Electronic Engineering

JUNE 1953

TWO SHILLINGS

CLASSIFIED ANNOUNCEMENTS

The charge or these advertisements at the LINE RATE (if under 1" or 12 lines) is: Three lines or under 7/6, each additional line 2/6. (The line averages seven words.) Box number 2/- extra, except in the case of advertisements in "Situations Wanted," when it is added free of charge. At the INCH RATE (if over 1" or 12 lines) the charge is 30/- per inch, single column. Prospectuses and Company's Financial Reports £14 0s. 0d. per column. A remittance must accompany the advertisement. Replies to box numbers should be addressed to: "Electronic Engineering," 28, Essex Street, Strand, London, W.C.2. Advertisements must be received before the 14th of the month for insertion in the following issue.

OFFICIAL APPOINTMENTS

ASSISTANTS (SCIENTIFIC): The Civil Service Commissioners invite applications for pensionable posts. Applications may be accepted up to 31st December, 1953, but an earlier closing date may be announced either for the competition as a whole or in one or more subjects. Age at least 17½ and under 26 years of age on 1st Janaury, 1953, with extension for regular service in H.M. Forces, but candidates over 26 with specialized experience may be admitted. Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science subject and of thorough experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces, covering a minimum of two years in one of the following groups of scientific subjects: (i) Engineering and physical sciences. (ii) Chemistry, bio-chemistry and metallurgy. (iii) Biological Sciences. (iv) General (including geology, meteorology, general work ranging over two or more groups (i) to (iii) and highly-skilled work in laboratory crafts such as glass-blowing). Salary according to age up to 25: £236 at 18 to £363 (men) or £330 (women) at 25 to £500 (men) or £417 (women); somewhat less in provinces. 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.59/53. Application forms should be returned as soon as possible. W 2501

B.B.C. requires a limited number of Technical Assistants in Operations and Maintenance Department, for service at Transmitter, Studio and Television Centres throughout the United Kingdom. Knowledge of mathematics, electricity and magnetism to School Certificate Standard; experience in electrical or radio engineering an advantage. Preferred age 20-25; others with experience considered. Salary £360 p.a. with annual increments to £470 p.a. maximum. Promotion prospects. Application forms from Engineering Establishment Officer, B.B.C., London, W.1 (enclosing addressed foolscap envelope). W 2447

BRITISH ELECTRICITY AUTHORITY. London Division. General Assistant Engineer (Communications), Technical Department. Duties in connexion with construction, testing and maintenance of Authority's Private Communications System, including equipment using Line, Teleprinter, and Radio Techniques. Previous experience of this work essential and experience in telephone manufacturer's Works valuable additional qualifications. Preference given to applicants having University Degree with First or Second Class Honours in Engineering or Physics. Salary and conditions in accordance with N.J.B. Agreement, Schedule C within Class AX, Grade 8, Salary £526 to £670 19s. rising to ultimate maximum £749 14s. p.a. Application may be made on form obtainable from Divisional Secretary, B.E.A., London Division, Generation House, Gt. Portland Street, W.1, and be received within 14 days of this advertisement. W 2430

CROWN AGENTS FOR THE COLONIES. Assistant Signals Officer required by the Government of Nigeria for the Aviation Department for one tour of 18 to 24 months in the first instance. Salary, etc., either (a) in scale £750 rising to £1,315 a year with prospect of permanency or (b) in scale £807 rising to £1,453 a year, on a temporary basis with gratuity at the rate of £100 a year. Outfit allowance £60. Free passages for officer and wife, and assistance towards cost of children's passages, or their maintenance in the United Kingdom. Liberal leave on full salary. Candidates must have a knowledge of the fundamental principles of electricity and magnetism and of radio engineering with experience in the maintenance of aeronautical radio transmitters and receivers, direction finders, test equipment and small petrol and diesel engine generator sets. Workshop experience and a knowledge of radar will be of advantage. Minimum examination qualifications are C. & G. certificate in radio communications or technical electricity, or satisfactory pass in M.C.A. radio mechanics course. Apply in writing to the Crown Agents, 4 Millbank, London, S.W.1, stating age, name in block letters, full qualifications and experience and quoting M2C/29637/EK. W 2496

JUNIOR TECHNICIAN wanted. Opportunity to train in high voltage X-ray and physics laboratory work while studying. Salary according to age and experience. Applications to the Director, Radiotherapeutic Research Unit, Hammersmith Hospital, W.12. W 2477

MINISTRY OF SUPPLY requires Physicists or Engineers for R.A.E., Farnborough, Hants, to work either on problems connected with generation and distribution of electric power in aircraft, or on problems of electro technology arising in design and development of aeronautical equipment. Aptitude for practical work essential, some knowledge of mathematics desirable. Qualifications: Higher School Certificate (Science) or equivalent but further training in Physics or Electrical or Mechanical Engineering to standard of Degree or H.N.C. may be an advantage. Salary within ranges: Experimental Officer (minimum age 26), £597-£754, or Assistant E.O., £264-£555. Women somewhat less. Posts unestablished. Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting D.146/53A. Closing date 12th June, 1953. W 2434

MINISTRY OF SUPPLY requires design Engineers at Harwell to assist on design problems of control and instrumentation for new types of reactors. Qualifications: British of British parents. Recognized electrical apprenticeship or equivalent training instrumentation or electronics and A.M.I.C.E., Mech.E. or E.E. or exempting qualifications. Experience in design and installation of instrumentation and control systems and servo mechanisms. Salary and Grade according to age, qualifications, experience within £597 (Eng. III age 25)-£1,454 (Eng. I maximum). Housing accommodation available later if married. Not established, but opportunities to compete for establishment may arise. Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting (D 186/53A). Closing date 13th June, 1953. W 2464

MINISTRY OF SUPPLY requires Electrical Engineer at Harwell to assist design of new control systems, inspect during manufacture, supervise installation; or maintain and develop existing installations. Qualifications: British of British parents. Recognized engineering apprenticeship and A.M.I.E.E. or equivalent or exempting qualifications. Experience in large-scale remote recording and control installations (temperature flow, pH, etc.), remote power control servo-mechanisms, ionization instruments, high stability amplifiers, ratemeters, scalers and discriminators. Salary, £597 (age 25)-£928. Not established, but opportunities to compete for establishment may arise. Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting D.185/53A. Closing date 12th June, 1953. W 2478

NEWCASTLE UPON TYNE Education Committee. Rutherford College of Technology. Principal: Dr. H. A. Scarborough, M.A. Applications are invited for the post of Assistant Grade B in the Department of Electrical Engineering. Applicants should possess graduate or equivalent qualifications. Ability to teach Telecommunications subjects an advantage. Salary in accordance with the Burnham Technical Scale for Grade B Assistants, £490-£765 with additions for approved qualifications and training. Application forms which may be obtained from the undersigned should be returned within 14 days of the appearance of this advertisement. H. V. Lightfoot, Director of Education, City Education Office, Northumberland Road, Newcastle upon Tyne, 1. W 1714

POST OFFICE: Assistant Engineer. The Civil Service Commissioners announce an open competition commencing 18th August, 1953, for not less than 33 posts for men. Age 17½-23½ on 1st March, 1953, with extension for regular service in H.M. Forces, and up to two years for other Forces service or for established Civil Service. For particulars (including prospects) and application form (preferably by postcard) to Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 159/53. Application forms must be returned by 25th June, 1953. W 2483

PROFESSIONAL ENGINEERS in various Government Departments. The Civil Service Commissioners invite applications for about 150 pensionable posts in a wide variety of mechanical and electrical engineering duties. Applications may be accepted up to 30th September, 1953, but an earlier closing date may be announced. Candidates must be under 35 on 1st January, 1953, with extension for regular service in H.M. Forces and up to two years for permanent Civil Service. For the Post Office they must be at least 21, for the Ministry of Supply and Ministry of Civil Aviation at least 23, and for all other Departments at least 25 on that date. Generally a candidate must possess a University Degree in Engineering or be a Corporate Member of one of the professional institutions—Mechanical Engineers, Electrical Engineers, or Civil Engineers—or have passes in, or exemption from, Sections A and B of the corresponding Associate Membership examinations. Exceptionally, candidates of high professional attainment, but without the specified qualifications, may be admitted. For some posts Associate Fellowship of the Royal Aeronautical Society or an Honours Degree in Physics will be accepted. Inclusive salary scale (men in London) £628 (at age 25) to £970. Starting salary according to age up to £875 at 34. Candidates entering below age 25 will start at salaries varying from £429 at age 21 to £549 at age 24. Prospects of promotion. Salaries of next higher grades are £970-£1,280 and £1,331-£1,536. Somewhat lower for women and in the Provinces. Further particulars and application forms from Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S85/53. W 2473

THE COLLEGE OF AERONAUTICS. Applications are invited for the following posts in expanding Electrical Section: (1) Lecturer in Electrical Engineering (Electronics), who will be required to cover fundamental electronic circuits, including pulse circuits and their application to the measurement of non-electrical quantities. He will also assist in the development of the specialized electronic instruments required by all Departments of the College in their research work. Honours Degree in Physics or Electrical Engineering required with experience in at least one of the following fields: airborne radio and radar systems; servomechanisms; electronic techniques in measurement and control. Salary within range £600-£1,000 p.a. with superannuation under F.S.S.U. and family allowance. Further particulars available. (2) Design Draughtsman, who will be responsible for the layout and detail design of the great variety of electronic and electrical equipment developed by the Section. Applicants must have had experience with electronic and/or light electro-mechanical equipments. Preference will be given to a person capable of assisting and supervising students in their project-design work. Salary according to qualifications and experience. Applications, giving full particulars and containing the names and addresses of not more than three referees, to the Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks. W 2465

UNIVERSITY COLLEGE of the Gold Coast. Department of Physics. Applications are invited for the appointment of an Electronics Technician in the Science Workshops. Some experience of instrument making is required. The appointment will be on a five-year contract in the first instance. Salary £800 p.a. plus a gratuity of £100 per annum in lieu of superannuation provision. Part furnished residential accommodation at rent of not more than 10 per cent of salary will be provided. Family allowances of £50 per child (up to a maximum of £150) if children are resident in the Gold Coast or £100 per child (up to a maximum of £300) if children are resident elsewhere. Free first-class passages will be provided for the selected candidate and his family on assumption and relinquishment of the appointment and for annual leave of eight weeks in the United Kingdom. Outfit and baggage allowances are paid on first appointment. The duties will

OFFICIAL APPOINTMENTS (Cont'd.)

include the construction, maintenance and repair of electrical equipment, the training of staff and responsibility for electronic components stores. Applications (six copies) with the names of three referees, should be sent to the Assistant Registrar (London), University College of the Gold Coast, 29, Tavistock Square, London, W.C.1, from whom further particulars may be obtained. Closing date: 30th June, 1953. W 1710

UNIVERSITY OF ABERDEEN. Electronics Mechanic required for Physics Laboratory, Natural Philosophy Department; without supervision, able to construct complex apparatus from theoretical circuit and design simple circuit to specification; some general workshop experience useful; wage £365 to £450, according to experience. Applications to the Secretary, University of Aberdeen. W 1711

VACANCIES in Government Department. Leading Draughtsmen and Draughtsmen are required, with experience in the layout of telecommunication and electronic equipment, involving detailed mechanical design, preparation of all mechanical drawings, sub-assemblies, and final assembly, circuits, specifications, and stock-lists; suitable for prototype and batch production manufacture. Practical workshop experience, and knowledge of modern methods an asset but not essential. Salaries (Consolidated Provincial Rates). Leading Draughtsman, £592 0s. 0d. × £20 0s. 0d. to £702 0s. 0d. Draughtsmen, £374 0s. 0d. × £20 0s. 0d. to £597 0s. 0d. Apply in writing: Personnel Department, G.C.H.Q., 53 Clarence Street, Cheltenham. W 2495

SITUATIONS VACANT

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

A DESIGN DRAUGHTSMAN with experience of layout of prototype electronic equipment and test gear is required by the Research Laboratories of The General Electric Co. Ltd., North Wembley, Middlesex. Candidates should also have some experience of designing electro-mechanical mechanisms. Apply in writing to the Staff Manager (Ref. RLO/4), giving full details of age, qualifications and experience. W 2472

A DESIGNER is required to organize and control a Section engaged on the design and specification of electrical and electronic equipment intended for production testing in a valve and cathode ray tube factory. This work involves familiarity with a wide range of techniques including pulse R.F., E.H.T., circuits and automatic switching systems. It is desirable that he shall have Graduate or equivalent status and essential that he can claim considerable practical experience in this or closely allied fields. Write, giving full particulars of experience, etc., to Box No. W 2451.

A DESIGNER/DRAUGHTSMAN with Higher National Certificate is required by the Research Laboratories of The General Electric Co. Ltd., North Wembley, Middlesex, for work on microwave receiving equipment. Some previous experience in this field is desirable, but not essential. Apply in writing to the Staff Manager (Ref. RLO/763), stating age, qualifications and experience. W 2419

A HIGH VACUUM Impregnation Unit—to R.I.C. Specification 214 or individual requirements. Good delivery at competitive prices from Vactite Components & Assemblies, 505, Lordship Lane, S.E.22. Forest Hill 7089. W 166

AERO RESEARCH LTD. (A Ciba Company) wish to appoint a salesman, with special knowledge of the technology of electrical insulation, to promote the sales of Araldite (epoxy) casting and laminating resins. This is a new position in an expanding industry. Applications should be made in writing, giving age and full details of previous experience, to Managing Director, Aero Research Ltd., Duxford, Cambridge. W 2456

AIRTECH LIMITED. Aylesbury & Thame Airport, Haddenham, Bucks, require Radio Mechanics and Testers, capable of working on own initiative to Ministry specifications. Small batch production. Varied and interesting work covering Audio to U.H.F. Preference given to applicants with experience on Aircraft Radar installation. Write giving age, details of experience and qualifications. W 1729

AN INSTRUMENT ENGINEER required in Research Laboratories for circuit design of electronic and electrical measuring apparatus. Applicants must have three years' design experience of electronic apparatus and minimum qualification of Higher National Certificate. Progressive post for successful applicant. Salary according to age, experience and qualifications. Full details to Personnel Officer, Ericsson Telephones Limited, Beeston, Nottingham. W 2437

AN INSTRUMENT MECHANIC is required for duties in the Electronics Division of the Research and Experimental Department. Applicants should possess a high Degree of mechanical skill and be able to participate intelligently in both design and manufacture of small electro-mechanical devices. Experience in a similar capacity, whilst desirable is not essential. Write, stating age, experience and salary expected to the Personnel Office, Saunders-Roe Limited, East Cowes, I.O.W. W 2428

APPLICATIONS ARE INVITED for the undernoted vacancies: Electronics Development Engineer with University Degree or equivalent qualifications, also practical experience in design and development work. Technical and Laboratory Assistant with Higher National Certificate in Electrical Engineering or City and Guilds Telecommunication Certificate. Preference given to person with practical knowledge of radar and laboratory work. Electronics Engineer with knowledge and practical experience in micro-waves, electro-mechanical measurements and servo-mechanisms. Applications by letter giving details of education, qualifications and experience to The Secretary, Messrs. Barr and Stroud Limited, Anniesland, Glasgow, W.3. W 2503

ASSISTANT ENGINEER for installation and maintenance duties X-ray and Electromedical apparatus. Training given if necessary, but sound basic knowledge electrical engineering essential. Write M.S.A. Ltd., 53, Park Royal Road, London, N.W.10. W 2474

ASSISTANT ENGINEER required for general development work on magnetic amplifiers and aircraft equipment, in a company situated about thirty miles S.W. of London. Applicants should preferably possess a Degree or Higher National Certificate in Electrical Engineering. Apply to Box No. W 1719.

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

BRITISH INSULATED CALLENDER'S CABLES LTD. require for their Telecommunications Laboratory, Kirkby Trading Estate, near Liverpool, capable draughtsmen for interesting design and development work on light Electro/Mechanical accessories. Applicants qualified to O.N.C. standard and with previous experience in a similar capacity preferred. Only keen and conscientious men need apply. Applications in writing to: The Staff Officer, B.I.C.C. Ltd., Prescot, Lancs. W 2399

BRITISH INSULATED CALLENDER'S CABLES LTD. require for their Telecommunications Laboratory, Kirkby Trading Estate, near Liverpool, Laboratory Mechanics for the development of light electro-mechanical accessories. Previous experience in polythene press moulding would be an advantage but this is not essential. Candidates for these vacancies should be first-class men capable of precise bench work. Applications in writing to: The Staff Officer, British Insulated Callender's Cables Ltd., Prescot, Lancs. W 2409

BRITISH INSULATED CALLENDER'S CABLES LTD. require for their Telecommunications Laboratory, Kirkby Trading Estate, near Liverpool, capable draughtsmen for interesting design and development work on light electro/mechanical accessories. Applicants qualified to O.N.C. standard and with previous experience in a similar capacity preferred. Only keen and conscientious men need apply. Applications in writing to: The Staff Officer, B.I.C.C. Ltd., Prescot, Lancs. W 2442

CHIEF DESIGNER required by Scientific Instruments and Electro Magnetic Assemblies Manufacturer located at Stevenage, Hertfordshire. This appointment, which will arise in July, calls for a highly qualified man with administrative ability and offers an exceptional opportunity. Practical experience with Relays, Temperature Control Equipment and Magnetic Amplifiers an advantage. Pension Scheme and house available. Send details of age, qualifications, experience and present salary to Box No. W 2438.

CHIEF INSPECTOR with wide mechanical and electrical experience, preferably in telecommunications or light electronic engineering, required at once. Applicants should not be over 45 years and will be required to produce satisfactory evidence of their organizing, technical and administrative ability in a similar capacity in a large engineering works. A salary commensurate with the responsibilities of the position is offered. Applications, which will be treated as strictly confidential, should be sent with full details of past career to Personnel Manager, The Phoenix Telephone and Electric Works Ltd., The Hyde, N.W.9. W 2494

CHIEF INSPECTOR required by well-known Company in S.E. London engaged in manufacture of light electrical appliances. Applicant must be technically qualified in electrical and mechanical engineering, and must have experience of modern inspection methods for quantity production, including quality control and administration. Executive post carrying appropriate salary and pension. Applications will be treated in strict confidence, but will not be considered unless they present a concise table showing education, training and positions held, with names, dates and salaries. Box No. W 2426.

DECCA RADAR LIMITED require draughtsmen and junior draughtsmen for Research Drawing Office, preferably experienced in any of the following fields: Radar, radio and electronic circuits, electro-mechanical devices, light mechanical engineering. Knowledge of workshop practice essential, applicants must possess Ordinary National Certificate or equivalent. Positions permanent and progressive: salaries based on A.E.S.D. rates. Write giving full details to Chief Draughtsman, Decca Radar Ltd., 2, Tolworth Rise, Surbiton, Surrey. W 161

DECCA RADAR LTD. invites experienced Electrical Engineers to apply for the post of leader of a group, to be formed, for the preproduction of microwave links. The post carries good starting salary, is pensionable, and there are good prospects of expansion in scope. Applicants must be of British nationality and should be under forty years of age. Write, quoting ref. SRT.B.: The Research Director, Decca Radar Ltd., The Research Laboratories, 2, Tolworth Rise, Surbiton, Surrey. W 168

DECCA RADAR LIMITED invites applications from experienced microwave engineers to join the Company in its extensive work in a wide field of microwave link and radar development. The Company offers excellent starting salaries and first rate opportunities for men to exploit their initiative and to rise rapidly to responsible posts. Graduates without industrial experience who are prepared to undertake intensive training are also invited to apply for junior posts. Applicants must be of British nationality. Apply in writing, quoting ref. MW, to Research Director, Radar Laboratory, 2, Tolworth Rise, Surbiton, Surrey. W 170

DECCA RADAR LIMITED requires a senior engineer to take charge of the testing of high-power centimetric radar equipment. Previous experience of high-power radar, including receivers and A.F.C. systems, is required. A good salary, commensurate with experience, will be offered to the right man, for whom there are excellent prospects in this progressive and expanding company. Please apply giving full details of experience and stating salary required to Ref. F.L., Decca Radar Limited, 1-3, Brixton Road, London, S.W.9. W 2471

DECCA RADAR LIMITED require a Senior Engineer to form a new Division of the Company undertaking the planning and erection of large radar stations both in the United Kingdom and abroad. The appointment calls for a man between 30 and 45 years of age, with exceptional experience in the engineering design, planning, and progressing of electrical projects of a major nature. While a knowledge of radio and radar engineering at high powers is a distinct advantage, very favourable consideration will be given to heavy power engineers. Sound engineering knowledge, experience, and ability

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SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

to plan and direct are the major requirements. A salary commensurate with the qualifications and responsibility will be paid. The post is permanent and pensionable. Apply in strict confidence to Managing Director, Decca Radar Limited, 1-3, Brixton Road, S.W.9. Ref. H.I.D. W 2470

DESIGNER / DRAUGHTSMAN required by The English Electric Co. Ltd., Luton. Must be fully experienced in radar or electronic equipment and conversant with RCS 1000 Standards. Good mechanical and circuit knowledge is essential. This is a responsible and progressive position leading a small team of draughtsmen. Salary around £700 with housing assistance for suitable married candidate. Applications to Dept. C.P.S., 336, Strand, W.C.2, quoting ref. 1119. W 2469

DESIGNER DRAUGHTSMAN. Higher National Certificate Standard, preferably with machine tool experience, a knowledge of hydraulics and up-to-date machine tool practice, required by well-known Engineering Company. North-West Birmingham. Five-day week, Staff Pension Scheme, Modern Drawing Office. Apply, giving details of age, experience and salary required, to Personnel Manager, Box No. W 2485.

DESIGNER DRAUGHTSMAN. Electronic Instruments or Radio. Good prospects and salary according to qualifications. Prospects of housing assistance to suitable applicant. Saturday interviews if required. Near City centre and all amenities. Within easy reach London. Apply Marconi Instruments Ltd., Longacres, Hatfield Road, St. Albans. W 2432

DEVELOPMENT ENGINEER required. Experience in electronic communication field an advantage. Excellent opportunity for man with technical and industrial experience to broaden experience with well-established and well-known Company. Near town centre and all amenities and within easy reach London. Apply Marconi Instruments Ltd., Longacres, Hatfield Road, St. Albans. W 2433

DEVELOPMENT ENGINEER required by well established firm to develop components and electronic apparatus. Ability to exploit ideas and work on own initiative essential. Send full details of previous positions held and type of work undertaken, together with approximate salary required, to Box No. W 2467.

DRAUGHTSMAN wanted for a small Drawing Office engaged in the design and drafting of Electronic Instruments for the industrial and telecommunications field. Write stating age, experience and salary required to Dawe Instruments Ltd., Harlequin Avenue, Great West Road, Brentford, Middlesex. W 2482

DRAUGHTSMEN, Senior and Junior, required. Design and Layout experience of Electronic and Electro-mechanical equipment and/or mechanical computors essential. Facilities exist for further technical training under the supervision of E.M.I. Institutes Ltd. Apply by letter stating age, nationality and experience to E.M.I. Engineering Development Limited, Wells Division, Penleigh Works, Wells, Somerset. W 2462

E. K. COLE LTD., Electronics Division, Malmesbury, Wiltshire, require Draughtsmen (Mechanical or Electrical of National Certificate Standard), aged 21 to 25 years, for interesting and varied work on Radar and Communication Equipments: also for Test Gear. Excellent conditions and prospects. Apply in writing to Personnel Manager. W 2458

ELECTRONICS. A vacancy exists with an Electrical Engineering Company on the North East Coast for an engineer to design and develop Electronic Circuits. Previous experience on this class of work essential. Applicants should submit full particulars regarding age, qualifications and practical experience to Box W 2435.

ELECTRONIC CIRCUIT AND DEVELOPMENT ENGINEERS are required by the English Electric Company Limited for interesting work on H.F. heating generators. A University Degree is desirable but practical experience of this type of work or on radio transmitters or similar apparatus is essential. Write with full details quoting reference 357F to Central Personnel Services, English Electric Co. Ltd., 336/7, Strand, London, W.C.2. W 2423

ELECTRICAL ENGINEER OR PHYSICIST, preferably with experience in high frequency measurements, required for industrial laboratory in West Midlands, dealing with insulation and dielectrics. Candidates should have a University Degree or equivalent and be between 24 and 30 years of age. The post is a permanent and pensionable one and carries a maximum salary of £1,000 in the case of a well qualified and experienced applicant. Write to Assistant Staff Manager, Box No. W 2445.

ELECTRONIC ENGINEER with Higher National Certificate or equivalent is required for the development of V.H.F. equipment and components. Applicants must have good laboratory experience and sound practical knowledge in this sphere. Write stating qualifications, experience and salary required to Wingrove & Rogers Ltd., Domville Road, Liverpool, 13. W 1720

ELECTRONIC ENGINEER required for development work in a laboratory (London S.E. Area) engaged in the application of electronic techniques in new fields. Pension Scheme. Give full details of qualifications, experience, age and commencing salary required. Box No. W 2427.

ELECTRONIC ENGINEER for work in connexion with the development and production of electronic measuring instruments. Sound theoretical knowledge and several years' experience in this field essential. Excellent opportunity for capable person to progress with young and rapidly expanding organization. Rivlin Instruments Ltd., 7a Maitland Park Villas, N.W.3. W 1724

ELECTRONIC ENGINEER required by new division of prominent Engineering Concern in Northern Ireland for development work on Guided Weapons and other projects. Degree or equivalent in electrical engineering or physics, with good practical experience, preferably of D.C. Amplifiers, Electronic Computation, Pulse Techniques, or Miniature Equipment. Good salary and prospects for man with originality. Details of housing accommodation available and facilities for removal supplied at interview. Send full details of age, qualifications and experience, quoting reference E.E.1, to Box No. W 2487.

ELECTRONIC ENGINEER required to work on development projects in small organization situated on South Coast. Experience on design of communications receivers essential. Some F.M. experience an advantage. Degree or equivalent desirable. Write full details and salary expected. Box No. W 1704.

ELECTRONIC ENGINEER, preferably graduate of recognized training establishment, required for design and maintenance of Industrial Electronic Control and testing equipment of all types. Salary according to qualifications and experience. Location, Midlands Engineering Plant. Apply Box No. W 1705.

ELECTRONIC ENGINEER. First-class man with commercial experience required by large organization. Applicant must have good basic training and preferably hold science Degree or membership of approved institute, and have sound knowledge and experience of electronics industry. Position offers excellent prospects for engineer aged 35/40 with initiative. Pensionable appointment. Minimum salary £1,000. Write giving full details of education, training and experience to 522, Box No. W 2490.

ELECTRONIC ENGINEER required by large food factory in London, in the development section on the construction of specialized factory electronic equipment. Age 20-28. Applicants should possess initiative and be capable of working with the minimum of supervision. Good canteen. Salary according to age and experience. Write Box E.344, c/o 191 Gresham House, E.C.2. W 2500

ELECTRONICS ENGINEER. Davy and United Engineering Company Limited, Sheffield, Europe's largest builders of rolling mills and forging presses, require the services of a young Physicist or Electronics Engineer for the development of electronic circuits for servo mechanisms and instruments for the Steel industry. A knowledge of industrial electronic instruments is essential. Salary will be commensurate with experience and qualifications. Staff Pension Scheme, good conditions of service and prospects. Apply, stating full particulars of experience and qualifications to the Personnel Officer, Davy and United Engineering Company Limited, Park Iron Works, Sheffield, 4. W 2499

ELECTRONIC ENGINEER/PHYSICIST required, primarily for component analysis. Applicants should have experience of electronic measurements and instruments, and theoretical knowledge up to at least Inter. B.Sc. standard. Some knowledge of instrument design would be an advantage. The position offers a good salary and prospects of promotion to assistant chief engineer to a keen and conscientious man. There is also a vacancy for junior work on similar lines. Five-day week, W. London area. Our staff have been informed of this advertisement. Apply giving full particulars in confidence to Box No. W 2507.

ELECTRONIC INSTRUMENTS. Salesman required for South Africa; should have a sound knowledge of basic physical principles, preferably with University Degree and an interest in nucleonics. The successful applicant will receive training at the A.E.R.E. Harwell. Initial contract three years. Suitable salary and travelling expenses. Box No. W 1718.

ELECTRONIC INSTRUMENTS LTD., of Richmond, Surrey, have a number of vacancies for drawing office staff and for junior technical development engineers. Age: 21 upwards. Qualifications: National or Higher National Certificate in appropriate subjects. Excellent prospects in expanding and progressive company. Apply in person or by letter, giving experience. W 1707

ELECTRONICS RESEARCH ASSISTANT wanted in physiological laboratory. Duties: to develop and construct apparatus (mainly electronic) for nerve and muscle research. EEG/EMG/CRO-photography or general workshop experience an advantage. Salary £520 × £25 to £620 p.a. with superannuation and children's allowance. Apply in writing to The Secretary, Department of Physiology, The Middlesex Hospital Medical School, London, W.1. W 1725

ENGINEER required to undertake the development of electronic instruments. The successful applicant must be capable of working substantially on his own initiative. Salary will be in accordance with qualifications and experience. Degree or equivalent preferred. Apply in writing to Advance Components Limited, Back Road, Shernhall Street, London, E.17. W 2466

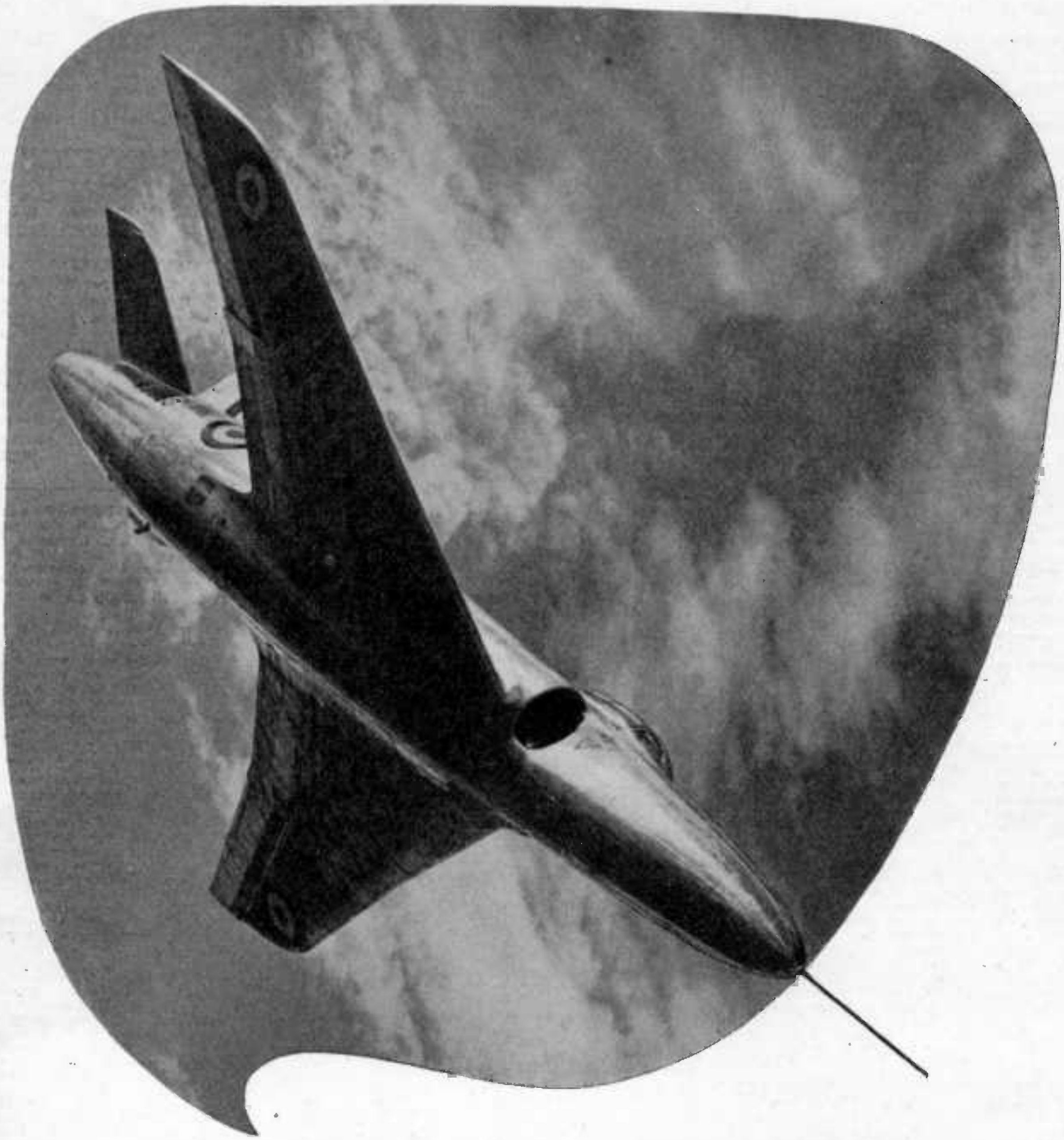
ENGINEERS: Mechanical, Electro-Mechanical and Electronic, required at Brentford and Feltham, Middlesex, for interesting development work on aeronautical and marine products and guided missiles. Applicants must have good technical qualifications together with appropriate practical experience. Pension scheme. Opportunities of advancement. Apply with full details of experience and salary required to Personnel Manager, Sperry Gyroscope Co. Ltd., Great West Road, Brentford, Middlesex, quoting No. 1098. W 2441

ENGINEERS, B.Sc. or equivalent, for design work in connexion with television circuits and associated components. Mechanical Engineers to undertake design of vibrators and/or switch and panel accessories. Good Degree or a wide industrial experience of this class of work. Engineers fully conversant with the design of transformers associated with Radio, Electronics and Telecommunications equipment. A large engineering Company invites applications for the above permanent and progressive appointments necessitated by expansion of the Company's business. Superannuation scheme in operation. Please write, in confidence, quoting reference EE/56, giving full details of salary required to Box No. W 2491.

ENGINEER-DRAUGHTSMAN required for works West London Area. Good electrical qualifications and at least ten years' drawing office experience, including design of precision light mechanical equipment. Competent to initiate design and take charge of small drawing office engaged on interesting electro/mechanical and electronic equipment, part of expanding company's engineering division. Pension scheme. Write stating qualifications, age, details experience, salary required. Box No. W 2452.

EXPERIENCED Fault-Finders wanted by Midland Manufacturers of Radio Equipment.

CLASSIFIED ANNOUNCEMENTS
continued on page 6



The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

Permanent posts located in the Midlands are offered to men with experience of Radar, Radio Control, V.H.F. Equipment. Write stating fully, experience and salary required to Personnel Manager. Box No. W 2318.

EXPERIENCED Radio Testers and Inspectors required for production of communication and radio apparatus. Also Instrument makers, wirers and assemblers for Factory Test apparatus. Apply Personnel Manager, E. K. Cole Ltd., Ekco Works, Malmesbury, Wilts. W 146

FERGUSON RADIO CORPORATION LTD. have vacancies for the following staff. Development Engineers, Senior and Junior, for Radio, Television and Electronics. Previous experience circuit development work absolutely essential. Draughtsmen, experience in Radio and Television Receiver Design (and small mechanical details), able to prepare drawings for manufacture of prototype equipment. Apply in writing. Employment Manager, F.R.C., Gt. Cambridge Road, Enfield, Middlesex. Posts are permanent, progressive and pensionable. W 2480

GLASGOW. Radio Mechanic, preferably experienced Tape and Wire Recorders. Permanent position with prospects. Commencing salary £7 10s. 0d. Land, Speight & Co., Ltd., 73 Robertson Street, Glasgow. W 1726

GRADUATE in Electrical Engineering or Physics required for very interesting development of new materials, for use in Telecommunication. Apply Personnel Manager, Standard Telephones & Cables Ltd., North Woolwich, E.16, stating age, qualifications and salary required. W 2440

GUIDED WEAPONS. Electrical Engineer or Mathematician with relevant postgraduate experience, required for theoretical work on design of automatic control systems. Some knowledge of effect of noise on servomechanisms an advantage. Senior staff appointment with good salary and prospects. Pension scheme. Write in detail to Personnel Manager, de Havilland Propellers Ltd., Hatfield, Herts. W 2488

IMMEDIATE APPLICATIONS are invited for post as deputy head of electrical/radio office of leading Aircraft Company in the South. Applicant must have sound design experience including aircraft, with specialist knowledge of installation of electrical, radio, radar and electronic instruments and the development of ancillary apparatus. Applicant should be good disciplinarian. The post carries senior grading and housing can be recommended after a short probationary period. Please write in first instance giving experience, and salary expected, to Box N.2990, A.K. Advg., 212a, Shaftesbury Avenue, London, W.C.2. W 2431

H.F. INDUCTION HEATING CONTRACT ENGINEER. Duties involve receiving customers' enquiries and/or samples, returning processed samples with report and equipment quotation. Acknowledging customers' order and issuing necessary information to works, D.O. and test room. Maintaining contact with customer. Ability to get on with other people and previous induction heating experience essential. Write giving age, past experience and salary required. Post in modern greenbelt factory with makers of one-third of all British R.F. heating plant. Radio Heaters Ltd., Wokingham, Berks. W 1715

INSPECTION SUPERVISORS required by a large engineering Company situated in the London Area. Applicants should have held a similar position and have previous experience of radar and/or radio equipment. A knowledge of pulse circuitry essential. Modern factory and good staff conditions. Please write, in confidence, quoting reference EE/IP, giving full details of experience to Box No. W 2443.

LABORATORY ASSISTANTS required on development of special materials for use in telecommunications. Applicants must have National Certificate or higher qualifications and a special interest in Chemistry or electrical measurements. Apply in writing to Personnel Manager, Standard Telephones & Cables, Ltd., N. Woolwich, E.16, stating age, qualifications and salary required. W 2486

JOSEPH LUCAS (Gas Turbine Equipment) Ltd. invites applications for Electronic Engineers. Some knowledge of Servo mechanisms would be an advantage. Should have University Degree. These appointments are pensionable and offer good prospects to individuals with initiative and technical ability. Salary will be in accordance with experience and qualifications. Details of experience and qualifications should be sent to Personnel Manager, Joseph Lucas (Gas Turbine Equipment) Ltd., Shaftmoor Lane, Hall Green, Birmingham. W 2459

LONDON BRICK COMPANY LIMITED has a vacancy for an Instrument Mechanic, preferably with some electronic experience, to work in the Research Department at Stewartby. Salary £400-£550 according to qualifications and experience. Apply in writing to the Personnel Manager, London Brick Company Limited, Stewartby, Bedford. W 1727

LONDON ELECTRICAL MNFG. CO. LTD. require Senior Production Engineers with theoretical and/or practical knowledge. Applicants should have had experience in the industry, preferably with components. Preference and considerably higher salaries would be offered to men who have been engaged in the production of ceramic condensers. Please write, giving full particulars, in confidence, to: L.E.M., Beavor Lane, W.6, or telephone Riverside 4824, asking for Mr. Lyons. W 2449

MESSRS. PYE LIMITED, Cambridge, have vacancies for Senior and Junior Test Engineers, also Electronic Wiremen, on very interesting work in their television transmission equipment Department. Apply in writing to Personnel Department, St. Andrew's Road, Cambridge. W 2401

McMICHAEL RADIO LTD. require Senior and Junior Engineers in their equipment division laboratory at Slough. Training and experience in the field of applied electronics (including communications) and experience of working with Government Departments are the chief qualifications required. Write stating age and full details of training, qualifications and experience to the Chief Engineer, Equipment Division, McMichael Radio Ltd., Slough, Bucks. W 157

MURPHY RADIO LTD. have vacancies for two or three Senior Engineers to lead development teams in their Electronics Division. Applications are invited from men with Engineering or Physics Degrees or equivalent, and with first class experience in the fields of Radar Navigational Aids, V.H.F. Communications Receivers and Low Power Transmitters. Salary upwards of £650 per annum according to qualifications and experience. Candidates prepared to bring energy and drive to their work may address their applications in confidence to the Personnel Manager, Murphy Radio Ltd., Welwyn Garden City. W 2361

NEW DIVISION of the G.E.C. Stanmore Laboratories requires Electronic or Electrical Development Engineers for work on design of prototype models of equipment for guided missiles and radar. 1. Men with good experience of work in these fields are invited to apply for senior positions for which qualifications of degree standard or the equivalent would be an advantage. 2. A number of vacancies also exist for more junior men with qualifications to Ordinary National Certificate or equivalent standard. Applicants' requirements for holidays will receive special consideration. Applications should be made in writing to the Personnel Manager (Ref. EE/E1), stating age, qualifications and experience, G.E.C. Stanmore Laboratories, Brown's Lane Division, The Grove, Stanmore Common, Stanmore, Middlesex. W 2493

PHYSICIST, first or second Honours Degree, required by electrical engineering Company in S.W. London. Preferably some knowledge of electronics, X-ray or nucleonics. Write stating age, experience and salary required to Box EE312, L.P.E., 110, St. Martin's Lane, W.C.2. W 2448

PHYSICIST required in the North West for the development of Capacitors for use in Telecommunication equipments, including silvered mica and paper and plastic dielectric types. The posts available are permanent, on full staff status with contributory Pension Fund, etc. Please write giving full details of qualifications and experience and the approximate salary required to Box 194, Dorland Advertising Ltd., 18/20, Regent Street, London, S.W.1. W 2489

PRODUCTION ELECTRICAL TESTERS required for television, radio and electronic equipment. Very interesting work. Good facilities and pay. Keen technicians only required. Dynatron Radio, Ray Lea Road, Maidenhead. W 2479

QUALIFIED MECHANICAL ENGINEER with electronic and light electrical experience required by Company engaged in design and development of guided weapons; preferably with knowledge of servo mechanisms to take charge of laboratory engaged on the design and development of control systems, power supplies, electrical gyros and other ancillary devices. Salary up to £1,500 p.a. for applicant with suitable qualifications. Pension scheme; housing assistance. Apply Box AC 80899, Samson Clarks, 57-61 Mortimer Street, London, W.1. W 2422

RADIO AND RADAR TESTERS. First-class men required for work on V.H.F. Communication Gear and Government Contracts for Radio and Radar Equipment by Midland Manufacturers. Men with wide experience of Fault Finding in any of the fields mentioned should write giving full details to Box No. W 2317.

RECORDING STUDIOS specializing in the production of commercial discs and radio programmes require the services of an experienced balance engineer who is fully conversant with disc and tape recording techniques. A good technical knowledge of the equipment used in this type of work is essential. Applications in writing giving age, experience and salary required to Box No. W 1713.

RESEARCH AND DEVELOPMENT ENGINEERS are required by British Telecommunications Research Ltd., a Company associated with The Automatic Telephone & Electric Co. Ltd., and British Insulated Callender's Cables Ltd., for work on long term development projects in Wide-band Line Communications. A number of posts with salaries in the range £500-£1000 per annum are available for suitably qualified engineers or physicists with experience in this field. Further posts are available for technical assistants with salary in the range £300-£600 according to qualifications and experience. Applications are also invited from Honours Graduates in physics or electrical engineering who are considering careers in the research or development side of the telecommunications industry. There is a superannuation scheme and the Company works a five-day week. Application should be made to the Director of Research, British Telecommunications Research Ltd., Taplow Court, Taplow, Bucks, giving age and full details of education, qualifications, experience and approximate salary required. W 2463

RESEARCH ENGINEERS required for automatic welding development projects. Applicants should possess the necessary aptitude and qualifications to undertake research work—a Degree in electrical engineering is essential—but ample opportunity is available for outstanding successful candidates to make further progress in the automatic welding field, in which this North-East firm occupies an important position. Apply in writing to Box No. W 1688.

SALES ENGINEER required for the sale in Great Britain of world known test gear in the electronic field. Write stating experience and suggestions to Box No. W 1706.

SENIOR, Intermediate and Junior Draughtsmen required by The English Electric Co., Ltd., Luton, for work on design of specialized electronic equipment. Applicants should have sound mechanical background and an interest in electrical or electronic work. Part time study for National Certificate encouraged. Applications from practical engineers without Drawing Office experience will also be considered for full time training course. Remuneration according to

CLASSIFIED ANNOUNCEMENTS
continued on page 8

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

qualifications and experience. Applications to Central Personnel Services, The English Electric Co. Ltd., Marconi House, 336/7, Strand, London, W.C.2, quoting reference 144J. W 2439

SENIOR Mechanical designer. Two or three vacancies exist in our Electronics Division for Senior Design Draughtsman on Electronic Equipment. Candidates should be of at least Higher National Certificate standard and should be capable of leading a design team in this class of work. Salary £650 per annum upwards according to qualifications and experience. Applications should include full details of experience to date and may be forwarded in confidence to the Personnel Manager, Murphy Radio Ltd., Welwyn Garden City. W 2360

SENIOR Test/Service Engineers required for Industrial Electronics Department. H.N.C. an advantage. Experience in electronic control gear, H.F. heating equipment or instruments preferred. Please apply, stating age, qualifications and experience, to Central Personnel Services, English Electric Co., Ltd., 336/7, Strand, London, W.C.2, quoting reference 979B. W 2424

SCIENTIFIC INSTRUMENT MAKERS in North London have a few vacancies for skilled laboratory assistants and wire-men for the development and production of high quality electrical and electronic apparatus. Please apply, in writing only, stating qualifications, experience and salary required, to Personnel Officer, Hilger and Watts Ltd., Hilger Division, 98 St. Pancras Way, London, N.W.1. W 2410

SENIOR DESIGN DRAUGHTSMEN required by a large engineering company due to expansion of company's services and commercial business. Applicants should have a comprehensive knowledge of mass production of radio, television and Services equipment. Salary £650 per annum: monthly status. The appointments are of a permanent and progressive nature. Company superannuation and life assurance scheme in operation. Please reply, quoting reference EE/53, giving details of experience to Box No. W 2460.

SENIOR RESEARCH ENGINEER required to supervise gyroscopic development programme. Applicants must possess first rate academic qualifications and must have had considerable experience of laboratory research techniques, together with detailed experience of practical engineering design and industrial manufacturing processes and knowledge of engineering materials. Understanding of instrument design techniques, servo mechanism theory, and electronics desirable. Company is situated West side of London. Apply with full details, including salary, quoting No. 1100, to Box AC81308, Samson Clarks, 57/61, Mortimer Street, W 1. W 2450

SEVERAL EXPERIENCED graduate electronic and electro-mechanical engineers are required for long term development in centimetric radar equipment, servo mechanisms and instrumentation. Candidates must be British born and should be capable of working as members of a team with little supervision. The posts are permanent and pensionable. Applications, giving full particulars of experience to date, will be treated in confidence and should be made in writing, quoting reference SP. to the Personnel Manager, The Plessey Company Limited, Vicarage Lane, Ilford, Essex. W 2425

TELEPHONE ENGINEER required for panel layout and component engineering work on carrier-current equipment. London S.E. area. Qualifications: up to Higher National Certificate, and experience of transmission or electronic apparatus work desirable. State age and commencing salary required. Box No. W 2475.

TEST AND JUNIOR Development Engineers are required to assist in the development and production of precision electronic laboratory instruments. Applicants should have a sound theoretical knowledge and have had substantial practical experience of measuring instrument circuits. Salary in the region of £450-£650 p.a. according to qualifications and experience. Apply stating full details to the Chief Engineer, Furzehill Laboratories Ltd., Boreham Wood, Herts. W 167

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD. Vacancies exist for three Electronic Technicians with Degrees or equivalent qualifications for work in connexion with Flight Trials of Guided Missiles. Experience on the Service Radio and Radar equipment would be an advantage. Applications should be addressed to the Chief Engineer, Sir W. G. Armstrong Whitworth Aircraft Ltd., Baginton, nr. Coventry. W 2331

THE BRITISH IRON AND STEEL Research Association. Young Electronics Engineer required by the Plant Engineering Division of the above Association to assist in instrumentation work involving use of strain gauges and multi-channel metering and recording circuits in connexion with new developments in steelworks plant. Applicants should have an Ordinary or Higher National Certificate in electrical engineering. Age range 20-24. Starting salary according to age, qualifications and experience within the range £430-£480 p.a. Location of work London, with visits to steelworks. Written applications only quoting "Instruments" to Personnel Officer, B.I.S.R.A., 11, Park Lane, London, W.1. W 2444

THE DE HAVILLAND ENGINE CO. LTD. Electronic Engineer required, interested in physical measurement rather than construction of apparatus, required for vibration measurement and analysis on gas turbine and piston engines. Please write in confidence stating age and full details of previous experience to the Personnel Officer, The De Havilland Engine Co. Ltd., Stag Lane, Edgware, Middlesex. W 2386

THE ENGLISH ELECTRIC Co., Ltd., Luton, have vacancies for Electronic Engineers for development work on V.H.F. Radio Sub-miniature equipment and/or recording techniques. Some Field Trials engineers and assistants also required. Applications stating age, experience and qualifications, and quoting ref. 456L, should be sent to Central Personnel Services, English Electric Co., Ltd., 336/7, Strand, London, W.C.2. W 2381

THE ENGLISH ELECTRIC CO. LTD., Luton, have vacancies for Electronic Engineers for work in Australia on V.H.F. Sub-miniature equipment with Trials applications. Assistance with housing will be provided. Applications stating age, experience and qualifications should be sent to Central Personnel Services, 336/7, Strand, London, W.C.2, quoting ref. 456. W 2468

THE ENGLISH ELECTRIC CO. LTD., Stafford, requires the following personnel for its new factory in the North Staffs area: 1. Engineer with experience of magnetic amplifiers; good academic and practical background is essential. 2. Engineer with experience on electronic servo control gear and servo analysis. Housing facilities may be available in 12 months. Salary up to £1,000 per annum. Apply to Department Central Personnel Services, 336, Strand, W.C.2, quoting ref. 1095. W 2457

THE GENERAL ÉLECTRIC CO. LTD., Brown's Lane, Coventry, requires Senior and Junior Electronic Development Engineers for work on Guided Weapons and like projects, particularly in the field of Microwave and Pulse Applications. Mechanical Development Engineers, Designer Draughtsmen and Draughtsmen, preferably with experience of Radar type equipments, also required for the above projects. Salary according to age, qualifications and experience. Houses available for selected senior staff. Apply by letter stating age and experience to the Personnel Manager (Ref. R.G.). W 169

THE GENERAL ELECTRIC CO. LTD., Brown's Lane, Coventry, requires Senior and Junior Electronic Development Engineers for work on Guided Weapons and like projects, particularly in the field of Microwave and Pulse Applications. Mechanical Development Engineers, Designer Draughtsmen and Draughtsmen, preferably with experience of Radar type equipments, also required for the above projects. Salary according to age, qualifications and experience. Houses will be allocated to selected staff. Apply by letter stating age and experience to The Personnel Manager (Ref. R.G.). W 158

THE PLESSEY COMPANY have vacancies at their Ilford Works for Engineers and Draughtsmen of senior and intermediate grades for development work on components and mechanisms for radio, television and communications equipment. These vacancies occur as a result of the enlargement of the laboratories to permit a substantially increased interest in the design of circuits and components for specific applications. All positions are permanent and pensionable and the expansion now in progress offers good prospects of advancement. Attractive initial and progressive salaries are offered to men who are qualified by reason of educational attainment or practical experience. All applications will be dealt with in confidence and should be addressed, in the first instance, quoting reference EE/ED, for the attention of the Personnel Manager, The Plessey Company Limited, Vicarage Lane, Ilford, Essex. W 2481

TECHNICAL JOURNALIST. The General Electric Co., Ltd., has a vacancy for a technical editorial assistant in the Press Relations Section of its Publicity Organization to undertake work in connexion with the Company's activities in the fields of telecommunications and electronics. Candidates should be between the ages of 25 and 38 and should have a good knowledge of radio and television techniques. Experience in journalism and ability to prepare interesting well-written articles essential. Application should be made in the first place to Personnel Dept., Magnet House,, Kingsway, W.C.2, stating age, education, experience and salary required. Samples of work should be submitted. W 2446

TECHNICAL WRITER required for Publicity Department of leading radio valve and electronic tube manufacturers. Advertising experience an advantage. Age 26-30. Apply stating salary required to 487 Box No. W 2455.

TECHNICIAN, with experience in electronic work, required for development laboratory in large Telecommunication Engineering Works. Give particulars of experience, education and technical training, qualifications and commencing salary required. London S.E. Area. Box No. W 2426.

TEST EQUIPMENT DESIGNER required to take charge of department producing hand-operated and automatic test equipment for capacitor production. Must have good technical qualifications. Previous experience of mass-production testing desirable. Reply giving full details of age, technical training, past experience and salary required to A. H. Hunt (Capacitors) Ltd., Bendon Valley, Garratt Lane, Wandsworth, London, S.W.18. W 2484

VACANCIES are available in the Transmission Department for: (1) Development engineers, experienced in the design of multi-channel carrier telephone systems, or in allied techniques including amplifiers, filters and radio. (2) Equipment engineers, with such knowledge of modern line communication practice as will enable them, after training in the company's methods, to prepare detailed specifications of equipment requirements and to develop arrangements for rack-mounting of the apparatus. (3) Draughtsmen to work with the engineers, preferably having experience in the telecommunications industry. The positions available are permanent, on full established staff status, with contributory Pension Fund and usual staff conditions. Please write to Personnel Manager, Automatic Telephone & Electric Co. Ltd., Liverpool 7, giving full details of experience, qualifications, age and approximate salary sought. W 2492

VALVE ENGINEERS required for an expanding Production Unit in Scotland which is making special valves and gas-filled tubes for Radar. Applicants must have design or production experience under one of the following headings: Thermionic Valves. Microwave Valves. Gas-filled Tubes. Radar Equipment. Microwave Measuring Equipment. The positions to be filled are: Senior Engineer. Salary £1,000-£1,500 per annum according to experience and ability. An Honours Degree in Physics or Engineering is essential, and applicants must have held previously a position of responsibility. Junior Engineers—Salary range £500-£1000 per annum according to experience and qualifications. These positions offer full scope for initiative and progress. Contributory Pension Scheme in operation. When applying, give full details of

CLASSIFIED ANNOUNCEMENTS
continued on page 10

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

qualifications and experience in chronological order, quoting reference VE, to Box No. 938 B McCallum Advertising, 21 Castle Street, Edinburgh, 2. W 2476

VICKERS - ARMSTRONGS LIMITED have vacancies in their Guided Weapons Department for Inspectors on inspection and test of complex electronic devices; thorough experience of electrical laboratory instruments and low power V.H.F. technique essential; knowledge of Servo Systems would be an advantage. Apply in writing to the Employment Manager, Vickers-Armstrongs Limited (Aircraft Section), Weybridge, Surrey. Applications, with certain exceptions, are subject to the approval of the Ministry of Labour and National Service. W 2418

VICKERS - ARMSTRONGS LIMITED have vacancies in their Guided Weapons Department for the following staff. (1) Electronic Engineers of degree standard, with at least three years' experience in one of the following: V.H.F. Transmitter and Receiver Design, Pulse Techniques, Aerials, Transformers Design, Servo-Mechanisms and Electro-mechanical Devices. (2) Technical Assistants with H.N.C. or C. & G. standard, for development work, electronics, servo-mechanisms and hydraulics. (3) Draughtsmen with experience in electronic, electrical or electro-mechanical design. (4) Jig and Tool Draughtsmen. Apply—quoting reference G.W.1 —to Employment Manager, Vickers-Armstrongs Limited, Weybridge Works, Weybridge, Surrey. Applications, with certain exceptions, are subject to the approval of the Ministry of Labour & National Service. W 2454

YOUNG ENGINEERS with some experience in television design and development are required for this type of work by a well-known Company in the North West of England. Ability to initiate and carry out development projects and a University Degree or equivalent are the essential qualifications. Arrangements will be made to house the successful applicant. Apply quoting reference C.I.H. to Box No. W 2453.

A further classified advertisement appears in display style on page 78.

SITUATIONS WANTED

CHIEF ENGINEER, ten years with present company, seeks similar appointment with expanding organization. Outstanding experience of development and production of airborne radio, servo-mechanisms, test equipment, etc. Interested in hard work and a high salary. Box No. W 1716.

ELECTRONIC ENGINEER, age 33, B.Sc., Grad.I.E.E., experience—4½ years R.E.M.E., 4 years in industry, requires post as technical representative for North East Coast area. Box No. W 1709.

ELECTRONIC ENGINEER with several years' experience in guided weapon field, including development, test and considerable trials experience, seeks position in same field. Responsibility more important than salary, but position preferred as sponsor or trials leader. Used to arduous hours, and enthusiasm for problems involved. Willing to go to Australia. Academic education extends to full technological standard, City and Guilds, Radio and Telecommunication Engineering. Box No. W 1717.

KEEN ELECTRONIC ENGINEER seeks change in employment. Experienced Public Address, Staff Location, Remote Control and allied systems; some telephone development experience, competent draughtsman. Excellent references. Box No. W 1723.

FOR SALE

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

CAMBRIDGE MODEL B two-way Recorders, 1, 0 to 1700°C and 1, 0 to 1400°C, also 4 Fery Radiation Pyrometers with adjustable stands. Details on request. Mullard, Blackburn Works, Blackburn. W 1703

ELECTRONIC COMPONENT SUPPLIES. We specialize in the supply of Electronic Components, Accessories, Test Equipment, etc., for Government Depts., Industrial Concerns, Research Establishments, Laboratories, Colleges, etc. Your enquiries and orders will receive our prompt attention. Holiday & Hemmerdinger Ltd., 74/78 Hardman Street, Deansgate, Manchester, 3. Tel.: Deansgate 4121. W 148

FOR SALE—surplus to requirements. Cossor Model No. 1035 Double Beam Oscillograph. Box No. W 1692.

FREE. Brochure giving details of courses in Electrical Engineering and Electronics, covering A.M.Brit., I.R.E., City and Guilds, etc. Train with the Postal Training College operated by an Industrial Organisation. Moderate fees. E.M.I. Institutes, Postal Division, Dept. EE29, 43, Grove Park Road, London, W.4. (Associate of H.M.V.). W 2808

MAGSLIPS at 1/10th to 1/20th of list prices. Huge stocks. Please state requirements. K. Logan, Westalley, Hitchin 1744, Herts. W 116

MINIATURE BALL BEARINGS. Steel Balls, Stainless Steel and Phosphor Bronze Balls. Prompt delivery. Distributors: Insley (London) Ltd., 21/22 Poland Street, London, W.1. Tel.: GERrard 8104 and 2730. W 155

SINE-COSINE Potentiometers, Magslips, Selsyns, Ipots, Velodynes and equipment and components for automatic control. Servotronic Sales, Inc. Hopton Radio, No. 1 Hopton Parade, Streatham High Road, London, S.W.16. STReatham 6165. See our advertisement on page 80. W 2502

SINE-COSINE RESOLVERS (3" Magslip Transmitters No. 5, AP 10861). Brand new, each in maker's tin. Offered in quantity at less than one tenth of cost. Export inquiries invited. P. B. Crawshay, 166 Pixmore Way, Letchworth, Herts. W 153

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

EDUCATIONAL

CITY & GUILDS (Electrical, etc) on " No Pass—No Fee " terms. Over 95 per cent successes. For full details of modern courses in all branches of Electrical Technology send for our 144-page handbook—Free and post free. B.I.E.T. (Dept. 337C), 17 Stratford Place, London, W.1. W 142

CITY OF COVENTRY Education Committee. Coventry Technical College. Session 1953-54. Electronic Engineering. Applications are invited for entry to the next 3-year full-time course commencing in September, 1953, from those requiring a comprehensive training to an advanced level in Electronic Engineering, to qualify them for technical posts in radio, telecommunications, television and industrial electronics. The syllabus will cover the requirements of C. & G., Brit.I.R.E., and I.E.E. examinations. Entry age 16 years or over. Application forms and further information available from the Principal, Coventry Technical College. W. L. Chinn, M.A., Director of Education, Council House, Coventry. W 1708

COUNTY BOROUGH OF BOLTON—Education Committee. Bolton Technical College. A three-year full-time course in Electronic Engineering commences in September, 1953. Applicants should be in the age range 16 to 18, and have obtained, or be taking, General Certificate (Ordinary Level) in Mathematics or Physics, or equivalent courses in technical institutions. This rapidly developing industry offers new and attractive openings to qualified men. Application forms and particulars may be obtained from the Principal, Technical College, Bolton, Lancs. W. T. Selley, Chief Education Officer, Education Offices, Nelson Square, Bolton. W 1658

PATENT

THE PROPRIETORS of British patent No. 645,975 concerning an electronic instrument for determining the degree of compaction of concrete mixes in the fluid state, desire to contact any firm interested in the purchase rights, or obtaining grant of licences hereunder. Further particulars from Box No. W 1728.

SERVICE

CONSTRUCTION of experimental and Laboratory equipments in Radio and Electronics can be undertaken by a small group of engineers. Box No. W 1721.

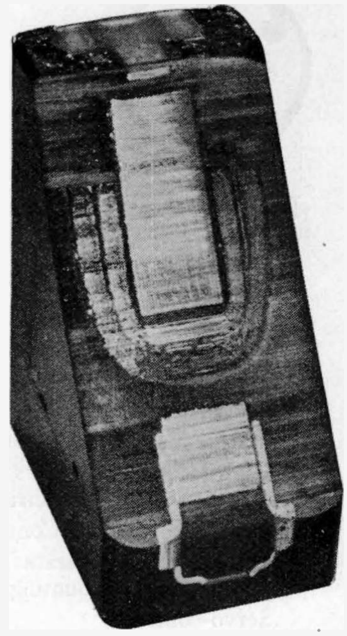
ENGINEER, 10 years' research experience, H.N.C., wishes to offer services as consultant to small manufacturer on a freelance basis. Experienced in V.H.F., audio tape recorders, etc. Own W/S and drafting effort available. Box No. W 1722.

MANUFACTURES. As specialists in all types of Sheet Metal Work for the Radio and Electrical Trade we are able to quote you very keen prices for a high quality job. Intensalite Sign and Fixture Co. Ltd., 89, Leopold Street, Birmingham, 12. Telephone Vic. 0065. W 1684

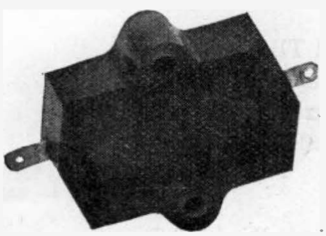
METALWORK. All types cabinets, chassis, racks, etc., to your own specifications. Philpott's Metal Works Ltd. (G4BI), Chapman Street, Loughborough. W 2197

REPAIRS AND MAINTENANCE to all types of electronic equipment and precision instruments. Enquiries invited from industrial users, government depts., research and educational establishments, etc. Glyndon Radio Service Ltd., Industrial Equipment Department, 68, Wellington Street, S.E.18. Phone: WOO 2749. W 1659

POTTED IN
'ARALDITE'
— PROOF AGAINST
CORROSION



'ARALDITE' is particularly valuable for potting transformers, capacitors, motor windings and a wide variety of radio and electronic apparatus. It has made "miniaturisation" more practicable; enclosing the equipment in a protective cover it provides complete insulation and offers good resistance to "tracking". High temperatures, humidity and other exacting requirements are not inimical to its use.



'ARALDITE' is a hot-setting ethoxyline resin proved by experience to be eminently suitable for large-scale production. Its shrinkage during casting is very low, as no water or volatile products are given off during setting.

MADE IN OUR DUXFORD FACTORY—DELIVERY FROM STOCK

We shall be glad to send full details of properties, casting temperatures and curing times.

NOTE 'ARALDITE' (Regd.) is also available in the form of hot-setting adhesives (Araldite Types 1 and 15) for bonding metals, porcelain, quartz, etc., and as a surface-coating resin (Araldite 985 E) for use as a primer or lacquer for light alloys.

'ARALDITE' (Regd.)
Casting Resin B

— a product of

AERO RESEARCH LIMITED

A CIBA COMPANY

DUXFORD · CAMBRIDGE 'PHONE: SAWSTON 187

Waveguide Impedance Measurement

Unique features of design give extreme accuracy

Metrovick Standing Wave Detector

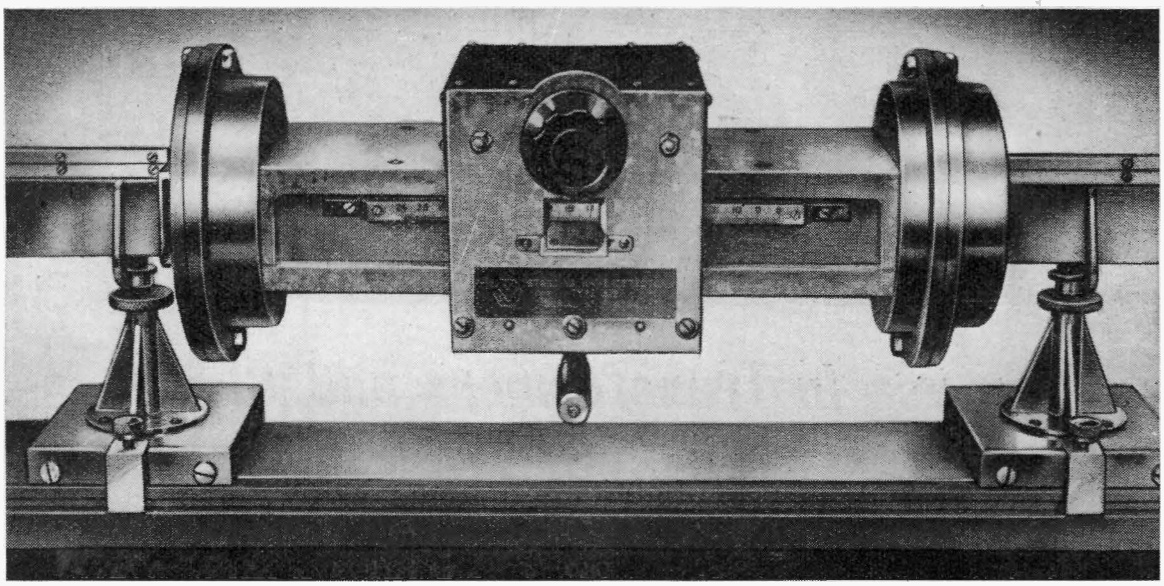
TYPE 512

This instrument consists of a waveguide section built up from solid material, and a moving carriage, on which is mounted a tunable crystal detector.

The carriage is of the non-contacting type, and is located directly from the inside surface of the waveguide, thus eliminating any variation in probe penetration along the travel of the carriage.

This unique feature makes possible extreme accuracy in the measurement of waveguide impedances.

It has been designed for operation over the band of wavelengths from 10 cms. to 11 cms. in size 10 standard waveguide and it is fitted with Inter-Service Standard waveguide connectors.



METROPOLITAN-VICKERS ELECTRICAL CO. LTD., TRAFFORD PARK, MANCHESTER 17

Member of the A.E.I. group of companies

METROVICK *Test gear for the microwave laboratory*

R/E 204

The Saunders-Roe Displacement Indicator

This instrument and its associated pick-offs have been designed to afford a degree of stability and linearity of calibration at least as good as that of a mechanical extensometer. In addition the maximum possible measuring flexibility and adaptability have been incorporated. It is normally supplied for two channel working but additional channels up to a total of six can be made available if desired. Displacement is indicated as deflection on a panel mounted 0-1 milliameter and additional facilities are provided to connect the output stages to suitable direct recording equipments.

THE PICK-OFFS

In order to secure linearity of calibration within a wide working range, the pick-off unit consists electrically of a constant impedance inductive half-bridge unbalanced by movement of a magnetic material in proximity to the inductive elements. Whilst this system is considerably less sensitive in terms of mechanical displacement/electrical output than the conventional differential transformer, it does provide extremely good linearity over a wide range, which is considered to be a prime feature in this type of equipment. The pick-offs may be used singly or in pairs. Paired use is a particularly valuable application, for instance, in process control, where dimensional monitoring is required in the absence of a convenient datum, e.g. plastic extrusion, wire drawing, foil rolling, etc.

An Inductive Pick-off

GENERAL SPECIFICATION

The instrument is engineered to the standard of robustness necessary for general industrial use. All electronic circuits are carefully stabilised against mains supply variations, and components are of high quality and stability. ALL SALES ARE SUBJECT TO THE COMPANY'S STANDARD CONDITIONS.

INSTRUMENT

Dimensions: Height: 10.5 in. Length: 17 in. Depth: 9 in.
Weight: ... ... 33.5 lb. (15.3 kg.)
Power Supply: ... ... 115-230 volts, 50-60 c.p.s. A.C.
Measuring frequency and range: ... Max. 600 c.p.s.
Measuring ranges:... ... ... 0-.005", 0-.015", 0-.050".
Other ranges available: ... ... 0-0.10"

PICK-OFF

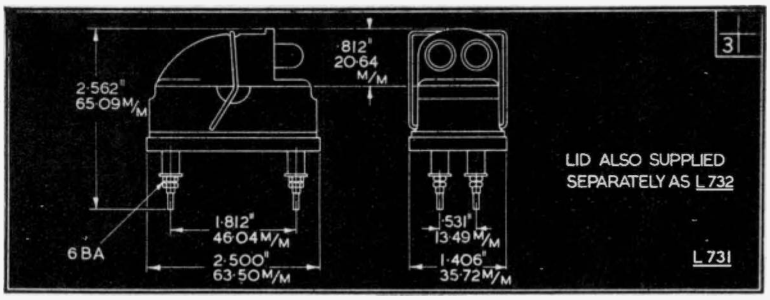
Dimensions: ... ... Length: 2.35 in. Dia: .90 in.
Mounting flange: 1.30 in. dia.
Weight: ... ... 57.5 grams.
Weight of moving element: ... ... 2.5 grams.

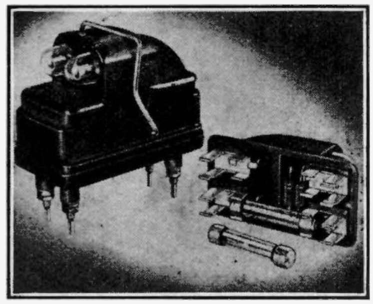
SAUNDERS-ROE LTD

ELECTRONICS DIVISION

OSBORNE • EAST COWES • ISLE OF WIGHT

The "Belling-Lee" page for Engineers





L. 732

TWIN NEON CARRIER WITH RETAINING CLIP

L. 731

AS L. 730 BUT WITH BACK CONNECTIONS

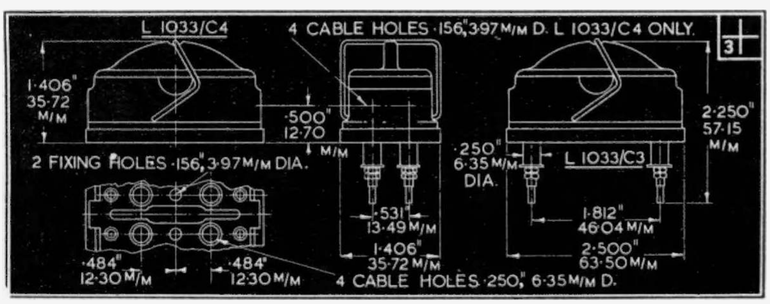
L. 730

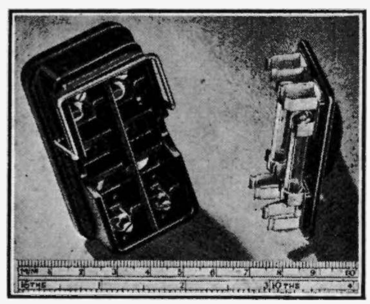
TWIN FUSEBOX WITH CARRIER AND RETAINING CLIP

TWIN NEON INDICATING FUSEHOLDER

The twin neon indicating fuseholder L732 illustrated above top right, carries two neon lamps, and where required, may be used to replace the normal fuse carrier on standard " Belling-Lee " twin fuseboxes L1033 shown below. The overall depth is thereby increased by $\frac{1}{8}$ in., but the panel area remains unchanged.

Two lamp-holders with resistors are built into the moulding, and are arranged in such a manner that the adjacent lamp gives visual indication when either fuse





L. 1033/C3

WITH LID RETAINING CLIP

L. 1033/C4

AS ABOVE, WITH BACK CONNECTIONS & BUSHES

blows. The neons will glow satisfactorily over a voltage range of 180/250v. a.c. (r.m.s.), or 220/250v. d.c.

A replacement retaining clip is supplied with the carrier. This ensures that when the box is properly wired, the neons can only be inserted in the correct phase of the supply.

Supplied separately or complete with bases.

BELLING & LEE LTD

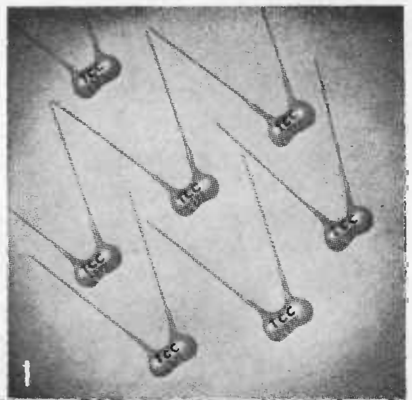
CAMBRIDGE ARTERIAL RD., ENFIELD, MIDDX., ENGLAND *a publication of interest to scientific and industrial electronic engineers*

This G.E.C. folder forms an invaluable reference to the latest developments in the field of electronic devices. It contains brief specifications, screen characteristics, pin connection tables etc. and is available free on application. Fuller details of all the electronic devices described in this folder can also be supplied.

Write to the Osram Valve and Electronics Dept. for Folder OV1782

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C 2 *present*

THEIR LATEST DEVELOPMENTS IN CONDENSERS...



FOR the benefit of those who were unable to visit the recent R.E.C.M.F. Exhibition, and for those who had not the time available to inspect our Stand in detail, we illustrate here the range of T.C.C. latest developments displayed thereon.

These are indicative of the progress which is constantly being maintained, and which ensures that "T.C.C. Leadership in Condensers" is a tangible reality.

1. SMALL CAPACITY CLOSE TOLERANCE TUBULAR CERAMICS
For top end coupling in Band Pass Filters. Capacity range 0.5 pF to 5 pF at 500 v. D.C. Tolerances ±20% and ±10%.

2. TANTALUM ELECTROLYTICS
The special neutral electrolyte prevents corrosive injury in the event of mechanical damage. These 8 μF condensers are for working voltages up to 120 v D.C. and for temperatures up to 120°C.

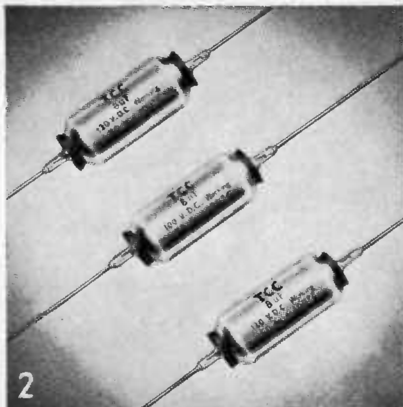
3. "METALPACK" & "METALMITE" PAPER TUBULARS IMPREGNATED in "VISCONOL-X"
New impregnant improves reliability at 100°C. Full Ministry Type Approval (R.C.S.131 Cat.A.H2) has been granted.

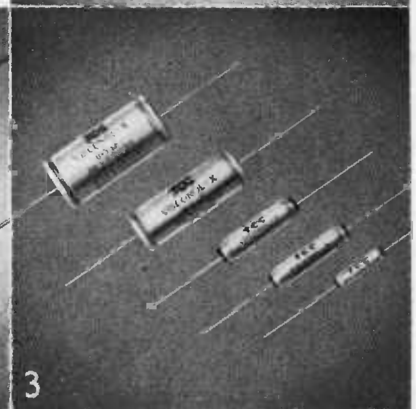
4. "METALPACK" PAPER TUBULARS with CERAMIC END SEALS
New external construction gives complete protection against moisture in 100% humidity at 100°C.

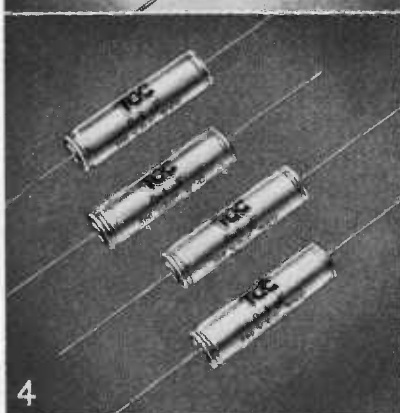
5. H.V. TUBULAR CERAMICS
For Pulse Feeders in Radar equipment and Line Time bases in T.V. receivers. Ranges available for 1 kV. to 10 kV. D.C. working. Capacities from 10 to 620 pF.

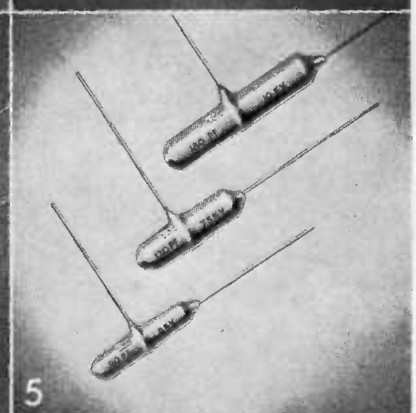
6. HIGH VOLTAGE PAPER SMOOTHING CONDENSERS TYPE C.P. 561
For 25 kV. E.H.T. smoothing in large screen T.V. receivers. Absence of metal at "hot end" prevents corona losses.

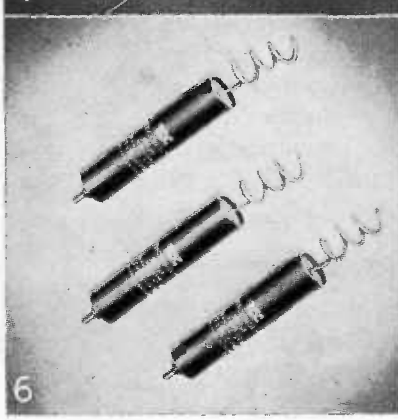
7. HIGH TEMPERATURE ELECTROLYTICS
Ability to work at 85°C. without voltage de-rating. Characteristics low leakage current and high ripple rating.

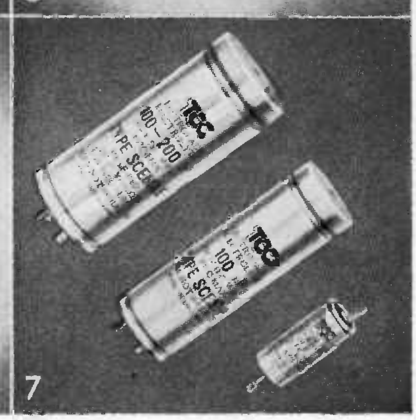






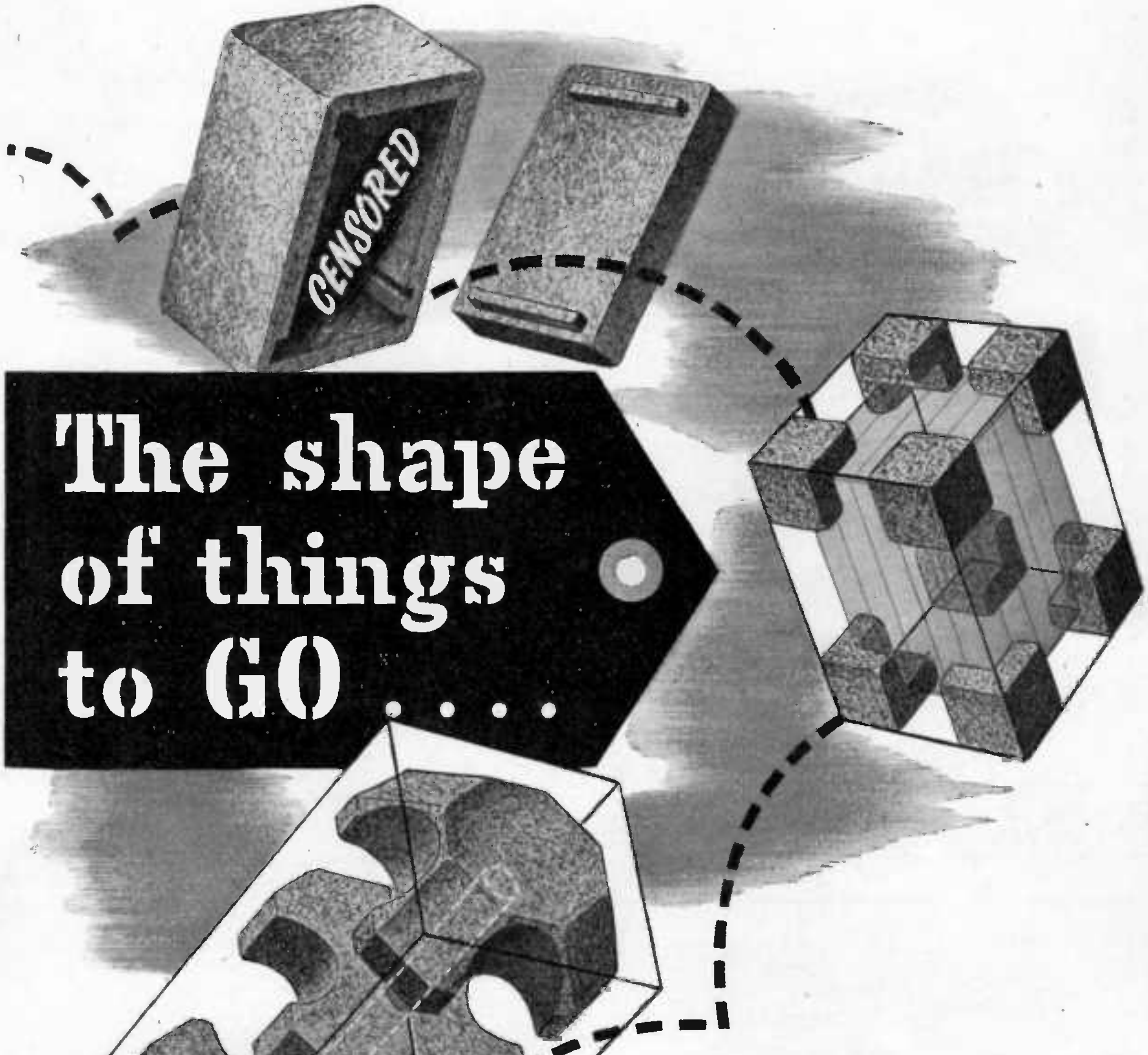






THE TELEGRAPH CONDENSER COMPANY LIMITED

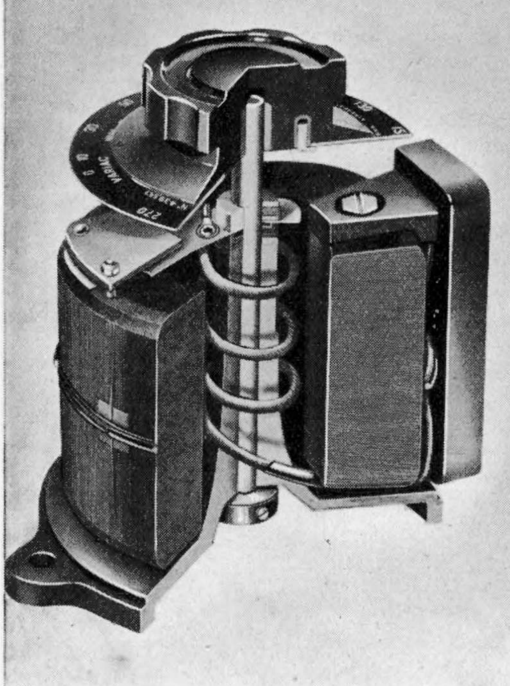
RADIO DIVISION: NORTH ACTON · LONDON · W.3 · Telephone: ACORN 0061 (9 lines)



You can now avoid the slightest risk that delicate electronic instruments will be "Damaged in Transit". HAIRLOK, which is a new form of resilient packing, ensures perfect protection because it is moulded to fit the shape of the product exactly. It can be moulded as hard or as light as required and will withstand any shock load including low frequency vibrations and varying climatic conditions. HAIRLOK complies with government specification and is non-staining to silver. To ensure that equipment is "Received in Perfect Condition" specify Hairlok packing. We shall be glad to send full details on request.

THE Hairlok COMPANY LIMITED

IDDESLEIGH HOUSE, CAXTON STREET, LONDON, S.W.1. TELEPHONE: ABBEY 6722



for smooth voltage control

'VARIAC'

Registered Trademark.

— the original continuously-adjustable auto-transformer — is the ideal device for controlling any a-c operated equipment. VARIACS not only supply perfectly smooth control of voltage from zero, but some models also include an "over voltage" feature. VARIACS are designed and built for many years of trouble free operation.

SPECIFICATIONS

SERIES "50" Variacs

Type	Load Rating	Input Voltage	Current: Rated	Current: Maximum	Output Voltage	No-Load Loss	Net Price £ s. d.*
50-A	5 kva.	115 v.	40 a.	45 a.	0-135 v.	65 watts	44 18 6
50-B	7 kva.	230/115 v.	20 a.	31 a.	0-270 v.	90 watts	44 18 6

SERIES "100" Variacs

Type	Load Rating	Input Voltage	Current: Rated	Current: Maximum	Output Voltage	No-Load Loss	Net* Price £ s. d.
100-K	2000 va.	115	15 a.	17.5 a.	0-115	20 watts	17 17 0
100-KM	2000 va.	115	15 a.	17.5 a.	0-115	20 watts	18 12 0
100-L	2000 va.	230/115	8 a.	9 a.	0-230	25 watts	17 17 0
100-LM	2000 va.	230/115	8 a.	9 a.	0-230	25 watts	18 12 0
100-Q	2000 va.	115	15 a.	17.5 a.	0-135	20 watts	18 9 0
100-QM	2000 va.	115	15 a.	17.5 a.	0-135	20 watts	19 4 0
100-R	2000 va.	230/115	8 a.	9 a.	0-270	30 watts	18 9 0
100-RM	2000 va.	230/115	8 a.	9 a.	0-270	30 watts	19 4 0
100-LH	1200 va.	480/240	2 a.	2.5 a.	0-480	25 watts	21 15 0
500-L ⊙	1450 va.	180	8 a.	9 a.	0-180	25 watts	17 17 0
2000-K †	1000 va.	125	8 a.	9 a.	0-125	25 watts	17 17 0

⊙ For 500 cycles. † For 2,000 cycle service.

SERIES "200" Variacs

Type	Load Rating	Input Voltage	Current: Rated	Current: Maximum	Output Voltage	No-Load Loss	Net Price £ s. d.*
200-CM 200-CU	860 va.	115 v.	5 a.	7.5 a.	0-135 v.	15 watts	7 17 6 6 15 0
200-CMH 200-CUH	580 va.	230 v. 115 v.	2 a. 0.5 a.	2.5 a. 2.5 a.	0-270 v. 0-270 v.	20 watts 20 watts	9 15 0 8 5 9

*All 'VARIAC' prices plus 20% as from 23rd Feb. 1952

Write for catalogue V549 which gives full details of 'VARIAC' transformers and suggestions for use, as well as data on other special patterns.

PROMPT DELIVERY

CLAUDE LYONS LIMITED

ELECTRICAL AND RADIO LABORATORY APPARATUS, ETC.

180 Tottenham Court Road, London, W.1; and 76 Oldhall Street, Liverpool 3, Lancs.

THE CORONATION TELEVISION PROGRAMMES

To viewers on the Continent by

Standard
PORTABLE
SHF Radio Links

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

For the first time in history television programmes were relayed to the Continent during B.B.C. tests on April 25th. Under contract to the British Broadcasting Corporation, S.T.C. will again be solely responsible for relaying the Coronation Television programmes from London to Cassel, in France, on June 2nd. At Cassel, high-quality picture signals will be made available for distribution to the French television network and also to The Netherlands, and Germany, via Belgium.

The equipment will comprise five *Standard* portable S.H.F. Links as supplied to the B.B.C. for numerous outside broadcasts since 1950. Monitoring equipment is being supplied by Kolster-Brandes Limited, an S.T.C. associate.

The complete network will be installed and operated by S.T.C. engineers.

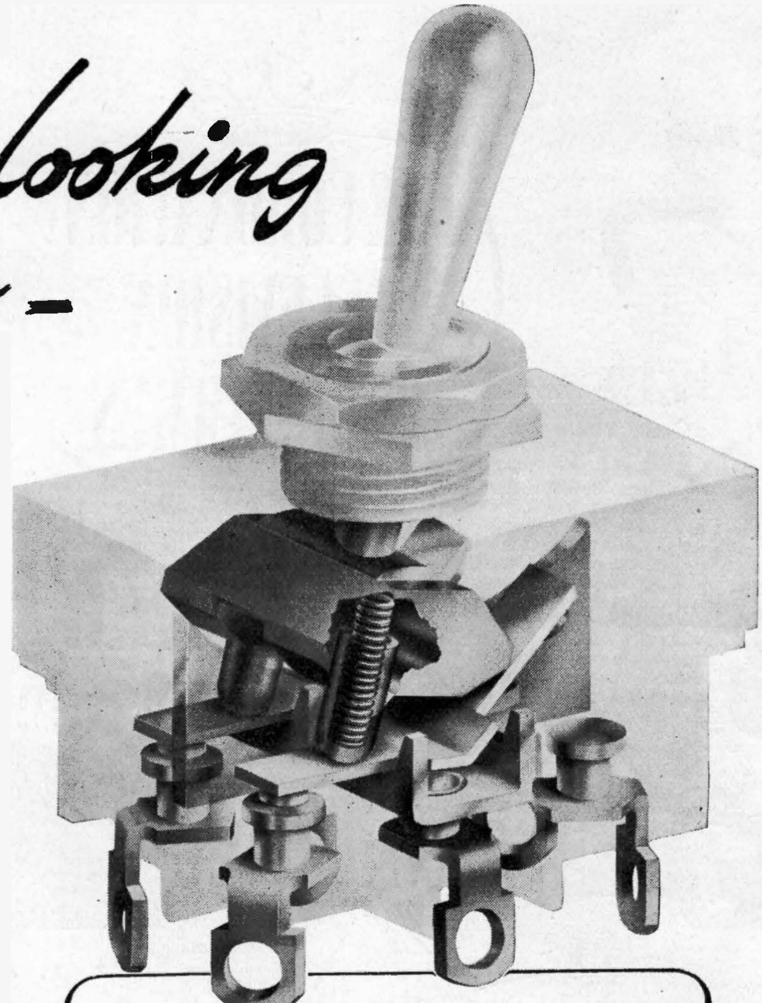
★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

Standard Telephones and Cables Limited

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

TRANSMISSION DIVISION, NORTH WOOLWICH, LONDON, E.16.

Worth looking into–



The NSF/Cutler-Hammer slow make-and-break switches have been designed to meet the increasing demand for small, high capacity switches for use on A.C. circuits. The simplification of the contact structure has resulted in a range of switches with exceptionally high ratings for their size and with a considerably longer life than that of corresponding quick make-and-break types. These switches are rated at 10 amps. at 250 volts A.C. or at 20 amps up to 30 volts D.C. Further details are available on request.

NOTE THESE C.H. FEATURES

Rocker type contact mechanism • Positive action by compression spring • Silver alloy contacts • Unaffected by vibration or severe shocks • Totally enclosed mechanism • Solder lug or screw terminals optional.

NSF

Switch to N.S.F. for **better switching**

CUTLER-HAMMER APPLIANCE SWITCHES C-H

OAK PRODUCTS

LEDEX

N.S.F. LIMITED

KEIGHLEY • YORKS

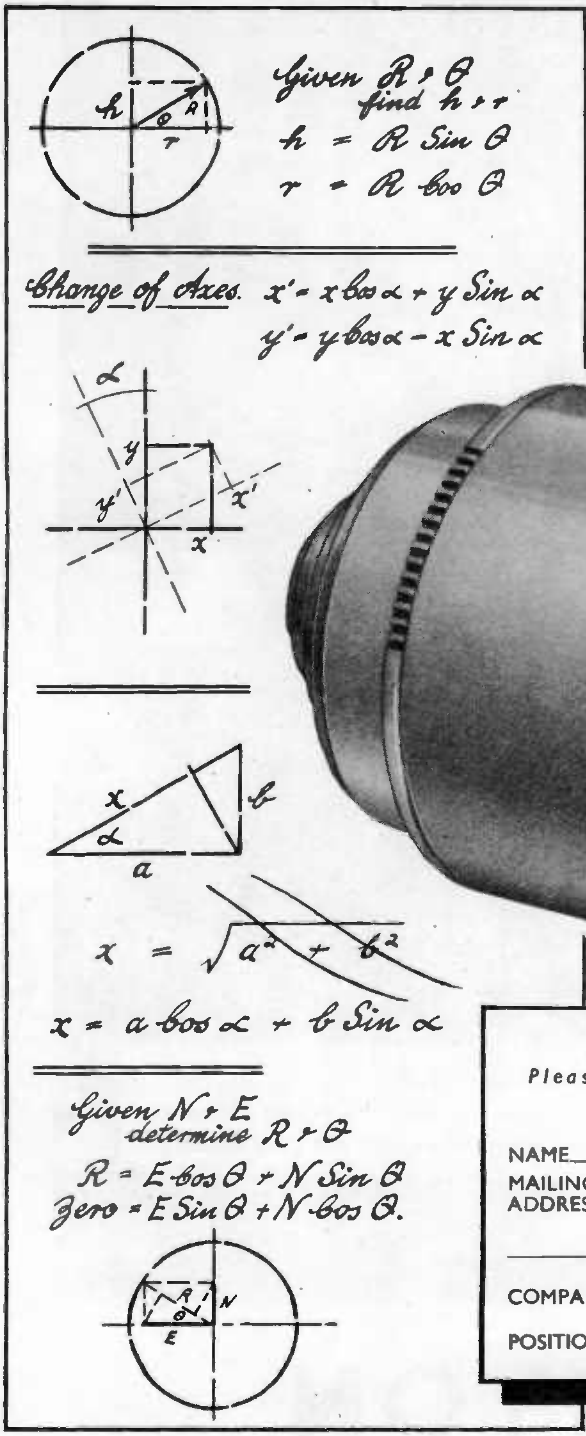
Phone: Keighley 4221/5

Grams: ENESEF, Keighley

LONDON OFFICE: 9 Stratford Place, W.1. *Phone:* Mayfair 4234

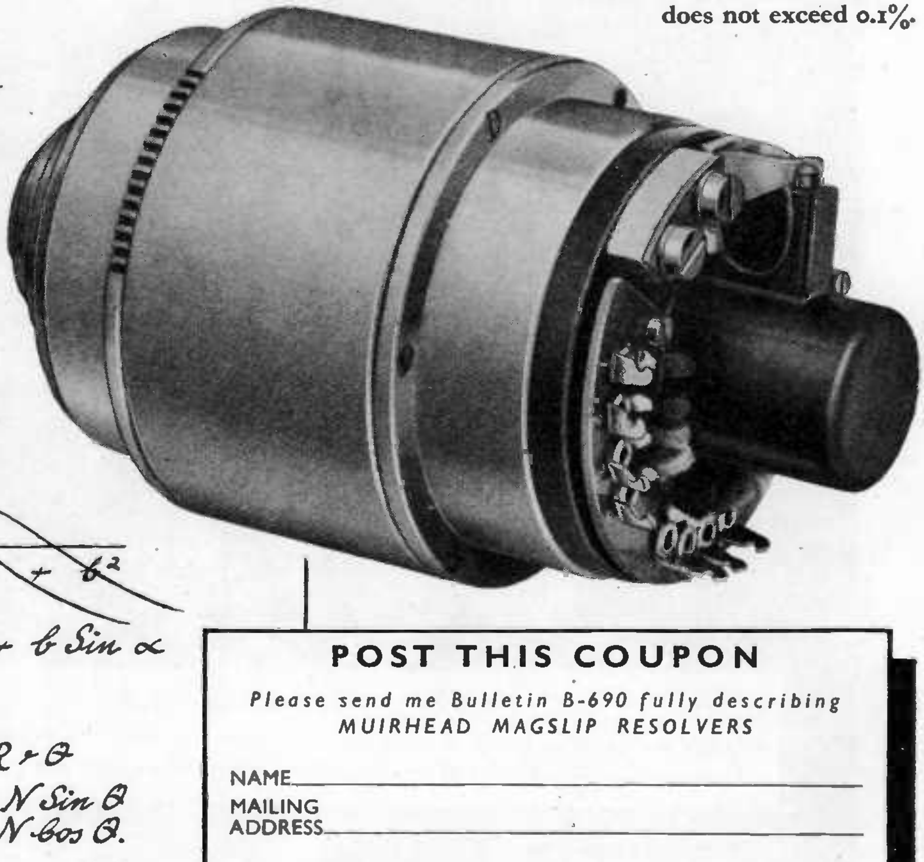
Sole licensees of Oak Manufacturing Co., Chicago, and G. H. Leland Inc., Dayton, U.S.A.
Licensees of Igranic Electric Co. Ltd. for the above products of Cutler-Hammer Inc. Milwaukee, U.S.A.
The products of N.S.F. Limited are protected by patents, and patent applications, in the United Kingdom and other countries.

MUIRHEAD MAGSLIP RESOLVER NO. 2



THE RESOLVER No. 2 is a special type of Magslip used for the solution of trigonometrical problems such as the conversion of polar to Cartesian coordinates.

Each stator phase is energized in accordance with an applied computing voltage. No power is taken from this source, energization being obtained by means of an amplifier and a second (feedback) stator winding. The rotor voltages are proportional to the exciting voltages and to the sine and cosine of the angle between the stator and rotor electrical axes. The error does not exceed 0.1%.



POST THIS COUPON

Please send me Bulletin B-690 fully describing MUIRHEAD MAGSLIP RESOLVERS

NAME____________________

MAILING ADDRESS____________________

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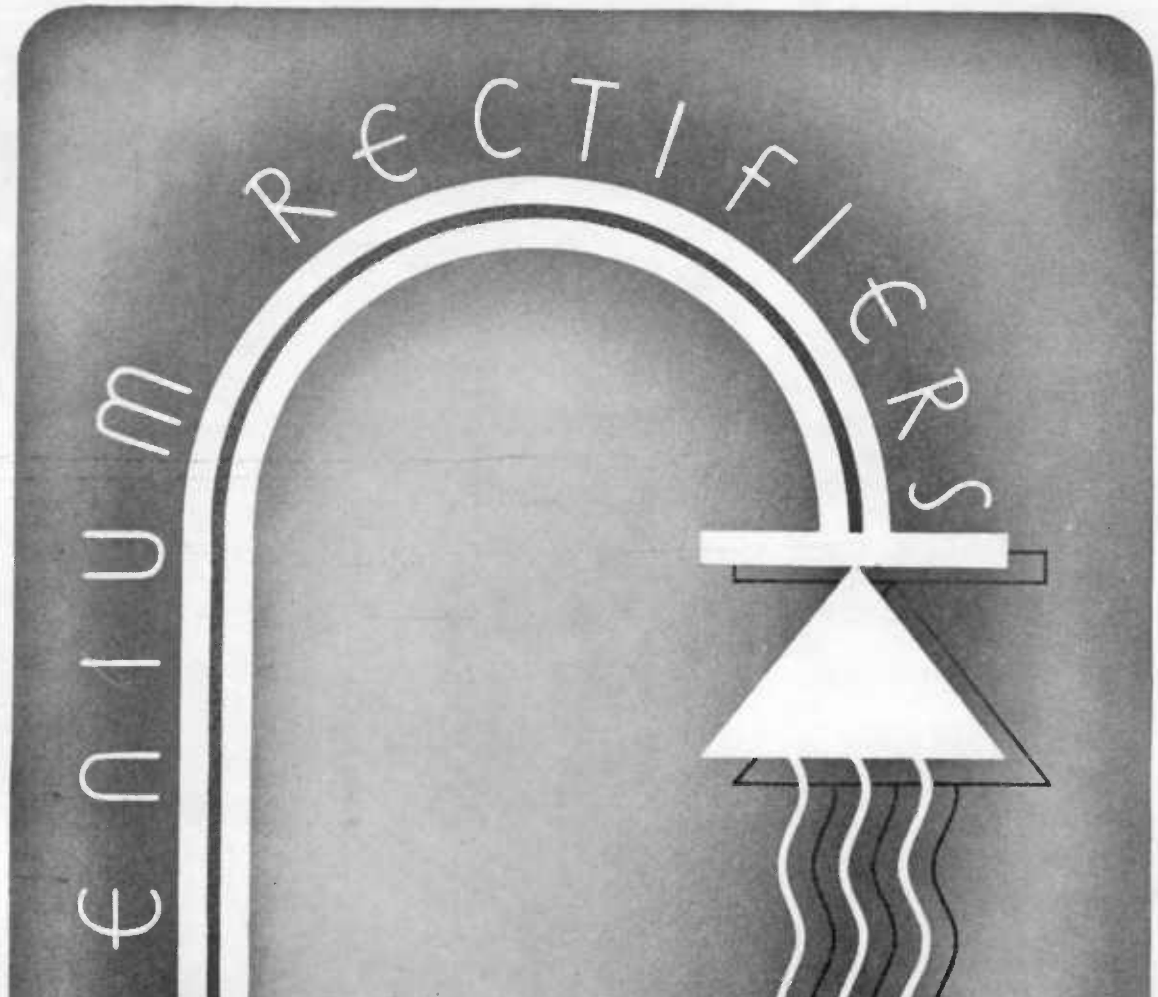
COMPANY____________________

POSITION____________________

79

MUIRHEAD & CO. LTD., BECKENHAM, KENT, ENGLAND

PRECISION ELECTRICAL INSTRUMENT MAKERS


SELENIUM RECTIFIERS
A G.E.C. Product
Full particulars of the the G.E.C. range of Selenium Rectifiers are available on application to your nearest G.E.C. Branch ; E.S. & V. Department, Magnet House, Kingsway, London, W.C.2., or the address below :—

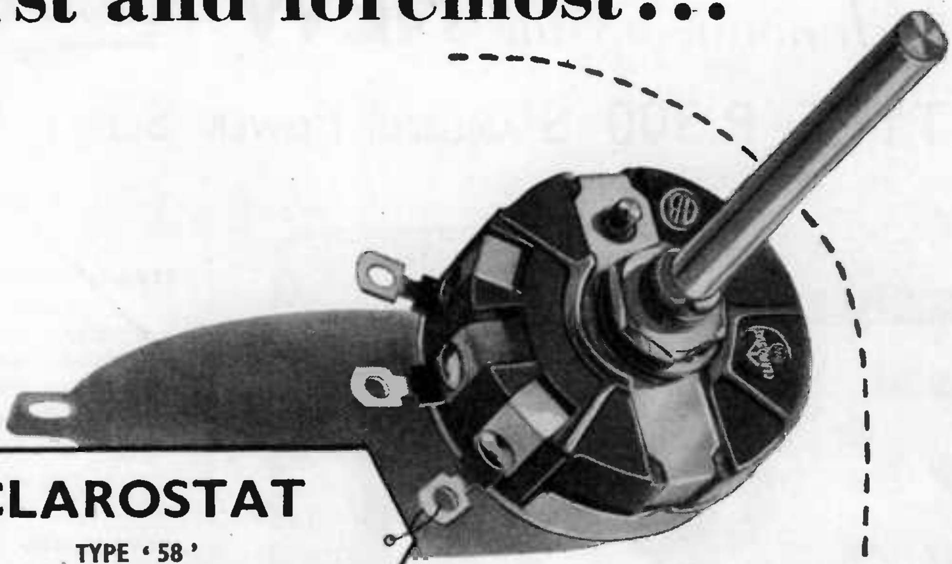
clatter?

To put up with noise and vibration in machinery is as modern as to ride a bone-breaker with solid-rubber tyres. "Clatter" in a factory shatters nerves, paralyses production, raises maintenance costs. Don't stand for it.

RING DUNSTABLE 533 OR WRITE TO RUBBER BONDERS LIMITED DUNSTABLE, BEDFORDSHIRE

We will send our new Flexilant catalogue. This illustrates all the recent progress in the science of bonding rubber to metal—thus deadening noise, killing vibration, cushioning shock. We're also glad to advise on special problems.

First and foremost...



CLAROSTAT

TYPE '58'
WIRE-WOUND POTENTIOMETER

We are proud to introduce the CLAROSTAT Type 58 Wire-Wound Potentiometer, designed by the world's foremost Potentiometer manufacturers and produced for the first time in this country. The Type 58 has many features which will immediately appeal to the discriminating user.

Features

- ★ Rated at 3-watts and available in all values up to 100,000 ohms Linear.
- ★ Special windings are available to requirements.
- ★ High Grade Bakelite Casing, of rugged construction. Solder Tags heavily silver plated and of special design making them completely immovable under all conditions.
- ★ Metal cover firmly keyed into bakelite casing, cannot loosen or turn. Connected to fixing bush providing automatic "grounding" of cover.
- ★ Obtainable with single or double pole mains switch.
- ★ Dimensions: Diameter 1 $\frac{21}{32}$ in. Depth of case without switch $\frac{25}{32}$ in.
- ★ Samples and full specifications available on application.

WHOLESALERS

CLAROSTAT. Type 58 Wire-Wound Potentiometers are supplied individually packed in attractive printed cartons. Delivery is prompt. Write for price list and details of very attractive trade terms.

CLAROSTAT

Controls and Resistors

METAL PRODUCTS LIMITED.
16, Berkeley Street, London, W.1.
Phone: GROsvenor 5206/7

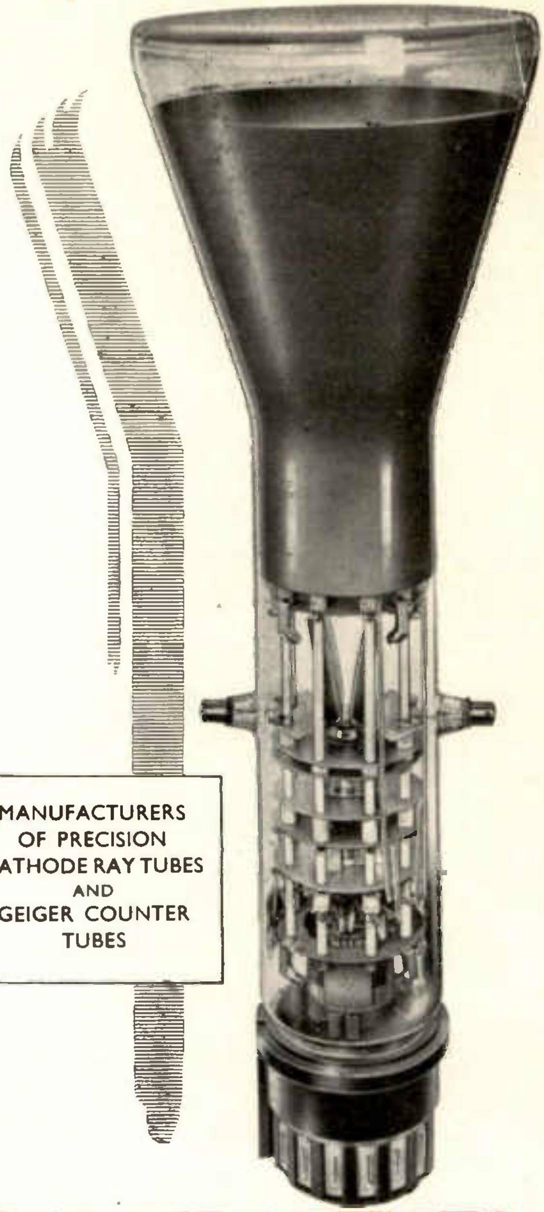
Precision Cathode Ray Tubes

Double Beam Tubes
Types D6 & D4

These tubes employ two fully independent guns characterised by accurate alignment giving freedom from spot aberrations. They have high plate sensitivities with the minimum deflection defocusing. Four pairs of push-pull deflectors are incorporated and the two beams are completely free from intermodulation. The tubes have flat faces and are based with standard 12 side-contact caps having four additional sockets in the base plates.

20th Century Tubes

Type		D6	D4
Diameter		6 in.	4 in.
Overall lengths (mms)...		480	370
Sensitivity mm/V × VA_3	X	700	400
	Y	700	350
Y Capacity		4μμf	4μμf
Heater Volts		6.3	6.3
VA_3 Max. KV		5	5
VA_1 Max. KV		2	2
VA_2 (VA_3=2KV) volts		300	300
Vg for cut-off (max.) ...		−100	−100
Drive for 20μa IB ...		20v	20v



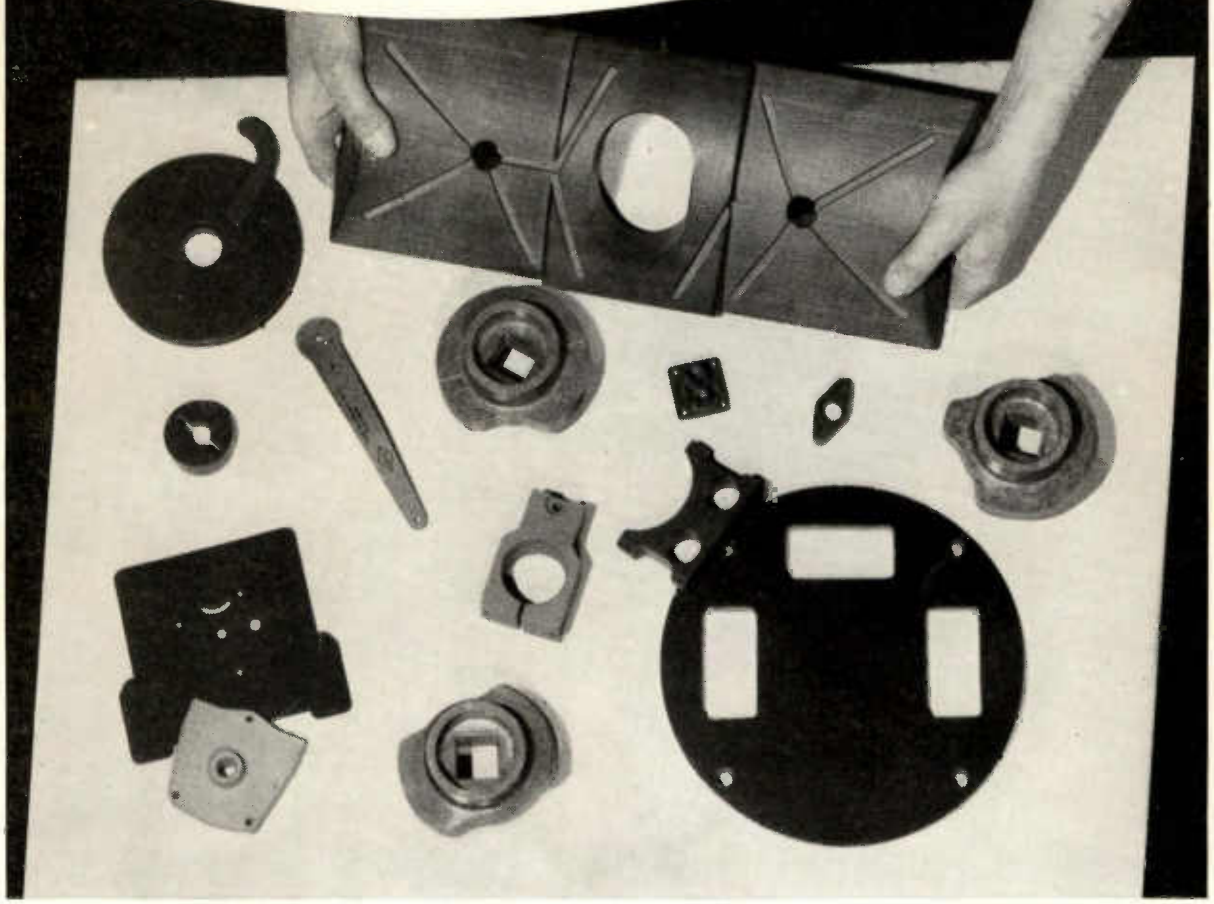
MANUFACTURERS
OF PRECISION
CATHODE RAY TUBES
AND
GEIGER COUNTER
TUBES

20th Century Electronics Limited

20th CENTURY ELECTRONICS LTD, DUNBAR WORKS, DUNBAR ST, LONDON, S.E.27
Telephone: GIPsy Hill 2277

Mechanical Applications of Paxolin

Paxolin laminates, used for a multitude of electrical applications, are also widely employed for mechanical purposes. The material is half the weight of aluminium but tough and easily machined and as it is supplied in a variety of grades the most exacting conditions can be met. Cams, drilling jigs, templates, and moulds can be fabricated from this versatile material as well as countless components for tools, clocks, instruments, and other devices. One special application is bearings. We have supplied not only small ones but some of massive proportions. We are also equipped for the production of very large moulded laminates such as door panels. Paxolin is well established in the mechanical as well as the electrical field.



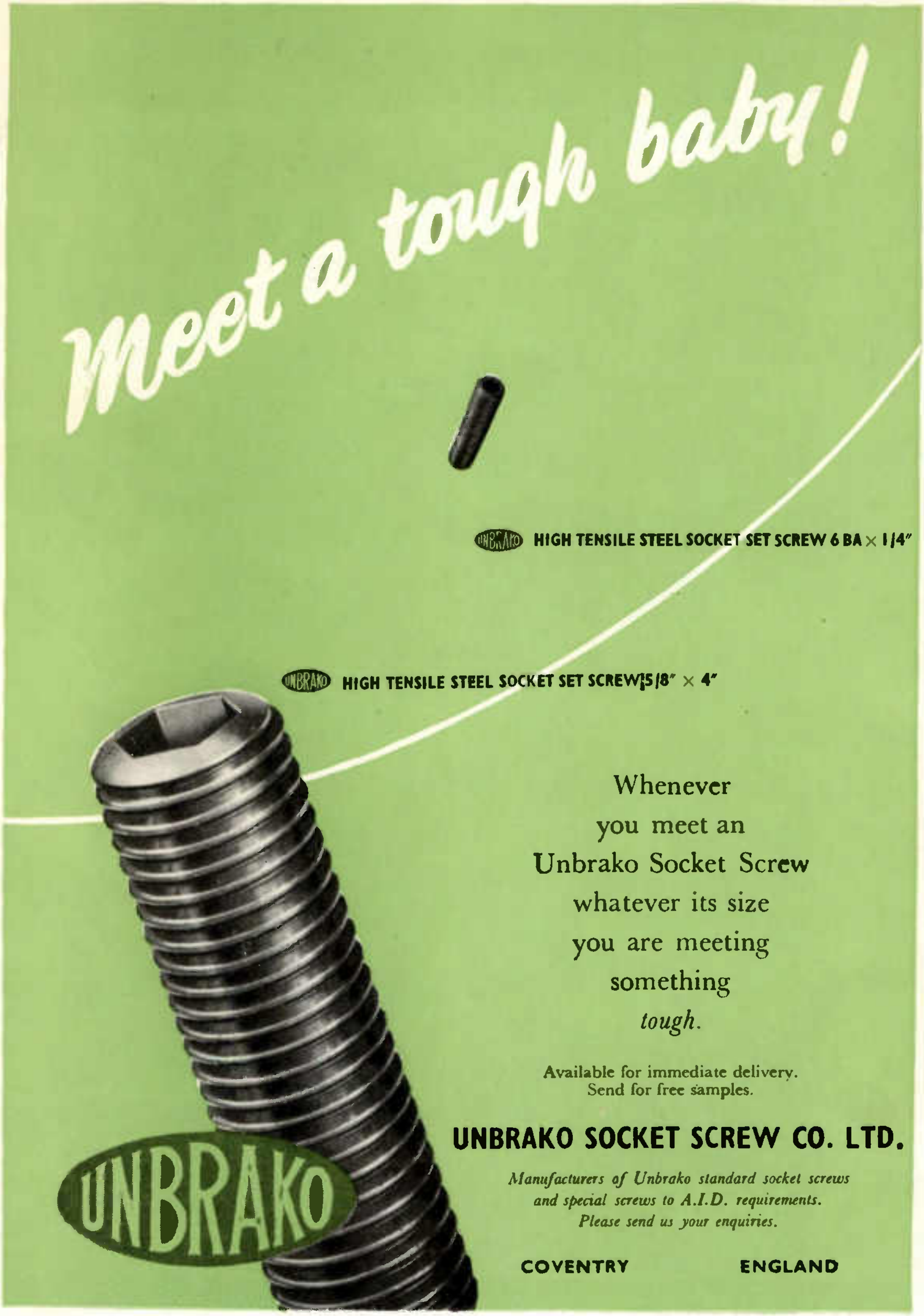
m and i

The Micanite & Insulators Company Limited

EMPIRE WORKS · BLACKHORSE LANE · WALTHAMSTOW · LONDON E.17

Manufacturers of MICANITE (Built-up Mica Insulation). Fabricated and Processed MICA. PAXOLIN Laminated Materials. PANILAX Laminated Materials and Mouldings. EMPIRE Varnished Insulating Cloths and Tapes. HIGH VOLTAGE BUSHINGS & TERMINALS. Distributors of Micoflex-Duratube Sleevings, Micoflex-Durosleeve (Plastics-covered flexible metal conduit) and Kenutuf Injection Mouldings (in most thermo-plastics including P.V.C.)


2oz. of this wire
would go round the
Coronation Route
ULATED
NG WIRES
STRIPS


Meet a tough baby!
UNBRAKO HIGH TENSILE STEEL SOCKET SET SCREW 6 BA × 1/4″
UNBRAKO HIGH TENSILE STEEL SOCKET SET SCREW 5/8″ × 4″
Whenever you meet an Unbrako Socket Screw whatever its size you are meeting something tough.
Available for immediate delivery.
Send for free samples.
UNBRAKO
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Electronic Engineering

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Commentary

THE thoughts of millions of Her Majesty's subjects will inevitably be turned towards Westminster Abbey on June 2 when Her Majesty will be crowned Elizabeth the Second, by the Grace of God, of the United Kingdom of Great Britain and Northern Ireland and of Her other Realms and Territories, Queen, Head of the Commonwealth, Defender of the Faith.

A privileged few, no more than 7 000, by reason of their high office, will be present in the Abbey itself to witness this solemn act of accession and dedication, while countless thousands will line the streets of London along the Coronation Route to acclaim our new Queen. But by the modern miracles of radio and television many millions at home and overseas will be brought to London to join in the ceremonies on this great day.

There have, of course, been many occasions in the past, notably the Royal broadcasts at Christmas, when the four corners of the earth have been linked to this country by radio, but never before on such an immense scale. The Coronation broadcast will, in fact, represent the greatest link up in history since nation first began to speak to nation, for over 200 narrators in London will provide commentaries throughout the day in some forty different languages.

It will also be a unique day, too, as far as the BBC Television Service is concerned, for although it is difficult to forecast an accurate figure, it is estimated that the British audience of viewers watching the scenes in the Abbey and along the Royal Route will not be less than twenty million. The problem of relaying direct across the Atlantic has not yet been solved, but elaborate arrangements have been made to fly telefilm recordings across to Canada by R.A.F. Canberras within a few hours for transmission over the Canadian and American networks. The great achievement from the technical point of view is that viewers in France, Belgium, Holland and Germany will be joining British viewers by means of the temporary television relay network which has just been set up for the occasion.

This network is part of a larger scheme to establish a permanent network across Europe which will eventually extend to the Scandinavian countries and across Switzerland into Italy. There are several European countries operating television services, but public interest has been at a low ebb largely owing to the poor standard of the programmes due to the sheer inability of the authorities to afford anything better. It has been realized for some time that one method of raising the standard would be in the exchange of programmes between neighbouring countries, and considerable attention has been given to this aspect in the development of the post-war European television systems. On a higher plane, too, it has been recognized that such exchanges would bring a wider culture to the viewer and go a long way towards promoting mutual goodwill and understanding among the nations.

The initial technical difficulties arising from the different television standards adopted by the European countries have to a large extent been overcome by the development of the convertor unit and the first exchange between countries with different systems took place last July when programmes originating in Paris were simultaneously transmitted in France and Great Britain.

In view of the world wide interest in the British Coronation, it was only to be expected that, while the time is not ripe for the building of a permanent network, the European television authorities would be anxious to relay the television programme of the Coronation to their countries. Some months have been spent by the BBC in discussing the arrangements with their European colleagues and plans for a temporary network were prepared early in the year.

Progress in this direction was undoubtedly stimulated by the BBC who offered the whole of the Coronation programme to the European network without charge.

The day is not far distant when a permanent network will stretch right across Europe from Scandinavia to Spain and it may yet be possible to bridge the Atlantic and join the American Continent. Viewers on Coronation Day, wherever they may be, might reflect on the words of Sir William Haley who described television as "an open window looking out on the world from every cottage in the land."

The Coronation

The Editor and Staff of Electronic Engineering send their loyal greetings to Her Majesty on the occasion of the Coronation on June 2

LONG LIVE THE QUEEN!

A Transmitter for Production Testing of Television Receivers

By J. M. Silberstein*, Dipl.Ing., A.M.I.E.E.

A television test transmitter is described in which a comprehensive pattern is distributed to testing points simultaneously on all BBC channels. Pulses of appropriate frequencies, locked to the mains, are synthesized directly into the pattern, sync and suppression waveforms. Sync and pattern waveforms are separately impressed on 17·7Mc/s. H.F. channels are formed by modulation with the necessary carriers using germanium double balanced modulators. Amplifier tuning is staggered for vestigial sideband transmission. Hybrid transformers join the vision and sound channels. Pulse and pattern monitors, and synchroscope for details of the television waveform are also described.

IN mass-production of television receivers it is not possible to use, for testing purposes, signals transmitted by the BBC since the time of transmission is limited to a comparatively short period within the industrial working hours, the reception of these signals may not be good enough for testing, and only one channel is available in any area. A mass-production organization must have its own source of television signals, working all day and transmitting on all channels.

The signals provided by the test transmitter must be basically similar to the BBC television signals. The strength of the signals should be comparable with that in a good reception area, vestigial sideband transmission should be used, proper ratio of sync and video signals must be maintained, the relation between the sound and vision signals must approximate that met in actual working conditions.

Video modulation is practically the only feature of the transmitter which is left to the decision of the test gear engineer. Several basic solutions are possible and used. A camera and a film can be used, if a live picture is desired, or a camera and a picture or pattern card continuously scanned. These are very expensive solutions. A simpler method of producing a stationary picture is to use a high voltage cathode-ray tube as a flying spot scanner and a photo-multiplier tube or a photocell and a thermionic amplifier as a pick-up device. A transparent picture placed against the face of the cathode-ray tube can be made to produce a satisfactory picture because of the varying light intensity transmitted to the pick-up tube through the transparency.

A better method, of course, is to interpose a lens and focus an image of the scanning raster on to the transparency, as in this way better definition can be achieved. A different and probably more popular method makes use of a monoscope[1] which is a device incorporating a cathode beam-forming gun, similar to that in a cathode-ray tube, and a prepared target plate over which the beam is made to scan. The target plate has a picture or pattern printed or otherwise impressed on it, the ink used having a different secondary emission ratio as compared with the metal plate. Due to the different secondary emission rate, a signal corresponding to the picture, point-by-point, is produced across the load resistor connected in the lead to the target plate.

The replacement cost of the tubes for the above methods of stationary picture production has to be taken into consideration when the transmitters are running for the whole of the working week. Auxiliary equipment is needed in every case to provide essential synchronizing and suppressing waveforms, scanning and power supplies.

A properly selected geometric pattern is probably the best means of rapidly testing television receivers, and a synthetic method of generating it from component waveforms is, in the long run, the most economical way of obtaining it. A pattern gives more quickly an insight into the operation of the tested receiver. Setting of the limits is much easier when a geometric pattern is produced on the screen, than when the tester has to watch a moving or even a still picture of natural, i.e. highly irregular design. The element of judgment is to a large extent replaced by objective criteria.

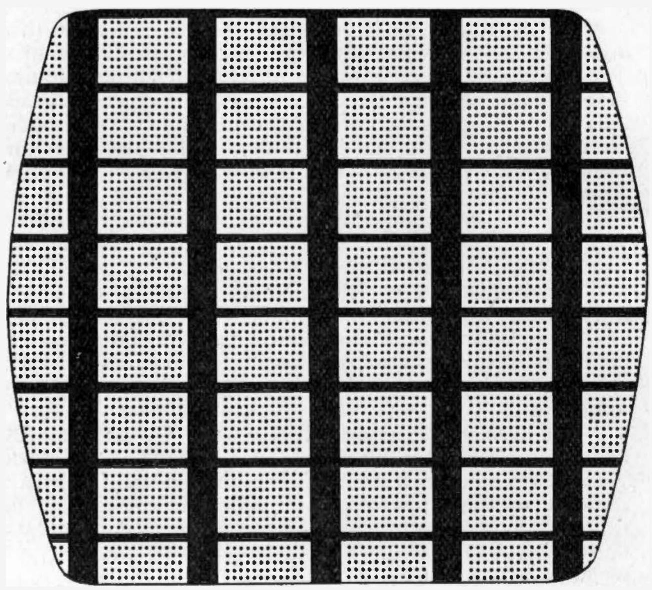


Fig. 1. Pattern used in the test transmitter

For normal production testing the pattern does not need to be very complicated. A simple pattern used in the test transmitter described, shown in Fig. 1, is sufficient to check all the main features which have to be watched in production, although it may not be adequate for development work on a new model. It permits, in conjunction with the controls of the tested receiver, a check of the picture size and of the aspect ratio; of the linearity in both directions, by observing the distances between the bars in different portions of the screen; of response, by observing the dots which correspond to high frequency components of the waveform; of time-base, by observing the clearness of the definition of the edges of bars; of interlacing, by observing the distances between the lines of dots; etc.

Besides all usual requirements of central testing equipment regarding its reliability and ease of maintenance, the test transmitter has to meet a specific condition which is

* *Advance Components Ltd., formerly Sobell Industries Ltd.*

of paramount importance. The transmitter must remain locked, not rigidly, but in a "spongy" manner, to the mains even in the most adverse conditions. The mains frequency varies to a great extent and only an exceptionally sound locking circuit can guarantee the absence of breakdowns due to this cause. As all pattern generator designers and users well know, this is not a condition which can be met with an over-simplified circuit, however cleverly it has been designed. No expense in valves and components should be grudged to obtain the best results in this particular respect.

A simplified functional diagram of the test transmitter is shown in Fig. 2. The transmitter consists of the following main component parts:—

1. Frequency generator in which pulses of all frequencies needed for subsequent stages are derived from a single fundamental frequency. Whenever feasible, pulses are formed directly of the required shape and duration. The master oscillator is tied to the mains frequency through the locking circuit.

2. Dots generator for the high frequency components of the video waveform. These are generated at time intervals related to other components of the waveform.

3. Pattern synthesizer which joins together all the parts of the video waveform corresponding to the pattern selected.

4. Synchronizing signals generator (sync generator) in which the waveform is formed containing frame pulses, line and half-line pulses. This waveform is then delayed by about 0·5μsec in a delay network.

5. Pattern suppressor in which those parts of the pattern waveform are suppressed which correspond to the periods of the flyback, horizontal and vertical.

6. Intermediate frequency modulator in which sync and pattern waveforms modulate an intermediate frequency.

7. Carrier oscillators producing the intermediate and channel frequencies (not the BBC channel frequencies) required to shift the vision and sound signals into correct (BBC) frequency bands.

8. Channel vision modulators and final amplifiers bringing vision signals in the correct channels in the frequency spectrum.

9. Channel sound modulators and final amplifiers bringing sound signals (BBC broadcast programme) in the correct frequency bands to form five television sound channels.

10. Junction circuits combining sound and vision channels to be transmitted together over coaxial cables to the testing positions.

11. Monitoring arrangements comprising meters for carrier and signal voltages, a pulse monitor, a waveform display unit, a pattern display unit and a loudspeaker unit.

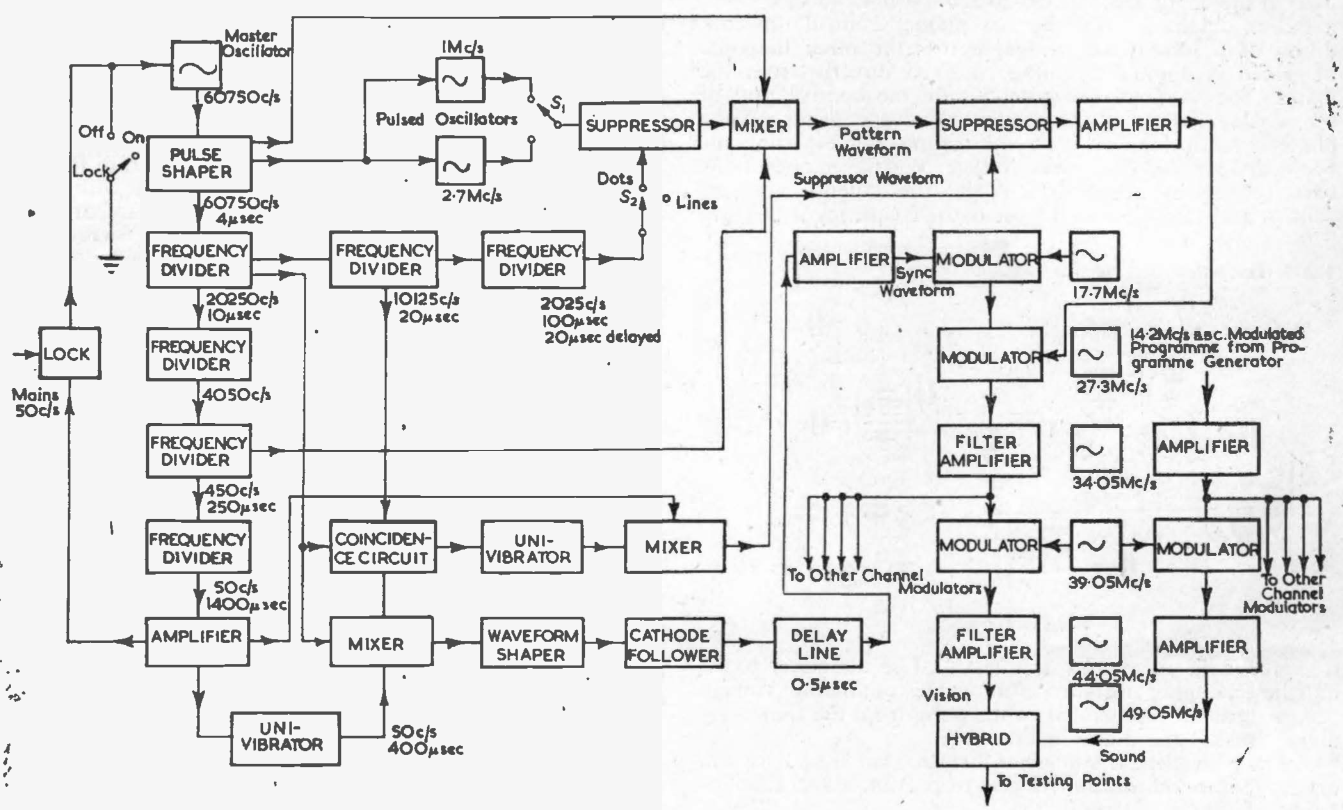


Fig. 2. The test transmitter

Frequency Generator

The analysis of the pattern (Fig. 1) gives directly the frequency of the pulses producing the vertical and horizontal bars. Vertical bars occur six times during one line (the sixth bar is not visible because it occurs during the horizontal flyback and is therefore suppressed), hence the repetition frequency of the pulses must be 6 × line scan frequency, i.e. 60 750c/s. The duration of the pulses must be about 4μsec corresponding to the 1 : 3 ratio of the thickness of the bars and of the distance between the bars.

Horizontal bars occur 9 times during each frame (one bar is suppressed for the vertical flyback), hence the frequency required is 9 × frame scan frequency, i.e. 450c/s. The duration of these pulses is about 250μsec corresponding to the thickness of 2½ lines on each frame.

Frequencies required for the sync signals are: 50c/s for the frame sync pulses, 10 125c/s for the line sync pulses and 20 250c/s for the half-line pulses.

All frequencies are derived from one master oscillator, its nominal frequency being 60 750c/s. Actual frequency is identical with the nominal value only when the mains frequency is exactly 50c/s, and it changes in proportion to the mains frequency. A simplified schematic of the master oscillator and of the locking circuit is shown in Fig. 3. The oscillator is of the negative resistance type using a pentagrid valve. Its cathode, grid 1 and grid 2, form a reactance of value dependent on the potential of grid 1. As this reactance is connected across the oscillator tank circuit it can be used for automatic frequency adjustment.

The sine-wave produced in the oscillator is converted into positive going 4μsec pulses in the pulse shaper and amplifier stage. The amplifier is required as fairly large pulses with a moderate source impedance are needed for subsequent operations. A single stroke multivibrator (univibrator) is used for pulse shaping in this as in many other cases throughout the transmitter.

A chain of frequency dividers follows the master oscillator, each producing positive going pulses of approximately 50V peak-to-peak. Nominal values of frequencies used in the chain are: 60 750-20 250-4 050-450-50c/s.

Pulses obtained from the last divider control the condition of a four diode bridge[2] across the other diagonal of which is applied a voltage derived directly from the mains. The value of the potential on the control grid of the reactance part of the oscillator valve depends on the phase relationship between the gating pulses from the 50c/s divider and the mains voltage. Whenever one of the two frequencies begins to change, the potential on the control grid changes and the oscillator frequency is brought

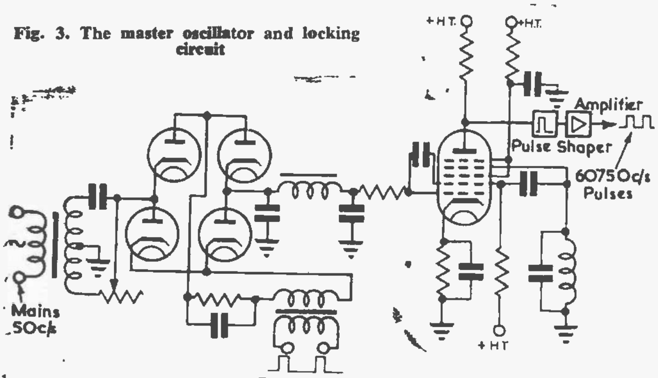


Fig. 3. The master oscillator and locking circuit

to agree with the mains frequency. The action is based on the changing instantaneous value of mains voltage occurring at the moment when the pulse from the frequency divider makes the diodes conducting.

A low-pass filter is connected between the output of the discriminator and the control grid to prevent a 50c/s modulation of the master oscillator.

The principle of operation of frequency dividers used[2] is illustrated in Fig. 4. At the input of the divider there is a two-stage amplifier. Two stages are necessary to preserve the correct polarity of the incoming pulses, otherwise the circuit would be triggered from the trailing instead of the leading edge of the incoming pulses. This would be equivalent to a delay between the originating and the generated pulse.

At each incoming pulse a large voltage is developed in the anode circuit of V_2. This voltage charges two capacitors separated by a diode. When the pulse ends, C_1 discharges through another diode and C_2 remains charged. After this process has been repeated several times, C_2 has accumulated enough charge to make the triode V_3 conductive, and this triggers the multivibrator causing a sudden rise of potential at the anode of V_5.

This type of frequency divider, although rather expensive in valves by comparison with other, more popular types, has a number of attractive features. Capacitor C_2 charges at a decreasing rate at each incoming pulse, but provided the last charging step is definitely higher than

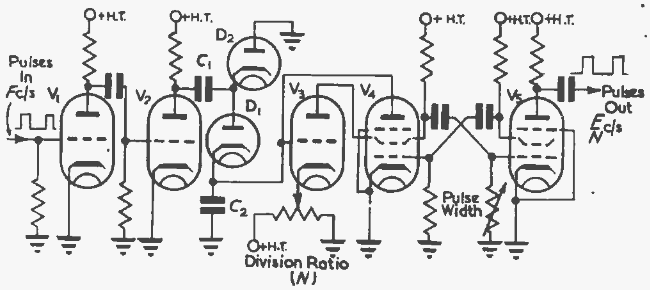


Fig. 4. The frequency divider

the uncertainty limits of the triode to be triggered, the operation of the divider is quite decided. For a higher division ratio a higher amplitude of the charging pulses is required. Actually, a division ratio of 9 can be obtained without difficulty, and higher division ratios could be obtained if required.

The duration of the output pulses depends solely on the parameters of the multivibrator and can be adjusted within wide limits. The multivibrator is designed to work at a much lower repetition frequency than is forced on it by the triggering action.

The divider is independent of the frequency within fairly wide limits. This is of particular value, because with the mains frequency varying from 48 to 50·5c/s many of the more economical dividers are prone to fail when working in a long divider chain. With the type of divider used it is possible to adjust all the dividers in the chain with the master oscillator running free and then just switch the locking on. If the adjustment was done correctly, the locking circuit will work whatever the difference of frequencies, within common-sense limits. Under normal conditions of supply voltage variations the locking circuit described can be expected to work unfailingly between 47 and 51·5c/s which provides a liberal safety margin.

Dots Generator

The vision signal produced by the test transmitter must contain some high frequency components to enable a rapid check of the frequency response of the tested receiver. These components are provided in the form of dots appearing on every fifth line. A switch serves to select very fine dots (2·7Mc/s), coarser dots (1Mc/s) or thin vertical lines, i.e. dots appearing on all scanning lines. It is desirable that the dots should not appear on the screen simultaneously with the vertical bars. A pulsed high frequency generator is used, shown in Fig. 5.

The oscillatory circuit of a Hartley type oscillator is connected in the cathode of a triode pulsed by 60 750c/s pulses (vertical bars). When the triode is conducting, i.e. in the time intervals of vertical bars, oscillations can not occur because the oscillatory circuit is damped by the impedance of the triode. When the positive going pulse

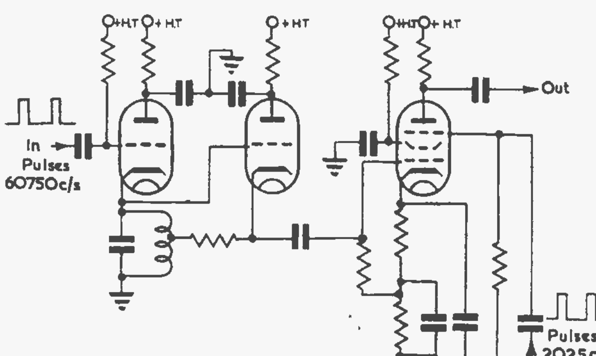


Fig. 5. The dots generator

ends, oscillations start immediately and continue until the beginning of the next 60 750c/s pulse. The oscillator is started afresh every time and this guarantees the recurrence of all the same effects every time. The dots can therefore remain stationary on the screen of the tested receiver, although their frequency is not tied to the master oscillator.

In one of the possible patterns the dots are to appear on every fifth line. To stop them on other lines a pentode gate is used. 2 025c/s pulses are applied to the suppressor grid of the gating pentode which transmits the high frequency components applied to its control grid only during the time when the suppressor grid is driven positive. Positive going 2 025c/s pulses last for about 100μsec and are delayed by comparison to other pulses in the system by about 20μsec. This delay is obtained in the frequency divider 10 125-2 025c/s by omitting one stage of the input amplifier and thus starting the outgoing pulses from the trailing edges of the originating pulses. The delay is necessary to ensure that the dots start at the beginning of the horizontal scan line and not towards its end as would have happened otherwise.

To facilitate the gating action without introducing very high amplitudes of the gating pulses, the cathode of the gating valve is kept at a fairly high positive potential, whereas the suppressor grid is brought to earth via a resistor. Normally the pentode is nearly cut off and only a small additional negative pulse provided by the A.C. coupling of the gating pulses is required to complete the effect.

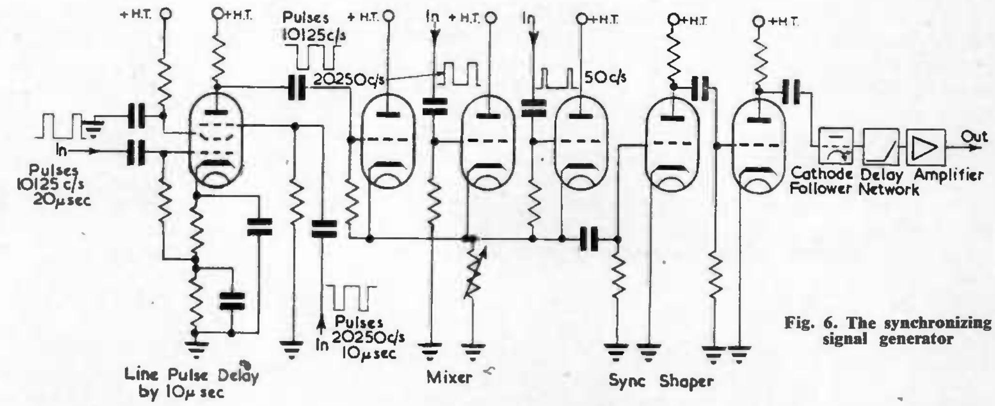


Fig. 6. The synchronizing signal generator

Synchronizing Signal Synthesizer

Component waveforms of the vision signal, i.e. the pattern and the sync waveforms, are formed from appropriate simple pulses in circuits called synthesizers. Of the two, the sync synthesizer is more interesting and will be described in detail.

The BBC sync waveform consists of line pulses and frame pulses interrupted by half-line pulses. Line and frame pulses are negative going, half-line pulses positive going. Television receivers respond to negative going pulses. To preserve the correct timing of triggering of the line time-base during the period of the frame pulse, it is necessary to shift line pulses by comparison with half-line pulses so that the period of time between the leading edge of the line pulse and the trailing edge of the half-line pulse equals 0 or a half-period of the line time-base. In the test transmitter described line pulses are derived from half-line pulses and their leading edges coincide.

The first function of the sync synthesizer is therefore to delay line pulses by the duration of the half-line pulses. This is done in a coincidence circuit. Line pulses of 20μsec duration are applied to the control grid of a pentode and half-line pulses of half duration and double repetition frequency are applied to the suppressor grid. Half-line pulses are first amplified in a triode amplifier and their polarity reversed. A simplified circuit is shown in Fig. 6. It is obvious that anode current can flow in the pentode only when the potential of the suppressor grid is positive and the potential of the control grid is not highly negative. This coincidence can occur only during the second half of the line pulse and in this period a large negative going pulse occurs at the anode of the valve. This pulse can be used as line sync pulse because it meets the requirements stated previously.

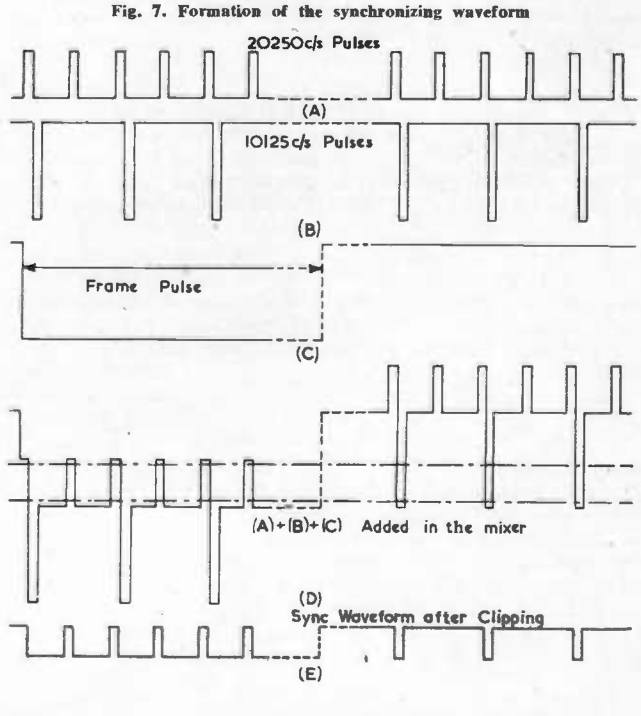
All the component pulses are now available for the synthesis of the sync waveform. A simple addition of the pulses would not be satisfactory as half-line pulses must not occur except during frame pulses.

The process of addition is performed in a mixer comprising three triodes, each having one type of pulse applied to its control grid. The output is taken from the common cathode impedance. The polarity of half-line pulses is the reverse of the polarity of the remaining pulses. Fig. 7 shows component pulses, A,B,C, and the direct result of their addition, waveform D. The latter contains in its middle part the exact form of the required waveform. The problem consists therefore of finding some simple means of removing the upper and the lower parts of waveform D.

The two triode amplifiers following the mixer are used as a waveform shaper. As their cathodes are earthed, they have a tendency to suppress all positive parts of the incoming waveform. The first triode suppresses the upper part of the waveform D, the second, the polarity having been reversed, suppresses the lower part of the waveform. The result of this operation is shown in Fig. 7 as waveform E. The operation does not call for any particularly critical adjustment of the relative values of the amplitudes of component pulses. One variable resistor is provided in the common cathode load of the mixer and this is quite sufficient.

The BBC television waveform has sync signals delayed

Fig. 7. Formation of the synchronizing waveform



by 0·5μsec to enable the receiver to recover from the peak white signal before the sync signal begins. In the case of the pattern as described above the delay is actually not necessary, but as some other types of video modulation were considered for introduction at some later date, the delay has been provided. To obtain it without upsetting the all-important rise-time of the sync pulses, a low-pass filter is used designed for a cut-off frequency of 5Mc/s. It is a ladder network containing inductors as the series arms and capacitors as shunt arms. The characteristic impedance is low and a cathode-follower stage is necessary before the filter.

I.F. Vision Modulator

The pattern waveform synthesized in a similar manner to the sync waveform must first pass through the suppressor stage before it can be used for modulation. The suppressor consists of a suppression waveform synthesizer and of a pentode gate. The pattern waveform leaving this stage is not changed fundamentally, but it is extinguished for the duration of the flyback, horizontal and vertical.

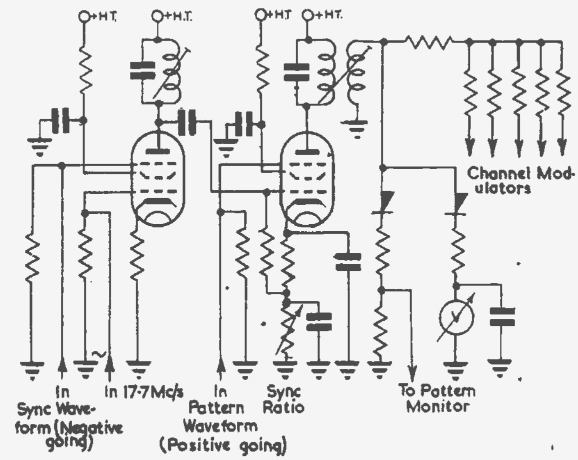


Fig. 8. The I.F. vision modulator

It is a distinctive feature of the test transmitter described that the two waveforms: pattern and sync are not combined before the modulation (i.e. on the video basis), but are used separately for modulating two consecutive stages of the modulator.

A simplified schematic of the I.F. modulator is presented in Fig. 8. Suppressor grid modulation is used in both stages. In the first stage the sync waveform, brought to an amplitude of nearly 100V in the preceding amplifier, is applied to the suppressor grid of a pentode which has the I.F. carrier voltage (0·25V, 17·7Mc/s) applied to its control grid. The result of this process is an I.F. signal of constant amplitude, except at the periods corresponding to the sync pulses (not half-line pulses) when the amplitude drops to 0. This signal is applied to the control grid of the second modulating pentode. The gain of this stage is controlled by the pattern waveform applied to the suppressor grid. When the pattern pulse (positive going) is present, the gain is about three times higher than in the periods between pattern pulses. The exact ratio of the change of the gain is controlled by the variable resistor in the cathode which makes it possible to find the correct working point. An I.F. signal appears at the output of the second modulating stage which has zero amplitude in the sync pulse periods, full amplitude in the pattern pulse periods and 30 per cent amplitude in all other periods (black level).

This system of modulation is characterized by the desirable feature of independence of the sync ratio (ratio of the black level to the peak white level) of the picture content, at least in the first approximation. In the test transmitter it makes it possible to change the pattern without readjustment of the sync ratio. With a different type of video modulation, i.e. live picture, the advantages would be still greater. In the test transmitter further advantages are gained by the fact that all video stages operate at two conditions only, whereas in the case of adding the sync and pattern waveforms on the video basis the amplifier preceding the modulator would have to work at three different conditions; zero signal, black level, full signal.

The intermediate frequency stage of modulation presents an easy way of distributing the vision signal to the five channel modulators. If a direct system of modulating channel carriers was used, a large amplifier would be required for video signals, working at low impedance level for the sake of coaxial cables used for distribution. The distribution at I.F. frequency is incomparably easier. Further advantage is gained when a part of the networks required for vestigial sideband transmission is transferred from channel modulators into the I.F. modulator with the resultant saving in the total number of tuned circuits in the transmitter.

H.F. Transmitter

Carrier frequencies used in the channel equipment are equal to the BBC channel carrier frequencies minus the test transmitter I.F., so that correct vision carriers are obtained at the output of the channel modulators when the upper sidebands are filtered out. Double balanced bridge modulators are used, with germanium crystal rectifiers and transformers wound on spiral tape cores. The difference between the carrier and modulating frequencies is fairly great in all cases and the elimination of unwanted modulation products does not present any serious difficulties. Tuned circuits in the amplifier stages following the modulator are tuned in such a manner that, in conjunction with the tuning of the I.F. stage, an overall frequency response is obtained approaching the BBC vestigial sideband transmission system.

Sound channel equipment is similar to the vision equipment. The intermediate frequency for the sound modulation has been chosen 3·5Mc/s lower than for the vision, i.e. 14·2Mc/s, and this makes it possible to use the same carrier frequencies for both the vision and the sound equipment, as 3·5Mc/s is the distance between sound and vision carriers on all BBC channels. The common usage of the same carrier sources for the sound and the vision imposes rather stringent requirements as regards leakage in the modulators, to avoid vision breaking into sound and vice versa.

The I.F. sound channel is obtained from the so-called programme generator reproducing an original BBC programme (Light or Home) on several frequencies, for testing radio receivers on all frequency bands. In the programme generator the original transmission is not demodulated to the audio stage. Various frequency bands are obtained by modulating the BBC transmission with appropriate carriers. By this means full modulation depth is preserved without difficulty.

All carrier frequencies used in the test transmitter are crystal controlled.

It is desirable to have the monitoring circuits, pattern display and loudspeaker units, as close to the final output of the test transmitter as possible, otherwise the faultless operation of the transmitter may be in doubt even when the monitors are producing normal effects. To avoid the mutual interference of the sound and vision signals which would seriously interfere with the monitoring, hybrid transformers are used for joining sound and vision signals to be sent out on common coaxial cables. At a loss of just over 3db in the main transmission path, a separation of the two signal sources is obtained amounting to at least 30db. Hybrid transformers are wound on spiral mumetal tape cores 0·001in. thick.

Nowhere in the H.F. circuits are really high levels used. All connexions are made at 75 ohms impedance by means of coaxial cables. Through these precautions it was found possible to avoid elaborate screening of the H.F. parts of the test transmitter.

Monitoring Facilities

For maintenance purposes the test transmitter is amply provided with monitoring facilities. All I.F. and H.F. channels, vision and sound, have at their outputs rectifier voltmeters to keep the transmission levels under constant control. Similar voltmeters are provided for the carrier outlets. An audio amplifier and loudspeaker can be switched to the output of every sound channel where rectifiers are provided for the purpose. In a similar manner a video amplifier and vision receiver, complete with sync separator and time-bases, is provided for monitoring the outputs of all vision channels, the detected vision signals being taken from germanium rectifiers connected immediately before the junction hybrids.

A simple double-beam oscilloscope is provided for rapid check of the frequency dividers belonging to the standard frequency generator. Double beam operation is particularly important in this case as the best way of checking the dividers is to display simultaneously the originating and the

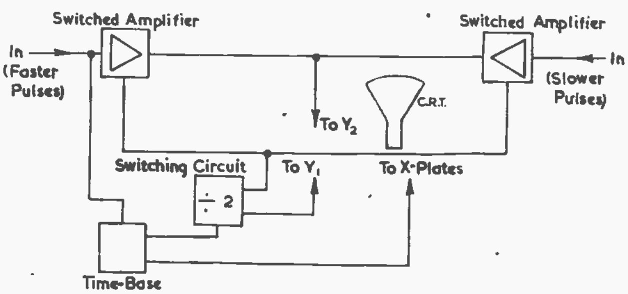


Fig. 9. The pulse monitor

generated pulses. The number of pulses occurring between two consecutive pulses of the slower rate shows directly the division ratio, all imperfections of adjustment are shown by the untidy appearance of the generated pulses, or even, in the most drastic case, by the impossibility of keeping one of the traces in lock.

The block schematic of the pulse monitor is shown in Fig. 9. The time-base is locked to the faster of the two displayed signals because the checking operation has obviously to start at the higher frequency end of the chain (with locking circuit out of action). A beam switching system is used for displaying the two waveforms. The beam is switched from one trace to the other at a frequency equal to half the frequency of the time-base. Both waveforms pass through amplifiers to the Y-plates of the cathode-ray tube, but at any moment only one of the amplifiers is actually working and the other is switched off by the action of the switching waveform applied to its suppressor grid. Blanking pulses are provided to suppress all display during the return stroke.

Normally the pulse monitor is kept in the position where it shows on one trace 50c/s pulses produced in the test transmitter and on the other trace 50c/s mains sine-wave. The two waveforms do not move with respect to each other when the transmitter is in lock.

Another specialized oscilloscope (synchroscope) is provided to display all details of the television waveform and in particular to keep control over the sync ratio. This is an oscilloscope with a triggered time-base. The triggering frequency is 25c/s as the whole of the television waveform is repeated at this rate. The speed of the trace in the horizontal direction has to be such that between 10 and 20 lines are displayed. The speed of the time-base must be completely independent of the triggering pulses. The beginning of the sweep should be determined by the time location of the triggering pulse. Fig. 10 illustrates the principles of the operation of the synchroscope.

It is an essential requirement that at every moment the triggering frequency must be identical with the picture frequency, otherwise two consecutive displays would not exactly coincide on the screen, the display would be blurred or subject to spasmodic jerks. This is not an easy requirement to meet. Dr. Sturley[3] described the difficulties met while building a similar apparatus. The solution adopted by Dr. Sturley is practically the same as the one derived independently for the test transmitter synchroscope. Broadly speaking, it consists of abandoning all efforts of making use of the mains frequency and developing instead a 50c/s sine-wave from pulses produced in the transmitter. In spite of the fact that the test transmitter is locked to the mains, the instantaneous value of the frame pulse frequency may differ from 50c/s mains sufficiently to cause the jitter. One of the reasons for it may be that in the long divider chain hunting processes occur while the frequency is controlled and adjusted. Observation showed that the jitter was particularly severe when the mains frequency was far off its nominal value, and so the locking was somehow more difficult, although this could not be noticed by any other means.

To display any part of the television waveform a phase

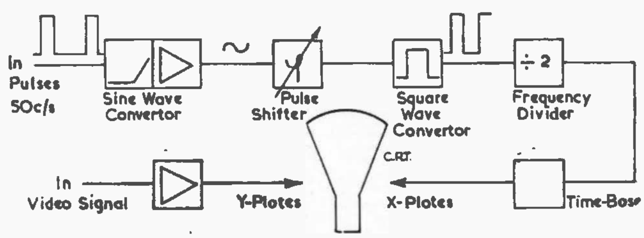


Fig. 10. The synchroscope

shifting network is provided following the 50c/s generator. It covers more than 360° which is enough to show one complete frame and the beginning of the next frame—the only period when the two frames differ.

The phase shifted 50c/s sine-wave is first squared and then applied to the input of the 50-25c/s divider producing very short pulses used for triggering the time-base in which a capacitor is charged via a constant current pentode circuit. A constant speed of the electron beam is thus obtained for the forward stroke. The speed of the beam, i.e. the number of the scan lines displayed, can be regulated within sufficiently wide limits.

The input signal to the synchroscope is the detected output of any I.F. or channel vision output amplifier. The connexion has to be done at low impedance level and so the signal level is very low. An amplifier is therefore provided in the synchroscope with a uniform gain in the video range; it consists of three pentode stages.

Acknowledgments

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The Relative Merits of A.C. and D.C. as a Signal Source in Analogue Computors

By K. H. Simpkin*, A.M.I.E.E., A.M.Brit.I.R.E.

The author has attempted, in this article, to marshal the factors upon which the choice of A.C. or D.C. as a signal source in analogue computors is based: the influence of this decision in the case of a large computor, such as a flight simulator, is considered in detail, both from the point of view of equipment design and of the overall accuracy and sensitivity of the computor. The design of power supplies, signal sources, and amplifiers, and the relative complexity of simulating mathematical operations are examined in relation to both A.C. and D.C. systems.

While no dogmatic decision (which would apply universally) can be attempted, the author does collate, in a usable form, the points which must be considered before a choice of signal can be made.

WHEREVER the design of analogue computors is discussed, there is usually considerable argument when the decision has to be made between an A.C. and a D.C. computor. Both methods have their devotees, but an examination of the problem will show that neither system is so overwhelming in its advantages as to remain in universal use.

The author has had occasion, in the past, to take part in such arguments and presents this article in the hope that, while not providing a final decision in itself, it may present the "pros and cons" in a condensed form, and thereby assist readers, faced with a similar problem, to make the decision themselves.

The type of computor envisaged in this article is of formidable size and complexity, such as might be used in a flight simulator, for example. The power supplies and the numbers of basic units called for are large, and any economy which might result from the choice of a particular system can have a marked effect on the price, running costs and the reliability of the computor.

In view of the wide nature of the subject, it is proposed to examine the merits of A.C. and D.C. under separate sections, each devoted to a particular aspect of the computor.

The Signal Supply

In a D.C. system, any amplitude variation of the signal supply results in a direct error proportional to that variation. In a large computor, this supply may be of the order of several kilowatts and is normally of low voltage, in order to reduce the dissipation in the resistive computing elements. The problem of supplying highly stabilized power at potentials of less than 100 volts inevitably involves the use of low efficiency stabilizing elements, which increase the complexity of the computor and the total power required. A rotary generator is normally called for, which is not easily obtainable these days, together with the means for stabilizing its output voltage and removing ripple, the components of which may lie in the useful band of the computor if any eccentricity is present in the rotor of the generator. Furthermore, since both positive and negative values of functions are normally handled in a computor, supplies of both polarity are required, one of which must be stabilized from the other in order to guard against zero errors.

In compensation, however, no radiation is experienced with direct current and provided that the source impedance of the supply is kept low for reasons of stability, there is no necessity for screening the main supply to prevent cross-modulation, since there are no frequency components of the signal of sufficiently high order to be subject to radiation.

In an A.C. system, error is produced by both amplitude and frequency changes in the signal voltage. It is essential, therefore, that both be stabilized. A rotary alternator is necessary in view of the high power required, together with the associated equipment for stabilizing the voltage and the frequency and for removing the unwanted harmonic content of the supply, since distortion of the signal voltage results in further errors in the computations. Filters for removing harmonics while passing several kilowatts of the fundamental frequency involve substantial losses and contribute to the power requirement of the whole.

When a suitable A.C. supply has been produced, it must be protected from adulteration by external signals and prevented from inducing unwanted voltages in the various circuits of the computor, since any such voltages contribute directly to the errors of the system, and may even result in instability of the computor. Extensive screening is therefore necessary in most cases, a factor which increases the cost of the computor and may add to the difficulties of experimental work undertaken during its development.

In the opinion of the author, unless it can be shown that the signal power requirement is markedly less, in the case under consideration, when an A.C. supply is used, the D.C. system has the advantage from the point of view of signal supplies.

Amplifier Power Supplies

In a D.C. amplifier, the working conditions of the valves depend upon the difference in potential of a positive and a negative H.T. supply voltage. Since these voltages may each be of the order of 200 times the bias voltage required, it will be seen that a high order of stability is desirable in these two supplies in order to prevent the valves being swung from cut-off to saturation by small changes in the supply line voltages. Furthermore, variations in these supplies result in direct errors in the output of the amplifiers, although this effect can be combatted by negative feedback, provided they are not of such magnitude as to affect the forward gain of the amplifier materially.

Heater supplies tend to be complex in a D.C. amplifier,

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however, since, in a high gain amplifier, a stabilized D.C. heater supply is generally necessary in the first stage to minimize drift and it may be necessary to provide several sources of heater supply when the valve cathodes in the various stages of the amplifier are working at appreciably different D.C. potentials.

There being no D.C. equivalent of the transformer, an amplifier is required whenever the signal needs to be changed in impedance or reversed in sign. The number of amplifiers required to solve a particular problem tends therefore to be greater in the D.C. system and, as a corollary, the H.T. power requirement also. This tendency is accentuated by the fact that, owing to the loss in coupling circuits in D.C. amplifiers, the number of valves in each amplifier is large and the power efficiency correspondingly low.

The responsibility for providing these supplies at low impedance rests wholly with the power supply designer, since the signal voltages are also at D.C. and additional decoupling at each amplifier cannot be relied upon. The stability of the whole computor rests therefore on the ability to produce and maintain a low source impedance in these supplies.

The H.T. supplies required for an A.C. system are far less complex. In general, the power output and gain for a given valve line-up is greater in the A.C. amplifier. Negative feedback enables a fair degree of amplitude variation and hum to be tolerated in the H.T. supply and, since the valves are isolated from one another at D.C., a single positive supply is needed.

It may be necessary to provide an additional heater supply to minimize hum pick-up in the first stages of high gain amplifiers, but the main heater supply can be common to all other stages.

Changes of impedance or polarity in the signal can be accomplished with a transformer, with the result that the number of amplifiers and hence the supply drain associated with them tends to be less in the case of the A.C. computor. The economic importance of power supplies in a large computor leads the author to believe that the arguments put forward in this section are strongly in favour of an A.C. system.

Computing Errors

Errors which are common to both types of computor, such as non-linearity in potentiometers, will not be considered.

In a D.C. computor, errors normally arise due to unwanted D.C. voltages in the signal channels. These result from supply variations and drift in the computing amplifiers. The former have already been considered in the previous section. Drift is a serious problem, for its removal requires the careful design of input stages, the selection of valves, and, in some cases, a more positive attack in the addition of a drift correction system, involving the use of a separate amplifier. Such amplifiers demand additional power from the system and, since their function is not primary in nature but arises solely due to the deficiencies of the computing amplifiers, their presence is a serious argument against the use of D.C. for computing purposes. Some relief from drift can be obtained by the use of high signal levels, however, since a direct improvement in signal-to-noise ratio results.

Errors peculiar to an A.C. system arise from two major causes. These are the presence of stray pick-up voltages of signal frequency in the computing circuits and the introduction of phase errors by the various components of the computor. Prevention of the former lies in extensive screening as has been mentioned before. Phase errors arise usually from the use of iron circuits, such as transformers and rotary resolvers, or as a result of variations in the supply frequency of the signal. The reduction of these phase errors involves the addition of numerous correction networks to the signal circuits and the application of large amounts of negative feedback over the non-linear elements in the amplifiers. Phase correction networks are generally sensitive of adjustment and may become misaligned should the signal frequency change slightly. Furthermore, owing to the spread of iron characteristics and the difficulties of maintaining accurate gap settings in the manufacture of transformers and rotary resolvers, it is often necessary to align, individually, the correction circuits of each amplifier in a production batch. Feedback over transformers demands careful control over the loop characteristic and results in the addition of further correction networks to the feedback chain. It appears therefore that phase errors are a serious drawback to an A.C. system and that much of the simplicity claimed for A.C. may be lost in the correction of these errors. No improvement can be sought in raising the level of the signal voltages, since errors due to phase are independent of the amplitude of the signal. The signal/error ratio can be improved only by the actual reduction of the phase error itself.

In view of the advance made in recent years in the design of stable D.C. amplifiers, the author is of the opinion that a D.C. system today is less subject to errors than an A.C. system of equivalent complexity.

Arithmetic Addition and Subtraction

Simple addition and subtraction is normally based, in an analogue computor, on the properties of Kirchoff's laws. These involve either the addition of voltages in a common mesh or the summation of currents at a common node. Since, however, D.C. voltages cannot be produced in an isolated form, except by the use of separate power supplies, the addition of voltages in a mesh is impracticable in a D.C. system. The addition of currents at a node is suitable to D.C. techniques, but involves a considerable loss of signal when the number of terms to be added is large. An amplifier is almost always necessary for adding, and drift and gain limit the range of addition available, since the output current at the grid node is always at a lower level than any other of the input currents.

Subtraction involves the use of negative signal supplies locked to the positive ones or else the introduction of a sign reversal by means of a buffer amplifier.

Since the transformer allows impedance changes without loss of power and the production of isolated signal voltages, it is possible, in an A.C. system, to use either mesh or nodal addition at will. The former system is preferable, however, since, by isolating each signal with a cathode-follower amplifier having a very low output impedance and summing into a high impedance load, it is possible to add voltages in a mesh with negligible power loss.

An A.C. system, however, adds voltages vectorially and it is therefore necessary to bring all the signal voltages into common phase before addition is possible.

Subtraction is no more complex than addition when a suitable transformer is available to reverse the polarity of one of the signals concerned.

The addition and subtraction of angles may be achieved equally well in either system, when the angles are available as shaft positions, and do not therefore come within the scope of this article.

Since some form of phase correction is required to make use of an A.C. system at all, the author is of the opinion that arithmetic addition and subtraction is simpler and less demanding in power when an A.C. system is used, than in the case of a D.C. system.

Multiplication

The multiplication of two voltages may be achieved in either of two ways. These comprise a group of methods under the generic title of "electronic systems" and the electro-mechanical method of multiplication. The latter involves the application of one of the voltages to a potentiometer, the wiper of which is positioned in accordance with the other voltage. There is little to choose in this latter system between A.C. and D.C. as a signal source. Potentiometers used with A.C. signals may require phase correction, but, on the other hand, there is a greater range of small A.C. motors available, which are suitable for instrument servo use.

Since non-linear impedance methods rely on the stability of the characteristic used being high, to be of value in computing techniques, there is an advantage in the use of an A.C. signal. The A.C. characteristics of valves, for example, are more stable and reproducible than the D.C. characteristics, which are less easy to control during manufacture. This criticism does not apply, however, to digital and sampling systems, in which an on-off characteristic is used, but these systems are outside the scope of this article.

It appears, therefore, that, since electronic methods of computation are inaccurate in both systems in the present state of the art, there is little to choose from the point of view of multiplication and division between the two systems.

Trigonometrical Solutions

There are no suitable resolving or compounding devices available which operate at D.C. Sine-cosine potentiometers suffer from a lack of resolution, unless built in an inconveniently large physical size, and Desynn resolvers are, at best, inaccurate devices for use in computing. It is generally necessary, therefore, to re-cast the problem, in a D.C. system, by the use of co-ordinate geometry for example, in such a way as to avoid the need for the resolution or the compounding of angles.

The design of A.C. resolvers has, however, reached a high stage of development; rotary transformer devices are available with high degrees of accuracy and resolution. These however do suffer from the lack of a definite zero, especially when there are traces of quadrature signal present. It is generally recognized, therefore, that for the solution of purely trigonometrical problems the A.C. computor has outstanding advantages over the D.C. model.

Integration and Differentiation

Electro-mechanical integration, by means of a servo motor whose speed is maintained proportional to the input voltage, is equally achievable by either system. Electronic integration, by the use of a Miller capacitor integrator, is essentially a D.C. device and has no equivalent in an A.C. system. In a computor, the high speed available in such an integrator is often necessary to the stability of the system, and the lack of an equivalent unit at A.C. is a very serious drawback to the purely A.C. system.

Differentiation by similar feedback methods is possible in the D.C. computor, but considerable care is needed in the design of the amplifiers to avoid instability and the maximum rate must be limited to avoid excessive deterioration of the signal-noise ratio.

Thus, in both these applications of the calculus, and indeed in any application calling for the shaping of the voltage function, a D.C. signal is essential.

Servo-Mechanisms

The behaviour of a high performance servo-mechanism is controlled by the motor amplifier characteristic and the performance of the motor.

A.C. servo motors have reached a high stage of development and, for a given size of motor, outweigh the D.C. motor of the same general characteristics in speed-range, acceleration and torque. The majority of D.C. motors available today have been designed for low voltage applications and, as a result, they require stabilized low voltage and high current supplies. These are inefficient to generate as a separate supply, while the provision of individual carbon pile regulators for each armature may become prohibitive in a large computor. Furthermore, these low voltage motors require high field currents to drive them, and these currents have to be supplied by the control amplifier. It is a well-known fact, however, that valve amplifiers are more suitable to the production of high voltage, low current outputs, than high currents at low voltages. The presence of brushes in a D.C. motor is an additional drawback, as they restrict the life of the motor, affect the slow running characteristics and produce spark interference, which can cause serious trouble with associated equipment such as the radio aids equipment in a flight simulator.

The control of the amplifier characteristic is another case of voltage shaping, and a D.C. signal is essential for obtaining the transient gain terms necessary for high grade servo performance.

Thus, the advantages seem to be shared equally between the two systems.

Amplifiers

The major design problem of D.C. amplifiers is drift in the input stage. Several methods of drift correction have been evolved in recent years, however, and in less critical cases careful design of the first stage and valve selection results in an amplifier with a useable drift figure.

Positive and negative H.T. line voltages are necessary and, due to the heavy loss in D.C. couplings, the gain per stage tends to be low. This is not always such a disadvantage, however, since the D.C. couplings can be made part of the loop correction networks. The loop design is simpler in a D.C. amplifier than in an A.C. one, since the phase shift is due only to capacitive shunting.

High stability resistors are necessary to maintain stable D.C. working conditions on the valves, and some form of zero-setting is normally essential. Furthermore the requirement of an earthy input and output, when the signal is zero, usually results in further loss of gain.

Hum is no great problem, except in so far as it must not be allowed to overload any stage or be rectified in non-linear impedances. Heavy negative feedback will reduce hum and other unwanted interference, except drift, to a harmless level. There is an inherent disadvantage, however, in D.C. amplifiers, that an odd number of stages is required for a feedback amplifier, which usually results in a minimum of three valves being used.

Linearity is not so critical as in an A.C. system, where non-linearity results in the production of harmonics of the input signal which are difficult to remove without causing phase shift of the fundamental.

The efficiency of D.C. amplifiers is low in the output stages, since the valve must be worked at the midpoint of its characteristic to give linear swings in both polarities. From a more general point of view, component replacement tends to be more critical in D.C. than in A.C. amplifiers.

In A.C. amplifiers, owing to the necessity of using transformers, considerable ingenuity is required in the design of the feedback loop. More valves are often required than might be apparent in order to obtain sufficient phase control to avoid oscillation. Furthermore, the phase shaping networks usually involve the use of tuned elements which are critical of adjustment.

Valves have no D.C. connexion to one another, and no loss is involved in coupling networks, so that the gain per stage is high, although limited by phase shift due to shunting capacitances.

Highly stable elements are necessary only in the feedback loop, for a high degree of feedback minimizes variations in the forward gain elements. The efficiency of output stages can be made high by using class-B operation, provided that distortion is reduced to an acceptable level by large amounts of negative feedback. The additional gain then necessary can be obtained from valves of low current drain.

The problem of component replacement is almost entirely obviated by heavy negative feedback.

In view of the fact that the design of D.C. amplifiers has been the subject of so much research in recent years, the choice between the two types of amplifier rests largely upon the "know-how" of the designer. Neither amplifier involves insuperable design problems, although, in the opinion of the author, the balance of advantage all round lies with the A.C. amplifier.

Non-Linear Functional Representation

Since there is, at the time of writing, no method of representing non-linear functions with adequate accuracy other than by the use of graded potentiometers, which are common to both systems, the subject will not be pursued further.

Response Time

On the reasonable assumption that A.C. amplifiers for computor use are designed as a low-pass amplifier with a low frequency cut-off, it will be obvious that the bandwidth necessary for a given speed of response in a D.C. amplifier will be less than half that required in an A.C. one. With the high degrees of feedback in use in computing amplifiers, 80db or more, this means that the loop response must be controlled for an additional octave, in the A.C. case, above the asymptotic limit of the D.C. amplifier. These asymptotic frequencies lie in the region of 50 to 100kc/s, where control is difficult and any alleviation in the frequency limit is of great help to the designer. The reduced bandwidth of the D.C. amplifier also results in a theoretical doubling of the gain/bandwidth factor; if the phase control design will allow it, a reduction in the number of stages required for a given application may thereby be achieved. It appears, therefore, that the D.C. amplifier has the advantage in respect of response time.

The General Wiring and Layout of a Large Computor

In a D.C. computor, wiring tends to be simpler, since screening can be dispensed with except where necessary to avoid instability. The frequency limit of the signals is sufficiently low as to make crosstalk unlikely and stability can be maintained, in some cases, by restricting the amplifier bandwidths. Some care is necessary, however, in applying this cure as an afterthought.

At A.C. the problem can be formidable, although it is no worse than any other crosstalk consideration in the communications field, except that high and low level voltages tend to be routed in close proximity to one another. During development, however, more care is necessary in bench layout since, at 400c/s for example, pick-up in high gain amplifiers without adequate shielding can result in false accuracy figures.

In the experience of the author, neither system has overwhelming advantages, although the D.C. system is less likely to give trouble if previous experience in the layout of such systems is limited.

Combined Techniques

It will be obvious that a system taking advantage of the best of both worlds would be an ideal choice. Such a system requires means for the conversion of A.C. signals to D.C. and vice versa. Unfortunately, such devices as do exist for that purpose have disadvantages of their own.

Conversion from an A.C. signal to a D.C. one can be achieved by the use of various forms of phase sensitive rectifier circuits. Most of these result in a certain amount of ripple in the resultant D.C. signal. Those that do not do so require to work into an infinite load impedance and are successful provided that the requisite conditions of operation are complied with.

Conversion from a D.C. signal to an A.C. one involves the use of a modulator. Valve modulators are unreliable in operation, since they introduce effects, analogous to drift, due to variations in contact potential of the rectifiers. A more reliable choice of modulator is the vibrating relay. As far as is known by the author, however, there is only one relay manufactured in quantity in this country which is suitable for such purposes, and that is both difficult to obtain and expensive for extensive use in a commercial computor. It is essential that the relay used be capable of maintaining a constant mark-space ratio indefinitely, without the need for constant maintenance, and of vibrating at frequencies up to the order of 1 000c/s.

The major drawback of mixed systems, however, is the need of suitable power supplies of both types. This may well complicate the design to a greater extent than if the deficiencies of one or the other were tolerated.

Conclusions

The merits of A.C. and D.C. as a signal source in analogue computors have been investigated in detail. It will be apparent that there is no serious argument in favour of either as a whole. The choice depends on two main factors. These are, firstly, the type of problem to be computed and hence the units of equipment necessary for the task, and, secondly, the experience and personal judgement of the designer, which is, after all, the deciding criterion in any complex project.

Acknowledgments

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MICROPOWDER MAGNETS

MORE than 20 years ago the General Electric Co., Ltd., began to produce iron dust components for electrical work. It has now developed a technique for making magnets —equal to any made from the finest cobalt steel—from microscopically fine iron dust made by a special process. The new magnets will be known commercially as Gecalloy magnets, and will be produced by the Salford Electrical Instrument Co., Ltd., a G.E.C. subsidiary.

Powder metallurgy is, of course, not new. Experiment showed, however, that the relatively coarse powder which was suitable for the core of an inductor was the exact opposite of what was required for a permanent magnet. The particles used are only 100 times the diameter of an atom of iron and 1/1 000th the diameter of the finest radio iron powder hitherto manufactured.

To produce the minute particles of pure iron was in itself difficult but in addition there were certain problems of handling to be overcome. Many fine metallic powders when loose are pyrophoric, i.e., they ignite on coming into contact with air; and therefore a method of handling had to be evolved which would remove this danger.

The results of exhaustive tests have proved conclusively that all the requirements of a good magnet have been met by the new process.

Until now the different steels used for magnets have all had one property in common. They are extremely hard and therefore the fabrication methods are limited to casting and grinding. Gecalloy micropowder magnets can be made—after the powder has been produced—in a great variety of shapes by the use of special press tools and power presses.

Another factor of great importance is that, strength for strength, a Gecalloy magnet only weighs approximately half as much as a conventional steel magnet, which will commend the micropowder magnet for use in the aircraft industry and for all mobile equipment.

This material should also prove of use for such applications as loudspeaker fields and television focusing magnets while the lack of eddy currents will commend its use in inductive devices. It is also worthy of note that this process will allow the production of magnets made only from pure iron obtainable in Britain.

Printed Circuits and Miniaturization

By P. Eisler*, Dr. Ing.

This article assumes that at present printed circuits for use in electronic equipment are largely for the purpose of wiring and shielding. The printing of actual components is not dealt with. The bearing of foldable, three-dimensional circuits on the miniaturization of electronic equipment is emphasized, and the main design features are pointed out. As long as most components are not printed integrally with the wiring these features will retain at least some of their validity.

PRINTED circuits are being used to an ever-increasing extent in electronic equipment of many kinds. Usually they have the shape of small wafers and are made of plastic, glass or some ceramic material "decorated", by means of a printing or stamping process, with a metallic pattern of silver or copper lines. Often such wafers form the coverplates of cast resin blocks inside which groups of small components are clustered. The terminals of the components, whether single or potted into sub-units, project through perforations in the wafers and can be solder-joined to the metallic lines of the wafers, for example, by means of a dip soldering bath. Other mechanization—or automatic assembly—procedures, are also possible with such wafers. In the interstices between the metallic lines some types of resistors can be deposited. Flat capacitors or tape resistors can be soldered on to the wafers, and spirals of a few turns may be provided as printed inductors.

The above briefly characterizes the well-known common type of printed circuit, irrespective of the particular "printing" method used. It has won the support of some of the U.S. and U.K. governmental agencies looking after service requirements, and has begun to be appreciated—though not yet on a large scale—by private industry. The defence interest in these methods of construction of electronic equipment is centred around two features, which also have an important bearing on civilian production. These are:—

(a) the miniaturization of equipment made possible by these production techniques.

(b) the saving of labour, tooling and change-over time in mass production and servicing of electronic equipment under war-time conditions.

Even if some of the possibilities listed below can be realized only when the printed circuit technique is much more developed than now, the interest taken by defence ministries in this technique is readily understood, so self-evident is the importance of saving weight, space and material in airborne and portable military equipment, not to mention the desirability of avoiding or reducing to a minimum the mobilization for electronic production purposes of large masses of workpeople in times of emergency. Consider, too, the advantages of freeing production from tooling operations and tooling delays, since the change-over from an old design to a new one can be effected by simply making a new drawing and printing plate. Also to be borne in mind is the way in which maintenance can be greatly facilitated, and even in part dispensed with.

Two main features of printed circuits, namely, miniaturization and labour-saving, become conflicting however, when the miniaturization is taken to a stage where the components are packed so closely (with due regard to the intrinsic electrical, thermal or mechanical limitations) that they become difficult to assemble, to test, or to exchange, in short, when the unit becomes a "watchmaker's job." As far as the bulk of electronic equipment is concerned, this "watchmaker's" stage is reached long before we come near to the limit of the miniaturization of components or of the definition of printing, (i.e., the degree of distinctness in the outline of the printed pattern).

The chances afforded by the art of printing and by all the other techniques capable of making for a much greater degree of miniaturization (of components particularly) must remain unexploited, as with the wafer form of construction the result would be assemblies so fiddling, so over-crowded and inaccessible, so unrepairable, etc., that costs would soar to exorbitant heights. Smallness alone is not objectionable from a labour cost standpoint, but over-crowding and the comparative inaccessibility of numerous joints of small components are.

It is usually found that in spite of the above mentioned limitation set by the requirements of accessibility, the reduction in size and cost which can be effected within these limits is by no means negligible, as when, for example, a wireless receiver previously made according to orthodox methods is being redesigned for mass production by the wafer type of printed circuits.

Nevertheless the field in which miniaturization by the wafer type of printed circuit can be applied is restricted because both production and maintenance of any piece of electronic equipment of which it forms a basic part demand a comparatively large amount of space for the purpose of accessibility. The demand for further miniaturization is insatiable, and it appears certain that any marked progress in miniaturization, apart from the ever-increasing extension of the printing technique to the components themselves as integral parts of the printed circuit, calls for a fundamentally different approach—a return in fact to first principles.

The "Three-Dimensional" Printed Circuit

Such an approach is exemplified by the idea of the three-dimensional printed circuit, or "folded" circuit, as it is sometimes called. This circuit consists of a piece of thin sheet or tape which, in the finished equipment has a three-dimensional configuration so that the printed conductors spread over the space in all three directions. They can therefore assume the functions of wires, thus obviating the necessity of going to the length of designing equipment with all conductors in one plane. They can form practically any three-dimensional network or pattern, and can conform to the shape and position of most component terminals. They also permit a direct connexion with component terminals owing to their flexibility and relatively large contact surface.

Instead of a three-dimensional pattern of lines which we have in the case of wire conductors, we have a three-dimensional arrangement of surface patterns. Our elements are *surfaces* in space, not linear conductors.

In the following only one major feature of the idea of three-dimensional printed circuits is described, namely, the scope it affords regarding the miniaturization of a piece of electronic equipment as a whole as distinct from the miniaturization of its actual components.

* *Technograph Printed Circuits Ltd.*

Printed components are not considered here specially—neither as independent entities nor as integral parts of the printed circuit. The main function of the latter is taken for the purpose of this article as providing electrical connexions between the terminals of the components joined to it, and as providing shielding (and special wiring facilities).

Packing into the Minimum Space

There are obviously several factors which set limits to the theoretically minimum space which any piece of electronic equipment needs, for example, the number and size of the electrically active components, their shape and the electrical, magnetic and thermal characteristics which determine their minimum theoretical distance from each other, the grouping of the components according to functional or maintenance requirements, etc.

If it were possible to achieve a packing factor of unity, that is, to arrange all active components in a space where one component would be so close to its neighbour (subject to the limitations set by the above-mentioned physical characteristics) as to leave no space between, and furthermore, if it were possible to eliminate all electrically non-active parts, for example, all parts or components having only a mechanical and structural function, then with the given components the ultimate degree of miniaturization conceivable would be reached.

Obviously, such packing and virtually complete elimination of other than electrically active components are for all practical purposes unattainable, but adoption of the three-dimensional printed circuit does permit some approximation to this goal.

Taking the printed circuit itself, it consists usually of a very thin, flexible sheet of insulating material such as paper or (plastic) film carrying on one or both surfaces a flexible metallic pattern. It is usually made by the foil technique[1], as foil conductors are superior to others besides excelling them in flexibility, but any technique capable of producing highly flexible suitable circuits could in principle at least be used. Thus, vacuum and electro-deposited metallic circuits on thin films are quite feasible where this type of conductor is not open to objection for other reasons. But techniques which form the conductor from a metallic powder with or without a liquid medium and consolidate the powder by heat or pressure or both, are counter-indicated mainly because of the brittle nature of the conductor thus produced.

Working in the Flat

The flexible sheet constituting the metallic pattern with its insulating support which has a three-dimensional shape in the complete equipment is produced in the flat, and as a flat sheet it is first given creases where it is to be subsequently bent. As a flat sheet it is also stretched, thickened, plated, punched, slit, cut, insulated by coverings and prepared for solder or other joints. While it is still a flat sheet, single components or groups of components, assembled or produced as a sub-unit elsewhere, are affixed to it either by hand or by automatic means. Only after all this is done in the flat is the circuit distorted into the third dimension. It is " folded " into the configuration the designer has foreseen and for which he has developed the flat pattern. If the sheet is folded at an angle of 180° the folding is said to be superimposed. The folding itself may be referred to as a fold or bend, and even as a winding if the angle of folding exceeds 180°. Depending on the radius of curvature the folding can be either smooth or sharp. There are some well-known regular folding configurations such as the concertina type folding and various folded box constructions which are fairly easily produced by automatic machines. Obviously the designer should be aware of these facilities. However, practically any spatial configuration of the originally flat circuit is possible, and the designer has therefore complete freedom to bring the components into any arrangement relative to each other and to situate them anywhere within the space available. The circuit can conform to any position; it becomes " three-dimensional."

In order to make the best use of this feature for the achievement of the maximum degree of miniaturization in the production of any piece of electronic equipment, the first problem facing the designer is how to arrange the components of the unit into as closely packed a grouping as is compatible with functional requirements, and also with such overall considerations of design as fitting to other units. Within these limits, but without any thought for the moment as to accessibility, mechanical structure, etc., he has to cram the components into the minimum amount of space.—(At this point some such picture as that of sardines packed in a tin ought to be at the back of his mind!)

Having settled on a desirable spatial arrangement of the components, the three-dimensional configuration of a thin sheet containing the electrical connexion of the components is devised, and this conception is then transferred to the drawing board where it appears flattened out (developed) into one (enlarged) plane design. Cross-connexions are taken care of by splitting the pattern into two superimposed ones, for example, into two patterns on opposite faces of the sheet. When the components are drawn in or placed on the flat development of the patterned sheet at their respective connexion points, it at once becomes obvious that many components are distanced further apart from each other on the flat development than they were in space on the patterned sheet in its three-dimensional configuration.

Spacing by Folding

This is an essential feature of the " folded " circuit and what has been demonstrated by observation, when developing the three-dimensional circuit into a plane, becomes a consciously planned feature of the design aimed at conveniently separating during their assembly components which will be in very close proximity in the finished equipment. Any two points of the three-dimensional printed circuit sheet between which it is folded (bent around or otherwise distorted) owing to its configuration, become wider apart from each other when the sheet is developed into one plane.

Even where the sheet in the finished equipment has no marked spatial configuration folding of the sheet on to itself is a readily adopted design feature. The three-dimensional nature of the circuit pattern in such cases is only nominal. But the effect of the folding-up of the sheet is very marked, resulting, as it does, in the closest possible packing together of components which were so far apart from each other on the flat sheet prior to folding that they could be assembled, tested, exchanged and worked on in perfect ease both by manual and mechanical means.

It must also be remembered that in order to allow for the development of automatic means of component insertion into a circuit, as well as to guard against damage by heat when soldering for purposes of maintenance, and to save labour, very tight packing of components during assembly should be avoided. The folded circuit enables this precaution to be taken, and yet still permits the components to be grouped into the minimum space.

In some cases the circuit is designed on a moulding or inside a casting. Here again, it is often advantageous to execute it as a flat development, carrying out as far as possible all operations on the circuit while it is in the flat state. Bonding it to the moulding, or packing it in, would be one of the last operations. Thus, work in a restricted space with poor accessibility may be avoided and a smaller moulding or casting may often be feasible.

From the above the principle underlying the claim of the foldable circuit technique to make possible a second degree of miniaturization in the production of electronic equipment can readily be seen, but except for "potted" assemblies two important points need clearing up before much use can be made of this principle.

Maintenance of Miniaturized Equipment

The first point concerns maintenance. There is a school of thought which tends to deny the importance of maintenance considerations for mass-produced equipment. It favours the building-up of equipment from a few "potted" throw-away units, and quite a number of arguments based on economics or military logistics are advanced in support of this view. Undoubtedly, this viewpoint is amply justified in certain instances, but in general it cannot be accepted by either the industry or the user of the equipment for reasons not open to question by the designer. The problem of maintenance (and mechanical support) must therefore in most cases be faced, and the easy way-out offered by potting cannot be resorted to.

Between accessibility and the ease of maintenance there is a direct relation. This is one of the reasons why miniaturization creates special maintenance difficulties.

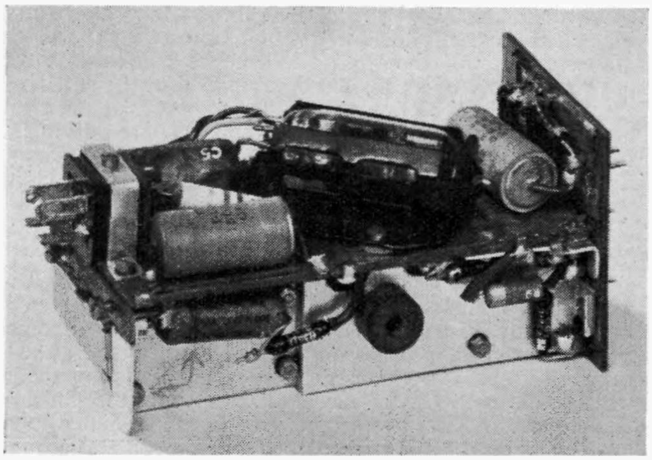


Fig. 1. An experimental amplifier

The three-dimensional circuit is not subject to the limit on the extent of miniaturization normally imposed by accessibility. At first glance, therefore, maintenance of such a circuit would seem to be impossible, and not merely just difficult as in the case of the wafer type of circuit. However, this conclusion is unwarranted. For the folded circuit can be unfolded again—and herein lies one of its biggest advantages. A sheet in a three-dimensional configuration developed out of a flat sheet can be brought back into the flat again for the purpose of exchanging components, effecting repairs, or making tests of all kinds. Of course, the circuit will in the first place have had to be designed with this in mind. For re-conversion of the three-dimensional configuration into a flat pattern practically the whole circuit must be complete in the flat, with none, or at most, only a few of the joints having to be undone when unfolding the circuit from the spatial shape into the flat. Nor must any major mechanical dismantling be involved in unfolding. It is obviously not possible to test all performance characteristics while the circuit is stretched out in the flat, but as folding and unfolding can be repeated in quick succession, a facility and ease of maintenance is created which is often not obtainable even with ordinary non-miniaturized equipment. In respect of accessibility, maintenance is thus made just as easy as production.

Mechanical Structure

The second point calling for special attention is the provision of a sound mechanical structure for the equipment. It is quite clear that a thin flexible sheet like the one used for a three-dimensional printed circuit cannot reliably support any but the smallest components. While a wafer type circuit made of a comparatively strong material like bakelite laminate or a ceramic can be used as a small chassis and support a fairly wide variety of components, no mechanical load or stress can be put on the foldable circuit. A separate mechanical structure has to be provided, which far from using the circuit as a support must actually support the circuit as well as the component. In some cases a chassis or a moulding provides this structure, the circuit being affixed to it in such a way that both the circuit and the components joined to the circuit are properly supported (see Figs. 1 and 2). This, however, is not a preferred method of design. Ideally only electrically active and indispensable components should be present in a piece of miniaturized equipment. A mechanical structure, such as a chassis or a moulding, does not belong to this category and should consequently be eliminated from the equipment wherever possible. Obviously many benefits would accrue to both producer and user from a realization of this aim.

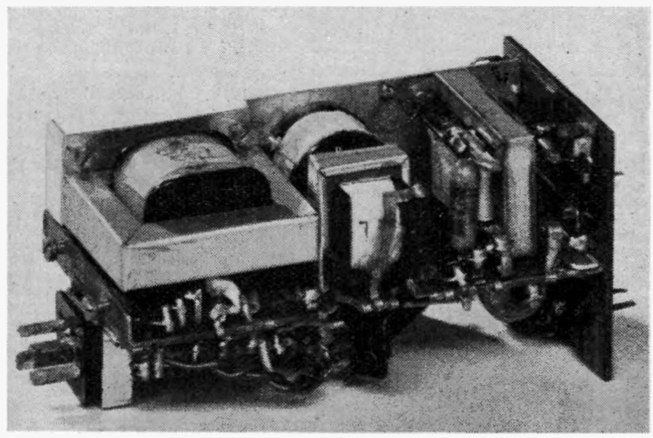


Fig. 2. Another view of Fig. 1

The function of the mechanical structure is to support. Shielding is already provided by the circuit and by the way in which components or sub-assemblies have been constructed. What, then, can provide the required support if a separate structural device is not desired? We have already found that the circuit sheet cannot do so. There remain only the components themselves. Clearly only the larger components can be expected to provide such support. Here, in fact, is the solution to the problem.

There are larger components (coil or tuning assemblies in metal containers, valves, transformers, instruments, controls, etc.) in most types of electronic equipment, and even where all the components are very tiny larger mechanical units of several smaller components can be easily created by packaging some as sub-assemblies. This packaging, too, can be done with the aid of a smaller printed circuit of either the foldable or wafer type. It can also be done by potting (casting) or cementing the small components into a unit, or by shrinking a plastic or elastomeric bag or tube over the group of components in question.

One of the most promising but as yet untried techniques in this direction appears to be the use of a foldable printed circuit made as (or for use with) self-adhesive tape to which the small components are joined while the tape is stretched out in the flat. The tape is then folded (wound) in such a way that its adhesive layers become superimposed and thus stuck together in an easily handled unit with the small components enclosed and reasonably sealed up between layers of adhesive tape, but with all required connexions leading from the tape.

Interlocking Components

The problem of the main assembly of the type of electronic equipment under consideration can therefore be taken as the problem of assembling the larger components and the sub-assembled units of small components into a mechanically self-supporting stable structure. The complication of the tiny components is overcome by grouping and fixing them into a larger unit. To bind them together it is not too difficult to provide these larger components or units with interlocking features (plugs, sockets, tongues, grooves, keys, slots, springs, hooks, pins, bolts, holes, etc.) which are so arranged that they interlock when the components are brought together by folding-up of the flat sheet into a three-dimensional configuration. The larger parts thus lock themselves together into a structure of any desired rigidity depending on the location and type of the interlocking device used. They thus form themselves into a self-supporting combination and at the same time also support the printed circuit to which they are joined at their terminals.

Here we have another principal difference between the wafer type and the flexible, foldable printed circuit. Whereas the former usually acts as a support or chassis for components, the latter is usually supported by the components themselves. It is readily seen that the substitution for a separate mechanical structural device of interlocking of the components achieved by the act of folding, parallels the great advantage in ease of maintenance that the possibility of readily unfolding the circuit into the flat affords. The components become unlocked when the circuit is unfolded, and in this way the mechanical structure is temporarily dissolved.

The role of potting or casting in such construction work is limited to the embedding of groups of small components together with interlocking devices, thus transforming these groups into larger interlocking units. Usually such a unit is not designed to permit exchange of its small components, but in some cases such provision can be made, for example, by using a two- (or more) section cast featuring a parting line along which the components are placed, and preferably making at least one part of the cast compounds from a flexible rubber-like material.

Although the basic patents and original development work on the three-dimensional printed circuit technique described above date back some ten years, comparatively very few practical examples have so far been published for a variety of reasons. It is hoped that it will not be equally long before general recognition is awarded to the claim of this technique to effect a second degree of miniaturization of electronic equipment, and at the same time satisfy any desirable level and requirement of maintenance, unit construction, and exchangeability of components.

The figures illustrate some of the aspects described in the article. Figs. 1 and 2 show an experimental 30db amplifier of the Post Office, one of the earliest uses of a three-dimensional flexible circuit in connexion with a chassis. This circuit is not designed to be unfoldable again. A full description of the equipment for which the printed circuit was designed has been published[2].

Figs. 3 to 6 illustrate various aspects of a design of a miniaturized 5-valve superhet "personal" wireless receiver. The size of the set is roughly that of a cigar case. and while this particular design would now be considered too complicated, it nevertheless includes most of the features of the interlocking concertina circuit described above which can be folded and unfolded. Fig. 3 shows the circuit sheets stretched out in the flat. Fig. 4 and 5 are cross-sections of the equipment showing the three-dimensional configurations (folded concertina) of the circuit sheets, and Fig. 6 gives a view of the "large" interlocking mechanical parts, forming in this case a semi-rigid interlocking structure by means of just two pairs of tongues and grooves and one bow. A full description of the equipment has been published[3], while some of the principles outlined in the article are the subject of a British Patent[4].

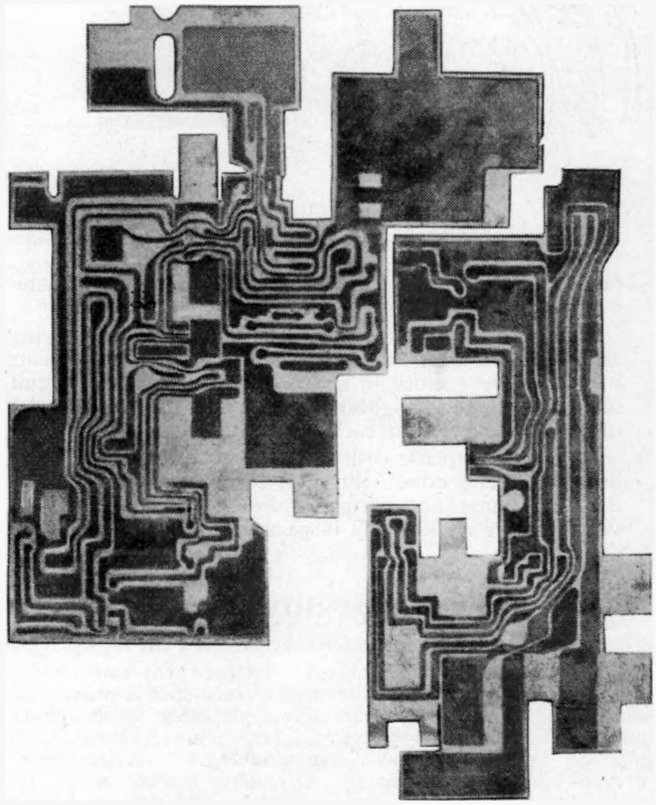
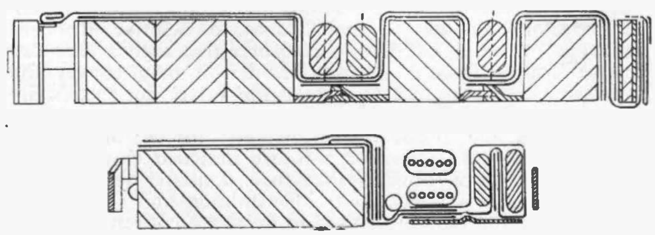


Fig. 3. The circuit sheets in the flat



Figs. 4 and 5. Cross-sections of the equipment showing the three-dimensional configurations

Summary

Leaving aside for the purpose of this article the development of components produced as integral parts of a printed circuit, and taking the latter as providing merely interconnexions and shielding of components, the wafer type of printed circuit makes possible miniaturization only to a degree compatible with the accessibility of components.

The three-dimensional foldable circuit permits miniaturization to be taken a stage further by virtue of the following:

1. It is a thin flexible sheet occupying only a very small space owing to its thinness.

2. It can be folded (deformed) from the flat into practically any three-dimensional configuration, and thus permits of the packing of components into any space, like sardines in a tin, irrespective of accessibility.

3. It can be unfolded from its spatial shape, becoming a flat circuit again, thus permitting access to all its com-

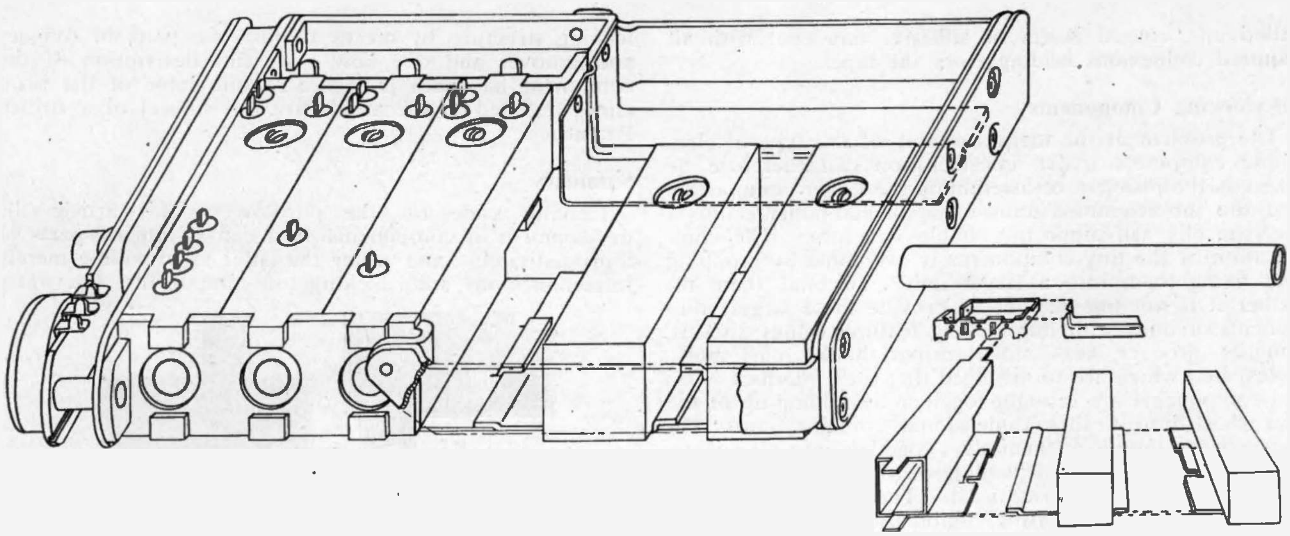


Fig. 6. The interlocking coil can assembly

ponents while in the flat state, both for assembly and maintenance purposes.

4. It enables the convenient distancing during assembly and maintenance of neighbouring components which are very close in space, as unfolding the circuit into the flat gets neighbouring points on opposite sides of a fold apart from each other.

5. It can dispense with many intermediary metal parts between circuit conductors and component-terminals as it can assume any shape and can contact terminals directly over a relatively large area.

6. It (often) enables all or much of the mechanical structure to be dispensed with altogether by combining the folding scheme with means for interlocking of the larger components and of the units of smaller components, so that they themselves form a structure which supports both itself and the circuit.

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1. Brit. Pat. 639178/43.
2. Duerdoth, W. T., Garlick, J. A Miniature Audio Frequency Amplifier. *P. O. Elect. Engrs. J.* 41, 228 (1949).
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4. Brit. Pat. 639111/43.

Special Quality Valves

An Announcement by the B.V.A.

It has been a matter of general knowledge that valve manufacturers have supplied for many years special valves for such uses as Post Office repeaters. In addition they have undertaken in the post-war years a large scale development to produce valves which will give trouble-free service under onerous conditions such as are encountered in communications and radar equipment in aircraft, warships, and armoured fighting vehicles where the apparatus is subjected to severe vibration and shock.

It has become the custom among those concerned with the development and use of such valves to describe them as "reliable" valves. The B.V.A. considers that such a term can be misleading in its implication in that it may convey the impression in some quarters that all the valves not specifically so designated are unreliable.

The valves sold by the B.V.A. members for use in ordinary domestic radio and television sets are designed expressly for this purpose. It is obvious that such domestic sets are not subject to the severe conditions of vibration and shock mentioned above and the valves used in them are entirely adequate on the score of mechanical strength and useful life. This is borne out by the satisfactory low level of field returns experienced over many years. It should also be noted that they are produced at a satisfactory economic price for the market concerned.

Thus the valves which have been developed for the onerous conditions mentioned in the earlier paragraph are in fact special quality valves designed for a variety of special applications, and as they are coming into more general use the B.V.A. intends to describe these valves in future as "Special Quality" valves.

The reason for the use of this term can best be appreciated from a knowledge of the technical definition of such valves which is as follows:—

A "Special Quality" valve is a valve which has certain design and manufacturing features making it suitable for use under conditions different from or in excess of those experienced in normal radio or television receivers and when operated under stated or agreed electrical or mechanical conditions it has an acceptable statistically determined expectation of life. The various electrical and mechanical operating conditions result in several classes of "Special Quality" valves among which are the following:

Class 1: Valves to give particularly long lives under conditions where they are not subjected to appreciable mechanical shock—Examples: repeaters and computors.

" 2: Valves to give normal lengths of life under moderate conditions of vibration and shock—Examples: equipment for the Armed Forces, civil aircraft, mobile communications and some industrial uses.

" 3: Valves to withstand particularly severe conditions of vibration and shock where comparatively short lives can be tolerated—Examples: projectiles and guided weapons.

" 4: Valves to give high electrical stability and normal lives under conditions where they are not subjected to appreciable vibration and shock—Example: D.C. amplifiers.

Note: These classes must not be regarded as mutually exclusive and combinations of the attributes inherent in each class may be incorporated in a particular type.

It must be realized that "Special Quality" valves require special design, special manufacture, special quality control and stringent testing at all stages. The necessarily greater cost is justified because the failure of such valves in the equipments concerned can involve the failure in service at a critical moment of a large fighting unit and loss of life.

While these "Special Quality" valves are intended mainly for Government service there is little doubt that in later years the ordinary domestic valve, good as it now is for its purpose, will be improved still further. The relations between the "Special Quality" valve and the normal commercial valve is similar to that between the special high priced racing automobile and the normal domestic motor car. The analogy is almost perfect since it is well known that the reliability and efficiency of the standard British motor car progresses year by year in proportion to the efforts made by designers and manufacturers to produce better and better racing cars.

Blocking Oscillators

By K. G. Beauchamp*, A.M.Brit.I.R.E.

The operation of electronic equipment, especially where associated with cathode-ray tubes, often necessitates the generation of non-sinusoidal waveforms of a pulse or sawtooth nature.

Many circuits exist for this purpose and perhaps the most used, and certainly the most economical in valves and components, is that of the hard valve blocking oscillator.

This can be considered as a limiting case of the squegging oscillator and is characterized by a short period of oscillation followed by a relatively long quiescent period.

Several forms of the circuit exist, and are extensively used in three different ways: (1) as a generator of voltage or current pulses, (2) as a generator of repetitive sawtooth current waveforms, (3) as a generator of repetitive sawtooth potential waveforms.

As the literature appertaining to the subject is so widely dispersed and in some of its aspects, non-existent, it is the purpose of this article to examine these three cases in some detail and outline their mode of operation and factors that influence their practical design.

IN radar equipment, blocking oscillators find many applications, as frequency dividers, and as low impedance pulse generators for triggering and switching purposes.

Very large current pulses can be obtained from a low-mu triode of the 6SN7 type if the positive grid excursion is used, as can be seen from the curves shown in Fig. 1. Where the ratio of pulse length to repetition period is kept small in order that the dissipation rating of the valve is not exceeded, pulses of the order of 1 ampere are easily obtainable. Voltage pulses may be obtained either from the anode or cathode circuit, or alternatively a separate transformer winding may be used.

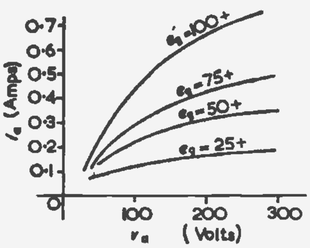

Fig. 1. Anode current/voltage curves for 6SN7

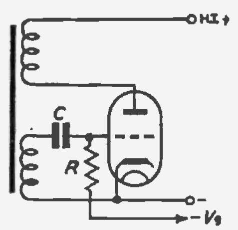

Fig. 2. Simple blocking oscillator

Two modes of operation are possible with the simple blocking oscillator shown in Fig. 2. In order to describe these, we may suppose the cycle to commence with a large negative charge at the grid sufficient to reduce the anode current to zero. The grid potential will begin to rise exponentially as the charge leaks away through R, towards the potential to which the grid is returned.

If this potential is greater than that at which the mutual conductance (g_m) of the valve would increase to such a value that the gain around the feedback loop exceeds unity, then regeneration will commence. The anode current (i_a) increases, with consequent drop in anode potential (v_a), the reflected increase in grid potential causing a further increase in i_a and so on, the process being rapidly cumulative, until at length grid current flows. As peak cathode current is reached i_a begins to fall, the grid acquiring a large negative charge. A second quiescent period ensues and the cycle repeats once more. This mode is known as the "astable blocking oscillator".

It will be seen from the above that two time-constants are involved, the larger one due to the grid recovery circuit RC, and the shorter one controlled by the feedback circuit.

Should the grid leak return potential be smaller than that necessary for regeneration, a monostable condition results, wherein an external control potential must be applied in order to produce the requisite current pulse. For this reason the mode is known as a "triggered blocking oscillator".

This is sometimes used in association with a delay line to produce a self-triggered arrangement. Here the generated pulse is passed through the delay line, the delayed output pulse being used to trigger the oscillator once more. In this way the properties of the artificial line, which can be strictly controlled, may be used to regulate the pulse repetition frequency.

The design of the coupling transformer involves maintaining the H.F. and L.F. response such that the desired pulse shape is obtained. Low leakage inductance (i.e., good coupling factor between windings), small stray capacitance, and core losses are necessary to ensure a good H.F. response, while high permeability of the core material is desirable to improve response at the L.F. end.

Low frequency response of the transformer controls the pulse duration, providing that C is large enough to have negligible impedance within the pass-band. With a small C the transformer windings have less effect and pulse width is reduced with reduction of C. However, the resonant period of the transformer and associated stray capacitance must be short compared with the pulse duration, thus setting a limit to the minimum pulse width obtainable by this method.

In practice, circuits and transformers have been designed to give pulse widths of from 0·1 to 25μsec.

Sawtooth Current Generation

A form of astable pulse generator such as is described above, has been used by several workers to control the charge and discharge of an inductive circuit, resulting in the formation of repetitive sawtooth current waveforms.

The earliest analysis of this type of circuit was given by Vecchaicci[1], who showed that an over-coupled triode oscillator having the ratio of inductance to capacitance, L/C, greater than the square of the triode internal impedance, R_o^2, is capable of generating continuous oscillations of sawtooth current waveform.

Due to the finite and varying R_o, coupled with the resistance of the transformer windings, the current increases

* General Electric Co., Ltd, Coventry.

exponentially rather than linearly with time during the scanning period.

As the sawtooth currents generated are usually employed to scan an electro-magnetically deflected cathode-ray tube for television and other purposes, a high degree of linearity is essential, and many attempts have been made and methods evolved to linearize this current.

One method is to include a gapped iron-cored choke in the circuit[2] where the inductance varies with the current flowing through it due to a partial saturation of the magnetic core.

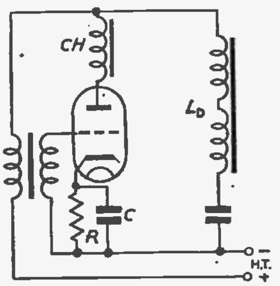

Fig. 3. Scanning generator using gapped choke

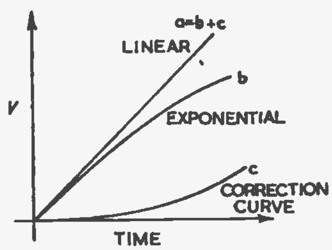

Fig. 4. Correction curve

A relationship for this has been given by Wilson[3] as:

$$L = L_0(1 - Ri/2E) \quad \ldots\ldots\ldots\ldots (1)$$

where: L_0 = total inductance of the circuit (including that of the choke and scanning coils with no direct current applied through windings).

R = total circuit resistance.

E = applied H.T. potential.

i = instantaneous value of current.

This principle has been elaborated by Taylor[4] who has produced several circuits using a gapped choke and using high impedance scanning coils in both triode and pentode circuits.

A typical circuit of this type is shown in Fig. 3, where it will be seen that the current through the deflector coils, L_D and also the voltage fed back from anode to grid is modified by the inclusion of choke CH.

As the current through this choke increases, its inductance is decreased, permitting an additional increase of current to take place. This additional increment of current, above the normal rise due to the charging action of the

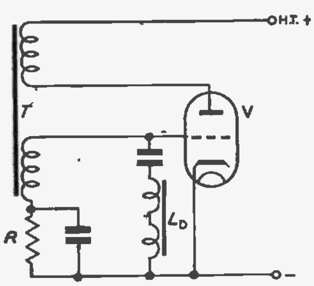

Fig. 5. Scanning coils connected in low impedance grid circuit

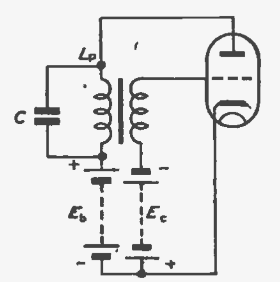

Fig. 6. Simplified circuit of Fig. 5

inductive circuit, approximates to the correction curve shown in Fig. 4, and linearizes the current waveform generated.

As with the pulse generators previously described, the repetition rate is controlled, in the absence of synchronization by the time-constant RC in the grid return circuit.

Synchronization can be effected by applying a positive pulse to the grid directly or through a separate winding on the transformer.

For television purposes, however, low impedance line scanning coils are desirable. The reason for this is that the rate of change of scanning current di/dt is large and of the order 6 to 10 × 10^4A/sec, therefore the voltage pulse across these coils, $v = L\,di/dt$ must be kept within the limits imposed by the nature of the coil insulation. Because of the peak voltage incurred and the large scanning currents required in the coils, certain modifications become necessary to the circuits previously described.

A form of blocking oscillator has been described by Malling[5] in which the coils are included in the low impedance grid circuit, the linearity during the scan period being adjusted by suitable variation of grid-cathode impedance. A high slope, large anode dissipation valve is used, with the anode connexion brought out separately and insulated for several thousand volts.

This circuit is shown in Fig. 5, and in order to understand fully, its mode of operation, which differs from the pulse generators already described, a simplified circuit is given in Fig. 6.

The valve V has a low impedance during the scan period and the reflected impedance of the scanning coils has a high ratio of inductance to resistance, L/R, so that the anode current rises exponentially. Regenerative feedback takes place, due to coupling between anode and grid by T, and soon grid current commences to flow.

Both anode and grid currents increase until cathode saturation results; further increase of grid current can then occur only at the expense of anode current and the latter falls. The effect is cumulative and the valve is rapidly cut-off by a large negative charge accumulating on the grid, g_1.

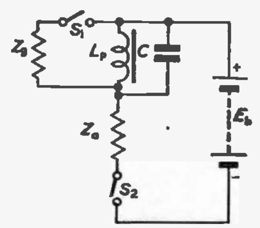

Fig. 7. Equivalent circuit of Fig. 6

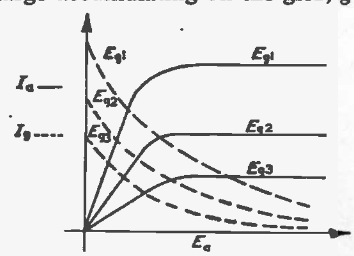

Fig. 8. Anode current/voltage curves

The inductive circuit, together with its associated stray capacitance, forms an oscillatory circuit and resonates under the stimulus of the application of a sudden change in potential across it. After half a cycle of oscillation, the charge on g_1 is dissipated and V commences to conduct once more, the cycle then repeats.

The difference between this mode of operation and that of an astable pulse generator is thus seen to be that with the former a long conducting period for V is permitted, followed by a short quiescent period during which the valve cathode current is cut-off by a large negative grid bias. With the pulse generator, however, the reverse is true; a short conducting period followed by a larger quiescent period.

The circuit of Fig. 6 is thus characterized by two unstable states which alternate with each other to form a continuous sawtooth current waveform; viz:

(1) A rigorous single sine wave oscillation of frequency $\omega^2 = 1/L_pC$ followed by a period of heavy grid current in which:

(2) Exponential rise of current takes place.

The sine wave oscillations are determined entirely by the L_pP product, while the rise of current is governed by the length of the damped grid current period, which in turn is controlled by transformer design and partly by applied negative grid bias.

It will be seen, therefore, that the circuit may simply be represented by the equivalent circuit of Fig. 7, where the valve acts as a switch S_1, S_2, both poles of which are closed during the scanning period and open for the retrace period. The two impedances Z_a and Z_g representing anode and grid impedance of the valve.

From the i_a/e_a and i_g/e_a curves for a typical valve (Fig. 8) it is seen that while Z_a remains substantially constant, Z_g changes considerably over the working range.

Hence the grid current i_g does not exactly follow the exponential charge of anode current and as the scanning coils are included in the grid circuit, this effect modifies to a certain extent the waveform of current through the coils.

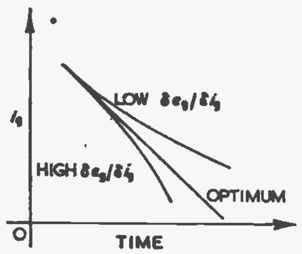

Fig. 9. Grid current/time

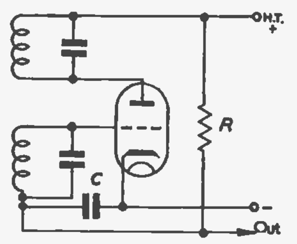

Fig. 10. Simple hard valve time-base

This is made clear in Fig. 9 where $Z_g = \delta e_g/\delta i_g$ is shown to cause a variation in grid current over the valve conducting period, in a manner determined by its varying rate of change.

The adjustment of Z_g is carried out, empirically by variation in the amount of energy fed back from the anode to grid circuit by alteration to the transformer turns ratio and applied negative bias. This will also be found to effect the frequency generated, and in practice, owing to the absence of a complete mathematical treatment for this time-base, the correct ratio and bias can be determined only by experiment.

The way in which the repetition frequency is controlled by the applied negative bias and hence R may be derived if we consider the scanning period as the D.C. charging period of L_D, i.e., S_1, S_2 closed in Fig. 7. Then as the current increases, a negative bias is developed across R of Fig. 5, this limits the amount of g_1 voltage excursion into the positive grid region and hence charging time. As the retrace time is fixed by L_DC, then the sawtooth current repetition frequency is controlled by variation of R.

Synchronization may be obtained by the application of a negative pulse to the grid a little before cathode saturation occurs, this will initiate the retrace by decrease of anode current.

Because of the long conduction period for the valve used in this arrangement, it must be of a generous power dissipation rating and capable of passing a large cathode current during a major part of the sawtooth cycle.

A heavy grid current pulse flows in the valve towards the end of the scanning period, a mean value of 40mA being quite common, hence care must be taken that grid emission does not take place.

During the retrace period the rapid changes in anode and grid current induce a potential in the grid winding of 1 to 2kV. Adequate insulation in the valve base and holder is thus necessary.

Despite the operational difficulties mentioned above, however, several manufacturers have in the past successfully incorporated this arrangement in commercial television receivers.

Sawtooth Voltage Generators

A fundamental defect of the type of line scanning circuits dealt with in the preceding section is that the valve is conducting over some 90 per cent of the scanning cycle. This leads to a very poor efficiency and for this reason is now seldom used in commercial television equipment.

An alternative arrangement is to use the "resonant return" system, first proposed by Blumlein[6] and later developed by Schade[7], wherein part of the energy stored in the deflector coils during the retrace period is returned to the circuit as useful power. A full description of these circuits is given elsewhere[7,8,9,10], but the particular aspect of their mechanism which deserves inclusion in this section is that a sawtooth waveform voltage generator is, in general, used to control these circuits. This is so often a blocking oscillator of the pulse kind considered earlier that it is proposed to devote some space to their consideration.

A blocking oscillator was first used as a hard valve time-base in 1923 by Appleton, Herd and Watson-Watt[11]. This followed the form of an astable pulse generator charging a capacitor by grid current through the valve and allowing the charge to leak away during the quiescent period (Fig. 10).

The repetition rate of the current pulse generated is such that the capacitor C never completely loses its total charge received during the valve conduction period. By allowing the capacitor to discharge to about 20 per cent of the potential to which the grid leak R is returned the exponential discharge curve approaches a linear rise of voltage with time.

This approximation to a linear rise is not always adequate, however, and several methods have been evolved to linearize the waveform generated.

In the original patent a diode was used in place of the resistor R, enabling a constant charging current to be obtained for C by using the cathode current saturation effect of the diode. Due to its i_ae_a characteristics a pentode may also be used in the same manner to keep the charging current constant and therefore the rise of potential across C linear with time.

Another method of improving the linearity is to use a correction circuit due to Hawkins[12]. This employs an auxiliary charging circuit across part of the charging capacitor C, which in this case consists of two capacitors C_1 and C_2 in series (Fig. 11).

At the commencement of the cycle C_1 and C_2 are charged rapidly in a time of t seconds.

The integrating circuit R_1, C_3 has a larger time-constant of the order $T = 75t$ and thus receives very little charge during the period t seconds. C_1 and C_2 then commence to discharge slowly; C_2 discharging exponentially, while C_1 discharges into the lower impedance path R_1C_3 and charges C_3 until no potential difference exists between points A and B. When this condition is reached C_3 begins to discharge through R_1 and R.

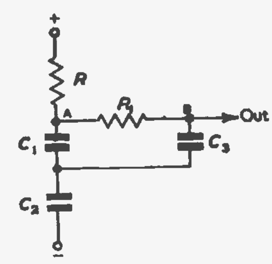

Fig. 11. Method of improving linearity

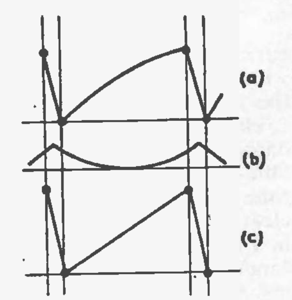

Fig. 12. Waveforms associated with Fig. 11

Thus the potential difference across C_2 is of exponential form (a) while that across C_3 is parabolic in shape (b). The total waveform across C_2 and C_3 is therefore the sum of (a) and (b) and is represented as waveform (c). By making R_1 variable, T can be adjusted until the summated waveform is a linear rise of potential with time (Fig. 12).

Returning to the mechanism by which the capacitor C receives its charge. During this period, when the valve is conducting, the circuit behaves as a Hartley oscillator,

Fig. 13, the frequency of oscillation being controlled by the transformer inductance and stray capacitance in a manner determined by the relationship:

$$f = 1/2\pi \frac{1}{\sqrt{(L_p + L_s + 2M)\, C_s}} \text{ c/s} \quad \ldots\ldots (2)$$

where L_p = primary inductance.
L_s = secondary „
M = mutual „
C_s = stray capacitance.

For correct operation with minimum retrace time it is essential that the first positive half cycle, after the valve is cut off shall not be of sufficient amplitude to bring the valve within its grid base. For this reason a very low Q factor is necessary for the tuned circuit, if the circuit is not to continue to function as a class C sine wave oscillator, the anode potential never being reduced to zero for a sufficient length of time to cause the valve to be cut off.

To avoid this effect use may be made of the eddy

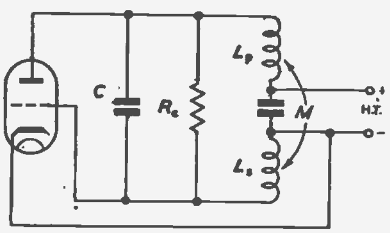

Fig. 13. Effect of transformer losses on Hartley oscillator

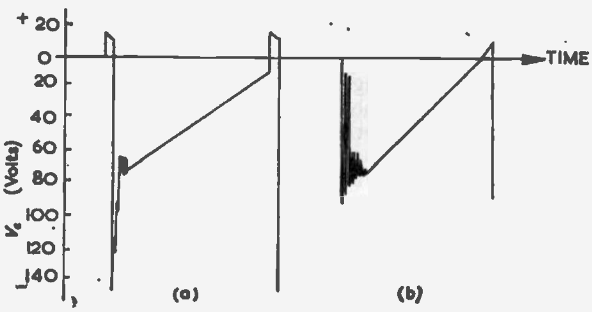

Fig. 14. Blocking oscillator (a) functioning normally and (b) with insufficient transformer damping

current, and hysteresis losses of the transformer core, which may be represented as a parallel resistor R_e across the tuned circuit of Fig. 13.

High losses in the iron core or alternatively external damping across the transformer windings are thus desirable with this form of blocking oscillator if the retrace time is not to be excessively long. This effect may be clearly seen from the two grid potential waveforms shown in Fig. 14. Waveform (a) is that of a blocking oscillator functioning normally, whereas (b) illustrates the effect of insufficient transformer damping, where the commencement of the linear rise of grid potential becomes somewhat delayed.

It will be noticed from (a) that very large negative pulses are possible at the grid, especially if a low repetition rate is desired, requiring larger grid inductances. These pulses are, however, of such small duration as not to affect grid-cathode insulation, and as far as the author is aware no cases of breakdown due to this cause have been experienced.

Turning now to the scanning period. From a consideration of Fig. 15, representing the potential across C with respect to time, an expression may be derived for the repetition rate of the sawtooth cycle in terms of the circuit time-constants and potentials. Commencing with the valve conducting, C is rapidly charged negatively to a potential V volts. With the valve biased beyond cut-off, the capacitor discharges through R towards the H.T. potential V_1. When the potential across C reaches the grid base of the valve V_2, C becomes charged by grid current and the cycle repeats.

The general formulæ for the charge or discharge of a capacitor C through a resistor R from a potential V, in a time t seconds is given as:

$$v = V\,(1 - e^{-t/CR}) \quad \ldots\ldots\ldots\ldots (3)$$

and at time t_1,

$$-V = V_1\,(1 - e^{t_1/CR})$$

$$\therefore \frac{V + V_1}{V_1} = e^{-t_1/CR} \quad \ldots\ldots\ldots\ldots (4)$$

at time t_2,

$$-V_2 = V_1\,(1 - e^{-t_2/CR})$$

$$\therefore \frac{V_1 + V_2}{V_1} = e^{-t_2/CR} \quad \ldots\ldots\ldots\ldots (5)$$

from equations (4) and (5)

$$\frac{V + V_1}{V_1 + V_2} = e^{(t_2 - t_1)/CR}$$

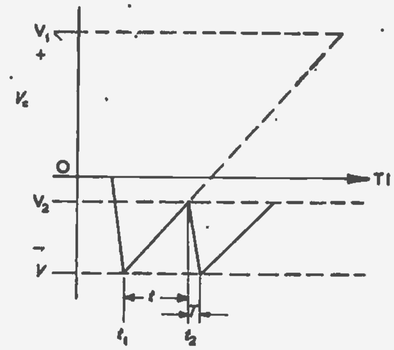

Fig. 15. The potential difference across C

Let $t = t_2 - t_1$ = discharging period for C

then: $t = CR \log_e \left(\dfrac{V + V_1}{V_1 + V_2}\right)$

giving total period of oscillation as:—

$$P = T + t$$

where T = period of charge for C,

thus frequency of sawtooth oscillation:

$$F = 1/P = \frac{1}{T + CR \log_e\left(\dfrac{V + V_1}{V_1 + V_2}\right)} \quad \ldots\ldots (6)$$

The frequency of oscillation can thus be controlled by variation of R, C or V_1. This latter is convenient as a wide range of control can be exercised with a comparatively small value of potentiometer by returning the charging resistor R to a potentiometer across the H.T. supply.

The coupling transformer is by no means critical in design, unlike the radar pulse generator where pulse shape is an important criterion. In order to ensure a rapid charging period for the capacitor a small step-up ratio is usual from anode to grid windings. The total inductance required can be derived from equation (3), given the frequency desired (noting that only a single half-cycle during the charge period is desirable) stray capacitance and mutual inductance between windings. These latter two factors will require estimating from the physical configuration of the completed transformer. High coupling factor is important to prevent oscillations due to the leakage inductance from lengthening the retrace time. In practice, the transformer is wound on a laminated iron core and the coupling factor exceeds $K = 0{\cdot}8$ and is sufficiently large for this effect to be negligible.

One disadvantage of the simple blocking oscillator described above is that an inductance is included in series

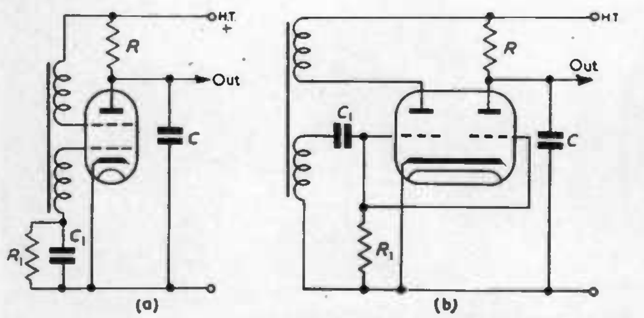

Fig. 16. (a) Electron coupled blocking oscillator; (b) blocking oscillator with separate charging valve

with the charging circuit. This may be avoided by using a pentode, after the manner of the electron-coupled oscillator, where the blocking oscillator circuit is included between cathode, g_1 and g_2, while a separate CR circuit is included in the anode circuit, (Fig. 16(a)).

Alternatively two valves may be used, one to act as the oscillator while the other, having its control grid strapped to the oscillator grid, controls the charge and discharge of the capacitor in its anode circuit, (Fig. 16(b)).

In either case the capacitor is charged slowly from the H.T. supply and discharged rapidly through the valve impedance. It is thus necessary to maintain a low internal impedance only during the conductive period, the retarding effect of the transformer inductance not being included in the circuit.

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Electronic Peak-Reading Kilovoltmeter

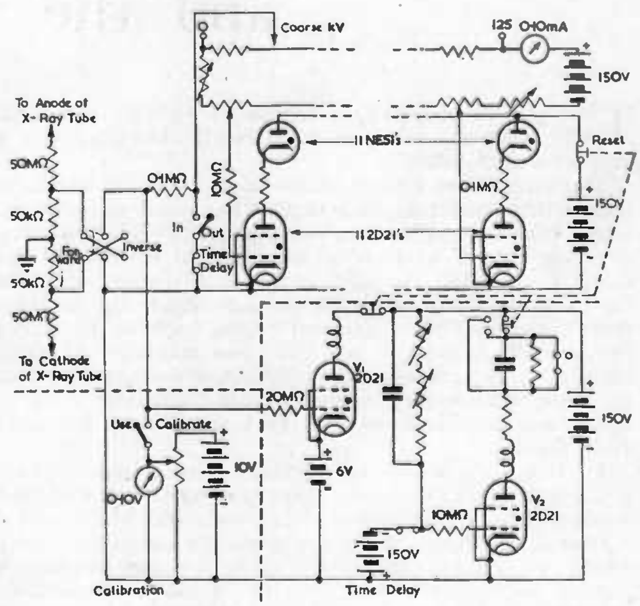
By M. Lorant

An instrument that rapidly and accurately measures the high voltages associated with medical X-ray equipment has recently been developed by the U.S. National Bureau of Standards. The unit is designed to indicate directly peak voltages between 30 and 125kV.

In principle, the kilovoltmeter operates as follows: A type 2D21 thyratron tube is used as the high voltage detector. The critical bias on the tube is about −3V at an anode potential of about 150V. If, for example, the bias voltage is 103V, the thyratron will fire when the voltage drop across two 50kΩ resistors between the bias cell and ground and the cathode and ground reaches 100V. These two resistors form part of a two-section voltage dividing network across the X-ray tube. Because the ratio between the sections of the voltage divider is nearly 1 000:1, the metering circuit will respond when the peak voltage across the X-ray tube reaches 100kV. Hence, any desired voltage may be measured by suitably adjusting the bias voltage.

The actual circuit of the Bureau's kilovoltmeter consists of eleven 2D21 thyratrons, each having an indicating neon light in its anode circuit. The grids of the thyratrons are biased in approximately one volt increments by potentiometers inserted into each grid circuit. Twenty series-connected resistors are connected to a 22-position selector switch so that a voltage adjustable from 30 to 125V in 5V steps may be added to the bias on each tube. These resistors and the grid potentiometers constitute a voltage dividing network across which 150V D.C. is applied. It is thus possible to pre-set the instrument to read the kilovoltage within any desired 10kV range, the reading being the sum of the setting on the coarse kV selector switch and the number indicated by the last activated neon lamp. A reversing switch between the voltage divider and the kV selector switch permits measurements of either the positive or negative peaks.

A calibrating circuit is included for setting the bias voltages of the eleven thyratrons. When the "use-calibrate" switch is closed and the coarse kV selector switch is set at zero, any



The basic circuit

desired voltage from 0 to 10 volts may be applied to the thyratron grids. This voltage is increased slowly and the bias potentiometers set until at each integral voltage the corresponding thyratron fires.

A time delay circuit, incorporating two thyratrons and two relays, is incorporated to prevent recording of the starting surge or of any surge occurring at the end of an exposure, includes two thyratrons and two relays.

EUROPEAN TELEVISION
and the Coronation

THE growth of television services in Europe, compared with what has taken place in North America, is at a very slow rate indeed.

There are in the United States alone some 150 television transmitters operating on a regular basis and many of the larger cities have more than one transmitter. In New York a viewer can, if he feels so disposed, sit in front of his receiver for nearly twenty-four hours of the day and take his choice of the thirteen transmitters which radiate from there. For important national events such as the recent Presidential elections of last year, vast audiences of many millions—there are over 23 million television receivers in use—can be assembled by the coast-to-coast relay network which now extends from New York and Florida across to Hollywood.

To this vast American television system has recently been added the Canadian network which opened last September with transmitters at Toronto and Montreal.

Outside the North American continent the only country which can claim comparable progress is Great Britain. A regular service—the first in the world—was actually operating as far back as 1936 from Alexandra Palace, but it was not until after the war that a scheme was prepared for national coverage which envisaged a chain of five high power and five medium power stations giving coverage to some 90 per cent of the population of the United Kingdom. The last of the high power stations was brought into use in the summer of last year, but work on the remaining five medium power stations has not yet been granted Government sanction.

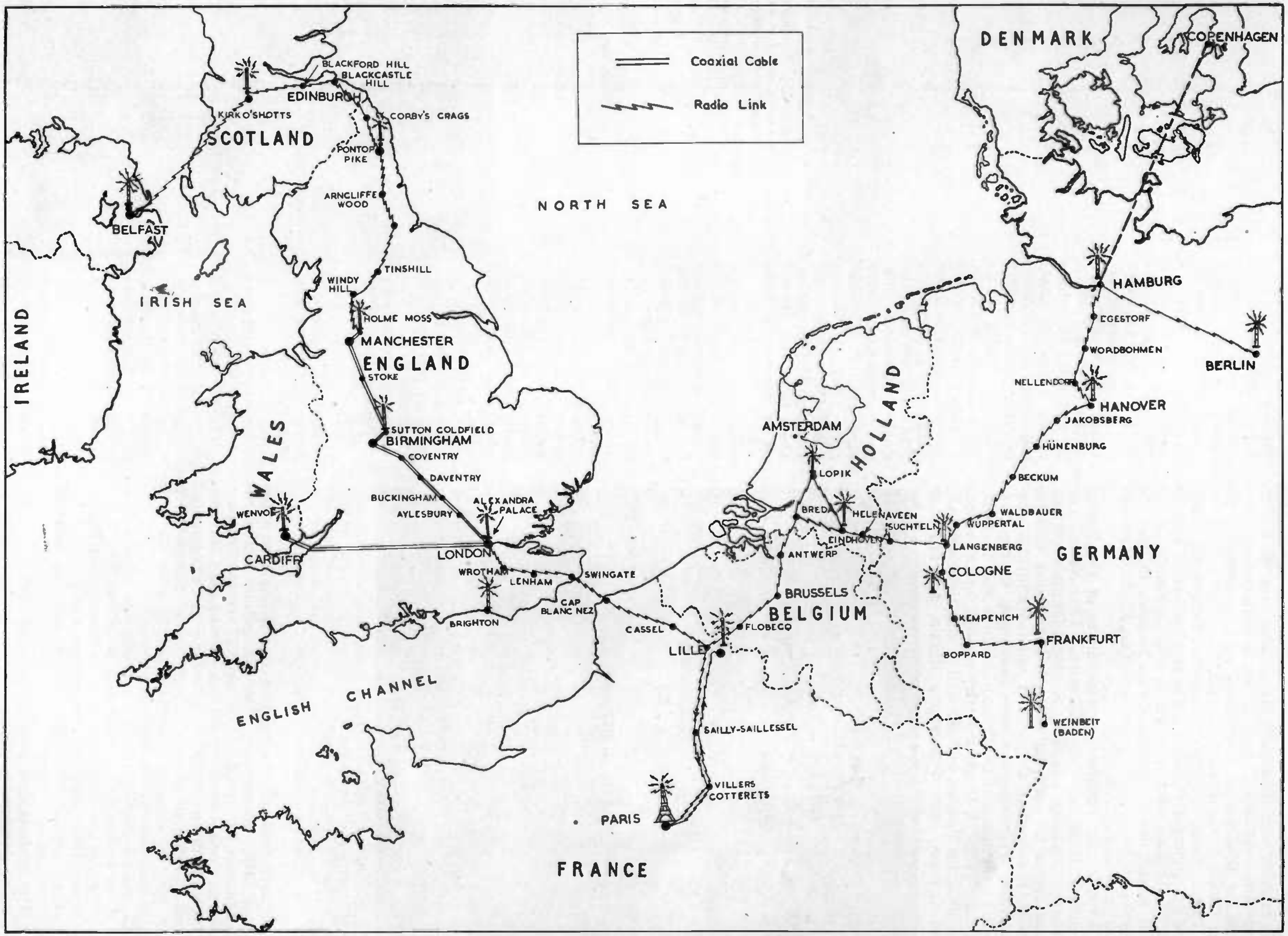
America and Great Britain each have a unified television standard and the limiting factor in the further growth is largely one of finance. In Great Britain matters from the technical point of view are simplified by the fact that there is a single network radiating a single programme for the whole country and consequently the simplest type of receiver is all that is at present required, although matters may be slightly more complicated when sponsored television starts in this country.

But when one turns to Europe, a very different picture presents itself. There are many small but densely populated countries bordering on one another, each with their separate languages and national interests, yet few are able to maintain a regular television service.

There was a pre-war television service operating on a 441 line system from Paris and this was augmented after the war by high definition 819 line transmitters at Paris and at Lille, but elsewhere in Europe television development has been entirely post-war and on a very small scale only.

The exchange of programmes had been put forward as a means of accelerating the growth of television in the various countries of Europe, but considerable technical difficulties lay ahead arising from the different television standards adopted. Indeed, direct exchange and simultaneous broadcast of programmes might have been ruled out entirely—but for the development by the BBC Engineering Department of a convertor unit.

The relay from Calais to Britain in 1950 was, in reality, an extension of the O.B. system of the BBC in which no conversion was involved, and the first direct exchange of programmes between countries operating on different standards took place last year when programmes originat-

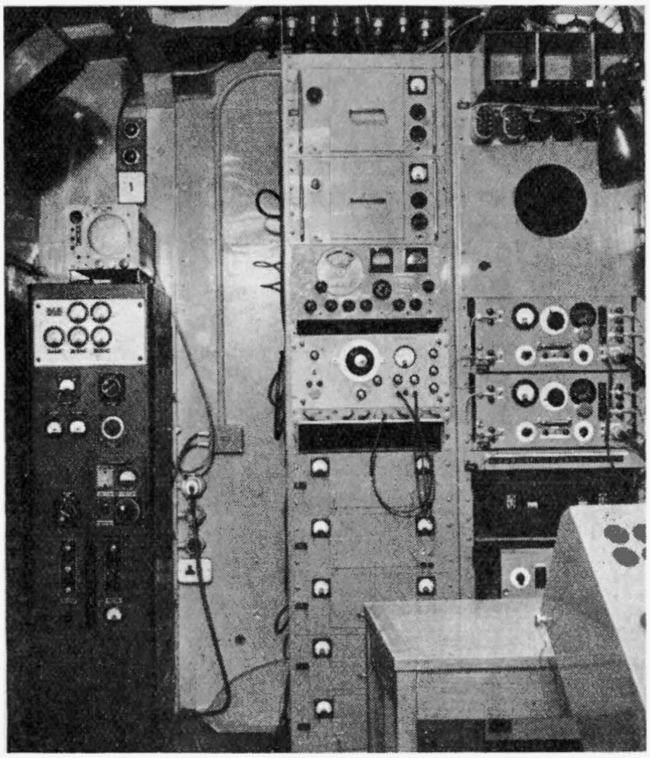


The television network for the Coronation broadcast

Place names on the coaxial cable links indicate the repeater stations. Place names on the radio links indicate relay points. London-Wenvoe cable route is not shown ing in Paris were simultaneously radiated over the French and British networks. In this case a convertor unit was installed at Cassel in Northern France to convert from the French to the British standard.

This exchange showed that direct exchanges were quite possible from the technical point of view and in view of the world wide interest in the British Coronation it was only logical that an attempt should be made to relay the Coronation television programme to Europe and to provide new relay links where required.

To this end, therefore, representatives of the Institut National Belge de Radiodiffusion, The Nederlandse Televisie Stichting and The Nordwest-Deutscher Rundfunk agreed to work out plans in conjunction with the British Broadcasting Corporation and the Radiodiffusion-Télévision Française, who were responsible for the technical arrangements of the Franco-British week of television in July, 1952. A temporary relay network has now been set up across Belgium and Holland linking those countries and Germany with France and Britain, and full scale tests have been recently carried out during which the normal BBC transmissions were successfully relayed to the countries concerned. In all some 27 repeater links are involved along a route of 900 miles across the Continent.



Mobile temporary transmitters are being installed at Pontop Pike, County Durham, and at Glencairn, near Belfast, in time for the Coronation. The programme input equipment bays and one of the duplicate vision transmitters are shown above. (Marconi's Wireless Telegraph Co., Ltd.)

Probably the most convenient manner of describing the actual relaying of the Coronation across Europe is to start with the cameras themselves and to trace the path of the television signals stage by stage.

On the Coronation Day some twenty-one cameras will be in use located at five main sites as follows:—

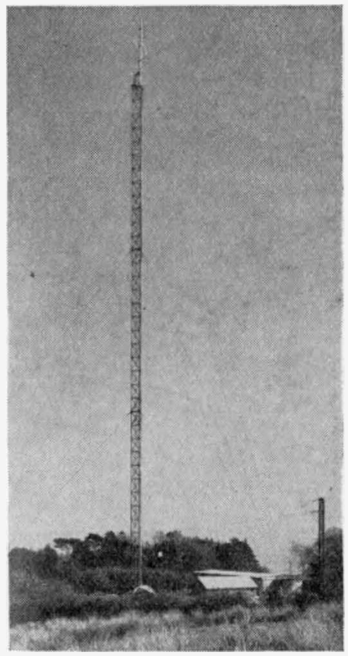
The Victoria Memorial opposite Buckingham Palace.
Inside Hyde Park near Hyde Park Corner.
The Colonial Office overlooking the west front of Westminster Abbey.
The Embankment near Westminster Pier.
Inside Westminster Abbey.

These cameras, together with the various control and commentator points, will be connected to Broadcasting House by cable networks provided by the Post Office. From Broadcasting House the television signals will be transmitted by the five high power stations which are connected to Broadcasting House by cable and radio links as shown on the accompanying map. A further cable link connects the studios at Lime Grove, where film recordings will be made.

In addition to the main transmitters, low power transmitters have been erected at Glencairn (Belfast), Pontop Pike (Newcastle) and Trueleigh Hill (Brighton). These have been erected on a temporary basis only, but will remain in operation until the approval of the Government has been obtained for the erection of the five medium power stations which form the remainder of the BBC's plan for national coverage.

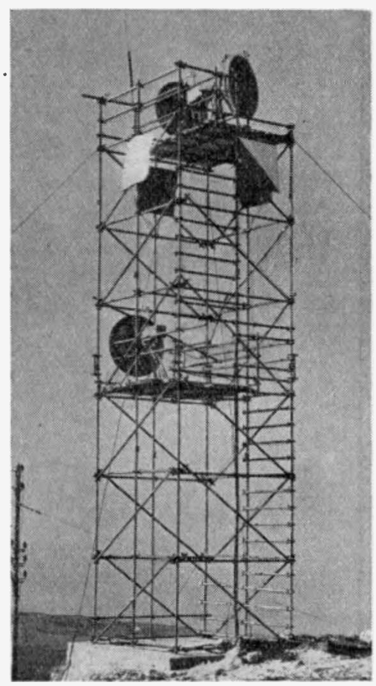
The Glencairn transmitter will be connected to the main BBC network by a temporary radio link provided by the Post Office, while the Trueleigh Hill transmitter will receive its signals by direct pick-up from Alexandra Palace. The temporary transmitter at Pontop Pike is installed on the site allocated for the permanent medium power transmitter and consequently it will receive its signals direct from the permanent television link.

The television signal on its journey across Europe starts from the Senate House of the University of London, which is connected to Broadcasting House by cable. From Senate House the signal is relayed by an S.H.F. radio link to Wrotham in Kent and thence by a similar link at



235 ft. mast with 23¼ ft. single-stack super turnstile aerial (horizontal polarization) which Marconi's Wireless Telegraph Co., Ltd., have erected at Glencairn Road, Belfast, in time for the Coronation

The scaffolding structure near Calais erected to mount the two receiving aerials for the Dover-Calais link and the transmitter for television signals to Cassel. The cross channel link was arranged with "space diversity" to ensure good reception



Lenham to Swingate near Dover. (The aerial assembly on the roof of Senate House is shown in the photograph at the top of page 244).

From Swingate the signal is relayed across the English Channel to Cap Blanc Nez, on the coast of France, where it is relayed to Cassel.

The whole of the equipment in this circuit from London to Cassel has been provided by Standard Telephones and Cables Ltd., under contract from the BBC and RTF.

The "Standard" portable S.H.F. link comprises lightweight equipment, forming a complete transmitter and receiver operating in selected bands in the frequency range 3 600-4 750Mc/s. The transmitter has a velocity modulated coaxial line valve delivering a power of 250mW into a four foot diameter paraboloid. A similar valve is used as the local oscillator in the receiver. The limiting of the power delivered to the aerial makes possible the use of a directly modulated coaxial line oscillator feeding direct to the aerial so that all the apparatus forms an integral part of the aerial and paraboloid assembly.

The output of a receiver unit can be connected directly to the input of a transmitter unit and a limited number of links may be so connected in tandem.

The system is frequency modulated with a deviation of 4Mc/s although a deviation of 8Mc/s can be obtained, with some loss of linearity, where difficult transmission conditions exist.

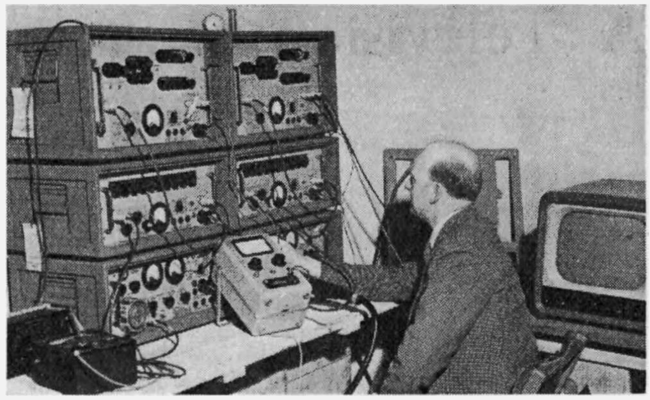
The repeater station near Calais which occupies a German dugout in the Cap Gris Nez area. The photograph shows the two sets of portable units.

From Cassel the signal, still at the British 405 line standard, is relayed to Paris by further radio links along the route of the Paris-London relay of last year. At Paris convertor equipment is installed to convert to the French 441 and 819 line standards of the two Paris television transmitters, the 819 line transmitter at Lille being connected to Paris by a further radio link.

There is at the moment no regular television service in Belgium although some parts of the country are in the service areas of the French transmitter at Lille and of the Dutch transmitters at Lopik and Eindhoven. It is hoped that there may be a limited closed loop system in Brussels in time for the Coronation from a direct pick-up at Flobecq from the Lille transmitter.

The INR have undertaken to relay the television signal across Belgium from the relay point at Lille to the Dutch frontier at Breda, through intermediate relay points at Flobecq, Brussels and Antwerp with centimetric radio link equipment, supplied by Philips.

There is a regular television service in Holland operated by the NTS with a permanent transmitter at Lopik with studios in Bossum. This transmitter located in the centre



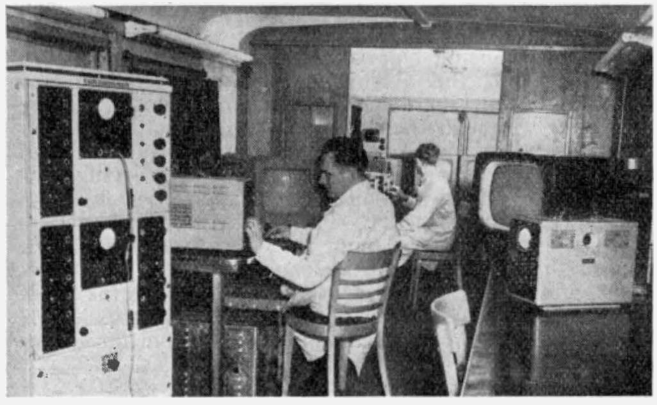
A view of the receiving terminal equipment at Cassel. This comprises a main and standby set of receiver control circuits. On the right may be seen the special large screen monitoring equipment provided by Kolster Brandes Ltd.

of Holland covers about 40 per cent of the population and is connected by a radio link to a low power experimental transmitter at Eindhoven.

Breda, on the Dutch frontier, serves as a convertor point where the British 405 line television signal is converted into the 625 European standard by a convertor of Philips manufacture. From Breda a radio link carries the signal, now at 625 lines, to Lopik and further radio links at Eindhoven, Helenaveen, and Suchteln carry the 625 line signal to Cologne, where it feeds the NWDR television network for the television transmitters at Cologne, Langenburg, Hanover, Hamburg, Berlin and Frankfurt.

This temporary route, of course, only covers those countries where television services are operating. As the remaining European countries develop their systems the network will be extended. In Denmark, for example, there is an experimental station broadcasting intermittently at Copenhagen. It is not certain at this stage whether Copenhagen can be connected by link to Hamburg. Should this not be so, film recordings of the Coronation made at Hamburg will probably be flown to Copenhagen for rebroadcasting. Of the remaining European countries, Sweden does not expect to start from Stockholm until the autumn of this year and Switzerland has a small experimental station near Zurich. There are three television transmitters operating in Italy and two more are due for completion this year. Spain has two small experimental stations, but no development plans have been announced. Much of the television relay network just described is on a temporary basis only and will be removed as soon as the Coronation ceremonies are over.

Interior view of the Philips mobile convertor stationed at the foot of the Grote Kerk in the Breda market square.



A Television Waveform Display Apparatus

(Part 2)

By G. N. Patchett*, Ph.D., B.Sc., A.M.I.E.E., M.I.R.E., A.M.Brit., I.R.E.

Performance

Having described the apparatus, some results will now be shown. The waveform (negative picture signal) of two lines on a BBC transmission of a moving picture is shown in Fig. 8(a). This should be compared with Fig. 1(a), a typical result on a normal oscillograph. Fig. 8(b) shows the frame synchronizing period (odd frame, positive picture signal) as received in the centre of Bradford from Sutton Coldfield (approximately 100 miles away). The line pulses, the half line, and eight frame synchronizing pulses can be distinguished. Although the interference pulses extend off the oscillogram a recognizable picture can be obtained under these conditions. Fig. 8(c) (negative picture signal) shows part of the frame period of early test signals (before official tests started) from Holme Moss. The "picture" was a white cross and it will be seen that only four half line synchronizing pulses were transmitted instead of the normal eight.

The waveform of approximately two lines of test-card C is shown in Fig. 9(a), while in Fig. 9(b) is shown the received picture on a television set with the corresponding two lines brightened by the pulse from the waveform display apparatus. An index to the various portions of the waveform is also given so that the waveform can be related to the actual picture. The actual picture is taken from a commercial set, but the connexion of the apparatus to the cathode of the picture tube upsets the high frequency response of the video stage and causes some lack of definition on the picture.

Fig. 10 shows in a similar way the frame synchronizing period on even frames, one set of flyback lines now being brightened by the brightening pulse. The oscillogram clearly shows the eight half line pulses followed by part of the blanking period. In. Fig. 11 is shown the odd frame synchronizing period, but at a reduced scan speed, a number of lines being shown before and after the period. The corresponding lines are shown brightened in Fig. 11(b).

Fig. 12 shows the results obtained on two frame synchronizing separator circuits. (a) Shows the effect of integrating the frame synchronizing pulses, this oscillogram being taken for the case of even frames. This oscillogram clearly shows the way the frame synchronizing pulses are lifted above the small line pulses and also shows the shape of the pulse at the start and, what may be equally important, at the end. (b) Shows the effect of passing the odd frame synchronizing pulses through a differentiating circuit. The original pulses were negative going, the pulses rising during the frame pulse period due to the change of D.C. component. This oscillogram shows the pulses clearly which is not possible on a normal oscilloscope.

As well as being able to view the video signal as it passes through the video amplifier and synchronizing separator circuits, the flyback of the time-base can be seen in detail. Although the apparatus was intended for television work it may also be used to view a small portion of any other waveform which contains small detail. Fig. 13(a) and (b) shows a small portion (approximately 1 per cent) of the approximately sinusoidal current taken by a high pressure mercury vapour discharge lamp. It will be noticed that over this portion small damped oscillations occur, presumably due to restriking of the arc in the lamp. The frequency of these oscillations is approximately 300kc/s and they only occur on this small portion of the

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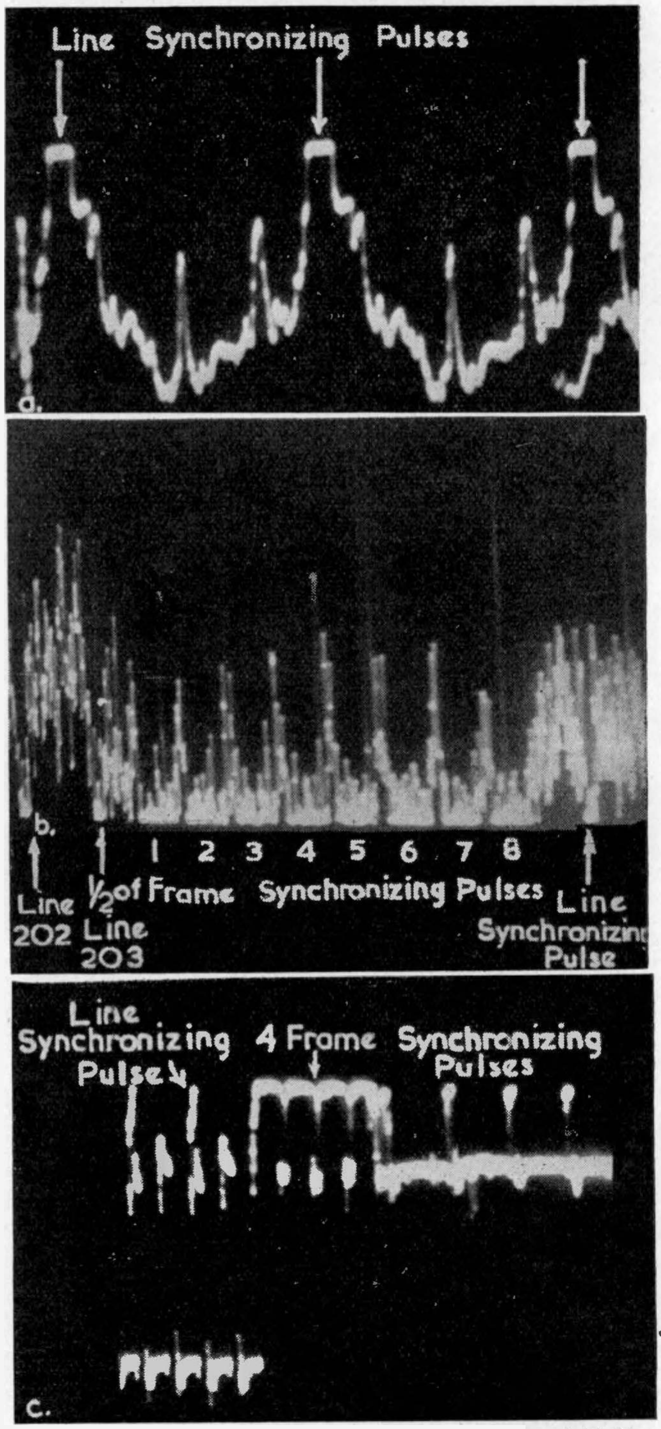
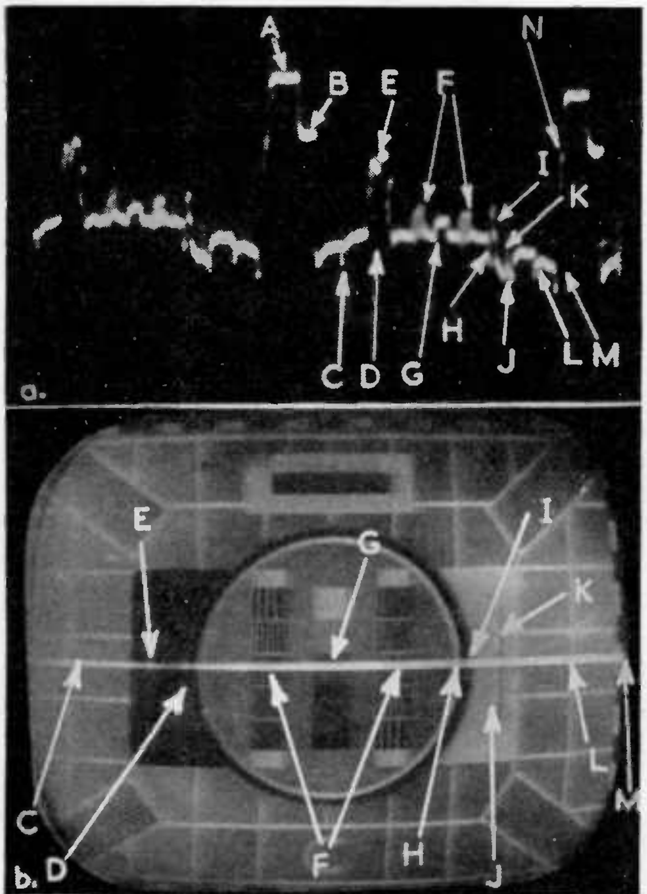


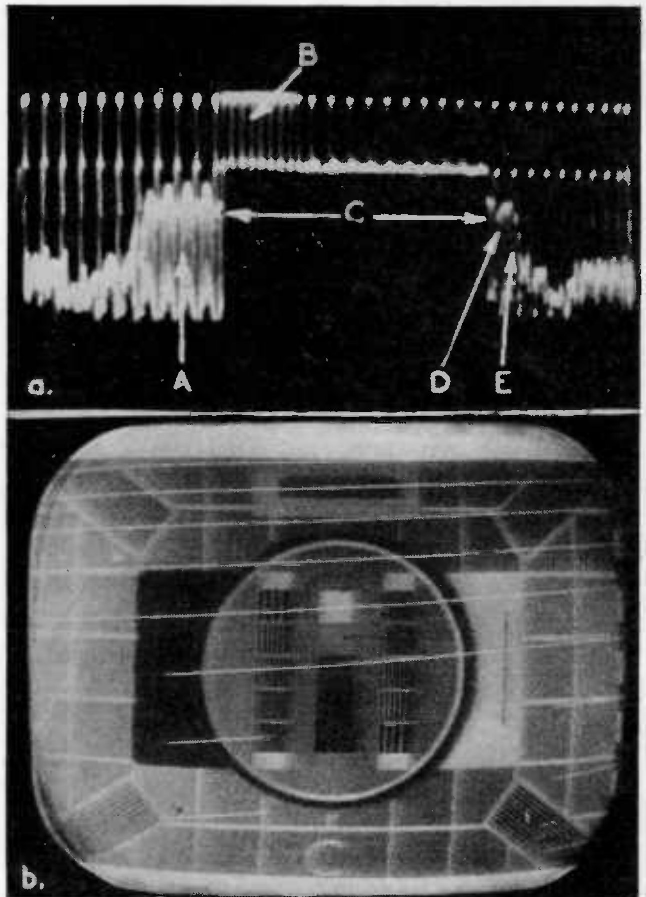
Fig. 8. Oscillograms taken with waveform display apparatus of television waveforms as received from the BBC on a receiver

(a) *Typical waveform with moving picture showing just over two lines. Negative picture signal. Holme Moss transmitter.*

(b) *Frame synchronizing period (odd frame) received from Sutton Coldfield in the centre of Bradford. Positive picture signal.*

(c) *Frame synchronizing period transmitted by Holme Moss during unofficial test period. Negative picture signal.*





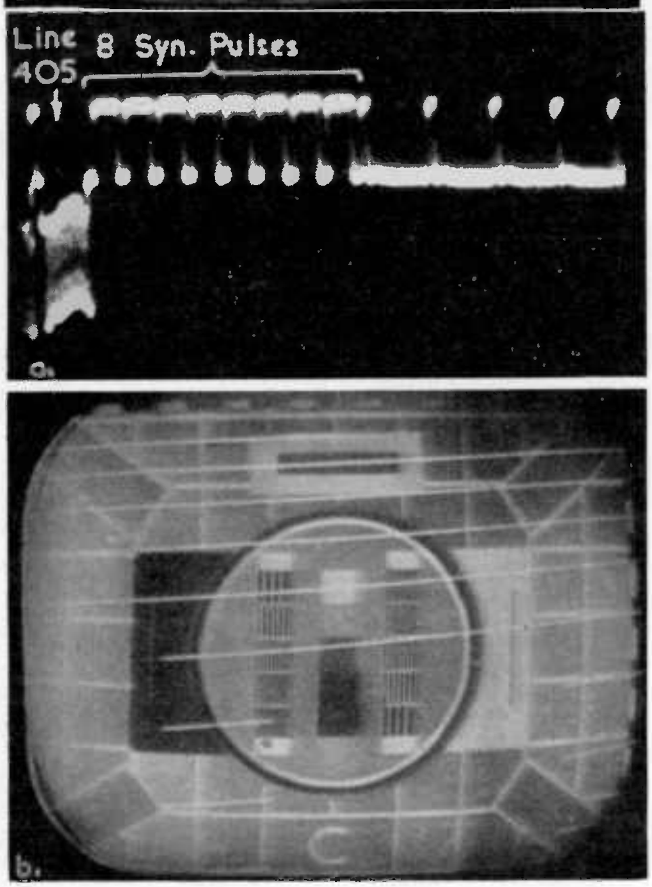


Fig. 9 (top left). (a) Waveform on display apparatus of portion of test card C. Negative picture signal. (b) Picture on television receiver with corresponding lines increased in brilliance

A. Line synchronizing pulse. B. Back porch. C. Vertical white line. D. Black portion on left of circle. E. White line on black portion D. F. Left and right hand 2Mc/s bars. G. Grey centre square. H. White circle. I. Black circle. J. White portion on left of circle. K. Black line on white portion J. L. Vertical white line. M. Castellated edge of picture. N. Front porth.

Fig. 10 (bottom left). (a) Waveform on display apparatus of frame synchronizing period (even frames) during transmission of test card C. Negative picture signal. (b) Picture on television receiver with corresponding lines (now flyback lines) increased in brilliance

Fig. 11 (top right). (a) Waveform on display apparatus of test card C. Nega'ive picture signal. (b) Picture on television receiver with corresponding lines increased in brilliance

A. Castellated edge of picture at bottom. B. 8 frame synchronizing pulses. C. Blanking period. D. Castellated edge of picture at top. E. Lines corresponding to the vertical lines on the picture and diagonal lines in the corner.

Fig. 14 (bottom right). Oscillogram taken with modified waveform display apparatus showing odd and even frame pulses after integration

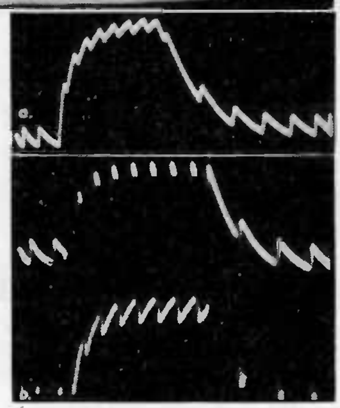


Fig. 12. Waveforms on display apparatus of frame synchronizing period:—

After (a) integration (b) differentiation

Fig. 13. Oscillograms taken with waveform display apparatus showing oscillations produced on a portion of the cycle of current taken by a high pressure mercury discharge lamp

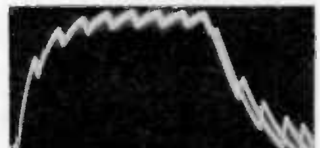
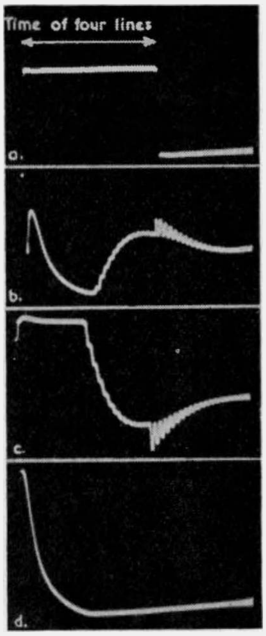


Fig. 15. Oscillograms taken with modified waveform display apparatus on blocking oscillator time-base

(a) Synchronizing pulse (inverted and applied to anode).
(b) Anode waveform.
(c) Grid waveform.
(d) Output waveform.
All oscillograms are to the same horizontal scale.



cycle of current and are quite invisible on a normal oscilloscope.

A modification of this apparatus which proved invaluable has been used by the author on some research on interlacing[7]. For this purpose it was necessary to operate the time-base at 50c/s instead of 25c/s, so that odd and even traces are superimposed, it then being possible to see any difference on odd and even frames. The actual waveform display apparatus could have been used by cutting out the frequency divider and delay circuit, but the display apparatus was required for other purposes. A time-base was constructed exactly similar to the one shown in Fig. 6 and the output from this was fed to the X-deflecting plates of a cathode-ray oscilloscope and the brightening pulse was fed to the grid. The research was performed using a pattern generator as signal source. It was necessary to trigger the time-base exactly at the start of the frame pulses. This was done by deriving simple pulses (four lines long) from the pattern generator which were at frame frequency and identical on odd and even frames. This pulse was differentiated, reversed in phase and used to trigger the time-base (g_3 of valve V_{12} of Fig. 6). Fig. 14 shows a result obtained in this way, which consists of an oscillogram of the integrated frame pulses. It will be seen that there are two distinct pulses, one for odd frames and one for even frames, the start and end of the pulses being different in the two cases.

Fig. 15 shows some oscillograms taken in this way on a blocking oscillator time-base circuit. The circuit was synchronized on the anode by the pulse shown in (a) (after phase reversal) which is four lines long. (b) Shows the voltage on the anode, where it will be noted that a damped oscillation is produced by the end of the synchronizing

Fig. 16. Oscillogram taken with modified waveform display apparatus on blocking oscillator time-base showing two different scans on odd and even frames, although the flyback is the same in both cases

pulse. The grid voltage is shown at (c) where again the damped oscillation can be seen and also the period during which the grid is driven positive. The output voltage is shown at (d) which shows the short flyback corresponding to about 2 lines. In Fig. 16 is shown an oscillogram on a similar time-base circuit, except that the time-base is synchronized (on the anode) by integrated frame pulses after passing through a limiter. It will now be seen that the flyback in the two cases is identical, but that two separate scans are produced, corresponding to odd and even frames. This is caused by the differences in the end of the integrated pulses (see Fig. 14 and Ref. 7). This difference in the two scans causes failure of correct interlace.

Conclusion

The waveform display apparatus has proved to be a very valuable addition to the television equipment and enables a student to see exactly what happens as a signal passes through the various stages of a set. It is also invaluable for fault finding on "sticky" faults connected with the synchronizing circuits. As well as being so valuable in servicing classes it has proved extremely useful in research on synchronizing separators and in its modified form enabled conclusive results to be obtained in connexion with the problem of interlacing.

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An Electronic Current Stabilizer for a Low Resistance Solenoid

By M. S. Wills*, B.Sc., M.A., A.Inst.P.

The 20Ω solenoid is supplied from a rectifier set with direct currents up to 5A. Voltage variations across a standard resistance in series with the load are amplified and fed back to a control unit which adjusts the A.C. input voltage to the rectifier. The design and performance of the equipment are described.

THE stabilizer described in this article was constructed to meet the need for stabilization of a small water-cooled solenoid supplied by a rectifier set. The resistance of the solenoid was too low and its current consumption too high for a circuit of the usual type, containing a series control valve, to be suitable; such a circuit has been described for example by Graham, Harkness, and Thode[1]. The difficulty, which arises from the order of magnitude of anode resistance of the control valve, was overcome by using a control unit circuit described by Patchett[2] the action of which may be looked upon as a transformation of the valve anode resistance to a lower and more convenient value. The degree of stability needed was not exceptionally high, and a maximum current variation of ½ per cent could be tolerated. Higher stability could however be obtained if required by using an amplifier of higher gain.

Design

A block diagram of the equipment is shown in Fig. 1. Current from the 3-phase 356V 50c/s mains passes through the control unit into the rectifier unit. Direct current of 5A maximum at 170V from the rectifier flows

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through the load in series with resistors R_{14} and R_{15} each of which consists of several rheostats in series. The resistor R_{14} has very heavy power rating in relation to the current it has to carry so that change of resistance due to heating is negligible. The voltage across R_{14}, which is thus proportional to the load current, is amplified and fed back to the control unit so as to compensate for changes of load current by adjustment of the input voltage to the rectifier unit.

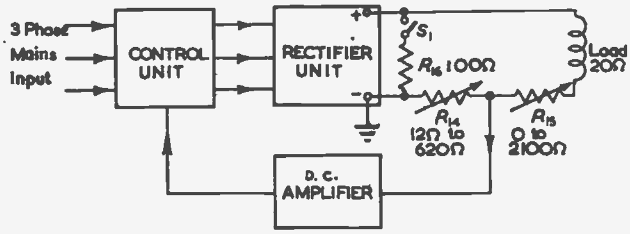

Fig. 1. The current stabilizer

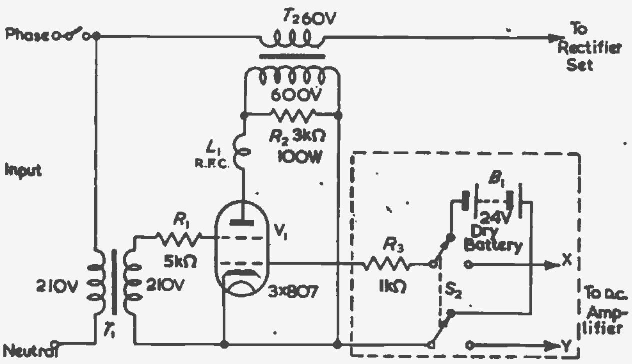

Fig. 2. The control unit

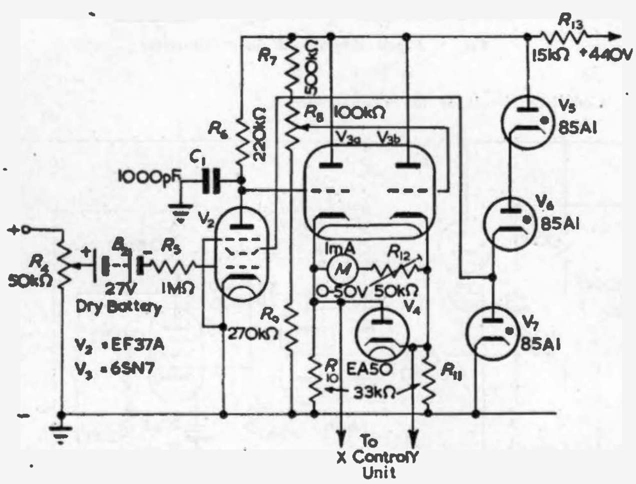

Fig. 3. The D.C. amplifier

The circuit of the control unit is shown in Fig. 2, and is repeated in each phase line, except for the part enclosed by dotted lines. The transformer connexions are arranged so that anode and screen are excited in phase so as to obtain a triode type characteristic in the way explained by Patchett[2]. The resistance connected to the secondary of T_2 *is* R_2 with V_1 in parallel and the effective resistance of V_1 is altered by change of the grid potential derived from the D.C. amplifier. The range of variation of grid potential is 0V to −50V. The secondary voltage of T_2 depends on the load and on the grid potential of V_1. On full load and with V_1 cut off this voltage rises to a maximum of about 600V. The choke L_1 of about 10 turns is needed to counter parasitic oscillations of very high frequency. R_3 is a grid stopper and the switch S_2 is used to cut out the stabilizing action when the load current is being changed. A peculiarity of the circuit is that the controlling effect becomes less as the load current is reduced. It is thus necessary to have a dummy load taking about 2A (R_{16} in Fig. 1) to be switched in when the true load current is small.

Fig. 3 shows the single stage D.C. amplifier. The voltage developed across R_{14} which ranges from about 30V to 120V depending on the load current and the value of R_{14} is applied to the small wire wound potentiometer R_4 and the latter is set to deliver a standard voltage, actually about 24V, to the grid of V_2 and this is opposed by the reference voltage of the dry battery B_2. R_5 is to prevent the grid of V_2 going appreciably positive should R_4 be turned up too high. The voltage gain of V_2 is 170. The output voltage of V_2 is applied to the cathode-follower valve-voltmeter V_3. *M* is graduated to read directly the output voltage appearing at XY. The acorn diode V_4 is a safeguard to prevent the grid of V_1 becoming positive. C_1 is to stop parasitic oscillations. The H.T. supply for this unit is provided by a normal power pack fed from a constant voltage transformer and stabilized by V_5, V_6 and V_7.

Performance

To use the equipment, after the supplies have been switched on and with S_2 switched to B_1, the load current is adjusted to the desired value by means of R_{14} and R_{15}. R_{14} and R_{15} each consist of several rheostats which are mounted and wired in such a way that, when they are cut out one by one in succession, the voltage across R_{14} is always greater than the standard voltage needed for stabilization. R_{16} is cut out by means of S_1 if the load current exceeds about 2A. R_4 is then adjusted until the meter *M* reads about 24V and S_2 is thrown over to stabilize the current.

There are three causes of load current variations, namely, drift, variations of the supply voltage, and changes of load resistance due to heating and cooling. The latter effect is particularly important with a load such as a solenoid or electromagnet since the windings are of copper and are often run up to a fairly high temperature to obtain high performance. It is desirable to "swamp" this effect as far as possible by series resistors of low temperature coefficient. The drift of the equipment has been tested by using a load in which change of resistance due to heating was negligible, and setting the input voltage before each observation to a standard value. The drift of the current under these conditions is about 1 part in 1 000 in 3 hours. The effect of change of input voltage varies according to the current and is least on full load. With a line to neutral voltage of 210V the effect of a change of ±5V is 0·21 per cent when the load current is 4·7A and 0·42 per cent when the load current is 0·17A. The voltage range over which the stabilizer acts is 23V in the former instance and 14V in the latter. The effect of increasing the load resistance is greatest with the largest current and less for smaller currents owing to the swamping effect of the rheostats. Thus at 4·5A the effect of an increase of 3Ω is to reduce the current by 0·6 per cent. Since the load resistance is about 20Ω copper this corresponds to a rise of temperature of about 40°C.

Acknowledgments

The author wishes to thank Professor R. W. Ditchburn for the facilities placed at his disposal, and Mr. K. Eccles for his assistance with the development of the equipment.

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A Portable High Speed Stroboscope

By A. E. Ferguson*, M.E.E., A.M.I.E. (Aust.)

A light source stroboscope is described using an xenon filled tube giving a substantially white light output lasting for approximately 30μsec. The flashing rate can be varied from 20c/s up to 500c/s. The whole equipment is mains operated and can be made readily portable.

THE electrical light source stroboscope, first developed by Edgerton and others[1] in America during the early 1930's, has proved a most versatile instrument in the hands of scientists and engineers. Although the gas discharge flash tube does not produce the short duration high intensity light output obtained from high voltage sparks—a technique which has been used for photographing projectiles in flight since the close of the last century[2]—it is considerably more convenient and can be triggered by a variable frequency oscillator for stroboscopic work. The flash obtained from a modern tube is sufficiently brilliant to allow stroboscopic observations to be made under conditions of almost normal illumination and has a duration sufficiently short for some ballistic purposes[3].

The development of flash tubes received a considerable impetus during the 1939-45 period by the demand for a high intensity light source for night photography. The British work in this period is well summarized by Aldington and Meadowcroft[4].

A recently developed stroboscope[5] is capable of giving up to 4 000 flashes per second for high speed photography, but is not sufficiently portable for many requirements.

The instrument to be described uses one of the flash tubes which has been produced as a result of these wartime developments. In association with auxiliary equipment, it can be used as a light source stroboscope giving up to 500 flashes per second and is readily portable.

General Description of Stroboscope

A block diagram is shown in Fig. 1. A capacitor, charged to about 3kV, is discharged through the gas-filled flash tube upon the application of a short duration triggering pulse. The peak voltage of this triggering pulse is also of the order of 3kV.

A multivibrator forms a convenient variable frequency oscillator which determines the trigger pulse repetition rate. In this design the repetition rate may be varied from 20c/s to 500c/s. To achieve a reasonably open scale two 5 to 1 ranges have been used. A high and a low voltage supply allow the whole equipment to be mains operated.

A complete circuit diagram is given in Fig. 2.

Flash Tube Circuit

The flash tube used is a Mullard type LSD8 which is xenon filled. The discharge takes place between two electrodes sealed into the ends of a glass helix. Under normal conditions where the discharge current is large the colour of the light emitted is approximately white. The trigger electrode is a helix of wire wound coaxially with and outside the glass helix.

The tube is designed primarily for stroboscopic applica-

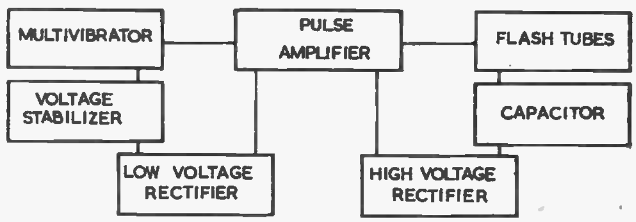
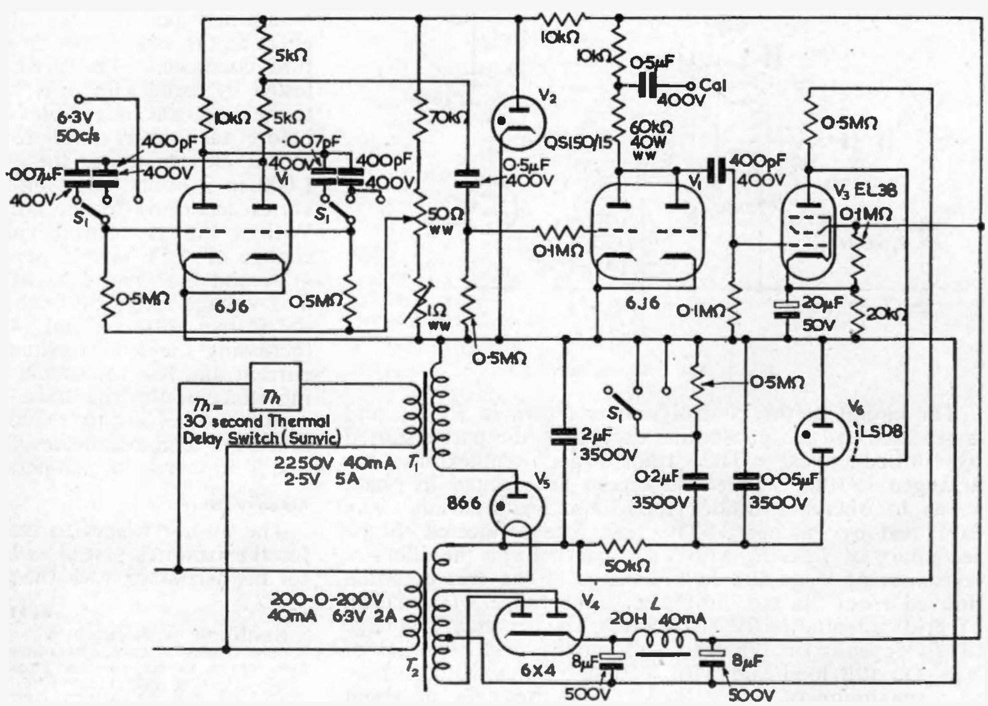


Fig. 1. Block diagram of the stroboscope

Fig. 2. Complete circuit of the stroboscope



* *University of Melbourne.*

tions. The mean dissipation should not exceed 30 watts. (With forced air cooling, this rating may be increased).

As already stated, a "storage" capacitance is discharged through the flash tube. For stroboscopic work, care must be taken that the wattage loading of the tube is not exceeded at high rates of flash.

If the storage capacitance is always recharged between flashes to the same potential, then the intensity of the flashes remains constant over the whole range of flashing speeds, but the wattage loading of the flash tube decreases in direct proportion to the frequency. At low flashing speeds it is clear that the maximum illumination capabilities of the tube cannot be realized without increasing the size of the storage capacitance. By careful design of the time-constant of the recharging circuit it is possible to maintain the wattage loading of the flash tube reasonably constant over a wide range of speeds without changing any components of the circuit. This means that the energy per flash increases as the flashing rate drops.

It is normal practice for this storage capacitance to be charged through a series resistance from a much larger capacitance shunting the output of the rectifier. This is used in the present design.

ing of the capacitance was responsible for this erratic behaviour. For this reason a design minimum for the ratio T/RC of 0·7 was adopted. This corresponds to the storage capacitance recharging to half the maximum voltage. A 5/1 range of flashing speeds is then obtained with the wattage loading within 33 per cent of the maximum.

Using $T/RC = 0{\cdot}7$

and $T_{min} = 2$ milliseconds (i.e. 500c/s)

$E = 3$kV

Wattage Loading = 30 watts (maximum)
the constants of the charging circuit can be evaluated. They are:

$C = 0{\cdot}046\mu$F

$R = 6{\cdot}2 \times 10^4\Omega$

The lower range from 100 flashes per second to 20 flashes per second uses a 0·25μF capacitor which is connected to the range change switch on the multivibrator. The maximum energy per flash with this capacitance is well within the rating of the flash tube. For stroboscopic

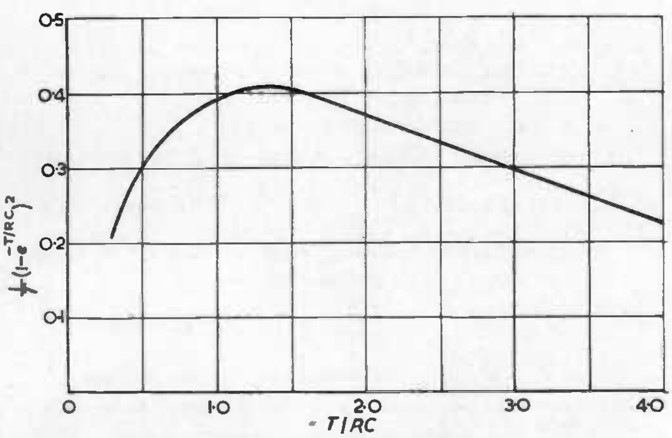


Fig. 3. Determination of optimum time-constant

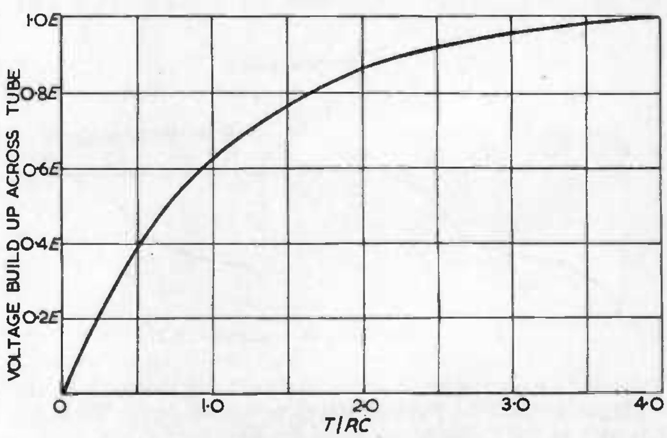


Fig. 4. Voltage build-up across tube

An analysis of the recharging of the storage capacitance and the loading of the flash tube is given in Appendix 1 where it is shown that the wattage dissipated in the flash tube is:

$$\frac{E^2C}{2T}(1 - e^{-T/RC})^2 \text{ watts.}$$

To determine the optimum value of the time-constant to use, the function

$$1/T\ (1 - e^{-T/RC})^2$$

may be plotted for a range of values of T/RC. This is shown in Fig. 3 where, for convenience, $RC = 1$.

It is clear from this graph that in the range $T = 0{\cdot}5RC$ to $T = 3{\cdot}0RC$ the function

$$1/T\ (1 - e^{-T/RC})^2$$

varies from 0·3 to just over 0·4. That is, for a 6 to 1 change in frequency of the flashing rate, the wattage loading may be kept within 25 per cent of the maximum wattage at any point of the range.

The larger the ratio T/RC, the greater the voltage build up across the flash tube between triggering pulses. This is shown in Fig. 4. If the trigger interval is of the order of $0{\cdot}5RC$ the voltage build up will be only 40 per cent of the maximum and some difficulty may be experienced in obtaining satisfactory operation at the high speed end of the range.

During the experimental development of the circuit it was found that when $T/RC = 0{\cdot}5$ the tube very occasionally missed firing. It was felt that insufficient recharg-

work the light output obtained per flash from the discharge is ample for most purposes.

Trigger Pulse Amplifier

The oscillator controlling the repetition rate is a conventional multivibrator operated from a stabilized voltage supply. The frequency is varied by adjusting the positive bias and switching the coupling capacitance. The characteristic square wave output of this circuit is "sharpened" in a 6J6 squaring amplifier and coupled to the grid of the EL38 trigger amplifier by a 40μsec time-constant circuit. The EL38 is a high transconductance output pentode capable of handling high peak anode voltages. The anode circuit of this trigger amplifier is operated from the high voltage rectifier output through a 0·5MΩ load resistor. The quiescent grid bias is below the cut-off value, hence a short duration negative pulse of approximately 3kV peak is developed in the anode circuit each cycle of the multivibrator. This is directly coupled to the flash tube trigger electrode.

Provision has also been made for synchronizing the multivibrator to the 50c/s mains supply.

The high tension rectifier is a half-wave mercury vapour hot cathode type with a shunt capacitance filter for smoothing. A 30sec time delay in the primary of the transformer for this rectifier is included to allow the recommended warming up period.

Performance

The wattage loading of the tube has been measured at various flash speeds and the experimental results are shown in Fig. 5. These are in reasonably good agreement with the results of the analysis given in Appendix 1.

The duration of the flashes has been measured using a multiplier photo-cell and an oscillograph. The photo-cell output was connected direct to the Y deflexion plate and

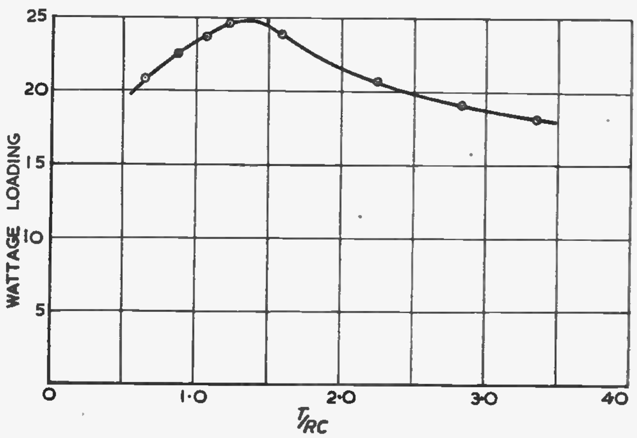


Fig. 5. Wattage loading

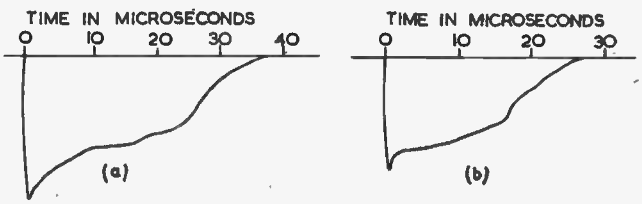


Fig. 6. Typical traces on screen of C.R.T.

the time-base triggered from the pulse at the grid of the trigger amplifier. Typical traces obtained direct from the screen of the cathode-ray tube are shown in Fig. 6.

It is seen that the duration of the flash is of the order of 35μsec when the repetition rate is 20c/s. This corresponds to an energy per flash of the order of 1·0 joules. At the maximum repetition rate of 500c/s, corresponding to an energy of about 0·04 joules per flash, the flash duration is slightly less.

Acknowledgment

The author wishes to thank Professor C. E. Moorhouse for the facilities offered in his department for the development and construction of the instrument described.

Appendix

The equivalent circuit of the flash tube and its associated network is shown in Fig. 7. In this representation the switch *S* can be assumed to close instantaneously at each trigger pulse, so discharging the capacitor *C*. In the interval between flashes (when the flash tube is non-conducting) the switch must be open and the capacitor *C* is then recharging from the high tension supply *E* through the resistor *R*.

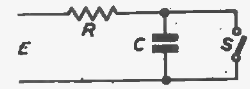


Fig. 7. Equivalent circuit of flash tube

The voltage across the capacitor increases exponentially during the recharging interval, given by

$$e_o = E(1 - e^{-t/RC})$$

where e_o = instantaneous voltage across the capacitor
t = time measured from the instant the switch opens
E = D.C. rectifier output voltage

If the interval between flashes is T seconds, then

$$\text{Energy per flash} = \frac{CE^2}{2}(1 - e^{-T/RC})^2 \text{ joules}$$

$$\text{Wattage loading} = \text{Energy flash} \times \text{number of flashes per second}$$

$$= \frac{CE^2}{2T}(1 - e^{-T/RC})^2 \text{ watts}$$

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Voltage Stabilization with Series Valve Control

By R. D. Trigg*, A.M.Brit., I.R.E.

It is intended to show in the following circuit analysis the criteria of voltage stability achieved by the circuit shown in Fig. 1.

FIG. 1 represents the conventional voltage stabilization network where mains supply fluctuations up to ±15 per cent have negligible effect on the load voltage, when the load takes a large current.

Terminals A and B are normally connected to the smoothing filter and power supply system, and terminals C and D to circuits taking a relatively large current and requiring a stabilized high-tension supply.

When the mains voltage decreases, the corresponding reduction in V_{do} is communicated via V_1 to the potential at C; and in turn, to the control grid of V_2. This results in a rise in potential at the control grid of V_1, and the voltage-drop across R_1 is reduced.

Since the cathode potential v_{do} of V_1 floats on the grid potential V_{a2} of this valve, a reduction in v_{do} is countered by the increased potential at V_1 control grid. In order for this to occur, however, V_{a2} must change by a finite amount in excess of v_{do}. The degree to which the difference $V_{a2} - v_{g1} = v_{do}$, is made small will therefore mainly depend on V_2 and its associated network.

It will be seen that a rise in mains voltage produces a similar result, the incremental change in potentials then having opposite sign.

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Unless the potential at E is maintained constant with mains variation, cathode feedback will occur in the V_2 grid circuit, and the incremental change in V_{a2} is reduced. This is avoided by employing the voltage stabilizer N, as shown.

For optimum results V_1 should have a high amplification factor rather than a steep slope, and an anode dissipation which permits it to pass the full load current (i.e. two or more valves should operate in parallel to meet this requirement). V_2 should possess a high mutual conductance.

Equivalent Circuit (Triode Operation)

If the potential at E in Fig. 1 remains constant over the range of operation, the incremental change in potential at C with respect to D, i.e. δv_{do}, will also be the same as that with respect to E. Thus if only incremental variations in voltage and current are considered in the equivalent circuit, the stabilizer N may be omitted.

It is to be observed, however, that the stabilizer voltage-drop modifies the performance of the equivalent circuit, in so far as it decides the ratio v_{g2}/v_{do}.

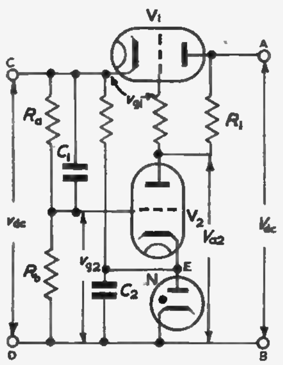

Fig. 1. Complete circuit diagram of voltage stabilizing network employing series valve

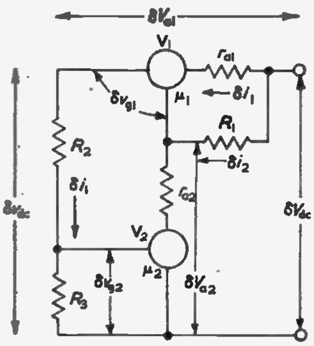

Fig. 2. Equivalent circuit of Fig. 1

The current in resistors R_a and R_b in Fig. 1, which are chosen to give the correct bias to V_2, can in practice be made negligible in comparison with the load current. The quiescent potential at V_2 grid may then be represented by i_1R_3 where $R_2 + R_3 = R_K$ = load resistance (see Fig. 2) and:

$$\frac{R_a}{R_a + R_b} = \frac{R_3}{R_2 + R_3} \quad \ldots\ldots\ldots\ldots (1)$$

$$R_K = v_{dc}/i_1$$

Thus from the figure:

$$\delta V_{do} = \delta V_{a1} + \delta i_1 R_K \quad \ldots\ldots\ldots\ldots (2)$$

$$\delta V_{a1} = \delta i_1 r_{a1} - \mu_1 \delta v_{g1} \quad \ldots\ldots\ldots\ldots (3)$$

$$\delta v_{g1} = \delta V_{a2} - \delta i_1 R_K \quad \ldots\ldots\ldots\ldots (4)$$

$$\delta V_{a2} = \delta i_2 r_{a2} - \mu_2 \delta v_{g2} \quad \ldots\ldots\ldots\ldots (5)$$

$$\delta v_{g2} = \delta i_1 R_3 \quad \ldots\ldots\ldots\ldots (6)$$

Substituting Equations (3) to (6) in (2):

$$\delta V_{do} = \delta i_1 \left\{ r_{a1} + R_K(\mu_1 + 1) + \mu_1\mu_2 R_3 \right\} - \delta i_2 r_{a2}\mu_1 \quad \ldots (7)$$

Also from Fig. 2:

$$\delta V_{do} = \delta V_{a2} + \delta i_2 R_1 \quad \ldots\ldots\ldots\ldots (8)$$

and substituting Equations (5) and (6) in (8):

$$\delta V_{do} = -\delta i_1 \mu_2 R_3 + \delta i_2 (r_{a2} + R_1) \quad \ldots\ldots\ldots (9)$$

Solving for δi_1, from Equations (7) and (9):

$$\delta i_1 = \frac{\begin{vmatrix} \delta V_{dc} & , & -\mu_1 r_{a2} \\ \delta V_{dc} & , & (r_{a2} + R_1) \end{vmatrix}}{\begin{vmatrix} \left\{ r_{a1} + R_K(\mu_1 + 1) + \mu_1\mu_2 R_3 \right\}, & -\mu_1 r_{a2} \\ -\mu_2 R_3 \quad , & (r_{a2} + R_1) \end{vmatrix}} =$$

$$\delta V_{dc} \left\{ \frac{r_{a2}(\mu_1 + 1) + R_1}{[r_{a1} + R_K(\mu_1 + 1)](r_{a2} + R_1) + \mu_1\mu_2 R_1 R_3} \right\} \quad (10)$$

whence $\delta i_1 R_K = \delta v_{dc}$

$$= \delta V_{do} R_K \left\{ \frac{r_{a2}(\mu_1 + 1) + R_1}{[r_{a1} + R_K(\mu_1 + 1)](r_{a2} + R_1) + \mu_1\mu_2 R_1 R_3} \right\} \quad \ldots\ldots\ldots\ldots (11)$$

and the stabilization ratio:

$$S = \frac{\delta V_{do}}{\delta v_{do}} = \frac{\left\{ r_{a1} + R_K(\mu_1 + 1) \right\} (r_{a2} + R_1) + \mu_1\mu_2 R_1 R_3}{R_K \left\{ r_{a2}(\mu_1 + 1) + R_1 \right\}} \quad \ldots\ldots\ldots\ldots (12)$$

since $\mu_1 \gg 1$, to a first approximation Equation (12) can be expressed as:

$$S = \frac{(r_{a1} + R_K\mu_1)(r_{a2} + R_1)}{R_K(r_{a2}\mu_1 + R_1)} + \frac{\mu_1 R_3}{R_2 + R_3}\left(\frac{\mu_2 R_1}{r_{a2}\mu_1 + R_1} \right) \ldots (13)$$

For triode operation:

$$R_K\mu_1 \gg r_{a1} \quad \ldots\ldots\ldots\ldots (14)$$

$$r_{a2}\mu_1 \gg R_1 \quad \ldots\ldots\ldots\ldots (15)$$

and the left-hand fraction in Equation (13) reduces to:

$$1 + R_1/r_{a2}$$

while examination of the right-hand fraction shows that this is a more or less conventional expression for the effective gain of V_2. Within the brackets it will be observed that V_1 increases the internal resistance of V_2, μ_1 times. That is, V_2 tends to operate as a pentode, due to the reason that a large variation in potential at A in Fig. 1 produces only a small change in potential at C by virtue of the self-biasing action of V_1. This, in turn, produces only a small fluctuation in grid potential at V_2, and consequently the plate current variation is small. This closely resembles the action of a pentode, and it is to be noted this occurs without change in the original mutual conductance of V_2.

The expression adjacent to the brackets in Equation (13) represents the coefficient of the input voltage to V_2 and is proportional to μ_1.

On the assumption given in Equation (15), Equation (13) can be simplified to:

$$S = 1 + R_1/r_{a2} + g_{m2}R_1\left(\frac{R_3}{R_2 + R_3} \right) \ldots\ldots\ldots (16)$$

$$(g_{m2} = \mu_2/r_{a2})$$

thus showing that V_2 should possess a steep slope. Normally, triodes have steeper slopes than pentodes for the same anode dissipation, and a double-triode, with each section in parallel, serves extremely well in this stage.

Modified Circuit of Fig. 1.

The occasion sometimes arises where the load current is in excess of the current which can be taken by the valve or valves employed for V_1; but the excess is not so great that it merits the use of another valve in parallel. This can be met by the inclusion of a resistor connected between anode and cathode of V_1, which accommodates the excess current, provided the deleterious effect this has on the stabilization ratio, does not reduce the latter below that required.

This shunt resistor causes V_1 to behave virtually like a valve having an amplification factor equal to:

$$\mu_1' = \mu_1\left(\frac{R_4}{r_{a1} + R_4} \right) \ldots\ldots\ldots\ldots (17)$$

and internal resistance

$$r_{a1}' = r_{a1}\left(\frac{R_4}{r_{a1} + R_4} \right) \ldots\ldots\ldots\ldots (18)$$

where μ_1 = original amplification factor of V_1
r_{a1} = original internal resistance of V_1
R_4 = value of shunt resistor

the mutual conductance remains unchanged.

Equations (13) to (16) will then not apply, and rearranging Equation (12) in the form:

$$S = \frac{(r_{a2} + R_1)\{R_K + r_{a1}'(1 + R_K g_{m1})\} + \mu_1'\mu_2 R_1 R_4}{R_K\{r_{a2}(\mu_1' + 1) + R_1\}} \qquad \text{............ (19)}$$

indicates the effect R_4 has on the stabilization ratio.

A fully worked example will reveal more clearly the operation of this circuit than the foregoing equations.

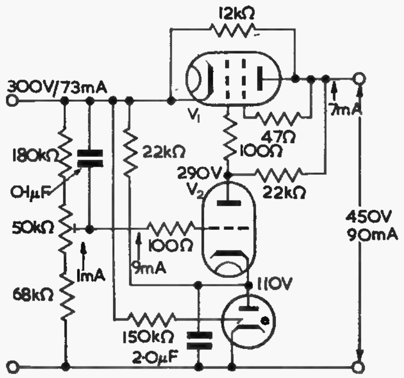

Fig. 3. Typical voltage stabilizing circuit employing shunt resistor R_4

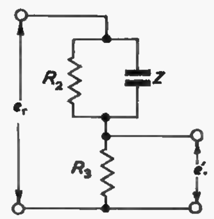

Fig. 4. Equivalent potentiometer network derived from Fig. 2

Capacitance is shunted across R_2 to increase hum voltage e'_r, applied to V_2 control grid.

The arrangement shown in Fig. 3 (which is now in operation), has the following circuit parameters:

$\mu_1 = 20$
$r_{a1} = 2{\cdot}5\text{k}\Omega$ (two valves in parallel).
$g_{m1} = 8\text{mA/V}$
$\mu_2 = 32$
$r_{a2} = 7\text{k}\Omega$ (two valves in parallel)
$R_K = 3{\cdot}62\text{k}\Omega = 300\text{V}/83\text{mA}$
$R_1 = 22\text{k}\Omega$
$R_4 = 12\text{k}\Omega$

V_2 has a quiescent bias of −4V and a constant cathode potential of 110V; hence the grid potential of this valve is 106V. The equivalent resistance from grid to ground, referred to the load resistance (see Equation (1)) is therefore:

$$R_3 = R_K \, . \, v_{g2}/v_{dc}$$
$$= 3\,620 \times 106/300$$
$$= 1\,280\Omega.$$

The equivalent amplification factor of V_1 with 12kΩ in parallel is (see Equation 17).

$$\mu_1' = 20\left(\frac{12 \times 10^3}{2{\cdot}5 \times 10^3 + 12 \times 10^3}\right) = 17{\cdot}5$$

and its equivalent internal resistance:

$$r_{a1}' = 2{\cdot}5 \times 10^3 \times 0{\cdot}875 = 2{\cdot}16\text{k}\Omega$$

Inserting these values in Equation (19) gives $S = 32{\cdot}4$ (it is of interest to note that with R_4 removed, $S = 33{\cdot}3$). When the mains supply causes V_{dc} to fall by 32·4 volts, then:

$$\begin{aligned}
\delta V_{dc} &= -32{\cdot}4\text{V}\\
\delta v_{dc} &= \delta V_{dc}/S = -1{\cdot}0\text{V}\\
\delta i_1 &= \delta v_{dc}/R_K = -1/3\,620 = -0{\cdot}276\text{mA}\\
\delta V_{a1} &= \delta V_{dc} - \delta v_{dc} = -32{\cdot}4 + 1 = -31{\cdot}4\text{V}\\
\delta i_1 r_{a1}' &= -0{\cdot}276 \times 10^{-3} \times 2{\cdot}16 \times 10^3 = -0{\cdot}6\text{V}\\
\mu_1'\delta v_{g1} &= \delta i_1 r_{a1}' - \delta V_{a1} = -0{\cdot}6 + 31{\cdot}4 = 30{\cdot}8\text{V}\\
\delta v_{g1} &= 30{\cdot}8/17{\cdot}25 = 1{\cdot}79\text{V (swinging positively)}\\
\delta V_{a2} &= \delta v_{g1} + \delta v_{dc} = 1{\cdot}79 - 1 = 0{\cdot}79\text{V}
\end{aligned}$$

also

$$\begin{aligned}
\delta V_{a2} &= -\delta i_2 R_1 + \delta V_{dc}\\
\delta i_2 &= -\left(\frac{\delta V_{a2} - \delta V_{dc}}{R_1}\right) = -\left(\frac{0{\cdot}79 + 32{\cdot}4}{22 \times 10^3}\right)\\
&= -1{\cdot}51\text{mA}\\
\delta i_2 r_{a2} &= -1{\cdot}51 \times 10^{-3} \times 7 \times 10^3 = -10{\cdot}57\text{V}\\
\delta i_2 R_1 &= -1{\cdot}51 \times 10^{-3} \times 22 \times 10^3 = -33\text{V}\\
\mu_2\delta v_{g2} &= -(\delta V_{a2} - \delta i_2 r_{a2}) = -(0{\cdot}79 + 10{\cdot}57) = -11{\cdot}36\text{V}\\
\delta v_{g2} &= -11{\cdot}36/32 = -0{\cdot}36\text{V}
\end{aligned}$$

This last result can be checked from:

$$\delta v_{g2} = \delta v_{dc} \, . \, R_3/R_K = -1{\cdot}0 \times \frac{1280}{3620} = -0{\cdot}36\text{V}$$

The quiescent values of voltage and current and their corresponding stationary values for $\delta V_{dc} = -32{\cdot}4\text{V}$ are, from the foregoing:

V_{dc} = 450V;	$V_{dc} + \delta v_{dc}$ =	450 − 32·4	= 417·6V
v_{dc} = 300V;	$v_{dc} + \delta v_{dc}$ =	300 − 1	= 299V
i_1 = 83mA;	$i_1 + \delta i_1$ =	83 − 0·276	= 82·72mA
i_2 = 7mA;	$i_2 + \delta i_2$ =	7 − 1·51	= 5·49mA
v_{g1} = −10V;	$v_{g1} + \delta v_{g1}$ =	−10 + 1·79	= −7·21V
v_{g2} = −4V;	$v_{g2} + \delta v_{g2}$ =	−4 − 0·36	= −4·36V
V_{a2} = 290V;	$V_{a2} + \delta V_{a2}$ =	290 + 1·79	= 291·8V
V_{a1} = 150V;	$V_{a1} + \delta V_{a1}$ =	150 − 31·4	= 118·6V

Hum Reduction

Since the circuit of Fig. 1 minimizes fluctuation in load voltage, it will be apparent that it also considerably reduces ripple voltage in the load. If the capacitor C_1 were removed, the reduction in hum would be in the same proportion as the reduction in load voltage variation; i.e. the ripple voltage E impressed at terminals A-B would be reduced S times in the load. This assumes that the stabilizer N in Fig. 1 maintains a ripple-free potential at V_2 cathode. As this is not quite true, the stabilizer is sometimes shunted as shown with a capacitor C_2, when a very low hum level is desired.

By connecting C_1 in parallel with R_2, the ripple voltage dropped across R_3 is increased. Reference to Equation (13) will show that this increases the ratio S to a new value $S_r = E_r/e_r$, where e_r is the ripple voltage in the load.

The ratio of the ripple voltage e'_r impressed on the control grid of V_2, to e_r is determined as follows. The impedance of R_2 and Z in parallel (see Fig. 4) is:

$$\frac{R_2 Z}{R_2 + Z}$$

hence the impedance across which e_r is impressed is:

$$Z_r = \frac{R_2 + Z}{R_2 Z} + R_3 = \frac{R_2 R_3 + Z(R_2 + R_3)}{R_2 + Z} \quad \text{.. (20)}$$

putting

$$Z = \text{j}KR_2 = -\text{j}X_c$$

where

$$X_c = 1/2\pi f C_1$$

$$Z_r = \frac{R_3 + \text{j}K(R_2 + R_3)}{1 + \text{j}K}$$

$$= \frac{R_3 + K^2(R_2 + R_3) - \text{j}KR_2}{1 + K^2} \quad \text{.......... (21)}$$

whence

$$e_r'/e_r = R_3/Z_r = \frac{R_3(1 + K^2)}{R_3 + K^2(R_2 + R_3) - \text{j}KR_2} \quad \text{.. (22)}$$

Usually C_1 is made sufficiently large, so that Equation (22) becomes effectively equal to unity. The ripple voltage ratio E_r/e_r then becomes equal to:

$$S_r = \frac{(r_{a1} + R_K\mu_1)(r_{a2} + R_1)}{R_K(r_{a2}\mu_1 + R_1)} + \mu_1\left(\frac{\mu_2 R_1}{r_{a2}\mu_1 + R_1}\right) \quad (23)$$

which approximates closely to $g_{m2}R_1$.

Logic and the Circuit Designer

By T. L. Craven*, B.Sc., A.M.I.E.E.

The increasing use of algebraic logic, or Boolean algebra, in the design of switching circuits must, one feels, cause the engineer to ponder on the nature of logic itself, a subject studied by the academics long before it found applications in technology. Accordingly, the aim of this article is to introduce Boolean algebra, and its uses, by way of some of the notions of the fascinating field of pure logic.

LOGIC concerns itself with the passage from evidence to conclusions, that is, with *inferences*.

Applied logic busies itself with the physical world about us. Is it true that all thunderstorms turn milk sour? What evidence do we require to make such a generalization? How do we test its truth? These are typical of the questions that applied logic seeks to answer.

Formal logic, which is the support of algebraic logic, is concerned with the nature or *form* of inferences, but is indifferent to their subject matter. The argument which runs "Some amplifiers are magnetic devices, therefore some magnetic devices are amplifiers" is to the formal logician no different from that which runs "Some X's are Y's, therefore some Y's are X's". He wishes to know nothing about amplifiers or magnetic devices. The argument, the inference, is the thing. Is it *valid* ? If so, what are the consequences of such validity ?

But first it is necessary to explain the word *valid*.

How often, when you have developed some argument, starting from what are known in logic as the *premises*, and arriving at what is known as the *conclusion*, must you have said that your conclusion followed *necessarily* from your premises. By that you had meant, perhaps not entirely consciously, that the conclusion followed from the premises simply because of the nature or the form of the argument, and not in any way because of its subject matter. You further meant that, while you did not guarantee that your premises were true, you insisted that your hearers, if they should choose to accept them as true, must then perforce regard the conclusion as true. And such is the point of view adopted when an argument is spoken of as being valid.

Validity is not the same thing as truth. The following arguments are all of the same form, and it is a valid one:

All humans are mortals
All logicians are humans
∴ All logicians are mortals.

All olotoxes are popocols
All quintopods are olotoxes
∴ All quintopods are popocols.

All Y's are Z's
All Xs' are Y's
∴ All X's are Z's.

All males are rascals
All engineers are males
∴ All engineers are rascals.

The first argument makes true statements, the second speaks of imaginary things, the third is purely abstract, and the fourth, one hastens to say, makes false statements. All, however, are valid. Of each one can say that, if the premises are true, then so, necessarily, is the conclusion.

Of such matters does formal logic treat, epitomizing the nature of validity in the statements that, in a valid argument, if the premises be true, then the conclusion must be true, and if the conclusion be false, then something in the premises must have been false.

Testing for Validity

We have now seen what validity is, and the bearing it has on implications of truth and falsity in the constituent statements of arguments. It is not enough, however, that logic should study such topics, for there remains also the matter of deciding whether any particular argument is or is not valid.

Logic has many rules for making such a decision. One of them, to give an example, is that we must not in the conclusion speak of "*all* X's" if in the premises we have only been presented with statements about "*some* X's". To do so would be to widen unjustifiably the scope of the available evidence.

It is this rule which tells us that it is not valid to argue

from All men are bipeds (premise)
to All bipeds are men. (conclusion)

For in the conclusion we speak of *all* bipeds. In the premise, however, we have not done so, for the premise merely states "All men are some (and only *perhaps* all) of the bipeds in the universe.

From "All men are bipeds" we may therefore only infer that "some bipeds are men".

It is probably felt, though, that these arguments could well have been dealt with by common-sense, and that logic is being tedious; it must be remembered, however, that logic is not attempting to compete with common-sense, but is merely exploring a field of study. And common-sense is not always a very efficient weapon. Can you say with certainty whether or not it is valid to argue

from Some quintopods are not men
to Some men are not quintopods ?

Think it over before you read on!

The answer is that the argument is not a valid one. It is invalid because in the premise we only speak of *some* quintopods, whereas in the conclusion we speak of *all* quintopods. You will be able to appreciate that better if we make our "some men" in the conclusion rather more specific. Let us suppose that, when we say "some men", we have in mind Tom, Dick and Harry. Then our conclusion really says that *all* quintopods have the property of not being Tom, Dick or Harry.

This may help to convince you—the true statement "Some humans are not engineers" does not imply that "Some engineers are not humans"!

Relationships—and Contradictions

We turn now to an intriguing branch of formal logic which has a direct counterpart in switching circuits. This is the study of *contradictory* statements.

Two statements are said to be in contradictory relationship to each other when they are such that they cannot

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both be true and cannot both be false, so that one must be true and the other false.

It is so easy to regard statements as contradictory when they are not so, that it will be better to consider first some relationships that are not contradictory though deceptively near it.

Consider Fig. 1. It will be readily seen that (A) and (E), though they cannot both be true, do not satisfy the definition of contradictories because they can both be false (if some, but not all, men are fools). They are said to be in *contrary* relationship to each other.

Nor are (I) and (O) contradictories for, while they cannot both be false. they can both be true. They are in *sub-contrary* relationship to each other.

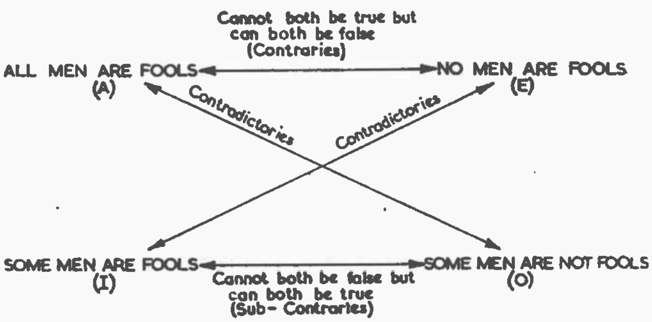

Fig. 1. Contraries, sub-contraries and contradictories

The true relationship of contradiction holds between (A) and (O), and likewise between (E) and (I). (A) and (O) cannot both be true, nor can they both be false. One must be true, the other false.

Where two statements are contradictory, then a knowledge that either one of them is true or false enables one to infer validly that the other is, respectively, false or true. Contradictories, therefore, stand in a more fruitful relationship for the making of inferences than do either contraries or sub-contraries. It a statement is true, one can infer that its contrary is false, but if a statement is false, one can infer nothing about the state of its contrary; a complementary shortcoming applies with sub-contraries.

Contradiction begins to be really intriguing when one turns to the study of *compound* statements. Each of the statements we have considered so far has made a single assertion, but a compound statement makes two or more assertions in combination. The two types of compound statements that are of greatest interest to us are exemplified thus:

(a) It was wet AND it was windy
(which is called an "AND" statement),

and (b) EITHER he is hungry OR he is greedy
(which is called an "EITHER/OR" statement).

What do you think is the contradictory of "It was wet and it was windy ?" Would you hazard a guess that it is "It was not wet and it was not windy ?" But those two statements are not contradictories, for it is possible for them *both* to be false (if it was wet but not windy, or if it was not wet though windy!).

So we shall have to look further afield and turn to a theorem propounded by Augustus de Morgan (English mathematician and logician, 1806-1871) for guidance.

De Morgan's theorem tells us that the contradictory of an "AND" statement is formed by contradicting its two halves and recombining them as an "EITHER/OR" statement—and vice versa. The respective contradictories of our two original examples (a) and (b) are, therefore

(α) Either it was not wet or it was not windy,

and (β) He is not hungry and he is not greedy.

On consideration it will be seen that

if (a) is true, (α) must be false,
if (a) is false, (α) must be true,
if (α) is true, (a) must be false,
if (α) is false, (a) must be true,

and that similar implications hold between (b) and (β).

The circuit (see Fig. 2) which is completed by the closure of switches A and B is broken by the opening of either A or B. That which is completed by the closure of either A or B requires, for its breakage, the opening of both A and B. Do you see, in each case, the likeness to De Morgan's theorem ?

Algebraic Logic and Switching Circuits

Algebraic logic was not invented with any technological application in mind, but is a recent development of pure logicians. It is an attempt to devise a symbolism, and rules for the manipulation of the symbols, whereby problems in logic can be set out and solved in a manner akin to that of algebra. (The name "Boolean algebra" is a tribute to the contributions of another English mathematician and logician, George Boole, 1815-1864.) It will be described

Fig. 2. Illustration of De Morgan's theorem

first from the point of view of the logician, and it will then be shown how it can be applied to switching circuits.

First, the symbolism. A suitable way of writing "Both A and B", which is itself an abbreviation of a statement like "It was wet (A) and it was windy (B)", is

AB, (as if multiplying),

and of writing "Either A or B",

A + B, (as if adding).

We can carry this principle further so that, for example. "A and either B or C" is written as

A(B + C)

A stroke through a letter can be used to denote negation. Thus:

$\not{A}$ means "not A"

These symbols will suffice for our needs, but now we must have rules for their manipulation. Here are some of them:

(A+C)(B+D)	= AB+AD+CD+CD	Rule 1
A+AB	= A	Rule 2
A(A+B)	= A	Rule 3
A+A	= A	Rule 4
AA	= A	Rule 5
A+$\not{A}$	= 1	Rule 6
A$\not{A}$	= 0	Rule 7

Rule 1 tells us that expressions in brackets can be multiplied together as in ordinary algebra. We can demonstrate it if we let A stand for, say Australians, B for Builders, C for Canadians and D for Decorators. Then the equation says (left-hand side) that all the people who are either Australian or Canadian and also either Builders or Decorators comprise the same group as do (right-hand side) all the people who are either Australian Builders or Australian Decorators or Canadian Builders or Canadian Decorators !

Rule 2 is quite different from normal algebraic practice and is one that often enables one to simplify an expression in algebraic logic. This particular example can be regarded as an exemplification of the fact that all the people who are either Australians or Australian Builders are no more or less than all the Australians. A similar counterpart can be found for rule 3.

Rules 4 and 5 are readily acceptable. "Either A or A" is the same thing as "A". So is "Both A and A".

Rule 6 expresses the logical principle that "everything must be either A or not A, no matter what A may be". Therefore, a collection of all the things that are either A or not A, i.e., $A + \not{A}$, consists of the entire universe, which we call "1". So $A + \not{A} = 1$.

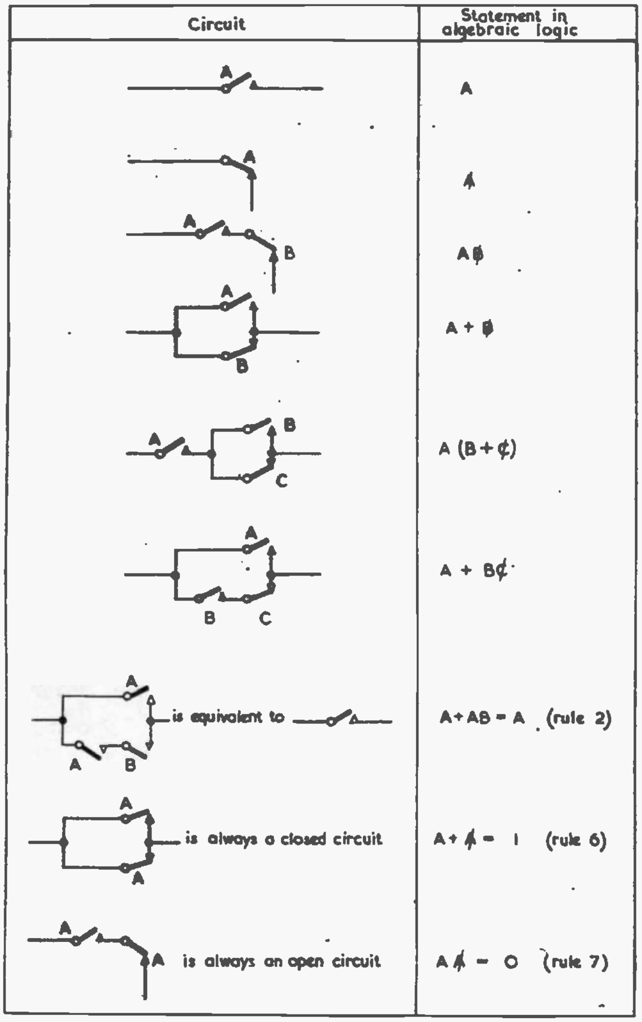

Fig. 3. Some circuits and their representation in algebraic logic

And lastly, in rule 7, $A\not{A} = 0$, we have a statement of the principle that nothing can be both A and not A.

We have already observed that formal logic exhibits a complete generality, so that once we have satisfied ourselves that an argument is valid we can use it to talk about any specific things, be they real or imaginary. This same generality allows us to use the symbols of algebraic logic in describing switching circuits, and to use the theorems or rules in designing them.

An immediate start can be made once we have agreed to represent normally-open and normally-closed relay contacts by A and $\not{A}$ (or any other letter as appropriate) respectively, to write parallel branches as if they were added, and series branches as if they were multiplied. Fig. 3 shows some circuits and their representations in algebraic logic.

Some authorities prefer to use addition for series branches and multiplication for parallel branches. This makes some of the working more difficult, some easier, but does not affect the general principles. The choice of convention is analogous to the choice between working with resistances or with conductances.

The value of algebraic logic in the design of switching circuits springs from the fact that the rules for manipulation of the symbols enable one in many cases to effect a considerable simplification of an expression in algebraic logic, with an equal simplification of the circuit to which it corresponds.

Suppose that one wishes to simplify the circuit of Fig. 4(a), which embodies contacts of relays, A, B, C and D.

The circuit is expressed in algebraic logic, using our agreed symbolism, as:

$$AC + (\not{A} + \not{D})(B + C) + C(B + \not{A}D).$$

This equals, on multiplying out the brackets by rule 1,

$$(AC + \not{A}B + \not{A}C + B\not{D} + C\not{D} + BC + \not{A}CD$$

$$= (A + \not{A})C + \not{A}B + B\not{D} + C\not{D} + BC + \not{A}CD$$

$$= C + \not{A}B + B\not{D} + C\not{D} + BC + \not{A}CD$$

Since $A + \not{A} = 1$, by rule 6

$$= C + \not{A}B + B\not{D}$$

Since $C + C\not{D} + BC + \not{A}CD = C$, by rule 2

$$= C + B(\not{A} + \not{D})$$

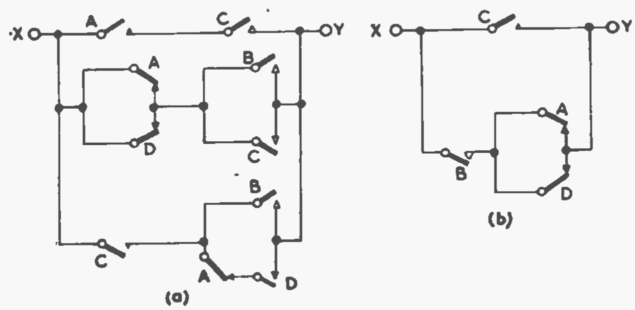

Fig. 4. The initial circuit and the simplified arrangement

No further simplification is possible and so the final expression is converted into circuit form to obtain Fig. 4(b). This uses only four contacts instead of the original ten, but the two circuits are equivalent in the sense that, for any given condition of the relays A, B, C and D, the path from X to Y will be open or closed in Fig. 4(b) according to as it is open or closed in Fig. 4(a).

The circuit designer would have arrived at Fig. 4(b) quite easily without the aid of algebraic logic. This particular example has been given only because it is simple, brings in three of the rules and shows how very effectively this new technique produces the right answer; but if the reader cares to pursue the subject further he will find, in current literature, examples of the use of algebraic logic as an effective method for the development of complex switching circuits.

Conclusion

An attempt has been made to show some aspects of that science which stands in the background of algebraic logic, and which is called formal logic. It is hoped that this will have been found interesting, and that the later remarks on the application of algebraic logic to switching circuit design will have given the reader an introduction sufficient to enable him to attack, without hesitation, further treatizes on the subject.

A Differential Input-Stage for Low-Frequency Amplifiers

By V. H. Attree*, B.Sc.

An A.C. *coupled differential input-stage is described in which the ratio of in-phase to anti-phase gain (i.e., the "transmission-factor") is theoretically infinite. In a practical circuit the measured transmission-factor is* 10 000 *at an in-phase signal level of* 1·0*V* R.M.S. *The frequency response is* 0·1-20 000*c/s which is sufficient for most applications in engineering and biology.*

A LOW-FREQUENCY amplifier is often required to measure a small anti-phase signal in the presence of a large in-phase interfering voltage. The usual type of input-stage for such an amplifier consists of two triodes with a common cathode load[1,2]; one of the requirements for good rejection of in-phase voltages is a high value of cathode resistance which can be obtained by using the A.C. resistance of a pentode valve as the cathode load. An amplifier with this arrangement was described by Johnston[3]. Unfortunately the balance also depends on the difference between the amplification factors (μ) of the two triodes and, as pointed out by Harris and Bishop[4], this effect may cause the performance to be very much worse than would be expected from an analysis based on the assumption that μ was the same for both triodes. The problem was further discussed by Parnum[5] who suggested a new term "transmission-factor" for the ratio between in-phase voltage and the anti-phase signal required to give the same output. Parnum[5] and McFee[6] have both proposed equalizing the μ's of the valves by anode to cathode feedback while Davis[7] employs a potentiometer in the grid of one of the valves. The use of the potentiometer has the objection that it sets a limit on the input impedance and gives an appreciable phase unbalance which will affect the performance. It is important to note that the transmission-factor will in general fall at high signal-levels, due to overloading, and therefore the in-phase voltage at which it is measured should be given.

In the present circuit the signals from the two inputs are fed to the grid and cathode of a triode in such a ratio that, when they are in phase, the triode output is substantially zero. This principle is essentially that of the μ bridge stabilizer[8] which is often used for regulating photomultiplier E.H.T. supplies[9]. The application to a differential input-stage appears to have been first described by Conrad[10].

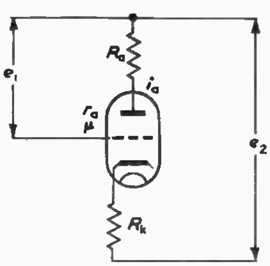

Fig. 1. Circuit operation

Circuit Operation

The rejection of in-phase signals is obtained in the manner shown in Fig. 1. One signal is applied to the grid of a triode and the other to the negative end of the cathode load. The anode current is:—

$$i_a = (\mu/r_a)\,[e_2 - e_1 - i_a R_k] + (1/r_a)\,[e_2 - i_a (R_a + R_k)]$$

If i_a is to be zero then we have the exact relation $\mu e_1 = (\mu + 1)\, e_2$ i.e., the balance depends only on μ which, in a given valve, is constant over a wide range of anode currents. In the practical circuit the voltages e_1 and e_2 are obtained from cathode-followers: this enables the necessary adjustment of the ratio e_1/e_2 to be made with a low-valued potentiometer.

Differential Input-Stage with Single-Sided Output

The circuit diagram of the differential input stage is shown in Fig. 2. The two halves, V_1 and V_2 of the 6SN7

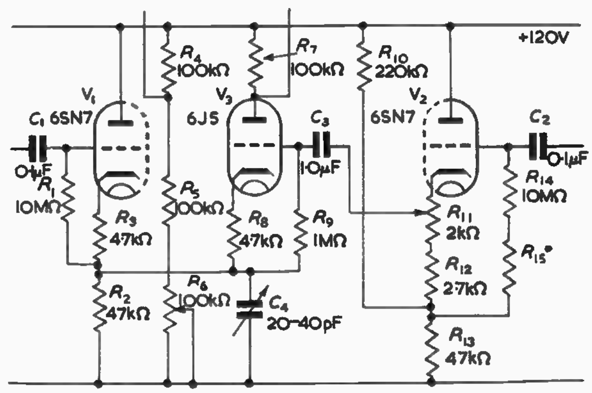

Fig. 2. Differential input stage with single-sided output

R_{15} = O – 2MΩ selected to match components.

provide the cathode and grid signals for the bridge valve V_3. The required ratio for zero output from V_3 anode, with an in-phase signal to V_1 and V_2, is set by adjustment of the 2kΩ potentiometer R_{11} in V_2 cathode. The anode current of V_3 is 0·3mA while V_1 and V_2 each take 0·7mA. The 220kΩ resistor R_{10} provides a current in V_2 cathode resistor R_{13} equal to the anode current of V_3; this equalizes the currents in R_2 and R_{13} and ensures that the D.C. operating conditions in V_1 and V_2 are similar. The capacitors C_1, C_2 and C_3 must have high insulation and low dielectric absorption and should be either 500-1 000V paper-dielectric or, better, of the plastic-film type.

Over the middle part of the frequency range the phase-change in the coupling time-constants, and at V_1 and V_2 cathodes, is negligible and an exact null-balance may be obtained at the output. However, at both high and low frequencies phase-change becomes of importance and it is necessary to provide for phase balancing in order to

* *Fluid Motion Laboratory, University of Manchester.*

maintain a high transmission-factor. One side of the heaters is earthed so that the heater-cathode capacitance of V_1 and V_3 appears across R_2. The capacitance across R_2 is somewhat smaller than the total across R_{13} which includes the stray capacitance of the metal-cased 1·0μF capacitor C_3. Capacitance balance is obtained by the 20-40pF trimmer C_4. When the amplifier is fed with an in-phase signal the voltage across R_2 is $\mu_3 K$ (where K is a constant) and the voltage at V_3 grid is $(\mu_3+1)K$. Thus the current in the 1MΩ grid leak R_9 is K/R_9, instead of the much greater current of $K(\mu_3+1)/R_9$ which would be obtained if R_9 were returned to a point of zero A.C. potential. The effective time-constant of the coupling capacitor C_3 and the leak R_9 is therefore (μ_3+1) times C_3R_9, or about 20sec. At 10c/s the phase-change in this time-constant is 1/1 256 radians or 1/20 degree and will be large enough to reduce the transmission factor from better than 10 000 down to about 1 000. Low-frequency phase correction is obtained by the resistor R_{15} in series with V_2 grid leak R_{14}; R_{15} also corrects for any small difference between the input time-constants. The correction is necessarily approximate, as it assumes that the phase-frequency relation of the two-stage network to V_3 grid can be made the same as that of the one-stage network to V_3 cathode. The phase-change in the coupling on V_3 grid is smaller than in the coupling to V_1 and V_2 as the leaks R_1 and R_{14} are "multiplied" to a lesser extent than R_9, so that in practice the input stages predominate and a good balance may be obtained over a wide frequency range. It is unnecessary to make R_{15} a variable control as the required resistance depends mainly on component tolerances and is little affected by valve changes. When setting up the circuit initially it is convenient to adjust R_{11} at 500c/s, C_4 at 10kc/s and R_{15} at 10c/s.

Although the circuit gives almost complete rejection of in-phase signals fed to V_1 and V_2 it provides very little attenuation of disturbances appearing on the 120V H.T. line. This is of no importance when the H.T. is taken from a well-screened dry battery but may be troublesome if it is derived from the supply mains. Where the subsequent amplifier has a balanced input a considerable reduction in supply ripple (about 100 times) may be obtained by connecting one side of the main amplifier to the junction of R_4 and R_5 instead of to earth. The circuit may be balanced for H.T. changes by injecting a small ripple voltage (1-10mV) into the H.T. lead and adjusting R_6 for minimum output from the main amplifier.

Performace

The gain of the stage for a signal applied to either V_1 or V_2 is about four times. The frequency response is substantially constant from 0·25c/s to 10kc/s; it is 3db down at 0·1c/s and 20kc/s. The transmission-factor is 10 000 for an in-phase input of 1·0V R.M.S. so that a signal of 1·0V applied to both grids gives the same output as 100μV applied to either grid separately. The transmission-factor falls as the in-phase signal is increased until, at 10V R.M.S. (28V peak-to-peak), it is 1 000. A 10 per cent change in the H.T. voltage (120-108V), or in the heater voltage (6·3-5·7V), have practically no effect on the transmission-factor. Increasing the H.T. impedance to 100Ω reduces the factor to about 3 000 (at 1·0V R.M.S.) but the original value of 10 000 or better may be restored by re-adjustment of R_{11}. The transmission-factor is uniformly high over the frequency band 5c/s-10kc/s; at very low frequencies it deteriorates by an order of magnitude. This falling off of the transmission-factor is unimportant as the in-phase interfering voltages are nearly always due to the supply mains.

Differential Input-Stage with Balanced Output

The circuit given in Fig. 2 may be modified to the symmetrical arrangement of Fig. 3 which has two bridge

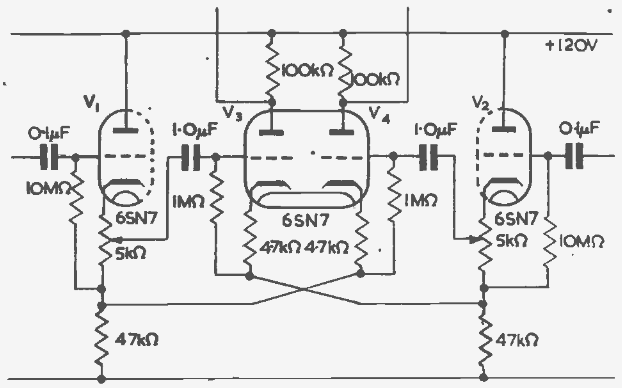

Fig. 3. Differential input stage with balanced output

valves cross-connected between the input cathode-followers. This gives a balanced output and reduces the effect of ripple from the 120V H.T. line. A similar circuit, but with D.C. connexion, has been described by Van Scoyoc and Warnke[11]: this amplifier did not have adjustment for the ratio of the grid and cathode signals on the bridge valves and hence the transmission-factor of the first stage was relatively low. The control on V_1 in Fig. 3 is set to give zero output from V_3 with an in-phase signal to V_1 and V_2 while the similar control on V_2 balances V_4. The use of two balance controls complicates the setting procedure and for this reason the circuit of Fig. 2 which requires only one control, is usually better in practice, although it gives a single-sided output.

Applications

The differential input-stage was originally used in this laboratory for coupling a bimorph crystal microphone to a single-sided A.C. amplifier. The microphone was used in some experiments on the aerodynamic noise associated with a turbulent air-flow. The frequency range of interest was 50-1 000c/s and the input capacitors C_1 and C_2 were 0·01μF mica dielectric. For biological work good low-frequency response is usually required and this is obtained fairly easily in the present circuit. In the particular case of electrocardiograms the desirable low-frequency response has been discussed by Dawson[12], Katz[13] and by Nickerson[14]. The response should be roughly equivalent to that of a single time-constant of two seconds so that the differential input-stage of Fig. 2 may be used prior to a conventional electrocardiograph in order to improve the discrimination against mains-frequency interference.

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LETTERS TO THE EDITOR

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

A Direct Reading Thermistor Bridge

DEAR SIR,—In Messrs. Pearson and Benson's article in your February issue, there appear to be several mathematical errors.

(a) assuming $\delta \ll A$ equation (3) should read:

$$I_g = \frac{E\,\delta}{4A(A+R_g)}\left(1+\frac{\delta}{4(A+R_g)}\cdot\frac{3A+2R_g}{A}\right)$$

However, from equation (4) using the authors' figures,

$$\delta = \frac{\partial R}{\partial P}\Delta P = 99{\cdot}2\Omega$$

where the increase of power, dissipated in the thermistor, ΔP = 2mW.

The graph (Fig. 2) shows this to be of the right order. This clearly does not satisfy the condition $\delta \ll A$ (where A = 300Ω).

(b) The authors' numerical substitution to obtain the second term of equation (3) gives 0·14, not 0·0014 as stated; moreover, using the correct expression for this term the value would become 0·20. This cannot be neglected compared with 1.

(c) Since δ is comparable with A, the change in D.C. power, when R.F. power is applied, must also be taken into consideration. It can be shown from an analysis of the bridge that the D.C. power W_{DC} dissipated in the thermistor is given by:

$$W_{DC} = \frac{A}{4}\left[\frac{E}{A}+I_g\left(3+\frac{2R}{A}\right)\right]\left[\frac{E}{A}-I_g\left(1+\frac{2R}{A}\right)\right]$$

where E = voltage across bridge. substituting the authors' values for A and R_g

$$W_{DC} = 75\left[\frac{E}{300}+6{\cdot}33\ I_g\right]\left[\frac{F}{300}-4{\cdot}33\ I_g\right] \quad \ldots\ldots\ldots\ldots\ldots \text{(A)}$$

For balance $W_{DC} = \dfrac{75E^2}{(300)^2}$ .... (B)

From Fig. 2 at 21°C. the power dissipated in the thermistor to give a resistance of 300 ohms.

$$W_{DC} = 9{\cdot}5\text{mW}.$$

hence from equation (B)

$$E = 3{\cdot}38 \text{ volts.}$$

It can be shown that:

$$I_g = \frac{E\,\delta}{4A\ (A+R_g)-(3A+2R_g)\delta}$$

$$I_g = \frac{E\,\delta}{960-1{\cdot}9\,\delta}\text{mA}$$

In paragraph (2) it was shown that δ = 99·2Ω for an increase in the total power dissipation in the thermistor of 2mW; therefore assuming E is constant:

$$I_g = 434\mu\text{A}$$

Using this value of I_g, the D.C. power dissipated in the thermistor from equation (A) is 9·88mW, giving an increase in D.C. power of 0·38mW. Hence the R.F. power required to increase the total power by 2mW is 1·62mW, assuming a constant-voltage generator.

From the authors' equation (6):

$$\frac{I_g}{\Delta P} = \frac{E\ \partial R/\partial P}{4A\ (A+R_g)} = 175\mu\text{A/mW}.$$

where ΔP = microwave power.

Putting I_g = 434μA, the microwave power would be 2·48mW. The correct value has been shown to be 1·62mW. Thus the total error involved in equation (6) is 53 per cent for the values considered.

Yours faithfully,

W. B. W. ALISON,
J. C. E. TAYLOR,
Teddington,
Middlesex.

The authors' reply:

DEAR SIR,—We thank Messrs. Alison and Taylor for pointing out that there is an error in our numerical substitution to obtain the second term of equation (3) and also that there is a factor of 2 missing from this term.

The fundamental accuracy of the bridge depends, however, on a practical check and not on equations (5) and (6) which are derived from equation (3).

When the bridge is balanced, with no microwave power in the thermistor, the meter-arm current is zero. Our meter-and-shunt arrangement was calibrated against a sub-standard instrument so that a current of 300μA gave full-scale deflexion with 25Ω of the 50Ω variable resistor in circuit. When the bridge was built it was checked so that 2mW of microwave power gave a full-scale deflexion on the meter. Thus we have two points on the graph of microwave power against meter deflexion, i.e., the origin 0 and point P (Fig. A). We have

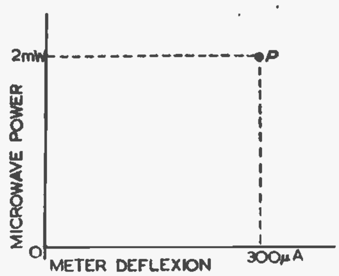


Fig. A. Graph of microwave

assumed that between 0 and P the graph is reasonably linear. If Messrs. Alison and Taylor's observations have a great effect then this curve will be markedly non-linear between 0 and P. Also, if it is, the bridge must be calibrated for the full range of the meter scale before use.

We have, therefore, checked our bridge theoretically for non-linearity by using equations (12) and (13) to find e_t and i_t for various values of I_g (assuming a constant temperature) and then putting e_t and i_t into equation (11) to find the resulting microwave power P_t. In this way we can determine whether P_t is proportional to I_g and if not then the extent of the non-linearity. Fig. B shows the result of these calculations assuming the temperature to be 21°C. It will be seen that the graph is not absolutely linear but the largest deviation, assuming points 0 and P are correct is around I_g = 150μA and amounts to about 4 per cent.

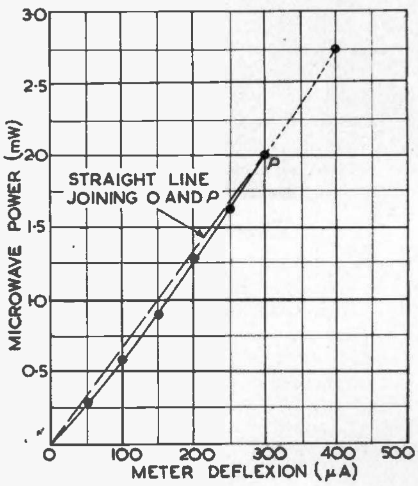


Fig. B. Result of calculations

It should be remembered that the bridge is not intended to be an accurate laboratory instrument but one for use as a portable power-checking device where absolute accuracy, although desirable, is not essential. It could be used as an accurate instrument, however, if it was calibrated all the way up the scale instead of just at one point.

In Messrs. Alison and Taylor's calculations given under section (c) it is assumed that there is a constant-voltage generator across the bridge and they ignore the fact that the bridge calibration was checked practically when a microwave power of 2mW was being dissipated in the thermistor. In our final design the voltage actually applied to the bridge is far from constant because of r and D.

We should like to take this opportunity of mentioning that there are two misprints in the article:—

(1) the voltage across the bridge should be 105V as stated on page 56 and not 150V as shown on Fig. 11.

(2) E' in equations (12) and (13) should be defined as $E/\ (1+r/D)$ and not $E/\ (1+r/R)$ as given on page 54.

Yours faithfully,

R. M. PEARSON,
F. A. BENSON,
Department of Electrical Engineering,
University of Sheffield.

Corona Discharge Tubes

DEAR SIR,—The article in your January issue by Mr. E. E. Shelton and Mr. F. Wade is interesting in connexion with the use of discharge tubes for interstage coupling in D.C. amplifiers. It has been pointed out by Miller[1] that the ordinary voltage stabilizer tube will function as a constant-voltage device for currents as small as 10 or 20μA, although the manufacturers' data on the tubes he used states that a current of 5mA is necessary to ensure stable operation.

The description in your January issue of the different types of discharge appears to explain the discrepancy. When the tubes are operated at 10 or 20μA a corona discharge presumably occurs, and larger currents produce the cathode-glow discharge. A substantially constant voltage over a range of current values results from either type of discharge, but we should expect to find a range of current somewhere between 20μA and 5mA over which the voltage falls sharply with increasing current.

I have made a few tests on stabilizer tubes which tend to support these conclusions. Some tests were made with VR105 tubes since these have been used in D.C. amplifiers by Harris[2] and others. A used tube of this type, of American manufacture, had the expected characteristics. The voltage across it was approximately the ignition voltage from zero current to about 0·3mA. At this current a bright spot appeared on the cathode (at lower currents a faint glow was seen near the anode) and the voltage fell to a value in the region of the normal running voltage.

On the other hand, two new tubes type VR105, of British manufacture, were found to have an ignition voltage very close to the running voltage, and no abrupt voltage change was observed between zero current and the normal operating current. In these tubes it was not possible to observe the discharge as the mica end plates were not sufficiently transparent.

The expected behaviour was shown very clearly by tubes, type 7475, in which the critical current for the change from corona to cathode-glow discharge was about 10μA. It is clear that when discharge tubes are used either as stabilizers or in D.C. amplifiers, the operating current should not be allowed to approach the critical value, though it may be either higher or lower.

In my letter which you published in your issue for August, 1952. I referred to the lack of information about the A.C. impedance of stabilizer tubes at high frequencies. I have since discovered that Iannone and Baller[3] give information about the impedance of the VR75, VR90, VR105 and VR150 at frequencies up to 20kc/s.

Yours faithfully,

A. M. ANDREW,
The University,
Glasgow.

REFERENCES

1. MILLER, S. E., Sensitive D.C. Amplifier with A.C. Operation, *Electronics*, p. 27 (Nov., 1941).
2. HARRIS, E. J., An Electrometer Impedance Convertor, *Electronic Engng. 23*, 109 (1951).
3. IANNONE, F., BALLER, H., Gas-tube Coupling for D.C. Amplifiers, *Electronics* p. 106 (Oct., 1946).

The authors' reply:

DEAR SIR,—Dr. Andrew's letter suggesting the application of corona discharge tubes as interstage couplings in D.C. amplifiers is of considerable interest. We would, however, like to point out that some difficulty may be encountered due to the generation of noise in the tube.

The bright spot to which Dr. Andrew refers in a VR105 operating at a current of 0·3mA, would appear to be caused by a sharp point giving rise to a local glow discharge prior to the spread of the glow discharge over the whole cathode surface.

Yours faithfully,

E. E. SHELTON,
F. WADE,
Hounslow,
Middlesex.

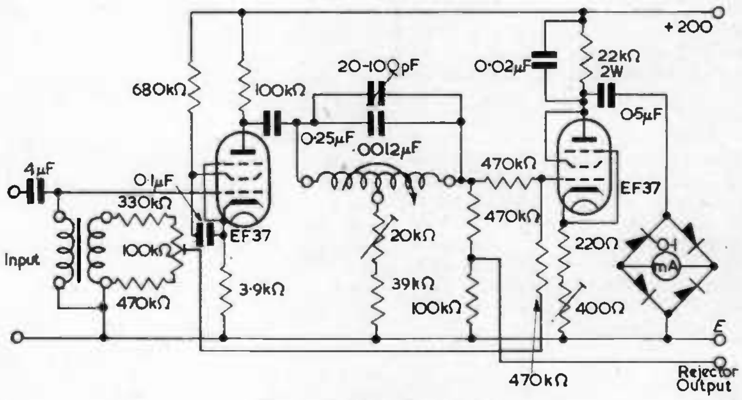


Fig. 1. The complete circuit

A Selector Rejector Circuit for a 3·2kc/s Pilot Signal

DEAR SIR,—Where a fixed frequency pilot signal is used in a transmission scheme for assessing the correct operation of apparatus, the need often arises to measure the level of the pilot signal and also to remove it from the transmitted frequency spectrum. This can be accomplished with a band-stop and a band-pass filter, however, in the circuit about to be described, a single frequency rejection filter is used for both operations.

Fig. 1 shows the complete circuit. The incoming signal, that is, speech plus a 3·2kc/s tone is applied to the control grid of an amplifying valve and the primary winding of a transformer. A bridged-T rejection filter in the anode circuit of this valve removes the pilot tone from the speech signal and this is available, through a resistance pad, for audible monitoring or re-transmission.

The secondary winding of the input transformer supplies a signal out of phase and equal in amplitude to the output of the rejection filter. These signals are combined in another resistance pad and applied to the control grid of a triode connected stage for measurement by a rectifier meter. Thus, at frequencies other than the rejection frequency of the filter, cancellation occurs, and no signal is presented to the control grid of the triode. At the rejection frequency, however, only the signal from the input transformer is available and this is measured by the meter.

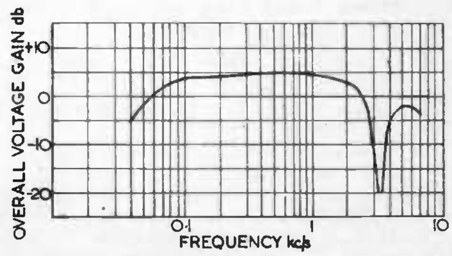


Fig. 2. Frequency characteristic of rejector path
Source and impedance 300Ω

The curves of Figs. 2 and 3 show the results obtained for both paths. In practice, the coupling capacitor between the first valve and the filter determines the frequency at which maximum cancellation takes place and hence, the rapidity of cut-off from the frequency of peak meter reading. The capacitor in this case provides maximum cancellation at about 400c/s and the potentiometer across the secondary of the transformer assures equality of amplitude.

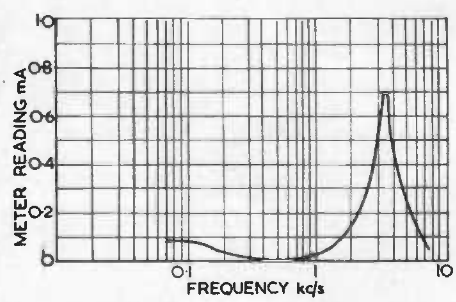


Fig. 3. Frequency characteristic of meter path
Input level 16·4 db REL 1V. Source impedance 300 Ω

A centre tapped inductance of 1·8H was used in the filter, the rejection frequency being adjusted by the trimmer capacitor and the balance by the parallel arm variable resistor. Initial calibration of the meter could be effected by a variable bias resistor in the triode stage. The transformer used had a ratio of 1 : 16 and a primary inductance of 2H at 50c/s.

Yours faithfully,

E. J. MILLER,
P.O. Research Station.

BOOK REVIEWS

Strain Gauges Theory and Application

By J. J. Koch, R. G. Boiten, A. L. Biermasz, G. P. Roszbach and G. W. Van Santen. 101 pp., 26 figs. Demy 8vo. Philips Technical Library. Elsevier Press Inc., New York, Cleaver Hume Press Ltd., London. 1952. Price 16s.

THIS little book has been produced "with the intention of providing . . . a concise but comprehensive description of the technique of measuring with strain gauges and everything appertaining thereto". The authors jointly have clearly had a great deal of practical experience in this field, and what they have to say is mostly accurate and to the point. It is a pity that not all the techniques are described in sufficient detail, and that the accuracy of the information is not maintained throughout. For example, on page 80 a method is given of constructing Mohr's strain circle from rosette data, and this is quite erroneous. The careful reader will be able to make the necessary change in the construction, but the need for this is unfortunate.

A general criticism of this book is that it refers with very few exceptions to gauges and apparatus manufactured by Philips Industries, and in places reads like a sales leaflet rather than a book of technical interest. The illustrations frequently have captions which refer to a Philips catalogue number, and a search in the text is required to amplify the caption. There is no bibliography or detailed index.

The chapter on the technique of cementing and connecting strain gauges is perhaps the best, the author having drawn on an intimate knowledge of the necessity for careful preparation. That dealing with the theory of elastic deformation is unduly elaborate, as it begins with the 3-dimensional case and later simplifies the theory to describe the 2-dimensional stress field. Since strain gauges can act in two dimensions only, this might have been done at the outset. A chapter on measuring instruments employing strain gauges is interesting. No effective discussion of slip ring problems appears.

J. YARNELL

Electronic Analogue Computors

By Granino A. Korn and Theresa M. Korn. 378 pp., 181 figs. Royal 8vo. McGraw-Hill Book Co. Inc. 1952. Price 59s. 6d.

THIS book deals with D.C. electronic analogue computors suitable for use as differential analysers and simultaneous equation solvers. The basic computing elements are adding devices (summing amplifiers), multipliers, integrators, and special function generators such as sine-law potentiometers. (Differentiators present certain practical snags, and fortunately it is usually possible to arrange computations so that their use is not necessary). The first chapter is a summary of the whole book, is excellently written, and can be thoroughly recommended to anyone wishing to obtain an overall picture of the principles, practices, and powers of this type of computor without going into much detail.

The dual authorship is clear from the text. Those chapters which deal with general principles and with the use of the machines are written clearly and go into considerable detail. They will be of great value to those who use or hope to use such computors. However, many readers might be rather dismayed by the freedom with which the operator P, defined as $d/d\tau$ (τ being time), is used, particularly in Chapters 4 and 5, and further explanation of this operator is desirable.

The chapters dealing with the design of the computing elements, which are of more interest to electronic engineers, are less satisfactory. The standard of the electronics presented is curiously uneven. For example, in Chapter 5 the elementary principles of the design of an amplifying stage are given, whereas in the same chapter there is a discussion of the stabilization of feedback amplifiers which will be beyond the mathematical ability of many competent practical engineers.

There is also some lack of performance figures. For example, there is nowhere any indication of the order of time-constants obtainable with feedback integrators. The accuracies obtainable with some of the other types of computing elements are, however, given.

One or two other criticisms may be briefly mentioned. The circuit diagrams are not well drawn on the whole; but this tends to be a common failing with American publications. More use might have been made of equivalent circuits, and more mention should have been made of photo-electric curve-followers, which are in fairly common use as computor input devices. In chapter 4 the authors imply that the parallel feedback integrator operates by increasing the effective value of the charging resistor, whereas a sounder physical explanation is that it increases the effective value of the capacitor.

There is a fairly extensive bibliography, the far greater part of which refers to works published in the U.S.A.

To sum up, the book is well produced, will be useful to users of electronic analogue computors, and will possibly be of interest to electronic engineers.

M. J. TUCKER

Storage Tubes and their Basic Principles

By M. Knoll and B. Kazan. 143 pp., 34 figs. Demy 8vo. J. Wiley & Sons Inc., New York. Chapman & Hall Ltd., London. 1952. Price 24s.

THE phenomenon of electronic storage in television, computor and signal-convertor applications is nowadays a well recognized principle, but storage tubes themselves have not been described in the literature in any great detail. This book consists, to a large extent, of information which was originally prepared as a report for the technical branch of the U.S. Army Signal Corps. The authors have not described in detail the construction of storage tubes, but have concentrated on the fundamental storage principles.

While the subject matter of the book is dealt with in what is obviously an authoritative manner the layout and type setting are unorthodox and curious to a degree. The use of a mixture of Roman and Arabic numerals, capital and small letters (carried in an extreme case to such limits as—Part III.A.5.a) can no doubt be attributed to the parentage of the book mentioned above, but it appears to the reviewer to be excessive filial devotion to deny the reader at least the good looks of justification of the printed lines. There is also an odd economy of type face, which seems to add unnecessarily to the severity of the book.

Part I deals with the potentials acquired by an insulated target element under a steady electron bombardment, an understanding of which is essential to any analysis of a charge pattern in a storage tube. Curves of equilibrium voltages and potential shifts are given and the significance of their precise shapes is discussed in detail.

Part II comprises a short chapter setting out the definitions of the terms to be used in the remainder of the volume. (The convention of alphabetical listing is ignored!)

Part III is of particular importance to the newcomer to the subject, as it discusses very thoroughly the various methods of writing, i.e., forming the charge pattern on the target, and reading, i.e., generating the output signal from the stored information, by controlling secondary emission and bombardment conductivity. The processes of photoemission and photoconductivity which are of importance in television camera tubes are also discussed.

Parts IV to VII are devoted to the discussion of various types of storage tubes. Signal-convertor tubes such as the Pensak Graphechon and the Haeff Memory tube are dealt with in Part IV. Viewing storage tubes in which the output signal is obtained as a visual signal on a phosphor form the subject of Part V. The cathode-modulation tubes of this general type may have applications in future developments of television and in radar operation.

Part VI deals with computor storage tubes which are designed to store Yes-No information for very long periods.

Part VII treats with storage tubes of the television camera type. The well known Iconoscope, Orthicon, Image Iconoscope and Image Orthicon tubes are described as well as the newer photoconductive Vidicon and the scattered electron Image Isocon.

The book is completed by a useful and comprehensive bibliography which forms a most valuable and important section of the book. References are by no means limited to work carried out in the U.S.A. In particular the references to the various tubes discussed in Parts IV to VII will put the reader on the track of the many design features which are (intentionally) omitted from the present volume.

Many of the tubes described in the

book are still of a developmental nature and the authors have made no attempt to deal with their practical applications. The subject matter of the book is so specialized that it is not to be expected that it will be of wide appeal, but it is sure to be welcomed by all tube designers and those workers in allied fields, whose need for a suitable storage tube often exceeds their knowledge of the complex theories involved. It is in essence a concise collection of theoretical data which has not before been collected together and within the limits explained in this review, it can be said to achieve its authors' aims.

R. E. B. HICKMAN.

Electron Tubes in Industry

By Keith Henney and James D. Fahnestock. 3rd Edition. 345 pp., 196 figs. Royal 8vo. McGraw-Hill Publishing Co., Ltd. 1952. Price 51s.

DISASTROUS results are caused by the limitation of theoretical discussions in this book, which is intended to satisfy the needs of non-technical industrial personnel who come into contact with electronic aids to industry. The allegations made by the authors concerning the Foster Seely fequency discriminator form a masterpiece of muddled misconception: "Each diode gets equal voltages so long as the incoming frequency is equal to the resonant frequency . . . . At other frequencies the diode input voltages are equal but out of phase with the input to the transformer. The diode output voltages are then unequal"! The essential vector diagrams which would have provided a true picture are omitted. On page 13, the sketch of a parallel resonant circuit shows the resistance in the supply lead to the tuned circuit instead of in the inductive branch. Only a fleeting reference, with neither a simple theory nor a circuit diagram, is made to the blocking oscillator. Phase shift *RC* oscillators, crystal controlled oscillators, the transitron, Hartley and Colpitts oscillators are conspicuous by their absence. The sketches on pages 3, 6, and 10, which are poor apologies, differing among themselves, for sinusoidal waveforms, are quite inexcusable in a 3rd edition. The cathode-follower is mentioned, but no reasons are given for its basic properties, and its limitations are ignored completely. The simple copper "slugged" relay is not included in the methods of delaying the operation of electromagnetically operated relays. In the otherwise detailed description of the telephone relay, no mention is made of the essential stud residual or of the reason for its existence. Typical of the looseness of expression and lack of precision which is rampant is the statement on page 126 that the efficiency of a typical R.F. E.H.T. unit is "fairly good".

The authors have succeeded in producing a hybrid of "electronics in three easy lessons" and a review of current practice, a hybrid that is neither flesh, fowl, nor good red herring. Although the seasoned engineer may, with due caution, be able to use parts of the book for reference, the newcomer to the art of electronics is advised not to delve into it. Most certainly, it falls short of the publishers usual high standard.

H. STIBBE.

Major Faults on Power Systems

By A. G. Lyle. 355 pp., 111 figs. Demy 8vo. Chapman & Hall Ltd. 1952. Price 45s.

AS the author states in his preface, this book is written primarily for the practising engineer, and as such would seem to succeed admirably, even if only for the mass of valuable data and information compressed between its covers. Judged upon the quality of the said data, first impressions are fully confirmed. The emphasis is throughout on the practical rather than the theoretical aspect of the subject, as is of course only right in a book of this nature.

The first few chapters are devoted to the general subject of faults and their calculation. The book then goes on to deal in detail with protective systems (including proprietary ones), oil and air circuit breakers, concluding with a section on the design of switchgear, and neutral inversion. The final chapter is devoted to conclusions based on a multitude of test results. Several appendices of calculations and an analysis and discussion of circuit breaker test results are included, illustrated with oscillograms and photographs. A short bibliography is included at the end of each chapter.

The whole book is very adequately illustrated with diagrams, photographs and oscillographic records. In addition to the switch and protective gear specialist, the advanced student will find parts of the book well worthy of his attention.

G. H. PLATT.

Higher Indnstrial Production with Electricity

145 pp., 104 figs. Medium 8vo. British Electrical Development Association. 1953. Price 9s.

THE whole subject of higher industrial productivity is an extremely wide one, but this book concentrates on the more striking examples of electrical methods, and should be of particular interest to industrialists as providing a review of the many ways in which modern applications of electricity have increased productivity. This volume is introductory to the Electrial Development Association's "Electricity and Productivity" series of eight books.

Electronics for Communication Engineers

By John Markus and Vin Zeluff. 610 pp., 750 figs. Crown 8vo. McGraw-Hill Publishing Co., Ltd. 1952. Price 85s.

THIS book is composed of 252 articles which have appeared in *Electronics*. Topics are arranged by subject in sixteen chapters, including such subjects as amplifiers, components, filters, oscillators, power supplies, and transmission lines. It gives selected design articles with many equations, charts, and nomographs. There are ten articles on electronic music, giving design data and circuit details of both commercial and custom-built electronic organs of various types. The chapter arrangement is alphabetically by subject, and indexing by title, author, and cross index of subjects all facilitate the reading of this book.

ELECTRONIC EQUIPMENT

A description, compiled from information supplied by the manufacturers, of new components, accessories and test instruments.

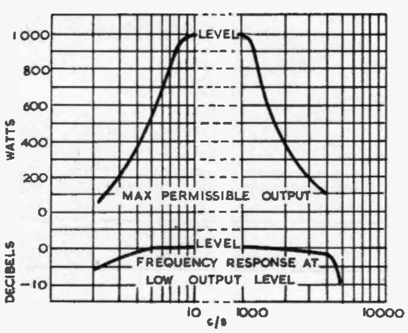
A V.L.F. Amplifier

THIS amplifier has been developed to provide a power source for transducers being used for vibration and fatigue tests at frequencies below the range of a standard audio amplifier.

All components, with the exception of the output transformer, are mounted on vertical panels and contained on a 78in. rack frame. The side and back covers are removable for inspection and maintenance of wiring and components, while the valves are accessible from the front of the rack.

Flexible cables connect the rack to the output transformer which is mounted in a separate cabinet. Wheels are fitted to make this heavy component more easily moveable.

The circuit arrangement consists of a paraphase 3-stage voltage amplifier feeding a grid driven, push-pull, triode output



stage. 15db of negative feedback is applied over 3 stages from the output to the cathode of the second stage. These feedback arrangements are such as to permit the connexion of either highly inductive or capacitive loads to the output transformer without upsetting the stability of the amplifier. However, with a purely reactive load, the maximum permissible output is 350VA. If this is insufficient to drive the transducer, the power factor of the load can be corrected to unity by the insertion of inductance or capacitance and the full 1 000 watts utilized.

The diagram above shows the maximum permissible output of the amplifier into a "matched" resistive load over the frequency range 2c/s-4 000c/s. The lower curve gives the inherent frequency response of the amplifier. The distortion at 1kW output is less than 5 per cent between 10c/s and 1 000c/s.

The output transformer secondary is wound in four sections of 50 volts each. These windings may be connected in series, parallel or series-parallel to match to load impedances of 2·5, 10 or 40Ω.

The input impedance of the amplifier is 600Ω free of "earth." A centre-tap on the input transformer primary permits "balanced to earth" working or, alternatively, one side can be "earthed" for connexion to an unbalanced input source. An input of 0·05V is required for full output.

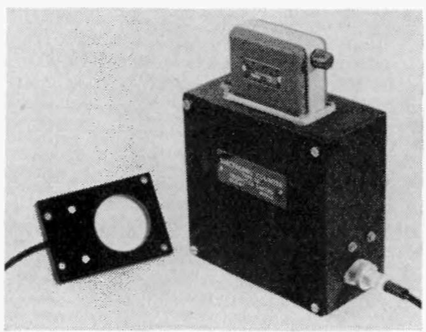
A gain control is included ahead of the 1st stage and a selector switch and meter provide means for checking the anode current in all valves in the voltage amplifier. The output valves have their own individual anode current meters.

At the side of the main On/Off switch is a 3-position rotary switch which either operates H.T. locally or allows remote operation.

W. Bryan Savage Ltd., Westmoreland Road, London, N.W.9.

Industrial Counting Equipment
(Illustrated below)

THE electronic counter, Type D.2, is a general-purpose unit for application to presses, automatic machinery and conveyors when the products to be counted are partially or entirely metallic and either ferrous or non-ferrous.



An installation comprises the detector unit, complete with 6-figure electromagnetic counter and a pick-up coil which is located at the point of counting. Components, such as turned parts and small pressings have merely to be dropped through the coil unit aperture, a count being registered as each component passes. Standard interchangeable coil units are available for components varying in size from, say, a 2B.A. screw up to 2in. diameter. The unit illustrated has a 2in. aperture.

For larger objects and for counting on conveyors, the coil unit is so positioned that the articles fall or move past the aperture within approximately 1in. This distance, which varies with the size of the article, is independent of the thickness of the metal and objects wrapped in tinfoil, for instance, are readily counted. Cardboard and other non-metallic containers may also be counted when they have either a tinfoil label or are metal-banded.

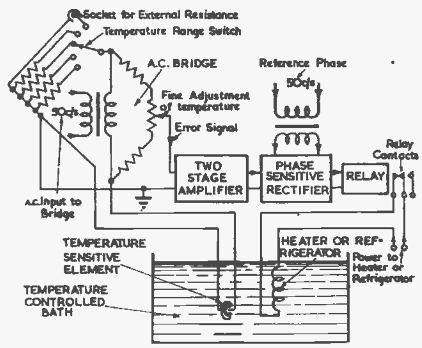
The equipment is suitable for 200-250 volts A.C. and is independent of supply variations.

Teledictor Ltd., 214 Birmingham Road, Dudley.

An Electronic Temperature Controller

IN a number of physical, chemical and biological laboratories, means are required for the precise measurement and control of temperatures, especially of water and oil baths. To meet such needs the Equipment Division of Mullard, Ltd., have recently made available a temperature controller, type E.7594. This instrument enables the temperature of water baths and similar apparatus to be controlled to within fine limits, the response time being very rapid. The instrument has the additional advantages of being simple in operation, and compact and robust in construction.

The sensitive element in the new temperature controller consists of a temperature-sensitive resistor, designed for direct immersion into the fluid to be controlled. This resistor forms one arm of an A.C. bridge network. The output from this network is amplified and is used to control a phase-sensitive circuit operating a relay. Since the phase of the bridge out-



put changes very rapidly at the point of balance, quick action of the relay is ensured.

The relay in the instrument is of the single-pole, double-throw type. This can switch up to 1A at 230V, so that most heating elements used in water baths can be effectively operated.

The instrument has a temperature range of 15-75°C. covered in three steps. A large dial allows the setting point to be precisely located and locked in position. Although the calibrated accuracy of the scale is ±1°C, it is possible to control the temperature to within ±0·2°C about the working point.

A four-position range switch is provided which alters the value of the resistor in the fixed or standard arm of the bridge circuit. The adjacent arm of the bridge contains the temperature-sensitive element, while the remaining two arms are provided by the potentiometer balance control. The fourth position of the range switch connects the bridge to a socket on the front panel of the instrument. This enables a precision external resistor to be connected into the bridge in place of the internally-connected standard resistor. By keeping the external resistor at a constant temperature, a greater accuracy of control can be effected. Moreover, through the choice of suitable resistance values, the range of the instrument can be extended to cover any temperature between minus 50°C and plus 80°C. At the lower position, however, the range covered by the fine control will be only 10°C.

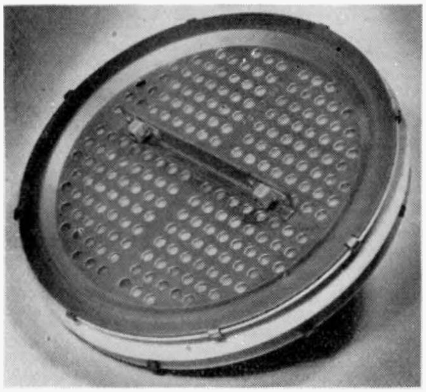
**Mullard, Ltd.,
Century House,
Shaftesbury Avenue,
London, W.C.2.**

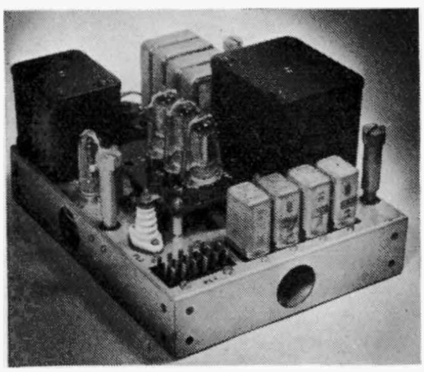
Humidity Measurement and Control

(Illustrated below)

THE Humicon was designed to meet an Inter-Service Specification and W. H. Sanders (Electronics), Ltd., have now been granted a licence to manufacture and supply this instrument to other users.

The detector head consists of glass fibre placed between two rhodium plated electrodes. The electrodes are





perforated to allow a free circulation of air through the glass fibre and are spaced apart by a ring shaped glazed porcelain insulator at the edges. Due to the affinity of very fine fibre glass with airborne moisture and the fact that a number of fibres are placed in close proximity, the moisture will flow between the fibres due to capillary action. Over the range 42 per cent to 100 per cent relative humidity the resistance of the detector varies from 100MΩ to 40 000Ω. The detector head contains no perishable material and is capable of operating throughout the temperature range of −40°C to +80°C without serious change in the response curve form or position.

The control unit allows an alternating current to flow across the detector head. A.C. is used to eliminate any polarizing effects which might occur with D.C.

The circuit itself consists of an A.C. bridge measuring arrangement, which incorporates three grid controlled hot cathode gas discharge tubes. Also incorporated are three relays from which humidity control apparatus can be operated.

**W. H. Sanders (Electronics), Ltd.,
48 Dover Street,
London, W.1.**

A High-Speed Counter

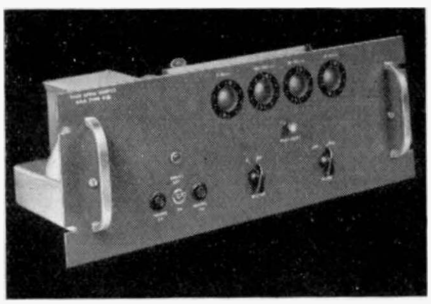
(Illustrated below)

THE Boulton Paul P181 high-speed counter serves two primary functions:

(a) The instrument includes a 1 000c/s frequency source which, though simple, is nevertheless highly stable for long periods and can readily and rapidly be corrected for drift, caused by ageing of valves and components, by the use of a pre-set trimmer control, checked by measuring the count over a known time interval.

When the counter is connected to this oscillator the instrument may be used for measuring time intervals between two events to an accuracy of ±5 milliseconds. The maximum interval counted directly is 10 seconds, but greater intervals can be measured by noting the number of times the one-second counter completes ten steps.

The commencement and completion of



a counting interval are controlled by high-speed relays, which are actuated either by means of push-button switches on the unit or, alternatively, by means of remote switches connected to relevant points on the system under test.

(b) For the purpose of counting pulses of either regular or irregular periodicity over a known interval of time, the internal frequency source is disconnected. Pulses derived from the system under test are fed into the unit, the counting interval being controlled, as before, by means of push-button switches or by remote auxiliary timing switches.

The maximum rate of counting is 1 000 pulses per second and the maximum direct count is 10 000 digits, although, as previously explained, a higher count can be obtained by observing the revolutions of the final indicator.

The instrument may be used as an R.P.M. indicator by coupling a detector element to the rotating shaft and noting the count over a fixed time interval. At 6 000 R.P.M. the speed would normally be checked over an interval of one or two minutes, the only error involved being the time error in synchronizing a stop-watch to the start and stop switches. If reduced accuracy is acceptable the speed can be measured over a proportionately shorter time interval.

**Boulton Paul Aircraft Ltd,
Wolverhampton.**

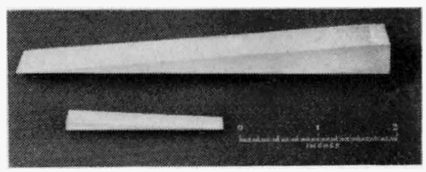
A Conductive Ceramic for Microwave Applications

(Illustrated below)

IN waveguides, dummy loads are required to absorb the radiation without appreciable reflexion.

Previously, such loads have consisted of conductive particles embedded in an insulating matrix, for example carbon in asbestos, or such materials as wood which are poor insulators. These materials, however, suffer from the disadvantage that, when high local temperatures occur, due to the absorption of high powers, their electrical properties alter, and, in some cases, they become distorted. To overcome this the conductive ceramic "Caslode," has recently been developed by the Plessey Company, Ltd. A white, homogenous material, it is capable of absorbing power at centimetre and millimetre wavelengths, and can thus be used effectively for high power dummy load and attenuator pads in waveguide applications. Caslode is a true semi-conductor, and does not contain dispersed conductive particles. At 3·2cm wavelength its dielectric constant is about 20, and the loss angle 10° to 20°.

During manufacture the material is fired at a high temperature to form a homogenous structure which is stable under extreme conditions of temperature and humidity. Its thermal shock pro-



perties are excellent, and its coefficient of linear expansion is 6×10^{-6} °C.

Mechanically, Caslode is similar to porcelain, but can be ground and shaped rather more readily. The raw materials are formed into the required shape before firing and precise dimensions and a good surface finish are subsequently obtained by wet grinding.

High power dummy loads of this material have been developed to meet the demand for a matched waveguide termination capable of absorbing high powers without the necessity for water cooling. Wedge shaped components have been designed to operate in the common sizes of waveguides. Recent measurements have indicated that units originally developed to give a match of about 0·95 and to dissipate about 100 watts mean power at 3cm wavelength, can absorb 250 watts mean power without any appreciable change in matching properties.

Where a load must occupy the minimum possible space Caslode can be formed into short wedges (e.g. 5cm long for X-band waveguides) which give a match better than 0·85 and an attenuation of the order of 30db.

The Caslode attenuator pad is still in the experimental stage, but units of the slot insertion type have been produced, having an attenuation figure of 28db with a match of 0·95. These units have been tested up to a mean level of 15 watts dissipation.

**The Plessey Co., Ltd.,
Ilford, Essex.**

Notes from the Industry

The President of the Institution of Electrical Engineers, Colonel B. H. Leeson, O.B.E., T.D., at a recent meeting presented the Certificate of Honorary Membership to Sir Harry Railing for his services to the electrical engineering profession and to science. The Faraday Medal was presented to Colonel Sir A. Stanley Angwin for his contributions to the development of telecommunications in Great Britain and in the international and intercontinental fields.

The Radio Corporation of America announces that a talk on the subject of transistor circuits and applications will be given by Mr. G. C. Sziklai of the RCA Research Laboratories, Princeton. Dr. R. L. Smith-Rose has consented to act as chairman of the meeting, which will be held in the Royal Society of Arts lecture theatre at John Adam Street, London, W.C.2, on Wednesday, 1 July, 1953, at 5.30 p.m. Those interested in attending are invited to write to RCA in advance at The Tower, Brook Green Road, London, W.6.

The Ampere Medal, presented by the Societé Française des Electriciens of France has been awarded this year to Monsieur H. Andre. This medal is awarded in consideration of a life's work in some branch of the electrical field. Monsieur H. Andre is the inventor of the modern form of silver-zinc accumulator, the Commonwealth rights of which are held by Venner Ltd.

British Insulated Callender's Cables, Ltd., announce that their Overseas Reception Office has been transferred to 11 Bedford Square, London, W.C.1, telephone Museum 1600.

Rees Mace Marine, Ltd., marine subsidiary of Pye, Ltd., Cambridge, have received an order from the Dover Harbour Board to equip the Port of Dover with V.H.F. radio-telephones for port control. Engineers from Business Radio (Southampton), Ltd., the Pye associated company, are fitting several new companies in the Southampton area with V.H.F.

Mr. C. L. G. Fairfield, Barrister at Law, has joined the Telegraph Construction and Maintenance Co., Ltd., as manager of the Overseas Division.

The BBC announce that medium-power standby transmitters having an output of 5kW vision and 2kW sound, have now been installed at the Sutton Coldfield television transmitting station. Switching is provided so that they can be used with either the main or reserve aerial systems.

20th Century Electronics, Ltd., have opened a new factory at Centronics Works, King Henry's Drive, New Addington, Surrey, for the manufacture of Geiger counter tubes. Mr. N. B. Balaam has been appointed general manager, and Mr. H. W. King, production manager.

The Minister of Supply (Mr. Duncan Sandys) has appointed Mr. S. Scott Hall, C.B., to be Head of Technical Services, British Joint Services Mission, Washington, in succession to Sir Alwyn Crow, C.B.E.

Pye, Ltd., in competition with several other manufacturers, including a number of American firms, have secured a substantial television contract for Radio Tokyo. During the summer three camera chains and the associated control equipment, all of which will operate on the American system, will be shipped to Japan.

The Directors of the Engineering Centre, Ltd., Glasgow, have resolved to close the Centre at the end of September. Certain industries, trade associations and manufacturers have shown preference for arranging their own exhibitions of their products in areas of their own choice.

The BBC have announced with regret the death of Mr. Simon Orde, engineering information department manager. Mr. Orde's work made him widely known outside the BBC, both in this country and overseas.

Standard Telephones and Cables Ltd. have announced with regret the death of Mr. Charles Eve, a former director of the company and a director of Kolster-Brandes, Ltd.

Dr. H. R. L. Lamont has recently joined the Radio Corporation of America as a member of the scientific staff of the European Technical Representative with headquarters in London.

The International Congress of Mathematicians will be held in Amsterdam from 2-9 September next year under the auspices of the Mathematical Society of the Netherlands. The Congress will be open to mathematicians from all parts of the world. Particulars may be obtained from the Secretariat, 2d Boerhaavestraat 49, Amsterdam.

Emitron Television, Ltd., announce that Radio Italiana of Turin have ordered two Flying Spot Film Channels for their new television station.

Exports of British radio equipment of all kinds in March were valued at £2 221 395, which was approximately £180.000 in excess of the average monthly value in 1952.

Vidor-Burndept's recently established Press Office is situated at 18 Abbey House, Victoria Street, London, S.W.1, telephone Abbey 1328.

Mr. L. Bainbridge-Bell, a contributor to ELECTRONIC ENGINEERING, will be retiring from Admiralty service this summer. Readers will be aware of his work to increase the clarity of electronic circuit diagrams.

Errata. In Letters to the Editor in the May issue, correspondence between Messrs. Simmons and Vale and Mr. D. T. R. Dighton, p.218, "Strains of 10^{-6}in." should read "strains of 10^{-6}in."

PUBLICATIONS RECEIVED

EDISWAN MAZDA RADIO AND TELEVISION VALVES AND CATHODE-RAY TUBES is a folder produced by the Edison Swan Electric Co., Ltd., 155 Charing Cross Road, London, W.C.2, and contains information on valves, cathode-ray tubes, E.H.T. rectifiers, etc. As a separate publication there is an index and price list of the various valves and tubes mentioned.

EDISWAN GERMANIUM CRYSTAL RECTIFIERS is a leaflet on germanium crystal diodes which are useful to radio and television set designers as they occupy a relatively small space, are self-supporting in wiring, have negligible capacitance, and require no heater power or socket. Two types suitable for television receiver applications are now available. Edison Swan Electric Co., Ltd., 155 Charing Cross Road, London, W.C.2.

PHILIPS ELECTRONIC MEASURING INSTRUMENTS is a leaflet displaying the wide range of electronic apparatus which this firm offer in the way of test gear required by engineers to meet increasingly stringent requirements. These instruments cover both the radio and the more recent television fields where pattern generators, valve voltmeters and oscilloscopes are used. Philips Electrical Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

STANDARD TELEPHONES AND CABLES have recently produced a general guide to capacitors. This guide features the standard forms and cases available, and the capacitances and voltages which can be accommodated for various ranges of working temperature. Important factors to the equipment designer are the capacitances and voltages that can be accommodated in a given container, and this guide is presented to assist such engineers. A brochure on suppressors produced by this company is also available. Standard Telephones and Cables Limited, Connaught House, Aldwych, London, W.C.2.

THE BRUSH ELECTRICAL ENGINEERING CO., LTD., present a brochure on a range of high rupturing capacity fuse links on which they have recently completed development. Details of construction, short circuit performance, protection of motor circuits, dimensions and prices are given. The Brush Electrical Engineering Co., Ltd., Hopkinson Works, Cardiff.

PHYSICAL PROPERTIES OF PHOENIX INDUSTRIAL GLASS is a booklet describing the physical data on the many useful properties of Phoenix glass. Its thermal properties, mechanical strength, electrical and optical properties, chemical stability, etc., are mentioned. The British Heat Resisting Glass Co., Limited, Phoenix Works, Loxdale Street, Bilston, Staffs.

THE SCIENTIFIC INSTRUMENT MANUFACTURERS' ASSOCIATION have recently produced a second edition of their brochure on Radio Isotope Applications. The new edition summarizes all the equipment necessary for use with radio isotopes in all applications and gives the sources of such equipment in this country. Copies of the brochure are available free of charge on application to The Secretary, Scientific Instrument Manufacturers' Association, 20 Queen Anne Street, London, W.1.

THE RAGOSINE OIL COMPANY, LTD., have produced a leaflet giving details of their molybdenized lubricants. Their general uses, range and application are mentioned, together with grades and prices. The incorporation of molybdenum disulphide in a range of orthodox lubricants represents a definite step forward in the science of lubrication. Ragosine Oil Company, Ltd., Minerva Works, Woodlesford, Nr. Leeds.

WIGGIN NICKEL ALLOYS—No. 18. The latest issue of this journal contains a number of interesting articles describing some industrial applications of various high-nickel alloys. Because of the diversity of uses of these materials, the articles cover a wide range of interests. Of special interest is an article on the Actarc Monta welding transformer which incorporates a Monel spindle in the variable current control. Other articles deal with the use of Monel staybolts in British Railways standard locomotives and with pickling crates in Monel used in the pickling of sheet iron. Also included are detailed descriptions of the Bristol Proteus engine and of the Allen gas turbine with notes on their use of the various Nimonic alloys for turbine blades and combustion chambers. Copies may be obtained free from Henry Wiggin & Co., Ltd., Wiggin Street, Birmingham, 16.

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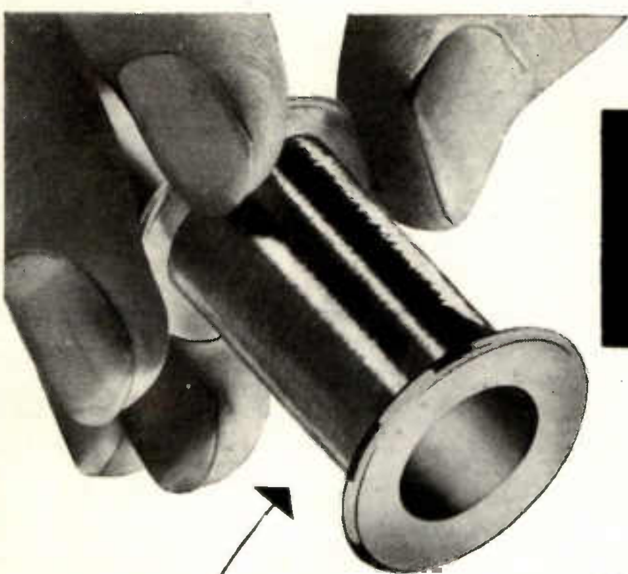

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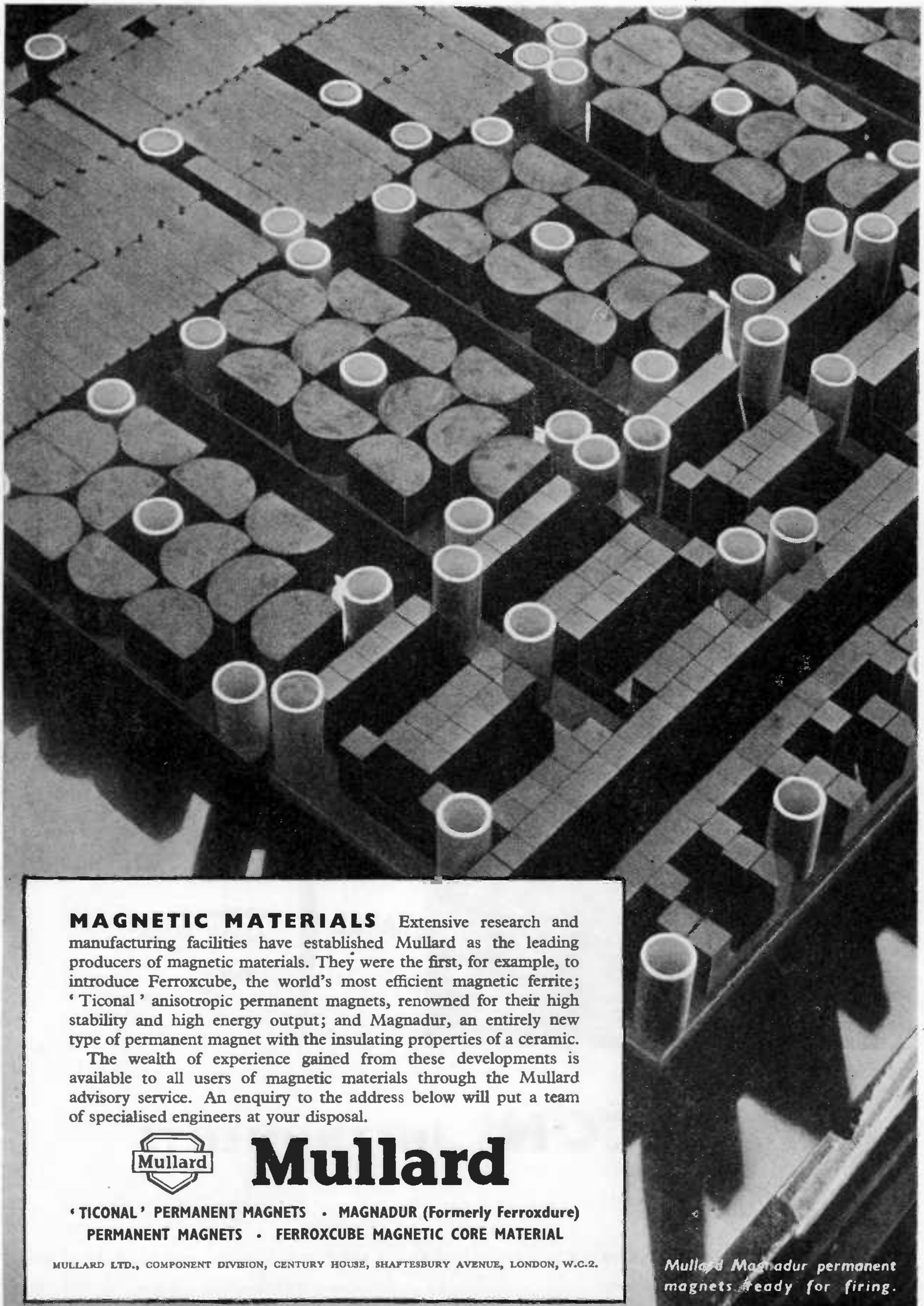

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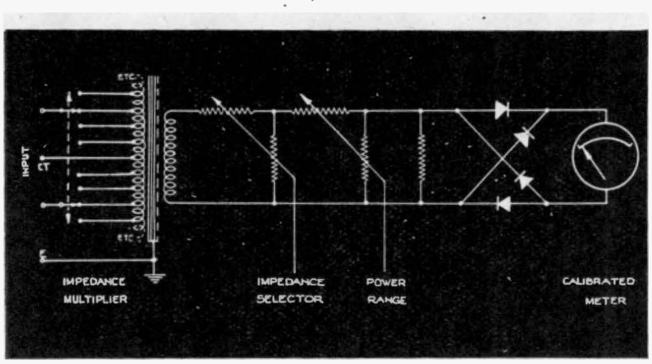

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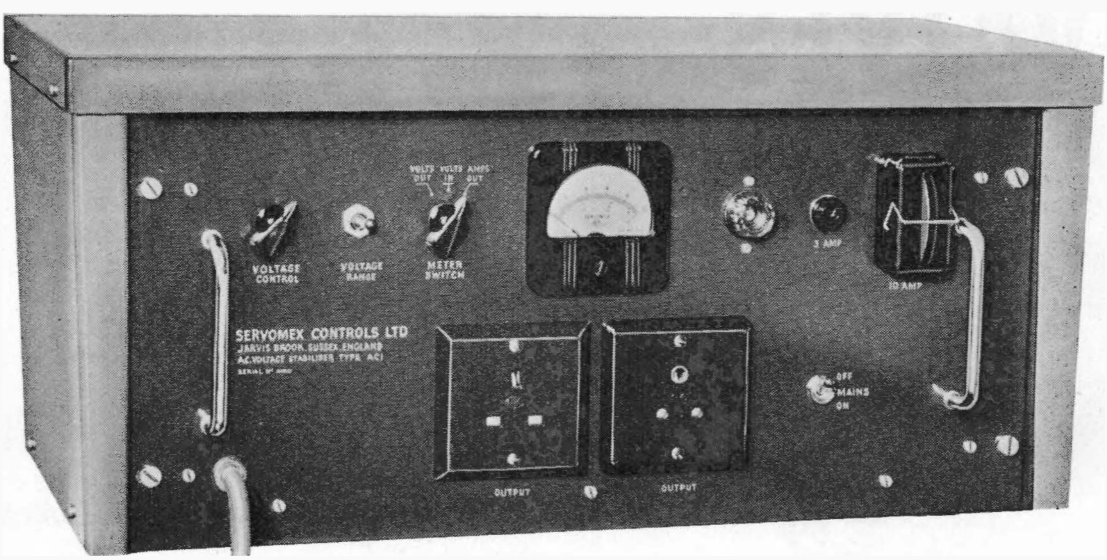

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FEATURES WORTH NOTING . . . .

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★ Input 1, which requires 35 millivolts on .5 megohm, is suitable for crystal P.U.s, microphones or radio inputs.

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★ Total power consumption is approximately 50 watts.

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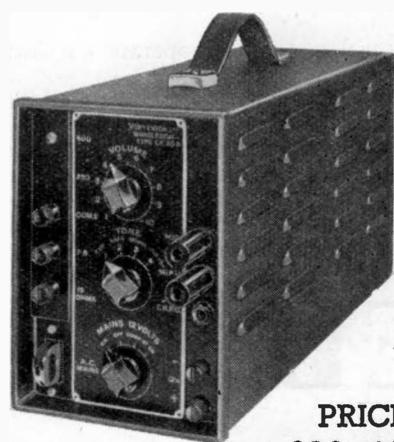

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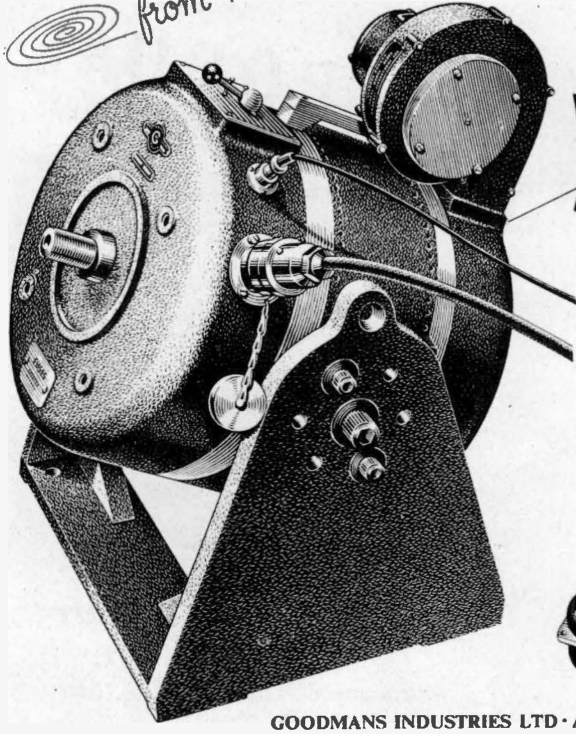

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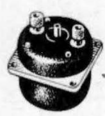

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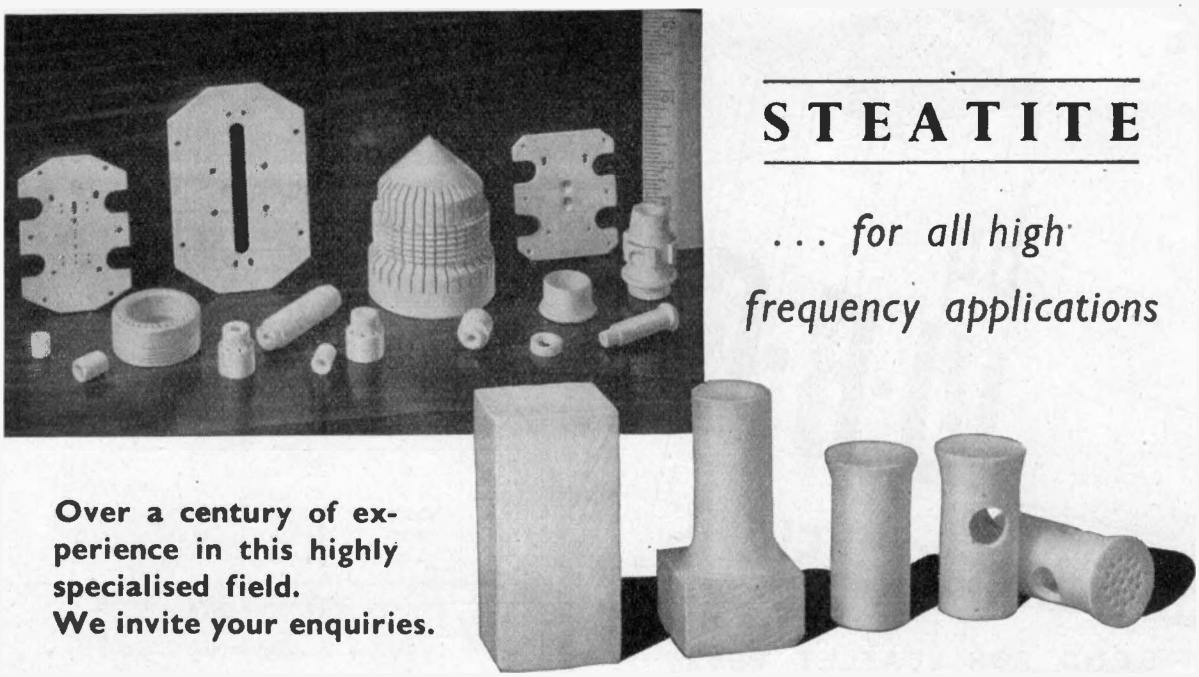

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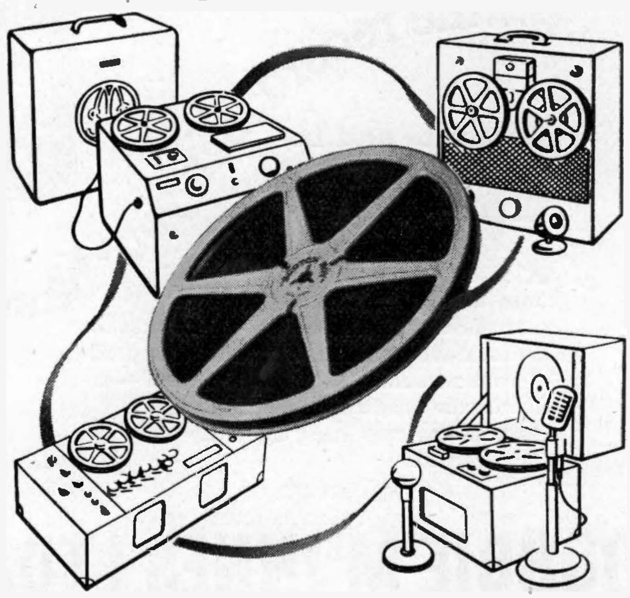

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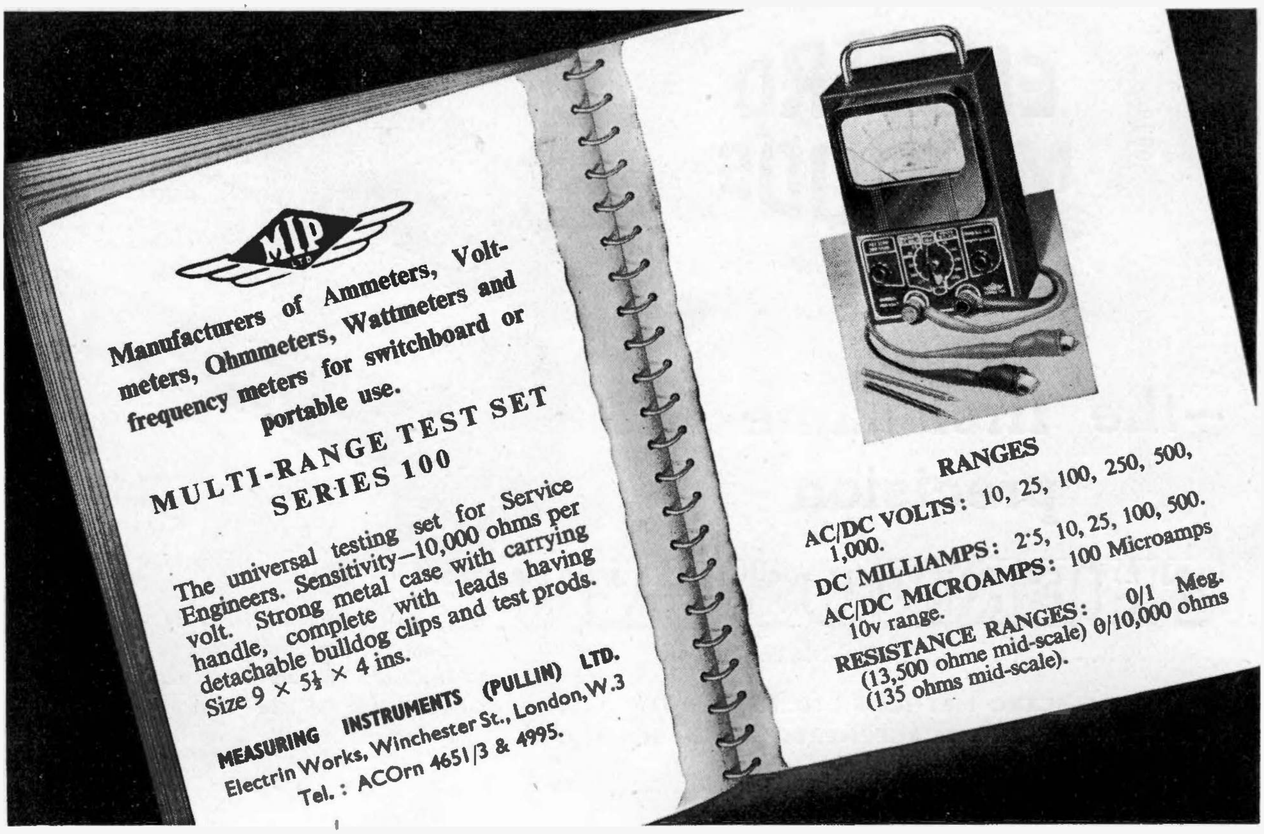

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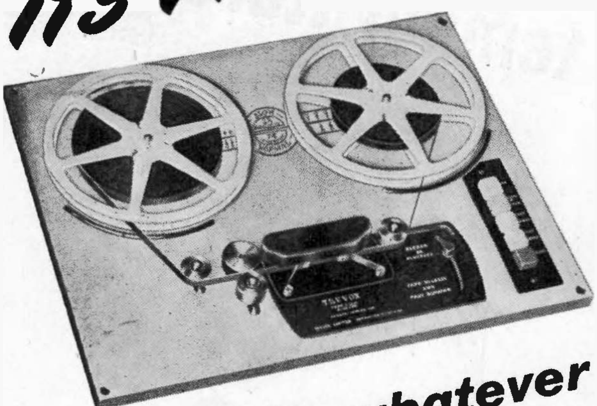

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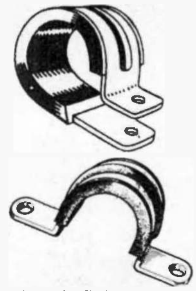

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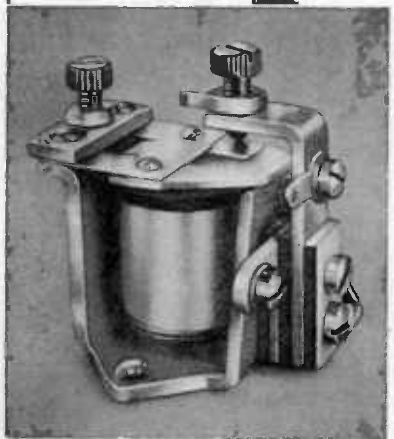

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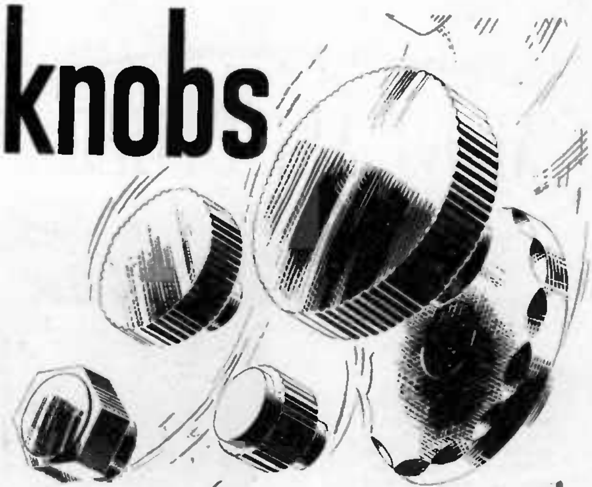

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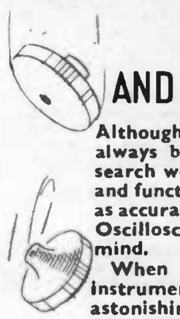

Although radio amateurs the world over have always been fond of knobs, the scientist and research worker likes his instruments to be efficient and functional and to perform their ancilliary tasks as accurately and unobtrusively as possible. Nagard Oscilloscopes are designed with just these points in mind.

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The Nagard Organisation exists to aid research, where accurate measurement of dynamic phenomena is involved. If you would like details of Nagard Wide Range Calibrated Oscilloscopes or Amplifiers, or would be glad of the co-operation of Nagard technicians to solve a definite problem, please communicate with the manufacturers.

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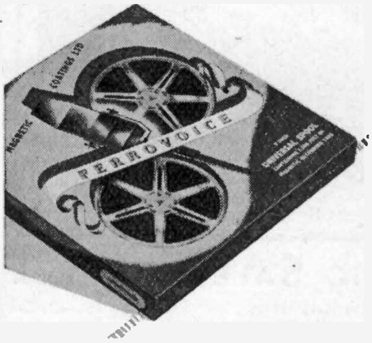

Specially wound on transparent perfectly balanced plastic spools which fit all popular types of tape recorders. FERROVOICE improves the performance of all recorders. Provides twin-track recording of the highest standards of quality and faithfulness. Tape wear and rotation noises are reduced to the minimum. Ferrovoice gives the highest standards of recording and reproduction.

Technical features:—Tape width 0.247 in. ±0.001 in. Medium coercivity—ease of erasure—frequency response 50 c/s to 10 Kc/s at 7½ in. per sec. Length of tape 1,200 feet. Spool 7" diam.

NOTE THESE OUTSTANDING FEATURES:

- Twin track recording with uniform response.
- High play-back level and low noise component.
- Lightweight precision balanced spool.
- Ferrovoice spools keep wear, tear and rotation noise to a minimum.

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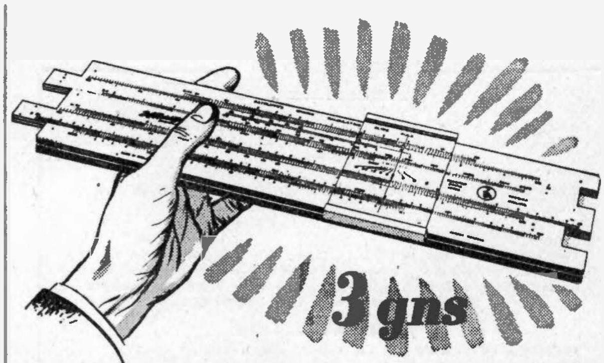

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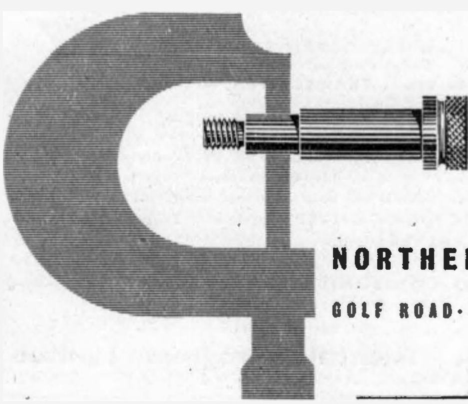

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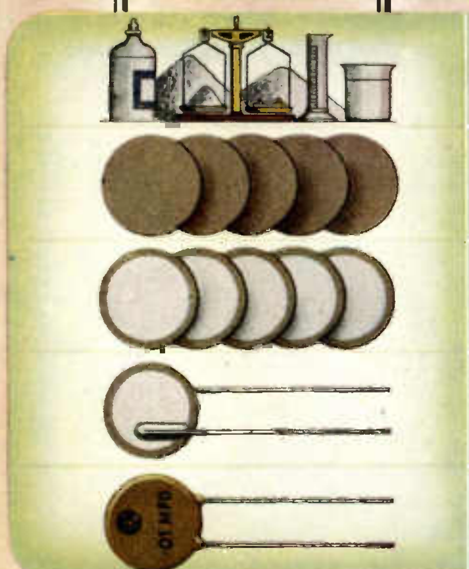
ERIE*

'Tele-Disc' Ceramicons* Type 811

MANUFACTURED ENTIRELY IN THE UNITED KINGDOM

Characteristics		Super-K 35	Hyper-K 70
Capacitance	:	.003 mfd. and .005 mfd.	.01 mfd.
Tolerance	:	+80% −20%	+80% −20%
Working Volts	:	500v. D.C.	350v. D.C.
Flash Test	:	1,500v. D.C.	1,150v. D.C.
Life Test	:	1,000 hours, at working volts, at 71°C.	
Power Factor	:	Not greater than 2.5%	

Temperature: Capacitance will not change by more than ±10% as the temperature is varied from +10°C. to +50°C.



All raw materials used for the manufacture of "Tele-discs" are of the highest purity and are laboratory-checked, by a skilled staff of chemists and engineers, prior to issue for production.

The ceramic discs are precision moulded on special Erie-developed presses and then fired in Erie-developed kilns, with precision electronic controls which ensure a uniform, consistant and superior product.

The disc surfaces are coated with a special Erie-developed silver paint, which is fired on to the body at high temperature, thereby ensuring intimate bonding and hard durable plates.

Leads are then soldered to the silver plates, the process being accurately controlled to ensure low losses and a rigid reliable connection.

Finally, the completed capacitor is insulated with the familiar Erie-developed, type-approved, phenolic finish, used on the well-known series of GP. Ceramicons*, and is clearly marked, as shown in the illustration.

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