Electronic Engineering

JANUARY 1951

TWO SHILLINGS

CLASSIFIED ANNOUNCEMENTS

The charge for 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 : Morgan Bros. (Publishers), Ltd., 28, Essex Street, Strand, London, W.C.2, and marked " Electronic Engineering." Advertisements must be received before the 14th of the month for insertion in the following issue.

OFFICIAL APPOINTMENTS

CANADIAN RED CROSS Memorial Hospital, Taplow. Technical Assistant required to assist in the development of electrical and mechanical recording apparatus in connexion with research in Juvenile Rheumatism. Practical and theoretical knowledge of electronic and mechanical engineering essential. Salary £279 10s. at 24, rising to £299 p.a. at 25 years and over. Applications stating age, qualifications and experience, with copies of three recent testimonials to be sent to the Administrative Officer. W 2619

APPLICATIONS are invited by Ministry of Supply from Physicists and Light Electrical Engineers for an unestablished appointment in the grade of Principal Scientific Officer at the Royal Aircraft Establishment, Farnborough, Hants. Candidates must be at least 31 years of age, and should have a good Honours Degree with a wide background of research and development experience, particularly in the design and use of magnetic and electronic amplifiers. A knowledge of servo - theory would be an advantage. Salary according to age, qualifications and experience within P.S.O. range £960—£1,295. Post carries benefits of F.S.S.U. Rates for women somewhat lower. Application forms obtainable from Ministry of Labour and National Service, Technical and Scientific Register, (K), York House, Kingsway, London, W.C.2, quoting A.345/50A. Closing date 12th January, 1951. W 2633

THE MINISTRY OF WORKS require an unestablished Engineering Assistant in the X-Ray section of the Engineering Division for duty in Edinburgh or Glasgow. Candidates should have had experience in the maintenance of X-Ray and Physio-Therapy apparatus, together with electrical power and lighting installations. Qualifications: Higher National Certificate in Electrical Engineering desirable with special consideration for applicants who are members of the Institute of X-Ray Technology. Salary range: £485-£610 per annum. Forms of application may be obtained from the Ministry of Labour and National Service, Technical and Scientific Register, (K), York House, Kingsway. W.C.2, quoting D.342/50/A. Closing date 12th January, 1951. W 2640

SITUATIONS VACANT

MARCONI'S WIRELESS TELEGRAPH Co. Ltd., have vacancies for two engineers for work on VHF Development. Applicants for the first post must have good practical knowledge and experience on VHF Low Power Transmitters. For the second post, experience on Multiplex Channelling Audio and/or Video is required. Applicants must be familiar with problems on linearity, distortion, etc., and a knowledge of centimetric techniques would be an asset. Salary will be not less than £650 per annum and may be higher for candidates with outstanding qualifications and experience. The Company has a Staff Pension Fund. Please apply giving full details, quoting ref. 822, to Central Personnel Services, English Electric Co., Ltd., 24-30 Gillingham Street, London, S.W.1. W 2612

HIGH FREQUENCY Induction Heating Applications Engineer required by progressive and expanding company specialising in the manufacture of high frequency equipment. Experience in induction heating essential and a good knowledge of metallurgy would be considered as an additional qualification. The position offers excellent opportunities for advancement to a really energetic man having the requisite experience. Write giving experience and salary required to Box No. W 1213.

ENGINEER with production and some commercial experience required to join development engineer in starting small manufacturing concern £2,000 available. Box No. W 1214.

FERRANTI LIMITED have vacancies in their Radio Works, at Moston, Manchester for Radio/Television Design Engineers, both senior and junior. Generous scale of payment, extending liberally into the four figure range, according to qualifications and experience. Permanent staff, appointments with superannuation benefits. Forms of application from The Staff Manager, Ferranti Ltd., Hollinwood, Lancs. Please quote reference R.E. W 2617

ADMINISTRATIVE ENGINEER with experience of technical correspondence and preparation of contracts required by department of Midlands firm engaged in electronic control equipments and R.F. heating. Salary £400-£600 per annum according to experience. Write giving details of age and experience mentioning reference HBG to Box No. W 2615.

ELECTRONIC ENGINEER required for development work by expanding industrial electronic team of well known manufacturing company. Previous experience of servo mechanisms and industrial process control together with Degree of H.N.C. essential. Write giving full details quoting reference GBH to Box No. W 2614.

ASSISTANT Mechanical Engineer required by large well known firm to undertake mechanical design of interesting new electro mechanical equipments. The work will be varied and the prospects good. Apply quoting ref. DIH to Box No. W 2616.

FOREMAN required for R.F. glueing department. Must be fully capable of designing jigs and controlling R.F. generators. Excellent salary. Apply: Exeloak Limited, Garman Road, N.17. W 1215

RADIO ENGINEERS with qualifications covering full City and Guilds course in Radio Communications required by large radio manufacturer in Eastern Area of London. Applicants having experience with manufacturer or in the forces will be preferred. Kindly state full details including age and salary required to Box No. W 2620.

INTERESTING vacancies exist with the Nelson Research Laboratories of the English Electric Co. Ltd., for university trained electronic engineers or physicists with an interest in the design of special circuits for computing machines. These vacancies are at Stafford and in the London area and offer scope for original work in this interesting field. Write giving full details mentioning reference 305A to Central Personnel Services. English Electric Company Limited, 24-30, Gillingham Street, London, S.W.1. W 2621

SPERRY GYROSCOPE CO. LTD., Great West Road, Brentford, Middlesex, require Mechanical Engineer. Good academic qualifications and recognised apprenticeship desirable. Preferably experienced in one or more of the following: precision mechanical design; hydraulics or pneumatic servo systems; servo theory, aerodynamics. Apply with full details of experience and salary required to the Personnel Manager. W 128

SPERRY GYROSCOPE CO. LTD., Great West Road, Brentford, Middlesex, require Electronic Engineer. Good academic qualifications and recognised apprenticeship desirable. Required for development work on control systems. Experience of D.C. amplifiers and computing devices an advantage. Apply with full details of experience and salary required to the Personnel Manager. W 126

SPERRY GYROSCOPE CO. LTD., Great West Road, Brentford, Middlesex, require Electro-Mechanical Engineer. Good academic qualifications and recognised apprenticeship desirable. Experience in electrical and electro-mechanical methods of computation; servo theory, and instrument design preferred. Apply with full details of experience and salary required to the Personnel Manager. W 124

E.M.I. ENGINEERING Development Ltd., have from time to time in the course of their gradual expansion, interesting vacancies for Senior Design Engineers, who have had several years experience of the design and development of electronic equipment. Suitable applicants must have proved experience in responsible positions and will be engaged with the view to taking charge of project team, or sections. The posts are for permanent staff and carry good salary and prospects. Applications will be welcomed at any time and should be sent with full details to Personnel Department, ED/S., E.M.I. Engineering Development Ltd., Blyth Road, Hayes, Middlesex.

TECHNICAL ASSISTANTS are required by Airmec Laboratories Ltd., Cressex, High Wycombe, Bucks. Applicants should have had previous experience in light engineering and electro-mechanical engineering and have technical qualifications to the Higher National Certificate standard. Apply to the Personnel Officer stating age, qualifications, experience and salary required. W 2622

RADIO VALVE ENGINEERS. The M.O. Valve Company have vacancies for qualified engineers in connection with the development manufacture and application of radio valves. Please apply by letter stating particulars and salary required to Personnel Department. The M.O. Valve Co., Osram Works, Brook Green, Hammersmith. W 2624

MARCONI'S WIRELESS Telegraph Co. Ltd., require an additional Lecturer in Electronic Engineering at Marconi College, Chelmsford. The applicant must be a graduate in Physics or Engineering, with preferably some experience in one or more branches of electronics and some practice in teaching. Duties will include lecturing, supervision of experimental work and development of equipment for the present and future College Courses which are mainly of post graduate standard. Salary according to qualifications and experience. Good staff pension scheme. Write giving full details mentioning reference 260 to Central Personnel Services, English Electric Co. Ltd., 24-30, Gillingham Street, London, S.W.1. W 2625

NORTH LONDON COMPANY. manufacturing electronic, industrial and medical equipment, invites applications for appointments below :- Development Engineers—Good electronic knowledge and experience with sound engineering background is essential. Senior grade (Ref. S.E.) to be capable of taking full responsibility for projects. B.Sc., A.M.I.E.E. or equiv. Junior grade (Ref. J.E.) with National Certificate and good experience or H.N. Certificate with limited experience. Draughtsman—Vacancy also for progressive draughtsman with knowledge of similar work (Ref. G.D.). Installation Engineer—Required to undertake installation and servicing of very complex equipment. Good personality, confidence in tracing obscure electronic faults absolutely essential. Previous association with medical work an advantage (Ref. I.E.). Good salary and permanency for first class men with interesting work and opportunities. Write stating full details and salary required, quoting particular reference to Box No. W 2626.

A VACANCY occurs for a Senior Draughtsman of at least H.N.C. standard for layout work, on interesting electro-mechanical projects. Salary according to qualifications. Apply to Personnel Officer, Mullard Electronic Research Laboratory, Salfords, Nr. Redhill, Surrey. W 2628

DEPARTMENT OF COLLOID SCIENCE, Cambridge University. Applications are invited for an Assistantship in Research. The holder of this post will be expected to devote his time to the application of electronic techniques to spectroscopy, especially in the infra-red and to related physico-chemical problems. Salary £300 to £450 p.a. (or possibly higher) according to qualifications. Tenure three years. Please communicate with Dr. N. Sheppard, address as above. W 1211

MARKETING MANAGER required by young expanding London Company (150 employees) manufacturing acoustic devices for world markets. Age 25-40. Take complete charge directing home and export sales. First class development and manufacturing facilities available. Electronic and works experience desirable. Ability to organise, handle men and develop markets essential. Commencing income up to £1,500 p.a. Great scope, directorship later for the right man. Write Box No. W 1222.

VACANCIES exist for Electro-Mechanical Designers used to engineering the mechanical side of communications and similar projects, and also associated with heavy mechanisms. A good degree on Mechanical and Electrical Engineering or similar qualification is desirable as well as several years' experience in a Laboratory or Factory design department. Salary according to qualifications. Apply to Personnel Officer, Mullard Electronic Research Laboratory, Salfords, Nr. Redhill, Surrey. W 2630

OCCASIONAL Technical Advice required on the production of various types of capacitors, ceramics, resistors and rectifiers. Write stating experience. Box No. W 1228.

COIL WINDER required for interesting development work on a wide variety of coils and transformers. The applicant should have had at least three years experience of factory methods on small tranformers and wave wound coils. A knowledge of design and testing methods would be an advantage. Staff appointment, salary according to qualifications. Apply to Personnel Officer, Mullard Electronic Research Laboratory, Salfords, Nr. Redhill, Surrey. W 2629

YOUNG ELECTRONIC Engineers are required for interesting programme of development work near Luton. Applicants should possess Ordinary or Higher National Certificates in electrical engineering and have an interest in radar or radio experimental work. Vacancies also exist for Laboratory Assistants, and young men and women who have School Certificate are invited to apply. Write, giving full details, mentioning ref. HAE, to Box No W 2635.

AN EXPERIENCED Valve Engineer is required for employment at Chelmsford. Applicants should be 25-35 years of age, qualified engineers and preference will be given to those with previous design or production experience of small transmitting valves. Write giving full details of experience mentioning ref. 497C to Central Personnel Services, English Electric Co. Ltd., 24-30 Gillingham Street, London, S.W.1. W 2632

RADIO-RADAR Development, Engineers urgently required, accommodation available. Applications are invited from Senior and Junior Development Engineers, preferably with experience of Radar or microwave technique, who are capable of developing equipment or components to Service Specifications. Successful candidates will be employed on work of great National importance. Write quoting reference CHC (5) to Personnel Officer, General Electric Co. Ltd., Radio & Television Works, Spon Street, Coventry. W 2642

TECHNICAL SALES Engineer required by a well-known Company to promote the sale of High Frequency Induction Heating Equipment in the Midlands Area, comprising Staffordshire, Shropshire, Warwickshire, and Worcestershire. Remuneration by generous Basic Salary and Commission on turnover. Expenses paid and car provided. The advertisers Employees are aware of this Vacancy. W 1226

H. TINSLEY & CO. LTD., have vacancies in their test room for skilled assistants, who must be capable of fitting, wiring and calibrating electrical instruments to fine limits. 44-hour week, no Sats. Write or 'phone for appointment. Werndee Hall, Stanger Road, South Norwood. ADD. 1400. W 1225

MURPHY RADIO LTD., having recently expanded their Electrical Design Department invite applications from television and radio engineers having good academic qualifications (Honours Degree in Physics or Electrical Engineering) and experience in industrial design Laboratories. There are also openings for graduates trained in these branches, but without industrial experience. Applications giving full particulars of training and experience should be forwarded to: Personnel Department, Murphy Radio Ltd., Welwyn Garden City, Herts. W 2639

MESSRS. S. SMITH & Sons (England) Ltd., require the services in the Cheltenham area of a number of qualified electrical engineers for research work in the field of small electro-mechanical systems. Knowledge of electronics and servo mechanisms is desirable but consideration will be given to ability, initiative and inventiveness rather than experience. Salaries will range from £500 to £1,500 per annum according to ability and experience. Housing accommodation is guaranteed to selected applicants. Application should be made in the first instance to The Personnel Manager, Messrs. S. Smith & Sons (England) Ltd., Evesham Road, Bishop's Cleeve, Nr. Cheltenham, Glos., giving a brief summary of the applicants qualifications and experience and stating age and salary expected. W 2631

IMPERIAL CHEMICAL INDUSTRIES Limited, Dyestuffs Division, has a vacancy for a Senior Instrument Engineer; age 28-35. A good Honours Degree in Physics, with engineering experience, or in Electrical Engineering with a thorough theoretical background in Applied Physics essential. The post, which initially would be in the Manchester Area, would involve the development and design of industrial process instruments and would include plant investigations leading to the application of instrumentation. Previous experience in industrial instrument development essential. A knowledge of servo theory and the design of electronic circuits would be an advantage. Written applications to Staff Department, Hexagon House, Blackley, Manchester, 9. W 2636

APPLICATIONS are invited from men aged 21-30 years for work of a permanent nature which offers considerable scope for advancement. Applicants should have experience in the development and construction of Laboratory Test or Instrumentation Equipment or Sub-Miniature U.H.F. Gear. Ordinary or Higher National Certificate or C. and G. Telecommunications (Parts II and III) desirable. Salary commensurate with qualifications and experience. Apply to Box No. W 2637.

ENGINEERS required for high frequency cable testing. Apply giving age, experience and salary required to Ref. 423. Siemens Brothers & Co. Ltd., Woodwich, S.E.18. W 2634

THE FOLLOWING vacancies exist in the Aviation Engineering Division for engineering development and production supervision work on Electrical and Mechanical Aircraft Instruments, Electric Auto Pilots and associated equipment. 1. Senior Engineers. Applicants should possess a University Degree, a Higher National Certificate, or experience of equivalent standard. They should have a minimum of three years laboratory experience in general physics, electrical or mechanical engineering together with a good knowledge of current drawing office and design practice and some knowledge of aviation requirements. Applicants for these posts should be capable of developing a new design without supervision to the production stage. 2. Assistant Engineers. Applicants should possess a National Certificate and previous industrial and/or laboratory experience of a similar nature to that required for Senior posts. They will be employed on work of a similar nature but under supervision. The salary offered will be in accordance with qualifications and experience. Applications, which clearly state the vacancy applied for, are to reach the Personnel Manager, S. Smith & Sons (England) Ltd., Bishops Cleeve, Nr. Cheltenham, Glos., not later than 31st January, 1951. W 2638

MARCONI'S WIRELESS TELEGRAPH Co. Ltd., have vacancies for Junior Engineers to work on VHF Transmitter Development and Multiplex Channelling. Candidates should have a Degree in Physics or Electrical Engineering or equivalent qualifications, or should have had good experience on radio development or research. Experience on VHF or Multiplex Channelling is desirable. Good salaries will be paid, based on qualifications and experience. The Company has a Staff Pension Fund. Apply giving full details quoting ref 822A, to Central Personnnel Services, English Electric Co. Ltd., 24-30 Gillingham Street, London, S.W.1. W 2641

APPLICATIONS are invited for the post of Assistant to Engineer in charge of research and development of light electrical mechanical and thermal equipment. Candidates should have good Degree in physics and flair for mathematics with sound practical and design experience. The post, which is in a modern factory in the West London area, is permanent, progressive and carries superannuation. Applicants should give full details of qualifications, experience, age and salary required to Box No. 2644.

SENIOR ENGINEER for experimental work on servo-mechanisms required for important defence project in special English Electric Company Laboratory. Permanent post. Good experience in servo-loop design essential. Honours Degree preferable. Married accommodation available. Commencing salary £700/£900 per annum. Apply, giving full details of qualifications and experience, mentioning ref 844 to Central Personnel Services, English Electric Co. Ltd., 24-30 Gillingham Street, Westminster, London, S.W.1. W 2643

SENIOR ENGINEER for experimental work on radar, radio and/or electronics for important defence project in English Electric Company Laboratory. Permanent post. Good experience in radar or electronics essential. Honours Degree preferable. Married accommodation available. Commencing salary £700/£900 per annum. Apply giving full details of qualifications and experience, mentioning ref. 456B to Central Personnel Services, English Electric Co. Ltd., 24-30 Gillingham Street, London, S.W.1. W 2645

McMICHAEL RADIO LTD. require Senior Project Engineers in their Equipment Development Laboratory at Slough. Training and experience in the field of Applied Electronics (including Communications) and experience of working with Government departments, are the chief qualifications required. Salary will be commensurate with ability. Write, stating age and full details of training, qualifications and experience, to the Chief Engineer, Equipment Division, McMichael Radio Ltd., Slough, Bucks. W 2563

APPLICATION ENGINEER required for High Frequency Heating. Experience of induction heating application essential, and a Degree or experience in Metallurgy preferable. This is a responsible senior position offering good conditions of employment in a department developing schemes into production processes. Write, giving full details, mentioning Ref. HAG. to Box No. W 2582.

SCIENTIFIC GLASSBLOWER for Vacuum Physics Laboratories, experienced in high vacuum work and knowledge of glass and metal seals an advantage but not essential. Interesting work in ideal conditions and surroundings. Permanent staff position. Apply, stating salary expected and giving full details of training, qualifications and experience, to Personnel Officer, Ferranti Ltd., Ferry Road, Edinburgh. W 2494

AN EXPERIENCED Valve Engineer is required for employment at Chelmsford. Applicants should be 25-35 years of age, qualified engineers, and preference will be given to applicants with previous design or production experience of small transmitting valves. Write, giving full details of previous experience, mentioning Ref. 497B, to Central Personnel Services, English Electric Co., Ltd., 24-30 Gillingham Street, London, S.W.1. W 2584

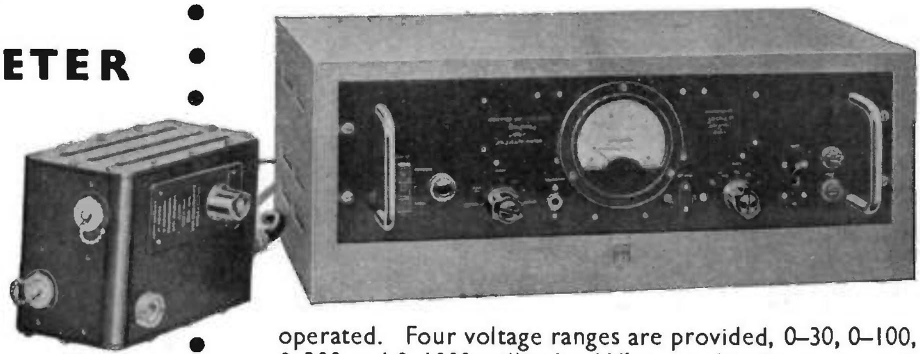
CLASSIFIED ANNOUNCEMENTS
continued on Page 4

EKCO
VIBRATING REED ELECTROMETER

THIS instrument has been designed in conjunction with A.E.R.E., expressly for measuring the small direct currents and voltages encountered in Nuclear research.

It can be used as a substitute for most electrometers and has a zero drift of only 1 to 2 mV per day.

Direct indication of the voltage being measured is given on the panel meter and simultaneously a recorder may be



operated. Four voltage ranges are provided, 0–30, 0–100, 0–300 and 0–1000 millivolts. When used in its most sensitive condition the Electrometer gives a full-scale deflection for a current of 0.03 micro-micro-amps.

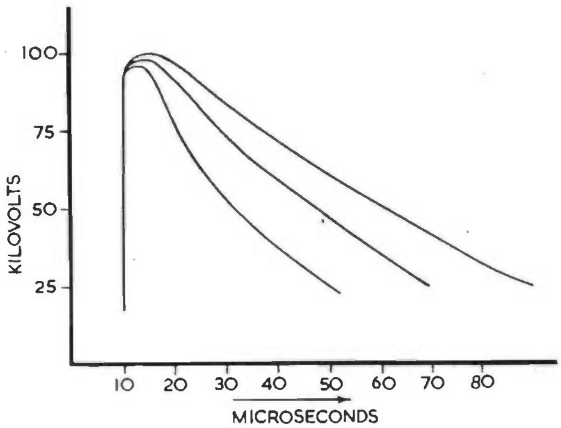
Please write for catalogue and further details.

EKCO *ELECTRONICS*

E. K. COLE LIMITED, ELECTRONICS DIVISION

Sales Office : 5, Vigo Street, London, W.1. *'Phone :* Reg. 7030.

IMPULSE GENERATORS
For 100 KV output



Enquiries are invited for impulse generators up to 100 KV peak with variable PRF, pulse width and output

This equipment is manufactured to a design produced in the research laboratories of British Insulated Callender's Cables Ltd.

HAZLEHURST DESIGNS LIMITED

34a POTTERY LANE, HOLLAND PARK, LONDON, W.11.

Telephones : PARK 6955/5237

A full range of D.C. E.H.T. equipment from 2,000 to 50,000 volts is also available

CLASSIFIED ANNOUNCEMENTS (Cont'd.)

TEST ENGINEERS required for design and manufacture of apparatus for production testing of Radar, Communications, and Electronic Equipment. Salary according to qualifications and experience. Full details to the Personnel Manager, E. K. Cole Ltd., Malmesbury, Wilts. W 2575

E. K. COLE LTD. (Malmesbury Division) invite applications from Electronic Engineers for permanent posts in development laboratories engaged on long-term projects involving the following techniques: (1) Pulse generation and transmission. (2) Servo mechanisms. (3) Centimetric and V.H.F. systems. (4) Video and feedback amplifiers. (5) V.H.F. transmission and reception. There are vacancies in the Senior Engineer, Engineer and Junior Grades. Candidates should have had at least three years' industrial experience in the above types of work, together with educational qualifications equivalent to A.M.I.E.E. examination standard. Commencing salary and status will be commensurate with qualifications and experience. Excellent opportunities for advancement are offered with entry into pension scheme after a period of service. Forms of application may be obtained from Personnel Manager, Ekco Works, Malmesbury, Wilts. W 2525

MECHANIC REQUIRED for the construction and servicing of industrial electronic apparatus maintenance of electro mechanical transducers, etc. West London area. Forward details of education, experience and salary required, to Box A.E., 152, Central News Ltd., 17 Moorgate, London, E.C.2. W 2607

FIRST CLASS Electronic Mechanics required. Applicants must be used to construction of specialized equipment. Excellent facilities. N.W. London area. Write, stating age, experience and salary required to Box No. W 2648.

JUNIOR ASSISTANT, either sex, required for interesting work in Research Laboratory, Kingston, Surrey area. Practical aptitude and matriculation standard in Physics and Chemistry essential. Write stating age, whether exempt National Service, experience and salary required. Box No. W 2649.

A SMALL and independent firm engaged on Electronic Development solicits applications from Engineers with qualifications and experience for three vacancies. The respective starting salaries are: £530, £640 and £800, with opportunities for advancement with expansion. The work covers Standard and Sub-Standard measuring devices. The Laboratories are well equipped and located in the W.1. district of London. Please write giving details to Box No. W 2650.

CITY OF BIRMINGHAM Education Committee. Birmingham Central Technical College. Department of Physics and Mathematics. Applications are invited for the post of Lecturer with Special Responsibility in Physics. Candidates should have a good Honours Degree in Physics and some industrial or Research experience, preferably in electronics. Facilities for Research will be available. Salary—Burnham scale plus £150 responsibility allowance. Present Burnham scale, which is under revision, is £300 to £555 with an allowance of up to £90 for Degree and training. Starting salary will depend on approved teaching and industrial experience. The person appointed will be required to take up duty as soon as possible. Further particulars and form of application may be obtained from the Registrar, Birmingham Central Technical College, Suffolk Street, Birmingham, 1, on receipt of stamped addressed foolscap envelope. Completed forms should be returned to him not later than two weeks after the insertion of the advertisement. C. McCaw, Clerk to the Governing Body. W 1231

NELSON RESEARCH Laboratories, English Electric Co., Stafford, have vacancies in their laboratories for men interested in experimental and theoretical work on small transformers and other allied iron core devices. This work will include the study of the behaviour of transformers, etc., under transient and steady A.C. conditions. Preference given to men with good Honours Degree in Physics or Engineering, interested in experimental work. Experience in this field desirable but not essential. Salary according to qualifications. Apply, stating age, qualifications and experience, quoting Ref. 821, to Central Personnel Services, English Electric Co., Ltd., 24-30 Gillingham Street, London, S.W.1. W 2593

NELSON RESEARCH Laboratories, English Electric Co., Ltd., Stafford, have vacancies for men with Higher National Certificate (Electrical) for design and development work on small transformers and other allied iron core devices. Work will include the study of behaviour of transformers, etc., under transient and steady A.C. conditions. Experience in this field desirable but not essential. Salary according to qualifications. Apply, stating age, qualifications and experience, mentioning Ref. 823, to Central Personnel Services, English Electric Co., Ltd., 24-30 Gillingham Street, London, S.W.1. W 2592

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

A VACANCY exists with a well-known Radio Engineering Firm near London, for a Technical Writer. Duties will be to originate technical sales literature of all kinds, to deal with printers and typographers, and to liaise with design engineers within the Company. Experience gained would range over the Company's many products and would be invaluable to a young engineer. Applicants should have a good general knowledge of telecommunications, be between 21 and 30 years of age, and have an ability for this special kind of writing. Apply, giving full details, mentioning Ref. BGH, to Box No. W 2599.

TECHNICAL ASSISTANT required by large firm in N.E. London suburb for experimental work in connexion with the industrial application of electronics (di-electric heating, process control, etc.). Applicants should have fulfilled liabilities under the National Service Act and have a good Degree (or near equivalent) in Electrical Engineering or Physics and some practical engineering or radio experience. A knowledge of radio frequency oscillators, transmission line theory and radio frequency measurement is essential. The post offers good scope, interest and experience. Commencing salary will be in the region of £400 to £450 per annum according to qualifications and experience. Successful applicant would be required to join staff pension scheme. Write giving full details of training and experience to Box No. W 1217.

ELECTRONIC Development Engineers. Senior and Junior Electronic Engineers required for design and development work on interesting new projects. Degree or Higher National Certificate essential. Good salary and excellent prospects. Pension Scheme. State age, qualifications and experience to Personnel Manager, Fairey Aviation, Company, Ltd., Hayes, Middlesex. W 2610

E. K. COLE LTD., have vacancies in their Electronics Division at Malmesbury, Wilts., for Senior and Intermediate Draughtsmen in the Development Drawing Office, for work on Radar, Communications, and Electronic projects. Previous experience in this field desirable but not essential. Apply, in writing, to the Personnel Manager, Ekco Works, Malmesbury, Wilts. W 2577

RADAR, Radio and/or Electronics Senior Development Engineer wanted for work on important defence project in special English Electric Company Laboratory. Salary, £600-£900 per annum, according to experience. Write, giving details of qualifications and previous experience, mentioning Ref. 456A, to Central Personnel Services, English Electric Co., Ltd., 24-30 Gillingham Street, London, S.W.1. W 2589

SERVO ENGINEERS for experimental work are required by a prominent Aircraft concern. Applicants preferably under 35 years of age must be educated technically to Degree standard, and have experience in the design of one or more of the following: Hydraulic systems, servo amplifiers, small electrical mechanisms. Apply, stating age, experience and salary required, to Box No. W 2562.

SITUATIONS WANTED

ENGINEER—Wide experience, government and manufacturing establishments co-ordinating development and production of electrical and electronic equipment seeks responsible position. Box No. W 1219

AN ELECTRICAL Instrument Engineer, B.Sc., age 36, with wide experience in the electrical industry on production research and development work of instruments, recorders and magnetic amplifiers, etc., requires progressive executive position. Box No. W 1207.

LABORATORY Engineer (Electronics), experience covers, Vibration and Fatigue of Metals, Design of Associate Equipment, etc. London or Home Counties preferred. Box No. W 1227.

FOR SALE

VARIAC. Type 100L—Thyratons—Two B.T.I.—Four BT45—sell or exchange. R107 or R1155N. 20 Second Avenue, Halifax. W 1220

AERIAL RELAYS. Price's Type 52. S.P.D.T. 24V. Coil. Will break 20A at 5 KV. 17s. 6d. each. Advertiser, 116 Blackheath Road, London, S.E.10. W 1212

ELECTROSTATIC VOLTMETERS. 2½ in. Plug-in. 0-3500, 35s. Rectifier Units, Input 200-250 V. A.C. c/w 524G, Choke, Smoothing Condensers, Fuses, Output Socket, Etc. 30s. Twin I.F. Filter Units. 465 Kcs 10s. Tubular Wire Wound Resistances. 4.8 Watts, 1s., 10 W. 1s. 3d., 20 W. 1s. 6d., 60 W. 2s. Assorted Resistors. 12s. per gross. Condensers, Tubular. .01 MFD. 30,000 V. 15s., .1 MFD 1,000 V. 7d. .01 MFD 600 V. Sprague 6d., 50 MFD. 12 V. 6d., 4 MFD 12 V. 4d. Oil Filled. 5 MFD 1,000 V. 8s., 8 MFD 600 V. 7s. 6d., 4 MFD 600 V. 5s. Other values in stock. Barrett, 7 Upper Kent Street, Leicester. W 1224

NEW BOXED VALVES. Fully guaranteed. 6V6, 5Z4, 6X5, 6K7, 6K7GT, EBC33, 12A6, 6M7, VR137, 9D2, 1C5, DDL4, 6SK7, 6AC7, 7Q7, 37, EL32, EK32, EC52, VR54, VR57, EF36, 6J7, 5s. 9d. each. 6Q7G, 6Q7GT, EF39, 5U4G, 6C5, 6C6, 6D6, 807, VR150/30, 7Q7, 5Y4, 77, 78, 6s. each. 1S4, 1S5, 1R5, 3S4, 1T4, 7s. each. Send for lists. C.O.D. or C.W.O. Carriage paid. Alpha Radio Supply Co., 5-6 Vinces Chambers, Victoria Square, Leeds, 1. W 2647

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

COILS. Special inductances 1μH to 2H at RF, singly or quantity, wound to order. Bel Sound Products Co., Marlborough Yard, Archway, N.19. Archway 5078. W 112

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

MAGSLIP TRANSMITTERS, 3 in., Mk. 2 and Mk. 4, 21s. 6d.; magslip hunters, 2 in., Mk. 1, 9s. 6d. S.A.E., details. K. Logan, Westalley, Hitchin, Herts. W 116

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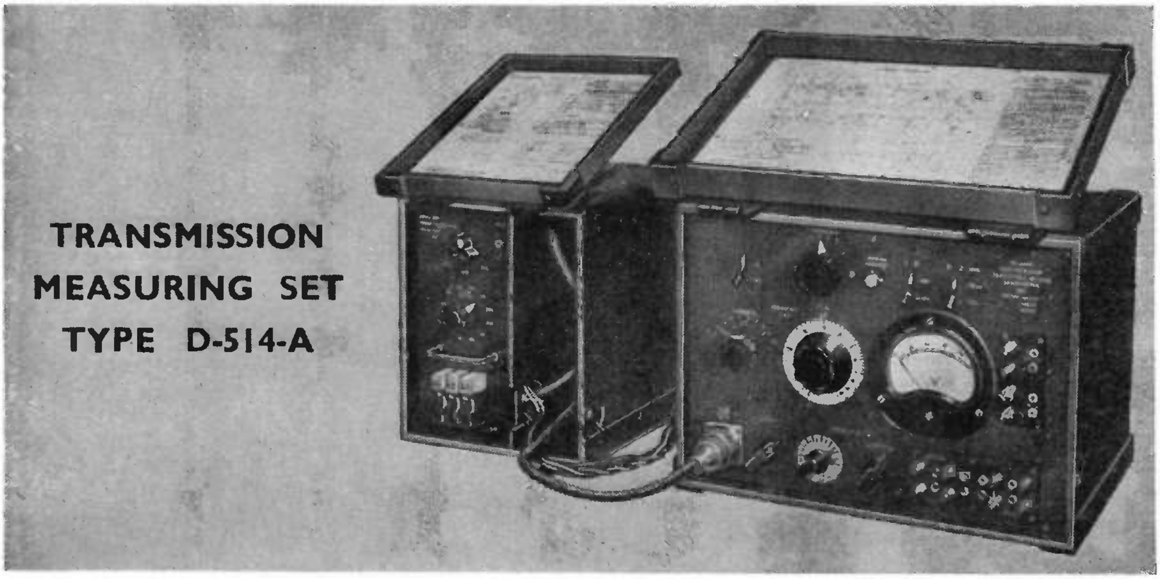
CLASSIFIED ANNOUNCEMENTS
continued on Page 6

TRANSMISSION MEASURING SET TYPE D-514-A



Laboratory measurements of the frequency response of filters, amplifiers, transformers and other components usually require a considerable amount of preparation, involving as they do the use of an oscillator, an attenuator, a valve voltmeter and various change-over switches.

The Transmission Measuring Set Type D-514-A combines all these items in one compact unit, and with its aid gain or loss measurements of up to 50 db at any frequency between 100c/s and 40kc/s may be carried out immediately with no preparation other than the connexion of a power supply.

This instrument also finds many applications in the field, especially for transmission measurements on telephone and carrier telegraph circuits. When an A.C. supply is not available, the turn of a switch enables the power unit to be operated from a 12 volt accumulator.

- **FREQUENCY RANGE:** 100c/s to 40 kc/s continuously variable.
- **FREQUENCY ACCURACY:** better than ±0.4% over entire range.
- **POWER SUPPLY:** A.C. mains 100 - 250 volts, 40 - 60c/s, or from a 12 volt accumulator.
- **OSCILLATOR** may be used separately, if desired.
- **LAMP BRIDGE LEVEL METER:** controls standard level of 1mW within ±0.25db.
- **RANGE OF MEASUREMENT:** gain and loss up to 50 db at any frequency.
- **OUTPUT IMPEDENCE:** for use on 600 ohm circuits.
- **PORTABLE:** contained in two tough laminated plastic carrying cases.

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BOROUGH POLYTECHNIC, Borough Road, S.E.1. Department of Electrical Engineering. Lectures on Pulse Techniques. A special course of 12 lectures for advanced students on Pulse Techniques will be held at the Polytechnic on Mondays from 7 to 9 p.m., beginning on Monday, 22nd January 1951. The fee for the course is two guineas. Applications for admission should be made to the Secretary. W 2618

THE POLYTECHNIC, 309 Regent Street, W.1. A course of six lectures on Radio Wave Propagation and the Ionosphere will be given by L. Prechner, Engineering Division, B.B.C., on Tuesday evenings from 6.30 to 8, commencing 16th January, 1951. A detailed syllabus is available. Application to attend the course should be made as soon as possible to the Head of the Department of Mathematics and Physics. W 2627

NORTHAMPTON POLYTECHNIC, St. John Street, London, E.C.1. Principal: J. E. Richardson, Ph.D., B.Eng., M.I.E.E., A.M.I.Mech.E. A course of Six Lectures on Magnetic Materials will be given by A. E. De Barr, B.Sc., F.Inst. P. (Research Laboratories of Elliott Bros. (London) Ltd.) on Wednesday Evenings at 7 p.m., commencing Wednesday January 31st, 1951. Fee for the course 20s. payable in advance on enrolment. Admission to the Course is effected by personal application at the Polytechnic Office any day 10 a.m. to 7 p.m. up to 29th January 1951, or by post. W 1230

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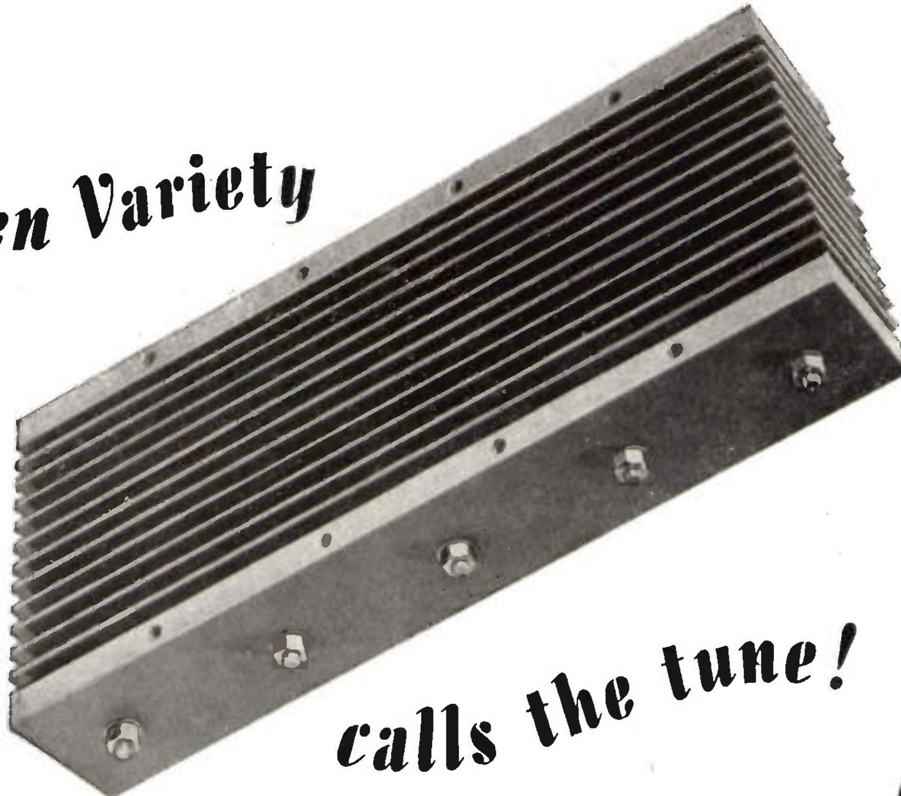
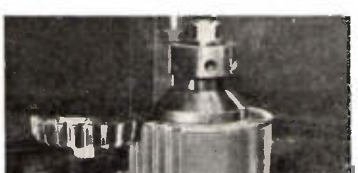
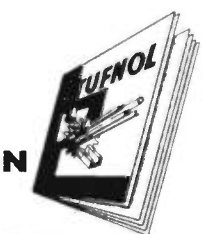


Playing up to the applause which comes our way from the experts, we present a picture of a lens-drying tray made of Tufnol which according to them more than comes up to scratch! For one thing it *doesn't* scratch, and that's important to optical glass; for another, it is unaffected by chemical action: two qualities not combined elsewhere.

Tufnol is, in fact, quite unlike any other material; yet it shares the virtues of many. The uses to which it can be put are of infinite variety! It is only half the weight of aluminium, yet structurally strong enough to work sympathetically with steel: it machines easily and accurately without splitting; does not warp; and is resistant to moisture and erosion. Added to these qualities is a high degree of electrical insulation. Supplied in sheets, tubes, rods, bars, angles, channels, or specially moulded shapes, Tufnol's astonishing versatility in use is the secret of its success!



Tufnol is easily machinable with ordinary workshop facilities. Photograph shows a Tufnol gear being cut.



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Are you likely to have a new use for Tufnol, any time in the future? Our Technical Staff will be glad to co-operate on any ideas you may have. If there is anything you want to know about what Tufnol has done, we will send you the appropriate technical publications. Why not get in touch with us TODAY!

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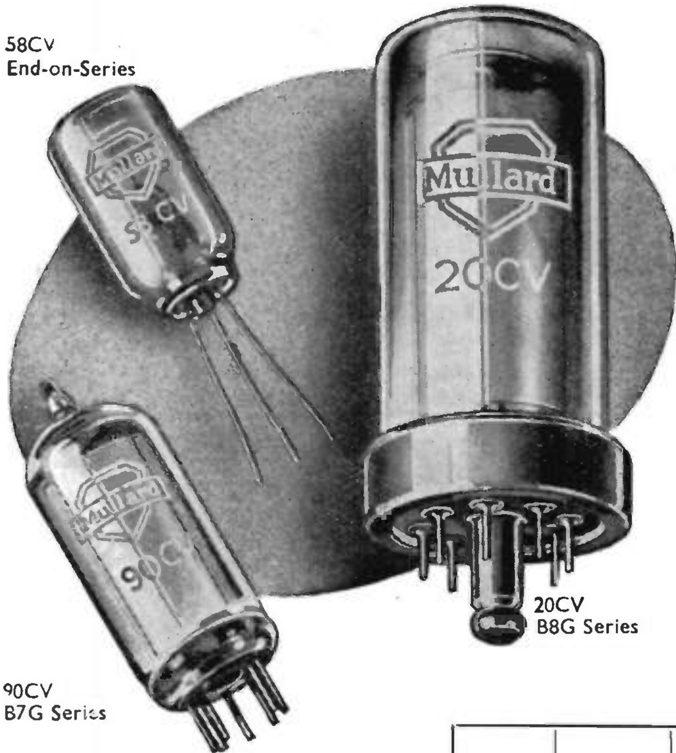
A Range of Industrial Photocells



As a result of extensive research both in material and design Mullard now make available a comprehensive range of photocells ideally suited for industrial applications.

The range falls into two main groups. The caesium-silver-oxide cathode (C type) cells, with a high sensitivity to incandescent and infra-red radiation ; and the caesium-antimony cathode (A type) cells, with a high sensitivity to daylight.

Brief technical details are listed below. Fuller information on these and special photocells is available on request.

Type	Base	Max. Anode Supply Voltage (V)	Max. Cathode Current (µA)	Dark Current (µA)	Sensitivity to colour temp. 2,700°K (µA/l)	Max. Gas Amplification Factor
20AV	B8G	150	10	0.05	45	—
20CG	B8G	90	5	0.1	150	10
20CV	B8G	250	20	0.05	25	—
90AG	B7G	90	2.5	0.1	200	7
*90AV	B7G	100	5	0.05	45	—
*90CG	B7G	90	2	0.1	125	10
*90CV	B7G	100	10	0.05	20	—
58CG	Wire-in	90	1.5	0.1	85	9
58CV	Wire-in	100	1.5	0.05	15	—

* These valves are included in the new Government list of preferred valves for the services.

Mullard
News Letter
If you are not already on the mailing list for this service of advance information on new valves, please write to us for full particulars on your business letterheading.

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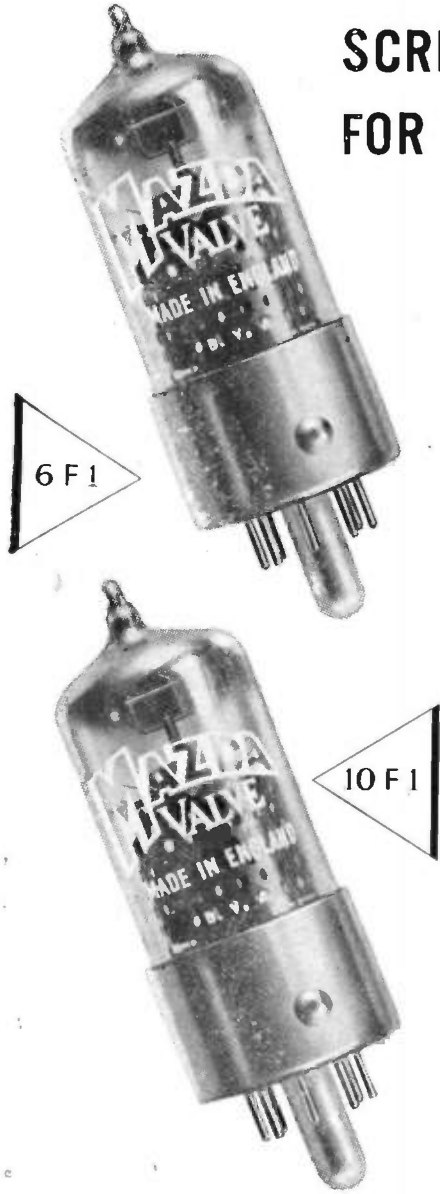


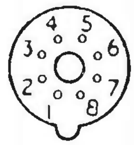
The 6F1 and 10F1 are two new screened H.F. Pentodes for AC and AC/DC mains operation respectively. Identical, apart from heater rating, they have twin cathode connections giving a considerable reduction in common anode and grid circuit H.F. impedance, thereby enabling a high input resistance to be obtained.

This high input resistance together with the high mutual conductance of these valves (9mA/V at 10mA Anode Current) makes them ideal for use in straight television receivers, particularly for operation at a carrier frequency of 61·75 Mc/s as used by the Midland (Sutton Coldfield) transmitter.

TYPICAL OPERATION

		6F1	10F1
Heater Voltage	V_h	6.3 volts	22 volts
Heater Current	I_h	0.35 amps	0.1 amps
Anode Voltage	V_a	200 volts	200 volts
Screen Voltage	V_{g2}	200 volts	200 volts
Anode Current	I_a	10 mA	10 mA
Screen Current	I_{g2}	2.6 mA	2.6 mA
Grid Voltage	V_{g1}	−1.8 volts	−1.8 volts
Mutual Conductance	g_m	9 mA/V	9 mA/V
Input loss at 61.75 Mc/s (approx.) ..	r_{in}	7500 ohms	7500 ohms

LIST PRICE: 15/6d



Base B8A
Viewed from free end of pins

CONNECTIONS

Pin 1	Heater	h
Pin 2	Anode	a
Pin 3	Internal cylindrical shield and suppressor grid	g3 & S
Pin 4	Screen Grid	g2
Pin 5	Cathode	k
Pin 6	Control Grid	g1
Pin 7	Cathode	k
Pin 8	Heater	h

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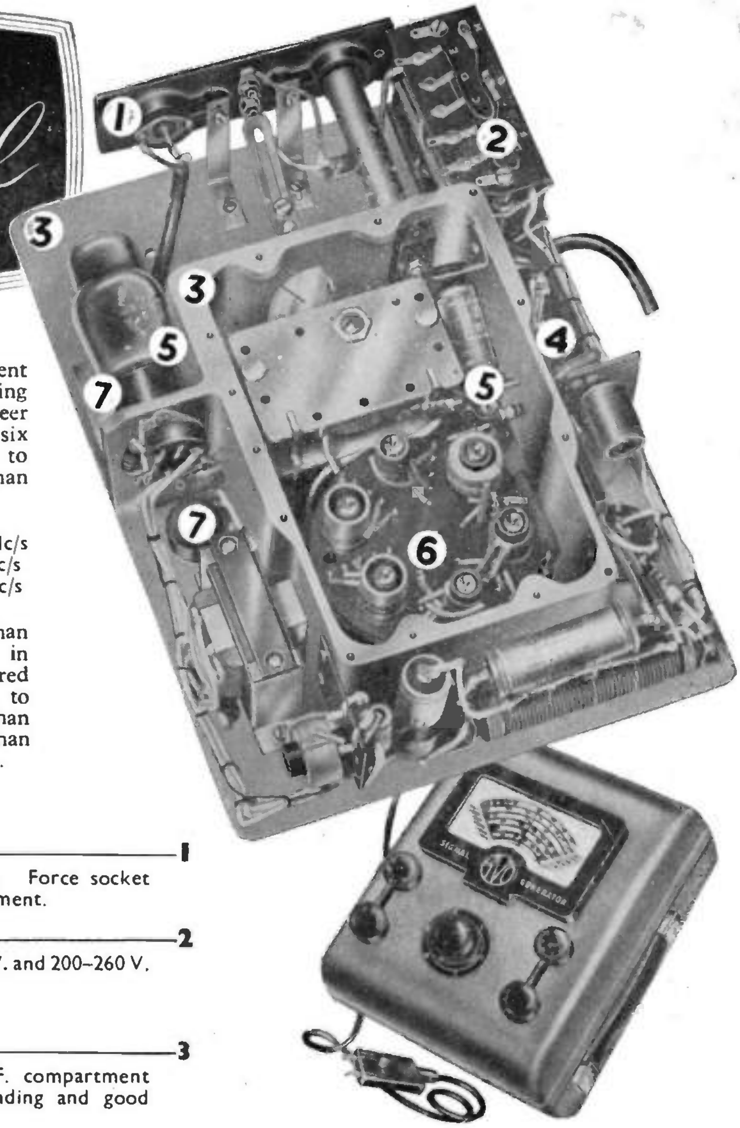

An inexpensive yet precision instrument designed especially to meet the exacting needs of the modern service engineer and laboratory technician. With six frequency ranges covering 50 Kcs. to 80 Mcs., its accuracy is better than ±1% of the scale reading.

50 Kc/s-150 Kc/s	1.5 Mc/s-5.5 Mc/s
150 Kc/s-500 Kc/s	5.5Mc/s- 30 Mc/s
500 Kc/s- 1.5 Mc/s	20 Mc/s- 80Mc/s

Scale sub-divisions provide more than adequate discrimination for use in television circuits. Note the starred features below, which combine to maintain a minimum signal of less than 1μV. up to 20 Mc/s. and less than 3μV between 20 Mc/s. and 80 Mc/s.

★ **OUTPUT** —— 1
Coaxial socket for attenuated output. Force socket located totally within H.F. compartment.

MAINS TRANSFORMER —— 2
Marked tagboard for inputs of 100–130V. and 200–260 V. A.C. 50/60 c/s.

★ **CAST ALUMINIUM H.F. COMPARTMENT & CHASSIS** —— 3
Large number of fixing holes for H.F. compartment cover ensures excellent electrical bonding and good screening.

FUSE —— 4
Easily accessible when replacement is necessary.

VALVES —— 5
Standard types run at a rating to ensure long life.

TURRET COIL SWITCHING —— 6
Standard "AVO" practice.

★ **ATTENUATOR SYSTEM** —— 7
Employs close tolerance, high stability midget carbon resistors, low reactance rotary potentiometer modified for H.F. operation with carefully designed screening.

Other features include:

ILLUMINATED SPOT RANGE SELECTOR
Gives rapid identification of operational band with intensified lighting round precise frequency. Fine hair line gives close discrimination, particularly on high frequencies.

STOPS
Separate stops prevent turning of dial with respect to condenser.

★ **MAINS FILTER SYSTEM**
This is screened from main electrical assembly.

BUSHING PLATES
provide additional rigidity for rotary controls.

SLOW MOTION DRIVE
substantially free from backlash.

MAINS MODEL 100–130V. and 200–260V. AC, 50–60 c/s. £25
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S.G. 1

Standard introduce

Thermal delay switch type VLS 631

The "Standard" VLS 631 has been designed to meet the need for a small and reliable thermal delay switch. The switch consists of a pair of bi-metallic contact strips operated by a 6.3 volt 0.5 amp heater. The whole assembly is sealed in a nitrogen filled bulb mounted on a miniature 7 pin (B7G base). Because of its small size and easy operation the VLS 631 is particularly useful for delaying the application of H.T. voltage to circuits using valves requiring a warming up period.

THERMAL DELAY SWITCH, TYPE **VLS 631**

Ratings	Heater	6.3 V : 0.5 A
	Nominal Delay at 20° C.	50-60 seconds
	Max. o/c voltage between contacts ...	220 V D.C.
	Max. Surge current on make	1.0 A
	Max. current on break	100 mA at 50 V. D.C.
Dimensions	Max. overall length	54 mm
	Max. seated height	48 mm
	Max. bulb diameter	19.1 mm
	Base	B7G

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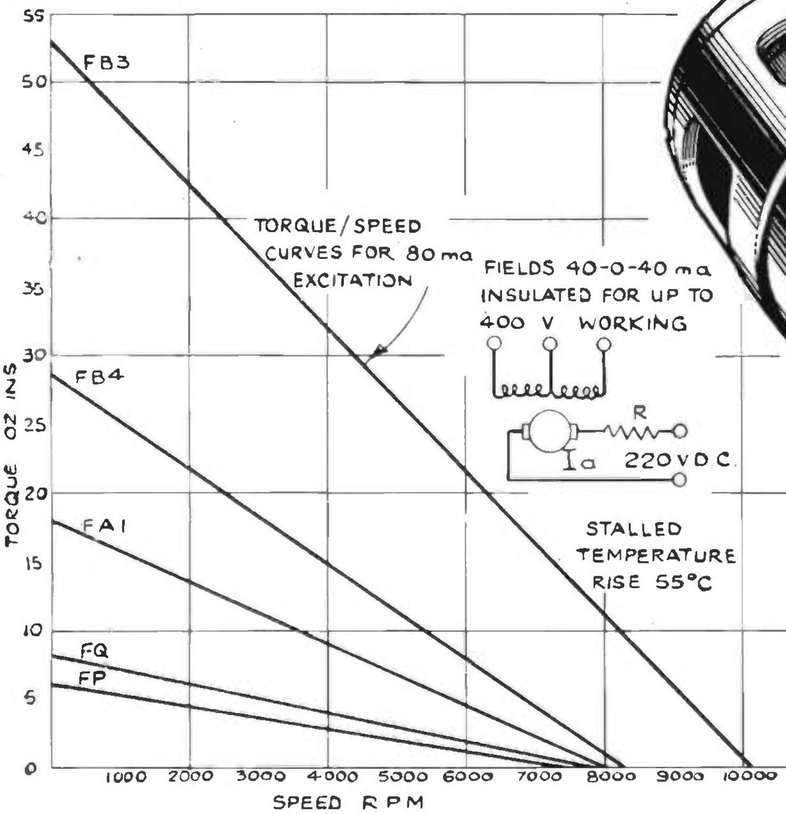

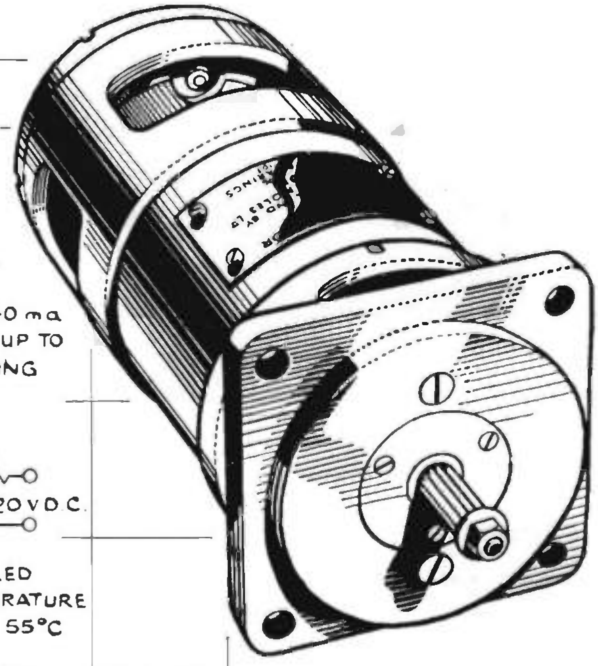

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F.Q.	0.75	0.5	0.33
F.A.1	1.8	0.5	0.75
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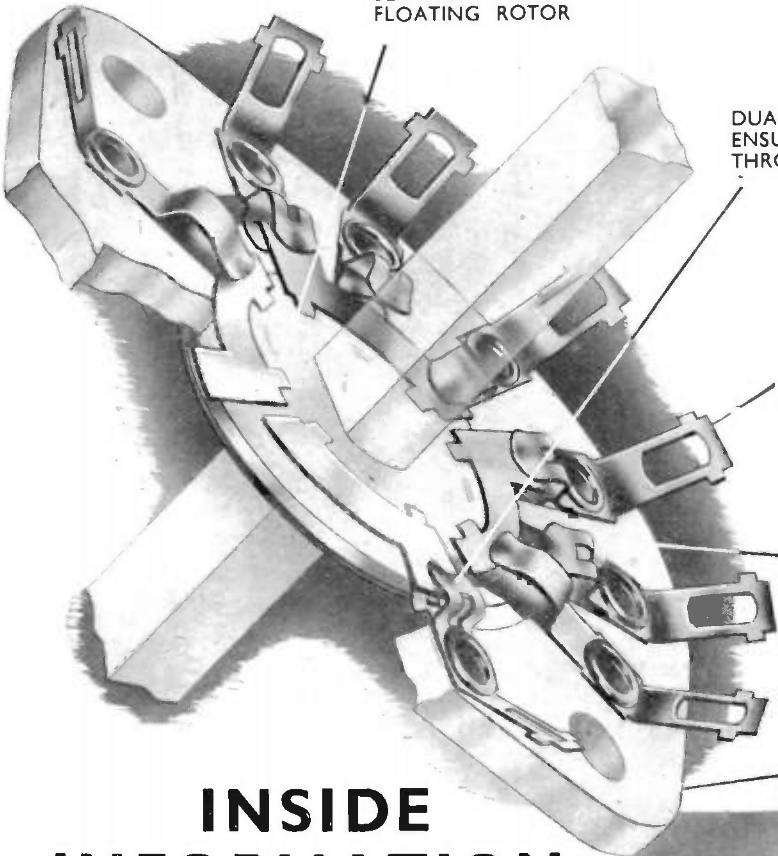

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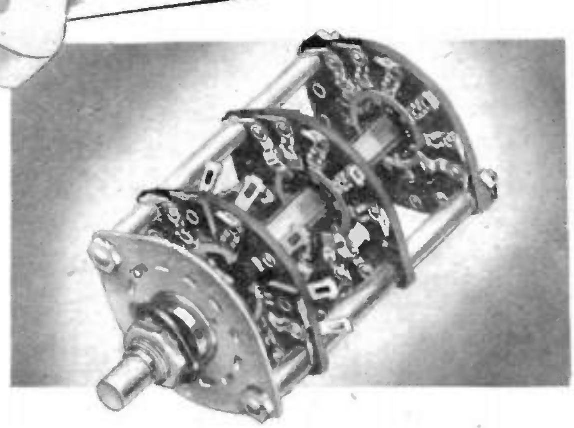
—about the switch that is superior

'OAK' switches—both rotary and push button types—are embodied in the majority of British radio receivers.

Throughout the radio world, the time-tested basic 'OAK' principles are recognised and acknowledged as superior. They form the basis for the standard inter-service wafer type switch to Specfication RCS.151 of the Radio Components Standardisation Committee.

The new miniature types, embodying all 'OAK' basic features, bring the range available in line with today's requirements for miniaturised equipments.



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Cutler-Hammer appliance switches; Carbon and wire-wound potentiometers for television and radio applications.

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Electronic Engineering

Incorporating
ELECTRONICS, TELEVISION
and SHORT WAVE WORLD

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

Vol. XXIII. **JANUARY 1951** No. 275

In This Issue

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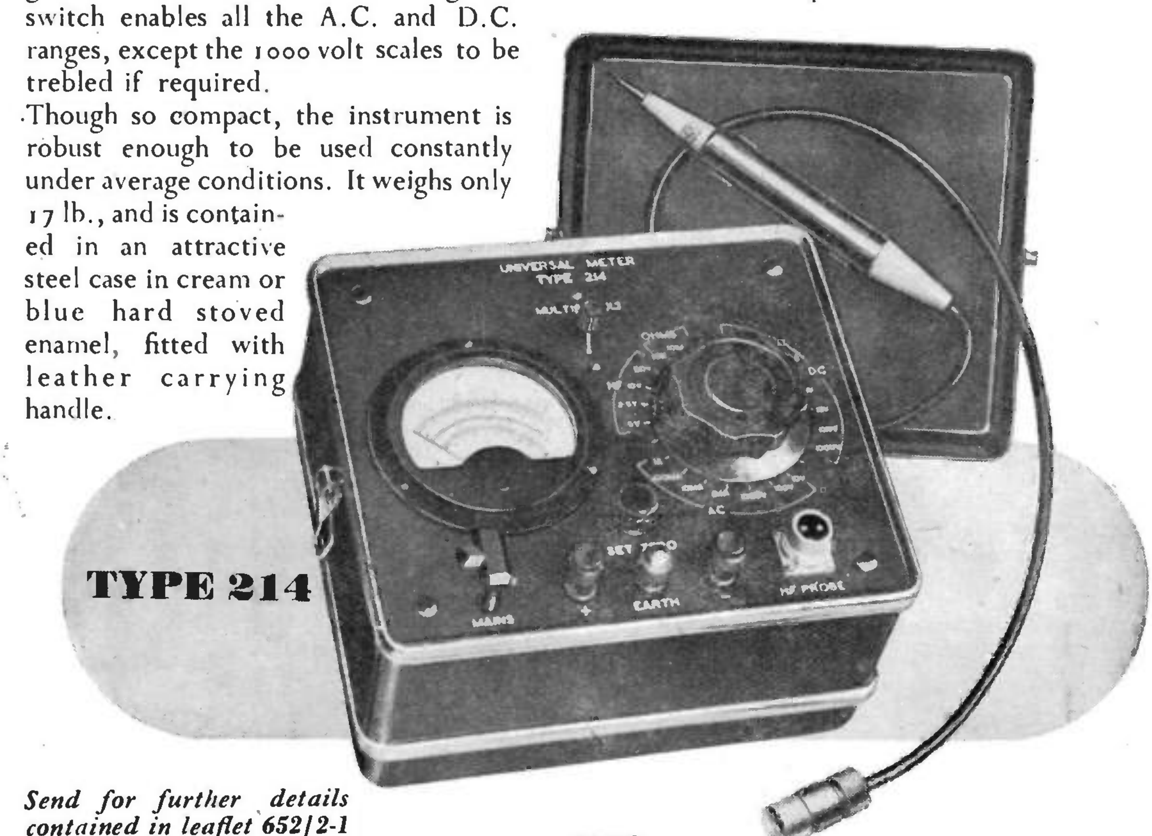
Classified Advertisements, Page 1.
Index to ADVERTISERS, Page 46

An entirely new development . . .

THE METROVICK UNIVERSAL METER

This latest Metrovick product in the field of electronics gives the Electronic and Radio Engineer all he needs in a multi-range instrument for the measurement of current, resistance and voltage. In addition, provision for R.F. Voltages is made by the inclusion of a probe which employs a diode valve for rectification. All sections give indication on the same moving coil instrument, and a multiplier switch enables all the A.C. and D.C. ranges, except the 1000 volt scales to be trebled if required.

Though so compact, the instrument is robust enough to be used constantly under average conditions. It weighs only 17 lb., and is contained in an attractive steel case in cream or blue hard stoved enamel, fitted with leather carrying handle.



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Electronic Engineering

Vol. XXIII. **JANUARY, 1951** No. 275.

Commentary

TWO announcements of considerable interest have recently been made by the Royal Society.

The first concerns Sir Robert Robinson's presidential address at the Anniversary Meeting on November 30, in which reference was made to a proposal to establish a National Science Centre in London. This proposal was outlined in the House of Commons by Mr. Morrison, Lord President of the Council on November 21 and it is hoped that he will be able to make a further announcement about the location of the site for the Centre early this year.

At the present moment, the Royal Society and a number of other leading scientific societies are housed in very cramped quarters which were provided by the Government about 100 years ago in Burlington House and elsewhere. Even as far back as 1900 there were complaints that the accommodation was inadequate, and difficulties have become increasingly acute with the passing years. In 1944 a deputation from the learned societies approached the Government to call attention to the needs and claims for accommodation of those societies which aim at the promotion of the independent advance of the fundamental sciences. Once it had become obvious that Burlington House was incapable of further expansion, a Scientific Societies Accommodation Committee was set up in 1947 to review alternative schemes. The Committee also examined the needs of the various societies in terms of meeting rooms, library space and offices, and decided that a floor space of 300,000 sq. ft. would be required. This would provide for such common ancillary services as a congress hall and certain lecture theatres, and allow for reasonable expansion at the same time.

After further negotiations it was announced that an adequate central site had been selected and that the Treasury had generously offered to provide the cost of the building. Mr. Morrison was therefore able to state in the House of Commons on November 21 that "it has been possible to overcome the remaining obstacles for the adoption of the long-term proposals originated by the Royal Society for a British Science Centre in London. Provision will be made for accommodating the Patent Office and its Library and new quarters will be built for the Royal Society and for other leading scientific societies, together with offices for the Department of Scientific and Industrial Research.

Only the general outline of the scheme has been discussed, but it is understood that the various societies will have their separate quarters and that many of the smaller scientific clubs and societies will receive hospitality under the new arrangements as they have done in the past.

While this enterprise cannot but receive warm approval by all concerned, it is to be hoped that the special needs of the provincial branches will not be overlooked. Too often societies well established in London tend to leave their provincial branches to shift for themselves, and those with experience of committee membership in the provinces are only too aware of the difficulties in finding suitable accommodation for meetings and lectures. Too often the only accommodation that can be obtained is a private room at a hotel or restaurant or, at the best, a spare room in the local technical college. It is admitted, of course, that present building difficulties and limitations of capital expenditure prevent any series consideration being given to this matter, but as soon as conditions allow something should be done to alleviate the lot of the provincial member.

* * *

THE second announcement is the appeal by the Council of the Royal Society for financial support for the creation of a suitable memorial to the late Lord Rutherford, who may be said to be one of the greatest experimental scientists of all time and the father of nuclear physics.

It is proposed that the memorial should take two forms:

(1) Travelling scholarships tenable for three years, to be awarded to post-graduate students within the British Commonwealth, for research in the natural sciences, with a preference for experimental physics.

(2) A Rutherford Memorial Lecture to be delivered at intervals at selected University Centres in the British Commonwealth, at least one in three to be given in New Zealand.

For this object a substantial endowment fund is needed and contributions amounting to over £30,000 have already been received. But a sum of at least £100,000 is needed and we are certain that our own industry, which owes so much to Rutherford's original work, will respond most generously. Contributions should be sent to the Rutherford Memorial Committee, The Royal Society, Burlington House, London, W.1.

* * *

READERS will have noticed some of the changes which have been introduced into the journal with this issue.

The size of page has been enlarged to permit better display of editorial features and to meet the convenience of those advertisers who prefer their announcements to be of a standard size. The adoption of Times Roman type in the editorial pages has been made to provide better legibility and to allow greater clarity in the presentation of mathematical formulæ by closely matching the various symbols which are in constant use.

The editorial "contents" have been moved to the last right-hand page before the editorial section, where has been grouped all the information about this issue which can reasonably be required.

We hope that it will be agreed that these changes make a real improvement to the general appearance of the book.

Electronic Guiding Aids for Blind People

By R. L. Beurle *

THE purpose of this article is to place on record the results of experiments carried out at St. Dunstan's on electronic guiding aids. When, at the end of the war, the principles of radar became known many people felt that there might be some possibility of applying the same principles in a portable device. If this enabled blind people both to detect and avoid obstacles they might be able to find their way about without escort to a greater extent than before. There had been earlier attempts to construct such a device. One of these made by Fournier d'Albe in 1918 failed because it merely indicated the presence of light and shade in any direction and, as it could not give any indication of range, obstacles could not readily be avoided.

After the recent war experimental work was started both in this country and in the United States with the idea of investigating fairly thoroughly all the various possibilities. The aim was to discover whether any of the wartime advances in technique could be applied and, if not, what further advances would be necessary before a practical guiding device could be made.

The character of a radar beam, and in particular the wavelength, makes it unsuitable for locating small objects at ranges of a few feet. Because of this it is necessary to consider some other form of exploring beam, the most promising alternatives being beams of light and beams of sound and ultrasonic energy. The wavelengths associated with these media are shorter than radar wavelengths and the difficulties which would be encountered in trying to use a radar beam are thereby lessened. The basic principle of any guiding device would be similar to that of a radar equipment, that is, when the exploring beam is intercepted by an object the latter reflects some of the energy in the beam back to the instrument where it is detected and thus informs the user of the presence of an obstacle.

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Essential Requirements for Guiding Aid

In attempting to design satisfactory guiding devices the following were taken to be the essential requirements:—

It should give the user sufficient information to enable him to walk freely at a moderate speed along the pavement or about the house. In order to do so it must detect and indicate the distance and direction of any obstacle within 6 ft. in front sufficiently rapidly to allow him to avoid it. By "obstacle" is meant any object which he may walk into or any major depression or rise in the ground or floor. The device should be portable, i.e., it should not weigh more than about 4 lb. and anything that has to be carried in the hand should not be greater than about 4 in. cube. The device must be inconspicuous and must not make any noise which is likely to attract attention. If the device is operated by batteries, the replacement or charging of these must not involve great expense or be so frequent that it becomes a nuisance to the user. The device must work reliably under all normal conditions of use and must not be adversely affected by the presence of daylight or traffic noise. If possible a guiding device should do more, but these were thought to be the minimum requirements necessary in order to make the device acceptable to a blind user.

The design of any guiding device is inevitably a compromise between the conflicting requirements set out above. For example, it is desirable to use a reasonably wide beam since an unduly narrow beam requires very careful scanning from side to side to ensure that obstacles are not missed. This takes time and can render progress very slow. Unfortunately, to detect objects at a given distance within a wide beam requires more power than is necessary with a narrow beam and this means increasing battery weight. Another disadvantage of a wide beam is that it is less easy to estimate the direction of any object because for obvious reasons a well-defined sharp beam is required for accurate location. In an acoustic guiding device this latter objection to a wide beam may be overcome because it is possible to determine the direction of an obstacle by using the normal direction-finding ability of the two ears used in conjunction. The choice of the most suitable design is also affected by factors such as the efficiency of the various types of transmitter and receiver which may be used at different frequencies for beams of different widths. Because it was difficult to estimate the practical effect of such factors it was decided that a number of devices of different types should be constructed. Thus, several ultrasonic devices of different types and two light transmitting devices were made and tested out over a period of several months with the co-operation of a number of blind people.

Light Transmitting Guiding Aid

Of the two light transmitting devices one (Fig. 1) employed a torch bulb as the source of light and the other (Fig. 2) employed miniature arc lamps, each of which sent out a regular series of pulses of light. The outgoing beam of light was split into a number of individual sections. The direction in which each section of the beam pointed was adjusted so that each section crossed the field of view of the detector at a different distance. Thus, when an object intercepted the beam at any given distance only the light from one section was returned to the detector, (Fig. 3). In order to distinguish the various sections of the beam so as to indicate the distance of an object the light in each section was interrupted at a different frequency. This was done in the case of one device by rotating a sectored disk in front of the torch bulb, while in the other the separate arc sources were arranged to emit pulses of light at different repetition rates, the light from each arc forming one section of the beam. The result in each case is the same. The presence of an object is indicated either by a note or by a series of clicks heard in an earphone which receives the amplified output of the photocell detector and the pitch of the note or the "click" rate indicates the range of the object. Further details about the size, weight, etc., of these devices are given in the Table on page 4 and Figs. 4 and 5 give the amplifier circuits of the two types of device.

All the acoustic devices employed the same method of range indication. It involved transmitting regular pulses of sound and arranging, in the case of the ultrasonic devices, that both the outgoing pulse and the returning pulse of sound reflected from an obstacle should be heard at about the same level in an earphone. In this way if an obstacle is present two "clicks" are produced in the earphone each time a pulse is transmitted. The time which elapses between the two clicks is the time taken by the sound to go to the obstacle and back and is therefore proportional to the range of the obstacle. It has been found that the variation of this time separation as the range of an obstacle varies can be detected quite easily and serves as a useful indication of the range. Thus, when an obstacle comes within the range of the beam the succession of pairs of "clicks" is heard as a "buzz" and this buzz has a characteristic pitch which rises higher as the obstacle is approached by the person carrying the instrument (Fig. 6).

This is, of course, only one of many ways in which the range may be indicated aurally. Another method is to allow a capacitor to charge during the time taken for an ultrasonic pulse to travel to the obstacle and back. The final voltage on the capacitor may then be applied to a reactance valve which controls the frequency of an audible signal which indicates the range of the object to the user. The same end may be attained by transmitting a frequency-modulated ultrasonic beam instead of a series of pulses. Because of the time taken by the sound to travel to the object and back, the outgoing and returning signals

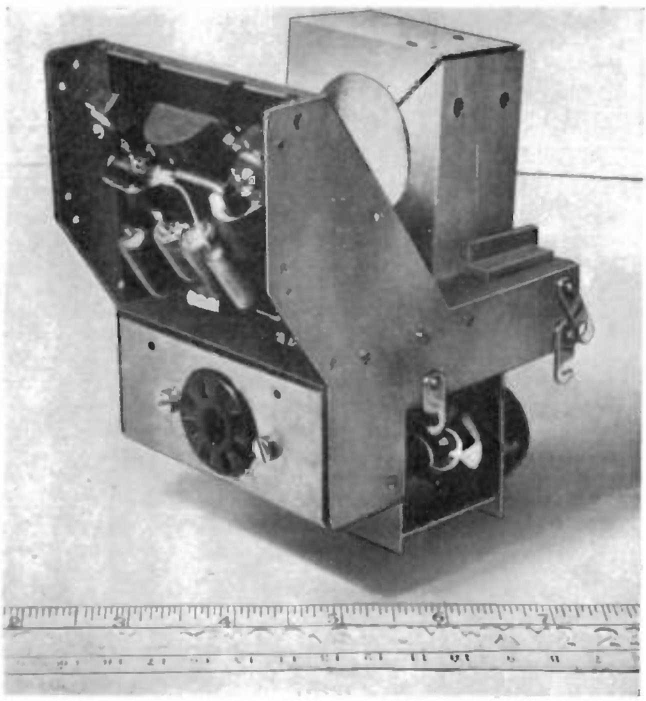
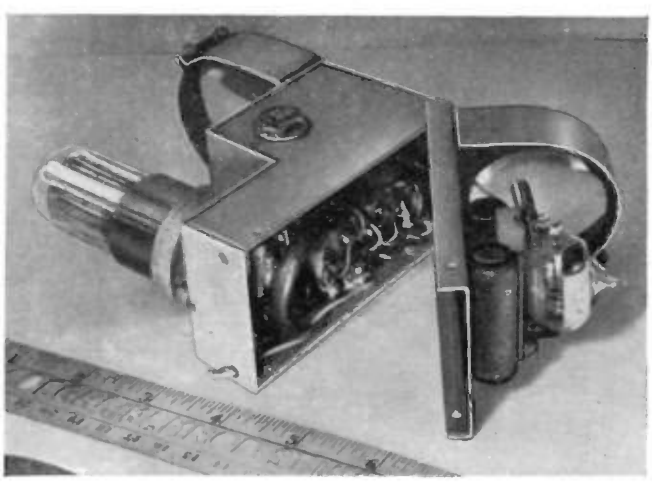


Fig. 1 (left). Light Transmitting Device employing torch-bulb light source. The cover has been opened to show the receiving lens and behind it the housing of the photocell and two amplifier stages. In the lower compartment the light source and one of the projecting lenses can just be seen. The octal socket on the left of the lower compartment takes the leads from the battery case which hangs on the shoulder strap.

Fig. 2 (below). Light Transmitting Device, employing arc light source The photograph shows the transmitting and receiving units without covers. The arc is contained in the glass envelope behind the lens on the right and beside it are the feed resistors and reservoir capacitor used to produce a series of discharges. The multiplier photocell is behind the receiving lens. The amplifier can be seen between the transmitter and the receiver.



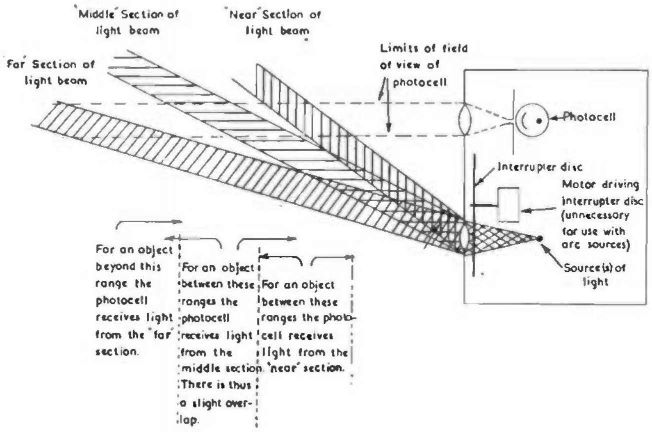


Fig. 3. Method of range-finding in light-transmitting devices

will differ in frequency. The difference frequency may be converted in a mixer valve to an audible beat note which, by suitable choice of modulation frequency and waveform, can be made proportional to the range of the obstacle. Yet another method is to allow the output of the receiver to trigger the transmitter so that each time a reflected pulse is received from an object the succeeding pulse is sent out by the transmitter. With this arrangement the period between successive pulses corresponds to the time of transmission from instrument to object and back. In consequence, the pulse repetition frequency is a measure of the range of the object and may be presented to the blind user as an indication of its presence and range. Though slightly different forms of range indication are obtained in each of these cases it was found that once they had become familiar the facility with which they could be interpreted in terms of the position of an obstacle varied little. The reason for adopting the first method described above was that the circuits involved were the simplest and the tolerance on supply voltages was less critical than in other cases, an important factor where battery supplies are used.

Ultrasonic Guiding Aid

In three of the ultrasonic devices the beam was made narrow enough for the direction of the object to be found by scanning the beam from side to side. These three devices, although otherwise similar, worked at widely different frequencies. The purpose of this was to enable the characteristics of different wavelengths used in a guiding device to be investigated. Fig. 7 shows the circuit of one of these devices. Fig. 8 gives some idea of the miniaturization problem involved in combining an acoustic transmitter and receiver in a portable device. In another ultrasonic device a wide beam was transmitted. Reflexions from obstacles were received on two separate pickup transducers. The transducer output passed through a two-path amplifier, incorporating a detector stage, to two separate earphones so that the natural direction-finding ability of the two ears could be utilized. Further details of the supersonic devices are given in the Table below.

The "Clicker" Device

When a practical comparison of the various devices was made it was found that one device in particular stood out as being more likely to achieve popularity. This was a relatively simple device (Figs. 9 and 10) in which a source emitting audible clicks was placed near the focus of a parabolic reflector to produce a fairly wide beam with a concentration of sound towards the centre of the beam. No internal sound detector was provided, the intention being that the user should listen directly to the sound reflected from any obstacle. This made possible a device with a relatively low bulk and weight and a longer battery life than the others. It is probably these two factors, as much as anything, which counted against the other devices, all of which incorporated internal detectors for the reflected energy. Another advantage of omitting the internal detector and amplifier system is that all the information which may be obtained from the nature of the reflexions is preserved intact. Much of this is lost if the echo is heard through an amplifier, in which some distortion is unavoidable because the power consumption must be reduced to a minimum and the sensitivity kept high.

The choice of a succession of clicks as the best form of sound to employ in this device was based on a series of tests in which a number of blind people were asked to detect certain objects with the assistance of a variety of different sounds. Although the clicks were not the best under all circumstances they did give the greater amount of assistance under a wide range of different conditions. The composition of the sound beam, i.e., a wide beam with a concentration of sound on the centre line, was also chosen as a result of tests with various types of beam.

Dimensions and Consumptions of Guiding Devices

Device	Beam Width	Hand-held Scanning Unit Dimensions	Hand-held Scanning Unit Weight	Total Weight	Battery Consumption	Minimum Life of Batteries
1. Torch bulb light source	Very narrow c 1°	3½″ × 4½″ × 5½″	2 lb.	5 lb.	2.1 watt	3 hours (Accumulator) 20 hours (L.T. Battery)
2. Arc lamp light source	Very Narrow c 2°	2″ × 4″ × 6½″	1 lb.	4½ lb.	0.15 watt	400 hours
3. Ultrasonic (150 kc/s.)	Narrow c 10°	2¼″ × 3½″ × 7½″	3 lb.	6¼ lb.	0.33 watt	10 hours (L.T. Battery)
4. Ultrasonic (17 kc/s.)	Narrow c 20°	9″ × 5″ × 5″	3½ lb.	3¾ lb.	0.13 watt	100 hours
5. Ultrasonic (55 kc/s.)	Narrow c 10°	9″ × 5″ × 5″	3½ lb.	3¾ lb.	0.26 watt	70 hours
6. Ultrasonic (17 kc/s.)	Wide with Binaural Reception	6″ × 5″ × 5″	1 lb.	7½ lb.	0.25 watt	100 hours
7. Audible Clicker	Wide with Binaural Reception	9″ × 2½″ diam. with 5¼″ diameter reflector	1¾ lb.	1¾ lb.	0.019 watt	750 hours

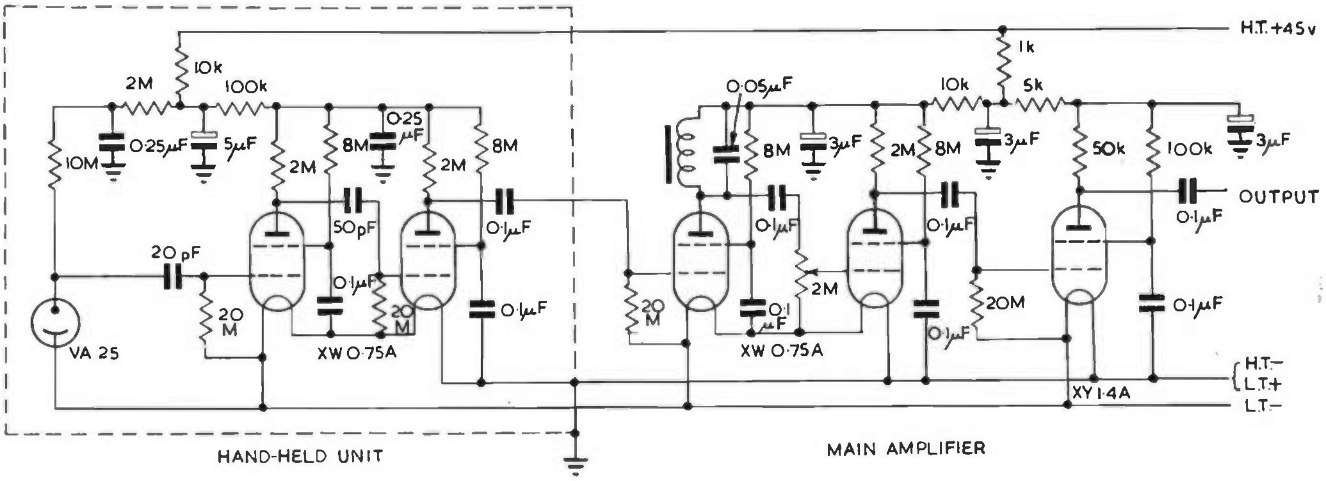
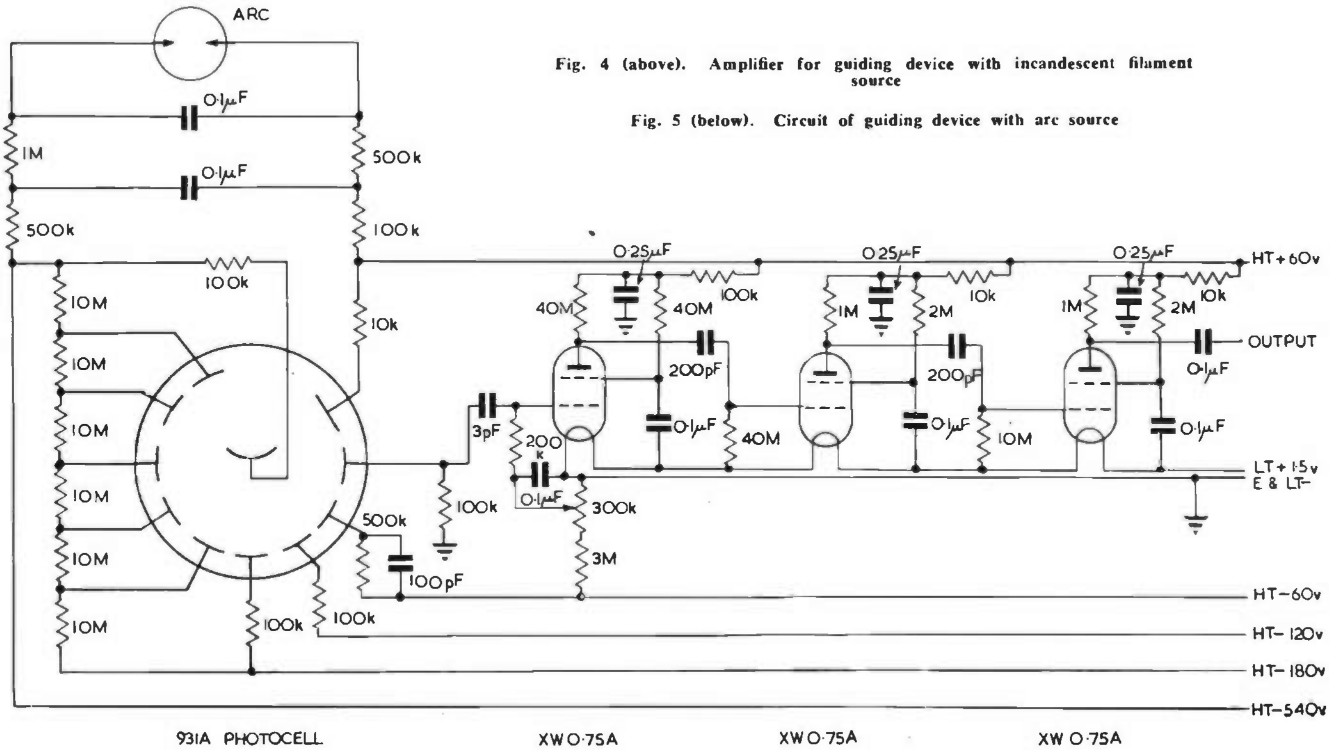


Fig. 4 (above). Amplifier for guiding device with incandescent filament source

Fig. 5 (below). Circuit of guiding device with arc source



It was found that the concentration of sound in the centre of the beam made it possible to pick out objects such as trees, pillar boxes, etc., some way ahead on the line of advance in the presence of larger objects close beside the user. On the other hand, the presence of at least some sound radiated towards each side made it possible to estimate the position of, for example, a wall beside which the user was walking, so that he could keep his distance from it without the necessity of continuously swinging the beam round towards it. These factors did not greatly alter the reliability or the accuracy with which an object could be located. They affected rather the speed with which an object could be detected and by rendering a complex scanning technique unnecessary made it possible to move at a reasonable walking pace. This simple acoustic device, which became known as the "Clicker", had two marked disadvantages when considered as a guiding device. One was that when the device was used in heavy traffic the noise drowned the sound emitted by the device and made it quite impossible to hear echoes from any obstacle. The other disadvantage was that the device, because it made an audible sound, occasionally drew the attention of some passer-by.

Results with the "Clicker"

To reduce the considerable expenditure of time which thorough training in the use of the devices involves, it was decided to test only the clicker device extensively. The object being to ascertain the reaction of blind people to using such devices, care was taken to minimize the known disadvantages of the clicker, e.g., by avoiding heavy traffic noise. Three groups of totally blind people, ex-servicemen at St. Dunstan's, a number of adults who had been blind since childhood and children from three schools in the London area, were given training in its use.

The results of the tests were at first very encouraging. Blind men who already had some experience in getting

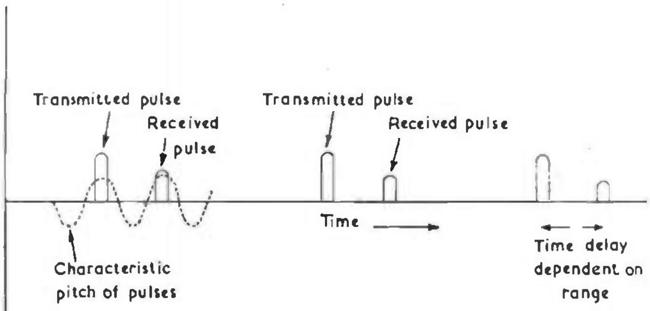
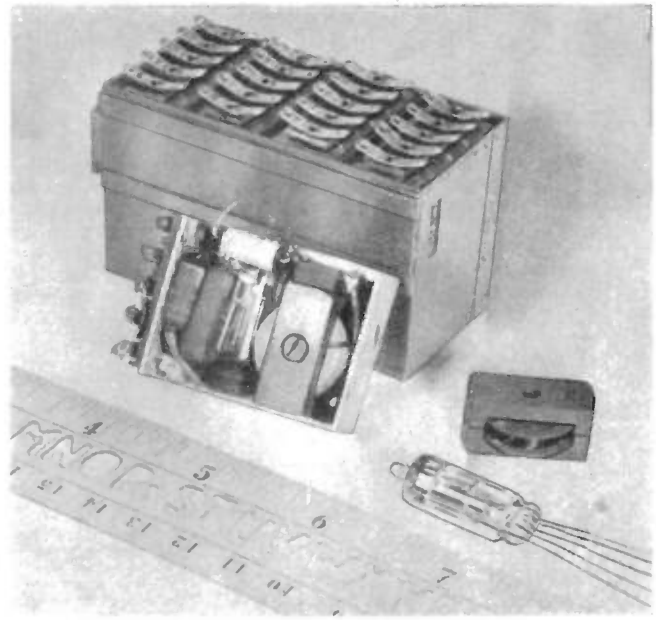


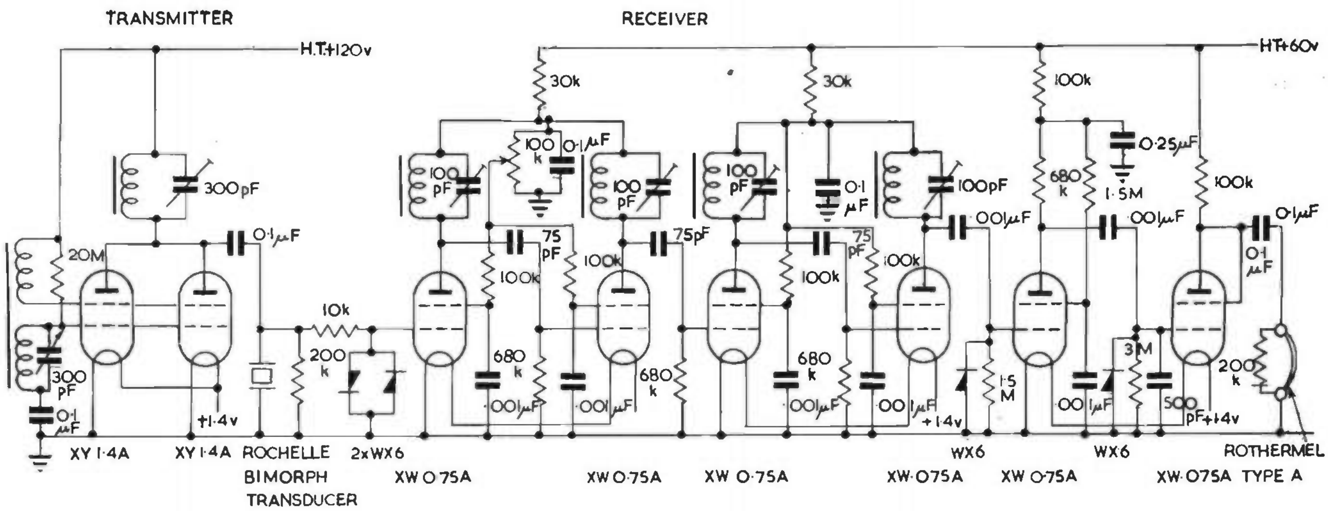
Fig. 6 (above). Characteristic pitch of " clicker " pulses

Fig. 7 (below). 50 kc/s. acoustic guiding device

Fig. 8 (right). Four stage tuned anode amplifier used in 150 kc/s. Ultrasonic Device



Each stage is assembled separately like the one shown in front of the amplifier, and all the supply leads are brought to the tag strip on the side. When the four stages have been placed side by side in their cover the connexions from the tag strips to the power supplies are easily made. Connexions between stages are made beneath the sliding panel in the cover. The anode circuit is tuned by moving the two halves of the dust core relative to each other. In assembling a stage into such a small space as this great care has to be taken over the positioning of components to avoid unwanted stray capacitances, e.g., between anode and grid, otherwise the gain may be seriously reduced.



about alone found that the clicker device could pick up many objects of whose presence they had previously been ignorant. People with less experience were surprised not so much at the information provided by the clicker which they were initially less able to appreciate, but at the fact that they could walk about unaided at all. Nearly all were keen on using the device and many inquired about the possibility of having one for personal use. Later the attitude of many changed. The more experienced found that the extra information provided by the clicker, though useful in strange surroundings, did not make much difference on routes which were familiar. The less experienced also, as they learned to use the device, learned in addition much about their surroundings which enabled them to move more freely even without the clicker than they had been able to do previously. As they thus gained in experience their outlook tended more towards that of the blind man who always had been able to find his way around. Thus, the device, while apparently useful in initiating people into the appreciation of echoes, would very probably be discarded later.

The period of training at the three schools culminated in a test in which the children were allowed to find their way, under supervision, but without assistance, along an unknown route (see the photograph at the top of page 2). The results are interesting in that they show how the speed with which a route is traversed increases as the route becomes familiar even if, as in this case, the route is only being traversed for the second time and in the opposite direction. The average speed at which test routes were covered with the clicker on the outward journey was 2.0 m.p.h., while without any form of aid it was 1.6 m.p.h. On the return journey, when the children knew the route because of their experience on the outward journey, the average times were 2.5 m.p.h. with the clicker and 3.0 m.p.h. without the clicker. It seems significant that the differences between outward and inward speeds, with and without the clicker, showed the same trend at all three schools. These speeds show clearly that, as far as speed alone is concerned, the device was only of assistance when the route was unfamiliar.

Conclusion

When these tests were complete the conclusion was reached that neither the clicker device nor any other device which could be envisaged at the present time is likely to

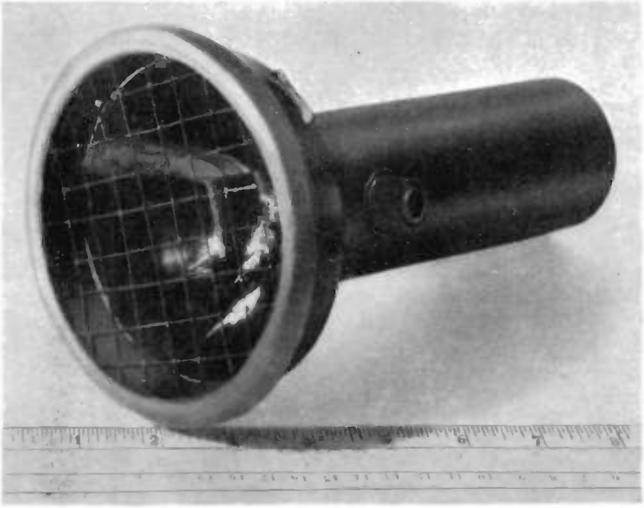


Fig. 9 (above). "Clicker" Guiding Device

The sound source, a rochelle salt bimorph pair, is actuated by the transient produced by the discharge of a capacitor through a cold cathode triode discharge tube (see Fig. 9). It is placed at the focus of a parabolic reflector to form a beam of high pitched audible sound.

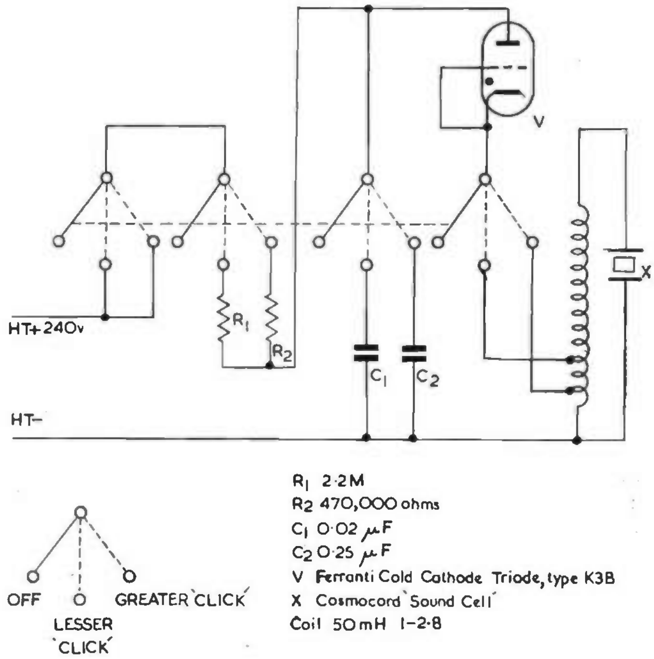


Fig. 10 (right). Circuit diagram of "clicker" guiding device shown in Fig. 9

become popular among blind people. The principal reason for this adverse conclusion about guiding devices is that not all blind people have the ability and inclination to learn to use them. A man who has, can usually learn to find his way about unassisted to a far greater extent than the average blind person does. With the aid of nothing more than a walking stick he can find his way to and from work or to a friend's house in the evening or on any similar journey which he knows well. It is thought that the percentage of blind people who can do this is not as high as it might be, principally because many of the blind people who do not find their way around to any extent were never encouraged to do so and in many cases were actively discouraged. Many are vaguely aware that they can "sense" a large obstacle but do not realize they are detecting it by means of echoes of their own footfalls. Few of them know how best to put this faculty to use.

It is with this in mind that we would stress the value of the opportunity for the blind to learn route finding as children if possible and of deliberate instruction of children and newly-blinded adults with the co-operation of blind adults who are experienced in this. It is considered that if such instruction was given the clicker device would probably be useful initially as an aid in teaching blind people to appreciate the significance of echoes if they were not already able to do so. It is anticipated that in most cases the clicker would be discarded once the person concerned had made good progress, but it is possible that a small percentage would retain one if given the opportunity. Most would, no doubt, make use of the usual white walking stick which, besides aiding balance, acts as a guard in case of a collision, and draws attention when its owner wants assistance in, say, crossing a road.

The Thermal Stability of Coaxial Line Resonant Circuits

TUNED circuits consisting of sections of coaxial line are commonly used for frequencies of the order of 100-300 Mc/s., and are tuned over a small frequency range by loading the open end with a small variable capacitor.

This capacitor may take the form of a disk on the open end of the inner conductor and another disk on a threaded shaft which is supported in a tapped hole in the end cap of the open end of the coaxial line. This second disk is adjusted by rotation of the screw to alter its proximity to the first disk so as to vary the capacitance between them and to change the resonant frequency of the system.

This known arrangement suffers from the defect that, as the component parts change in magnitude with thermal changes, the resonant frequency also changes. When the resonant circuit is mounted on a chassis together with heat-producing components, the outer conductor becomes heated more rapidly than the inner one, with the result that the resonant frequency of the circuit changes.

In order to avoid this defect, the disk on the end of the inner conductor is replaced by a cylinder, whose sides are sufficiently close to the inner walls of the outer conductor to provide the major part of the required capacitance. A smaller disk which is again mounted on a screwed support is arranged to pass into the cylinder and, by varying its spacing from the bottom of the cylinder, a limited change of capacitance is obtained for tuning the device. Since most of the capacitance appears between the concentric surfaces of the cylinder and the outer tube and relative axial movements have no effect on this part of the capacitance, the stability is much improved. The relative axial movements have no effect because the cylinder and the wall are parallel and the cylinder does not approach the extreme end of the outer tube so that the distribution of the electric field between them is unaffected by thermal expansion.

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Industrial Television

By V. K. Zworykin *

TO the average person television means but one thing—the home receiver to which he and his family may repair for an evening's entertainment or instruction. And, indeed, the growth of the industry which serves this function has been so phenomenal that it may seem unreasonable to ask more of television than the dissemination of cultural values and relaxation through the medium of broadcasting.

Actually, this is only one of the uses of television; others may, eventually, appear even more important. To appreciate its full range, we should recall that television is, in essence, an extension of human sight. As an instance of this, broadcast television extends the sight of the television audience to include the studio presentation, film showing, or other event which has been selected by the broadcaster for its wide appeal. Evidently, this is only a very restricted example of the extension of vision. We are here concerned with the vast number of applications other than broadcasting which, for convenience, are grouped together in the term " industrial television ".

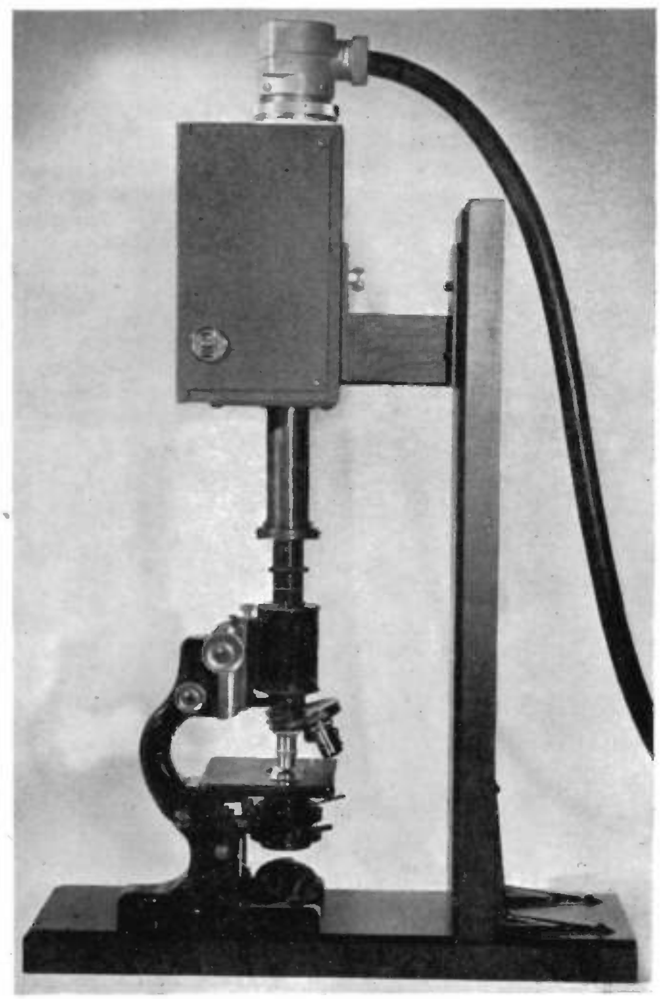
More specifically, what are some of these applications? They are to be found wherever the most favourable point of observation of a process or event is dangerous, inaccessible, or uncomfortable for a human being. Heat and fumes generated in chemical processes which may preclude the presence of a human observer have little effect on the operation of the television camera. The same applies to harmful radiations from radioactive materials, which are coming to play an increasing role in research and industry. In the famous Bikini tests television cameras were set up at a point at which the presence of human observers would have been unthinkable. Also in standard industrial operations, such as coal mining, industrial television may serve as a valuable complement in mechanization, permitting remote control of the digging machines and increased economy in the following of narrow seams. In the automobile industry, performance tests are facilitated by mounting the television camera at suitable points on the chassis, indicating the reaction of car components from favourable, but normally inaccessible, points of vantage. Finally, the employment of industrial television links for the surveillance of boiler gauges is a specific illustration of their use for the checking of numerous semi-automatic units from a single central station.

The services which industrial television equipment can render in education are comparable to those in industry. Here the pattern resembles, in general, that in broadcast television insofar as the television link serves to increase the audience which can, simultaneously, watch a particular event. However, both the character of the audience and the nature of the event are more highly specialized. Thus, the showing of surgical operations to medical students and visiting physicians has proved particularly valuable; the television camera suspended directly above the subject yields a much more detailed and intimate view of the operation than can be attained even from the best seats of an operating theatre. Again, in the biological and related sciences the combination of a television camera with a microscope makes it possible for a large group of students to watch simultaneously the events taking place on a microslide, whether following their natural course or disturbed by micromanipulation. Fig. 1 shows a television camera mounted for this purpose on a microscope. In fact, wherever a demonstration is on too small a scale to be successfully observed from the back seats of an auditorium, industrial television becomes a valuable educational accessory.

One of the features which makes the use of the industrial television camera attractive in connexion with surgical operations is that it is an " aseptic observer ", which introduces a minimum of disturbance. The same property might well be employed to give visitors visual access to astronomical observatories and their carefully adjusted giant telescopes, without any danger of upsetting their thermal or mechanical balance.

Industrial television has, of course, also its purely commercial applications. Thus, it gives large department stores the opportunity of presenting to customers, at a number of strategic points in the store, fashion shows and exhibitions of goods whose sale they wish to stress. Whereas advertising by broadcast television may implant

Fig. 1. Television camera for demonstrating microslides



* *Vice President and Technical Consultant, Radio Corporation of America.*

an interest in the advertised merchandise in the public at large, industrial television may be employed to direct the customer when he is already minded to make a purchase.

Before proceeding to a discussion of actual industrial television equipment, it may be worthwhile to point out a feature which should prove particularly attractive to the television development engineer. This is the fact that industrial television provides a field for testing the effectiveness of novel techniques in picture signal generation, transmission and reception, unhampered by the necessity of adhering to pre-established standards. Since every television link is a closed system, its operation may be planned exclusively on the basis of effectiveness and economy. At the same time, the experience gained in industrial television may react favourably on the development of broadcast television.

It may be taken for granted that the best possible design for any one application of industrial television will not be quite the same as that for any other. However, the requirements of the majority of applications are sufficiently similar to permit the development of standard equipment which combines great versatility with moderate cost. It consists of a camera, a receiver-monitor, and some 500 ft. of connecting cable. Some of its distinctive features are:

1. High sensitivity and compactness of the camera;
2. Remote control of the camera from the receiver-monitor; and
3. The employment of broadcast television standards to the extent of making possible the insertion of standard receivers at the viewing terminal.

The camera weighs only about 8 lb. It is a flat box, 10 in. by 5 in. by 3¼ in., with the lens and the cable connector at the two ends. The lens is a standard objective for 16 mm. motion picture film, in a focusing mount which is rotated by a monitor-controlled motor at the back of the camera case. Apart from this motor and the video preamplifier, in the upper half of the case, the camera contains only the pickup tube and its magnetic focusing coil, gun alignment coil, and deflecting yoke.

The character of the pickup tube is primarily responsible for the compactness, and yet high sensitivity, of the camera. It is a vidicon; this resembles the magnetic orthicon in geometry and in the method of focusing and deflexion, but differs from it in the nature of the photo-sensitive target. The latter is, in the vidicon, a photo-conductive layer with a sensitivity of some hundred of microamperes per lumen. The transparent signal plate, on which the photoconductive layer is deposited, is biased some 10 to 30 volts positive with respect to the gun cathode. In darkness the layer acts as an almost perfect insulator, so that its surface assumes a potential substantially equal to cathode potential under the beam and retains this potential up to the next scan; at an illuminated point, on the other hand, positive charge proportional to the illumination is transferred from the signal plate to the surface throughout the period between scannings. This charge is released by the beam in its sweep, giving rise to the picture signal. From the operation described it is evident that, at high light levels, the target surface can rise at most by the bias voltage, i.e., 10 to 30 volts. Thus very high light levels do not lead to instability as in the orthicon, but simply to the blotting out of contrast.

The outside tube diameter of the vidicon is 1 in. and the target area normally utilized corresponds to 1 frame of 16 mm. film. Nevertheless, picture resolution adequate for the full utilization of a standard television channel can be achieved with such tubes.

The receiver-monitor or master control unit, which weighs about 58 lb., contains, in addition to the kinescope and its associated circuits, controls and power supplies for the camera. It contains altogether about 44 tubes and consumes approximately 350 watts of 115 volt, 60 cycle power. A fan at the rear, behind the power supplies, prevents any overheating of the compact equipment. The video-amplifier strip is located at the bottom of the case, the kinescope at the upper right.

The control knobs are placed directly below the kinescope face on the front of the unit. They determine the beam current, blanking adjustment, optical focus, and magnetic focus of the pickup tube as well as the signal level and brightness at the kinescope. A jack at the rear of the cabinet permits connexion of the video amplifier output to a standard receiver unit by means of 75-ohm cable.

Although the standards of the system are essentially those of broadcast television, several of the circuits employed are unconventional. This applies, in particular, to the generation of the deflexion and synchronization signals. The deviations from standard television practice are dictated in part by the necessity of transmitting the

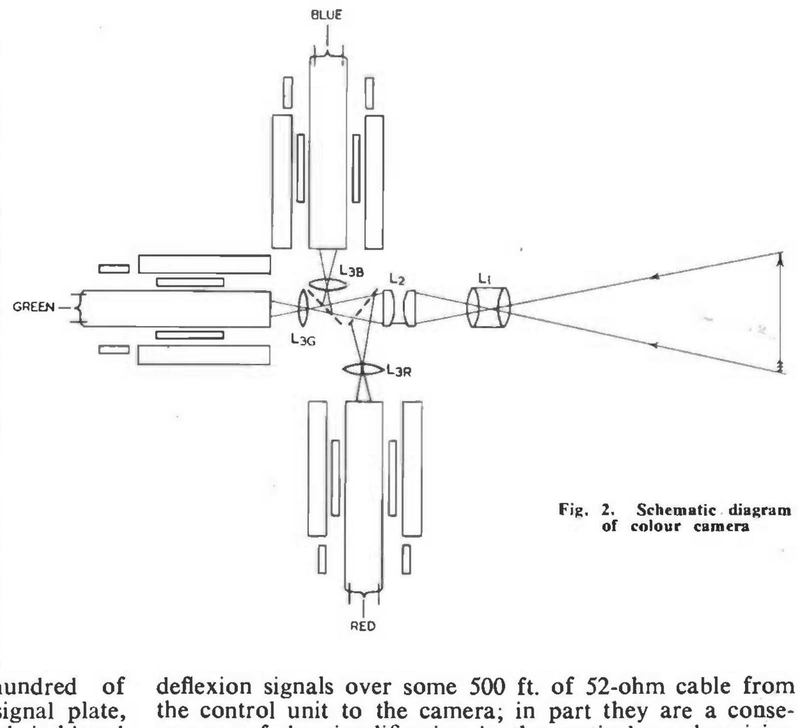


Fig. 2. Schematic diagram of colour camera

deflexion signals over some 500 ft. of 52-ohm cable from the control unit to the camera; in part they are a consequence of the simplification in the vertical synchronizing signal permitted by the freedom from interference signals in a closed system.

The central element in the generation of the deflexion sawtooth waves and synchronizing signals is an oscillator* which resembles the multivibrator. This oscillator provides, at different points of the circuit, both a sawtooth voltage and a sharp pulse voltage. A master oscillator of this type, with a frequency of 31.5 kc/s.—twice line frequency—is followed by a sequence of oscillators with submultiple frequencies, the frequency-reduction factors being 7, 5, 5, and 3. Each oscillator is locked in step with the preceding one with the aid of the latter's pulse output. The last oscillator of the chain has a frequency of 60 c/s. and supplies the vertical blanking pulse. Comparison of the output of this oscillator with the power line frequency generates an automatic frequency control signal

* *K. Schlesigner, U.S. Patent 2,383,822.*

which locks the master oscillator in step with the power line. The front edge of the vertical blanking pulse, in conjunction with a pulse delay tube, furthermore controls a second 60 c/s. oscillator, from which a simplified vertical synchronizing signal is derived. Its duration is less than half a line period, so that, with interlaced scanning, it can be inserted alternately just ahead and just behind the nearest horizontal synchronizing pulse.

The problem of transmitting the deflexion signals over the cable is solved in the following manner: The inductance L represented by the deflexion coil is shunted by a capacitance C such that $\sqrt{L/C} = R$, the impedance of the cable; in addition, the resistive component of each branch of the resulting parallel resonant circuit is made just equal to R. Then the input impedance of this circuit, which is critically damped, becomes simply R at all frequencies, so that it provides a deflexion-free termination for the cable. To determine the proper wave-form at the input of the cable, it is then only necessary to add the voltage wave generated by the desired sawtooth currents across the coil inductance and the resistance R in series with it. Fortunately, both the sawtooth and the pulse components of this wave are available directly at the appropriate oscillator; they only have to be added in the proper proportion and to be amplified subsequently by a small class-A amplifier.

The performance of the simple television link just described has been found entirely satisfactory. There are, however, a number of steps which may be taken—and in part have been taken, at least on an experimental basis—to extend the scope of industrial television equipment.

Fig. 3. Stereo television camera and control units

One of the most obvious of these steps is that of adding colour. Although for a large number of applications this is of secondary interest, there are others where it can contribute very greatly to the information and value of the pictures transmitted. Among the various applications of industrial television which were listed before, the presentation of surgical operations and the exhibition of goods and fashions in department stores fall into this category.

Fig. 2 shows diagrammatically a colour pickup camera incorporating three vidicons with different spectral characteristics. The outputs of these three vidicons control the pictures appearing on the faces of the three kinescopes in a colour receiver, which yields a natural-colour picture by optical superposition. This is, of course, but one possible method of colour transmission in industrial television.

Another extension of the industrial television system which may be of considerable value in specialized applications is the addition of a third dimension to the pictures viewed. For this purpose two cameras mounted side by side are employed, viewing the object from slightly different angles. The signals are transmitted (over two channels, or by time multiplexing, over a single channel) to two separate kinescopes. If these kinescopes are small in dimension, they may be viewed directly through a lens stereoscope. Otherwise the two images would have to be roughly superposed optically and be observed through polaroid viewers matching complementary polaroid filters in front of the two kinescopes. The second arrangement permits the viewing of the three-dimensional pictures by larger audiences. It may be noted that, since deflexion and synchronizing circuits would be common to the two channels, such a stereo television system does not require complete duplication of a single television link.

Fig. 3 shows an industrial stereo television system of the type described. The pair of cameras are built into a single unit; the objectives, separated by the normal eye distance, are focused together by a single motor.

Two control units are provided; one of them contains the synchronizing signal generator and a 7 in. monitoring kinescope connected to one of the two video channels. The second, or stereo, monitor contains two small kinescopes with $1\frac{1}{4}$ in. screens which are observed through a lens stereoscope. This unit is provided with a pair of jacks from which the video signals for the two kinescopes of a large console receiver may be obtained. In this receiver the images from the two kinescopes, plane polarized in mutually perpendicular directions by polaroid film, are superposed by a semi-reflecting mirror and are viewed through polaroid spectacles, so that each eye sees one of the two images. With such an arrangement larger groups can view the three-dimensional image simultaneously.

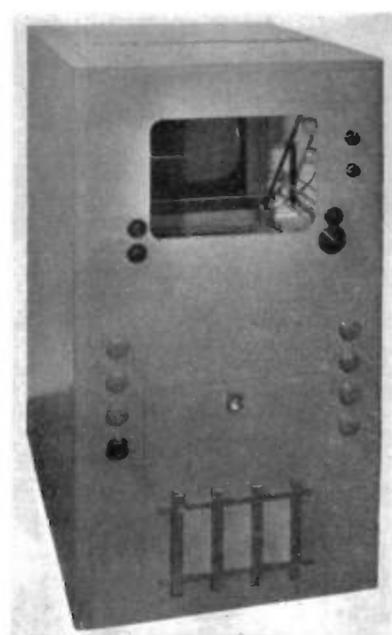
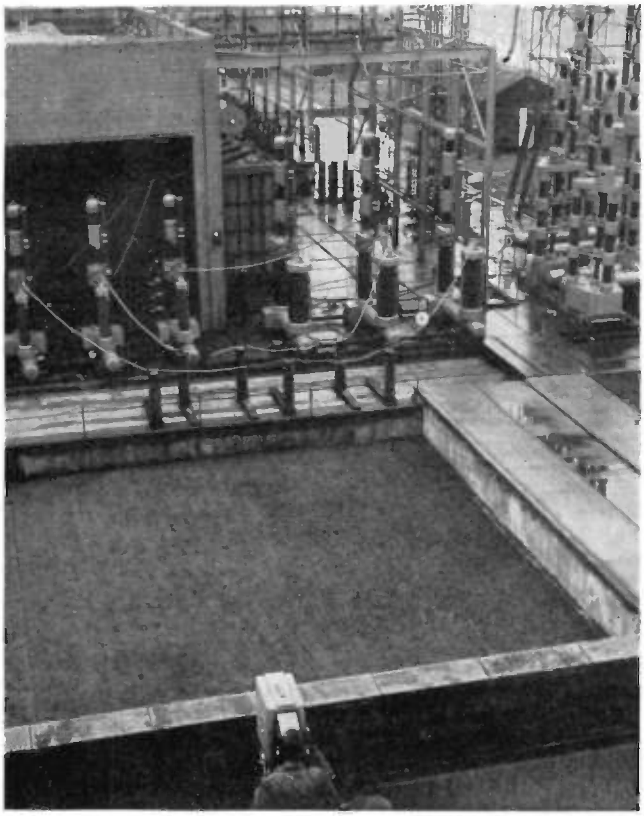
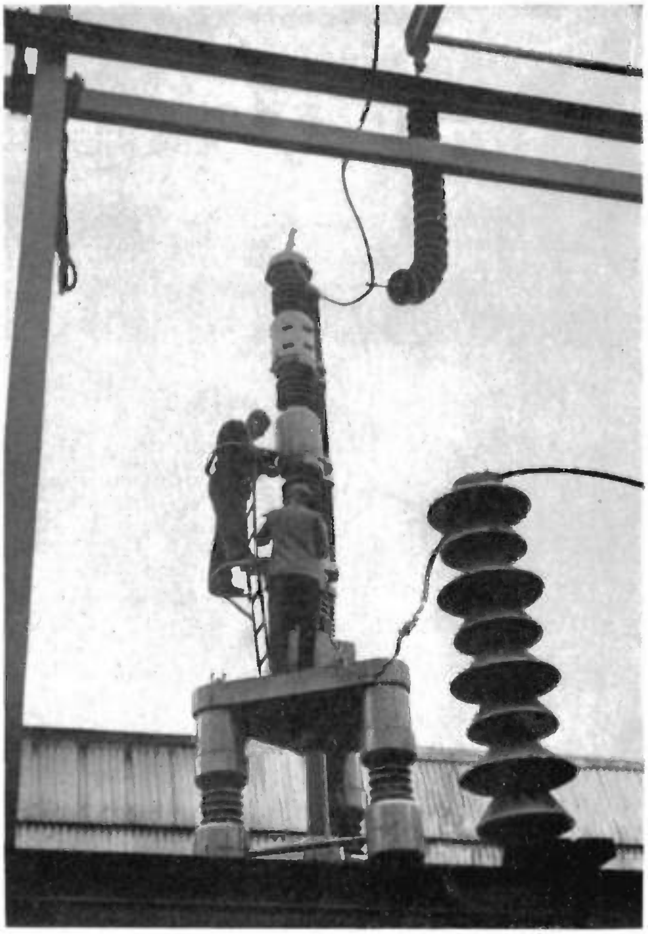


Fig. 4. Console Receiver for stereo images

Another obvious modification would incorporate a directional ultra-high-frequency transmitter with the camera so that the cable—at the cost of increasing complexity of the control problem—could be omitted. The stress to be placed on such further developments would depend on a balance between probable utility and probable cost. For the more complex systems of industrial television this balance may be favourable for only a relatively restricted range of applications. This is not true, however, of the simple television link which was described first. In it we have a tool of wide utility which should fill real needs in industry, research, education, and commerce. Such equipment represents a material step forward in the direction of fulfilling the basic function of television—extending human sight.





INDUSTRIAL TELEVISION IN BRITAIN

An excellent demonstration of the application of television to industry in this country was given at the Nelson Research Laboratories of the English Electric Co., of Stafford, on Nov. 2, 1950.

At this demonstration a number of High Voltage Outdoor Air Blast Circuit Breakers with ratings up to 400 kV. at 10,000 MVA. were tested under short-circuit conditions, and Marconi cameras were set up at salient points in the switchgear control room, the power generator house and in front of the circuit breakers under test.

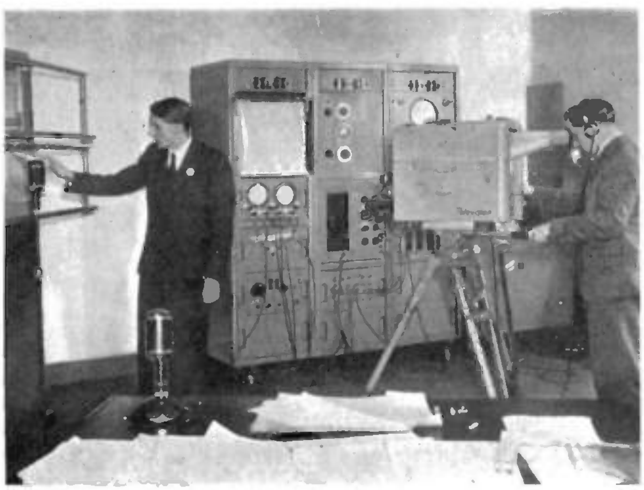
The accompanying photographs show :

(Top left). A general view of the switchgear under test with a Marconi camera, fitted with a telephoto lens in the foreground.

(Top right). The removal of the contacts on a 275 kV. circuit breakers after test.

(Bottom left). A Marconi camera is focused on equipment for the simulation of transients in high power electrical networks, including the recovery voltage transient at the instant of current interruption in the circuit.

(Bottom right). The improvised television camera control room.



Ultrasonic Energy

By A. E. Crawford *

THE rapid development over the past few years in the technique of ultrasonic generation has stimulated great interest in industry, as the potentialities of its application to processing are very large and cover a vast field.

It is proposed to limit this paper to the methods of generating ultrasonic energy for direct applications where this energy is utilized for producing a change in the physical or chemical state of the material under treatment. There are many types of instruments such as marine depth gauges, submarine detectors, flaw detectors, consistency meters and thickness gauges that utilize the generation of ultrasonic waves as a means of obtaining an indication, but most of these instruments are adequately covered in contemporary literature.[1]

The term "ultrasonic" is now used to cover the description of any vibrational wave possessing a frequency higher than that of audible sound. In normal human adults, this corresponds to a frequency of about 16 kc/s. and the range of usable ultrasonic frequency can extend to hundreds of megacycles. Vibrational waves can only be propagated through a medium and the velocities of such waves vary considerably with different media. The wavelength will, of course, vary in different materials for any given frequency.

It will be seen that the differences in values over the range is very great and phenomena produced by waves of high frequency may be very different from low frequency effects.

Theoretical Considerations

The transmission of waves at ultrasonic frequencies follows normal laws of wave motion. Any material possessing elasticity can be used for the propagation of waves, taking the form of a displacement of successive elements of the medium. Since inertia is also present the elastic restoring forces will tend to oscillate the particle with constantly diminishing amplitude. Each element of the material will execute different orbits as the wave travels and it is the difference in these movements that characterizes basic wave types.

A number of different types of waves can be produced through a medium and these can be classified in various forms. It should be appreciated that the type of wave propagation is not affected by the modulation impressed on it and any type can be continuous, modulated or pulsed.

Longitudinal Waves

When particle motion is excited parallel to the direction of wave propagation it is referred to as longitudinal waves, and is the most common form of wave motion experienced in practice. Such waves are easy to generate and detect and have a high velocity of travel in most media. As the wavelengths in common materials are usually short in comparison with the transducer cross sectional area, the energy can be focused into a sharp beam.

Such waves can be generated within the medium by the vibration of any one of its surfaces in a normal direction and at an ultrasonic frequency.

Shear Waves

If shear waves are propagated, the particle movement in the medium is at right angles to the direction of propagation. Their existence can be in a limited area or universally throughout the medium. Their velocity is approximately half that of longitudinal waves, and thus their wavelength is much shorter. Since there is no elasticity to shear in liquids and gases, such waves cannot be propagated in these media. They can be generated by applying a shearing force to the face of a material, for example a rocking motion can be imparted in a direction parallel to the surface.

Rayleigh or Surface Waves

If an area of surface of a medium is shaken in a similar manner to that in the generation of shear waves, a surface wave can be generated that does not extend to any extent below the surface of the material. These waves are very similar to those generated on the surface of a liquid. Their velocity depends on the material and is about nine-tenths of the velocity of shear waves. They are usually of an extremely short wavelength and the thickness of the body over which they travel should be several wavelengths. Under these conditions very little displacement of particles below the surface is experienced.

Wave Transformation

Transformation of the wave type can occur when it strikes a boundary between two media of varying acoustic impedances if the angle of incidence is other than 90° This should be taken into account when such conditions arise as the effects ascribed to any one type of wave may be quite different to another.

Velocity

The propagation of an ultrasonic wave is usually made up of a number of complex velocities. The various velocities described do not refer to the speed of the individual particles but to the overall movement and associated repetitive phenomena.

Group Velocity

This term refers to the velocity of travel of the envelope of a wave when such a wave is amplitude modulated.

Phase Velocity

As previously mentioned, it is possible for the wave to be modulated. When this is the case, there will be a phase difference along the wave due to the inertia of the particles. The speed of this phase change along the wave is referred to as the phase velocity.

Signal Velocity

If the medium is dispersive, different waves travel with different velocities. The speed of travel of any individual signal is known as its signal velocity.

Velocity Calculations

From the foregoing, it will be seen that the physical characteristics of the material will influence the velocities of the wave.

LONGITUDINAL WAVES. The velocity of such waves can be given by the relation:

$$c = \sqrt{\frac{E}{d} \quad \frac{1-\mu}{(1+\mu)(1-2\mu)}}$$

* *Mullard Electronic Products, Ltd.*

VELOCITY OF SOUND IN SOLIDS

Material	Longitudinal Bar Velocity in cm. per sec. ($\times 10^5$)	Plate (Bulk) Velocity in cm. per sec. ($\times 10^5$)
Aluminium	5.24	6.4
Antimony	3.40	—
Bismuth	1.79	2.18
Brass	3.42	4.25
Cadmium	2.40	2.78
Constantan	4.30	5.24
Copper	3.58	4.6
German Silver	3.58	4.76
Gold	2.03	3.24
Iridium	4.79	—
Iron	5.17	5.85
Lead	1.25	2.4
Magnesium	4.9	—
Manganese	3.83	4.66
Nickel	4.76	5.6
Platinum	2.80	3.96
Silver	2.64	3.60
Steel	5.05	6.1
Tantalum	3.35	—
Tin	2.73	3.32
Tungsten	4.31	5.46
Zinc	3.81	4.17
Cork	0.50	—
Crystals, Quartz—		
X-cut, ADP($NH_4H_2PO_4$)	5.44	5.72
45° Z-cut	3.28	4.92
Rochelle Salt—		
45° Y-cut	2.47	—
Rochelle Salt—		
L-cut	—	5.36
Tourmaline, Z-cut	—	7.54
CaF_2 (fluorite), X-cut	6.74	7.18
NaCl (Rock Salt), X-cut	4.51	4.78
NaBr, X-cut	2.79	3.2
KCl (Sylvite), X-cut	4.14	4.38
KBr, X-cut	3.38	3.48
Glass—		
Heavy Flint	3.49	3.76
Extra Light Flint	4.55	4.80
Heaviest Crown	4.71	5.26
Crown	5.30	5.66
Quartz	5.37	5.57
Granite	3.95	—
Ivory	3.01	—
Marble	3.81	—
Slate	4.51	—
Wood—Elm	1.01	—
Oak	4.1	—

VELOCITY OF SOUND IN LIQUIDS

Material	Temperature in deg. C.	Velocity in cm. per sec. ($\times 10^5$)
Alcohol, Ethyl	12.5	1.24
	20.0	1.17
Benzene	20.0	1.32
Carbon Bisulphide	20.0	1.16
Chloroform	20.0	1.00
Ether, Ethyl	20.0	1.01
Glycerine	20.0	1.92
Mercury	20.0	1.45
Pentane	18.0	1.05
	20.0	1.02
Petroleum	15.0	1.33
Turpentine	3.5	1.37
	27.0	1.28
Water, Fresh	17.0	1.43
Water, Sea	17.0	1.51

VELOCITY OF SOUND IN GASES

Material	Temperature in deg. C.	Velocity in cm. per sec. ($\times 10^5$)
Air	0.0	0.331
	20.0	0.343
Argon	0.0	0.319
	300.0	0.307
Ammonia Gas	0.0	0.415
Carbon Dioxide	0.0	0.259
Carbon Monoxide	0.0	0.338
Chlorine	0.0	0.206
Deuterium (Heavy Hydrogen)	0.0	0.890
Ethane	10.0	0.308
Ethylene	0.0	0.317
Hydrogen	0.0	1.28
Hydrogen Bromide	0.0	0.200
Hydrogen Chloride Gas	0.0	0.296
Hydrogen Iodide	0.0	0.157
Hydrogen Sulphide	0.0	0.289
Helium	0.0	0.97
Methane	0.0	0.430
Neon	0.0	0.435
Nitric Oxide	10.0	0.324
Nitrogen	0.0	0.334
	20.0	0.341
Nitrous Oxide	0.0	0.26
Oxygen	0.0	0.316
	20.0	0.328
Sulphur Dioxide	0.0	0.213
Water Vapour	0.0	0.401
	100.0	0.405

Fig. 1. Velocity of longitudinal waves in common solids, liquids and gases

SHEAR WAVES. The velocity of shear waves is about 48 per cent of longitudinal waves. For general calculations, this proportion can be taken:

$$c = \sqrt{G/d}$$

SURFACE WAVES. The constant in the formula for such waves changes with the properties of the medium:

$$c = 0.9\sqrt{G/d}$$

GASEOUS AND LIQUID VELOCITIES. It will be seen that only longitudinal waves can be transmitted in liquids or gases and it is usually assumed that the movement is too rapid for any heat exchange to take place:

$$c = \sqrt{K/\rho B_{IS}} = \sqrt{1/\rho B_{AD}}$$

In the above calculations the following factors have been used:

c = velocity (group).
E = Young's modulus.
μ = Poisson's ratio.
d = density.
G = modulus of rigidity.
K = ratio of specific heats.
B_{AD} = adiabatic compressibility
B_{IS} = compressibility at a constant temperature.

Wavelength and Frequency

The normal relationship holds for calculations of wavelength and frequency, thus:

$$\lambda = c/f$$

where λ = wavelength, c = velocity, f = frequency.

Fig. 1 gives a table showing the velocity of longitudinal waves in common solids, liquids and gases[2] and a nomogram giving the relationship of velocity, wavelength and frequency is shown in Fig. 2.[3]

Acceleration

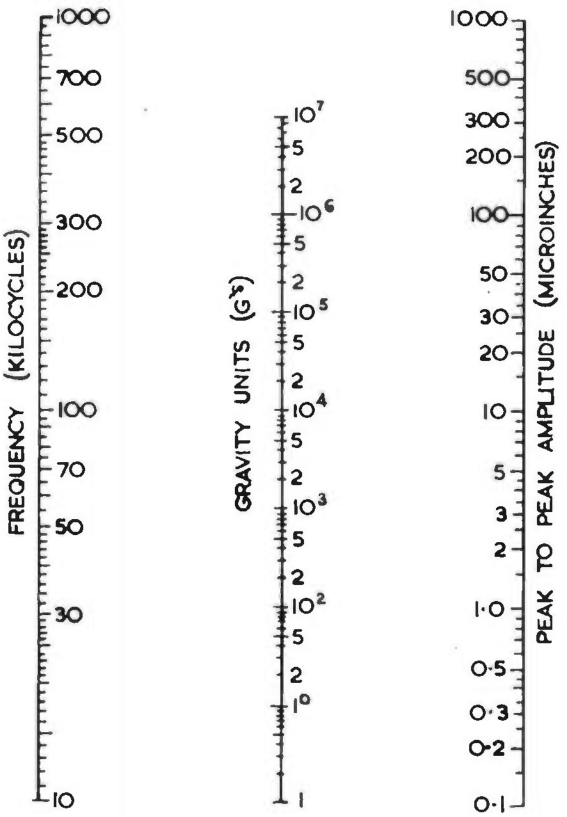
It is believed that high molecule accelerations are necessary to initiate physical changes in most media, and the effects produced are analogous to those brought about by a centrifuge. Accelerations can be computed theoretically but factors such as intensity and frequency can alter considerably the practical results obtained. Fig. 3 shows a nomogram relating frequency, amplitude and acceleration produced by the basic formula:[4]

$$G = 0.102\, F^2 A$$

Reflexion

When an ultrasonic wave is transmitted through a medium and reaches a boundary between the first and a second medium, part transmission and part reflexion occurs. The factor determining the amount of reflexion is known as the specific acoustic impedance and is equal to the product of density and velocity. The reflected wave amplitude is related to the incident wave:

$$A_r = \frac{R_1 - R_2}{R_1 + R_2}$$



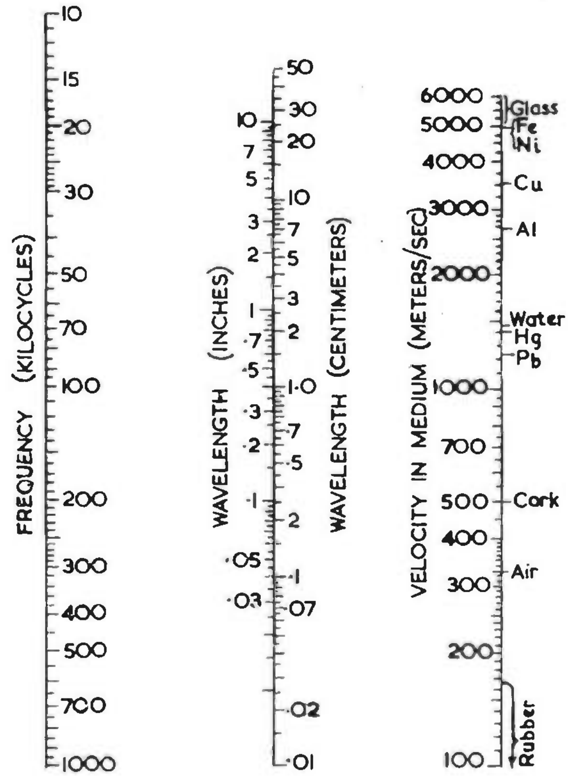


Fig. 2. (*left*) Wavelength, velocity and frequency relationships

Fig. 3. (*above*) The relationship of frequency, amplitude and acceleration

If the wave is propagated in the same medium, the energy is proportional to the amplitude squared. Thus:

$$R = R_0 \left(\frac{\rho_1 c_1 - \rho_2 c_2}{\rho_1 c_1 + \rho_2 c_2} \right)^2$$

A_r = amplitude of the reflected energy. c = velocity.
$R_1 = \rho_1 c_1$ R = reflected energy.
$R_2 = \rho_2 c_2$ R_0 = incident energy.
ρ = density of each material.

When a solid or liquid to air boundary occurs, reflected energy amounts to practically 100 per cent. The above calculations do not take into account any scattering or attenuation, and dissipation at the boundary may cause very different results when experimentally measured. The calculations are based on infinite media and perfect boundaries and any discontinuities will alter the results considerably.

Ultrasonic Generators

The generation of ultrasonic energy is possible by many different methods. The type of generator and transducer selected depends on two main factors, the frequency of the required wave and the medium in which it is to be propagated. For propagation in gases, sirens, whistles and electro-magnetic transducers can be used; for liquids and solids, electro-magnetic, piezo-electric crystal and magnetostriction units are commonly employed. In some cases, whistles and resonant cavities can be used for the propagation of energy into liquids; and also air jets can be employed for exciting solids if the natural resonant frequency of the solid is high enough for the purpose in mind. For example, the testing of turbine blades under ultrasonic vibrations such as are experienced in gas turbines is often done by exciting them to resonance by impinging a jet of air on the edge of the blade.

The range of frequencies covered by the various types of transducers varies considerably, but physical limits can be set at which the amount of energy propagated commences to fall off rapidly and the efficiency of the system becomes so low that a further increase in the frequency of operation is impractical.

Practical results have given the following upper frequency coverages:

Tuning fork (Koenig type)	90 kc/s.
Whistle (Galton type)	50 kc/s.
Whistle (Hartmann type)	100 kc/s.
Siren	50 kc/s.
Electromagnetic	30 kc/s.
Magnetostriction	200 kc/s.
Quartz Crystal	500 Mc/s.

All of these methods have been known for a considerable time and most of the early experimenters used them. With the exception of tuning forks the types of transducers listed are still used for experimental purposes in the ultrasonic region. The crystal transducer is the only type that can be used to any effect for frequencies above 200 kilocycles and advancement in this region of the ultrasonic spectrum is of comparatively recent origin, as the design of the necessary power supplies has depended on the production of suitable oscillator valves for the high powers and frequencies required.

Whistles

One of the earliest methods of generating frequencies above the normal hearing range was by means of a vibrating column of gas. The Galton whistle is a well-known

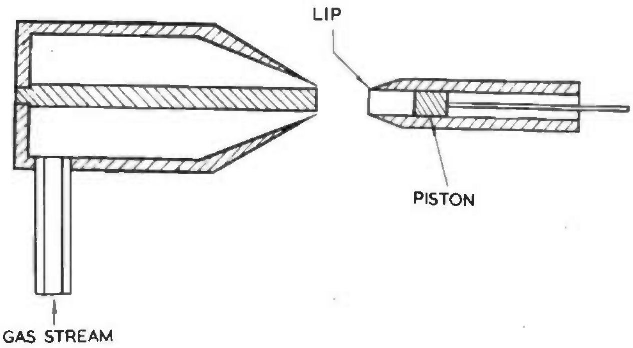


Fig. 4. Modified Galton whistle

example of this type and many variations have been developed. The gas column is usually excited to resonance by means of a vibrating lip on the resonant cavity, the system being somewhat analogous to an organ pipe. German research during the war produced a version of such a system for operating in liquids[6] and a diagrammatic view and photograph of an experimental unit similar to the German whistles is shown in Figs. 4 and 5.

The operating frequency of this type of resonator is extremely difficult to calculate with any accuracy, as many factors in the mechanical construction tend to alter the theoretical limits. As the velocity of sound in the medium passing through the whistle must be considered, the frequency of operation will vary with the medium. It is possible to impart ultrasonic energy to liquids in this way and such devices have been experimentally used as emulsifiers.

A modification of the Galton type of resonator that can be used for the production of higher frequencies is the

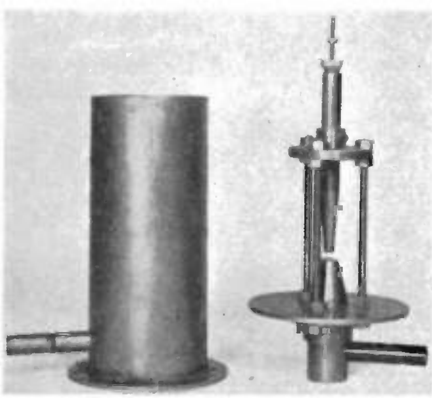


Fig. 5. Modified Galton whistle arranged for use with liquids

Hartmann whistle. In this system, the vibrating lip on the resonant chamber is dispensed with and initial excitation is provided by imparting a pulsation to the gas stream impinging in the cavity, diagrammatically shown in Fig. 6. The conical expansion chamber tends to produce a cross-over in the issuing medium and causes the gas contained in the resonant chamber to vibrate. The frequency of vibration will depend on the physical proportions of the chamber, and an adjustable piston is used to alter these characteristics and thus the frequency. Hartmann-type whistles have been used for a number of purposes in the transmission of ultrasonic waves through gases and powers high in comparison to other methods have been obtained. Fig. 7 shows an example of this type of transducer being used for experimental work on focused waves. By using other gases than air, the frequency can be raised considerably. For example, the speed of sound through air is 3.31×10^4 cm./sec., whereas in hydrogen this speed becomes 13.01×10^4 cm./sec. Using hydrogen, frequencies of 500 kc/s. have been produced.

Sirens

Although whistle systems are a simple and effective means for the production of ultrasonic waves in gases, the amount of power capable of being transformed into acoustic energy is comparatively small. It is possible, however, to obtain a much greater energy conversion by means of a siren type generator. In its simplest form, this consists of a jet of air that is interrupted periodically by means of a toothed or perforated disk.

The frequency of the wave produced by a siren will be dependent on the number of teeth or holes in the interruptor disk and the speed of rotation of the disk. The acoustic power of the unit will be determined by the volume of gas passing through the system. It will be seen that to reach ultrasonic frequencies, the speed of rotation must be very high, and many mechanical problems have been experienced Ultrasonic sirens for particle precipitation have been produced in the U.S.A. and satisfactory results are claimed for the precipitation of materials such as carbon black.

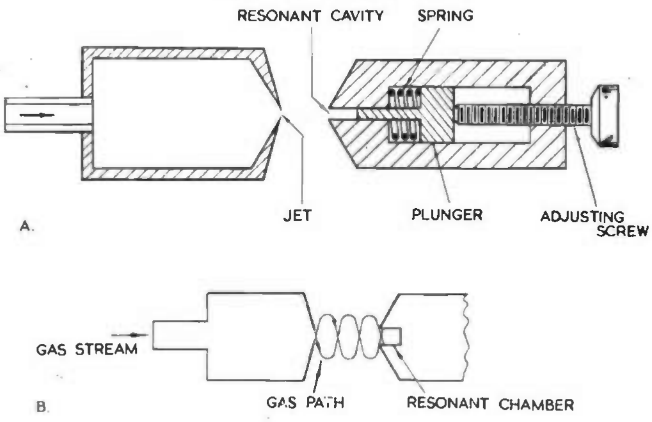
Electro-magnetic Systems

A number of attempts have been made to produce a transducer based on an excited coil in a magnetic field. Commercial exciters of this type are made for vibration testing and can be made to provide a useful power output up to about 10 kc/s. These are, however, usually made for vibration study and are designed to be mechanically coupled to the body under examination. By replacing the mechanical coupling with a plane or shaped surface, it is possible to obtain an acoustic output into a gas, but efficiencies are low in comparison with other methods, and the frequency range is at present limited. It is possible that the problems connected with such systems will eventually be solved and then the electro-magnetic transducers will have many advantages over sirens for gas propagation.

Magnetostriction Transducers

It has been known for many years that all ferro-magnetic materials constrict or expand when placed in a magnetic field. These metals include iron, cobalt and nickel and many alloys composed of these three. The physical changes are quite small and for example, the greatest change per unit length in nickel is only about thirty parts in one million. This metal, incidentally, exhibits one of the largest changes in the magnetostrictive materials. The force exerted during this change in length is also limited and is determined by the modulus of elasticity of the material and the amount of longitudinal change. In nickel this force amounts to about 1000 pounds per square inch and is lower for iron and cobalt.

Fig. 6. Hartmann whistle



Ferromagnetic materials show considerable differences in the magnitude and polarity of change. Fig. 8 shows changes in length per unit length in iron, nickel and cobalt, and it will be noted that iron expands in a relatively low magnetic field and contracts in a high field.[7] Nickel contracts at all field strengths. The polarity of change is also not affected by the polarity of the magnetic field and in normal electromagnetic systems, it is necessary to provide an initial polarizing field by means of a D.C. voltage through the exciter coil.

Fig. 7. Hartmann whistle mounted in reflector

It was realized that such materials could be used as sources of ultrasonic power by subjecting them to varying magnetic fields and this principle was adopted for such equipment as underwater echo sounders and submarine detectors.

The maximum dimensional change is obtained when the magnetostrictive element is excited at its natural resonant frequency, so it will be seen that the physical dimensions of the transducer will govern the frequency of operation to a large degree.

Many different types of transducers have been developed; they can be of tubular form, solid rods, laminated packs etc.

Due to the strong magnetic fields, large eddy current losses are experienced unless precautions are taken. In the case of tube transducers this is usually done by cutting a slot in the tube for part of its length. Metal fatigue due to edge vibration is then produced and the life of the tube is very short. A satisfactory assembly for marine purposes has been evolved and consists of a number of small tubes secured to a common diaphragm; the tubes being insulated from each other.

For industrial applications, probably the most satisfactory form is a laminated structure somewhat resembling a transformer core. By using thin laminations and insulating them from each other, eddy current losses can be cut to a minimum and workable efficiencies achieved. A Mullard transducer of this type is shown in Fig. 9 and by using alloys containing cobalt, high powers per unit area (up to 25 watts per square centimetre) have been generated for continuous use.

The generator for supplying power to such a transducer is very similar to an amplifier of the public address type and is provided with a suitable variable frequency oscillator as its exciting source. The Mullard unit, Fig. 10, has a small oscillator based on a Wien bridge circuit. The output voltage for feeding the transducer is obtained via a matched output transformer. The initial D.C. polarizing voltage is provided by a selenium rectifier, and the A.C. exciter component is separated from this in the common winding by a series capacitor and choke. The choke also serves approximately to balance the reactance of the transducer at resonance.

The magnetostriction transducer possesses many advantages over other types for industrial applications. It is very robust and can withstand severe thermal and mechanical shocks without damage. It can be coupled in various ways to the medium through which propagation is required. The voltages applied to it are comparatively low and the system can be scaled up almost indefinitely if needed.

Coupling to the work can be arranged in many ways. In the case of liquids, it can be directly immersed, the liquid can flow over the actuating surfaces, or the unit can be indirectly coupled by means of flexible diaphragms. Ultrasonic waves can be transmitted through solids by securing coupling rods to the actuating face and the work. In this case, the length of the rod would be adjusted to be a function of the wavelength of sound being produced. The rod can be made of metal or many other materials: for example, German research workers have used ceramic rods for the propagation of ultrasonic waves through molten metals.

An example of a specific application of a magnetostriction transducer combined with a coupling rod is found in the Mullard ultrasonic soldering iron. In this unit a transducer is coupled to a heated soldering iron bit by means of a half wavelength bar. The bar is hard soldered

Fig. 8. Change in length per unit length for iron, nickel and cobalt

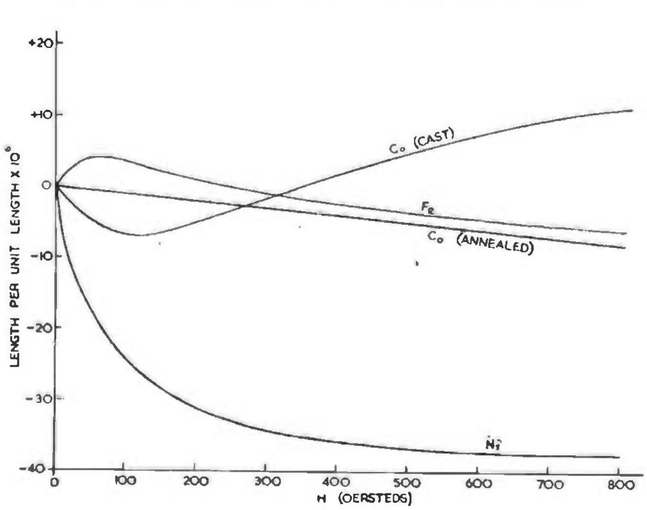
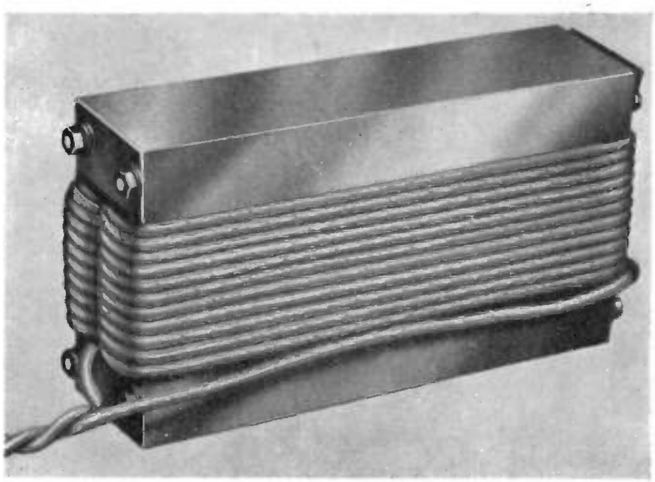


Fig. 9. Laminated Pile Magnetostriction Transducer for use with Mullard generator



to the actuating face of the laminated pile and the bit. The transducer is mounted at its centre or nodal point and rigidity of the bit is achieved by means of a supporting flexible diaphram.

PIEZO-ELECTRIC TRANSDUCERS.

Probably the best known method of generation of ultrasonic waves is the application of the piezo-electric effect exhibited by many natural and synthetic crystals; a number of generators utilizing such transducers have been described.

The piezo electric effect is too well known to require description in detail, but from the point of view of ultrasonic generation it is essentially a change in dimension of the crystal when an electric charge is applied to its faces. Many materials exhibit this effect but only a few can be utilized for the generation of ultrasonic waves as the electro-mechanical coupling must essentially be high. Crystals of Quartz and Rochelle Salt are commonly used as they possess high coupling factors, and most generators at present constructed utilize one or the other of them.

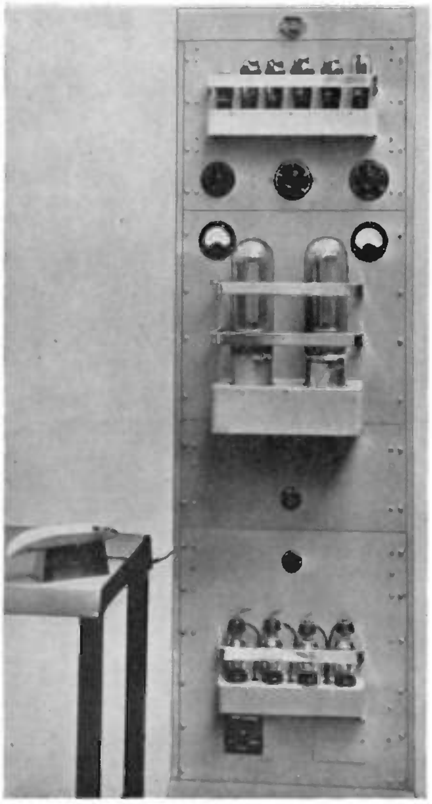


Fig. 10. Mullard magnetostriction ultrasonic generator

Rochelle Salt possesses a very large piezo electric effect—considerably greater than quartz—but the units are much softer and therefore cannot withstand large mechanical shocks. Apart from mechanical handling, the forces produced at high frequencies of vibration are very large and the crystals tend to shatter. The uses of Rochelle salt are therefore mainly restricted to low frequencies.

Quartz plates for ultrasonic work are cut from the natural crystal. It is possible to produce crystals for the generation of longitudinal, shear or surface waves depending on the cut taken from the natural crystal. The physical proportions of the crystal will determine its resonant frequency, but a crystal can be driven at any frequency so long as adequate power is available, and overall efficiency is not a binding factor.

When working with fundamental crystal frequencies, it is possible to cover a range of up to about 15 Mc/s. At

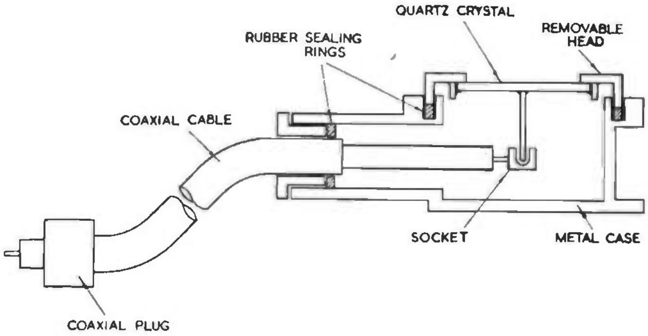


Fig. 11. Transducer assembly—simplified view

this frequency the plate is very thin and although higher frequencies are possible, there is a very large tendency towards mechanical failure. Crystals for higher frequencies can however be cut at a subharmonic but with correspondingly lower energy transfer efficiencies.

CRYSTAL CALCULATION.

An X-cut crystal is used for the generation of longitudinal waves and is normally mounted with a contact electrode on each face for imparting the exciting voltage. A longitudinal vibration occurs in the thickness dimension at a fundamental frequency and this can be calculated.

The plate thickness is determined by

$$t = \frac{\lambda}{2}$$

where λ is the wavelength of the stationary wave.

The density of quartz is 2.654 grams per cubic cm. Young's modulus is 770×10^9 g/cm/sec. The velocity of longitudinal waves is

$$c = \sqrt{\frac{E}{d}} \text{ giving } 540 \times 10^3 \text{ cm/sec.}$$

But, $\lambda = c/f$. and $e = \lambda/2$

Then,

$$F = \frac{c}{t} = \frac{2{,}700}{t} \text{ kc/s.}$$

Due to the movement in other directions in the quartz, experimental results do not confirm this and come closer to

$$F = \frac{2870}{t \text{ (m.m.)}} \text{ kc/s.}$$

The other movements occurring are mainly shear waves.

A beam of ultrasonic waves is usually propagated through a medium with very little divergence. Although the beam is usually considered to be confined to the face area of the transducer, there is actually some spreading that is a function of the ratio λ/D where λ is the wavelength and D is the transducer diameter. In a quartz plate there is a cone of energy whose half angle is given by:

$$\sin A = 1.2 \frac{\lambda}{D}$$

Experimental results usually diverge from this formula as the crystal mounting affects the beaming characteristics, and often secondary beams produced by edge effects will occur. In the past, the design of mountings for the crystal has presented many problems, especially if the power output is to be at all high. It was realized that to obtain unidirectional maximum output in a liquid, an air backing was necessary. This prevents losses due to a back support, and led to the well known edge support for the crystal. It will be appreciated that due to the high electrical impedance of the crystal at low frequencies, the voltage for maximum power output will be very high, usually between 2 kilovolts and 10 kilovolts and this presents an appreciable problem

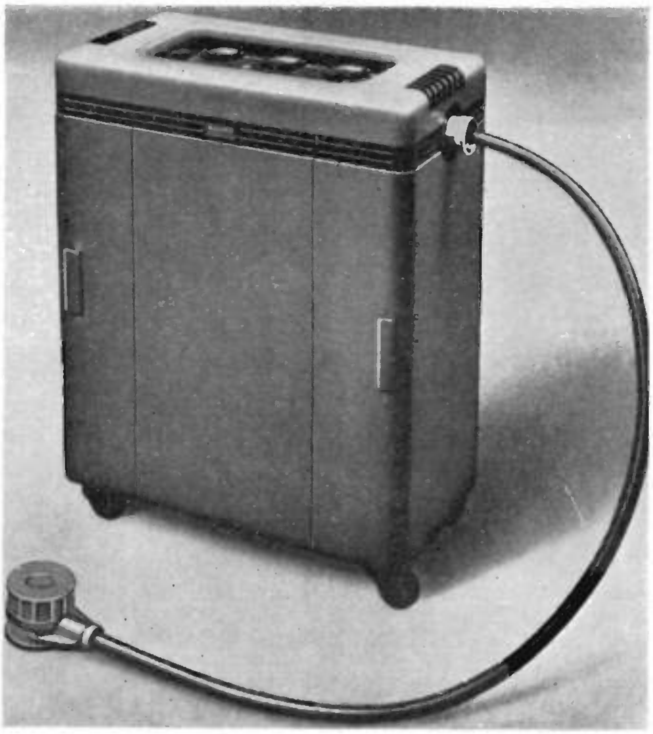


Fig. 12. Mullard quartz crystal ultrasonic generator

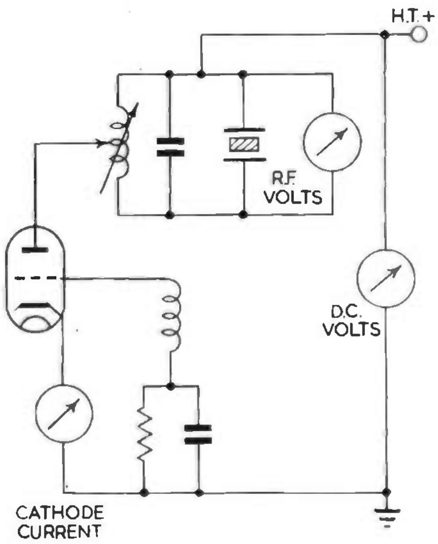


Fig. 13. Basic circuit of generator

of insulation. A number of different types of transducers have been described embodying various features to overcome this problem, but they are all basically similar in that they rely on an insulating liquid such as transformer oil to prevent flashover between the electrode leads and supports. This means that the top or actuating face of the crystal is covered with the oil and transmission is effected via this medium. Transmission losses are usually quite high due to attenuation by the oil and it is also impossible directly to irradiate liquids at high powers.

It was realized that these disadvantages presented a serious obstacle to the wider applications of power ultrasonic waves, and an air backed transducer capable of being operated in conducting liquids was developed, Fig. 11. In this unit, corona discharge has been avoided by careful design of the crystal mounting and the conducting leads. The crystal is cemented to the top mount, and an insulating ring secured over it to increase the length of the flashover path. The upper surface of the crystal is of course at zero potential with respect to earth, and the transducer can be directly immersed in conducting and non-conducting liquids.

A complete Mullard ultrasonic generator comprising the source of R.F. power and the transducer is shown in Fig. 12. The oscillator is of the tuned anode, tuned grid type utilizing a single silica triode valve; a basic circuit is given in Fig. 13. Plug-in coils are provided for a wide range of frequencies and matching to the crystal impedance is effected by tapping the anode down the coil. Fine tuning of the output circuit and adjustment of the grid coupling is carried out by means of variometers. The oscillator is self biased. Coupling between the crystal and the generator is by a co-axial cable and the capacitance of this cable and the crystal forms part of the oscillator circuit. Output power is varied by the use of grid controlled rectifiers in the main power supply.

Conclusion

It will be seen that there are many methods for the generation of ultrasonic frequencies, and it is quite conceivable that in the future new techniques will be evolved that can also be utilized. As efficient generators are produced, so the application side of ultrasonics will advance and it is probable that the many effects produced by ultrasonic waves will eventually be applied as an established factor in many productive industries.

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A Recording Oscilloscope

THE Atomic Energy Research Establishment, Harwell, has under development a cathode-ray oscilloscope designed for the photographic recording of single non-recurrent pulses. When a pulse is received by the oscilloscope the following sequence of events occurs.

(a) The cathode-ray tube is brightened and the time base triggered.

(b) The pulse is delayed in time and then displayed on the cathode-ray tube.

(c) The time base cannot be retriggered by incoming pulses until event (g).

(d) A short time after the end of the time base a second time base displaying time calibration pulses is triggered.

(e) After this event a clock is illuminated.

(f) The film is moved through one frame.

(g) The time base triggering circuits are reset.

This whole sequence takes about 1 second to complete. The film, which is continuously exposed, records events (a), (b), (d) and (e). The time base duration can be set to 3, 10, 100 or 1,000μs., and time calibration pulses at intervals of 1, 10 and 100μs. are available.

The Broad Principles in the design of Automatic Monitors

By H. B. Rantzen, B.Sc., M.I.E.E., F. A. Peachey, M.I.E.E., and C. Gunn-Russell, M.A.*

The British Broadcasting Corporation is at present augmenting several of its technical services, notably the rapid extension of the television service, and this has produced a demand, and will shortly increase that demand, for experienced engineering staff. Some part of this demand may be met by outside recruitment, but the majority of the new posts will inevitably have to be filled by transferring engineers from other departments. To make a large enough number of engineers available for this new work, the BBC has had to devise means of reducing the staff employed on various tasks, and one of the more attractive ways of doing this is the mechanization of the necessary, but uninteresting, job of technical monitoring.

This article discusses the problem of automatic monitoring and describes apparatus and practice that have been developed.

As near to its source as possible, whether the source is a studio or an outside broadcast point, a programme is checked for its aesthetic value and technical quality. This checking at the source demands the constant attention of an operator who is experienced in programme matters and has also sufficient technical knowledge to recognize and remedy any technical imperfection that may arise.

The programme, checked or monitored at source in this way, is transmitted over an extensive line system to the various transmitters from which it is to be broadcast. On the way to these transmitters it may pass through other B.B.C. premises. These premises usually have studio facilities from which local programme may be orginated. At such points the incoming line links are equalized, amplified and branched out to other premises.

In order to ensure that good quality of transmission is maintained it is necessary to check the technical quality of the programme at these points, and finally to check by a receiver local to the transmitter from which the programme is broadcast. In some cases several different programmes pass through the same premises and some economy in staff may be made by listening to the programes sequentially for short periods. This method has the disadvantage that the check is intermittent and is disturbing to the observer as he hears a succession of short pieces of different programmes.

It is not easy for an observer to maintain a highly critical standard of observation regarding technical quality for hours on end. He may be alert to serious faults such as breaks or heavy noise, but experience has shown that he is likely to become "conditioned" to other defects. Many hours of his day have been spent just waiting for something which does not happen. When a fault does occur he must have sufficient technical appreciation to notice it, estimate its cause, and set in motion the steps to remedy it. In fact, he must be an experienced operator.

We do not want to employ skilled people in this way if it can be avoided. The Automatic Monitor is an attempt to avoid such employment. It is hoped that such gear will eventually release such operators to other jobs in which more use may be made of their skill and at the same time enable a good grade broadcast service to be maintained.

The saving in man power can be appreciated by a comparison of Fig. 1 and Fig. 2. These diagrams show the Home Service network. In Fig. 1 staff are shown at the source, intermediate and terminal monitoring points. Fig. 2 shows the same system evisaged when it is equipped with automatic monitors. These diagrams do not do full justice to the saving until it is realized that due to shift operation each staffed position saved actually represent a saving of several men. Automatic Monitors are in course of manufacture for this purpose. They will not replace all the monitoring staff as for various reasons it is not always profitable to do so.

The Automatic Monitor will be applied to other networks, such as the Light Programme Services, some of the Overseas Services, etc. It also strengthens the design of unattended transmitters as it permits a watch to be kept at premises which are not manned at all.

This article will be confined to the application of the Automatic Monitor to broadcasting as it is with that particular application that the authors are most concerned. It obviously has other uses, however, such as the monitoring of radio relay services.

Scope of Automatic Monitor

On a well maintained simultaneous broadcast system, appreciable imperfection should be rare. Regular maintenance testing, special testing and equalization and a proper organization for directing effort towards improvement of the weak sections, ensures this.

The purpose of the Automatic Monitor should be to call attention to an imperfection of such magnitude that a normal listener would be disturbed by it. It should not call attention to say a small change in frequency response, slight overload, or a very faint noise background. These marginal defects are looked after in another way. If they were not attended to periodically, the system as a whole would drop in technical standard and an accumulation of minor faults produce an unsatisfactory overall result. Periodical testing for distortion and conformity to close limits on individual links should look after the general standard. The Monitor should call attention to appreciable deviations from standard during programme transmission.

Technical Faults

Noise

Apart from complete or intermittent breakdowns in transmission, noise is without doubt the most likely fault to mar programme transmission. The degree to which it is noticeable depends on a number of factors such as the nature of the programme, the general volume of the pro-

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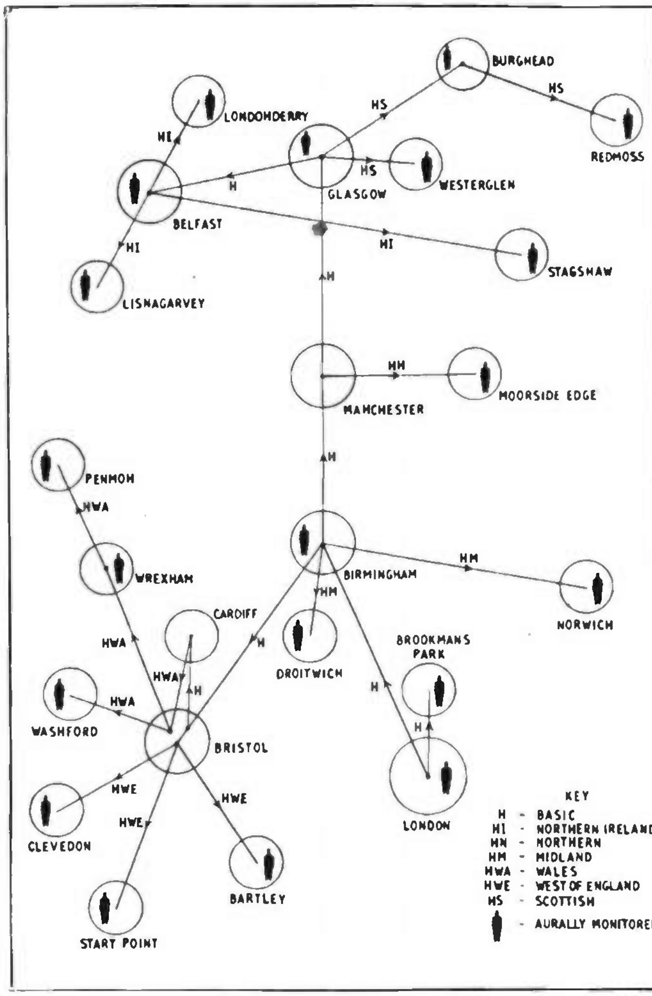


Fig. 1. Home Service, Existing Monitoring System

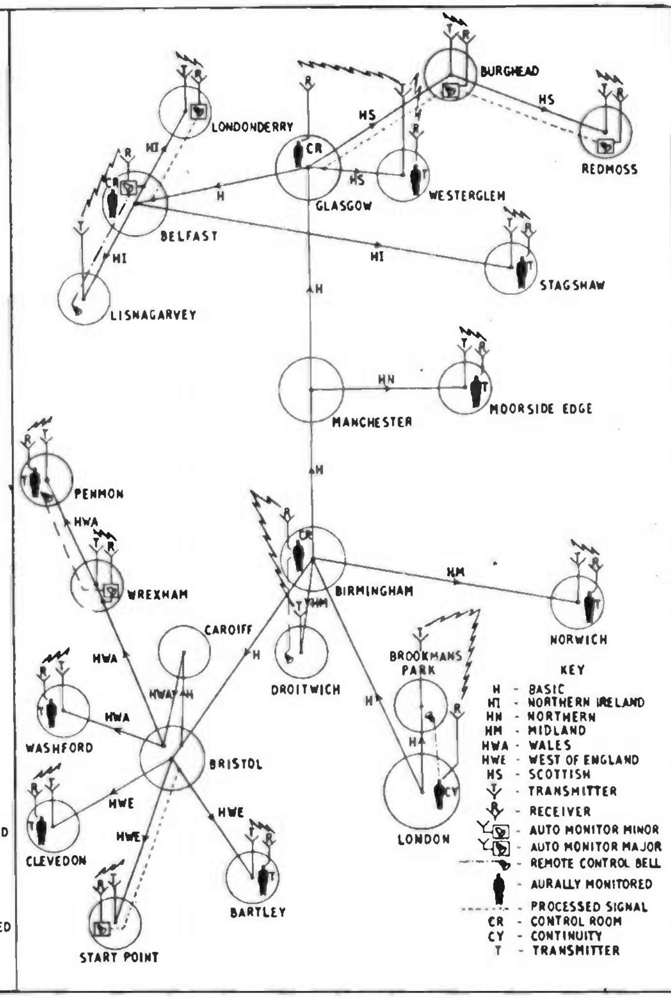


Fig. 2. Home Service, Proposed Monitoring System

gramme, and of course, the nature of the noise. If the programme has a noisy background, spurious noise may go unnoticed. Noise is usually most discernible to the listener during the weak and silent passages in programme, It is well known that the audibility of noise depends on the frequencies it contains (and on its volume). This is appreciated by reference to Fig. 3.

For the purpose of automatic monitoring it was decided that a trained operator monitoring a programme would discern a noise volume (weighted) at approximately 40 db below maximum programme volume in the intervals or low volume passages.

Frequency Response

Naturally, every reasonable effort is made to maintain good frequency response. A range of 50-7000 c/s. with a variation of, say, $\pm 1\frac{1}{2}$ db gives realistic quality. Very few listeners would recognise an improvement beyond this, in fact most use receivers substantially restricted to a response range not better than 80-3500 c/s. Such a restriction is certainly noticeable but there is no doubt that most programmes still have good entertainment value under these conditions.

The job of the Automatic Monitor should be to give warning if for some reason the transmitted quality falls substantially below the wider range and approaches the narrower range. It should look for a fault which causes appreciable damage to the value of the programme and not be critical of small variations in the wide response range.

It should, of course, be mentioned that the nature of the particular programme will determine the degree to which deviations from ideal frequency response may be noticed. It is desirable that the Automatic Monitor should follow a similar tendency.

Overload or Non-Linearity

In most broadcast transmission circuits, discernible non-linearity is normally due to the overloading of the valve-circuits at peaks of programme signal. This may happen at the line amplifiers or at the transmitter. Occasional overload of the transmitter cannot be avoided if it is used to give an economic coverage. Attempts are made to reduce overload by controlling the volume of programme at source, but for very short periods there will be overmodulation. The periods may last several mill-seconds only and therefore produce little audible distortion. Excessive overmodulation will, however, give noticeable distortion. It is therefore a requirement of the Monitor that it should ignore the one and register the other.

Non-linearity is usually measured in terms of the ratio of the total harmonic (RMS) to the fundamental. Aural sensitivity is not linear with respect to non-linear distortion. A large amount of non-linearity is tolerable at low frequencies. For instance, for a link to have good quality transmission, the harmonic distortion should not exceed about 4 per cent at 100 c/s and 1 per cent at 1000 c/s.

Amplitude distortion does not give a true assessment of audible non-linear distortion. On the other hand amplitude distortion may be regarded as the cause of non-linearity in programme transmission over line circuits. The volume of the programme signal sent to the transmission chain is normally fixed at the optimum between the overload and noise level of the circuit. This means that occasional high volume peaks of programme are likely to cause overload for short periods.

It should be mentioned here that the "volume" of programme sent over the systems used by the Corporation is constantly checked for this optimum value by means of a special "peak programme meter". It has a logarithmic scale, a forward time constant of about 2.5 milliseconds and a backward time constant of several seconds. The meter is calibrated on zero level tone (0.775 volts) and "zero volume" of programme is that value of programme which will occasionally peak the reading of the meter 8 db higher than this.

"Zero volume" is the peak amplitude at which the transmitter is set to give 100 per cent modulation. From this cause alone, therefore, peaks of programme in excess of this value are frequently "clipped". Some of these peaks are of very great amplitude indeed compared with the R.M.S. value of the programme. If they were not clipped the modulation of the transmitter would have to be maintained at a very low value and reasonable coverage would be lost. Fortunately, these peaks are of short duration and contain very little energy. When they are unavoidably clipped they contribute very little to audible non-linear distortion. These comments certainly apply to the limitation of the transmitter and apply in a comparable degree to the line repeaters and amplifiers used in the transmission chain.

in this respect, and in most cases a change of 5 or 6 db in transmission equivalent must be avoided.

Phase Distortion

It is fortunate for the economics of programme (sound) transmission that the ear is very tolerant of delay. Recent C.C.I.F. recommendations suggest that the group delay time compared with the minimum group delay time in the range of frequencies under consideration should not exceed:—

Frequency.	
50 c/s.	80 milliseconds
100 c/s.	20 milliseconds
10,000 c/s.	8 milliseconds

Up to the present the Corporation have taken no steps to correct for phase distortion on individual links of the programme networks. Excessive phase distortion on long chains is avoided by combining links having dissimilar phase characteristics, and although the resultant distortion may not be audible, it is responsible for big form factor changes.

Audible phase distortion is not likely to arise suddenly during programme transmission unless some other serious fault has occured. If, on the initial tests, the circuit is satisfactory in this respect, it is likely to remain satisfactory. It would seem, therefore, that the Automatic Monitor need not be made sensitive to this form of distortion. (Actually it has been found quite difficult to make it sufficiently insensitive to this!)

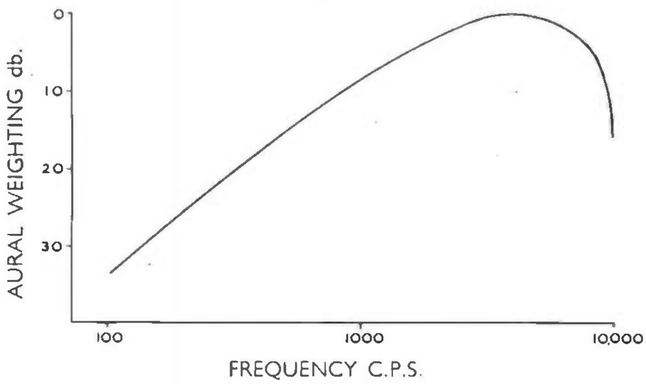


Fig. 3. Aural Weighting of Noise

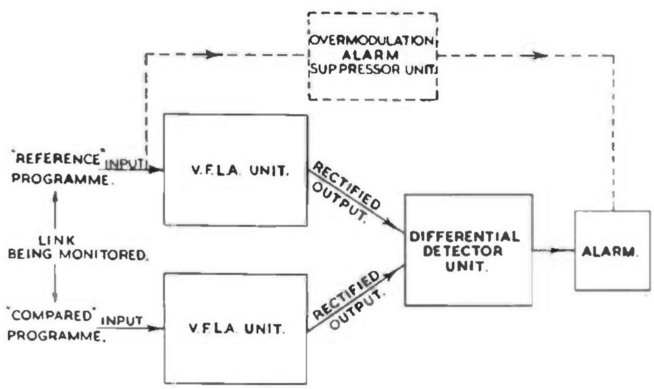


Fig. 4. Automatic Monitor Minor. Basic Block Schematic

Attention is drawn to this for three reasons. Firstly, it gives a fair interpretation of the nature of overload or non-linear distortion commonly experienced in programme transmission. Secondly, as throughout this article the term "programme volume" is used, the brief description of the programme meter gives its meaning. Lastly, as it shows that (for the purpose of Automatic Monitoring) the degree of compression of the peaks of programme is a reasonably good measure of the usual type of non-linear distortion during programme transmission.

Variation of Transmission Equivalent

Small slow changes of transmission equivalent in the order of 2 db do not produce appreciable audible change in programme volume. Due to the drift in gain of amplifiers, line loss, etc., which is bound to occur over long transmission links, such changes are to be expected. If this value is appreciably exceeded, not only will the listener notice a change in volume but either background noise or overload distortion will increase. Very few transmission circuits are designed to have large margins

Automatic Monitor Minor

The scope of the Automatic Monitor should be to give alarm indication if a fault arises from any one of the causes, i.e.:—

(1) Noise.

(2) Frequency response.

(3) Overload or non-linearity.

(4) Transmission equivalent variation (including breaks).

Amplitude Sensitivity

From the foregoing it will be realized that all those faults may, with respect to a programme signal, be reduced to a measure of amplitude. The average programme signal is intermittent in nature. Its volume varies from the highest peak value that the transmitter can deal with, down to the inherent noise volume of the transmission chain. Its composition varies considerably with the type of programme matter but the whole of the frequency range of the transmission channel will be explored some time. How frequently this occurs matters little as neither the Automatic Monitor nor the listener is concerned with the reproduction of frequencies which are not present.

In fact, programme seems the ideal testing signal. The Automatic Monitor is therefore an amplitude comparison device. It watches the amplitude of the programme at the two ends of the transmission circuit being monitored and compares them with each other. If the amplitude difference between these points which, for convenience, we may call the "reference" point and the "comparison" point, differ by more than a certain amount, an alarm may be operated. The form of the Automatic Monitor is shown in Fig. 4.

This is the simple basis of the Automatic Monitor. There is, however, a little complication in the way the Monitor is graded to give the right amount of indication with respect to various types of faults.

Programme may be at zero volume (the volume required to give 100 per cent modulation of the transmitter) or at noise volume. The ratio between these two quantities is possibly 100 : 1 or 40 db. The Monitor must assess both with respect to amplitude difference between the "reference" and "compared" signals. At maximum peak values it must discern a compression in volume due to overload, and at noise volume, the presence or absence of noise. Frequency response and Transmission Equivalent (T.E.) variation would be discernible at either top or bottom volume but as long periods may elapse before the programme has such values, a "middle" volume should be considered. At such a middle volume there will be a programme signal very frequently. The middle volume will not be affected appreciably by either overload or noise.

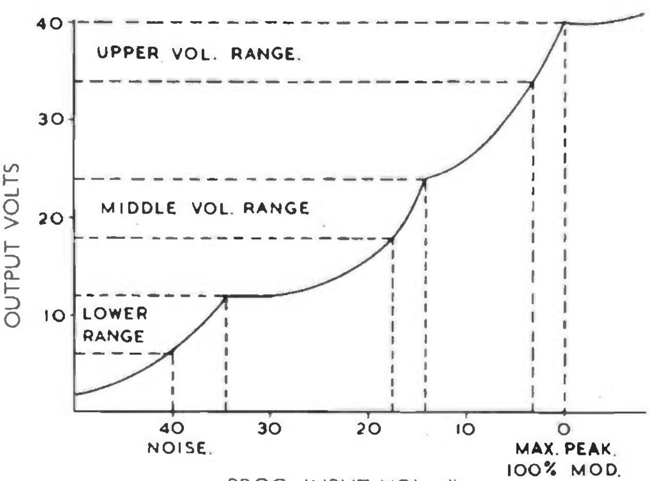


Fig. 5. Basic Input/Output Law of V.F.L.A. Unit

In fact, the Monitor must be sensitive to the required degree at:—

(1) Top volume—for overload.
(2) Some middle volume—for frequency response and transmission equivalent.
(3) At noise volume—for noise indication.

This selection of volume ranges shows the lines on which the design has been pursued. Three such ranges are selected between maximum programme volume and noise volume and at other volumes the programme signal is compressed. This reduces the programme maximum volume-noise volume range from 40 db to less than 20 db and gives consequent simplification. The amplitude law of the Monitor is then devised so that over the three ranges an "alarm-worthy" fault gives the required difference in output. The top and bottom volume ranges give emphasis to different faults, i.e., overload and noise respectively. They will also be sensitive to differences in T.E. and frequency response variations, but as the average peak of programme signal is between these values, the middle range is added to augment sensitivity to T.E. and frequency response faults. By further grading the amplitude law of the Monitor, the three ranges may be given to a degree the respective sensitivities they require.

For further simplicity this is done by providing an equal sensitivity at each of the three volume ranges. The three ranges, compressed together, are given an approximately logarithmic law so that the overall input output law is of the form shown in Fig. 5. This process is carried out by the Volume Folding and Limiting Amplifier (V.F.L.A.) shown in Fig. 4. The output voltage change (see Fig. 5) for 3 db change in input is the same at top volume, middle volume and the volume at which noise is to give alarm. This is an arbitrary value but it is satisfactory as it not only represents the amount that T.E. may vary before alarm is given, but with a suitable integration time gives a satisfactory sensitivity to both frequency response and overload faults.

Integration Time

Owing to phase distortion which occurs even over short circuits, the true comparison of peak values of signal is practically impossible. The phase difficulty is overcome by rectifying the output signal indicated in Fig. 5. Peak value is used and the integration time constant of sufficient value to reduce the effect of form factor difference (due to phase distortion) between the "reference" and "compared" programme. The limit to this time constant is determined by the broad average length of the periods in programme which are likely to have a marked predominance of upper or lower frequencies. This is required for frequency response operation. The word "sugar" for instance, begins with a marked sibilant, and if the transmission link over which it is transmitted has, due to a fault, a droop in response of 6 db at 4,000 c/s., the "reference" and "compared" signals are likely to differ by at least 3 db if the build-up time constant of the rectified output is shorter than the sibilant sound. Observation has shown that the build-up time constant should not exceed about 10 milliseconds, and should be faster if possible. In the simplest form of the Monitor this value was actually used.

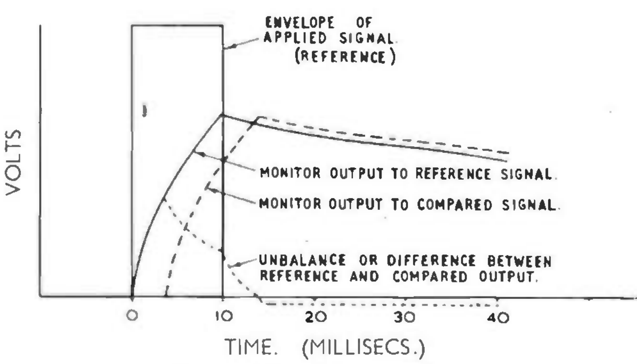


Fig. 6. Effect of Transmission Delay

In spite of integration of the peak value of the signal over such a period, transmission delay time in a line will show unbalance between the "reference" and "compared" programme signals as may be seen in Fig. 6. The line transmission time has delayed the arrival of the programme "compared" pulse so that it appears 4 milliseconds after the "reference" pulse. The "reference" and "compared" outputs of the Monitor units will be as shown and it will be seen that during the build-up period a big unbalance can arise (shown by the dotted line).

If the decay time constant of the output circuits is made large (Fig. 6) the "reference" and "compared" output signals will become almost equal about 15 milliseconds later. The detector used for comparing these two signals is therefore given a build-up time constant of a greater value.

The decay time constant at the Monitor output circuits is limited by the need to clear the output as soon as possible after a signal pulse, so that a comparison for (possible) noise may be made at lower volume. The Monitor is expected to approach full sensitivity in this respect between words in speech. A decay time constant of about 100 milliseconds seems suitable for this.

Extensive tests indicate that these time constants are suitable *with programme as the "testing signal"* for the indication of non-linearity due to overload, or overmodulation of a transmitter. This does not mean that *normal* peaks in programme must be compressed by 3 db before the alarm is given. If compression of a much smaller extent is appearing on normal peaks, *occasional* excessive peaks will give the required value for operation.

Much could be written on this subject but the above facts indicate some of the modes of operation. A given fault, which should sound the alarm, does not operate the Monitor every time it appears. Its chance to give operation depends on a number of circumstances such as the volume at which it occurs, the type of signal that has preceded it, etc. The net result of these devices is that the alarm will operate *sometime* on an "alarm-worthy" fault. The more severe the fault, the more frequently will be the alarm.

The units which form the arms of the bridge shown in Fig. 4 and which produce the non-linear input output law (shown roughly in Fig. 5) contain frequency discriminating networks. These are arranged so that the output sensitivity with respect to low volume input is graded in accordance with the aural weighting curve for noise shown in Fig. 3.

A further network arrangement provides different grading at middle and top volume so that the Monitor sensitivity is approximately in accordance with aural sensitivity at normal programme listening volume.

These networks also serve to restrict operation due to differences between the "reference" and "compared" programme at the extremities of the frequency band being transmitted.

Full details of these circuits cannot be given at the present time.

Differential Detector or Comparator

This unit receives the opposed outputs from the two V.F.L.A. units. If the difference between these outputs exceeds the predetermined amount (shown roughly in Fig. 5) the alarm relays operate.

It is fitted with a self-balancing or self-centring arrangement so that if an unbalance is persistent, such as is due to a change in T.E., it tends to rebalance. This allows for small slow drifts in T.E. and avoids appreciable encroachment from this cause, on the limits of balance.

Applications

Two types of Automatic Monitor have been designed. One which will monitor a programme link if both the reference and comparison programmes may be brought together for comparison. Another which will monitor longer transmission circuits and those in which the "reference" and "compared" programmes are at remote ends of the system. This latter system will be briefly described later.

The former is known as the Automatic Monitor Minor. Examples of its application are shown in Fig. 8.

Prototypes of this Monitor are in satisfactory service already. For instance, the Home Service programme is watched from Manchester to the output of the transmitter at Moorside Edge.

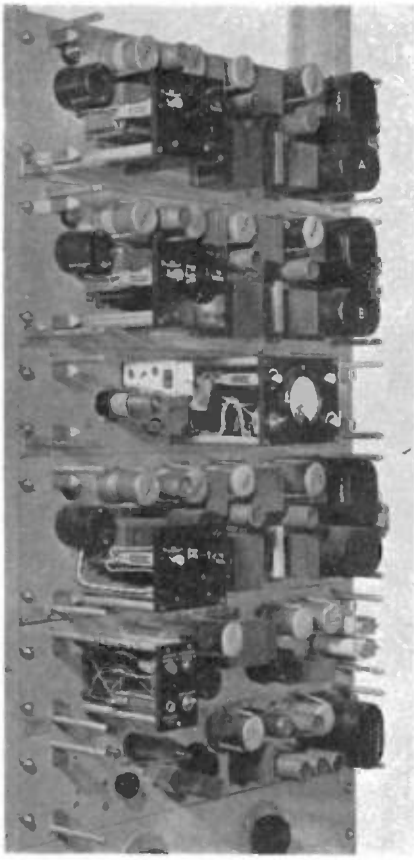


Fig. 7. Automatic Monitor Minor

The "reference" and "compared" programme are brought together in this particular case by a spare programme line between Manchester and Moorside Edge.

The spare line is held as a reserve facility against transmission breakdown for both the Home and Light programme services. The Monitor watches *both* the normal programme line and its reserve.

Another prototype of this Minor has been installed at Broadcasting House where for some months it was used on an experimental basis to check the Home Service programme from Brookman's Park transmitter. The "reference" programme was taken from the source at Broadcasting House and the "compared" programme derived from Brookman's Park by means of a radio receiver in Broadcasting House. The receiver was designed for this purpose to have a wide band response and good A.V.C. In spite of the fact that the reception point was in a good service area it was known that there would be many background noises, atmospheric interference and pick-up from local lift machinery, etc. In thunderstorm periods atmospheric background is, of course, particularly heavy and would give many monitor alarms. This was not desirable as the object of monitoring in this particular case was not to check the radio link, but to check the technical quality of the transmitter output at Brookman's Park. The Monitor was therefore fitted with a "Static Alarm Suppressor".

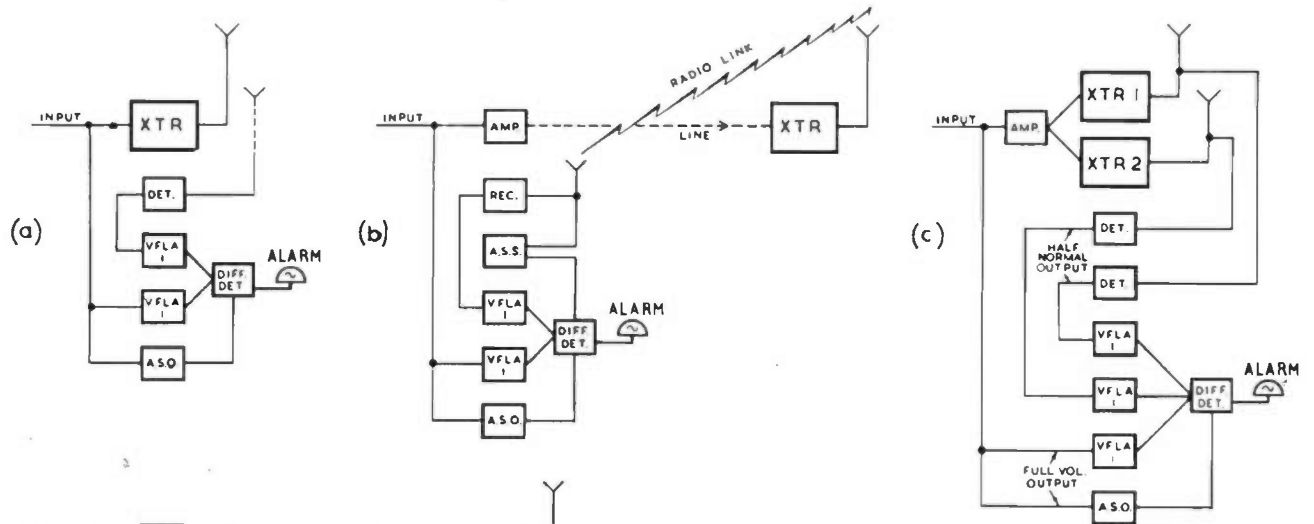
Static Alarm Suppressor

This comprises a very simple narrow band receiver connected in common with the normal monitor receiver aerial but tuned to a waveband near to the Home Service transmitter frequency. The waveband was chosen so that there was little or no received signal apart from that occasioned by static or other spurious signals picked up on the receiving aerial.

The rectified output of this receiver operates a quick acting relay circuit so that a rectified static signal suppresses the alarm indication which otherwise would be given by the Monitor.

In case the " static " becomes persistent and heavy, such as happens in a very local thunderstorm, or in case another station causes sufficient interference to operate the suppressor relay, a suppressor integrator was fitted. The integrator operates and gives alarm if the suppression of the Monitor is unduly persistent. It warns staff that local reception conditions have temporarily become unsuitable for proper monitoring.

This particular device has been mentioned as it demonstrates the extreme flexibility of these automatic monitors. It will not be brought into very general use as in most cases the " reference " and " compared " programmes are, for other reasons, available to the Minor without an appreciable radio link. Obviously, long distance transmissions cannot be treated in this way as the reception conditions are not suitable for good grade monitoring. On the other hand, receivers local to high power transmitters are not usually affected much by static interference.



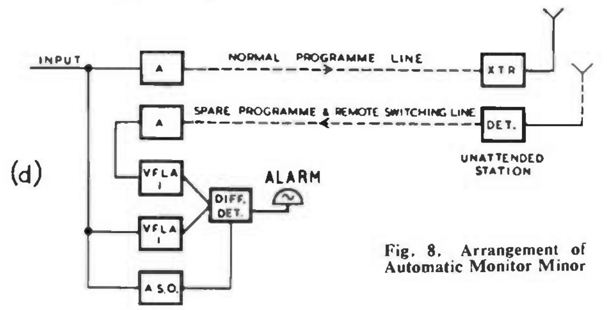


Fig. 8. Arrangement of Automatic Monitor Minor

Overmodulation Alarm Suppressor

It has been mentioned earlier in this article that in order to use a transmitter to give reasonable coverage the average percentage modulation must be held at such a value that some peaks in programme are clipped. At times, such clipping produces sufficient difference between the " reference " and " compared " signals to give monitor operation. Such operations are not desirable unless they are caused by excessive clipping which produces very noticeable distortion. They dilute the more legitimate alarm operations and call the attention of the maintenance engineer to a slight fault about which he can do little or nothing.

For this reason an overmodulation alarm suppressor is fitted to Automatic Monitors if a transmitter is included in the loop being monitored.

It is very similar to the static suppressor but works from the A.F. input to the transmitter. A quick action relay circuit operates on peaks of programme approaching 100 per cent modulation and suppresses the alarm circuit in anticipation of its possible operation.

This destroys the sensitivity of the Automatic Monitor to distortion at very heavy peaks in programme but the suppressor unit replaces this sensitivity by an integrator alarm circuit which operates if such suppression is excessive. This is a very satisfactory compromise as it avoids alarms on the occasional peaks which inevitably arise in programme but draws attention to more persistent and excessive overloading of the transmission circuit. An integration period of about $1\frac{1}{2}$ minutes has been chosen. Fig. 7 shows a typical Automatic Monitor Minor mounted on a transportable bay.

The circuits are self-alarming so that any breakdown in the Monitor such as a valve failure, a broken connexion or a failure in power supply, sounds the Monitor alarm. It therefore requires no routine servicing or maintenance to ensure that it is functioning properly.

Automatic Monitor Major

It has been mentioned earlier in this article that these Automatic Monitors fall into two classes.

The simpler type, the Minor, in which both the " reference " and " compared " programmes are available at the same place, has already been broadly described.

The other type is the major, which has been designed to monitor long distance circuits in which the " reference " and " compared " programme signals are separated by the length of the system.

In many ways they are closely related. In fact, the logical course in design was pursued; the main problems of the Major were solved and the Minor developed from it.

A typical use of the Major is the scene of field trials which, for the past several months, have been carried out on the prototype gear.

The West of England Home programme is routed from Bristol to the transmitter at Start Point. There is no return circuit from Start Point to Bristol. Comparison of the "reference" and "compared" programmes is made at Start Point by transmitting the output of a V.F.L.A. unit from Bristol to Start Point as an auxiliary signal superimposed on the music circuit.

It may be seen straight away that this presents special problems which cannot be dealt with in adequate detail in an article of this nature. A broad survey will therefore be given. Fig. 9 shows the block schematic of the system.

At the "reference" end of the transmission circuit the rectified output of a V.F.L.A. unit supplies the input to a modulator. This modulator converts this rectified output current into a modulated carrier wave of very small sideband width and restricted amplitude range. A narrow channel is provided at the upper end of the normal audio frequency band of the programme signal so that this monitor or "processed" signal may be transmitted over the common line. At the distant end, the processed signal is filtered from the normal programme signal, demodulated, and compared with another signal which at the far end of the system has been derived from the similarly processed "compared" signal.

The primary object behind the "synthesis" of the programme signal into another signal which might be regarded as a concentrated extract of programme distortion may now be appreciated. In order to avoid appreciable encroachment into the programme band the information in the "processed" monitor signal must be restricted. As it must be so restricted, it follows that the fullest emphasis must be given to those parameters which will be used in fault assessment. The V.F.L.A. unit does this.

The V.F.L.A. used in the Major is very similar to that in the Minor. It differs largely in the extra general compression given to the signal so that transmission in this way is feasible. The modulator is of a special type and provides a further compression to assist in transmission. For various practical reasons which cannot be discussed fully here amplitude modulation is used and the transmitted signal is reduced to a band width of about 200 c/s. with a 10 db amplitude range. This signal has a carrier of 7,500 c/s. or any frequency which may be squeezed into the upper end of the A.F. band of the transmission system. A modulator unit (complete with stabilized carrier oscillator) is shown in Fig. 10.

Processed Monitor Signal Transmission Difficulties

The concurrent transmission of the programme and the processed signal over a long repeatered transmission line presents many complicated problems. Such lines, although they may add very little to audible distortion in programme, are by no means perfect. Slight non-linearity will produce terms from the programme signal which lie in the "processed" signal channel. A form of amplitude intermodulation occurs between the two signals so that programme amplitude variations may affect the processed signal volume other than by the proper derivation process. On the other hand the volume of the processed signal must be kept very low indeed or it produces audible intermodulation with the programme.

Much could be said on this subject. It has possibly been more difficult to solve this transmission problem than the basic design of apparatus. In the Automatic Monitor Major, problems which in the Minor are small and may be countered by fairly simple expedients, approach magnitudes which demand closer attention.

One such problem relates to form factor. Every now and then programme happens to contain sustained frequencies, near to each other in amplitude and nearly related in frequency multiple. These produce a resultant wave with a low frequency amplitude variation. If one of these primary components is displaced in phase with respect to the other, the phase of the low frequency amplitude variation may be shifted by a considerable amount*. Long transmission circuits, because of their phase distortion, give emphasis to this kind of effect, and if

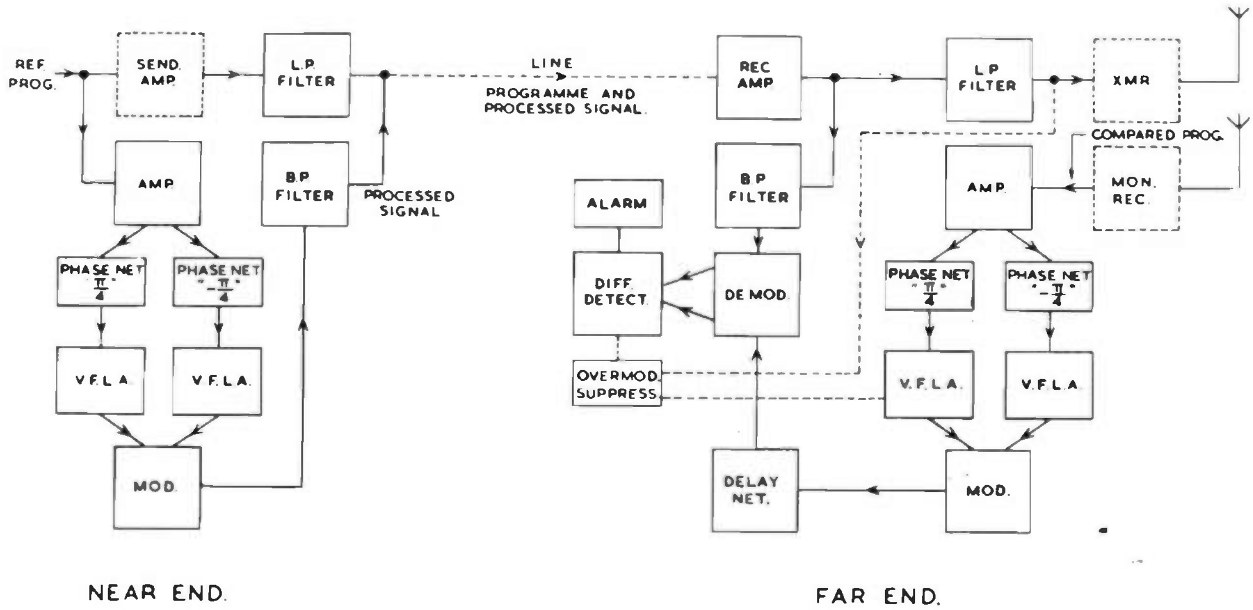


Fig. 9. Block Schematic. Automatic Monitor Major

* *This produces inequality between the reference and compared signals.*

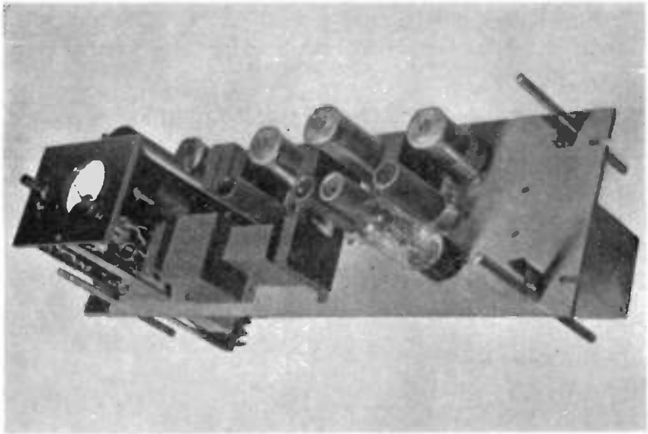


Fig. 10. Modulator Unit (Major)

special automatic monitoring precautions were not adopted, spurious alarm operations would ensue.

This particular difficulty has been mentioned as the block schematic in Fig. 9 shows two V.F.L.A. units virtually in parallel but with their respective inputs shifted apart in phase by 90°. It can be shown that this method of "phase scrambling" in relation to the programme signal reduces such low frequency amplitude effects so that spurious unbalance of the Monitor is unlikely to occur from this particular cause.

A.V.C.

A.V.C. is provided by the processed signal itself. It tends to hold balance with respect to variations in both the transmitted processed signal and the programme signal.

"Black" Level

A "black" level or residual carrier tone guards the system against a disconnexion of both processed monitor signal and programme signal. This is necessary as both processed and programme signal are carried by the same line. Without this "black" level a disconnexion of the line would give the impression to the far end that there was merely a gap in programme transmission.

Conclusions

Programme is a strange testing signal. It is not homogenious, but on a very long average it contains every conceivable mixture of frequency, amplitude and phase. Some types of programme are rich in one particular kind of combination of these qualities; others are completely devoid of them. In continuous programme, hours may separate peculiar group combinations which can momentarily break down the normal balance of the system, and a spurious alarm is given.

As far as we know, we have not succeeded in completely avoiding occasional operation of this kind but the drive to reduce such occasions to the order of rarity appears to have succeeded.

It is possible to do much more than we have done, particularly if there were no limit to the amount of apparatus and its complexity that could be installed at a station. The aim has been to produce something which is relatively simple to maintain, occupies little space and costs little.

For this reason the circuits have been so devised that once set up they remain stable, valves may be replaced without new adjustment, and no daily routine adjustment or servicing is necessary.

It is intended as a staff saving device—and in that respect it approaches the ideal—as it not only releases staff for better purposes, but may be forgotten until it sounds an alarm. An alarm means that something is wrong either with the programme or the Monitor. It is then the first duty of the maintenance engineer to examine the programme, and if it proves faulty, use his skill to restore good transmission conditions. It is his second duty to attend to the Monitor gear if that is faulty.

This, of course, demands technical skill—the Automatic Monitor cannot claim to have dispensed with that—but it has been designed so that faults, if they arise, can normally be located quickly. Simple test facilities are provided so that this may be done, and spare "plugable" units are available so that in most cases the actual Monitor fault may be cleared at the most economic time.

It would seem that if this device yields the fruits it promises, its scope may be extended one day to the much more complex problem of automatically monitoring television signals.

The authors wish to express their gratitude to the Chief Engineer of the British Broadcasting Corporation for permission to publish this article.

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[3] British Patents : Nos. 16794/48 ; 16795/48 ; 16796/48 ; 31283/48 ; 5890/49 ; 6489/49.

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The Application of Automatic Monitoring to Recording Processes

SINCE the above article was written a number of brief experiments have been made in the application of the automatic monitor to recording processes.

The requirements are practically the same as those for "live" programme signals, with two main differences. In the first place, the time interval between the recording of the signal on to the medium which is to store it and the reproduction from the displaced pick-up is much longer than over "live" circuits. With the recording head quite close to the pick-up head, the interval may amount to 100 μsecs. or more.

Another form of distortion may also occur. "Wow" or "flutter" is not experienced on live circuits, as there can be no distortion of frequency during transmission. In a recording process "wow" or "flutter" may introduce very noticeable distortion.

No attempt will be made in this article to relate "wow" to aural sensitivity. Much more work is to be done in this field before there is even available the scanty information such as exists on the audibility of noise or frequency response. Suffice to say that at a low frequency recurrence, an unwanted shift in frequency of less than 1 per cent can be very noticeable.

Two methods of using the automatic monitor to alarm

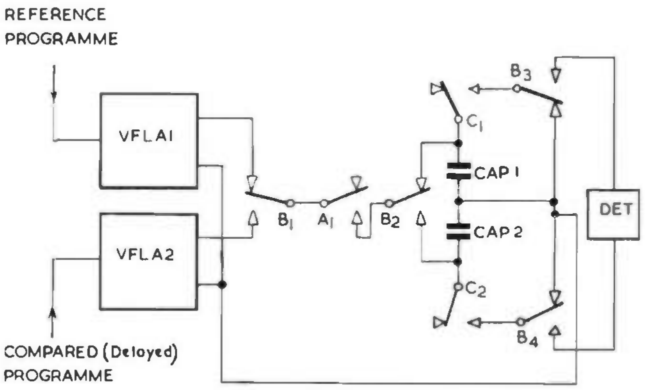


Fig. 11. Automatic Monitor Minor adapted for monitoring recorded programmes

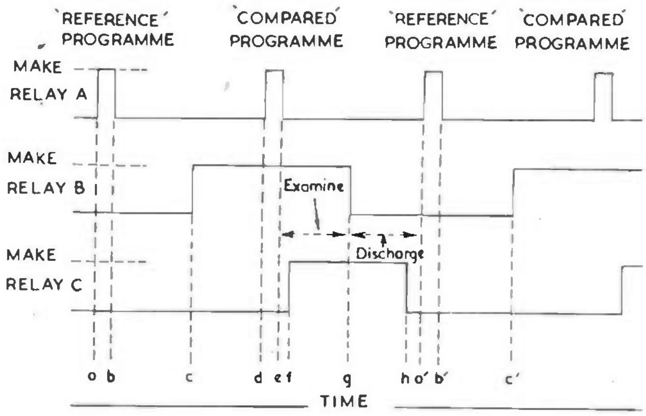


Fig. 12. Timing of relays shown in Fig. 11

on audible distortion in a recording process have been partially investigated, and they will be briefly described.

The main difficulty is to cover the relatively long delay between the "reference" and "compared" signals. Obviously, it is impracticable to introduce delay on the signals themselves when it is remembered that for reasonable quality in transmission a band of about 50-7,000 c/s. is required. At the output of the V.F.L.A. Unit (Fig. 4), however, there is a better opportunity to establish delay. At this point the programme signal has been converted into direct current which is varying slowly in amplitude in relationship to the input programme signal.

It is evident that if this slowly varying direct current signal can be integrated over a short period and stored as a charge on a capacitor, it may be held in storage until a comparison may be made with a similarly integrated signal. If the integration period is short, the sensitivity to the various forms of distortion is enhanced. "Wow" can be detected by this method, as fundamentally it represents a variation in time, and if the integration period is short, a variation in the relative time at which it occurs will produce amplitude variation and give alarm. In practice it was found rather difficult to make these integration periods so short that the monitor was very sensitive to "wow." If necessary, the circuit which is about to be described could be augmented by a parallel circuit which gives special emphasis to the time factor.

Fig. 11 is similar to Fig. 4, but with a relay circuit making the connexion between the V.F.L.A. units and the differential detector. "V.F.L.A.1" is supplied from the source feeding the recording head, and "V.F.L.A.2" from the pick-up head. The delay on the latter may be about 100 μsec., depending, of course, on the speed of the recording medium, the physical dimensions of the head, etc.

The process is as follows: A sample of the output from V.F.L.A.1 is taken for a specific period and stored on a capacitor. At a slightly later time a sample of the output from V.F.L.A.2 is taken in a similar way and stored on a capacitor. The delay between these times is adjusted to be equal to that which normally exists between the reproducing and recording heads. The two capacitors are then connected in opposition across the input of a differential detector. If the voltages are equal on the two capacitors no discharge current will flow and the detector indicates balance. If, on the other hand, a difference in voltage exists, the detector will be unbalanced. It can be adjusted to alarm for the desired amount of difference. After a suitable examination period has elapsed, the capacitors are completely discharged. The process is repeated continuously. The rate of repetition is determined largely by the delay in comparison required. The relays shown in Fig. 11 are operated from a common stable tone source. Some contacts operate at double the frequency of the others. This is secured by using the fully rectified wave to operate them. The delays in operation are obtained by conventional R.C. circuits.

A cycle of operations may be described as follows (See Figs. 11 and 12):

At time "a", relay A operates and capacitor 1 is charged from the output of V.F.L.A.1.

At time "b", capacitor 1 is disconnected from the output of V.F.L.A.1.

At time "c", relay B operates in readiness for capacitor 2 to be charged from V.F.L.A.2.

At time "d", capacitor 2 charges from V.F.L.A.2.

At time "e", capacitor 2 is disconnected from the output of V.F.L.A.2.

At time "f", capacitors 1 and 2 are connected in opposition across the input of the detector.

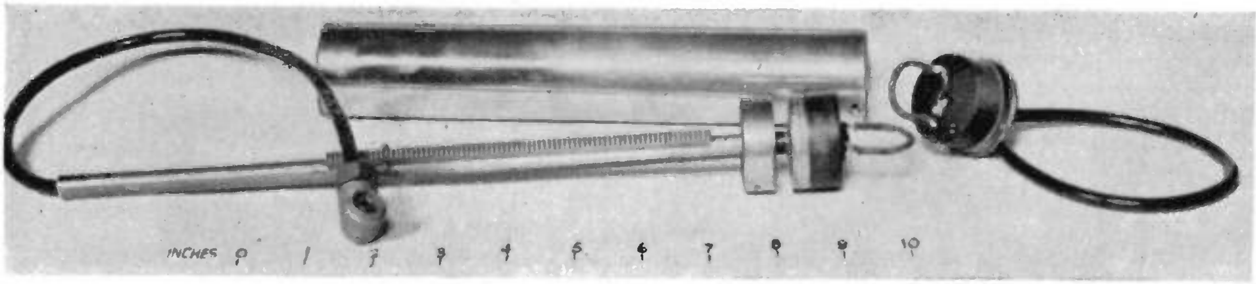
At time "g", relay B releases and discharges the capacitors. The discharge continues until time "h".

Another and similar method of comparison, which has shown some promise, uses a rotary switch between the V.F.L.A.'s and the detector. The delay in the comparison process is obtained by providing two or more brushes on the switch set at the required angle apart with respect to the studs. The speed of drive is adjusted so that the brushes scan with the required delay between them.

It will be seen that apart from alarm operation on all the faults listed in the main part of the article, operation of the alarm will also occur if the delay time varies between the signals from the two heads.

For such a circuit to operate well, the delay time of the differential detector must be reduced. This is simple, as in the case of "live" line transmissions it was deliberately increased to cover the normal delay in the transmission system. The reason why the delay in the one case may be ignored, while in the other case it must be examined, is obvious.

So far, this particular part of the work has not been taken beyond the experimental stage, but the device has several possible practical applications. For example, where recording apparatus is grouped together, then possibly one man could service several machines while the automatic monitors keep a check on the quality of the recording. This device might also have application in the checking of gramophone records in the course of manufacture.



A Piston Attenuator

By C. H. Banthorpe *

IT is difficult to make an accurate attenuator with resistors for frequencies up to, say, 20 Mc/s., and the problem becomes steadily more difficult as the frequency and attenuation becomes greater.

The piston attenuator, on the other hand, is a simple device which requires very little mechanical skill to construct, and whose range of frequency extends up to thousands of megacycles. Its characteristics may be predicted very closely indeed and it is, in fact, used by such laboratories as the N.P.L. as a primary standard, that is to say, one which needs no calibration from another source. There is a considerable amount of written information[1] on the theory of such attenuation and this note is only intended as a short summary of such information, and a description of a practical unit.

Briefly, if a wave is launched into a conducting tube, it will travel almost unattenuated as in waveguides, or be attenuated, depending upon the frequency of the waves and the diameter of the tube. The frequency at which a particular tube changes from a guide to an attenuator corresponds to a free space wavelength approximately equal to the diameter of the tube.

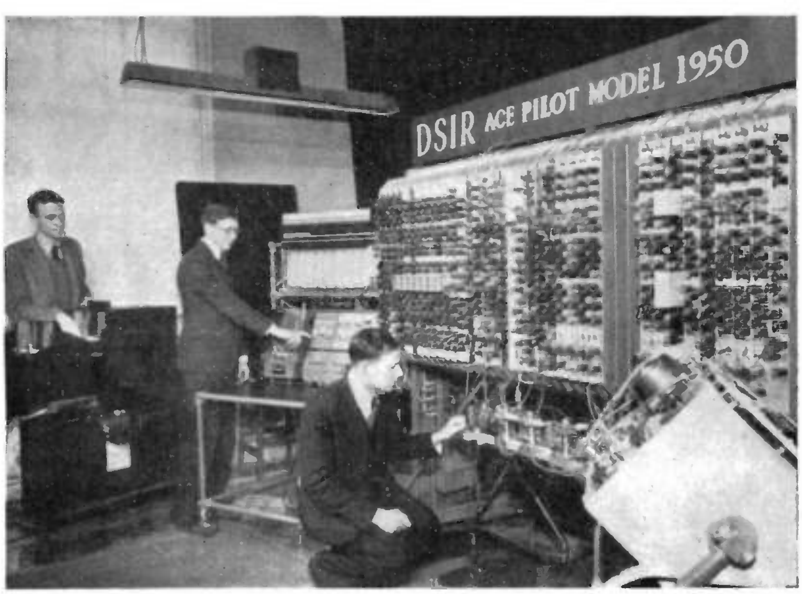
Waves can be launched in a number of ways or modes, and will be attenuated differently according to which mode is used. It is clearly an advantage to confine the wave launched to one mode, and if any unwanted component does get launched, to arrange that it gets attenuated much more rapidly than the wanted component.

For these reasons a practical attenuator may be one in which the wave is launched by means of a current-carrying loop whose axis is normal to that of the tube, and in which the attenuated wave is collected by means of a similar loop whose position from the first may be varied. This type of attenuator may be considered as an inductive attenuator, the two coils being magnetically coupled. Unfortunately an electric component is also launched and this is best removed by means of a Faraday screen. Unwanted modes, not stopped by the screen, have relatively high rates of attenuation and will cause little trouble, particularly when the normal attenuation is increased. The attenuation is exponential and has, therefore, a linear db scale. For the mode discussed above, the attenuation is 16 db per distance of the radius of the tube, to within 1 per cent.

The photograph shows an attenuator which has been used successfully by the author at television frequencies.

* *Central Equipment, Ltd.*

[1] *G. F. Gainsborough, J.I.E.E., 24, Part III, No. 29.*



The Pilot Model A.C.E.

A Pilot Model of the Automatic Computing Engine (A.C.E.) is now working at the National Physical Laboratory, D.S.I.R., where it has been designed and constructed. The A.C.E. itself will be built later, but the Pilot Model is a complete computer, which has already been used for solving some problems and the Superintendent of the Mathematics Division, N.P.L., will be glad to hear of industrial problems whose solving requires lengthy and intricate arithmetical calculations.

The Pilot Model of the A.C.E., which is shown in the photograph, consists of about 40 plug-in chassis on a rack 12 ft. long, and employs some 800 valves. A separate control desk is provided and the memory unit of mercury delay lines has a capacity of 8,000 binary digits. The whole machine occupies a floor space of approximately 60 sq. ft. and requires a power supply of 5 kW.

Sunderland Shore-Based Radar Station

THE function of this installation is to provide radar navigational aid for the pilotage of vessels entering and leaving Sunderland Harbour; the area under control is displayed on the P.P.I. of a marine radar equipment, and instructions for shipping movements are issued by the pilot staff who operate the equipment. Communication is established by radio-telephony between a fixed radio installation located with the radar equipment in the Pilot Office, and either the transportable set fitted on the pilots' launch or the portable (" walkie-talkie ") apparatus carried by the pilot.

Radar Equipment

The radar equipment, which is Kelvin Hughes Marine Radar Type 1A Series 2, comprises the standard units as provided for shipboard installation. The range scales

provided are 25 M, 15 M, 10 M and 1—5 M, but since the operational area is covered by a radius of 1½ M, the 5 M range will normally be used: on this setting the range scale may be varied to any value between 1 M and 5 M.

In this particular equipment the I.F. signal and lock pulse are split after the pre-amplifier, thus providing for a second display unit which is located on the ground floor and is to be used for experimental purposes by the Admiralty Signals Research Establishment—the technical authority for the installation.

Communication Equipment

The pilotage channel operates two-frequency simplex, amplitude modulation, on a transmit frequency of 163.1 Mc/s. and a receive frequency of 158.6 Mc/s. To provide this channel, a mains operated transmitter/receiver (A.T.E. Type PM 1A) giving 10 watts output working into a coaxial dipole is used.

An additional facility is available in that equipment is installed for communication on the international marine frequency of 156.8 Mc/s. Sunderland is the first Port in the British Isles to be fitted with equipment providing this facility. This International Guard Channel on 156.8 Mc/s. is provided by a type PM 1A set working single-frequency simplex, again with a coaxial dipole.

Operational Performance

Trials have shown that the pilots' launch can be seen continuously, in the worst conditions, to a range of 2½ M. The launch has a very low freeboard, and the larger cutter can be seen to 4 M. Communication ranges of seven miles have been obtained using the pilots' portable set.

Multi-Lingual Railway Station Announcer

TO speed Customs and immigration formalities and generally assist the foreign visitor, recorded multi-lingual announcements have recently been introduced at Harwich. Magnetic tape recording equipment supplied by The General Electric Co., Ltd., to the requirements of Mr. A. Moss, Signal and Telecommunications Engineer, Eastern Region British Railways, is used for this purpose and provision is made for all announcements to be given in English, Dutch, Danish and German.

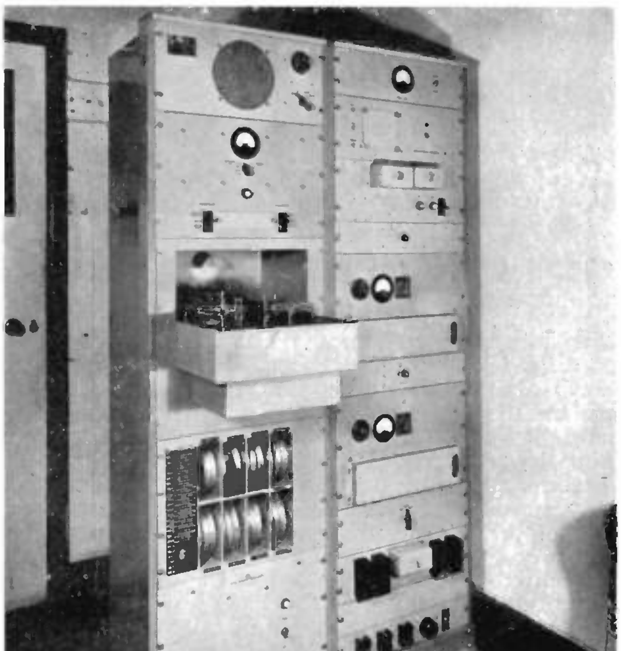
The tape, in 80 yard lengths, is wound on to standard 5 in. diameter 8 mm. ciné-film spools. As will be seen from the photograph, storage facilities have been provided immediately below the mechanism unit, 24 cans and spools being supplied, six blank spools being provided for local special recordings.

Each spool of the tape gives a maximum announcement time of six minutes, excluding a 30-minute run-up blank length. The tape speed used is 7½ in. per second, giving an upper frequency response of approximately 8 kc/s., which it was considered was necessary to give clearly intelligible speech reproduction under the poor acoustic conditions met on railway stations.

As the arrival of a boat train or ship is known well in advance, the operator is able to select the appropriate tape spool prior to the actual arrival.

Thirty seconds of blank tape has been allowed before the start of an announcement and the operator waits for the preliminary announcement which identifies the tape, giving its number, the language and brief details of the main announcement to follow.

At the appropriate time the operator has merely to re-operate the main control key to " play or record " and change over the control key to " main amplifier." The complete recording is then reproduced over the loud-speaker system.



The Measurement of High Vacuum by Electrical Methods (Part 1)

By F. Wade *

THE measurement of high vacuum is by no means a problem that has been confined to engineers and physicists of the 20th century. Since the 17th century, when Torricelli and Van Guericke reduced the pressure in an enclosed vessel, there has been constant research to improve the methods used by the early scientist, the first of these methods being the use of a barometer tube.

In 1705, Hauksbee[1] began to investigate the electrical discharge in an evacuated glass vessel. His first observation was a faint luminous glow in the vacuum of a barometer tube when the mercury was made to oscillate; this was only visible when the room was in total darkness. To prove his theory that this luminous glow was the result of some electrical action, he conducted another experiment where an evacuated bell jar was rotated on a wheel. When he held his hand against the outside of the bell jar he was able to see a luminous glow developing on the inside. He also obtained a faint purple glow by rubbing some wool against a piece of glass, both of which were in an evacuated bell jar.

Further experiments were made by Nollet[2] in 1704 and Morgan[3] in 1875; the latter also observed that the colour of the discharge varied with the pressure. By this he was able to judge approximately the degree of vacuum obtained.

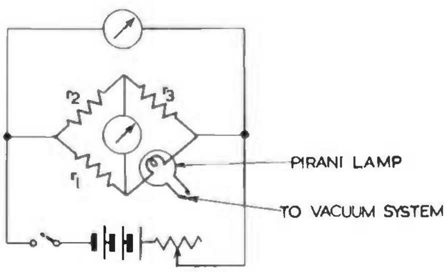


Fig. 1. Pirani gauge circuit

Crookes[4] and J. J. Thompson[5] also conducted experiments on the gas discharge phenomena. These early experiments proved that it was possible to express the breakdown voltage and the Crookes dark space as a function of the pressure. It was also found that the colour discharge varied with the pressure. These methods of vacuum measurement are qualitative only, and it was not until latter years that gauges were developed for quantitative measurements. One of the first quantitative methods of measuring low pressures is due to Pirani.[6] The action of this gauge is determined by the thermal conductivity of the gas medium present in an enclosed space. Pirani expressed the ohmic resistance of an electrically heated wire as a function of pressure.

Previous to the appearance of Pirani's gauge, a considerable amount of research on the thermal conductivity of gases had been conducted by Maxwell[7] and Kundt and Warburg[8]. Schleirmacher[9] and Bottomley[10] both observed the variation of the temperature of a heated wire as the

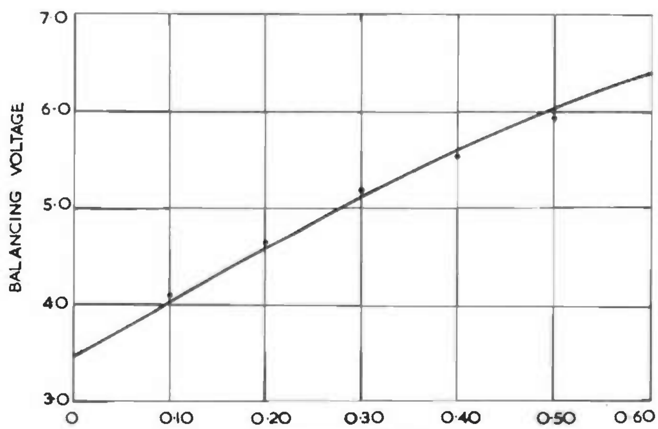


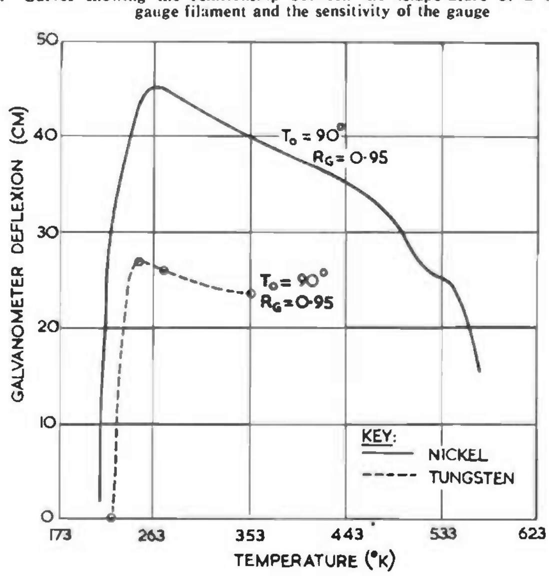
Fig. 2. Calibration curve of a 40-watt electric lamp when used as a Pirani gauge

pressure varied but Pirani was the first to apply this knowledge in a practical manner.

Another type of high vacuum gauge that is widely used is the thermo-couple gauge. This gauge also depends upon the variation of the thermal conductivity of the gas medium surrounding the heated element. Voege,[11] Rohn[12] and Rumpf[13] have recorded their observations with gauges of this type.

Gauges in which the gas medium is ionized by electron collision are used in most laboratories where low pressure measurements are made. The first of these gauges were in the form of a three electrode thermionic valve and were the results of work conducted by Buckley,[14]

Fig. 3. Curves showing the relationship between the temperature of a Pirani gauge filament and the sensitivity of the gauge



* *Atomic Energy Research Establishment, Harwell.*

Misamichi So.[15] and Hausser-Gandswint and Rukop.[16] Investigations were also carried out by Dushman and Found,[17] Kaufman and Serowy[18] and Simon.[19]

Penning[20] introduced an improved version of the two electrode cold discharge tube which now bears his name. He found that by using a permanent magnet he was able to increase the sensitivity of the discharge tube beyond the point where the discharge was no longer visible.

The most recent of all gauges is the "Alphatron." This gauge contains a small amount of radium which ionizes the gas surrounding the electrodes of a small ionization chamber, the ionization current being expressed as a function of the pressure. This gauge has been described by Meller.[21]

The electrically operated high vacuum gauges can be divided into two distinct groups:

(i) Those gauges, i.e., Pirani and thermo-couple, in which electrical methods are used as a convenient means of measuring the change of thermal conductivity.

(ii) Discharge tubes and ionization gauges whose principles are based on pure electrical phenomena.

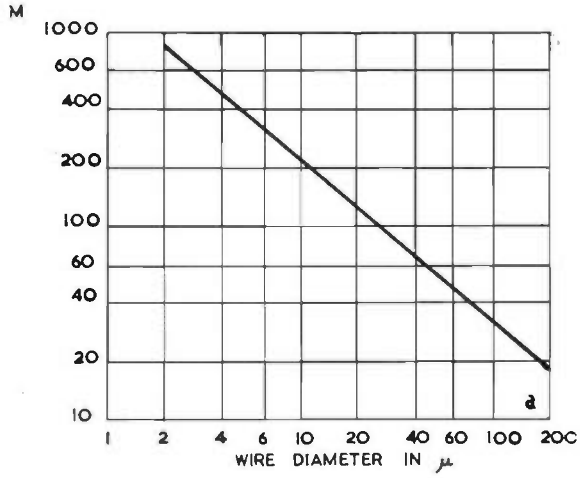


Fig. 5. Curve showing the relationship between filament diameter and the ratio of heat lost by radiation to that lost by thermal conductivity

Gauges Depending on the Thermal Conductivity of Gases

Before dealing with the various types of gauges that come under this heading it is well to consider the effect of the thermal conductivity of gases.

Consider a glass bulb containing a gas; sealed into this

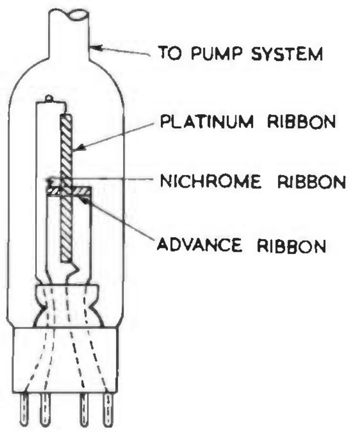


Fig. 4. Dushman's thermocouple gauge

bulb is a filament whose temperature is greater than that of the walls of the glass bulb. In order to keep the temperature of this filament constant a certain amount of energy must be put into the filament; this must be equal to that conducted by the gas. On the average, the gas molecules that strike the filament rebound with more kinetic energy than they had before impact with the hot filament. This energy is distributed to other gas molecules by collision until it finally reaches the walls of the bulb.

Maxwell[7] in his theory of kinetic gases came to the conclusion that the viscosity and thermal conductivity of a gas are independent of pressure. When the pressure is halved there is only half the number of molecules, but they travel twice as far. When the pressure is so low that the molecules travel from the filament to the wall of the glass bulb without colliding, the thermal conductivity is no longer independent of the pressure. On decreasing the pressure beyond this point the mean free path of the molecule is limited only by the physical dimensions of the glass bulb. Thus, when the mean free path becomes greater than that of the dimensions of the bulb, the thermal conductivity decreases with pressure.

When the above conditions are satisfied it is possible to calculate the heat transfer from the number of molecules per unit volume. The quantity of heat conducted by the gas is Q.

$$Q = \frac{nGA\tau H}{N6} \quad \ldots\ldots\ldots\ldots \quad (1)$$

where n = the number of molecules per cm^3.

G = mean molecular velocity.

A = area of heated element.

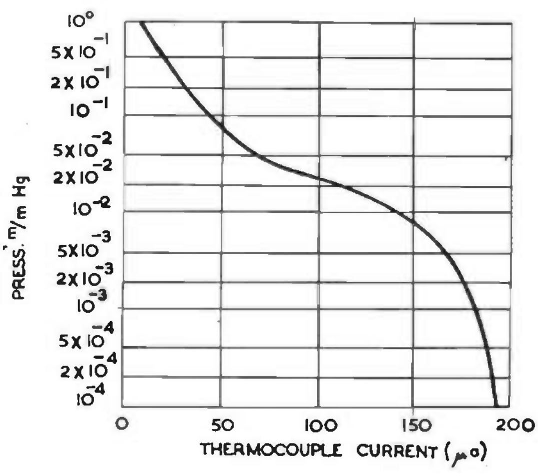
τ = temperature difference between heated element and its surroundings.

H = molecular heat at constant volume.

N = number of molecules per gram molecule.

However, in practice the quantity of heat conducted is less than that given in Equation (1). This can be explained by the fact that the molecules do not carry off the full amount of energy corresponding to the temperature of the wire, or in other words, they do not attain a temperature equilibrium with the heated surface. The ratio of the amount of heat conducted from a heated element to the theoretical value, as calculated from (1), is known as the "accommodation coefficient." Soddy and Berry[22] have given values for this coefficient for several gases when striking a heated tungsten surface. These vary from 0.25 for Hydrogen to 1.0 for Argon.

Fig. 6. Calibration curve of a typical thermocouple gauge



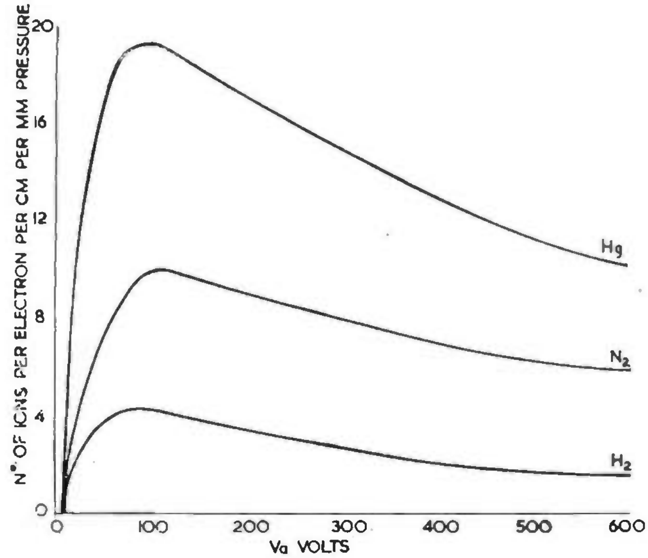


Fig. 7. Probability of ionization as a function of electron velocity

The observations of Kundt and Warburg[8] on the behaviour of gases at low pressures enabled later research workers to evolve two methods of measuring low pressure.

(1) Measuring change of resistance (Pirani Gauge).

(ii) Measuring change of temperature (Thermo-couple Gauge).

Pirani Gauge

Pirani[6] was the first to apply the "thermometer effect" to a useful measuring instrument. His first gauge consisted of an ordinary incandescent filament lamp which had not been evacuated. This lamp was connected to the vacuum system by a glass tube joined to the top of the bulb, the filament of the lamp was connected so as to form one arm of a Wheatstone bridge, Fig. 1. The resistance varied as the temperature, and in turn the temperature varied with the number of gas molecules that collided with the filament.

Pirani suggested two methods of operating the gauge.

(i) Keeping the heating current constant and measuring the changes in resistance.

(ii) Keeping the temperature and resistance constant and measuring the change of energy supplied.

Hale[23] slightly modified the mode of operating the Pirani gauge. He placed a lamp of similar electrical and physical characteristics to the vacuum measuring lamp in the opposite arm of the Wheatstone bridge. The second lamp was evacuated of air and sealed so as to maintain its vacuum. The purpose of this was to compensate for slight variations in room temperature.

Another method of using the Pirani gauge is due to Campbell.[24] Instead of measuring the change of resistance, he measured the potential that had to be supplied to the Wheatstone bridge in order to keep the resistance and the temperature constant.

The calibration curve, Fig. 2, for a Pirani gauge when used as described is plotted for pressure against $\frac{(V^2 - V_0^2)}{V_0^2)}$ where V_0 is the voltmeter reading corresponding to the lowest attainable pressure. Campbell has shown that when the heat losses along the support wires due to conduction and radiation are independent of pressure, then

$$\frac{V^2 - V_0^2}{V_0^2} = kf(p) \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The value of k does not undergo any wide variations for different gases, this is shown in Table I.

TABLE I

Gas	k
H_2	0.0057
H_2O	0.0081
N_2	0.0097
O_2	0.0097
CO	0.0097
CO_2	0.0097

A full theoretical treatment of the Pirani gauge has been given by Ellett and Zabel.[25] For the basis of their theory they state that the energy supplied to the filament must be equal to that which is dissipated. This is when lead losses, etc., are neglected, thus

$$E^2/R = A\sigma(T^4 - T_0^4) + A\gamma p(T - T_0) \quad \ldots\ldots (3)$$

where E = potential across the ends of filament.
R = resistance of filament.
A = area of filament.
T = temperature of filament } degrees Kelvin
T_0 = temperature of medium surrounding filament } degrees Kelvin
p = pressure of gas.
γ, σ = constants.

The first term applies to the heat radiated and the second term to the heat conducted by the gas.

After making certain assumptions and differentiating Equation (3), they state that the optimum relationship between T and T_0 for maximum sensitivity of a Pirani gauge is when

$$T = 3T_0/2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

On the assumption that the normal result of a small change in pressure is a small change in temperature, then:

$$R = R_0[1 + \alpha(T - 273)]$$

then:

$$dT = dR/R_0\alpha \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Ellett and Zabel used their Pirani gauge in a Wheatstone bridge circuit and from their calculations the current flowing through the galvanometer is:

$$I_g = \frac{kR_0(AR)^{\frac{1}{2}}}{R R_g + R^2} \, \frac{T - T_0}{T} dp \quad \ldots\ldots\ldots\ldots (6)$$

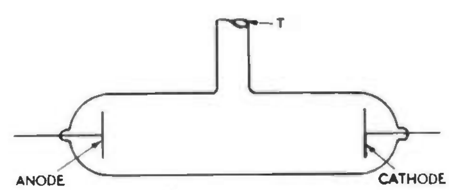


Fig. 8. Gas discharge tube

From Equation (6) the temperature of the filament for maximum galvanometer deflexion will be

$$= dp/3 \; . \; K \; . \; \frac{R_0 A^{\frac{1}{2}}}{R^{\frac{1}{2}} R_g - R^{3/2}} \quad \ldots\ldots\ldots\ldots (7)$$

It can be seen from Equations (6) and (7) that the length of the wire used in the Pirani lamp has a considerable effect upon the sensitivity. This effect can be pre-determined because A, R, and R_0 are proportional to the length of the wire.

The choice of the type of wire used for the Pirani filament also has a considerable effect upon the sensitivity of the gauge. Fig. 3 shows the comparison between two wires of exactly the same physical dimensions. The conditions of operation were identical in both cases and the sensitivity of galvanometer deflexion in cm. is shown as a function of temperature (T), in degrees Kelvin. The unbroken line denotes that the wire is nickel and the broken line is that for tungsten. From this curve it is obvious that the gauge with the nickel filament is the more sensitive. This is due to the fact that the temperature coefficient of resistance for nickel is 0.006, while that of tungsten is 0.0045. This is of some consequence in Equation (5). Nickel also has the advantage that it is very much easier to increase its area by flattening. To do this to tungsten would be a difficult procedure.

Thermo-Couple Gauges

The principle of the thermo-couple vacuum gauge is similar to the Pirani, i.e., it is dependent upon the amount of heat conducted from a hot wire by gas molecules. In gauges of this type the temperature of the hot wire is measured by means of a thermo-couple, the temperature is then expressed as a function of pressure.

Voege[11] first used a gauge of this type in 1906 and since then others[12,13] have suggested modifications.

A simple and typical thermo-couple gauge is shown in Fig. 4. It consists of a fine tape of platinum as the heater and a Nichrome-Advance thermo-couple which is held in good thermal contact with the heater. The whole of this assembly is sealed in a glass bulb which is connected to the vacuum system by a glass tube. The thermal E.M.F. is measured with a sensitive millivoltmeter and the readings are expressed as a function of the pressure inside the glass bulb. This gauge has been described in greater detail by Dushman.[26]

The behaviour of a thermo-couple under vacuum conditions has been discussed by Kovalenko.[27] He shows that for small values of temperature difference between hot and cold junctions (assuming the ambient temperature to be 20° C. = 293° K.), the energy radiated by a body of unit area in unit time is proportional to the temperature difference between the body and its surroundings.

$$Q_1 = 7.0 \times 10^{-5}\tau \text{ cals./sec.} \quad (8)$$

It is also shown that the amount of heat lost by gas convection is:

$$Q_2 = 2.8 \times 10^{-3}p\tau \text{ cals./sec.} \quad (9)$$

where p is pressure in mm. Hg.

From the Equations (8) and (9) it is possible to determine the lower pressure limit of the working range of a thermo-couple gauge. It we take as a practical limit of measurement the pressure p_0 for which the heat lost through gas convection is only 1 per cent of the amount of heat lost by radiation, then:

$$Q_2 = 1/100\ Q_1$$

or:

$$p_0\tau \ .\ 2.8 \times 10^{-3} = 1/100\ .\ 7 \times 10^{-5}\tau$$

then:

$$p_0 = 2.05 \times 10^{-4} \text{ mm. Hg.} \quad (10)$$

In determining the higher pressure limit, Kovalenko considers a simple case of two cylinders arranged coaxially. The radius of the inner cylinder being equal to the radius of the filament and the outer cylinder being equal to the internal diameter of the glass bulb containing the gauge. It is assumed that the bulb diameter is 1 cm., and that the temperature of the bulb is constant. The quantity of heat passing from the inner to the outer cylinder is given as:

$$Q_3 = \frac{2\pi\lambda}{\log_e (r_2/r_1)} \quad (11)$$

The relationship between the amount of heat lost by radiation to that lost by thermal conductivity is derived with the aid of Equations (8) and (11) and is given as:

$$M = \frac{0.8(1/r_1)}{\log_e (r_1/r_2)} \quad (12)$$

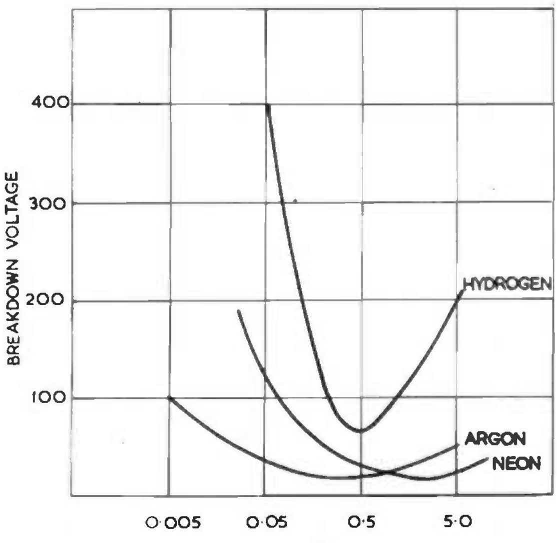


Fig. 9. Variation of breakdown voltage with pressure (Altbenhum, Reger and Seeliger)

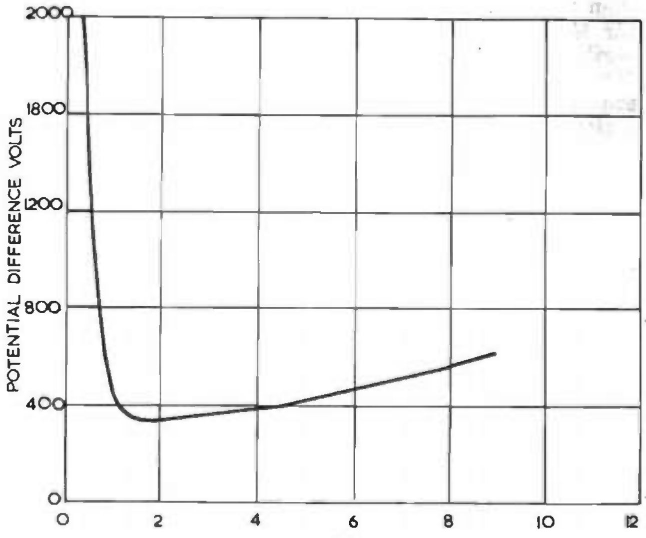


Fig. 10. Variation of breakdown voltage with pressure (Carr)

This relationship between M and the diameter of the filament is shown in Fig. 5. With a decrease in pressure the radiation from the surface of the filament is reduced. If with careful design, only a small fraction of the heat is conducted away by the filament leads and the temperature of the filament is not high, the value of M will be an approximate indication of the increase in sensitivity of the thermo-couple due to the reduction of pressure.

From Kovalenko's work it is possible to form a relationship between the sensitivity and pressure. The thermal conductivity of the air will be independent of pressure from atmospheric pressure to such a pressure that the mean free path is of the same order as the dimensions of the filament. For example, if the diameter of the filament is 30μ, the sensitivity will begin to rise at approximately 1.5 mm. Hg., since:

$$L = \frac{4.5 \times 10^{-3}}{p} \quad \therefore \quad p = \frac{4.5 \times 10^{-3}}{3 \times 10^{-3}}$$

$$= 1.5 \text{ mm. Hg.} \quad (13)$$

where L = mean free path.

Fig. 6 shows the calibration curve of a typical thermocouple gauge that has been described by Dunlap and Trump.[28] It will be seen that between the limits of 1 mm. and 10^{-3} mm. Hg. the sensitivity will vary considerably with both increase and decrease of pressure. At pressures greater than 1 mm. Hg. the sensitivity of this gauge will be almost independent of pressure, and at pressures of less than 10^{-4} mm. Hg. when the heat carried away by the gas molecules is a small fraction of the heat radiated, the sensitivity will also remain practically unchanged. This agrees quite well with the theory that has been discussed.

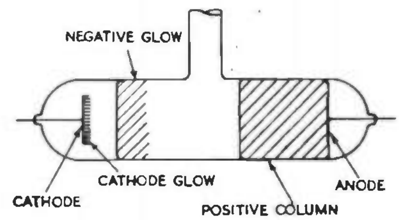


Fig. 11. Appearance of a glow discharge in a two-electrode discharge tube

Gauges Depending on the Phenomena of Ionization

The phenomena of ionization is a complex subject and within the scope of this article it is only possible to consider the main factors that apply to the gauges to be described.

The main factor we have to consider is ionization by electron collision. Thompson[5] has shown that provided the electron has sufficient energy ionization will take place. The probability of an electron ionizing a gas molecule has been studied by Compton and Van Voorhis[29] and Hughes and Klein.[30] Fig. 7 shows the results of their experiments with a two electrode discharge tube.

Gas Discharge Tube

Fig. 8 shows the construction of a simple two electrode discharge tube. If a tube of this construction is evacuated to a known pressure and the electrodes are connected to a source of high voltage which is variable, on increasing the voltage a point will be reached at which a discharge takes place between the electrodes. The value of this voltage is the break-down voltage and the luminous glow that occurs is due to excitation by electron collision. The value of the break-down voltage is dependent upon the nature and pressure of the gas as well as the chemical nature and geometry of the electrodes in the discharge tube. Fig. 9 shows the results of the investigations of Althenhum, Reger and Seeliger[31] and Fig. 10 those of Carr.[32]

The discharge that occurs when the break-down voltage has been exceeded has several well defined features which vary with the pressure. At a pressure of a few centimetres the discharge takes the form of thin streamers that pass between the cathode and anode. They will also be confined to the centre of the tube. With a further reduction of pressure the streamers gradually merge and expand until they reach the inside surface of the glass tube. At a pressure of less than 1 mm. the glow appears to break up and assume well defined features as shown in Fig. 11. The two spaces that separate the sections of the glow discharge are the Crookes and Faraday dark spaces. The Crookes dark space can be used to give an approximate indication of pressure as this will vary with the pressure. Two typical calibration curves are shown in Figs. 12 and 13.

Yarwood[33] has shown with the aid of coloured prints the discharge that takes place as the pressure is reduced, and he also illustrates the effect of various gases upon the colour of the discharge. Stintzing[34] has also investigated the discharge tube as a means of pressure indication.

(*To be continued*)

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Fig. 12. Length of Crookes dark space as a function of pressure in a simple discharge tube

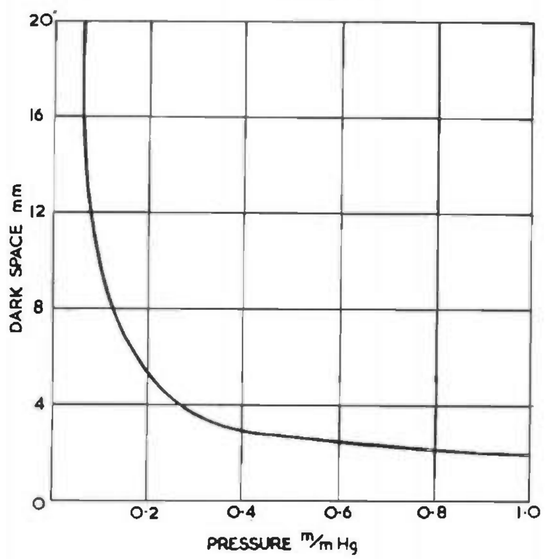
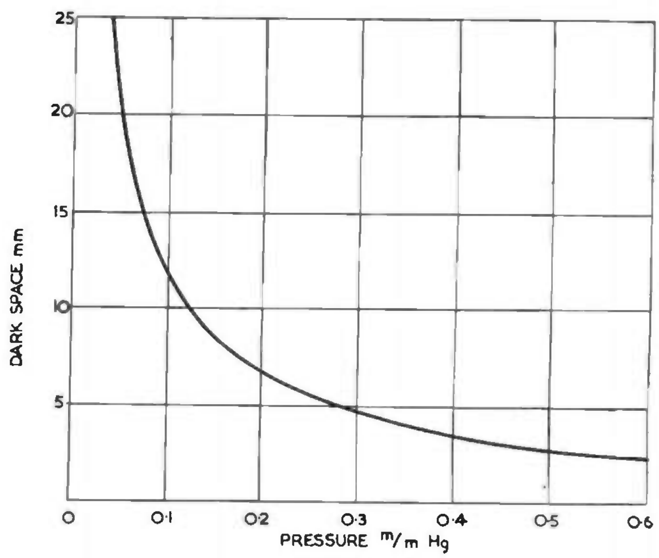


Fig. 13. Curve showing the effect of pressure on the length of the Crookes dark space



Letters to the Editor

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

The Influence of High Order Products on Non-Linear Distortion

Dear Sir,—Mr. D. E. L. Shorter in his article "The Influence of High Order Products on Non-linear Distortion" proposes to weight the distortion harmonics alternatively by factors unity, $n/2$ or $n^2/4$. This seems fundamentally incorrect since the sensitivity of the human ear drops away fairly rapidly for high-frequencies, and, in fact, Mr. Shorter points out the poor convergence of his data for the $n^2/4$ weighting.

When designing power supplies for G.P.O. equipment it is usual to weight the disturbing voltages according to the C.C.I.F. factors used by the G.P.O. for "psophometric measurements."

The figures still most commonly used were decided at Oslo in 1938 and a few are given below. (New figures were decided at Paris in 1947 but are not yet generally available.)

Frequency c/s.	200	500	800	1000	1500	2000
Factor	0.105	0.472	1.00	1.84	0.419	0.25

and are given in "The Circuit Noise Meter (Psophometer) and its Applications" by H. R. Harbottle, *J.I.E.E.*, Aug. 1938. The noise is really calculated to 800 cycles.

After the noise voltages have been weighted in this manner the R.M.S. sum is taken. Typical figures permitted are 2 mV of weighted (psophometric) ripple on a 50 volt automatic telephone exchange battery. Since the G.P.O. figures are based on the subjective effects on the combination of ear and telephone earpiece they are unlikely to apply exactly to a subject listening to a high quality loudspeaker. It would appear however that this type of weighting factor is more likely to accord with subjective measurements than the methods cited and it would be interesting to know what correlation appears in Mr. Shorter's experiments by using the psophometer factors.

Yours faithfully,

D. B. Corbyn

Chippenham, Wilts.

Mr. Shorter replies:

Dear Sir.—The use of some form of aural sensitivity weighting in distortion measurement has been considered but this approach has not so far proved very fruitful. Networks of the psophometer type are designed to weight the various components of a signal according to their contribution to the loudness or annoyance value rather than by their effect upon the quality.

The change in quality produced by removing high order harmonics too small in amplitude to affect the unweighted sum of the distortion products can be clearly heard for fundamental frequencies above 1000 c/s. If the unweighted total distortion figure shows no evidence of the change in this case, the introduction of a form of weighting which discriminates against the higher frequencies is surely a step in the wrong direction.

Let us assume, however, that an adequate form of "aural" weighting can be found for the distortion introduced when a single frequency is applied to a transmission system. Since the weighting for each distortion product will depend on the frequency and not on the order of the latter, the total figure arrived at will vary with the frequency of the tone with which the measurement is made. If therefore we wish to apply the results of our measurement to the distortion of a complex signal, such as the wave-form of music, we should presumably have to make tests at a number of frequencies within the range covered by the main signal components. Correlation of our results with a set of subjective judgements of the simple "good-or-bad" type, might then be possible, but only if we knew how to combine our data to give a single figure of merit.

The distortion figures given in my article were measured with a single fundamental frequency for each transmission system. From the foregoing it will be seen that the result of applying aural weighting to these figures would be meaningless.

Yours faithfully,

D. E. L. Shorter

Balham, London, S.W.12.

Photographing Sound Waves

Dear Sir.—I should like to suggest that your readers may have been puzzled by the article "Photographing Sound Waves" (October, 1950, p. 413), as I was until I looked up the original record; because they were not informed that a reference signal was injected at the microphone to produce the interference patterns photographed. As it stands, the article gives the impression that the system responds to instantaneous sound pressure!

Yours faithfully,

M. G. Scroggie.

Bromley, Kent.

Radiation ?

Dear Sir,—Mr. Scroggie's letter on "Radiation" is timely, for there is much confusion of thought in many directions: for instance, "Short Wave Therapy," in which the actual radiation plays no part, being a mere by-product, and a nuisance to communications! I think it was in *The Wireless Engineer*, many years ago, that a similar note appeared, but the distance from the source where the induction fields gave place to true radiation was given (I feel sure as $\lambda\frac{1}{4}$4). However, the principle remains. I have been interested in this matter for a very long time, not only in connexion with therapy, but for its relation to dowsing and the homing of pigeons; but so far I have not been able to induce anybody with the necessary equipment and appreciation of the physics to carry out the necessary observations to confirm my contention that there is, indeed, a link.

Again a long time ago, it was reported that the operator of an experimental (radio) transmitter in Germany, whose duty consisted in sending a long dash at stated intervals, was looking out of the window when he noticed a group of people not far away behaving in rather a strange way: whenever he sent his dash there would be a buzz of excitement, then, as the transmitter went quiet, things would settle down to normal again. He found out in due time that the group was watching a demonstration of dowsing, and that the dowser would lose his sensitivity at odd times, and unaccountably. When they got together they decided that it was something to do with the wireless transmitter, but I do not remember that anything was said about the distance from the aerial at which the influence acted. I recalled this incident when I became interested in water divining some years later, and have always thought that, if a test were made, the dowser would feel no effects outside the induction field. If this can be followed up some day it may give a clue to this mystery surrounding the business of dowsing, which has been ascribed vaguely to "electricity" or sometimes "magnetism" by people without a scientific background; while those who do know something of science are usually so sceptical about dowsing that they refuse to attend a demonstration.

From laymen's reports, too, it seems certain that homing pigeons, released "near" a wireless transmitter in action, are confused, and either flutter aimlessly around before landing again, or sweep in wider and wider circles and eventually pick up their course—I suggest outside the electro-magnetic induction fields.

Yours faithfully,

L. J. Voss.

Plymouth, Devon.

Mr. Scroggie replies:

Dear Sir,—Having no direct knowledge of dowsing or pigeon homing, I am not qualified to comment on Mr. Voss's suggestions; but to exclude any impression that at a certain range the induction field is replaced by the radiation field I would emphasize that both fields exist at all ranges. Owing to the more rapid attenuation of the induction field it is weaker than the radiation field at long ranges, though stronger close to the source. Although this general statement is true for all sources, the exact rate of fall-off depends on the shape and size of the source, which accounts for apparent discrepancies in some of the statements that have been published.

Yours faithfully,

M. G. Scroggie, B.Sc., M.I.E.E.

Bromley, Kent.

ELECTRONIC EQUIPMENT

A selection of the more interesting apparatus, components and accessories compiled from information supplied by the manufacturers

Plessey Dual Diversity Receiving Terminal, Type PR.52

(Illustrated above)

DESIGNED by The Plessey Company Limited, Ilford, Essex, to International Aeradio Specification, the Dual Diversity Receiving Terminal, Type PR. 52, provides for space or frequency diversity radio/telephony reception in the H.F. frequency band 2-20 Mc/s. Primarily designed for ground/air communication, it is also suitable for installations where consistent reception over long-range H.F. circuits is essential. Once set up on the required frequency, no further adjustments are necessary.

The complete equipment comprises two identical H.F. receivers, an electronic switching unit—each with an integral power supply—and a local loudspeaker unit. All units may be mounted in a standard 19-inch rack.

The superheterodyne receivers cover the operating band in four ranges by plug-in tuning units which incorporate their own calibrated tuning dials. They are designed basically for crystal-controlled operation, the crystal oscillator operating on its fundamental over the entire range. For frequency diversity reception each receiver functions as a crystal-controlled unit on the frequency selected. When it is desired to operate a space diversity system both receivers are controlled by a common R.F. oscillator. The R.F. oscillator in either receiver may be selected for this purpose by a switch mounted next to the oscillator coil in each. This switch also provides a change over from crystal control to manual tuning.

The audio output from each receiver is fed into the electronic switching unit via a gating circuit which is controlled by an electronic switch. This switch is in turn controlled by amplified A.G.C. voltages received from the two receivers, and ensures that the strongest incoming R.F. signal is selected at all times. The audio component of this signal is thus passed through the gating circuit and the succeeding A.F. stages to the loudspeaker.

With the exception of the loudspeaker unit, all units have a hinged front cover providing ready access to valves, plug-in tuning units, etc. These latter have staggered pin arrangements, making it virtually impossible to plug the unit into a wrong position.

The Plessey Co. Ltd.,
Ilford, Essex.

"Spearette" Components

(Illustrated below)

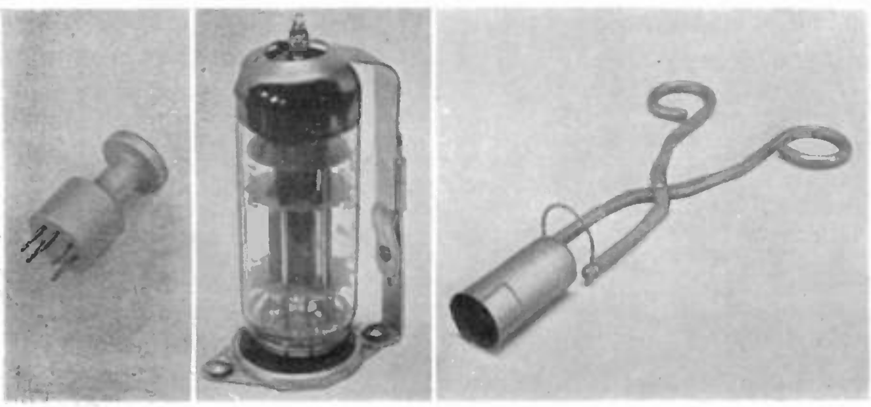
TO the "Spearette" range of components has been made three useful additions, illustrated below. Reading from left to right, they are: a Type "M" valveholder wiring jig; a miniature valve retainer clip, and a miniature valve screen can extracting tool.

The Type "M" Valveholder Wiring Jig is made to the same tolerances as the standard "Spearette" jig, and is intended to provide the radio manufacturer with a serviceable and cheap jig when use in quantity is desired. The body, which is of duralumin, is light and easy to handle, the pins being of steel, hardened and tempered.

The Miniature Valve Retainer Clip consists of two small pressings which slide telescopically on to each other, thus covering various valve lengths. One member is attached permanently to the valve holder when this is assembled to the chassis. The top, or cap member, slides completely off the fixed member when the necessity to remove the valve from its holder is desired. The design of the clip enables valves to dissipate the heat generated during the functioning.

The Miniature Valve Screen Can Extracting Tool enables screen cans to be extracted from valves more easily, and it is fitted with an exclusive swivelling reversible link. The can to be removed is gripped by a piece of flexible cable which tightens by the scissor action of the tongs.

Spear Engineering Co. Ltd.,
Warlingham,
Surrey.



Amplivox Model 70 Portable Audiometer for Schools, Industry, etc.

(Illustrated above)

THE early discovery of hearing impairment by routine audiometric tests of schoolchildren and industrial workers, claiming increasing attention all over the world. Considerable experience has already been gained with various methods of test and types of equipment, and this has shown that individual sweep check testing by a pure tone audiometer is by far the most suitable method.

To meet this specific need Amplivox have produced the Model 70 portable audiometer, a simply operated and accurate instrument, providing for air conduction testing at eight pure tones, with frequencies from 125 to 8,000 cycles per second, and with a maximum intensity range of 100 decibels in 5 decibel steps. There is a single zero reference, so that the same figures are read on the hearing loss scale for all frequencies. This permits of testing by the rapid sweep check method in which the hearing loss dial is set at 15 or 20 decibels and the desired frequencies checked in rapid succession, in order to screen out any child unable to hear each at the selected intensity above the normal threshold of hearing.

The instrument utilizes a cathode coupled Hartley oscillator with iron-cored coils tapped for the various frequencies. The output of this highly stable oscillator is fed via a bank of equalizing resistors to a wide range attenuator which is divided into two sections, a high impedance section operating in the grid circuit of the output valve and a low impedance section following the output transformer.

The attenuator is designed and manufactured to ensure freedom from "residual" errors over its very wide range of attenuation and to ensure freedom from the introduction of spurious noises throughout its life and with a minimum of service attention.

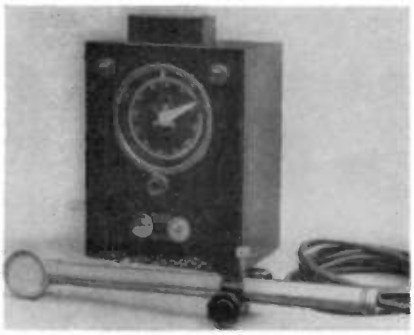
The test tone is introduced and interrupted via a special tone interruptor switching circuit which permits rapid build-up and decay without "overshoot" or frequency modulation.

The instruments are individually equalized in course of manufacture to compensate for variations in the circuit elements and in the moving coil earphone. The final calibration is carried out by an acoustical measurement of the sound pressure developed by the earphone into a carefully standardized artificial ear.

The calibration of the audiometer is extremely accurate, all tolerances being within the published requirements of both the British Medical Research Council and the American Medical Association. A voltage regulator is incorporated which automatically compensates for mains voltage variation.

The instrument operates on either A.C. or D.C. mains from 100 to 250 volts, and weighs only 14 lbs.

Amplivox, Ltd.,
2, Bentinck Street,
London, W.1.



Integrating Light Counter

(Illustrated above)

THE Baldwin Light-Counter is an integrating meter, and measures quantity of light radiation. A reduction in light intensity thus increases the length of time needed for a given photo-chemical effect, and an increase in intensity shortens the time. The meter compensates for variations in intensity and accurately repeats exposures with constant photo-chemical effects.

The apparatus consists essentially of a vacuum photo-cell which generates a photo-electric current strictly proportional to the light intensity falling upon it. The photo-current charges a capacitor connected in parallel with a special impulse valve. When the potential across the capacitor reaches a certain value, the impulse valve conducts, thus discharging the capacitor. The resulting impulse is amplified to operate a mechanical counting mechanism. Each impulse corresponds to a fixed number of foot-candle-seconds and moves the indicating pointer of the counter one step.

The counter unit, which is usually fixed to the wall, is started by pressing a button. Terminals are provided for a remote push-button, which may be located near the photographic equipment. Pressing either button switches on the light source and sets the counting mechanism in motion.

The counting dial on the front panel of the instrument is set to the required light quantity. An indicating pointer moves on the dial from zero towards the preset limit as the exposure proceeds. If the exposure is interrupted due to failure of the arc or the power supply, this point gives a clear indication of the exposure already given. Terminals are provided for a "cancel" switch to restore the pointer to zero.

The voltage ranges are 100-120 V and 200-250 V, 40-60 c/s. An invertor for D.C. supply is available.

Baldwin Instrument Co Ltd.,
Dartford,
Kent.

S.E.M. 2-speed Gramophone Motor

WITH the recent offer to the public of long playing 33 1/3 R.P.M. microgroove records, Small Electric Motors Limited offer to the radio and associated industries the S.E.M. 2-speed gramophone motor operating at 78 and 33 1/3 R.P.M.

The two speeds are selected by means of finger-tip control and the complete gramophone motor assembly, which is of the rim-drive type, is compact and suitable for mounting direct on to a metal or wooden baseboard.

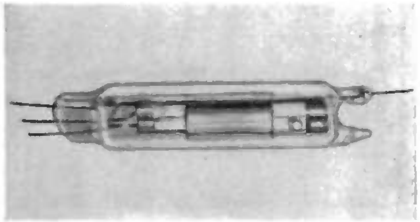
Although at the moment the standard unit is for use on A.C. mains only, 50 cycles, an equivalent 60-cycle unit can be offered for the export market.

Small Electric Motors Ltd.,
Eagle Works,
Churchfields Road,
Beckenham, Kent.

Sub-Miniature Electrometer Triode

INFORMATION is received from The General Electric Co. Ltd. of the introduction of a new sub-miniature electrometer triode, known as the Osram ET3.

Because of its small physical size, stability and low inter-electrode capacitance, this electrometer valve is in many cases better than the older types of elec-



trometer and the new valve is particularly good with regard to stability capacitance, which is only 1.3 pF between the control grid and the outer electrodes. Filament heating is 0.025 amp. at 1.25 volt.

The uses of electrometer valves for ionization measurements, and in connexion with piezo and photo-electricity, etc., make a high grid insulation very important and the ET3 has an insulation resistance of not less than 10^{14} ohms.

The General Electric Co., Ltd.,
Osram Valve and Electronics Dept.,
Magnet House,
Kingsway, London, W.C.2.

pH Meter, Type 1900

(Illustrated below)

DAWE'S new *p*H Meter, Type 1900, combines high stability and great accuracy. The stability is such that the accuracy is unaffected by fluctuations in the mains voltage between 200 and 250 volts, claim the makers.

It is directly calibrated in *p*H units over two ranges of 0—8 and 7—14, and subsidiary millivolt ranges of 0—800 and 700—1,500. The *p*H accuracy has a discrimination of better than 0.025 *p*H and millivolt discrimination of better than 2.5 mV.

A calibrated control enables the meter to be set up to read *p*H values of solutions at any temperature from 10-40° C. The instrument may be used with most types of electrode assemblies, but the dip-type glass electrode is supplied as standard. A special glass electrode is recommended for use about *p*H9.

The power supplied is 200-250 volts A.C., and consumption approximately 12 watts.

Dawe Instruments Ltd.,
130, Uxbridge Road,
Hanwell,
London, W.7.

BOOK REVIEWS

Elements of Sound Recording

By John C. Frayne, Ph.D., and Halley Wolfe, Ph.D. 686 pp. 1st. Edition. John Wiley and Sons, Inc., New York and Chapman and Hall, Ltd., London. 1949. Price 68s.

THIS book fulfils a genuine need for a comprehensive reference book on sound recording. The outgrowth of a group of courses given by the authors at the University of California, at Los Angeles, in connexion with the war training programme of the Government of the U.S.A., it covers in detail those subjects which belong peculiarly to the restricted field of sound recording and reproducing and which are not discussed in books devoted to the allied fields of electronics and mechanical engineering. The book is clearly printed and of admirable format and there are some 480 illustrations—most of them first class.

Complex mathematical analysis is limited to those subjects in which it is desirable for a basic understanding of the point under discussion and in many cases numerical examples are used to illustrate the use of design formulae. Each chapter is concluded with a bibliography and to the earnest student this is one of the most valuable features.

The opening chapter, on sound, though good as far as it goes, is barely adequate for a book of this pretention. One would have expected rather more than 14 pages out of 674 to be devoted to this basic subject. The chapter ends with an interesting reference to the effect of loudness on frequency characteristics and the authors make the important point—not perhaps widely realized—that voice spectra depend on the effort put into speaking.

The next chapter deals fairly comprehensively with electro-mechanical analogies—though the authors confine themselves to the popular impedance concept and eschew the rather more esoteric admittance concept beloved of Olsen.

It is a pity that the authors, in the chapter on filters, have persisted with the old practice of giving the full section component values when the formulae for the half-section values are much more uniform and consequently more easily remembered.

In Chapter 13 effective use is again made of electro-mechanical analogies to show the working of disk cutter and reproducing heads but there is no mention of the special problems involved in cutter-head mounting or of the various methods of obtaining variable groove speed. It is regrettable too that there is no explanation of the change in frequency response with groove speed—a phenomenon which is casually mentioned on page 256—and that no details are given of the many interesting ways of providing what the authors term "diameter equalization," but which, in this country, is generally called "automatic radius compensation." Some of the illustrations too are a little disappointing—it is difficult, for instance, to sort out Figs. 13-4, 13-7 and 13-10.

The authors have admirably treated the highly complicated photographic methods involved. There are numerous illustrations—mostly unusually clear—and the text reveals a full understanding of the many problems encountered.

In so detailed a treatment it is a little surprising to find no description of the Philips-Miller system of variable-area film recording—a mechanical process that—for broadcasting purposes at any rate—possesses some advantages over the photographic methods. On page 367, Fig. 19-8b—*Curves of harmonic distortion versus amplitude of modulation for the R.C.A. magnetic galvanometer*—does not agree with the text on the previous page.

Chapter 29, on magnetic recording, is not as satisfying as most of the other chapters. The section on self-demagnetization, on page 578, for example, is a poor one. In dealing with the high-frequency bias method of magnetic recording the explanation given is, by acknowledgment, borrowed from a paper by W. W. Wetzel which appeared in *Audio Engineering* in December 1947, but Wetzel's paper has been so abridged here that the text is sometimes difficult to follow. Moreover there are in the literature certain other hypotheses which may proved to be more nearly correct. By a printer's error on page 594 the cut-off frequency, f_0, is given equal to x/v (where x is the width of the air gap and v is the velocity of the medium), whereas of course $f_0 = v/x$ (where x is the *effective* width of the gap).

In the final chapter a good description is given of the Fantasound and Compandor systems. Here is a field full of possibilities for the future and the authors are right when they claim that "our present concept of single channel quality will need severe revision when applied to the stereophonic medium."

To sum up, this book will be of considerable interest and value to all those in the recording field whether they are engaged on design, maintenance or purely operational work. Although it is of special value to those in the film industry, it should still be read by everyone interested in the complexities of sound recording.

P. J. Guy

Industrial Electronics and Control

By R. G. Kloeffler. Pp. 478. John Wiley & Sons, Inc., New York. Chapman & Hall, Ltd., London. Price 33s. 1949.

THE author, with very commendable courage, has attempted the well nigh impossible task of trying to cover adequately the theory and practice of electronics between the covers of one book. This problem is made all the more difficult by the fact that there is no agreement, and possibly never will be, as to where the subject starts and where it finishes. Let it be said, therefore, that the author has probably made as good a job of it as any author is likely to.

The book sets out to give engineering students a survey of the applications of electronics. This object it can be said to accomplish with more credit than many similar treatises.

The first five chapters, which deal with electron emission and conduction through gases, are included for students who have no previous basic training in the theory of electron tubes. Thereafter, the subjects of photoelectricity, rectification, inversion, high frequency heating, welding, precipitation, and practical applications of these subjects are dealt with in easily understandable style. Nevertheless, there are some shortcomings. The cathode ray tube is dismissed in just over two pages. The caesium-antimony emission type photocell which has been in commercial production for about ten years is not mentioned at all; nor is there any reference to the important subject of radioactivity and the industrial uses of isotopes.

The line drawings, which are presumably the author's work, are very clear and instructive but some of the half tones are less satisfactory. It is a pity that the section on electron tubes is interspersed with pages so obviously taken from manufacturers' catalogues. The idea of following each chapter with a series of questions is an excellent one, but it is of little value to the self instructed student unless he can find somewhere the answers to those which require numerical solution. On the whole, a well produced treatise; better than the average of its class.

R. C. WALKER

The Electronic Photographic Speedlamp

By John Harrison. 1st Edition. 62 pp. 23 figs. Bernards (Publishers), Ltd., London, 1950. Price 3s. 6d.

THIS is a useful little book for those who have sufficient fundamental knowledge and skill to build their own Electronic Flash Outfit. The honesty and frankness with which the book is written is refreshing. Not even the expense at which an Electronic Flash Equipment could be constructed at home is under-estimated. The description of the subject is clear, the diagrams are easily understandable, and the matter is dealt with in logical sequence. Warning is also given in the appropriate place that an Electronic Flash Equipment can spell danger if not treated with the necessary care.

The reviewer has his doubts as to whether the majority of photographers would be capable of constructing their own Electronic Flash Equipment, even if they had the time to do so. However, he recommends this little book to all those who are already using electronic flash and desire to acquire a fuller understanding of its operational characteristics, especially as at present there is no other British guidebook giving such a wealth of information with regard to the electronic working method. Getting familiar with the tool one is using nearly every day must lead to a better understanding of its scope and its limitations, resulting finally in producing a better job.

Those readers who are fully conversant with radio terms and corresponding circuit diagrams will very much appreciate this little book. It is regrettable, however, that the author did not provide a complete list of all manufacturers supplying the various components required to make an Electronic Flash Equipment. Surely there is more than one maker of Electronic Flash Tubes, Vibrators and other parts. The good intention of trying to give a complete survey has, unfortunately, not been carried through in the case of listing the available sources of supply.

H. K. PAUL

Television for Radiomen

By Edward M. Noll. McMillan, New York, 1949. 595 pp., 365 figs., including many complete receiver circuits. Price 52s. 6d.

THIS book is described on the jacket as "A complete, thorough, and up-to-date study of television for radio servicemen, practical electronic technicians in either plant or field work, the radio amateur and experimenter, and the technical school student."

The book is as up-to-date as is possible in such a rapidly changing field. It is also sufficiently complete for the purposes of an American service engineer, though it concerns itself only with the U.S.A. standards so that it will be considered far from complete in this country.

The author starts with a preliminary outline of television, and goes on to deal in turn with R.F. and I.F. systems, video amplifiers, picture tubes, synchronizing, scanning F.M. sound, and projection systems. He then treats those problems most interesting to the service man, such as aerials, installation problems, alignment, and trouble-shooting. Finally there is a chapter on mathematics.

One gets the impression that the author is in close touch with American television practice and has taken great pains to include every worth-while development in his book. On the other hand the explanations given in some cases are so shallow, or even wrong, that one's faith is a little shaken. As an example, on pages 247 and 248 nearly a page is devoted to an attempt at explaining a phenomenon which cannot possibly occur. One is not surprised when the explanation proves difficult to follow!

Even genuine phenomena are not always explained as clearly as they could be. In an attempt to make use of already familiar ground the author tries to explain transient phenomena in terms of frequency concepts, and thereby makes the work far more difficult. To make matters worse his style is loose and inaccurate, for example the terms "integrated" and "differentiated" are given many different meanings. On p. 263 line 9 "integrated" is used to describe the folding over of a sawtooth current waveform due to operating

BOOK REVIEWS (Continued)

a valve in the "knee" of its I_a V_a characteristic, whereas true integration of a sawtooth wave produces a parabola, which has the opposite curvature.

Much more serious, however, are some of the misconceptions such as that on pp. 190 and 193: "The low order and high order harmonics are vested in the leading and trailing edges and flat top of the pulse" and "The leading edges of a pulse are made up of high frequency components." Now in fact all the components of a periodic waveform are present all the time and contribute to every part of the waveform; they merely happen to pass through zero together at the instants when the sharp fronts occur. The author apparently thinks that the h.f. components come along in bursts every time a sharp front arrives, and this leads to such statements as that on p. 255 line 16. "During the intervals that the high-frequency components of the deflection voltages are felt across the deflection circuit, the deflection system is resistive . . ." Of course it is resistive all the time. The argument proceeds in the same vein on p. 256 and a prospective purchaser would be well advised to read this page where he will find a *circuit* at one time deficient in high frequency components and at another deficient in low frequency components. If this page does not irritate him he will no doubt be able to enjoy the rest of the book, and will be rewarded, once circuit explanations are over, by the much more readable and informative sections on installation and servicing.

To sum up, the book is an excellent survey of current American television technique, being up-to-date and in close touch with industry. It includes a wealth of practical information, of special use to the serviceman, but its explanations of circuit operation are confused and often erroneous.

EMLYN JONES

The Acceleration of Particles to High Energies

58 pp. 24 figs. Institute of Physics, May 1950. Price 10s. 6d.

THIS book is based on a series of papers on accelerators, presented at the 1949 Convention of the Institute of Physics, and is the latest of the Physics in Industry series. As such, it is intended to be read by people who are interested in accelerators "in applied nucleonic research, in industry and in medicine." This statement of purpose, which would be read inside the cover by a casual "browser" in a bookshop, is a little misleading. The reviewer cannot help thinking that the book will be useful and interesting to many people who are not interested in these applications.

An excellent Foreword by M. L. E. Oliphant puts accelerators in their proper perspective, by stating succinctly the reasons for their existence and their consequences upon the thinking of physicists and engineers engaged in this field, and by pointing out that the influence of one branch of physical technique can be spread to related branches only by its being made accessible to all working in physics.

There are four articles, each devoted to a type of accelerator of considerable present and future importance. The first, by J. Rotblat, is devoted appropriately to the cyclotron, which is the best known and, so far, the most valuable accelerator for nuclear research. The bulk of this article is concerned with the conventional, fixed frequency cyclotron; the principles of operation and practical features and limitations of these, the "pre-war" machines are covered in some detail, in easily understood language. Conventional cyclotrons, though still valuable, are of diminishing importance in nuclear physics; the "frontier" must be probed by particles of higher energy than they can produce, and the lower energy work now often requires a precision more easily obtained with other accelerators. Higher energies are produced by the frequency-modulated cyclotron, and the development of this from its smaller predecessor is described and explained by Dr. Rotblat. Total acceleration voltages of nearly 400 million have been produced—compared with a maximum of about 20-30 million volts from conventional cyclotrons. Moreover the newer type, for reasons which are adequately presented, is, with proper engineering design, somewhat easier to operate.

Betatrons and synchrotrons are dealt with by F. K. Goward. While the cyclotron can accelerate only heavy particles such as protons and deuterons, these machines were developed for electron acceleration; a modification of the synchroton will almost certainly become a standard accelerator for very high energy protons beyond the economic range of the cyclotron. It is refreshing to see credit given for the pioneering work of Slepian, Breit and Tuve, Wideröe and Walton; this is not always done. Many people learning about accelerators for the first time are confused by the numerous types; the differences between cyclotrons, betatrons and synchrotrons are well brought out here. There is a discussion of the special difficulties of operating betatrons and synchrotons, concerned with particle injection and magnetic field distribution, followed diplomatically by a list of advantages. Here Mr. Goward is on shaky ground when he mentions proton energies of "perhaps 300 MeV upwards" as the reasonable domain of proton synchrotrons. The advantages of a frequency-modulated cyclotron are, with present techniques, overwhelming wherever the necessary money can be found to build one, and it is reasonably economical at energies up to about 500 MeV. The crossover region is probably nearer 1,000 MeV.

The third contribution is an article by E. S. Shire on electrostatic generators. Here one descends from the great energies produced by cyclotrons and synchrotrons into a more prosaic region of a few million volts. The standard accelerator is the Van de Graaff machine, and the design features are discussed with emphasis on the dominating problems of voltage breakdown, in the generator and the accelerator tube, and the ion source. This article is shorter than the first two, but leaves the reader with a good general impression and properly stresses the important advantages of excellent energy resolution.

A short survey of linear accelerators, also by E. S. Shire, follows. This machine is an excellent example of the dependence upon technology generally of instrumentation for research. Although originally intended before the cyclotron, suitable radiofrequency techniques became available only during the war, while the techniques required for development of the cyclotron were available when the first one was built. With the aid of radar techniques, the linear accelerator is now being developed rapidly, particularly for electrons, although a large proton model is in successful use. The various types are reviewed and contrasted.

The fifth and final section records discussion between people attending the convention; in particular, more information is given about the output of electron linear accelerators, and details of various applications of several machines are mentioned. Some of the discussion on betatrons and synchrotrons will be above the heads of many non-specialists in accelerator work; the same phenomenon is noticeable in Mr. Goward's article, which contains more technical detail than do the others.

All the articles carry good lists of references for those wishing to study the literature of accelerators, and there is a very complete index. The material in the articles is authoritative and up to date, and the book can be recommended to all those who are interested in the subject but who do not specialize in accelerator work. It is excellently printed and illustrated, and probably forms the most compact source of useful information on modern particle accelerators yet made available.

T. G. PICKAVANCE

Radio Handbook

By Editors and Engineers, Ltd. 12th Edition. 320 pp. Editors and Engineers, Ltd., 1300 Kenwood Road, Santa Barbara, California. 1949.

THIS edition of "The Radio Handbook" includes chapters on: single sideband and F.M. equipment, H.F. power amplifiers, mobile equipment and installation, speech and A.M. equipment, exciters and low power transmitters, and television and broadcast interference.

The 12th edition is a purely constructional one, and does not in any way supersede the 11th edition, and should prove interesting for the home constructor and experimenter.

Notes from the Industry

British Standard for Letter Symbols for Electronic Valves (B.S. 1409:1950). The revised edition of this standard contains some additional symbols and alterations rendering it more complete. It covers a suitable range of letter symbols which should be useful to valve manufacturers and in technical literature generally. These relate to different types of valves, their electrodes and other components as well as to the quantities used in valve technique.

Copies of this standard may be obtained from the British Standards Institution, Sales Department, 24 Victoria Street, London, S.W.1, price 2s. post free.

A.C.E.C. Revue. Owing to the general interest shown in *Ateliers de Constructions Electriques de Charleroi* it has been decided to publish this technical journal in English as well as French, the English edition appearing within three months of the French one.

British engineers already on the mailing list will, in future, receive the English edition, and in view of the wider scope made available by this translation, the A.C.E.C. office, at 59 Victoria Street, London, S.W.1, is ready to receive application from firms who may not have appreciated the French edition.

Royal Society Medallists. His Majesty the King has been graciously pleased to approve recommendations made by the Council of the Royal Society for the award of the two Royal Medals as follows:

To Sir Edward Appleton, G.B.E., K.C.B., F.R.S., for his work on the transmission of electromagnetic waves round the earth and for his investigations of the ionic state of the upper atmosphere.

To Dr. C. F. A. Pantin, F.R.S., for his contributions to the comparative physiology of the invertebrata, particularly his work on nerve conduction in crustacea and actinozoa.

The following awards of Medals have been made by the President and the Council of the Royal Society: the Copley Medal to Sir James Chadwick, F.R.S., for his outstanding work in nuclear physics and in the development of atomic energy, especially for his discovery of the neutron; the Rumford Medal to Air Commodore Sir Frank Whittle, K.B.E., C.B., F.R.S., for his pioneering contributions to the jet propulsion of aircraft; the Davy Medal to Sir John Simonsen, F.R.S., for his distinguished researches on the constitution of natural products; the Darwin Medal to Professor F. E. Fritsch, F.R.S., for his distinguished contributions to the study of algology; and the Hughes Medal to Professor M. Born, F.R.S., for his contributions to theoretical physics in general and to the development of quantum mechanics in particular.

Four Year Scholarship Scheme in Electronics. The fulfilment of important development work and other long term contracts by Electric and Musical Industries, Ltd., has raised a need for increasing numbers of highly trained electronic engineers in their research and design companies. To meet this growing need E.M.I. Institutes, Ltd., have devised a scholarship scheme for a special four years course in electronics.

Briefly, the scheme provides for a grant to each successful applicant of £50 per annum towards the fees of the course and in addition, in suitable cases, a maintenance grant of at least £50 per annum. In return, beneficiaries under the scheme are required to place their services at the disposal of the company for four years after the satisfactory completion of their course.

The course consists of three years full time study at E.M.I. Institutes—embracing the recognised examinations held by the City and Guilds of London Institute—together with a year's practical experience (coupled with further studies) in the factories and workshops of E.M.I. Engineering Development, Ltd. Candidates should be in the age group of 16-18 years, preferably of Higher School Certificate standard in Science.

Industrial Electronics Exhibition. The Institution of Electronics, Midlands Branch, will be holding their second annual exhibition of industrial electronics in the Midlands, in Birmingham from 1 to 6 January, 1951, inclusive. January 2, however, has been set aside for a private traders view. Free admission tickets for this day are obtainable on request from the Chairman, "The Orchard," Beech Road, Bournville, Birmingham 30. Further details can also be obtained from the above address.

Elliott's New Chairman. Sir Walter St. David Jenkins, C.B., C.B.E., who has been chairman of Elliott Brothers (London), Ltd., for many years, has felt it necessary to hand over the onerous duties connected with this post to a younger man.

The directors have pleasure in announcing that Captain R. E. F. de Trafford, O.B.E., has accepted the chairmanship.

B.B.C. Orders Microwave Television Equipment. The British Broadcasting Corporation have placed an order with Marconi's Wireless Telegraph Co., Ltd., for six sets of Microwave Television Links. The equipments are designed to work within the band 6,500 to 7,500 Mc/s. and use wide band Frequency Modulation. Intercommunication facilities are a feature of these links; a standard headset can be plugged in for telephonic communication by line or separate radio link with other units and to other mobile equipment, the studio, or the transmitter.

PUBLICATIONS RECEIVED

THE NICKEL BULLETIN Vol. 23, No. 8-9. This issue consists of short abstracts from recently published information dealing with nickel and nickel alloys. The Mond Nickel Co., Ltd., Sunderland House, Curzon Street, London, W.1.

PERTRIX CATALOGUE. The new edition of this gives full details of Pertrix radio accumulators and dry batteries for H.T., grid bias, torches, gaslighters, hearing aids and other appliances. Holsum Batteries, Ltd., 137, Victoria Street, London, S.W.1.

MONEL AND SOME OTHER HIGH-NICKEL ALLOYS VERSUS SULPHURIC ACID. The first part of this book discusses the effect of temperature, aeration, agitation and acid concentration on the corrosion-resistance of Monel, nickel, Noresist, Inconel and other nickel chromium alloys when attacked by straight sulphuric acid solution. The reports of these, and other tests, are also given. Henry Wiggin & Co., Ltd., Wiggin Street, Birmingham 16.

MANUFACTURES AND SUPPLIES—BOOKLET 477 is a catalogue of the products of W. T. Henley's Telegraph Works Co., Ltd., 95, Aldwych, London, W.C.2.

SOLEX AIR OPERATED GAUGES is a general catalogue of the measuring equipment supplied by Solex (Gauges), Ltd., Solex Works, 233/231 Marylebone Road, London, N.W.1., being at the same time the first of a series setting out to cover the description and utilization of gauges which this firm manufacture.

A "DIGEST" OF EDWARDS HIGH VACUUM EQUIPMENT is a form of condensed catalogue compiled to inform workers in research, industry and education of the many high vacuum products made by W. Edwards & Co., (London), Ltd., Worsley Bridge Road, Lower Sydenham, London, S.E.26.

BULLERS INSULATORS AND FITTINGS is a catalogue of their range of insulators, spindles, etc., covering the majority of patterns likely to be required in the field of telephone and telegraph operations. Bullers, Ltd., 6, Laurence Pountney Hill, London, E.C.4.

B. I. CALLENDER'S RADIO-FREQUENCY CABLES is an attractively produced and illustrated brochure, using some explanatory text and listing the various types manufactured by British Insulated Callender's Cables, Ltd., Norfolk House, Norfolk Street, London, W.C.2.

SINGLE PHASE MEDIUM CURRENT RECTIFIERS. This bulletin gives technical details of single-phase rectifier stacks in general use. Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2.

THE EXTRUSION OF UNPLASTICIZED POLYVINYL CHLORIDE is a reprint of an article by A. Burness, J. R. Cann and P. Ions, which appeared in "British Plastics." Imperial Chemical Industries, Ltd., Plastics Division, The Hall, Welwyn, Herts.

ELECTROENCEPHALOGRAPHY AND CLINICAL NEUROPHYSIOLOGY, VOLUME 1, 1950. This international journal contains a number of papers on different aspects of these subjects, and is the official organ of the International Federation of E. E. G. Societies. The E.E.G. Journal, 3801, University Street, Montreal 2, Canada.

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1950 INDEX

The 1950 Index, Volume 22, is still available. Copies may be obtained without charge and post free, on application to the Circulation Department of this Journal.

MEETINGS THIS MONTH

INSTITUTION OF ELECTRICAL ENGINEERS

All London Meetings, unless otherwise stated, are held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2.

Measurements Section

Date: January 30. Time: 5.30 p.m.
Symposium on: Electrical Meteorological Instruments. (Joint Meeting with the Radio Section and the Royal Meteorological Society.)

Radio Section

Date: January 10. Time: 5.30 p.m.
Lecture: The Use of Saturable Reactors as Discharge Devices for Pulse Generators.
By: W. S. Melville, B.Sc.(Eng.).
Date: January 22. Time: 5.30 p.m.
Discussion: How Reliable is a Radio Valve?
Opened by: G. H. Metson, M.C., Ph.D., M.Sc., B.Sc.(Eng.).
Date: January 30. Time: 5.30 p.m.
Symposium on: Electrical Meteorological Instruments. (Joint Meeting with the Measurements Section and the Royal Meteorological Society.)

District Meetings

Date: January 22. Time: 5.30 p.m.
Held at: Great Eastern Hotel, Reading, Berks.
Lecture: Trends of Development in Radiocommunication.
By: Professor Willis Jackson, D.Sc., D.Phil.

Cambridge Radio Group

Date: January 16. Time: 5.30 p.m.
Held at: The Cavendish Laboratory, Cambridge.
Lecture: The Use of Saturable Reactors as Discharge Devices for Pulse Generators.
By: W. S. Melville, B.Sc. (Eng.).

Mersey and North Wales Centre

Date: January 8. Time: 6.30 p.m.
Held at: The Liverpool Royal Institution, Colquitt Street, Liverpool.
Lecture: The Determination of Time and Frequency.
By: H. M. Smith, B.Sc.

North Eastern Radio and Measurements Group

Date: January 15. Time: 6.15 p.m.
Held at: King's College, Newcastle-on-Tyne.
Informal Lecture: The Operation and Maintenance of Television Outside-Broadcast Equipment.
By: T. H. Bridgewater.

North Midland Centre

Date: January 9. Time: 6.30 p.m.
Held at: British Electricity Authority, Yorks. Division, 1 Whitehall Road, Leeds.
Lecture: The Continental Development of Single-Anode Mercury-Arc-Rectifier Valves of High Power.
By: H. von Bertele, Dip.Ing., Dr.-Ing.

Northern Ireland Centre

Date: January 9. Time: 6.45 p.m.
Held at: Queen's University, Belfast.
Lecture: Fifty Years' Development in Telephone and Telegraph Transmission in Relation to the Work of Oliver Heaviside.
By: W. G. Radley, C.B.E., Ph.D.(Eng.).

South Midland Centre

Date: January 16. Time: 6 p.m.
Held at: The Town Hall, Birmingham.
Lecture: Faraday Lecture on Lamps and Lighting—A Record of Industrial Research.
By: L. J. Davies, M.A., B.Sc.

South Midland Radio Group

Date: January 29. Time: 6 p.m.
Held at: James Watt Memorial Institute, Great Charles Street, Birmingham.
Lecture: The Operation and Maintenance of Television Outside-Broadcast Equipment.
By: T. H. Bridgewater.

Western Centre

Date: January 8. Time: 6 p.m.
Held at: The Technical College, Bath.
Lecture: Oliver Heaviside.
By: Professor G. H. Rawcliffe, M.A., D.Sc.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Date: January 9. Time: 5 p.m.
Held at: Institution of Electrical Engineers, Savoy Place, W.C.2.
Lecture: Local Line Development—by an Area Planning Officer.
By: R. M. Richards.

Informal Meeting

Date: January 24. Time: 5 p.m.
Held at: The Conference Room, 4th Floor, Waterloo Bridge House, S.E.1.
Lecture: Eng. Service.
By: C. Feather.

INSTITUTE OF NAVIGATION

Date: January 19. Time: 5 p.m.
Held at: The Royal Geographical Society, 1 Kensington Gore, S.W.7.
Lecture: Submarine Navigation.
By: Lieut. Commander P. G. Satow, D.S.C., R.N.

RADIO SOCIETY OF GREAT BRITAIN

Date: January 26. Time: 6.30 p.m.
Held at: Institution of Electrical Engineers, Savoy Place, W.C.2.
Lecture: Equipment for the 420 Mc/s Band.
By: D. N. Corfield, D.L.C., A.M.I.E.E.

BRITISH SOUND RECORDING ASSOCIATION

Date: January 19. Time: 7 p.m.
Held at: Royal Society of Arts, John Adam Street, W.C.2.
Lecture: Design Requirements for Magnetic Recording Tape.
By: P. T. Hobson.

THE RADAR ASSOCIATION

Date: January 2. Time: 7.30 p.m.
Held at: The Albert Tavern, Victoria, London, S.W.1.
Monthly Meeting.

THE SOCIETY OF INSTRUMENT TECHNOLOGY

Midland Centre

Date: January 19. Time: 7 p.m.
Held at: The Arden Hotel, New Street, Birmingham.
Lecture: The Time Factor in Temperature Measurement.
By: E. W. R. Little, B.Sc., A.Inst.P.

London Meeting

Date: January 30. Time: 7 p.m.
Held at: Manson House, Portland Place, London, W.1.
Lecture: The Machining of Small Instrument Parts.
By: K. J. B. Wolfe and P. Spear.

BRITISH INSTITUTION OF RADIO ENGINEERS

Date: January 10. Time: 6.30 p.m.
Held at: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Symposium: Hearing Aids.
Chairman: J. R. Hughes, M.Brit.I.R.E.

North Western Section

Date: January 4. Time: 6.45 p.m.
Held at: The College of Technology, Manchester.
Lecture: Marine Radar.
By: G. W. L. Davis, Assoc.Brit.I.R.E.

North Eastern Section

Date: January 10. Time: 6.0 p.m.
Held at: Neville Hall, Westgate Road, Newcastle.
Lecture: Stages in the Development of a Small High Frequency Oscilloscope.
By: H. A. Dell, B.Sc., Ph.D.

Scottish Section

Date: January 11. Time: 6.45 p.m.
Held at: Institution of Engineers and Shipbuilders, Glasgow.
Lecture: Frequency Modulation and F. M. Measuring Equipment.
By: E. D. Hart, M.A., and A. G. Wray, M.A.

SECRETARIES OF ASSOCIATIONS

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

North-Eastern Radio and Measurements Group

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

North-Western Radio Group

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

South Midland Radio Group

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

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

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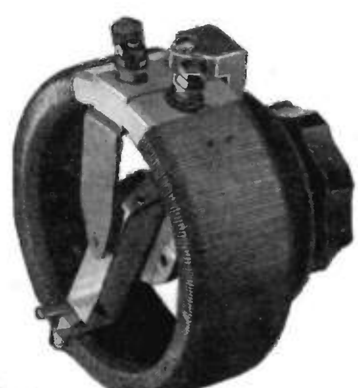

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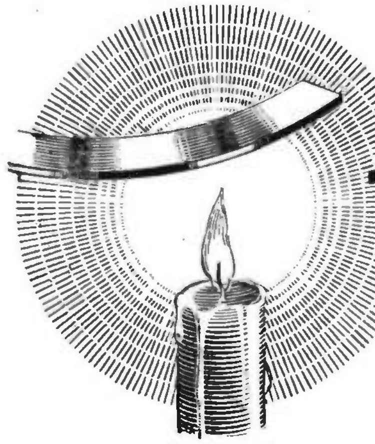

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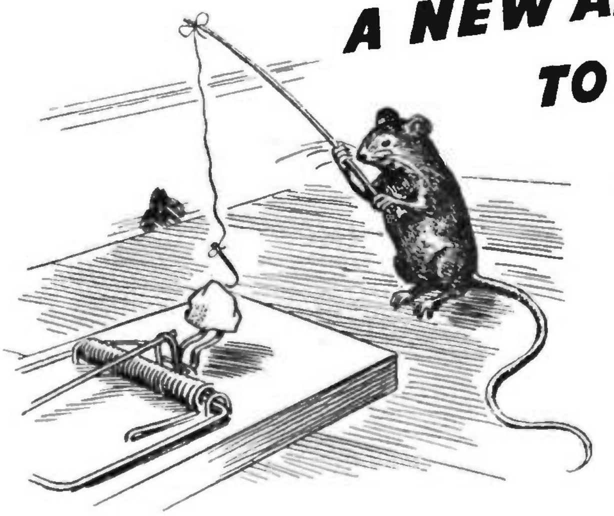

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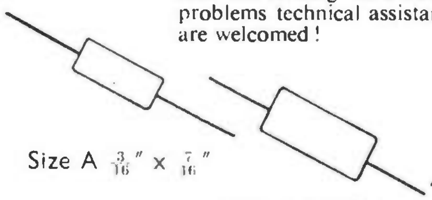

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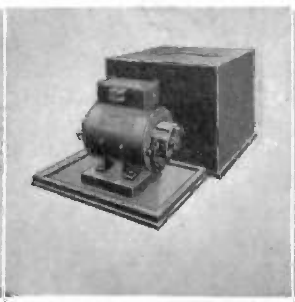

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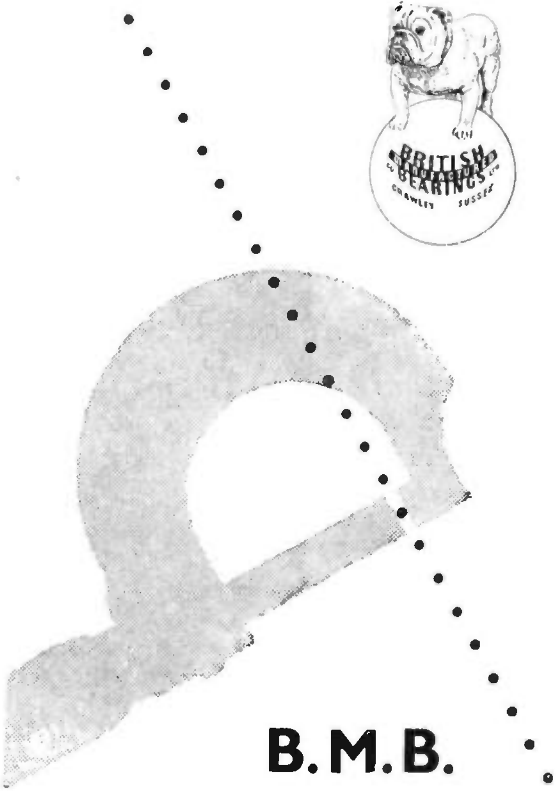

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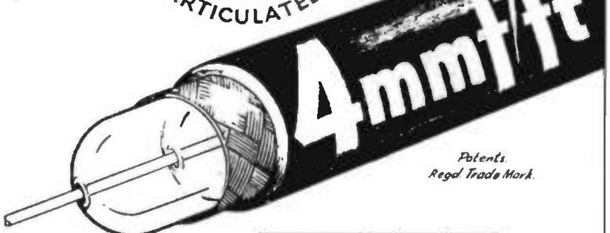

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C22	5.5	184	2.8	0.44
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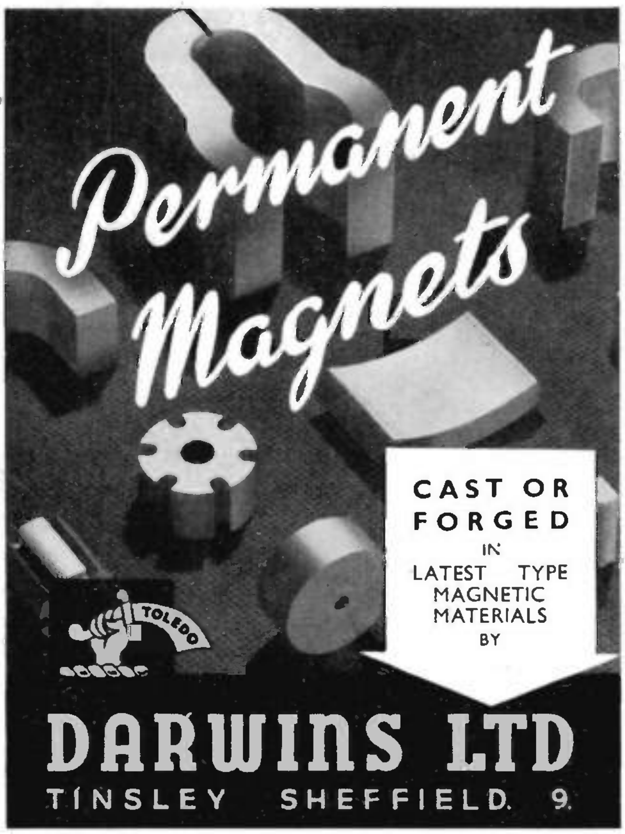

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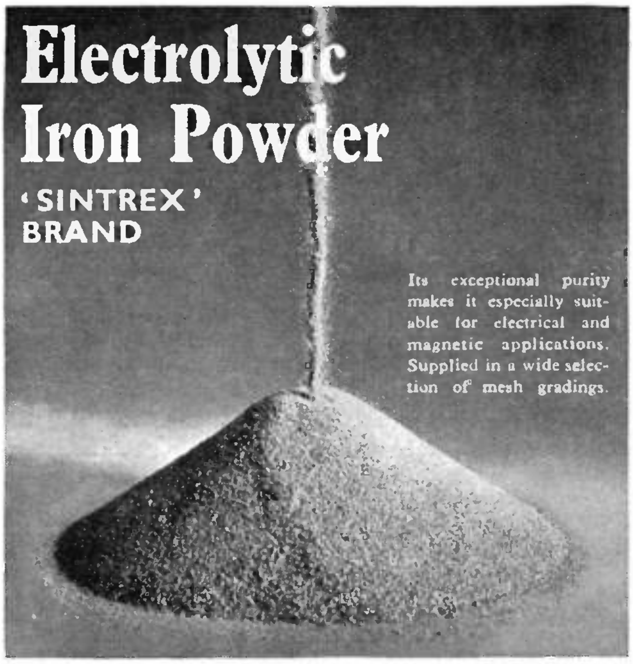

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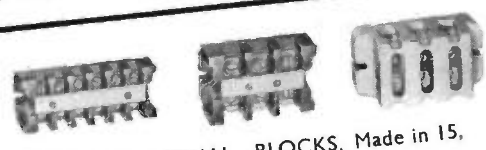

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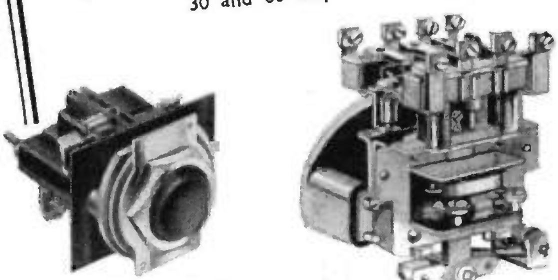

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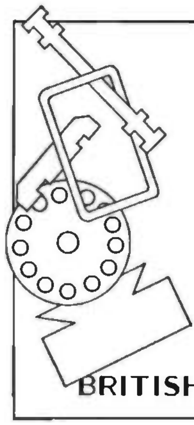

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