cases have a common (H.T. – EARTH) side. In the wiring development each ladder takes the form of a tag board having two spaced parallel rows of mounting tags, or of two parallel tag strips.

(iii) In order to avoid undue lateral extension of the actual component ladders, and to make use of all available tags, zig-zag connexions across the tagboard may be adopted, but in a regular manner (Fig. 3).

Although a proportion of the components (valves, transformers, switches, etc.) are not amenable to tagboard mounting and, at certain points, the need for short connexions may run counter to any attempted pattern or system it is believed that such difficulties are not sufficiently important to preclude a successful attempt to seek correlation on the lines being described.

A simple example of the foregoing technique is shown in Figs. 2, 3. It is particularly adaptable to the method of construction sketched in Fig. 4,, where the tag board planes are parallel to the chassis plane, and the chassis is fitted to allow vertical mounting on a standard rack. The paired tag-boards may alternatively be placed back to back with their planes perpendicular to that of the chassis, but with reduced accessibility, or, intermediately, the signal ladder may be mounted parallel to the chassis plane above the valve holders, with the supply ladder at right angles to it—this is possibly the best compromise between compactness and accessibility (Fig. 5). In either case C.R.O. monitoring sockets may be mounted in a row on a strip running closely parallel to the "live" side of the signal ladder thereby allowing short direct connexions to the latter, subject to the necessity of avoiding the throwing of appreciable additional stray capacitance across the signal path.

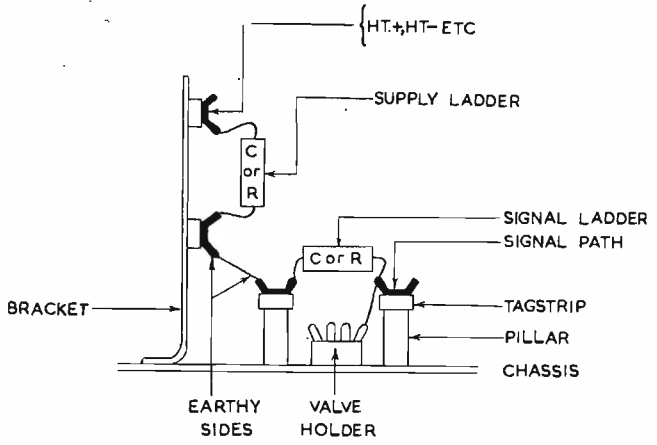

Fig. 5. A more compact alternative to the tagboard arrangement illustrated in Fig. 4

Conclusion

The object of the present note is to draw attention to the existence of the difficulty and to indicate one method of alleviating it. No attempt has yet been made to develop the method or to find alternatives, but it is believed that the complexity of electronic systems has reached the stage where such considerations warrant investigation, since any step which facilitates servicing is well worth while. It is realized, of course, that there are cases such as R.F. circuits, where the technique would be quite inapplicable, or, as where multiple feedback loops occur, it would need careful application.

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Electrical Manufacturers Endow Chair at Cambridge

THE endowment of a Professorship of Electrical Engineering at the University of Cambridge was foremost among the University's post-war requirements formulated in 1944. As there was a possibility that circumstances might prevent the plan being put into force sufficiently quickly after the end of the war, the President and Council of the Institution of Electrical Engineers offered to provide the endowment of a Professorship of Electrical Engineering for a period of five years.

On the expiry of the five-year period, the Council of the British Electrical and Allied Manufacturers' Association, recognising the benefits that the electrical profession and industry have derived from the Professorship, undertook to raise money for its endowment in perpetuity. The Association has now asked the University to accept a gift of £71,000, this being the amount subscribed by some 150 member-firms of the BEAMA.

Correlation of Circuit Diagram and Wiring Development of Electronic Systems

A. W. Keen, M.I.R.E., A.M.I.E.E.*

THE increasing complexity of electronic equipments calls for greater attention to the problem of maintenance, particularly in such applications as computing and military radar where considerable superiority in speed of action of electronic over other methods may be rendered futile by the failure of the equipment to remain serviceable for long periods. It is most important that when a breakdown does occur the fault should be readily recognized, quickly traced and rapidly rectified.

Fault Tracing Procedure

Fault tracing following recognition of incorrect performance by the operator may be divided into three phases:

(i) Before probing into the equipment the mechanic makes a systematic study of the response of the equipment

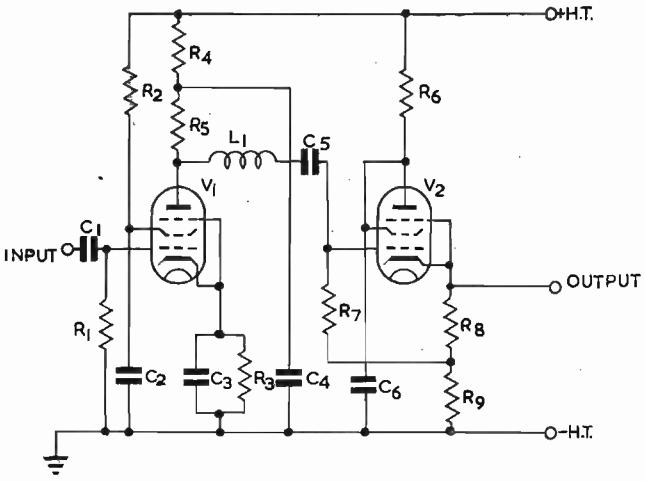


Fig. 1. Section of typical circuit diagram as conventionally drawn

to its controls as disclosed by C.R.T. displays, check meters, etc., and endeavours to deduce the location of the fault as accurately as possible.

(ii) Most electronic systems may be resolved into chains of stages, through which a signal is transmitted, and in each stage a signal path may be distinguished (Cf. Figs. 1, 2). Having suspected one or more stages of faulty performance it is usual to check the signal (for amplitude, shape, etc.) at each point in turn along the signal path, using an appropriate indicator (e.g., C.R.O., valve voltmeter, etc.), until the point at which it is incorrect in some respect, or even entirely absent, is reached.

(iii) Having located the defective stage the fault will usually yield to systematic voltage-current and/or resistance analysis using conventional test instruments.

In general it may be stated that the time taken over phases (i) and (iii) is largely a matter of the ability of the mechanic, given suitable test equipment. On the other hand, phase (ii) can be considerably facilitated in the mechanical design of the equipment. It is customary to systematize and colour-code inter-unit and inter-bay (or-rack) cabling but in most cases internal unit wiring rarely follows any readily recognized pattern and signal path

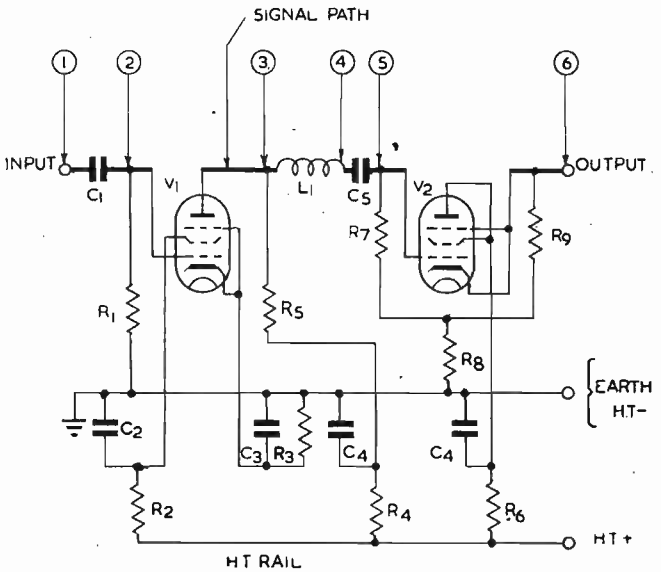


Fig. 2. Rearrangement of Fig. 1 to assist correlation with actual component layout (cf. Fig. 3)

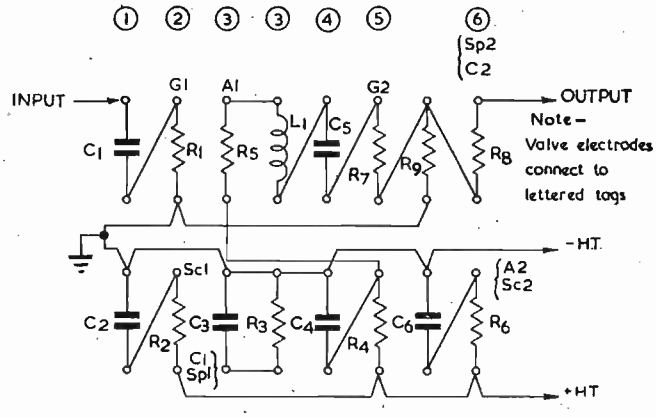
tracing is thereby rendered lengthy and tedious unless the mechanic is very familiar with the detailed layout.

Correlation of Circuit Diagram and Wiring Development

The absence of any semblance of a pattern in stage wiring is probably due in most cases to the fact that apart from stipulating that certain critical connexions must be direct and short, and (possibly) well clear of certain circuit points, the circuit engineer leaves the placing of components to the draughtsman, and the wiring to the wireman, neither of whom may be concerned with the servicing problem or even aware of the general fault-finding procedure. At the other extreme the engineer may detail an arrangement of components and interconnexions, which make all of the latter as short and direct as possible, although this is not at all necessary in many cases.

Returning to the problem noted at the end of the last section it is usual to provide the mechanic with two sets

Fig. 3. Ladder grouping of component layout with signal components in same sequence as signal path (cf. Fig. 2)



* *E.M.I. Research Laboratories, Limited.*

that required to alter the phase of the pulses by one microsecond and thus a very accurate control of the frequency is possible.

A simple explanation of the action of the reactance valve is as follows: When the valve is biased to cut-off there is no feedback from the anode and the input impedance is represented by two 68pF capacitors and the 22kΩ resistor in series, which are equivalent at 514kc/s to about 5.5pF and 11kΩ in parallel, ignoring the valve strays. With the valve turned "on" the impedance is that of a capacitor of 68pF in series with another $\mu \times 68$pF, where μ is the amplification in the valve. Since μ is approximately 100 this means that the input impedance is very nearly 68pF. The valve can therefore be regarded as the equivalent of a variable capacitance of about 60pF across the tuned circuit of the oscillator. Since the total tuning capacitance is about 500pF, the change in frequency is roughly 8kc/s, or roughly 1kc/s per volt change in suppressor bias. Now the change in frequency necessary to raise the output of the integrator from 0 to 60 volts is just under 1 part in 1,000 or 0.5kc/s., corresponding to the pulse width of one

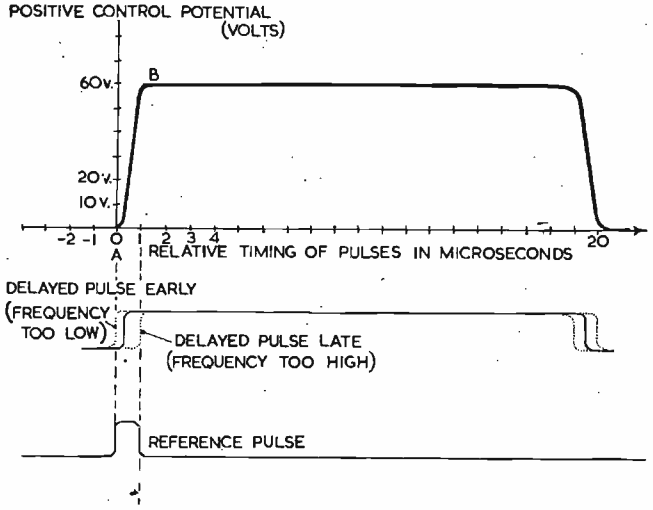


Fig. 2. Control potential developed at grid of V2 as a function of relative phase of delayed and reference pulses

microsecond compared with the delay of 1.2 milliseconds. But 0.5 volts applied to the reactance valve would produce the same frequency shift. It follows that this circuit reduces errors in the frequency of the oscillator by about 120 times. From the earlier discussion it therefore follows that the tolerable variation in temperature has been increased from 0.15 degrees Centigrade to 18 degrees Centigrade, making a thermostat unnecessary, and the inherent stability required in the oscillator is reduced from 4.5 parts to 540 parts in 10^5, or 0.5 per cent, which is readily obtainable without special precautions.

In order to make the circuit work in practice it is necessary to eliminate 50 cycle hum from the control voltage very completely, because any frequency modulation of the 514kc/s oscillation causes serious trouble in the operation of the calculator. The degree of freedom from frequency modulation must be such that the modulated phase shift of the clock pulses is less than 0.1 microseconds. To achieve this the time constant C_1R_1 in Fig. 3 was made 0.05 seconds and C_2R_2 one second. In addition the screen of the reactance valve $V3$ was fed from a neon stabilizer and all D.C. potentials used for bias supplies were carefully decoupled.

The effective time constant of the control system was about a second, which made it possible to tune the oscillator slowly by hand, steadily decreasing the frequency from a value known to be too high. The delayed pulse will then be later than the undelayed pulse, and, if they do not overlap at all, the meter will read zero (or a few volts). As soon as there is any overlap between the two pulses the meter reading will increase sharply by perhaps 25 volts, then increase only slowly for 7-8 volts in the range over which the frequency is being controlled. When the reactance valve is fully turned on and cannot exert any further control, the meter reading increases sharply once more to the maximum control voltage, in this case about 60 volts. It is thus very simple to set the tuning control at the mid-frequency of the controlled range. Once this has been done the relative phase of the pulses can be adjusted to the desired value, using the bias control until the storage system of the calculator will "hold" pulses correctly. This final adjustment is conveniently made using a double beam oscilloscope with the ungated and clock-pulse gated circulating pattern displayed on two traces. For the maximum operating margin the ungated pulse should overlap the gated symmetrically.

It is found in practice that once the circuit has been set up in this way it will remain in adjustment for days or even weeks at a time, and pulls the frequency to the correct

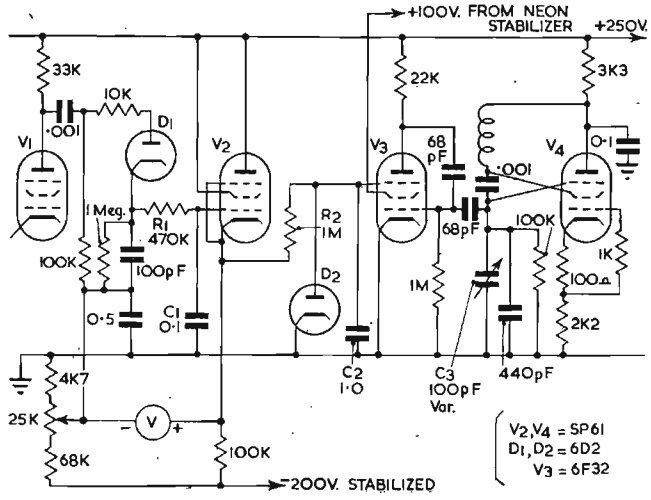


Fig. 3. Circuit of integrator, reactance valve and transitron oscillator

value automatically when the power is switched on.

The author wishes to express his thanks to Mr. K. Camm, who ably carried out the greater part of the experimental work involved.

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The Canberra's Atlantic Crossing

THE English Electric Canberra which set up the fastest time for a Transatlantic crossing, on February 21, 1951, was fitted with a radio installation designed to meet the very special requirements of this unique aircraft.

To ensure that the Canberra's fighter-like performance and manœuvrability are not impaired by the usual protuberances associated with aircraft wireless aerials, the suppressed direction finding loop recently designed by Marconi engineers was employed, and the radiator for the high-power communications transmitter was a special type of buried antenna, designed by the Royal Aircraft Establishment in conjunction with the Marconi Company.

The aircraft was able to remain in perfect radio communication when 1,500 miles out over the Atlantic, and it was found that the use of the suppressed D.F. loop in no way reduced the ranges at which bearings could be taken.

AUTOMATIC FREQUENCY CONTROL

A Circuit for Controlling the Clock Pulse Frequency in Digital Calculators

By J. M. M. Pinkerton, M.A., Ph.D.

IN digital calculators such as the EDSAC[1,2] which use the ultrasonic system of storing the digits it is necessary to provide a continuous supply of "clock" pulses at a suitable recurrence frequency. This recurrence frequency has to be fairly precisely related to the time delay experienced by the pulses travelling down the delay lines, since to preserve the pattern the delayed and amplified pulses have to be gated with fresh clock pulses. This means that a clock pulse must occur at the same time as the ungated pulse arrives at the gate; if not, the output from the gate will be mutilated either at its rising or falling edge. In the extreme, the output from the gate may be either a pair of spikes or nothing at all. It is further necessary that the clock pulse arriving at the gate should be the correct one, that is the pth after the pulse entered the delay circuit and not the $(p-1)$th or the $(p+1)$th, otherwise the number of pulses stored in the tube would be different from p, with disastrous results for the operation of the calculator as a whole, although circulation might still be possible. p is usually of the order of a few hundred, and in the EDSAC it is 576. However, the delay in the ultrasonic tank is dependent on temperature to the extent of about 30 parts in 10^5 per degree Centigrade, if it is filled with mercury. (The temperature co-efficient of nearly all other liquids is greater). Hence to preserve the circulating pattern it is necessary either to control the temperature to suit the frequency or the frequency to suit the temperature. It is also possible to hold both temperature and frequency at the correct values independently. Hitherto the practice seems to have been to adjust the frequency by hand to the correct value from time to time, or to stabilize both the frequency by using a crystal controlled oscillator, and the temperature with a thermostat. It seems preferable, however, to control the frequency automatically to suit the temperature which therefore need not be regulated precisely, although, of course, if several delay lines are used they must all be kept at the same temperature.

The variation in frequency that can be tolerated in the storage system may be increased by deliberately widening the ungated pulses before gating. In spite of this, in practice, the permissible variation in delay is often only about ± 0.1 microseconds. Therefore if the repetition frequency is 514kc/s and 576 pulses are stored in a delay tube the frequency tolerance is ± 0.1 parts in 576000/514, that is about 9 parts in 10^5. This is at the limit that can be obtained from an ordinary LC circuit without special precautions. If both the frequency and temperature are to be held fixed at the correct values we might perhaps assign half the tolerance to each, that is ± 4.5 parts in 10^5. This corresponds to a change in temperature of $4.5/30 = \pm 0.15$ degrees Centigrade, which means that a good thermostat will be required. Under these conditions there would be little margin for incorrect adjustment of either parameter. It seems therefore that there is an overwhelming case for controlling the frequency automatically. The circuit described below has been designed to do this; it incorporates only well-known elements, but it is believed to be new in application to this purpose.

The principle of the system is to compare the phase of a pulse which has travelled down the ultrasonic delay line with a later pulse of the same series which has not been delayed, and to derive a potential proportional to their phase difference. This potential can then be used to alter the frequency of the master oscillator producing the clock pulses using a suitable reactance valve arrangement, thus altering the phase difference in such a way as to bring it to the desired value. It is also convenient to obtain a manual adjustment of the frequency to which the control circuit adjusts the oscillator, by offsetting the controlling potential by means of a preset bias.

A block schematic of the arrangement is shown in Fig. 1. The oscillator feeds a 514kc/s sine wave into a squaring circuit to produce square pulses about 1 microsecond wide which are fed to various parts of the calculator and are known as clock pulses. One clock pulse in 36 is selected by a dividing circuit and used in the calculator as a "minor cycle pulse." It is also fed down the controlling ultrasonic delay line modulated onto a 13.5Mc/s carrier.

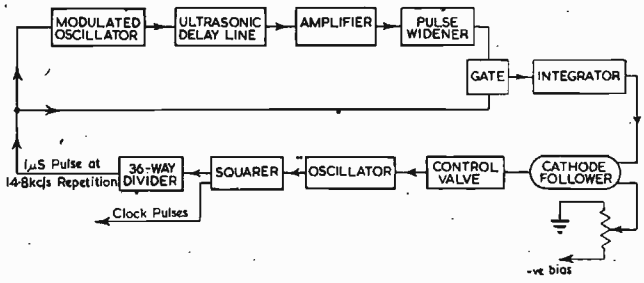


Fig. 1. Block schematic of automatic frequency control system

After being delayed it passes in turn through a 13.5Mc/s amplifier, a detector and pulse amplifier to a widening circuit, which lengthens it to about 20 microseconds. The front edge of the widened pulse remains co-incident with that of the delayed pulse. The widened pulse is applied to the gating circuit together with the undelayed pulse from the divider. In practice this pulse is actually the 16th following the delayed pulse. This, however, does not impair the action of the control circuit in any way. The output from the gating circuit is a pulse whose width is proportional to the phase difference between the delayed and undelayed pulses, except that if the delayed pulse is much too early the output pulse will be of the full width (one microsecond). The negative gated pulse is reversed and fed to a diode integrating circuit $D1$ to produce a positive potential varying directly as the phase, as illustrated diagrammatically in Fig. 2. The integrator output is arranged in series with a variable preset negative potential from $P1$ as shown in Fig. 3 and fed via a cathode follower $V2$ to the reactance valve circuit. The variable reactance circuit uses a type 6F32 pentode having a short suppressor base connected as a Miller valve with a D.C. bias applied to its suppressor. A diode $D2$ prevents the suppressor being driven positively, and since the suppressor base of this valve is only about 9 volts the control is exercised only over that part of the range AB in Fig. 2, which corresponds to the setting of the control $P1$. However, the frequency shift produced by this change is much greater than

the correct phase with the number pulse train. The distortion of the clock pulses introduced by delaying them is, in this case, an advantage, as it tends to give a more intense brightening pulse lasting for about 0.25 microseconds. It is found that a slight differentiation of the signal pulses produces a better shaped one, and lifts the zeros towards the centre. The plates of the cathode ray tube are fed from two "long tailed pairs," with differential bias on the grids in each case providing a limited amount of shift. The signal pulses are mixed with the frame time base signal by using the two grids of one long tailed pair. Fig. 4 shows the circuit of the frame deflexion circuit.

This method of displaying the contents of the store of a computor will, of course, show only one section of it at a time. It is reasonably simple, however, to provide a switching system so that the contents of any one of a number of ultrasonic delay lines may be displayed on one tube by selection on a switch.

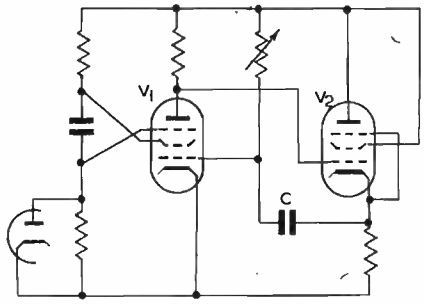
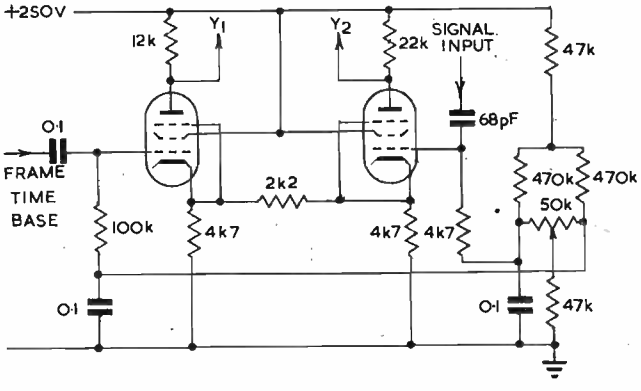


Fig. 3. Time Base circuit

If, for example, the complete store of a computor consists of 64 such delay lines, the electronic circuits controlling those delay lines may be arranged in eight racks, each rack carrying eight circuits. Then by means of two switches, one selecting a rack, and the other (an eight way, eight wafer switch) selecting one of the circuits in a rack, the contents of any one section of the store may be displayed. The switching cannot conveniently be done on the wires bearing the actual pulses to be displayed; it is in fact done on control lines operating gates to which the pulses are applied. These gates may be opened by applying an earth to the control line. Any combination of two switch positions opens one gate only (Fig. 5) and the contents of the store connected to that gate are thereby displayed on the one monitor tube.

A novel feature on a machine using this system of switching is the method of indicating the number of the store whose contents are being displayed. In a machine working in the binary form it is usual to give the store positions and racks binary numbers. So in each rack the eight units are numbered from 0 to 111. For the purpose of programming, however, the sections of the store are numbered from 0 to 111111 (0 to 63) so that rack 0 will control store sections 0 to 111 (0 to 7), rack 1 will control 1000 to 1111 (8 to 15) and so on.

Fig. 4. Frame mixing and deflecting circuit



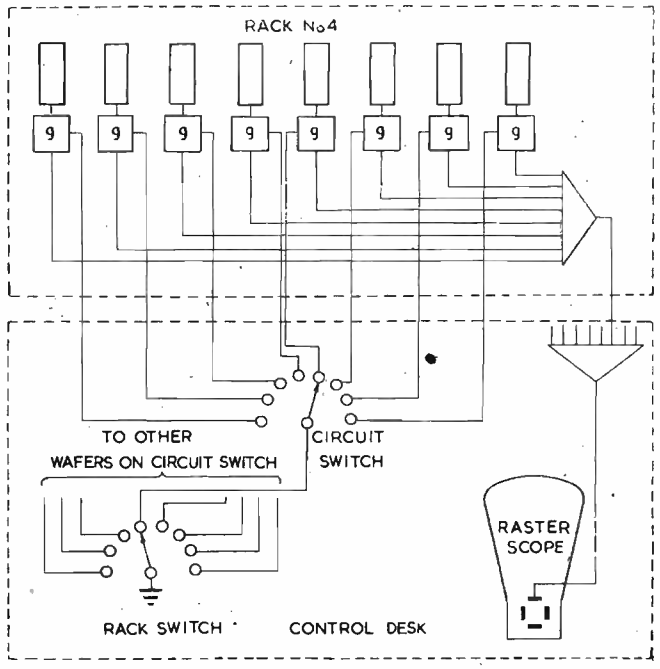


Fig. 5. Arrangement for store circuit selection

The switches used to select the store sections have disks fixed to the spindles below the level of the surface on which they are mounted, and the binary numbers 0 to 111 are engraved on the disks. When the unit selecting switch is set to select unit 101 (5) in a rack the engraved 101 appears in the right hand side of a window in the mounting surface, similarly when, say, rack 100 (4) is selected, 100 appears in the left hand side of the same window. Now unit 101 (5) on rack 100 (4) controls store section 100101 (37) and as the positions of the two disks, visible above the mounting surface, are adjacent to each other the number if read as a whole is in fact 100101 (37). This arrangement is shown in Fig. 6.

The author would like to express his appreciation of the work done by Mr. R. T. Shaw in building and testing the instrument described.

REFERENCES

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[2] Wilkes, M. V., *Proceedings of the Royal Society*. A. *195*, 274, 1948.

Fig. 6. Store switch indicator