# Electronic Engineering

Incorporating . . . ELECTRONICS, TELEVISION & SHORT WAVE WORLD

VOL. 21 No. 251 JANUARY 1949 PRICE 2/-

# CLASSIFIED ANNOUNCEMENTS

**The charge for these advertisements is twelve words or less 5/- and 4d. for every additional word. Box number 2/- extra, except in the case of advertisements in "Situations Wanted" when it is added free of charge. 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 10th of the month for insertion in the following issue.**

## OFFICIAL APPOINTMENTS

*Vacancies advertised are restricted to persons or employments excepted from the provisions of the Control of Engagement Order, 1947.*

**THE ADMIRALTY INVITE APPLICATIONS** for appointment as temporary Draughtsman (Mechanical, Electrical, Electronic, Constructional), at Research and Development Establishments situated in various parts of England and Scotland (principally Southern England). Candidates must be British subjects and have served an engineering apprenticeship or had equivalent workshop experience. If 23 years of age or over, they must possess the Higher National Certificate (or equivalent); if under 23, they should possess the Ordinary National Certificate (or equivalent). Drawing office experience in the preparation of designs of components and complete projects desirable. Experience connected with experimental and development work will be additional advantage. Salary will be assessed on age and experience within the range of £283-£440, rising to £525 according to age, experience and location of employment. Appointments will be on temporary basis but with an opportunity, which it is expected will arise within twelve months, to compete for established appointment. Successful applicants will be liable to appointment to any of the establishments concerned. Applications should be sent to C.E.11 (Room 88), Empire Hotel, Admiralty Bath. Original testimonials should not be forwarded. Only candidates for interview will be advised.

**THE MEDICAL RESEARCH COUNCIL** have a vacancy for a Technician (Male) at their Unit for Research on Molecular Structure of Biological Systems at Cambridge, for the construction and maintenance of X-ray equipment. Candidates should be aged between 25 and 35, and must have had experience in electrical engineering and, if possible, vacuum technique. In addition, they should have taken the Higher National Certificate in Electrical Engineering or some equivalent qualification, and have some knowledge of workshop practice. The salary will be at a point on the scale £450 by £20-£530 per annum, according to qualifications and experience. The appointment would be subject to a six months' probationary period, and if this period were served satisfactorily, the member of the staff would be admitted to a contributory superannuation scheme. Annual and sick leave would be given at the same rate as for Civil Servants in analogous grades. Applications, in writing, giving name, age and address and full details of scholastic qualifications and subsequent career, and the name and address of at least one referee under whom the candidate has worked, should be sent to Dr. M. F. Perutz, Cavendish Laboratory, Cambridge.

**MINISTRY OF SUPPLY** invites applications for following unestablished posts at the Tropical Testing Establishment, Nigeria:—(1) Senior Scientific Officer, to lead a group of physicists and engineers studying effect of tropical conditions on Service materials and equipment. Candidates must have a good Honours Degree in Physics or Electrical Engineering, with experience of radio communications or of methods of physical and mechanical testing. (A.403/48A.) (2) Scientific Officer, to work in analytical or biochemical investigations into deterioration of equipment under tropical conditions. Candidates must have a good Honours Degree in Chemistry, with experience of micro-analysis or biochemistry. (F.429/48A.) Inclusive salary ranges (men only) are:—Senior Scientific Officer, £700-£900; Scientific Officer, £400-£650. Foreign service allowance varying from £200 to £680 also payable. Write, quoting the appropriate reference number, to Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, for application form, which must be returned completed by 10th January, 1949.

**B.B.C.** invites applications for a senior post in the Television Section of the Research Department at Kingswood, Surrey. Candidates must possess a University Honours Degree in Electrical Engineering or Physics, and must have a sound knowledge of telecommunications theory. They must also have a sound knowledge and practical experience of modern television. Knowledge and experience of the optical and colour problems involved in television, and of the workshop techniques involved in the construction of electrical and optical apparatus are very desirable. Experience of laboratory vacuum plant and a knowledge of photo-electricity are also desirable. The successful applicant will be expected to show initiative and take a leading part in Research work in television, especially that on high definition and colour. Such work will include the development of experimental monochrome and colour television apparatus, and of ancillary equipment. It will also involve the devising and carrying out of subjective and objective appraisal tests. Copies of any original papers should accompany applications for this post. The salary is in a grade rising by annual increments of £60 to a maximum of £1,360 per annum. Applications, stating age, qualifications and experience, should reach the Engineering Establishment Officer, Broadcasting House, London, W.1, within seven days of the appearance of this advertisement.

## SITUATIONS VACANT

**SENIOR DEVELOPMENT ENGINEERS** required. Must have good technical training, preferably with Honours Degree in Physics or Engineering and Radio Laboratory experience. Able to carry through development, with assistants, to production stage. Salary up to £800, according to qualifications. Apply, in writing, to Personnel Department, Murphy Radio, Ltd., Welwyn Garden City, Herts.

**LABORATORY ASSISTANT** required for the Association's electronics section, to be engaged mainly on construction of laboratory equipment. Must be able to work direct from circuit diagrams. Written applications, giving age, experience and salary required, to Motor Industry Research Association, Great West Road, Brentford, Middlesex.

**E.M.I. ENGINEERING DEVELOPMENT** offer outstanding opportunities for experience and advancement in development work in many branches of electronic engineering, including major radar projects, radio communication, television receivers, audio-frequency engineering, magnetic recording, etc. Applications will be welcomed from men with Engineering or Physics Degrees or the equivalent, with design experience. Starting salaries, £400 to £800, according to qualifications, experience and degree of responsibility. Also Juniors for the same work, with Inter.B.Sc. and preferably some practical experience. Send full details of experience and qualifications to Personnel Department, E.M.I. Ltd., Blyth Road, Hayes, Middx.

**PROGRESSIVE LAMP FACTORY** in Yorkshire manufacturing low-voltage electric lamp bulbs and employing about 350 women, require a highly efficient manager; must be very thoroughly experienced, highly qualified and good disciplinarian. Permanent and progressive post for right man. Applicants should state in detail, age, education, qualifications, references and salary required, to Box 398, E.E.

**APPLICATIONS** are invited by the Standard Telecommunication Laboratories Ltd., for the following posts:—(1) A Research Engineer or Physicist for design of specialised testing equipment for making measurements on dielectrics, magnetic materials, semi-conductors, rectifiers, crystals, etc. Mathematical analysis, electronic circuit design, constructed work and composition of reports is involved. (2) An Assistant Chemist for development and research work on materials and processes for telecommunication components. Work will be mainly of an experimental nature, involving both physico-chemical and organic operations. Candidates must have aptitude for the job, and should preferably be University Graduates with some practical experience. Applications should be made to the Personnel Manager, Standard Telecommunication Laboratories Ltd., Progress Way, Enfield, Middlesex.

**DRAUGHTSMAN.** Vacancy, London, for young draughtsman with general experience precision light mechanisms or instruments. Electronic knowledge an advantage but applicant with interest in design of electro-mechanical product preferred. Good practical and technical training. State age and full details experience and technical qualifications, also salary required. Box 416 E.E.

**YOUNG RADIO ENGINEER** required for assisting in amplifier production and servicing, now starting. Must have had practical experience. Salary according to qualifications and experience. Apply MANsion House 6744.

**VACANCY** occurs in Engineering Division of established company for young technician to assist with production and engineering problems. London area. Applicants should preferably be of Higher National standard in Electrical Engineering or Radio and have had sound practical training. Experience with test gear or similar work, including circuitry and ability to produce sketches an asset. Good prospects. Minimum commencing salary, from £350 per annum, depending upon experience and qualifications. State age and full details education, technical training and experience. Box 417, E.E.

**APPLICATIONS** are invited from Engineering and Physics Graduates and from designer-draughtsmen with a degree or equivalent qualifications, by the Research Laboratories of the General Electric Co. Ltd., East Lane, North Wembley, Middlesex, for work on telecommunications equipment. Experience of pulse and wave-form techniques an advantage. Apply to the Director, stating age, academic record and experience.

**SENIOR CHEMIST** for electronic research required for new chemical laboratory in Essex. Applicants must have B.Sc. in Chemistry and not less than seven years' research experience. A flat in the country will be available for the successful applicant. State full details to Box 419, E.E.

**RADIO TECHNICIANS** required at Ongar W/T Transmitting Station. Candidates should have had practical experience of operating high-power transmitting apparatus. Preference given residents North Weald and district. Apply, in writing, to Manager, W/T Station, Cable and Wireless Ltd., North Weald, Epping, Essex, giving qualifications and experience.

**LARGE WELL-KNOWN FIRM** in N.W. London has vacancies in its Engineering Department for several qualified Engineers. Applicants must have Degree or equivalent in Electrical Engineering and will be required to undertake design and development of light electro-magnet mechanisms and/or, small rotary A.C. machines. Applicants should be preferably under 30, have some natural ability for this type of work and state experience and qualifications in full and salary required. Box 408, E.E.

**EXPERIENCED** senior and junior radio, radar, television, electronic, acoustic engineers, preference B.Sc., H.N.C. Also similarly experienced draughtsmen. Other positions also available Technical Employment Agency, 179, Clapham Road, S.W.9. BRIxton 3487.

**YOUNG INSTRUMENT ENGINEER** for engineering laboratory of large N.W. London concern. Applicant would be required to test and develop small electrical instrument mechanisms of an experimental nature and should have ability to construct these mechanisms where necessary. Applicant should state experience in full, qualifications and salary required. Write Box 407, E.E.

**TECHNICAL REPRESENTATIVE** required. Must have sound electrical knowledge. Preferably some experience on aircraft electronic equipment, although not essential. Flying experience or previous association with aeronautical industry an advantage. Position involves a certain amount of travelling. Apply, with full details of age and experience, Box A.C. 35271. Samson Clark, 57-61, Mortimer Street, W.1.

**TECHNICAL INSTRUCTORS** required. Must have electronic experience, preferably in aviation, and be used to organising and conducting Instrument and Electronic Technical Courses. Write, with full details of age and experience, Box A.C. 32574, Samson Clarks, 57/61, Mortimer Street, W.1.

**ELECTRONIC ENGINEER** required with a Degree or equivalent technical qualification and design experience of centimetre wave transmitters, receivers and test equipment. A vacancy also exists for a general Electronic Circuit Engineer. Write, indicating salary required, etc., to Personnel Manager, The Sperry Gyroscope Co. Ltd., Great West Road, Brentford, Middlesex.

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## CLASSIFIED ANNOUNCEMENTS (Cont'd.)

**VACANCIES** exist in the research laboratories of a large electrical engineering firm in the North-East of England for Electrical Research Engineers and Physicists as under:—(1) An Electronic Engineer (B.Sc. or Hons. B.Sc.) with some research and general engineering experience. Experience of industrial applications of electrical techniques an advantage. (2) An Electrical Research Engineer (B.Sc. or Hons. B.Sc.) interested in high voltage engineering research. Some experience of electrical power plant, especially transformers, desirable. Preference given to a good mathematician. (3) An Electrical Research Engineer (B.Sc. Standard) for experimental work, mainly on magnetic measurements in connexion with electrical power plant. (4) A Research Engineer (B.Sc. or Hons. B.Sc.) possessing a sound theoretical and experimental chemical background to carry out experimental work on the development of insulating materials in connexion with electrical power plant. (5) Vacancies also occur for a few Assistant Electrical Research Engineers with Higher National Certificate or equivalent qualifications, for work in each of the above fields. Salaries according to age and qualifications. Write, Box 411, E.E.

**TECHNICAL ASSISTANT** required by S.W. London firm. Aged approximately 25, with B.Sc.(Eng.). Should have had some experience of electronic development work. Write, giving full details of age, experience, qualifications and salary required, to Box 635, c/o J. G. King & Son, 150, Fleet Street, London, E.C.4.

**CORRESPONDENCE CLERK** required by leading manufacturer of radio and electrical components. Essential qualifications are ability to handle voluminous and varied correspondence, rudimentary technical knowledge and similar recent experience. Write, stating age, experience and salary required, to Box 414, E.E.

**THE ADVERTISERS** under Box 342, in the issues dated October, November and December, wish to thank applicants and to advise that the vacancies have now been filled.

**LEADING COMPONENT MANUFACTURERS** require chief inspector possessing drive and initiative. Applicants must be sound technicians with qualifications at least equivalent to Inter-B.Sc., and with experience of modern testing technique. Duties would include dealing with government inspection departments. West London area. Write, stating experience and salary required, to Box 420, E.E.

**VACANCIES** for Draughtsman Designer (Mechanical) and junior Television Development Engineers. Write, Personnel Manager, Sobell Industries Ltd., Langley Park, Langley, Bucks, stating age, qualifications, experience and salary required.

**MAINTENANCE ENGINEERS** required by S.W. London firm. Successful applicants should have Higher National Certificate or equivalent and some experience in service and maintenance of electrical control equipment, with particular reference to programme controllers and general electrical furnace control equipment. Age 25-30. Write, giving details of age, qualifications, experience and salary required, to Box 634, c/o J. G. King & Son, 150, Fleet Street, London, E.C.4.

**RADIO OPERATOR MECHANIC** required for radio station situated fifteen miles north of London. Applicant should be able to receive Morse at 30/35 w.p.m., using typewriter, and possess good all-round technical knowledge, particularly communication receivers. Experience in teleprinter operation and maintenance an advantage. Shift duties. Salary according to qualifications. Write, stating experience, qualifications etc., to Box 410, E.E.

**PLANNING** and Estimating Engineer required for modern South Wales factory engaged in the manufacture of sound and electrical equipment. Applicants must be thoroughly conversant and have considerable experience in process planning and estimating. Knowledge of fractional H.P. meters an advantage. Write, in first instance, giving details of experience and positions held, to Box No. T., Smith's Library, Aberdare, S. Wales.

## SITUATIONS WANTED

**HONS. GRADUATE,** 28, wide experience high vacuum engineering, adaptable, seeks post in Southern England. Box No. 424, E.E.

**RADIO ENGINEER,** 22, desires post in London, or overseas, working on audio equipment. Five years' extensive experience of telecommunications and television—in civilian and government departments. Box 409, E.E.

**EX-SERVICE MAN,** Student of Physics (evening classes), hard and enthusiastic worker, linguist, desires apprenticeship in electronic industry or valve manufacture in London area. Box 423, E.E.

**TECHNICIAN,** age 27, married, three years as transmitter engineer in B.B.C., five years in R.A.F. as radio mechanic and operator/aircrew, industrial experience, seeks post as technician in research or development laboratory. Prospects more important than pay. Box 412, E.E.

**RADIO ENGINEER,** 23, studying City and Guilds, Brit.I.R.E. Studentship examinations. Secondary Grammar education. P.O. radio mechanic (Radar) in F.A.A., desires junior post, radio or allied. Home or overseas. Experienced in servicing all television receiving equipment. Box 413, E.E.

**RADIO ENGINEER,** 26, Grad. Brit.I.R.E., City and Guilds Final Certificate, seeks progressive post in industry. N.W. England preferred. Box 415, E.E.

**CONSULTING PHYSICAL CHEMIST,** own laboratory, high academic qualifications, offers services for Research and Development on Physical and Chemical problems, development of inventions, etc. Box 418, E.E.

**ADVERTISER.** Senior Engineer small electronics firm, seeks new responsible position in communications or radar. Ten years' experience receiver, transmitter and measuring instrument design. Component design. Familiar with mass production and services requirements. 2nd Class Hons., City and Guilds Radio Communications. Grad. I.E.E. Box 422, E.E.

**ELECTRONIC ENGINEER,** 30, good education, ten years' radio communication experience; research last six including industrial electronics, photographic oscillography, mechanical designing, technical writing, seeks post where inventive and organising ability required. Good references. Proof of original work. Box 421, E.E.

## EDUCATIONAL

**A.M.I.E.E., City and Guilds,** etc., on "NO PASS—NO FEE" terms. Over 95 per cent. successes. For full details of modern courses in all branches of Electrical Technology send for our 112-page handbook—FREE and post free. B.I.E.T. (Dept. 337B), 17, Stratford Place, London, W.1.

## SERVICE

**LOUDSPEAKER** repairs, British, American, any make, moderate prices.—Sinclair Speakers, 12, Pembroke Street, London, N.1.

**REWINDING.** A specialist winding service covering A.F. transformers, relays, solenoids, and to specification. S.T.S., Ltd., 297/299, High Street, Croydon, Surrey. Telephone: CROydon 4870.

**RADIO MANUFACTURERS** can undertake development and assembly of radio or electronic equipment. Winding shop with vacuum impregnation plant. Ample space and labour available. Box 316, E.E.

**COMPLETE** coil winding service. Rewinds, "Specials," Prototypes or quantity production. Layer, Wave and Progressive wave winding. Design and Development. Rynford Ltd., 17, Arwenack Street, Falmouth.

## MISCELLANEOUS

**WE WILL BUY** at your price used radios, amplifiers, converters, test meters, motors, pick-ups speakers, etc., radio and electrical accessories. Write, phone or call, University Radio Ltd., 22, Lisle Street London, W.C.2. GERrard 4447.

**PHOTOGRAPHY.** We specialise in advertising and catalogue-photography, and in series photographs for instruction sheets. Our pictures tell the story. Behr Photography, 44, Temple Fortune Lane, N.W.11 (SPEedwell 4298).

## PATENT

**IT IS DESIRED** to secure the full commercial development in the United Kingdom of British Patent No. 565,206 which relates to "Transmitting Pictures between Spaced Points" either by way of the grant of licences or otherwise on terms acceptable to the Patentee. Interested parties desiring copies of the patent specification and further particulars, should apply to Stevens, Langner, Parry & Rollinson, 5 to 9 Quality Court, Chancery Lane, London, W.C.2.

## FOR SALE

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

**IN STOCK.** Rectifiers, Accumulator Chargers, Rotary Converters, P.A. Amplifiers, Mikes, Mains Transformers, Speakers of most types, Test Meters, etc. Special Transformers quoted for.—University Radio, Ltd., 22, Lisle Street, London, W.C.2. GERrard 4447.

**COPPER WIRES:** enamelled, tinned, Litz, cotton, silk covered. All gauges. B.A. screws, nuts, washers, soldering tags, eyelets. Ebonite and laminated Bakelite panels, tubes. Paxolin coil formers. Tufnol rod. Permanent detectors, etc. List S.A.E. Trade supplied. Post Radio Supplies, 33, Bourne Gardens, London, E.4.

**BRAND NEW PHASE-CONTROL UNITS** Design "E." Input, 230V 50 cycles, containing transformer. Output, 250-0-250V, 75-0-75V, 4V at 3 amps, 4V at 1.5 amps., valves UU4 rectifier, thyratron GT1C, condensers, resistances, etc., in super metal cabinet and packed in wooden container, £3, carriage paid. Brand new ex-R.A.F. power units, containing 0-1mA MC meter, metal rectifier, 2 × 32 $\mu$F 600 VDC condensers, 2 × 300mA 20 Henry L.F. chokes, heavy duty mains transformer, input 230V 50 cycles, output 350-0-350V at 300mA, 2 × 6.3V, 5V, 20-0-20V 2×EF50, EA50, 5U4G condensers, resistances, thermal delay switches, fuses, etc., all in wooden packing case, bargain, £6 15s., carriage paid. Valves: GT1C, 10s.; EF50, 5s.; EF54, 7s. 6d.; EA50, 4s.; V1907 (5,000V rectifier), 7s.; 5U4G, 10s.; television condensers: 0.01-4,000 VDC, 0.03-2,500 VDC, 0.05-3,500 VDC, 1s. S.A.E. list, Cross, Skerries, Cross Lane, West Kirby, Cheshire.

**RADAR SETS,** type AN/APN4, 5 in. short persistence electrostatic C.R.T., suitable for oscilloscope or television, 25 valves, circuit diagram available, £7; 6SN7's, 6SJ7's, 6SL7's, tested, 6s. each. Stamp for details. Box 378, E.E.

**AIR POSITION INDICATORS.** Ex-R.A.F. An incredible bargain, containing a host of precision parts, approx. 40 gear wheels, 14 roller bearings, repeater motor rev. counters, etc. Ideal for experimenters, model constructors, 25s., carriage paid. Passingham (Dept. E.E.), North Street, Keighley.

**TELEVISION E.H.T. TRANSFORMERS** in stock: 5KV, 4V, 1.5A, rect. guaranteed. C.O.D. or C.W.O. at 3 gns. each, post 1s. 6d. R. F. Gilson Ltd., 11a, St. George's Road, Wimbledon, S.W.19.

**AUDIO FILTERS.** Field-free, Hi-Q, toroidal windings on Permalloy cores. Low-, high- or band-pass, scratch, whistle or cross-over filters to specification. Individual inductors supplied. Stock list. Lyncal Laboratories, 29, Camborne Road Morden, Surrey. LIBerty 3247

**SWITCH PLUGS,** best quality 5a 3p, 6s. each. Sapphire gramophone needles, 4s. 3d. each, plus 1s. 4d. Purchase Tax. Drive cord, spun glass, nylon covered, everlasting wear, 4s. 6d. dozen yards. Petter Radio and Electrical Supplies, 203, Forest Road, Walthamstow, E.17.

**AN IMPROVEMENT** in Signal Noise ratio for long-distance television reception can be effected by employing a SPENCER-WEST television pre-amplifier. List price, 10 gns. complete. Full particulars from Spencer-West, Quay Works, Great Yarmouth.

**TRANSFORMER LAMINATIONS.** Offers wanted for 480 gross 4a Sil. H 1,000 lb. each of 108 Sankey, stalloy and 188 nickel-iron. Jack Davis, 30, Percy Street, London, W.1. MUSeum 7960.

**MAGSLIPS** and Selsyns from 20s.; many types in stock, including resolvers, coincidence transmitters, B.T.H. and Admiralty type Selsyns for up to 45 lb. per inch torque. Send for list and technical literature. Also high torque motors (Rotax), A.C. D.C., 12-24 volts, 600 : 1 reduction drive, final torque 45 lb. per inch, reversible, and fitted with magnetic brake, 30s. Berco M10 linear potentiometers 10 watt wirewound 1,000 ohms, 4s. 9d; 50 K, 5s. All goods guaranteed and post free. Hopton Radio, 1, Hopton Parade, Streatham High Road, London, S.W.16. STReatham 6165.

**MAINS LOW.** If you are troubled on your production line soldering or on your test benches, by low mains volts, a Ferranti automatic voltage regulator will give you 7K.V.A. of steady 230V. Ideal for television receiver testing, lamp life tests, fluorescent installations, etc. Delivery ex-stock. Telephone TUDor 5277. BCM TESTGEAR, London, W.C.1.

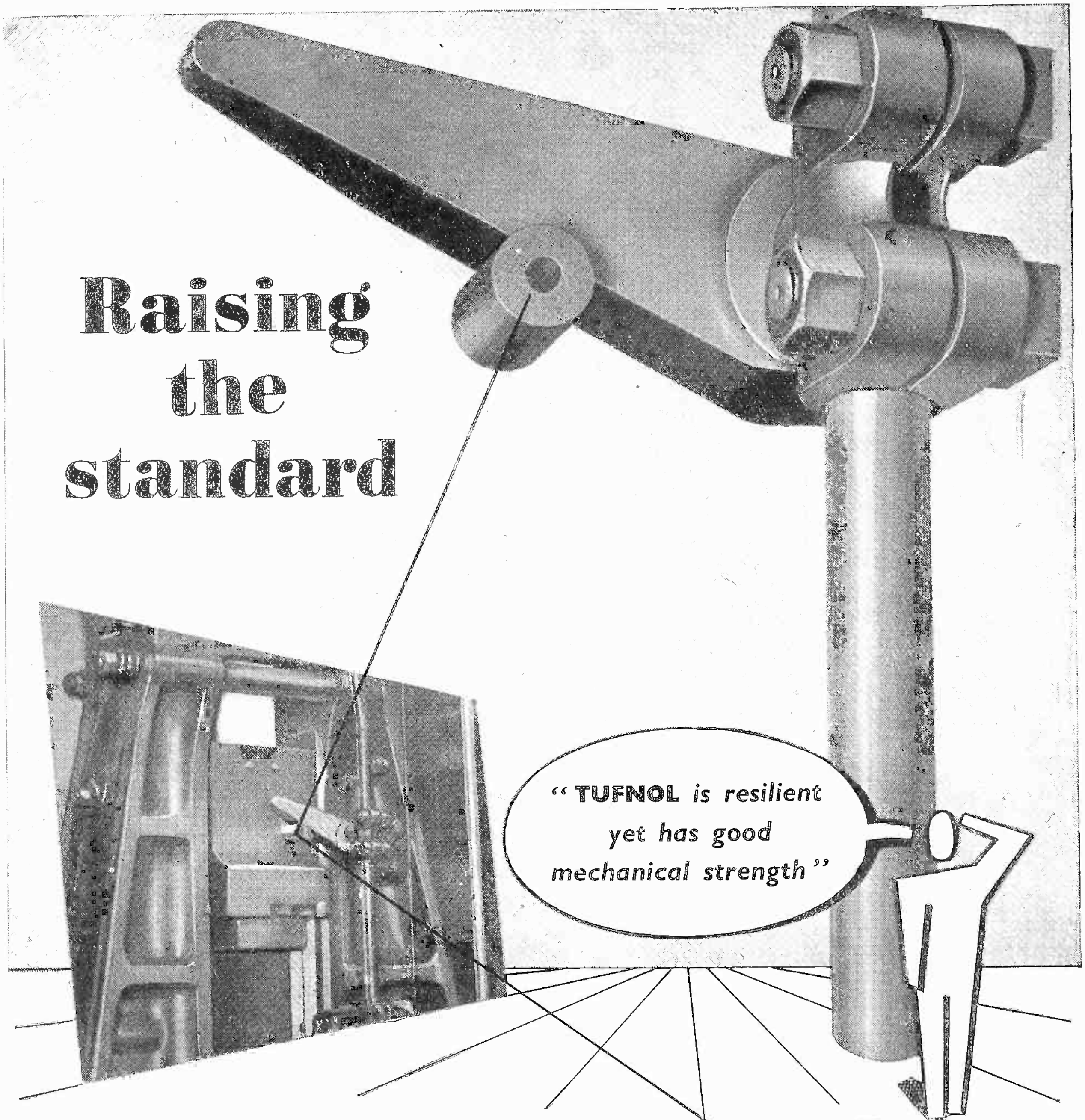
**SIGNAL GENERATORS** for television production testing. We have a large stock of high-grade signal generators by Marconi Instruments, Ferris, General Radio, etc., which are suitable for television receiver testing (both stations) and can also supply special modified types for production lines. Telephone: TUDor 5277. BCM TESTGEAR, London, W.C.1.

**SECOND-HAND AND SURPLUS TEST GEAR** is often a snare and a delusion, BUT—we specialize in high-grade laboratory and production testing instruments, and carry comprehensive stocks of signal generators, oscilloscopes, valve voltmeters, wave-meters, megohmmeters, impedance and inductance bridges, audio oscillators, etc. All our apparatus is reconditioned and checked or recalibrated throughout up to makers' specifications. You can therefore save money on your budget with every confidence by consulting us. Telephone: TUDor 5277; BCM/TESTGEAR, London, W.C.1.

## WANTED

**URGENTLY REQUIRED.** Jnl. I.E.E., Vol. 93, 11A, No. 5. Write, Librarian, A. C. Cossor, Highbury Grove, N.5.

# Raising the standard




Tufnol trip bars raised the standard of operations on electrically operated drop stamp hammers by withstanding well over a million and a half knocks in eight months and still giving reliable service—previously, Lignum Vitae had lasted only 4 weeks.

Engineers in practically every industry have found the value of Tufnol in thousands of different ways.

Can TUFNOL improve your products or plant?

*Our Engineers will gladly help you*

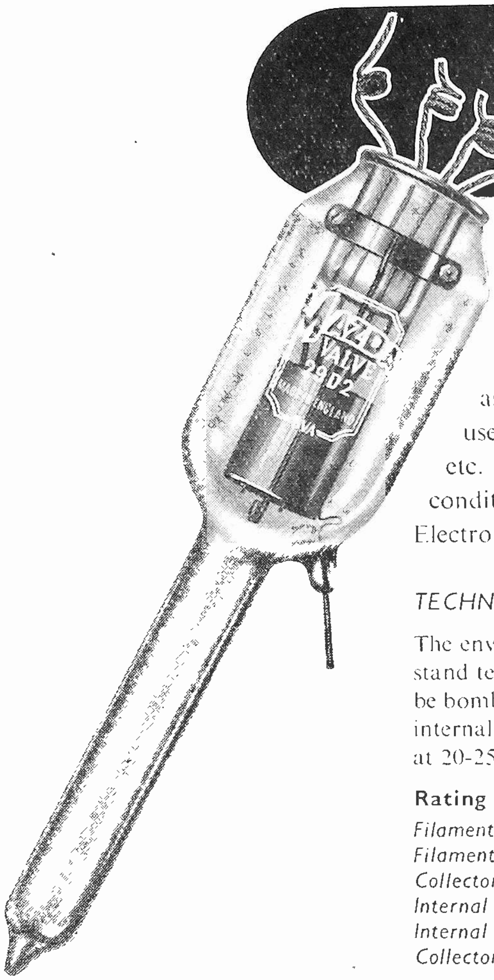
**TUFNOL**

**TUFNOL LTD** · PERRY BARR · BIRMINGHAM 22B

212

# MAZDA VALVES

## For SPECIAL PURPOSES




The Mazda 29D2 is a directly heated Ionisation Gauge designed for use in High Vacuum Measurement work. Coupled with a meter of 1 microamp sensitivity it is capable of recording pressure as low as 1 millionth of an atmosphere, making it particularly useful for research purposes in laboratories, universities, etc. Its accuracy and sensitivity under stringent operating conditions has been proved by its use in the fields of Electron Microscopy, Vacuum Plating and Atomic Research.

*TECHNICAL DATA*

The envelope is of C9 glass (Boro Silicate type) which will withstand temperatures up to 450 C. The collector is nickel and can be bombarded up to approximately 40 w at 150 mA maximum: the internal wire electrode is of molybdenum and can be bombarded at 20-25 w with 60-100 mA.

**Rating**

| | |
|---|---|
| *Filament Volts (approx)* | 6.0 |
| *Filament Current (amps) (approx)* | 1.3 |
| *Collector Voltage* | -25 * |
| *Internal wire electrode voltage* | 185 † |
| *Internal wire electrode current (mA)* | 1.0 |
| *Collector current μA/micron pressure* | 20 |

* It is advisable to include 100,000 ohm resistor in series with this electrode

† It is advisable to include a 500 ohm resistor in series with this electrode

*Further details on request.*

**List Price £4.10.0**

# EDISWAN
# MAZDA

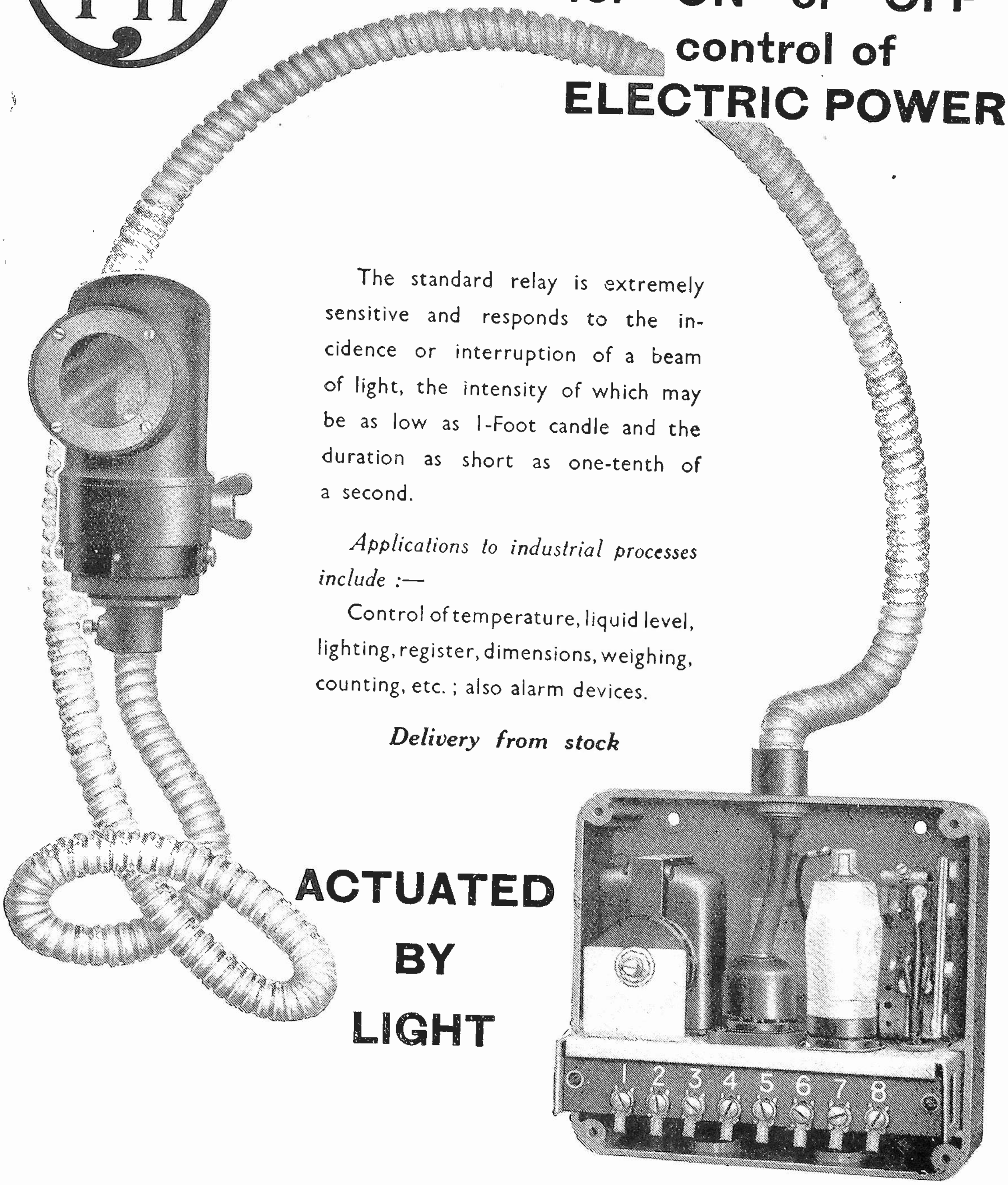
**RADIO VALVES AND CATHODE RAY TUBES**

V83

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

# PHOTO-ELECTRIC RELAY

## for "ON" or "OFF" control of ELECTRIC POWER




The standard relay is extremely sensitive and responds to the incidence or interruption of a beam of light, the intensity of which may be as low as 1-Foot candle and the duration as short as one-tenth of a second.

*Applications to industrial processes include :—*

Control of temperature, liquid level, lighting, register, dimensions, weighing, counting, etc. ; also alarm devices.

***Delivery from stock***

**ACTUATED BY LIGHT**

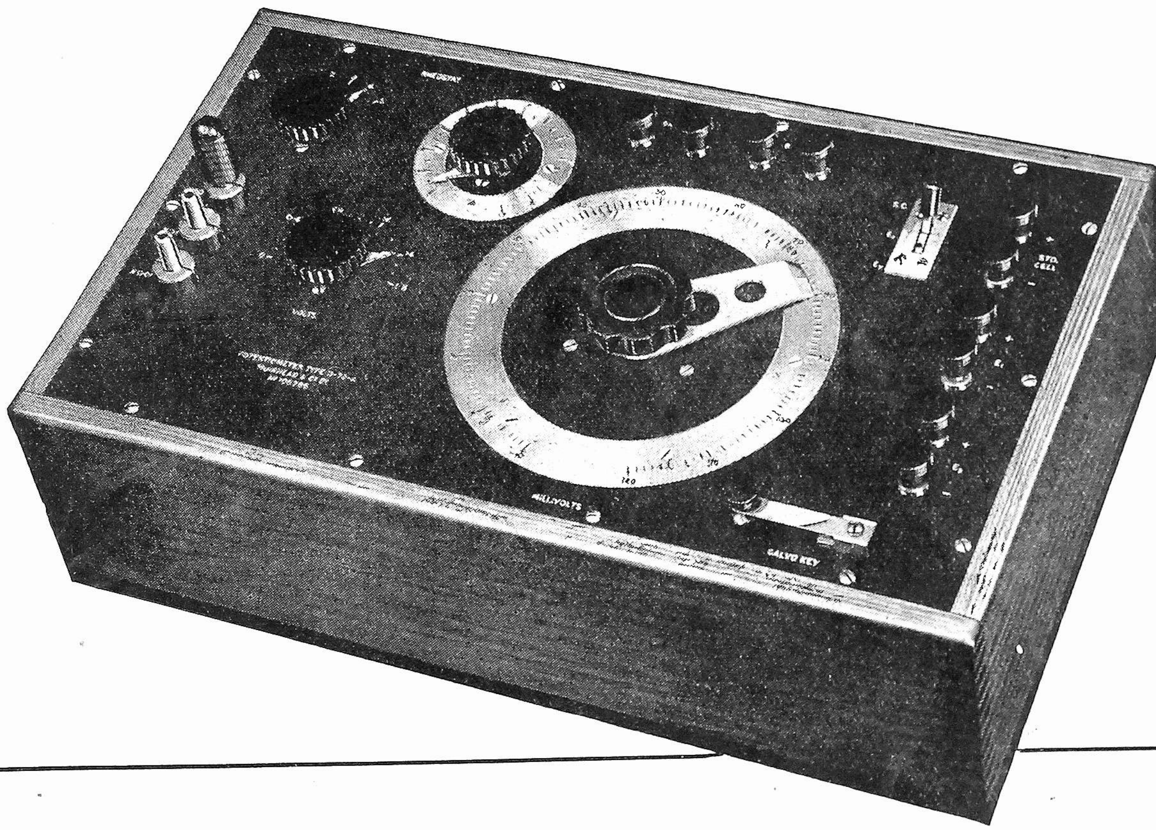
# BRITISH THOMSON-HOUSTON

THE BRITISH THOMSON-HOUSTON COMPANY LIMITED · RUGBY · ENGLAND

A3854

# POTENTIOMETER
## TYPE D-72-A

*For all measurements based on potential difference*



Measures from $-0.01$ volt to $+1.92$ volts on three ranges of $\times 1$, $\times 0.1$ and $\times 0.01$.

Smallest subdivision on $\times 0.01$ range, 10 microvolts.

Small negative reading ensures absolute zero volts position.

Accurate current control by stud rheostat and slide wire.

Separate standard cell balancing circuit.

Terminals for two external circuits selected by switch.

*ACCESSORIES FOR USE WITH THIS INSTRUMENT*

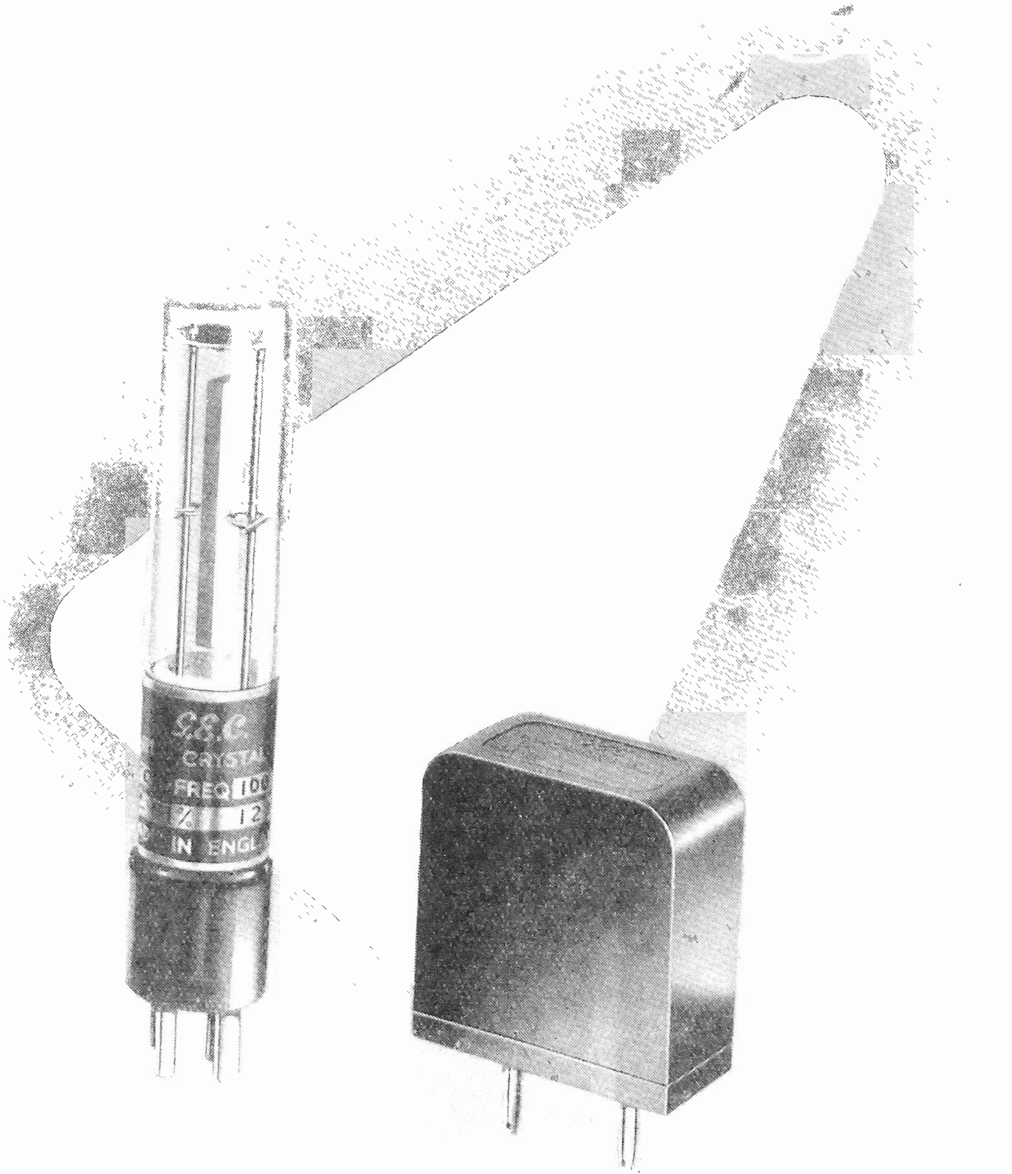
| | |
|---|---|
| VOLT RATIO BOX .. | .. TYPE A-202-A |
| WESTON STANDARD CELL | TYPE D-113-A |
| GALVANOMETER .. | .. TYPE D-41-A |
| LAMPSTAND .. .. | .. TYPE D-74-A |

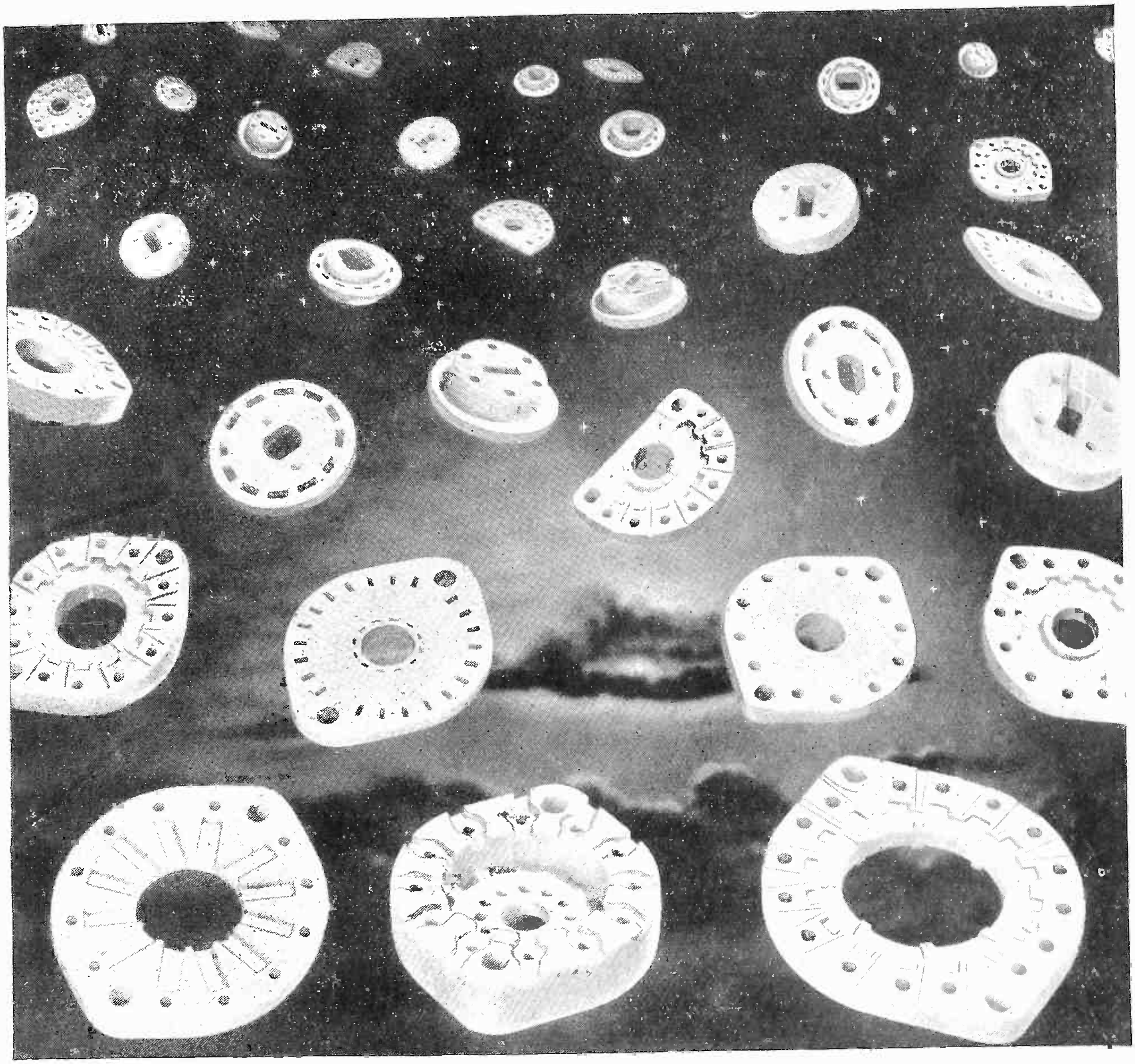
**MUIRHEAD**

*Muirhead & Co. Limited, Elmers End, Beckenham, Kent. Telephone: Beckenham* 0041-2

FOR OVER 60 YEARS DESIGNERS & MAKERS OF PRECISION INSTRUMENTS

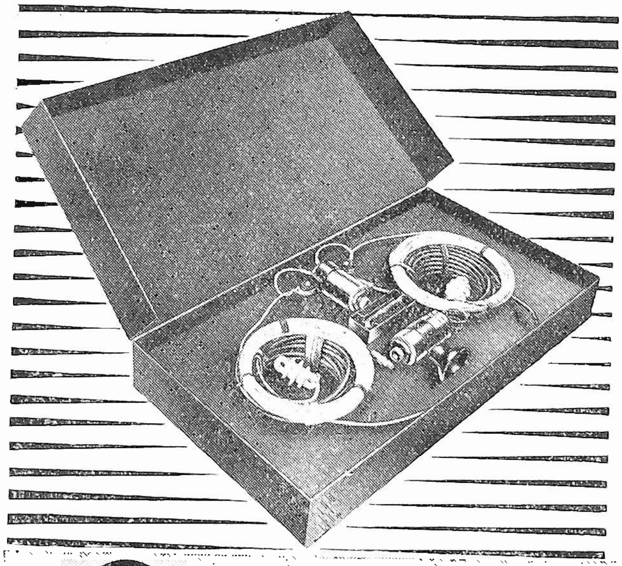
C.R.C.35





# *Interference? never heard of it!*

Never had your favourite programmes spoilt by a background of hissing, crackling and spluttering noises? No? Lucky you! But for thousands living in towns and cities near industrial electrical apparatus, near trolley-bus routes or in the vicinity of high frequency equipment such interference is only too common.



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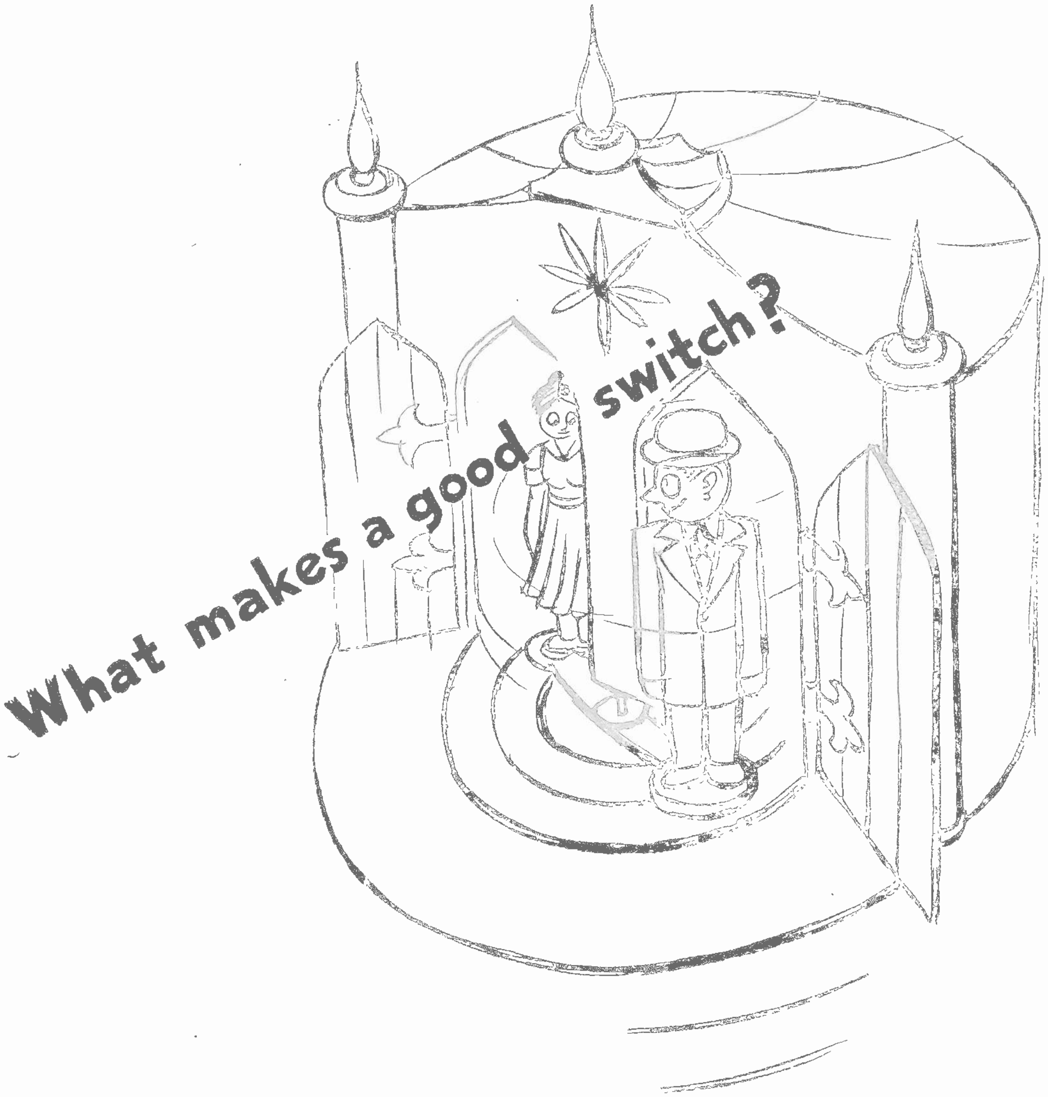
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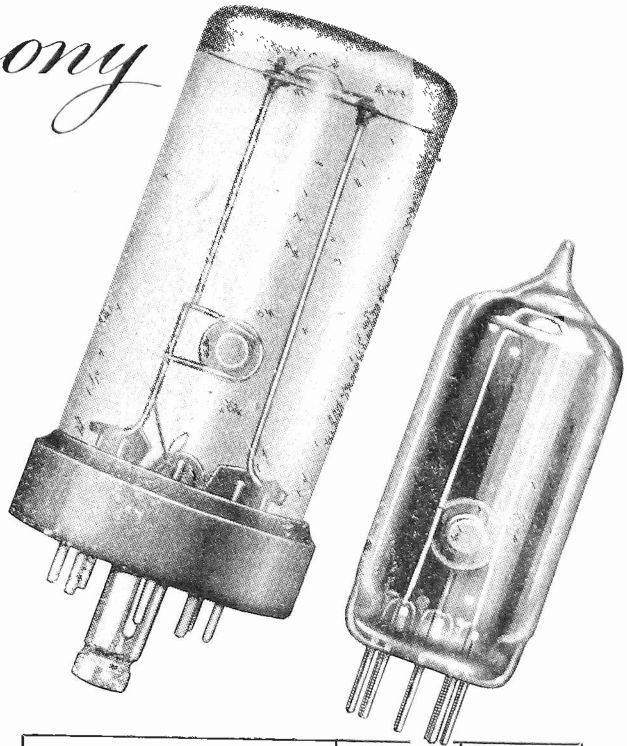
## photocells for industry and research



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|---|---|---|
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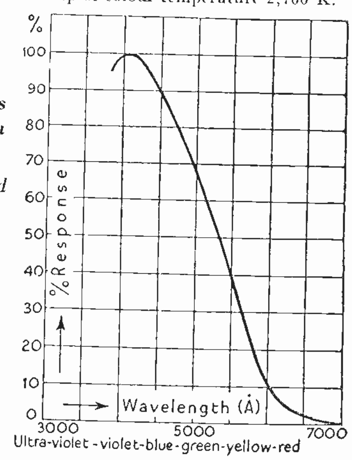
| Max. Cathode Current (μA) | 10 | 5 |
| Max. Dark Current (μA) | 0.05 | 0.05 |

* Measured with lamp of colour temperature 2,700°K.




Spectral Response Curve of Type 'A' Cathode Surface

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# Electronic Engineering

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Vol. 21. No. 251 January, 1949


## CONTENTS



## Information

WITH the commencement of a new volume we extend a cordial welcome to new readers of ELECTRONIC ENGINEERING and for their benefit we are re-stating the service and publications available at the present time.

**Index**

The present issue commences Vol. 21. The Index for Vol. 20 is now in preparation and will be sent to all subscribers as soon as published. Separate copies will be sent on application, price 6d. post free.

**Binders**

" Easibind " self-binding covers, which can be used as temporary or permanent binders for ELECTRONIC ENGINEERING can now be supplied.

Each self-binder will hold 12 copies securely, and is lettered in gold on the spine with space for marking the year of issue. The price, in maroon cloth, is 12s. 6d. (postage 6d. extra) and orders, together with remittance, should be sent to the Circulation Dept. at the address given above.

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Before applying for back copies, please inquire whether they are available. This will save the staff time and trouble in returning money sent for copies not in stock.

The Circulation Department will be pleased to hear from readers who have back copies in good condition for disposal. Please send in full details of the month and year of issue, but do not send the copies until requested.

**" Televisor " Booklet**

The third edition of the booklet covering the construction of a high quality television receiver is now ready, and includes all amendments and corrections to the previous editions (see also p. 27 of this issue). For less experienced constructors, a detailed wiring diagram for the receiver is also available, price 3s. 6d. post free.

**Monographs**

The following monographs are in stock at the prices quoted:

Frequency Modulation (3rd Edition) ... ... 2s. 8d.
Photocells in Industry ... 3s. 2d.
The Electron Microscope (2nd Edition) ... ... 4s. 9d.
Electronic Musical Instruments ... ... ... 3s. 9d.

All the above prices include postage.

Other monographs are in preparation and details will be announced on this page when available.

**The Synchrodyne**

This original receiver design was first described in the March, 1947, issue and further details appeared in the August and September issues of that year. We regret that reprints of the original article can no longer be obtained, but reprints of the second series of articles, including circuit diagrams of the receiver, are still available, price 2s. 2d. including postage.

**A New Editor for "E.E."**

THE Publishers announce that they have appointed

Mr. H. G. FOSTER, M.Sc., M.I.E.E.

as Editor of ELECTRONIC ENGINEERING in succession to Mr. G. Parr, who is resigning his appointment in February to join the Board of Messrs. Chapman & Hall as Technical Director.

Mr. Foster graduated at King's College, Strand, in 1924, and joined the Western Electric Co. as development engineer. He has also had experience in electrical and electronic apparatus design, and for the past ten years has been engaged in the teaching of telecommunications engineering at Cape Town and the University of Birmingham.

The Publishers are confident that, under Mr. Foster's direction, the journal will continue to maintain its high reputation for technical accuracy and the quality of its contents.

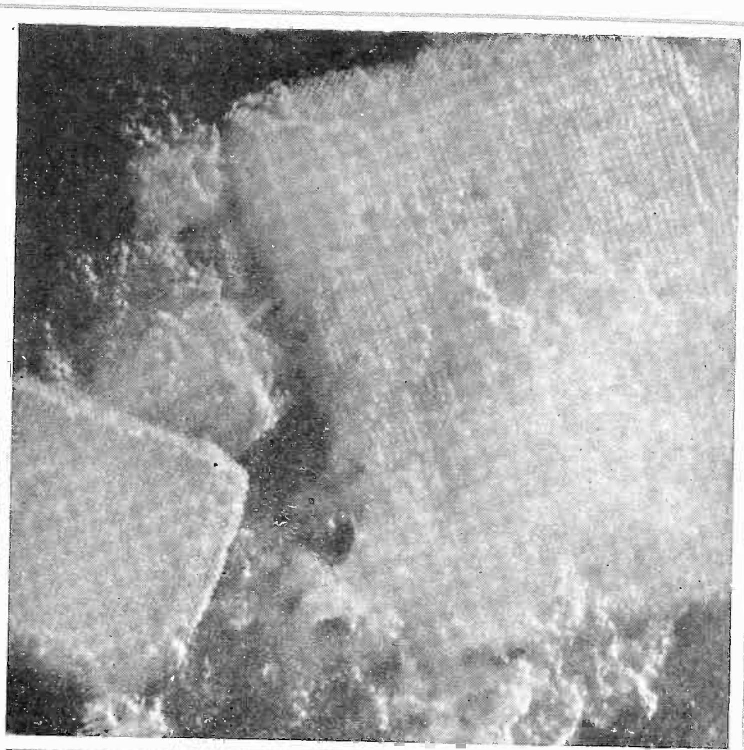
# The Electron Microscope in Medical Research

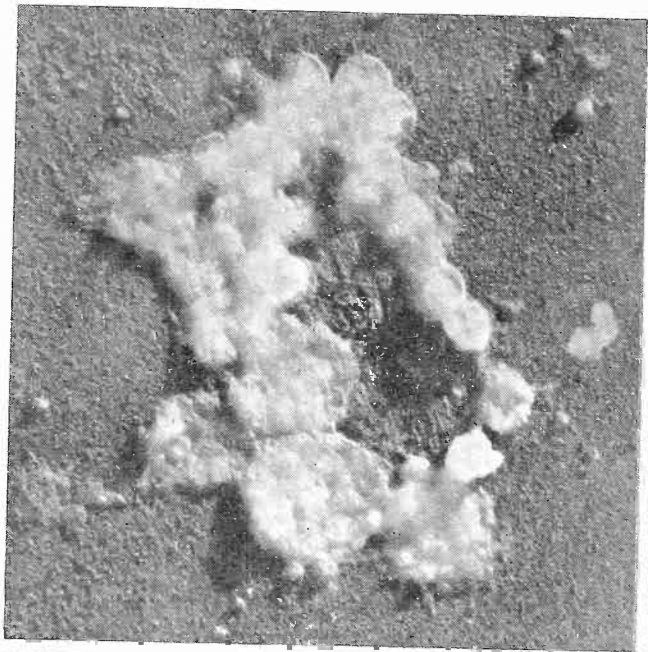
## New Electron Micrograms of Viruses

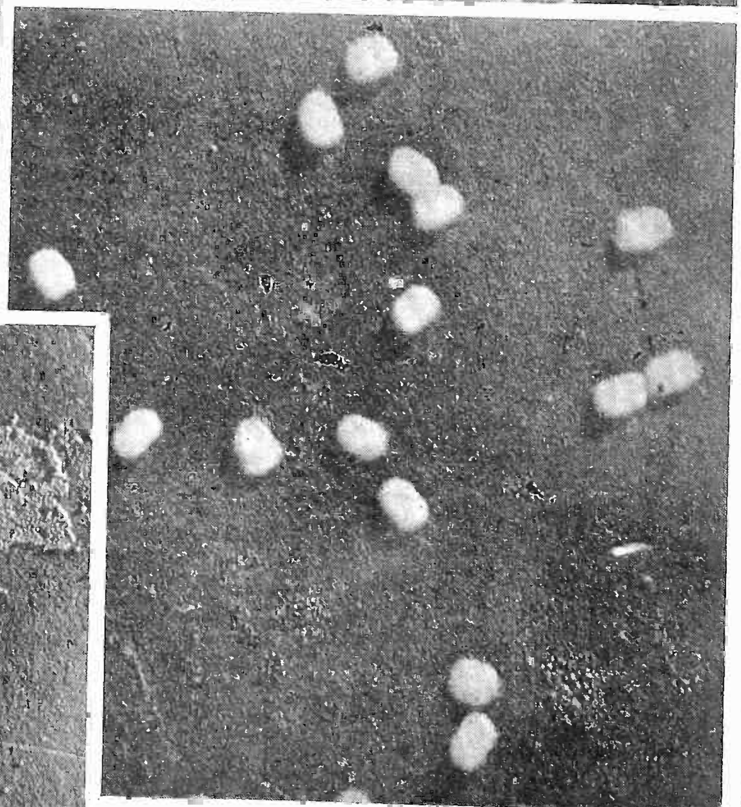
**Right : Single crystals of the necrosis virus, showing molecular arrangement. Individual molecules are shown as spheres approx. 1 mm. diameter (× 100,400)**

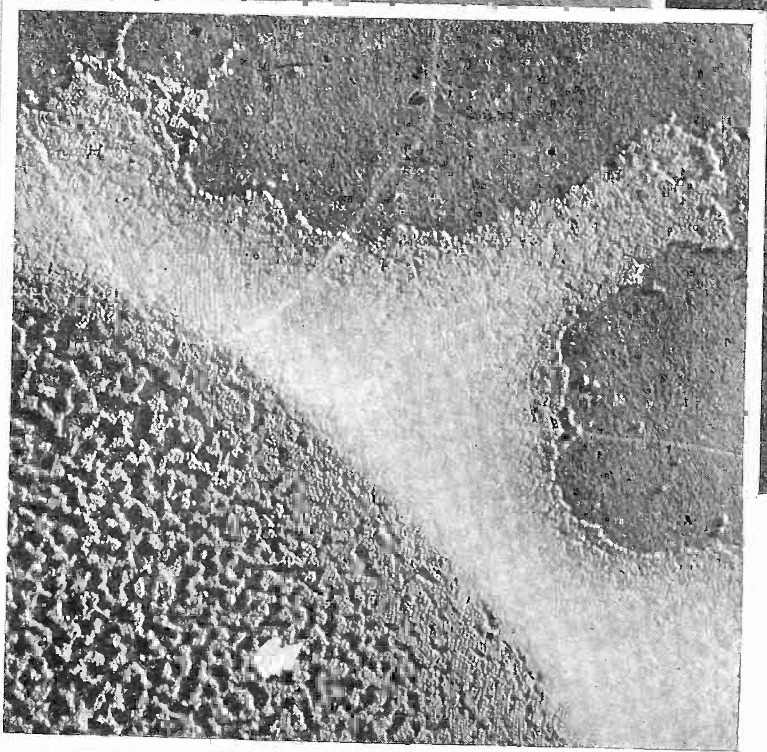
**Below : Elementary bodies of psittacosis virus (parrot fever) shadowed with chromium (× 33,200)**

*—both by courtesy of Dr. R. Wyckoff, Nat. Inst. of Health, U.S.A.*









**Above : *Molluscum contagiosum* virus from human lesions, verifying Dr. Helmut Ruska's work (gold shadowed). This shows the direct application of the electron microscope to the diagnosis of diseases of the skin (× 32,300)**

*—by courtesy of Dr. Rake, Squibb Institute*

**Left : Molecules of plant virus protein aggregating round periphery of a dried droplet of solution (× 100,700)**

*—by courtesy of Dr. Wyckoff*

*Photographs supplied by R.C.A.*

# Frame Synchronising Signal Separators

By A. W. KEEN, M.I.R.E., A.M.Brit.I.R.E.*

This article is a slightly condensed version of a Paper read before the Television Society in January 1947

## 1. Introduction

THE general adoption of interlaced scanning in modern television systems has raised the problem of accurate synchronisation of the frame time base at the receiver. From an inspection of the standard signal waveform (given for the B.B.C. transmission in Fig. 1) this problem would not appear to be formidable, but commercial receivers are often incapable of maintaining exact frame registration over a sufficiently wide range of operating conditions. This failing is usually due to the choice, dictated by the need for the utmost economy, of the simplest types of frame signal separator. On the other hand a wide variety of circuit arrangements are feasible and these will be described briefly in the following sections.

An important feature of the B.B.C. signal is the difference between alternate frames of the length of the last active line (Nos. 203, 405 of Fig. 1). While this irregularity does not preclude or render difficult the achievement of satisfactory interlacing, it must be borne in mind when the circuit constants are selected.

* Sobell Industries Ltd.

## 2.0. General Characteristics of Framing Signal Separators

### 2.1. Specification of Requirements

The input to the framing signal separator will ideally be the synchronising signal of Fig. 1, either in the polarity shown or inverted. In practice spurious fluctuations will also be present and may easily be sufficiently strong to make perfect synchronism very difficult to obtain.

The framing signal separator must satisfy the following general specification:

(i) The framing pulses must be raised sufficiently above the line pulses to render the latter ineffective or readily removable by "clipping."

(ii) The "build-up" of the framing signal produced must occur sufficiently rapidly to enable the frame flyback to be completed within the period available.

(iii) The amplitude accentuation process must be achieved without the loss of the discontinuous serrations provided for correct timing of the flyback ($\gamma_n, \gamma'_n$ of Fig. 1).

(iv) The transmission of spurious signals must be as small as possible.

(v) The separator must be insensitive to the waveform irregularity previously pointed out.

As usual these restrictions are mutually conflicting; thus (ii) and (iii) require a wide frequency response characteristic, whereas (iv) necessitates a narrow pass band. For a given band width, the circuit having the shortest time constant is best. The majority of separators have a low-pass characteristic; such a response is superior to a band-pass characteristic, since for a given time constant the latter type of response has double the width of the former. Moreover, band-pass structures having a sufficiently short time constant require rather high Q components.

### 2.2. Classification of Types of Separator

A study of the large number of practical circuit arrangements employed or proposed reveals several fundamentally different types: (i) The most obvious way of accentuating the framing pulses is to pass the synchronising signal through a network sharply responsive to the frame frequency. (ii) Consideration of the synchronising signal as a recurrent transient, on the other hand, suggests the use of shaping networks. (iii) The best method of retaining the steep edges of the original wave, however, involves the super-position of two or more time separated versions of the signal. (iv) A similar method uses a locally generated waveform to provide pedestals for the frame synchronis-

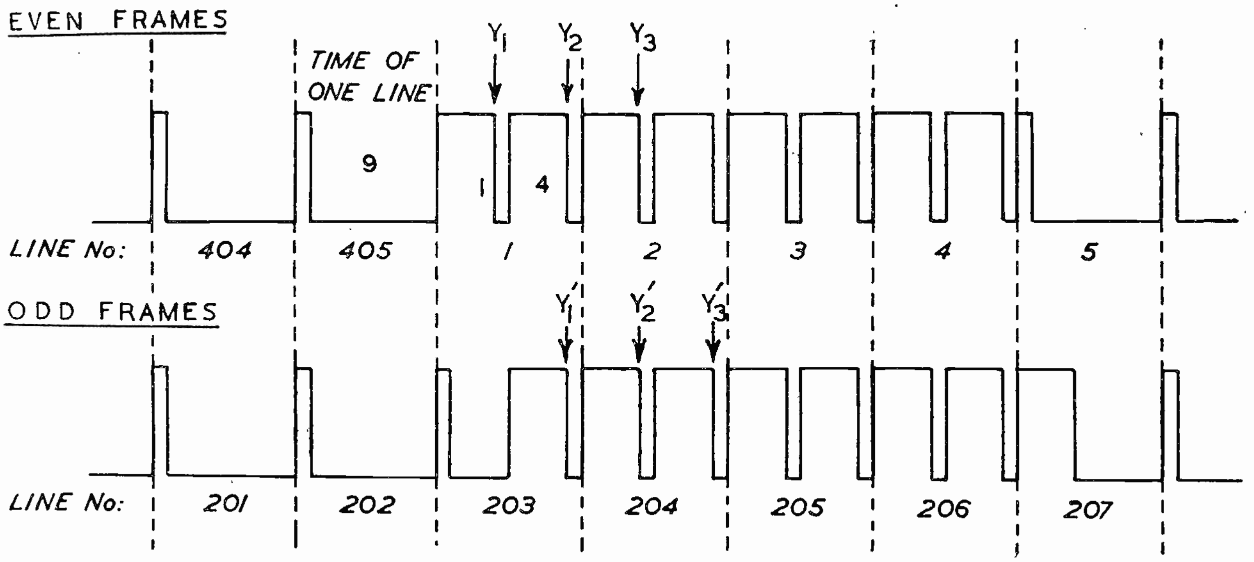



Fig. 1. The B.B.C. frame synchronising signal

ing pulses, thus allowing separation by an amplitude filter.

### 2.3 Facilitation of Separation by Pulse Shortening

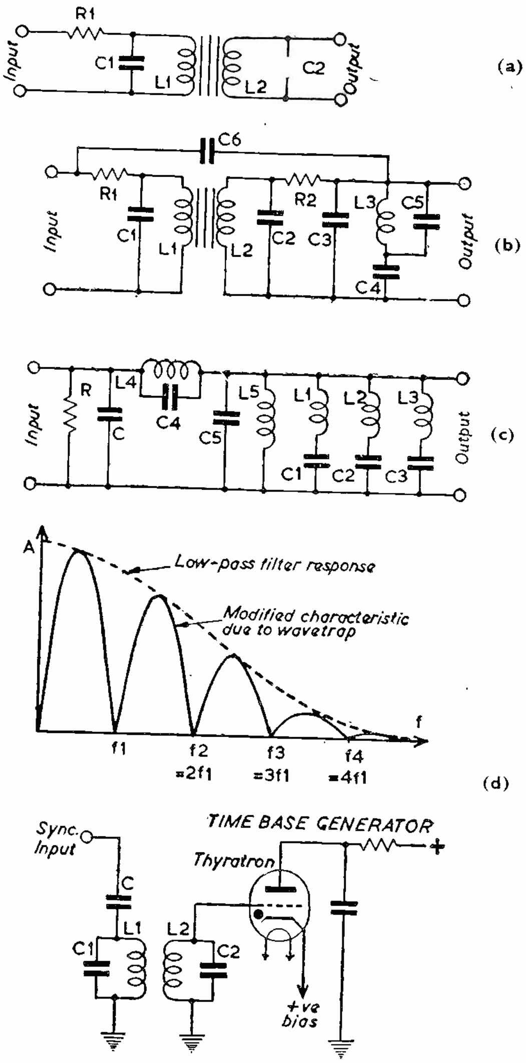
Before proceeding with a detailed discussion of these four lines of attack, it will be appropriate to discuss briefly a general method of facilitating the problem. The ratio between the pulse periods, only 4 : 1 in the current B.B.C. transmission, can be increased by reducing the period of all pulses by the same amount, say $n$ micro-seconds, since $(40 - n)/(10 - n) > 40/10$ for all *positive* values of $n$. Thus for $n$ = 1, 2, 3, . . . 9, the ratio becomes 4.3, 4.8, 5.3, 6, 7, 8.5, 11, 16, 31 respectively. A practical method of applying this principle involves passing the signal through two parallel channels having suitably different transmission times; the two signals produced are combined in a mixer before being passed to the separator circuit.

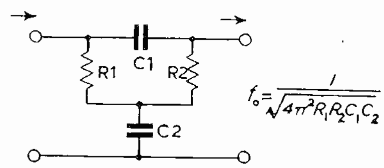
## 3.0. Framing Signal Separation by Frequency Selective Networks

### 3.1. The Use of Circuits Tuned to Frame Frequency

This method was employed almost exclusively in the earlier days of television and is still frequently found in commercial receivers. The simplest arrangement uses a transformer with the secondary circuit only resonant, but normally both windings are tuned. In more refined developments, the tuned transformer is associated with additional filter sections. The latter commonly include a low-pass filter in order to reduce all forms of H.F. interference (Fig. 2(a)). An interesting elaboration of the method (Fig. 2(b)) incorporates a composite filter between the tuned transformer secondary and the time base; elements, $R_1, C_1, R_2, C_2$ and $C_3$, form a low-pass filter, and the series combination $L_3$, $C_4$ effectively short-circuit any line frequency (10, 125 c/s.) component of the input, while $C_5$ tunes $L_3$ to twice line frequency and serves, together with coupling over $C_6$, to accentuate the fundamental frequency of the framing pulses in order to improve interlacing.

The majority of time-base generators are of the relaxation type and are not disposed to oscillate at a definite frequency, as determined chiefly by the linear circuit elements; they lack the " flywheel " property of oscillators based on a low-pass tuned circuit. This property is desirable to a certain extent in a time-base generator, however, particularly when the synchronising signal is small or accompanied by heavy random interference. It is therefore noteworthy that a tuned circuit through which the synchronising signal is filtered can, by suitable connexion (Fig. 2d) be arranged to exercise a marked stabilising effect on the scanning oscillator. If the time base is rendered sharply frequency sensitive, however, automatic frequency control becomes essential.



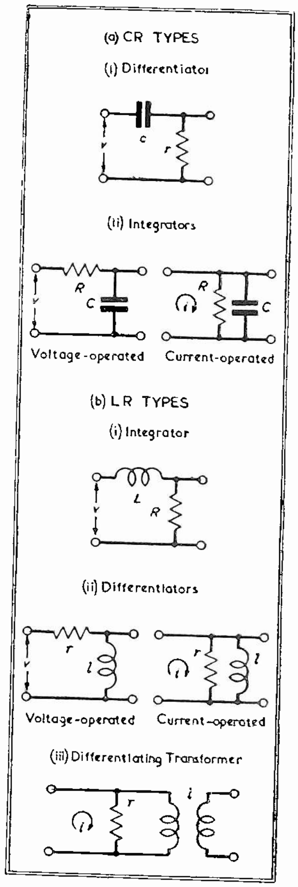




Fig. 2 (*left*). Use of tuned circuits and low-pass filters in frame signal separators

Fig. 3 (*above*). Differentiating and integrating networks

### 3.2. Frequency Selective Networks Based on the Low-Pass Filter

A better basis is provided by some form of low-pass filter. A typical example of this development is shown in Fig. 2c, in which a $\pi$ type low-pass section is followed by a number of series resonant shunt arms tuned to successive harmonics of the line frequency. It is particularly desirable to eliminate the line fundamental and its odd harmonics. An additional trap can be obtained by parallel tuning of the inductance in the series arm of the filter.

Since sharp cut-off is not essential, the basic *LP* filter may be of the *RC* type. Additional elements may be inserted to produce a transfer minimum which can be set at line frequency by suitable choice of element values. The simple bridged-T arrangement of Fig. 2e is a typical example.

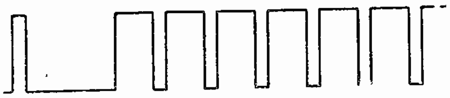
### 4.0. Frame Pulse Separation by Shaping Networks

#### 4.1. Linear Non-Resonant Circuits

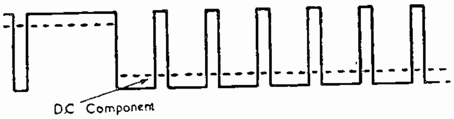
The transient approach to the synchronisation problem has led to the development of a wide variety of simple non-resonant shaping networks well-suited to the trigger method of synchronisation. These networks, which are widely used in commercial receivers, are built up from the familiar integrating and differentiating circuits (Fig. 3) and achieve accentuation of the framing signal by distorting it as a whole, rather than by bringing out particular components of it—as in the case of the arrangements discussed in Section 3.

A certain measure of amplitude discrimination may be obtained simply by passing the signal through a *CR* coupling (configuration of Fig. 3a (i)) having a time constant of the same order as the period of the framing pulse, *i.e.*, 40 microseconds. The change in value of the D.C. component upon commencement of the framing signal (Fig. 4b), causes the entire waveform to drift exponentially to a new equilibrium level (Fig. 4c), which must be reached well within the duration of the framing signal to ensure good separation. A very short time constant brings out the waveform difference between alternative frames; a satisfactory compromise is 40 micro-seconds. Practical circuit arrangements based on this principle have been developed; an example is given in Fig. 5a. Satisfactory operation requires a large signal and the shaping circuit should be followed by a limiting circuit adjusted to clip off the line pulses.

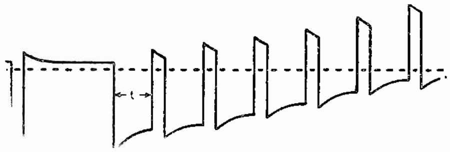
It is more usual to employ the arrangement of Fig. 3a(ii) in which *C* and *R* of the preceding circuit are transposed to form the familiar "integrator." The output waveform is now as shown in Fig. 4d; it will be noted that, for the same output polarity of the resulting synchronising pulses, the input wave must be inverted as compared with the previous case, in which the difference between the input and output waveshapes (*i.e.*, the waveform of the voltage across *C*) is of the same form as the integrator output wave. This waveform (Fig. 4d) is less satisfactory than that of Fig. 4c because of the absence of sudden increases; on the other hand the integrator forms an effective noise filter and provides a basis for improved circuits. Superior results can be obtained with a cascade of integrating sections. It is possible to place the integrator ahead of the synchronising signal separator so that the entire signal is integrated before the amplitude limiting process is carried out.



(a) Sync. signal (positive going)

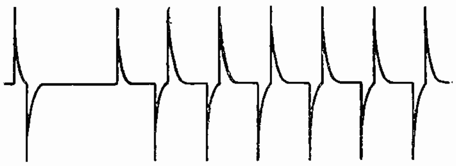



(b) Sync. signal (negative going)

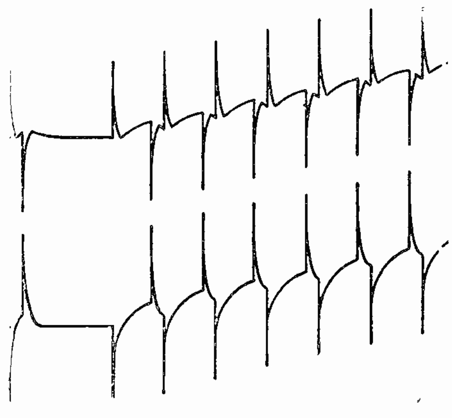


(c) Output of medium time constant CR coupling with input (b) (CR≈t)

(d) Integrator (CR≈t) output for input (a)



(e) Differentiator output for input (a) (CR = 1μS.)



(f) Addition of (d) and (e)
(g) Addition of (d) to inversion of (e)

Fig. 4. Waveforms derived from the synchronising signal by differentiation and integration

With current input, as from a pentode sync. separator, *C* and *R* are connected in parallel (Fig. 3a(ii)).

Precise synchronism is most readily achieved by the use of a synchronising waveform having a "spiky" nature, as may be obtained by differentiation of the signal (Fig. 4e). Addition of this peaky wave to the integrator output represents a considerable improvement and may be arranged without difficulty since a waveshape closely approximating the signal is available across the integrator *R*, (Fig. 3a(ii) (voltage-operated case). Accordingly, connexion of a *CR* differentiating branch across *R*, with appropriate change of output terminal is all that is necessary to obtain the required result. The resultant network is of the form of a bridged-T (Fig. 5d). Element values will depend to some extent upon the terminating impedances and must be chosen to obtain differentiation without impairing the integrator action. The choice of element values should also take into account the steady state frequency response of the circuit, since the latter can have a transmission minimum in the region of line frequency.

To achieve a similar effect with a current-operated integrator the differentiator is connected across an additional *R* placed in series with the parallel *CR*. Element values are less interdependent in this case (Fig. 5c).

Another method of utilising the differentiator to improve the performance of the simple integrator involves conversion of the integrated frame signal into a single square pulse in a limiting amplifier. The latter, which is also operated as an amplitude filter against line pulses, feeds through a short coupling *CR* to the time base.

More satisfactory combination of the integrator and differentiator outputs can be achieved "electronically" by the use of a mixing valve, which need not be additional since an existing valve may be arranged to serve as a mixer while performing its normal function. Two basic arrangements may be distinguished

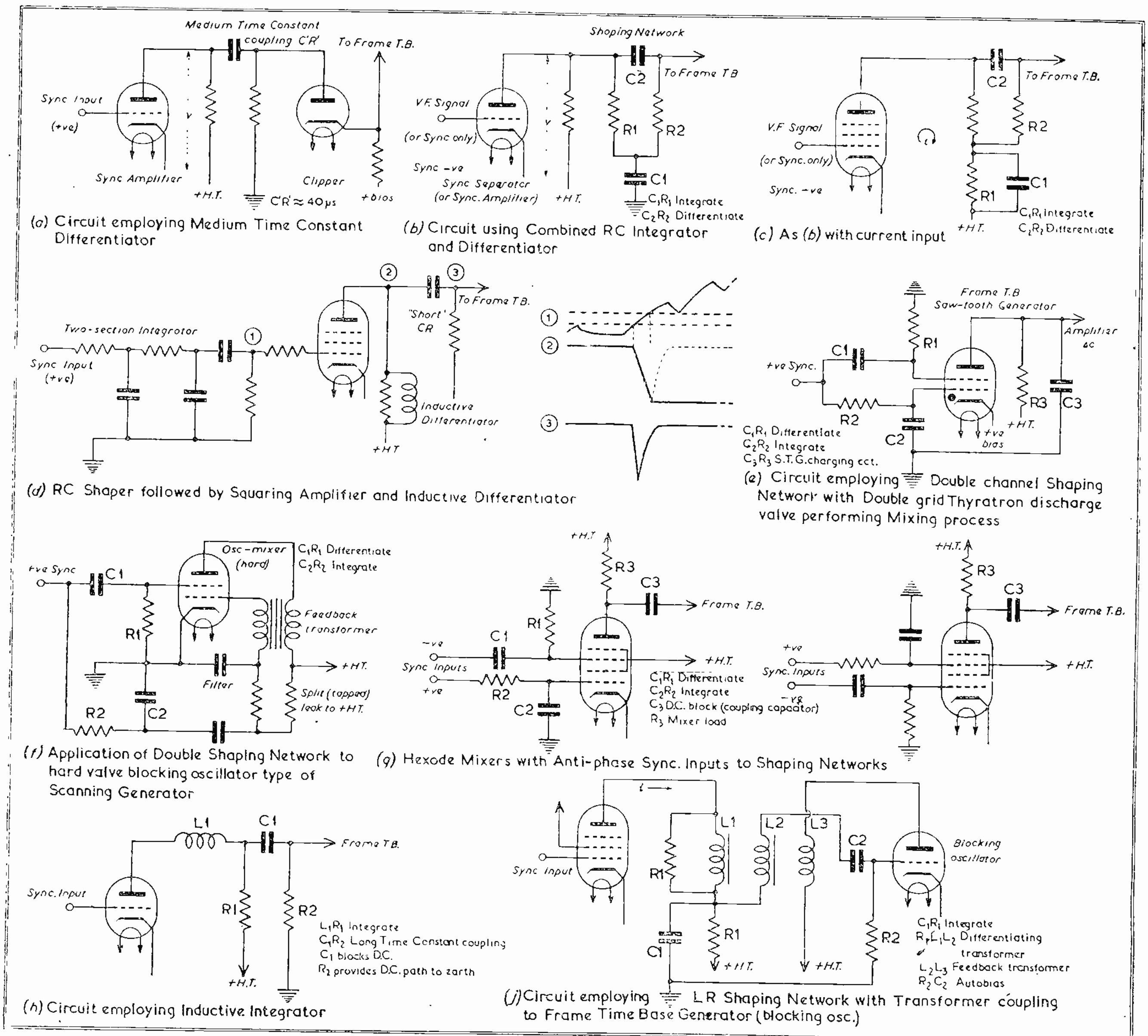



**Fig. 5. Separators employing differentiating and integrating networks**

according as the two shapers are operated with in-phase or anti-phase inputs.

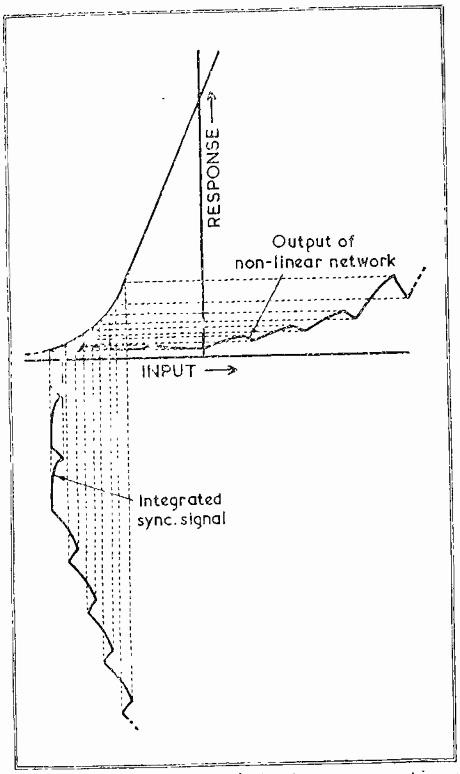
Two developments of the first type are included in Fig. 5e and f. In both cases the time base discharge valve acts as the mixer. The first arrangement requires a special (double-grid) type of thyratron, but no such restriction occurs in the application of the method to the blocking oscillator type of scanning generator in which an ordinary screened-type hard valve is used.

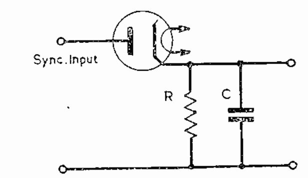
It will be evident from a comparison of Fig. 4f and g that operation of the two shaping circuits with anti-phase inputs provides an improved synchronising waveform. There are a variety of methods of supplying the necessary biphase output from the single phase sync. separator output, *e.g.*, an amplifier type circuit with anode and cathode loads, or a paraphase arrangement. The hexode is the most suitable type of mixer for this method. *See* Fig. 5g.

The shaping networks discussed so far are all constructed from *CR* integrating differentiating circuits. These have *LR* equivalents (Fig. 3b) derived by substituting *L* for *R* and *R* for *C*, which are capable of developing the same waveshapes provided the inductances have a high Q factor. This practical restriction limits the usefulness of these equivalents and the *CR* arrangements are generally preferred. Inductive shapers are particularly suitable, however, for use with blocking oscillator scanning generators since the inductive element may take the convenient form of an additional winding on the feedback transformer, allowing phase inversion of the signal, together with impedance transformation if required (Fig. 5h and j). Combined inductive integrators and differentiators have been used.

#### 4.2. The Use of Non-Linear Elements

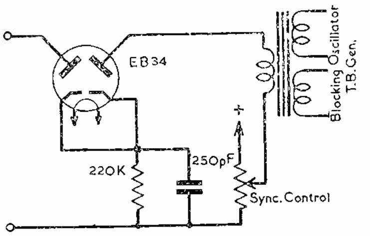
The degree of discrimination between pulses of dissimilar width obtainable with purely linear shaping networks is limited, and, particularly in the case of transmissions not including equalising pulses, improvement in this respect is




(b) Association of Diode (Non-linear Element) with CR Integrator.

Fig. 6. Use of non-linear elements in frame signal separators




(c) Typical Practical Arrangement Incorporating (b) – Pye Ltd.

necessary for satisfactory practical performance. This can be achieved by the use of non-linear devices in either of the two ways:

(i) By passing the output of the linear shaper through a network having a suitably non-linear transmission characteristic.

(ii) By inserting non-linear elements into the shaping network.

The principle of method (i) will be clear from Fig. 6a. During the small amplitude line pulses the operating point remains on the low slope part of the transmission characteristic. The cumulative effect of the framing pulses, however, brings the operating point up to the steep portion of the curve. The overall result is a considerable increase in the amplitude ratio between the frame and line synchronising pulses, particularly when the curve cut-off is sharp.

A good example of the second method is the use of a coil having a core of high-permeability ferromagnetic material (*e.g.*, Mumetal, Radiometal) in the inductive type of integrator. By operating the magnetic circuit over a suitable portion of its characteristic, a large drop in impedance, with a corresponding amplitude change of output, can be obtained during the framing signal; circuit Fig. 5h is often used in applications of this principle.

Another example is shown in Fig. 6b; in this case a diode is associated with a current-operated *CR* integrator. The applied synchronising pulses are negative-going and have sufficient amplitude to cut off the normally conductive diode, thus allowing the diode cathode potential to drop by an amount depending on the duration of the cut-off period, *i.e.*, on the synchronising pulse width. In the practical example of Fig. 6c a separator of this kind is followed by a diode amplitude filter which blocks the smaller amplitude line pulses in the separator output.

## 5.0. Frame Pulse Separation by Delay Networks

### 5.1. The Principle of the Method

The methods of pulse width discrimination described in the last section all depend on amplitude difference arising from the time constant characteristic of circuits containing lumped reactive elements. The next line of attack is quite different, since it involves no deliberate distortion of the original signal, but only shifting of its phase, usually in a network having distributed parameters. The amount of phase shift required increases linearly with frequency, so that the entire signal is shifted in time without change of form. The principle is the addition of two copies of the sync. signal having a time difference just sufficient to avoid superposition of the two sets of line pulses. Amplitude doubling (for equal signal amplitudes) then occurs during the framing signal and the latter is easily separated from the line pulses by a clipping circuit. *See* Fig. 7.

### 5.2. Double Channel Circuit Arrangements

The obvious method of applying the above principles requires a double channel circuit. A hexode is usually chosen for combining the phase separated signals (Fig. 8a); the triode hexode is the basis of several practical variants, one of which is shown at Fig. 8b.

### 5.3. The Use of Artificial Lines

The most suitable network for use in these circuits is the familiar delay " line " composed of a chain of low pass ladder type filter sections having such small element values that the parameters are substantially distributed and the entire network behaves as a continuous line so that the waveform is not seriously impaired. Such an arrangement is shown in Fig. 8c; it will be noted that the terminal capacitances are one-half the value of the remainder due to the mid-shunt termination. The total amounts of $L$ and $C$ required are determined simultaneously by the two restrictions:

(i) $t = \sqrt{(LC)}$ seconds
($L$ henries, $C$ farads)

(ii) $z = \sqrt{(L/C)}$ ohms

where $t$ is the end-to-end transit time and $z$ the characteristic impedance of the " line."

### 5.4. Reflecting Line Arrangements

Since, for the current B.B.C. transmission the delay must exceed 10 $\mu$s the minimum number of sections required to ensure reasonable preservation of the steep edges of the waveform is approximately 10, which is rather large from the point of view of cost and compactness. This difficulty may be halved by operating the " line " with the end remote from the input on open circuit. Complete reflexion of the signal then occurs and the two waves are readily combined at the input end of the network. Two skeleton circuits embodying this modification are shown in Fig. 8d and e.

## 6.0. Frame Pulse Separation by Combination with Locally Generated Signal

### 6.1. Comparison with Preceding Methods

The methods of separation so far described have a common feature, *viz.*, the signal received from the synchronising separator is passed through a network and emerges considerably changed in one or more of its parameters, but retaining its original form in at least a recognisable degree. Thus, there is a definite correspondence between the sections of the input and output waveforms (*cf.* Fig. 4). Various circuits have utilised a basic process involving the additive combination of the original sync. signal and a derivative, or of two derivatives, of the signal. In the next, and last, method of attack to be described, the distinguishing feature is the superposition of the undistorted sync. signal on a locally generated waveform synchronised with it. The term "locally generated" is used rather broadly and includes fluctuations produced by applying the signal, directly or indirectly, to a low-decrement resonant circuit, *i.e.*, by "ringing," or shock excitation.

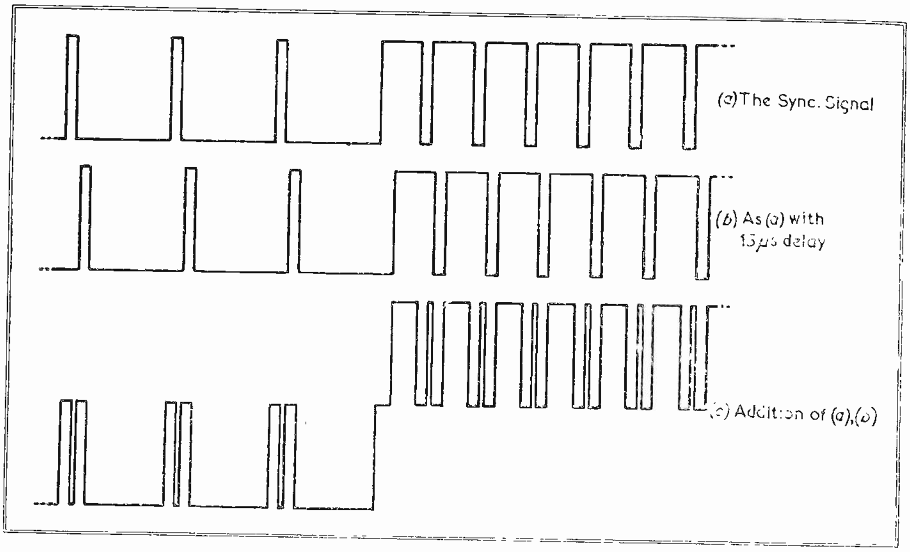



Fig. 7. Principle of delay method of frame signal separation

### 6.2. Arrangements Employing "Ringing" Circuits

The simplest method of developing rapidly an amplitude-separable signal upon commencement of the frame pulse train consists in shock-ing into oscillation a lightly damped tuned circuit. The oscillation trains may be arranged to occur either during the framing pulses or in the intervals between them.

In the first case the process involved is illustrated by Fig. 9A. If a voltage step, of the form of Heaviside's Unit Function, (a) is applied to the series $L$, $C$, $R$ combination (b) having less than critical damping, *i.e.*, $\left(\frac{R}{2L}\right)^2 < \frac{1}{LC}$ the voltage set up across $C$ swings from 0 to $2E$ (nearly) in time $T/4$, where $T$ is the period of natural resonance of the circuit, and decays in an oscillatory fashion about the mean value $E$ (c). If the applied voltage is removed (d) before this oscillation has ceased, the latter will end abruptly and a new oscillation will commence in the opposite direction (e). It can be arranged that this reverse oscillation be heavily damped; moreover, damping is necessary in the present application and may be achieved in various ways, *e.g.*, by alternate switching, due to the signal, of the output impedance of the driving stage. A skeleton practical circuit shown in Fig. 9B(a); a useful secondary feature of this arrangement is the possibility of choosing the resonant circuit parameters to produce attenuation at the line time base frequency. The reactive elements ($L$, $C$) may be paralleled, however, with magnetic (Fig. 9B(b)) coupling to the time base. It will be noted that heavy anode current flows between the frame sync. pulses, thus severely damping the resonant circuit during these periods.

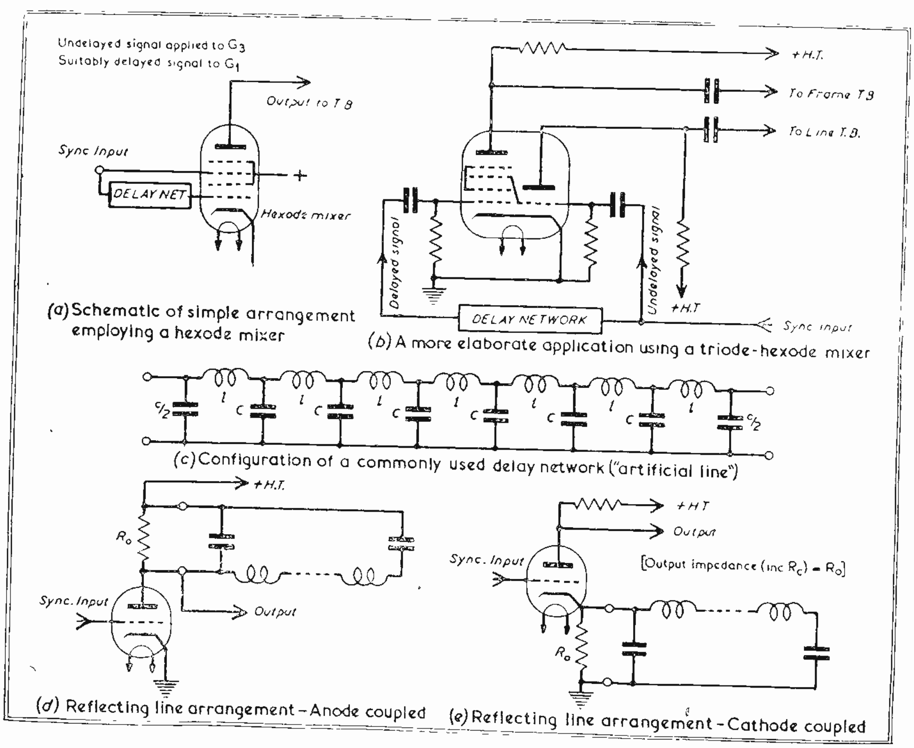



Fig. 8. Separators using delay networks

In the second method of using shock excitation the input signal to the driving valve is in positive phase so that the large amplitude ring occurs between sync. pulses. In this case a higher resonant frequency is necessary, thus allowing smaller component values and providing a steeper response. This method is superior to the former, also, in that the oscillatory responses are more

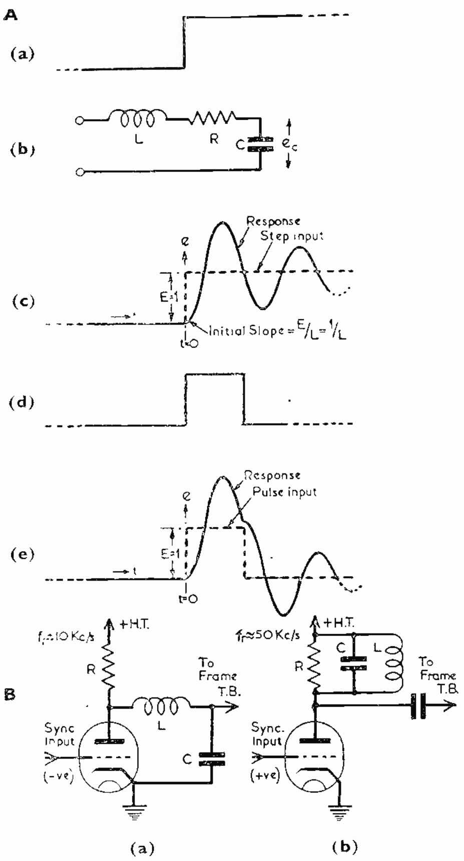



**Fig. 9. Separators employing shock-excited tuned circuits**

suitably phased for correct synchronism. Again the actual resonant circuit may have *L*, *C* in series or in parallel.

#### 6.3. The Use of a Local Oscillator Circuit

A more elaborate interpretation of the technique just described uses a valve-maintained oscillatory circuit which is keyed by the sync. signal and whose output is used as a pedestal wave for the signal. This method is illustrated in Fig. 10a. Practical applications of it differ in the manner of deriving the synchronous sine (or similar) wave and in combining it with the sync. signal, although in the latter process conventional mixing methods are employed. The frequency of the local oscillations is, of course, twice line frequency (20, 250 c/s.); methods of producing it include:

(i) A separate local oscillator, locked to the sync. signal.

(ii) The line time base scanning circuit energising a resonant circuit tuned to its second harmonic.

(iii) A tuned circuit maintained in oscillation at the required frequency by suitable injection of the sync. signal.

Of these (i) is probably the most satisfactory but (ii) and (iii) have the advantage of not needing an additional valve.

A similar development is the combination in a mixing stage of the signal and a rectangular pulse wave derived in appropriate phase at line frequency from the line time base. *See* Fig. 10B. In effect the pulse wave is used to key the channel feeding sync. to the frame generator.

#### 7.0. Conclusion

In the case of commercial receivers economic limitations continue to restrict choice of separator from the wide variety of possibilities outlined, to the simpler forms of Section 3, 4. Of these, the shaping circuits, used in conjunction with a simple non-linear valve circuit, are most popular. It is probable, however, that familiarity gained in artificial line design for radar equipment during the war will tempt designers to develop the methods of Section 5. While television is confined to the metropolis, the interference menace will continue to influence circuit choice and may lead to general adoption of flywheel sync.; already this method is in use commercially in the U.S.A.

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* Jour. Television Society Vol. 5 No. 2 p. 49.

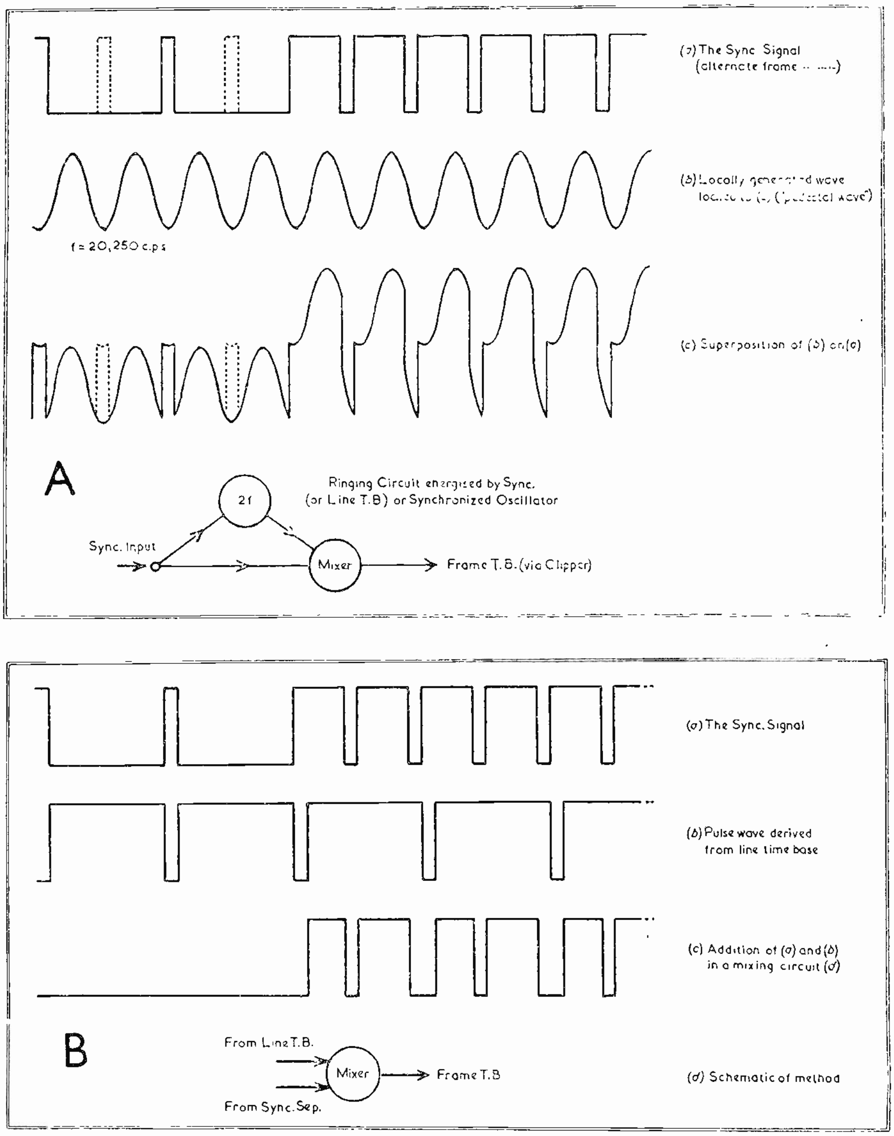



**Fig. 10. Methods of employing synchronised oscillators.**

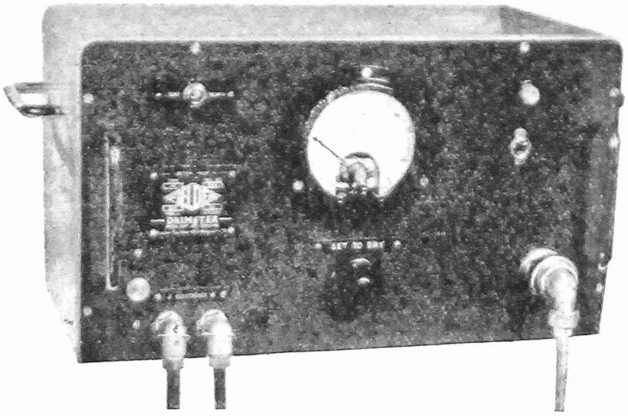


Fig. 1. View of front panel of Drimeter

# THE DRIMETER

## *An Automatic Moisture Control Equipment*

THIS equipment, designed and manufactured by Fielden (Electronics) Ltd., of Manchester, provides an interesting example of modern electronic technique applied to a problem in one of our oldest industries. In the manufacture of textiles, particularly in the bleaching and dyeing industries, it is necessary to dry the materials several times, and this process is one of the major costs in these factories. There are many different types of machine, each with its particular application, but basically the process consists of passing the fabric over heated cylinders or through a heated chamber at a speed adjusted by the operative to deliver the material in a dry state.

This practice inevitably resulted in the operative tending to over-dry the material, with a consequent loss of production and deterioration in the quality of finish. As is well known, all textile materials are hygroscopic, thus the drying process need only be continued until the material contains its normal moisture. It was impossible to achieve such an ideal by human judgement, but it has been possible since the introduction of the "Drimeter" some two years ago, and now there are many hundreds of these instruments in use throughout the textile industries of the world. In some cases the introduction of this instrument increased the production of the machine as much as 50 per cent.

The "Drimeter" (Fig. 1) operates by making a continuous measurement of the dielectric constant of the material. The fabric is passed through two plates arranged as a capacitor supported by a stout casting which is bolted to the frame of the machine. A modulated R.F. of about 500 Kc/s., is applied to an R.F. bridge system, which is arranged to balance with no material between the test condenser plates. The introduction of any material between the electrodes produces an out-of-balance current which is amplified, demodulated and applied to an output meter calibrated in terms of moisture content. The zero of the moisture scale is positioned at about one quarter F.S.D., which enables the instrument to be adjusted for different weights of material. The first blank part of the scale represents the out-of-balance due to the dry basic material, and the numerical scale the % of moisture in the material. The instrument has only one control, the gain of the amplifier, and the operational procedure is very simple. The operative runs his machine very slowly at the start of each batch of cloth so that the output is quite dry. He then adjusts the control until the meter shows

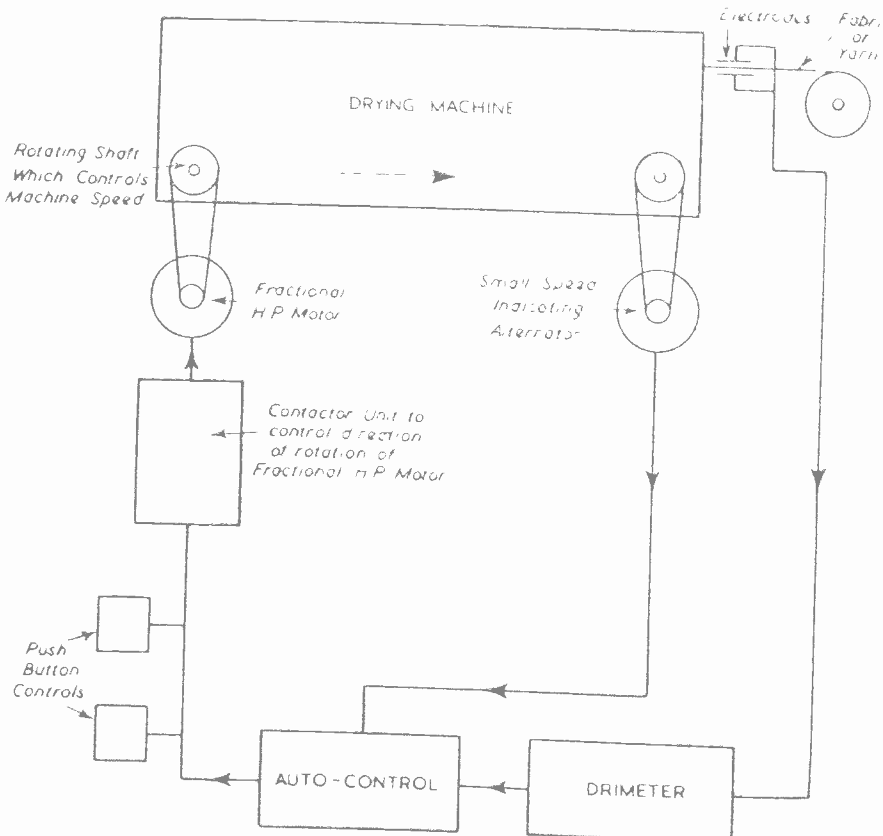



Fig. 2. Arrangement of moisture control and indication applied to drying machine

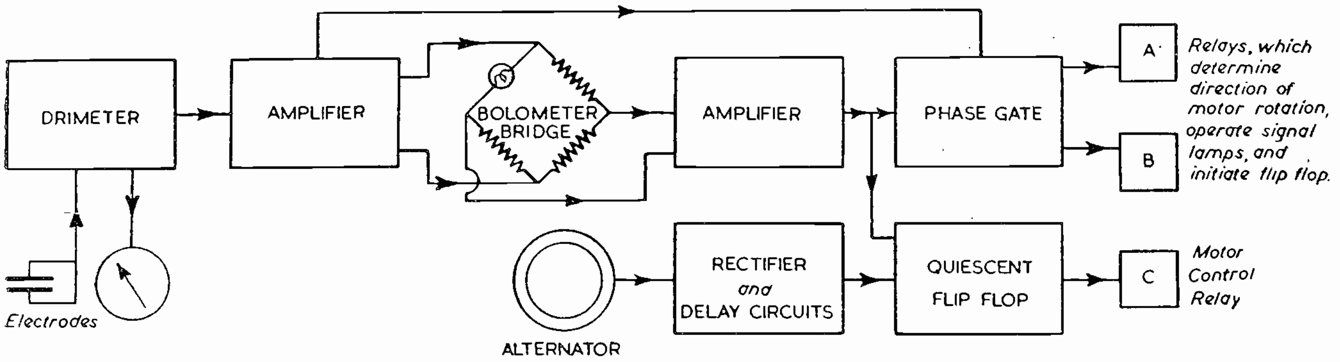



Fig. 3. Simplified schematic arrangement of Drimeter automatic control system

" dry " or zero moisture content, then runs the machine up in speed until the required moisture is present.

In some instances it is more convenient to record the dry setting sensitivity so that the instrument can be adjusted without stopping the machine, and in these cases a Calibration Unit is supplied. This auxiliary equipment enables the operative to switch the Drimeter from the condenser head of the machine to a calibrated variable capacitor shunted by a pre-set capacitor, the latter being adjusted to equal the capacity of the electrodes. The variable capacitor has a suitable value to cover the increments in capacity due to dry fabric, thus various fabric settings can be recorded on a suitable chart, and the equipment adjusted at any time without recourse to a dry sample.

This visual indication of moisture content enables the operative to maintain the drying machine at maximum efficiency, but to do so he is called upon to make corrections constantly to maintain a level output. The Automatic Control Unit about to be described takes this responsibility from him and discharges this task in a more efficient manner.

The problem of controlling drying plant efficiently is complicated by the time delays, which are inevitable between any correction to the speed of the machine and the effect of that correction on the moisture content of the output. It will be readily understood that if a correction to speed were to be continued until the required moisture content was obtained, the result would be a large over correction, and the machine would be constantly accelerating and decelerating (hunting). Consequently, it is necessary to replace the " judgement " of the operative, and to make the amount of correction suitable for the error in moisture content. Once a correction has been made, it is necessary to wait to see its effect before making any further correction. The period between corrections must be long when the machine is going slowly, and short when the machine is going quickly. If the corrections are too frequent hunting will result, and if they are too infrequent, efficiency is lost.

The mechanism which provides the correction must be initiated by the error. Otherwise, if it is merely timed at set intervals by the machine, a considerable amount of wet material could be delivered if a correcting period had just passed.

The control must also become inoperative if the machine is stopped or runs out of material.

A simplified schematic arrangement is shown in Fig. 2. A small fractional H.P. motor is fitted to turn the " Handle " which controls the speed of the drying machine. The direction and amount of rotation of this motor are controlled by manually operated push buttons or by the automatic control unit.

Information is fed to the control unit from two sources:

1. The Drimeter which gives an output voltage having a relationship to the moisture content of the material.

2. A small alternator driven by the machine providing a voltage proportional to machine speed.

The control unit with the information received from 1 and 2 takes complete charge of the machine and satisfies the conditions outlined.

A simplified schematic diagram of the electronic control circuit is shown in Fig. 3. The output from the Drimeter, an alternating voltage of 500 c/s., is fed to a stable power amplifier which provides one output at low impedance which is applied to a bolometer bridge and another at relatively high impedance which is used as a reference phase in a phase discriminating gate.

The input voltage to this amplifier is controlled by the moisture level dial on the front panel of the instrument which is suitably calibrated to allow the bolometer bridge to balance at the required level of moisture content. When the material is being delivered at the correct moisture level, there is no out-of-balance voltage at the bridge; any departure from the required moisture level produces an out-of-balance voltage proportional to the error. The out-of-balance voltage (when present) is amplified and used, first to determine the direction of rotation of the correcting motor and, secondly, to control the length of time for which the meter will run, *i.e.*, the amount of correction to the speed of the drying machine.

The phase gate consists of two pentodes with their suppressor grids driven in anti-phase by the reference voltage derived from the pre-amplifier, and their control grids driven by the amplified out-of-balance voltage from the bridge. These valves are biased to a non-conducting condition and the two relays A and B in their anode circuits are normally de-energised. Any unbalance of the bridge produces a voltage at their control grids, which opens up one of the valves and energises the appropriate relay.

These relays are fitted with multiple spring sets and perform several operations. They determine the direction of rotation of the correcting motor. (They do not start the motor; relay C attends to this). They operate suitable signal lamps on the front panel of the instru-

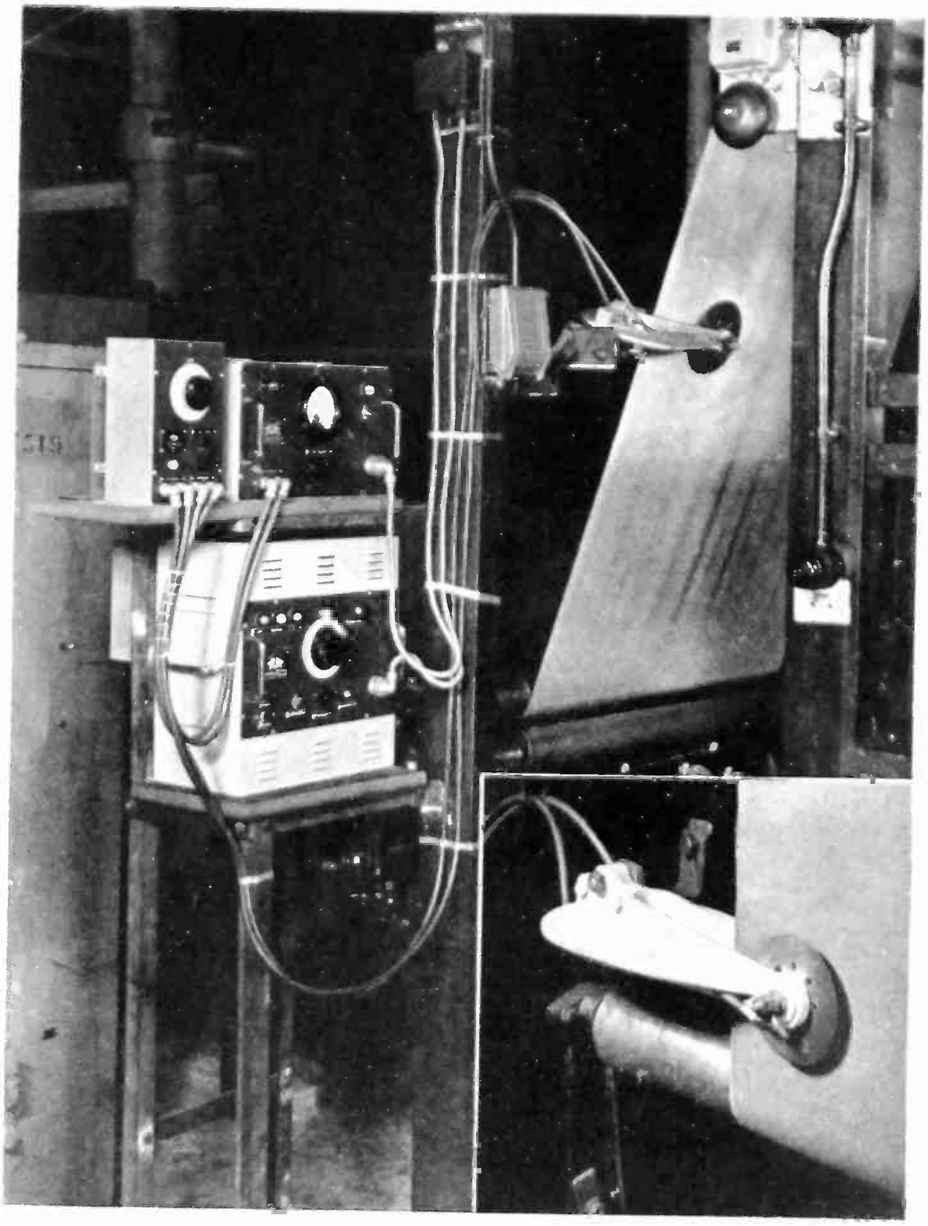


Fig. 4. The complete installation applied to a hot air drying stenter. Inset: View of electrodes through which the cloth passes

*(Photo by courtesy of Samuel Heap and Son Ltd., Rochdale)*

ment, and prepare an interlock circuit (completed when relay C operates) which prevents the reversal of the motor while it is running. They start the charge of a capacitor which, after a three-second time interval, initiates the quiescent flip-flop. This time delay of three seconds allows wet sewings and other irregularities to pass without any correction being made. If during this interval normal conditions are restored, relay A or B is again de-energised and the flip-flop never operates.

The quiescent flip-flop is of unconventional design, and the anode current of one of its valves energises relay C, which starts and stops the correcting motor, locks the circuit while the motor is running and operates a signal lamp at the front panel. The "flip" period of this circuit is the time for which the correcting motor runs, and its "flop" period is the interval between corrections. It is so designed that the "flip" period is proportional to a rectified voltage derived from the out-of-balance voltage amplifier, thus the resulting correction is proportional to the error in moisture content.

The "flop" time is inversely proportional to a rectified A.C. voltage derived from a small alternator driven by the drying machine, thus the intervals between corrections vary inversely with machine speed. If the machine is stopped and there is no voltage present from this source, the circuit can never operate.

If the machine has been stopped and is re-started it is necessary to prevent any corrections to speed until the over-dried material has been delivered, otherwise changes will be made from a speed level which had been previously established as correct. To achieve this delay, the rectified voltage from the alternator is fed to the flip-flop via a time delay R.C. network which is discharged through diodes if the source voltage fails. This circuit is of no consequence to the normal time intervals of the flip-flop, but is adjusted to give the necessary extra time when the machine has been stopped and is re-started. The period of this extra delay also varies with the machine speed.

If the machine runs out of material, the output falls to zero, the input to the bolometer bridge is zero, thus there is no out of balance voltage. Relays A and B are de-energised and the flip-flop cannot operate.

All the C.R. time constants in the equipment are adjustable by pre-set controls housed inside the case, thus on installation, the equipment can be adjusted to suit the characteristics of any drying machine. Unfortunately, owing to the many different types of machine and methods of drive, the fitting of this equipment becomes a complex problem, and to solve this Messrs. Fielden now manufacture a whole range of auxiliary electro-mechanical equipment for this purpose and they have established an installation and service organisation not only in this country, but in most of the textile centres of the world. It is interesting to record that they have recently formed an associated company, Messrs. Fielden Electronics Inc., New York, who have now successfully introduced this equipment to the American textile industrialist and who are at present engaged in setting up a similar organisation in that country.

The equipment described in this article is covered by British and foreign provisional patents.

# The Electronic Measurement and Control of Heat

*Part I of a series of three articles*

By JOHN H. JUPE, A.M.I.E.E.

BEFORE starting to consider details of electronic devices in connexion with heat it is as well to consider a few general points.

Temperature and temperature changes affect human affairs and desires practically more than any other physical phenomenon. The successful cooking of a cake, the operation of a synthetic oil plant, or even the correctness of a decision to carry a raincoat, may all depend on a knowledge of temperatures.

To have complete control of changing circumstances, however, one must be able to gauge and record past and present conditions and it is obvious that any accurate system of temperature control must start with accurate temperature measurement.

This is a point on which there is a certain amount of misunderstanding and the degree of accuracy with which temperatures can be measured is shown below. This table represents the best figures attainable which are internationally recognised.

| Temperature Range | Accuracy of Measurement |
|---|---|
| 0—100° C. | .001° |
| 101—44.5° C. | .01° |
| 44.6—960.5° C. | .1° |
| 960.6—1,063° C. | 1.0° |

So anyone claiming to measure the temperature of molten steel to within 0.1° C. is claiming something that cannot be substantiated. *Changes* of temperature, however, can be detected with a much higher degree of accuracy and the detection of variations of the order of 0.000001° C. are not impossible. Confusion of actual temperature measurement with change of temperature sometimes leads to large errors and loose statements.

Another important point to be borne in mind is that in any measuring instrument, accuracy and sensitivity may be widely different factors and may not follow the same laws of variation.

In temperature measurement, too, we are faced with the troublesome fact that few bodies are at a perfectly uniform temperature and that unless elaborate precautions are taken, any material will have a large number of temperatures and isotherms, all changing at speeds too fast to permit recording and yet too slow for an averaging method to be very accurate.

In control we are faced with the difficulty of various forms of lag, varying from thermal and mechanical forms to the transit time of electrons across thermionic devices. Thus we are only able to act on a knowledge of temperature as it *was* and not as it is. The variation takes the form of a complex wave which defies mathematical analysis—at least, in any reasonable period of time. This does not mean that accurate temperature measurement is a hopeless task but it is a sound principle in any problem to keep the inherent difficulties well to the front.

Most electronic devices have been applied in the field of heat acting in conjunction with other mechanical or electrical devices, often with very good results, but because of a certain amount of conservatism which tends to hold all electronic development back, the correct method of approach to the problems has hardly been attempted, *i.e.*, to design temperature measuring devices which are intrinsically electronic. This point will be dealt with later.

### Qualitative Control—Combustion

Under this heading are included alarm and guard devices and certain labour saving systems. A common arrangement is to interrupt a beam of light falling on to a photo-cell and although this scheme is simple, it works well and has some variations worth detailing.

Fire alarms using this principle have the tremendous advantage of being able to detect smouldering fires by the presence of smoke—a very difficult matter without using photo-cells, particularly in the case of ships' holds and large warehouses. One method has small pipelines running to each space being protected and air is drawn from each in turn and subjected to photo-electric observation. At four-second intervals a motor-driven selector switch operates solenoid valves in each pipeline and drives an indicator showing which line is being sampled. Smoke causes operation of an alarm bell and stops the selector switch so that the indicator shows the smoke producing area.

With some inflammable materials, however, flame may precede smoke and a simple photo-cell and light arrangement can be made to cover both these conditions. A cell and a mirror are mounted on parallel wires of similar material, one wire being covered. Light falls on to the mirror and is reflected on to a photo-cell, thus catering for smoke- detection by the interruption of the beam.

Should, however, a sudden outbreak of flame occur, the wires will have hot air circulate around them and as one of them is covered, will expand at different rates, resulting in the mirror twisting, and again interrupting the beam. Slow changes of ambient temperature will affect both wires uniformly and so will not cause the mirror to be twisted.

### Naked Flame Control

With gas- and oil-fired furnaces there is always the danger of jets clogging or the flames failing from other causes, raising the possibility of explosions and fires. A successful method of guarding against this has been devised and utilises the fact that a flame is rich in ions and is therefore an electrical conductor. A single electrode is mounted on a heat resisting insulator, so as to be in direct contact with the flame, and is connected to a valve amplifier circuit so that the valve receives its correct grid bias so long as the flame touches the electrode. If the anode current changes, following on the removal of grid bias by flame failure, electrically operated valves cut off the fuel supply.

Like so many electronic devices this one is capable of much flexibility and can be set up to allow a delay in cases of momentary faltering, or for automatic ignition under safe conditions; also for cut-off to take place if the flame increases in size and touches a second electrode. Breakdown is guarded against by interlocks and this method is rather more robust than one using a photo-cell to observe the flame.

**Resistance Thermometer with Electronic Additions**

The "bridge" principle has been applied in many ways to the measurement of temperature, but only three particularly interesting examples will be mentioned here. As in a great part of the field covered by this series of articles, there is but a small division between the measurement of heat and its control and these three examples cover combination instruments.

The first was developed by the Shell Development Co., and is capable of very precise control within a few thousandths of a degree at any temperature between zero and about 240°F. It is arranged that when the temperature moves from the set value the usual out-of-balance voltage appears across the "galvanometer" points of the bridge, which is fed with A.C. at mains frequency. This voltage is passed through a phase shifting network and a two stage amplifier, the output of which is applied to the grids of two thyratrons as shown simplified in Fig. 1 and a voltage 180° out of phase with the line voltage as applied to the anodes. The anode current is passed through a saturable reactor, one winding of which is in series with the mains supply and an electric heater for supplying heat at the point being controlled. To prevent overloading, automatic gain control is incorporated in the circuit.

The second instrument using a resistance thermometer is in the Foxboro electronic recorder, where the bridge is composed of two resistors (one being in the chamber whose temperature it is desired to control) and two capacitors, one fixed and the other variable. A 1,000 c/s. oscillator feeds the bridge circuit as shown in Fig. 2, also the power amplifier; the latter supplying power for the push-pull reciprocating solenoid motor. The motor windings consist of two solenoids mounted co-axially, with the core suspended between them and connected by a link to the recorder pen, and the rotor of the balancing capacitor. Both coils of the motor are continuously energised and any unbalanced voltage is amplified and fed to the motor, which then has unbalanced currents through its coils and moves to drive the variable capacitor back to the balanced condition. The action of the motor is fully reversible, as the direction of

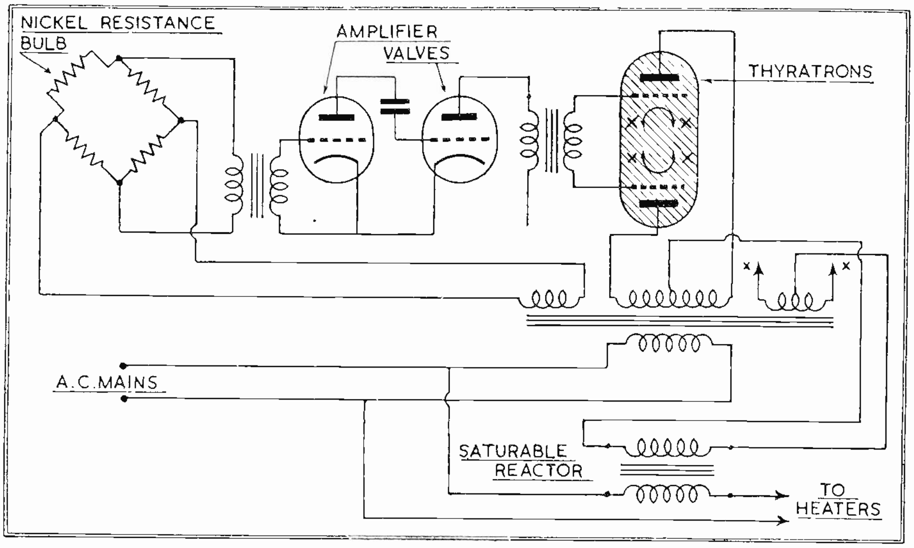



Fig. 1. Simplified diagram, high precision automatic temperature control system.
—*Shell Development Co*

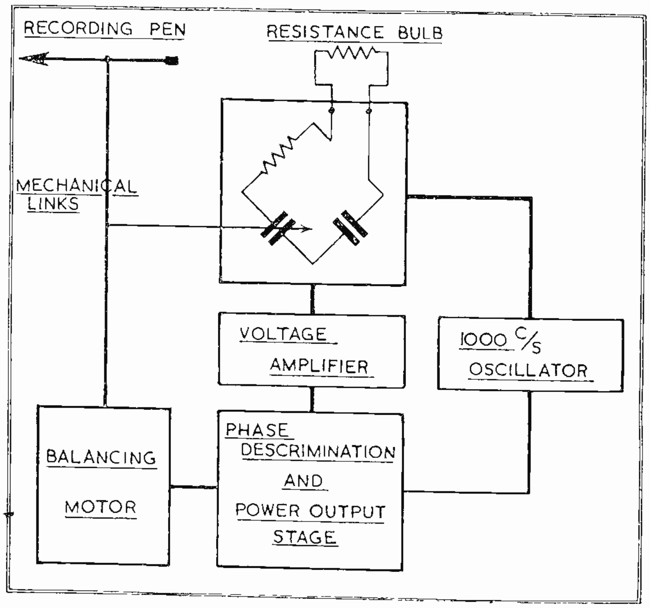
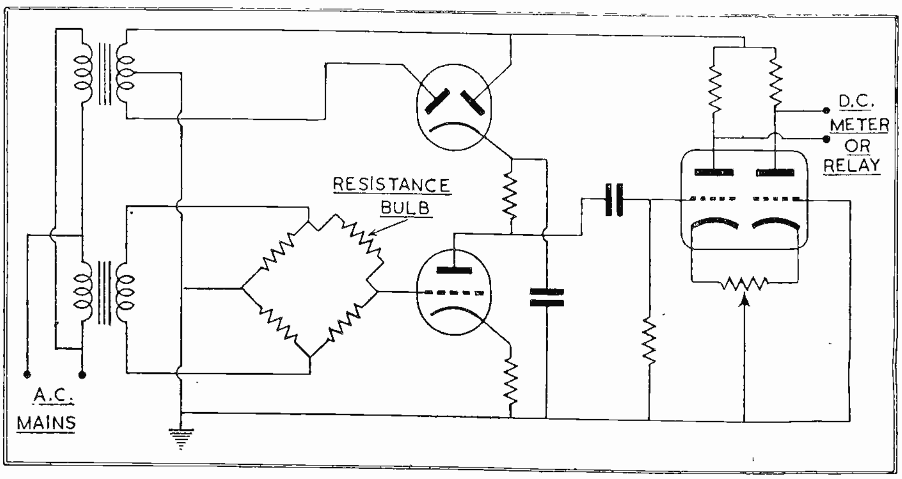



Fig. 2. Block diagram of Foxboro electronic temperature recorder.

Fig. 3. (below) Electronic thermometer.



core movement depends only on the relative coil currents and not on the core position.

The third type of instrument serves once again to show that a branch of electrical engineering very well known and perfectly straightforward, *i.e.*, the Wheatstone bridge, is still capable of holding hidden surprises.

The development consists of using a resistance bulb in one arm of the bridge made up of metallic wires dipping into a liquid having a very high temperature coefficient of resistance, approximately 2.5 per cent per degree F., and with a high specific resistivity. This results in a device which can be easily coupled to a valve amplifier and the input leads may be hundreds of feet long if necessary.

The basic circuit is shown in Fig. 3, and operates as follows. When the resistance of the bulb changes, an A.C. voltage appears across the usual " galvanometer " points and is applied to the triode amplifier in the next section.

The output stage is a discriminating circuit which receives an A.C. input and delivers a pulsating D.C. flow between the anodes of the two triodes, capable of operating an indicating instrument or a sensitive relay. This stage is in itself a Wheatstone bridge, with one triode section serving as the variable arm. Change of D.C. output with variation of the resistance of the bulb is produced by feeding the double triode in the last stage with A.C. If the A.C. voltage from the bulb circuit is in phase with the anode voltage of the output stage the triode anodes will be positive when the grid of the left hand valve is positive. Consequently, the impedance of the left hand valve will be lower than that of the right hand one and current will flow in one direction through the meter or relay. If, however, the bulb circuit voltage is 180° out of phase with the output stage anode supply the meter or relay will be supplied with D.C. of reversed polarity.

The advantages of this electronic thermometer over the more conventional types are:

1. The control circuit is independent of mains voltage variations.

2. The bulbs can be made exceedingly small.

3. The heat lag of the bulbs, even when of normal size, is much less than with most conventional types of temperature controls.

4. The device is inherently a remote control or indicating device owing to its high input impedance.

### Simple Heat Control Methods

Probably the easiest method of applying electronics to heat control is to use a photo-cell in conjunction with a mercury or alcohol thermometer set up as shown in Fig. 4. It is very useful for many observation purposes since it is generally easier to note the change in anode current of a thermionic valve rather than to read a thermometer accurately. In addition, a relay may be operated as well. The arrangement has the advantage over thermometers with fused-in contacts, that any thermometer can be used and the device is adjustable over quite a wide range of temperature. The pinhole should be near to the thermometer, in fact, it should be set up in a similar manner to the light beam in the sound head of a talking film projector, *i.e.*, with a very narrow slit. Under such conditions a sharp cut-off will be obtained.

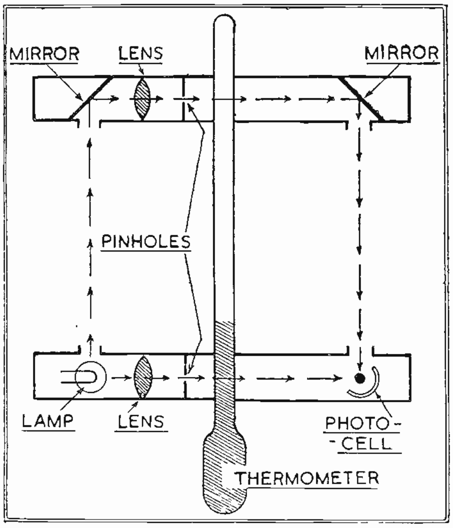



**Fig. 4. (left)**
**Ordinary thermometer with simple high/low photocell observation device.**

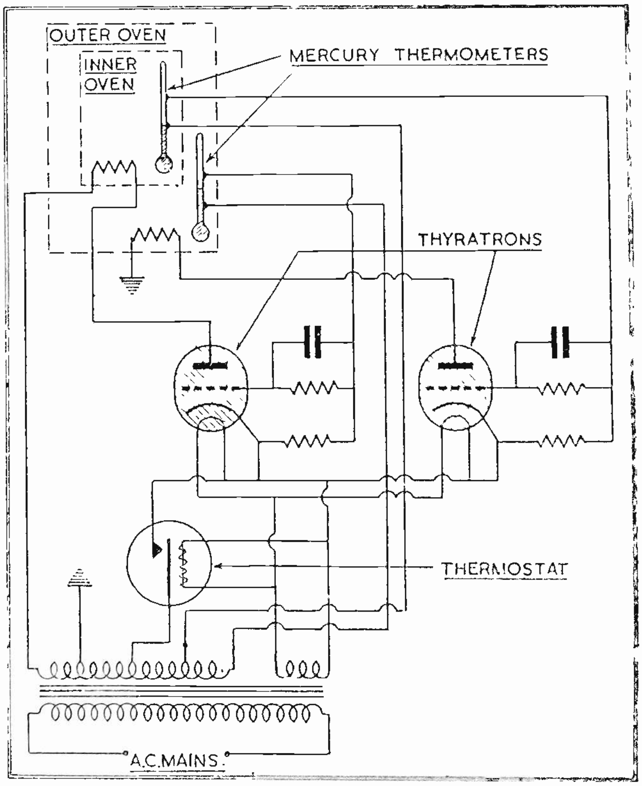



**Fig. 5. Arrangement for maintaining constant temperature oven, suitable for crystal oscillators**

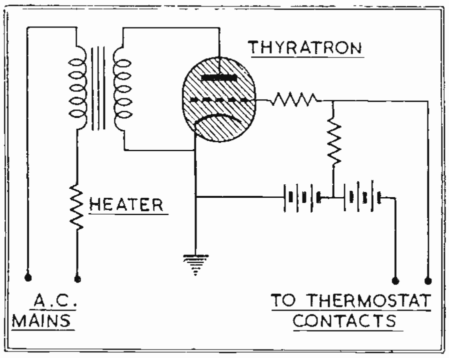



**Fig. 6. (right)**
**Simple electronic thermostat using thyratron relay.**

**Resistance Thermometer with Electronic Additions**

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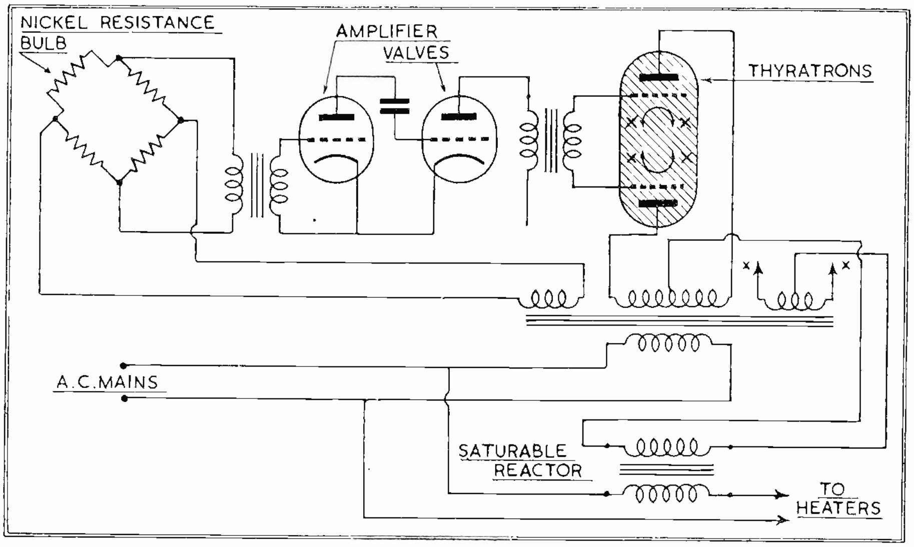


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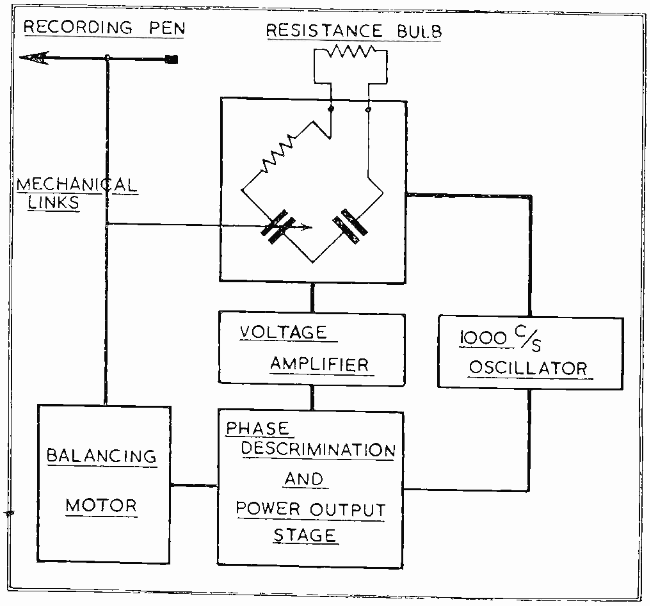


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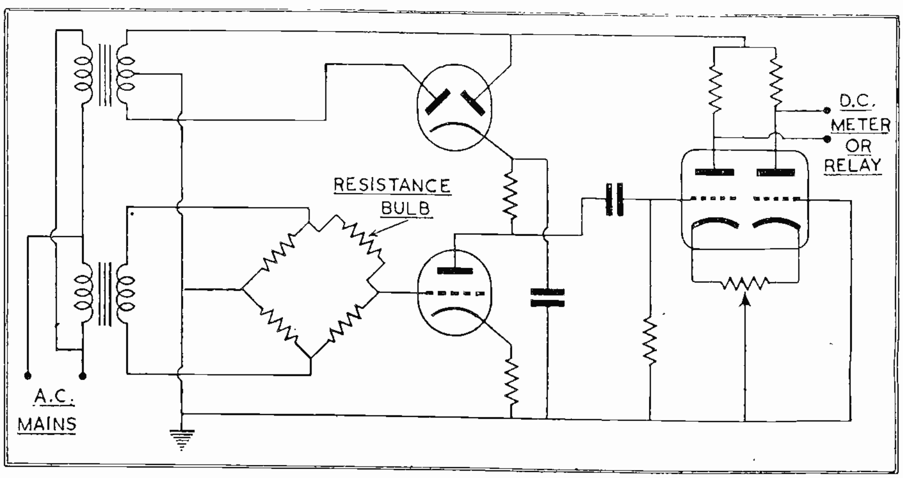

core movement depends only on the relative coil currents and not on the core position.

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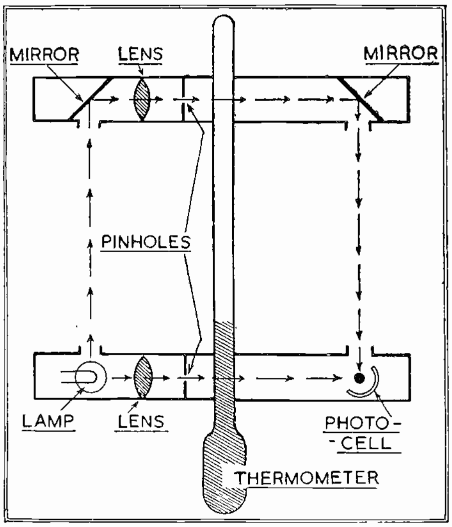



**Fig. 4. (left)**
**Ordinary thermometer with simple high/low photocell observation device.**

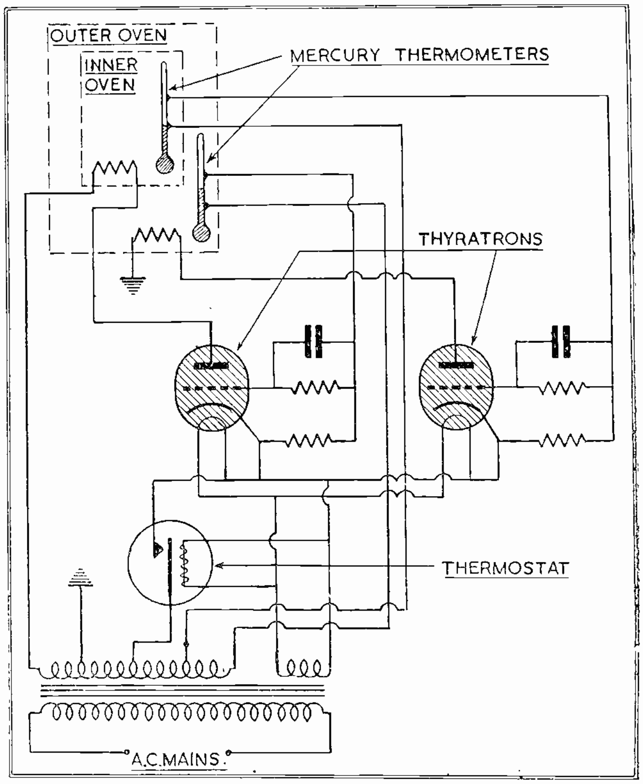
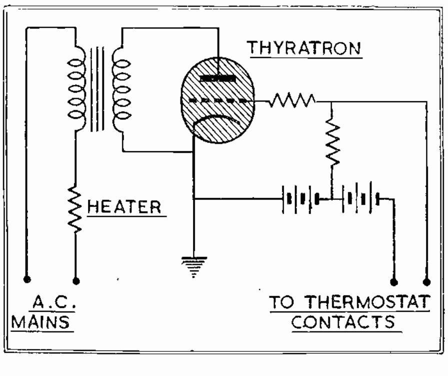



**Fig. 5. Arrangement for maintaining constant temperature oven, suitable for crystal oscillators**

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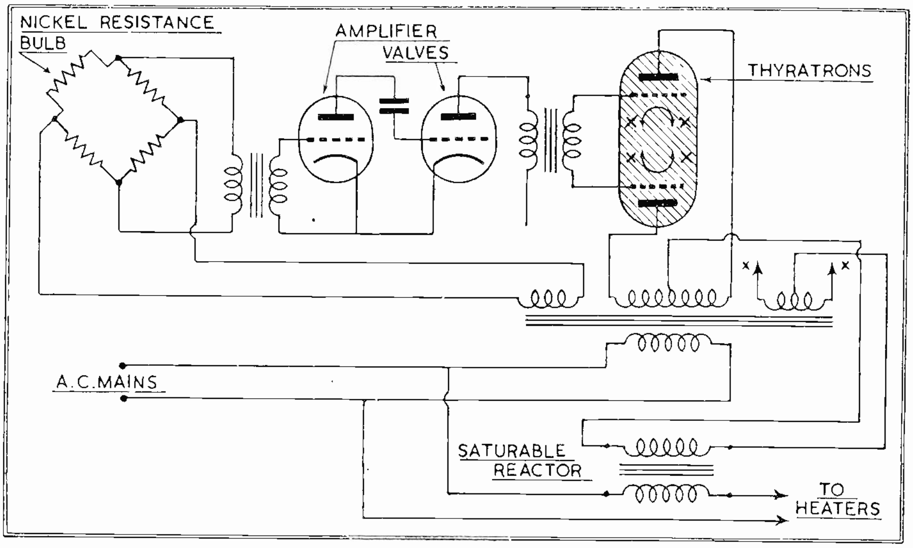


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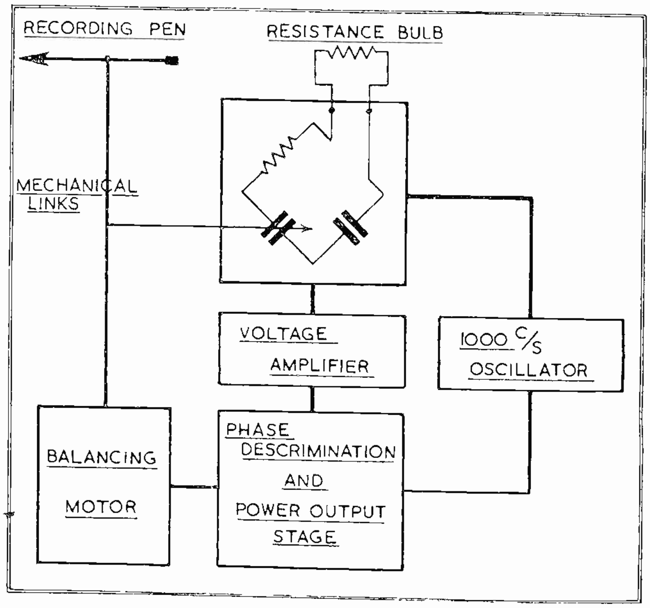


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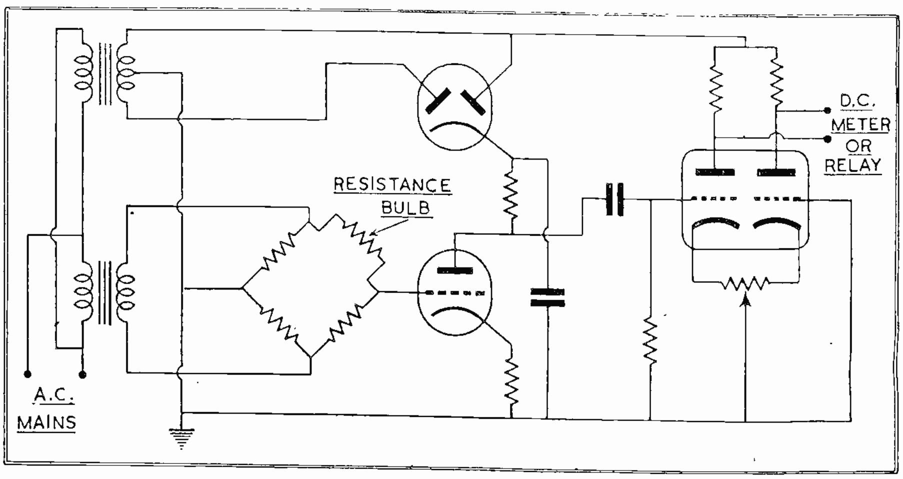

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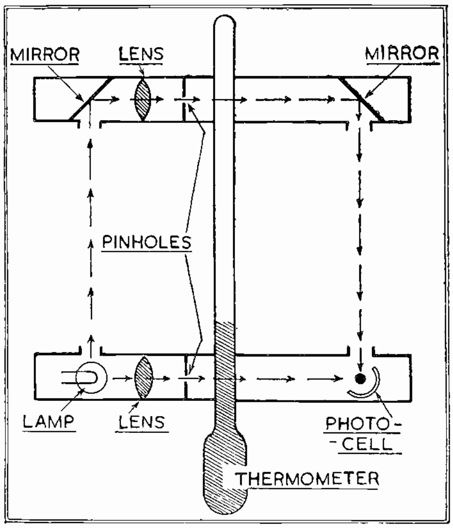


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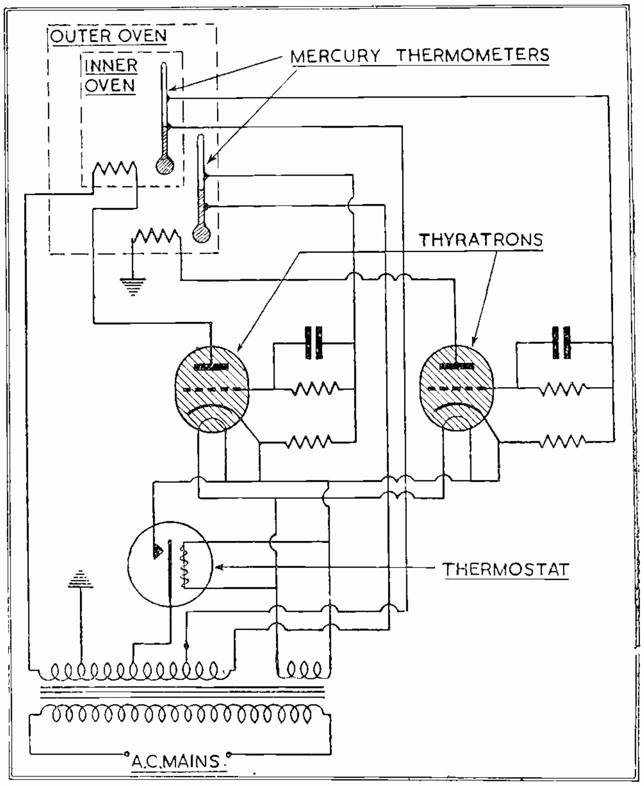


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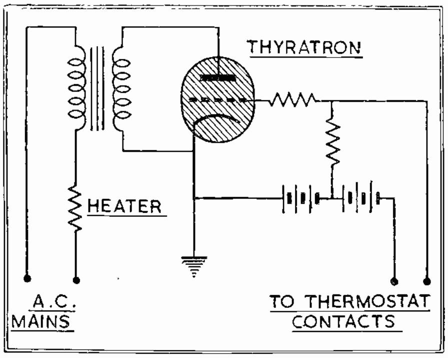


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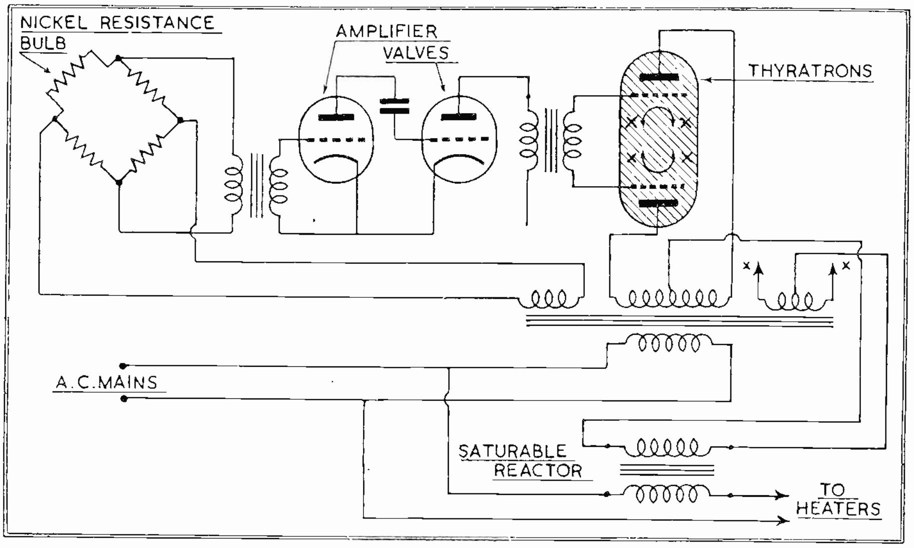


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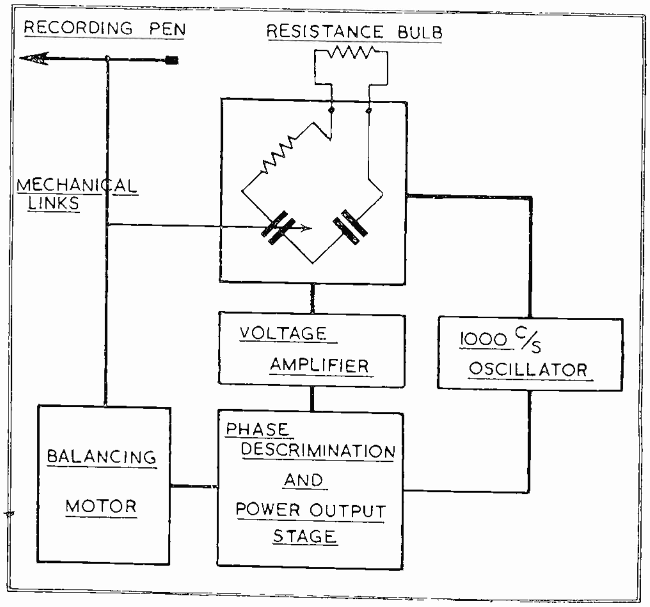


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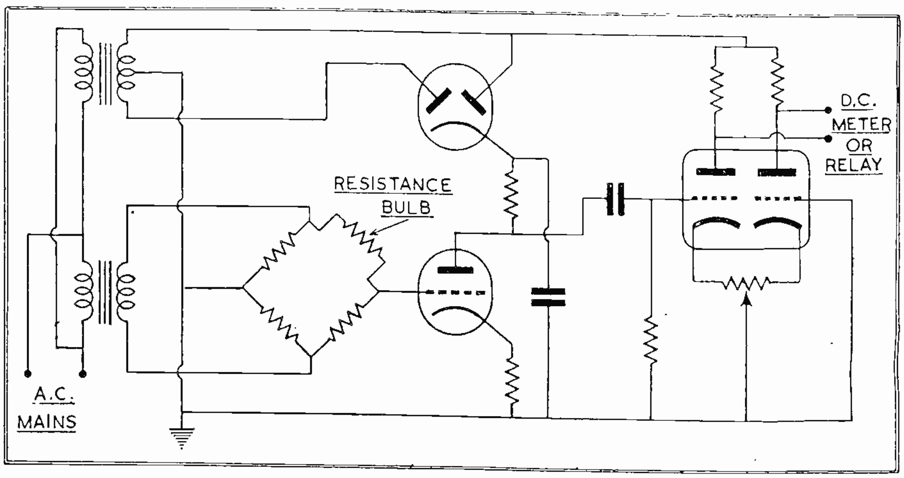

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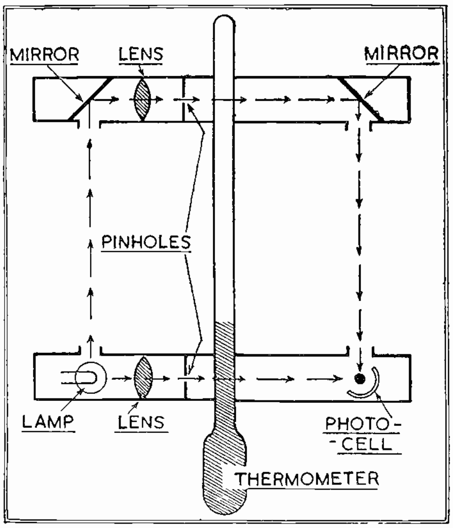


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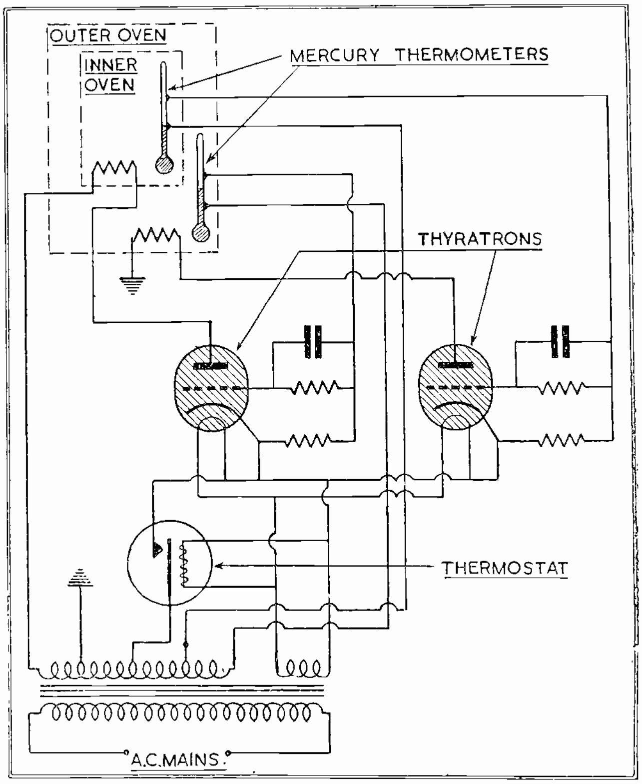


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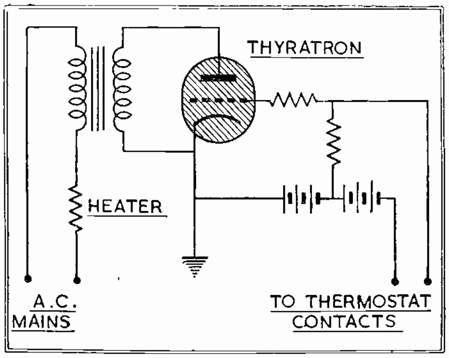


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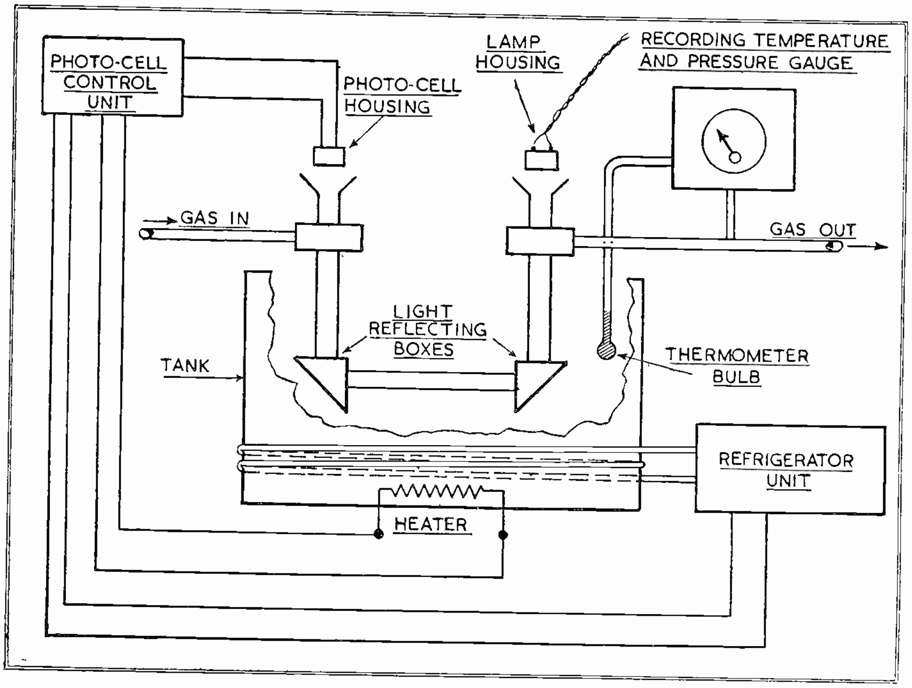



Fig. 7. Dew point determination apparatus.

Where the operating temperature of a chamber is permanently fixed, such as in the constant temperature ovens used for housing the quartz crystals of radio transmitters, another but almost as simple method may be adopted.

At first consideration, it would seem that a greater constancy of temperature could be achieved if the oven was lagged with asbestos, glass wool or cork in addition to a simple thermostatic control.

This is, of course, true, but an even better plan is to surround the chamber under control with an air space maintained as closely as possible at the same temperature. Then, since the perfect heat insulator for a body is something at the same temperature, the inner chamber will remain at a very constant temperature over a long period, providing that BOTH chambers are maintained individually at the desired temperature.

A typical circuit arrangement is shown in Fig. 5 where the primary thermostats are mercury-in-glass thermometers with platinum contacts fused into the glass.

Another convenient plan for keeping chambers at comparatively constant temperatures is to use a bi-metallic strip in conjunction with a valve amplifier having a relay in its anode circuit. The advantage of using a valve is that the strip contacts have only to break the minute grid current and can be made to work with very small gaps and without danger of destruction by sparking. Should it be desired to dispense with moving parts, it is possible to use a toluol thermostat and a grid controlled valve in a circuit similar to Fig. 6, where electro-mechanical relays are not used, the local current being carried by the thyratron.

### Dewpoint Recorder

A somewhat unusual use of an electronic device in connexion with temperature is in a dewpoint recorder developed by the company handling the natural gas given off by certain American oil wells in Texas. The reason for wishing to know the dewpoint was to guard against condensation and freezing in the pipes during winter.

A diagram of the apparatus is given in Fig. 7. It consists of a small tank filled with a non-freezing solution into which is immersed a U-shaped tube, gold plated and highly polished on the inside; also fitted with windows of plate glass at each end. The gas passes through the tube and light shines in at one window while a photo-cell is placed at the other. For controlling the temperature of the tank solution, cooling is provided by the coils of a small domestic refrigerator unit and heating is provided by strip heaters.

The liquid is cooled until the gas is chilled sufficiently for a film of moisture to condense on the inside of the highly polished tube and so reduce its power of reflecting light on to the photo-cell. Relays operated by the cell switch on the heaters which warm the solution until the condensate disappears and the cycle then repeats.

A recording thermometer registers the temperature at which condensation appears and vanishes, with a pressure record on the same charts and from these data the dewpoint can be calculated. The cycle repeats about every 10-15 minutes and the apparatus does automatically what would otherwise require the continuous attention of an operator.

## S.I.M.A. Electronics Symposium

SPEAKING at the Electronics Symposium organised by the Scientific Instrument Manufacturers' Association at Caxton Hall, Westminster in November last, Sir Edward Appleton, Secretary of the Department of Scientific and Industrial Research said that every industrial firm ought to be constantly asking itself the question "Cannot we do this operation better by electronic equipment?"

Very often the introduction of electronic equipment in industrial processes resulted in remarkable economies. In sugar refining, for example, the presence of pieces of metal will cause scoring of the rollers which may result in a drop of output of as much as 5 per cent. In an average mill this would mean a loss of 3,750 tons of sugar annually, worth £100,000. This can be saved by installing, at a cost of about £600, an electronic metal detector associated with an automatic rejection mechanism.

Another example, from the manufacture of plaster building boards, illustrated the extraordinary range of applicability of electronic devices. The plant often delivers boards of lengths which are greater or less than the permitted range. At one time the boards were measured and sorted by hand—a tedious business. Electronic devices nowadays measure the boards automatically during manfacture and mark them undersize or oversize with splashes of coloured paints so that subsequent sorting can be carried out easily and quickly.

# Simplified Resistance Calculations

## 1. Operating Chart for Resistors

By J. C. FINLAY*

THE basic resistance laws are very simple, but their application in electronic circuits is often tedious, owing to the small current and high resistance values generally dealt with. To a certain extent, working can be eased by modifying units such as volts equal not only amps × ohms, but milliamps × kilohms or microamps × megohms. Even so, wattage dissipation is not so readily dealt with and, in moments of stress particularly, it is easy to slip a decimal point. Consequently, the Resistor Chart has been designed to give at a glance all the useful interrelated values of current, resistance, voltage and power.

Providing any two of the four factors Current $I$, Resistance $R$, Voltage Drop, $V$ and Power $P$ are known, the remaining two can be read off immediately as a consequence of the well-known formulæ: $V = IR$ $P = VI = V^2/R = I^2R$

Logarithmic scales are used to make plotting linear, and give uniform accuracy of reading at any point. The ranges cover all low to medium power electronic apparatus, working up to 10 KV to include cathode-ray tubes. It will be noted that the resistance scale is based on the ISCC † standard range of carbon resistors from 10 Ω to 10 MΩ, the intervals corresponding to the 20 per cent. tolerance range. These figures are evenly spaced on the logarithmic scale, each being approximately 1.5 times the previous value. The 10 per cent. tolerance range can be used by halving the spacings, as laid out, by eye. When dealing with any other general values of resistance the intervals 1, 1.5, 2, 2.5, 3, etc., agree with the corresponding intercepts of the diagonal voltage lines on the resistance scale.

In reading values from any given *point* on the chart, current is taken horizontally, resistance vertically, voltage on the light 45° diagonals and power on the heavy diagonals. The lowest power rating shown is $\frac{1}{4}$ W, but $\frac{1}{8}$ W resistors are now commonly available and the chart can be extended for this value by drawing another line equidistant below the $\frac{1}{4}$ W line. The highest power ratings are included for convenience in dealing with composite systems and voltage droppers, etc.

* Welwyn Electrical Laboratories Ltd. Formerly of A. Reyrolle & Co., Ltd.

† Interim Working Schedule of Fixed Resistors ISCTechC RC.L/110.11 Issue 1 Sept. 1944.

### Single Resistance Values

*Example* 1.—What current may be passed through 1W resistors of 680Ω and 100 KΩ? The respective values are given horizontally as 38 mA and 3.2 mA, respectively, where the 1 W power line cuts the verticals for 680Ω and 100KΩ.

*Example* 2.—A bias of 2.5 V is required for a tube passing 5 mA. Then the resistance required is given where the 2.5 V line cuts the 5 mA horizontal just near the 470Ω vertical, which is therefore the correct standard value to use. This point is also well below the $\frac{1}{4}$ W line, so that a $\frac{1}{4}$ W rating will afford a large safety margin.

*Example* 3.—Design a bleeder to take 20 mA at 400 V. From the chart, the resistance is 20 KΩ and must dissipate 8 W. Assuming only 2 W components are available, this could usually be done sufficiently well by connecting four 4.7 KΩ 2 W resistors in series (the resistance scale also acts as a convenient reminder of standard values).

### Series and Parallel Working

Apart from giving data on a single resistance value, composite chains, etc., may be quickly solved by suitable procedure:

*Example* 4. — A 500 V supply operates three parallel resistors of 6.8 KΩ, 22 KΩ and 1 MΩ. Then the currents and wattages are read off along the 500 V line against the respective resistances as 74mA 40 W, 23 mA 12 W, and 500 μA $\frac{1}{4}$ W.

### Equivalent Parallel Resistance

The chart can also be used to give approximate values of the equivalent resistance of several parallel resistors without using any other calculation than simple addition. The method is essentially to find the current flow in each resistor for a given voltage, sum the currents and hence find the equivalent resistance against the common voltage. Any convenient voltage diagonal may be used for this purpose, the method of working being essentially the same as for Ex. 4.

*Example* 5.—Find the equivalent resistance of 1 KΩ, 4.7 KΩ and 10 KΩ in parallel. Using the 10 V line for convenient reference, corresponding currents are 10 + 2.1 + 1 mA = 13.1 mA and against this figure on the 10 V line is read approximately 800 Ω (762 Ω correct).

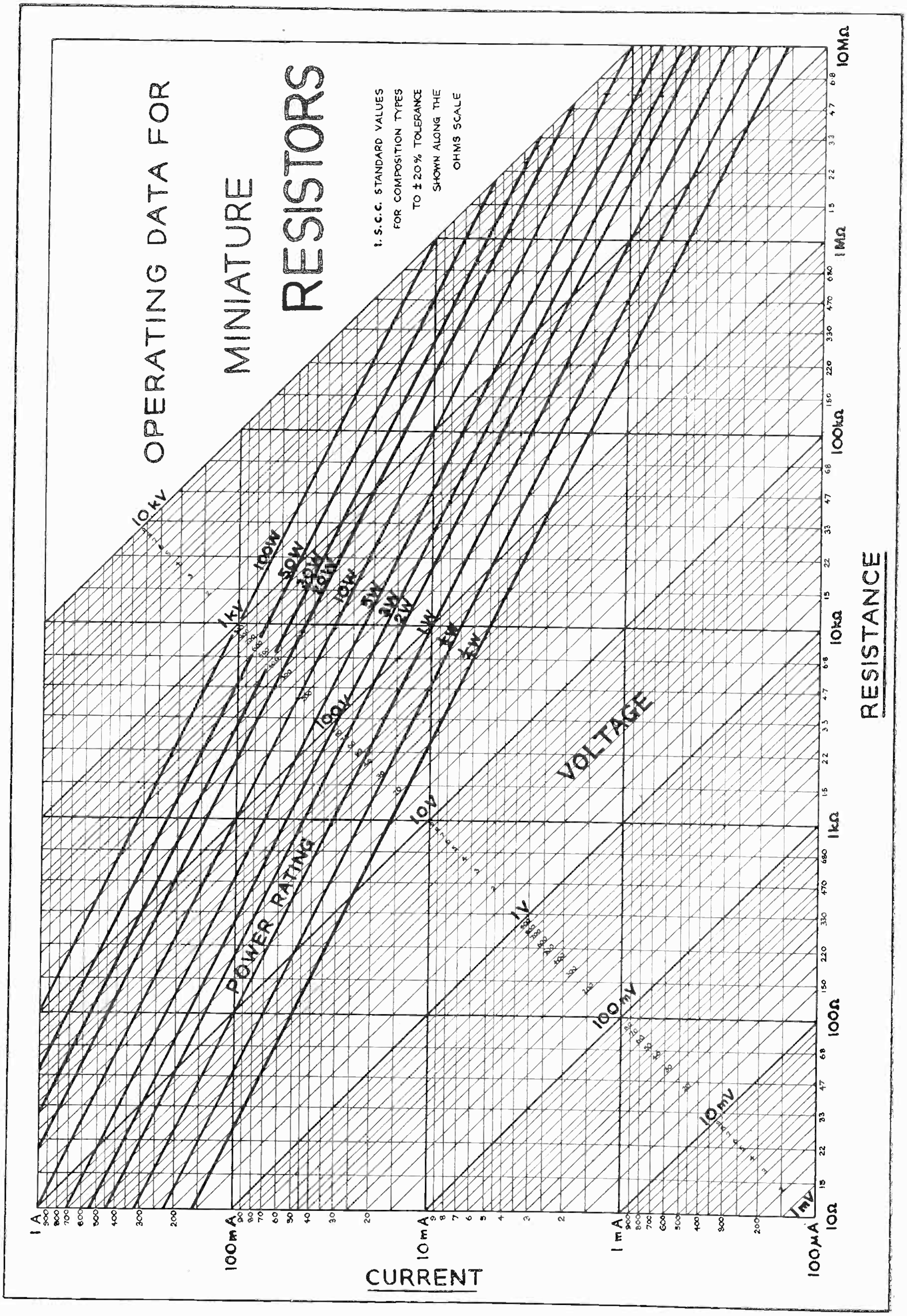
### Accuracy

The general accuracy of working should be within 5 per cent minimum. This covers all calculations in the Grade 2 range*, resistors of the carbon composition type. Of the three accepted tolerances, ± 20 per cent is commonly used for grid-leaks, decoupling and filtering, ± 10 per cent for load and autobias resistors, electrode voltage droppers, etc., and ± 5 per cent for more critical amplifiers, feedback control resistors, etc. Grade 1 resistors are intended for use where the stability of the resistance under under all conditions is important, such as in voltmeter dividers, attenuators, etc. The tolerances here are ± 5%, 2%, 1%, which can be met by cracked-carbon or "pyrolytic" films. The chart is insufficiently accurate to evaluate VIR relations for the highest Grade 1 tolerances, but it may be used to estimate the necessary wattage ratings.

### Current and Voltage Ratings

The wattage rating is of prime importance to the manufacturer, but the user is more concerned with the *current* which can be passed through a given resistor. It might therefore seem desirable to mark resistors directly with current and voltage ratings, but it is difficult to do so, particularly on small diameter resistors, owing to the amount of essential information already required. It should be remembered that there is an upper limit of safe working voltage which, particularly in the case of individual resistors over about 100 KΩ may prevent the wattage rating being realised.

* Guide on Fixed Resistors ISCTechC BS RC.G/110 Issue 1 Aug. 1944.


OPERATING DATA FOR
MINIATURE
RESISTORS
I.S.C.C. STANDARD VALUES
FOR COMPOSITION TYPES
TO ±20% TOLERANCE
SHOWN ALONG THE
OHMS SCALE
POWER RATING
VOLTAGE
RESISTANCE
CURRENT
10kV
1kV
100V
10V
1V
100mV
10mV
1mV
100W
50W
20W
10W
5W
3W
2W
1W
1 A
100mA
10mA
1 mA
100µA
10Ω
100Ω
1kΩ
10kΩ
100kΩ
1MΩ
10MΩ

# 2. Calculation of Parallel Resistances

By F. OAKES

VARIOUS methods have been suggested in the past to find the substitution value for a combination of resistors in parallel,[1,2,3,4] (or capacitors in series, which amounts to the same numerical problem). Most of them are based on finding the reciprocals of each value to be combined, and consequent summation to obtain the reciprocal of the final result. One calculator makes use of two pieces of thread fixed to a sheet of graph paper on cardboard. This type, although quite easy to operate, suffers from the inherent inaccuracies and other draw-backs of its mechanical construction. All these methods involve the jotting down or the reading and re-introduction of intermediate results, especially where more than two resistors (or condensers) are combined.

A method overcoming these disadvantages is the use of the simple, accurate, and easily constructed nomogram shown in Fig. 1. It consists of four linear scales A, B, C, and D, meeting in a centre point O so that each two adjacent scales include an angle of 60°. To find the combination of two resistors $R_1$ and $R_2$ in parallel, place a straight edge cross the nomogram so that it meets A in $R_1$ and C in $R_2$. The combination value $R_{1,2}$ will then appear where the edge meets B. This is illustrated by the dotted line $R_1 - R_{1,2} - R_2$ in Fig. 1.

To find the combination value of several resistors, say, $R_1, R_2, R_3, R_4$, a process of "successive shunting" can be used as follows: Place the edge across $R_1$ on A and $R_2$ on C, then turn the edge about $R_{1,2}$ thus obtained on B (this value need not be read off) until it meets $R_3$ on D, thus obtaining $R_{1,2,3}$ on C. Now turn the edge round $R_{1,2,3}$ until it meets $R_4$ on A, thus obtaining $R_{1,2,3,4}$ on B, which is the required value. This is illustrated by the dotted lines in Fig. 1. Obviously this process can be continued for any number of resistances. As in all these methods, it is a good scheme to begin with the highest resistance, and to work down to the lowest.

### Shunting Resistances

The nomogram is also very useful in finding the shunt for a given resistance to reduce it to a given

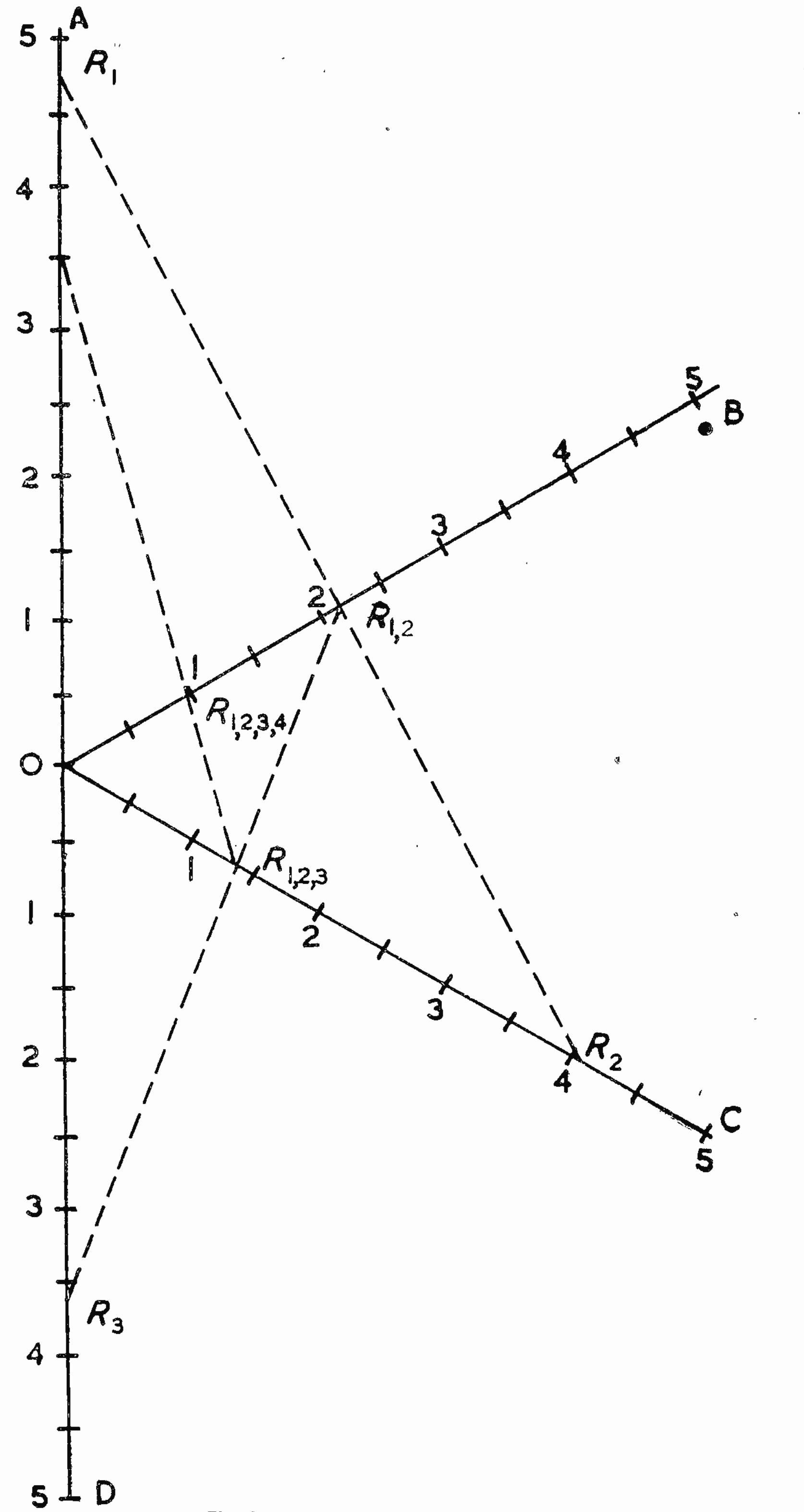



Fig. 1. Nomogram for parallel resistors

lower value. The procedure is as follows: Place a straight edge through the mark for the given resistance on scale A, and the given lower value on scale B. The required value of shunt resistance will then lie where the edge meets scale C. An application of this is the selection of two fixed resistors of "preferred" value to be combined to a given required value.

A model of the nomogram is easily made by using a piece of white cardboard or by pasting a sheet of paper on cardboard.* The four scales can then be drawn accurately at 60°, and the scales marked in. If an alternative set of figures is put to the scales in red ink (*e.g.*, 1, 2, 3, in black and 5, 10, 15, in red) the most suitable of them can be selected for any given problem.

### Proof

A geometrical proof of the method is given below. Consider Fig. 2. A straight line parallel to scale OB is drawn through the mark D, at a distance $R_2$ from O. Thus, AOB and ADC are similar triangles.

$$R_{1,2} : R_1 = R_2 : (R_1 + R_2)$$

$$\therefore R_{1,2} = \frac{R_1 \times R_2}{R_1 + R_2} \text{ or}$$

$$\frac{1}{R_{1,2}} = \frac{1}{R_1} + \frac{1}{R_2}$$

This is the formula for two resistors in parallel.

### Use of Slide Rule

For those who prefer the use of a slide rule to the graph or nomogram, a method is given below whereby the jotting down of intermediate results, reciprocals, etc., for subsequent summation, the summation of more than two terms at a time, reversing of the slide, and other tedious operations, are eliminated. The possibilities of numerical errors are thus considerably reduced. The normal scales on the slide rule are used.

According to Fig. 3, the combination resistance appears under $R_2$ if the sum of the resistances is set above $R_1$. In other words, to find the combination resistance, proceed as follows:

(1) Set the cursor-line to $R_1$ on the rule.

(2) Move $R_1 + R_2$ (easily added without jotting down) on the slide so as to lie under the cursor-line.

(3) Move the cursor-line to $R_2$ on the slide.

* The paper must be allowed to dry before drawing the chart.

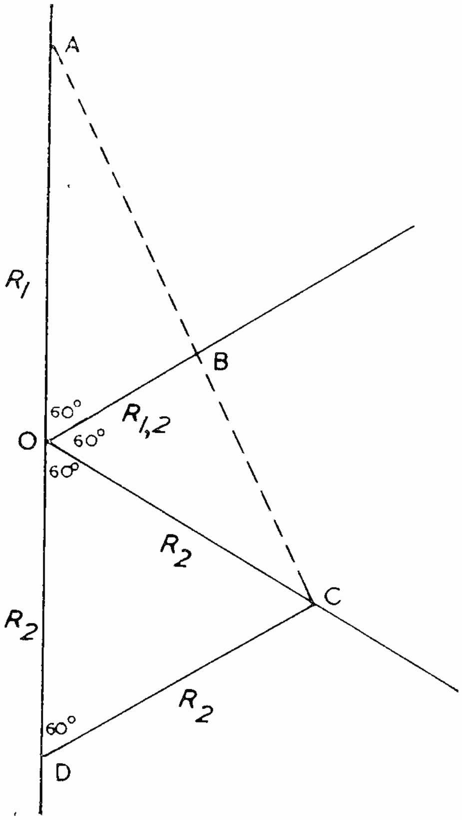



**Fig. 2. Construction for geometrical proof of method**

(4) Read the result, namely $R_{1,2}$ on the rule under the cursor-line.

If a further resistor $R_3$ is also in parallel, proceed as follows:

(5) Add $R_3$ to the result just read off, (this can be done mentally and need not be written down) and move the slide so that the sum just worked out lies under the cursor-line.

(6) Move the cursor to $R_3$ on the slide.

(7) Read the result $R_{1,2,3}$ under the cursor-line on the body.

Further resistors can be shunted analogously.

It may be objected that in this method additions have to be carried out just as in the reciprocal value method, but it should be remembered that there, all the reciprocals have to be evaluated and written down for subsequent addition, whereas in the method given here, only two numbers have to be added at a time; the sum is immediately utilised and not needed later on for subsequent operations. (It will also be found in practice that the additions to be carried out become progressively simple for each step.

A proof is given below. The slide rule is shown in the final position in Fig. 3. For this position, the following equation is valid, as is well known.

$$\frac{R_{1,2}}{R_2} = \frac{R_1}{R_1 + R_2}$$

$$\therefore R_{1,2} = \frac{R_1 R_2}{R_1 + R_2} \text{ or}$$

$$\frac{1}{R_{1,2}} = \frac{1}{R_1} + \frac{1}{R_2}$$

For consequent steps the same proof can be used remembering that $R_{1,2}$ then just replaces the first two resistors, and $R_3$ is shunted to $R_{1,2}$. The process is simply repeated.

### Example

*Given* $R_1$ = 4,750 ohms
$R_2$ = 4,100 ohms
$R_3$ = 3,650 ohms
$R_4$ = 3,550 ohms

To find the combination resistance of $R_1$ and $R_2$ use the graph as shown in Fig. 1 by the dotted line $R_1 - R_2$ or slide rule as shown in Fig. 3.

$R_{1,2}$ = 2,200 ohms

If the process is continued, as shown in Fig. 1 by the other dotted lines, or by slide rule, as described in this paper, the result will come out as very nearly:

$R_{1,2,3,4}$ = 1,000 ohms.

### References.

1 R. T. Beatty *Radio Data Charts* (Iliffe).
2 *Wireless World*, September, 1942.
3 *Wireless World*, March, 1945.
4 *Wireless World*, April, 1945.

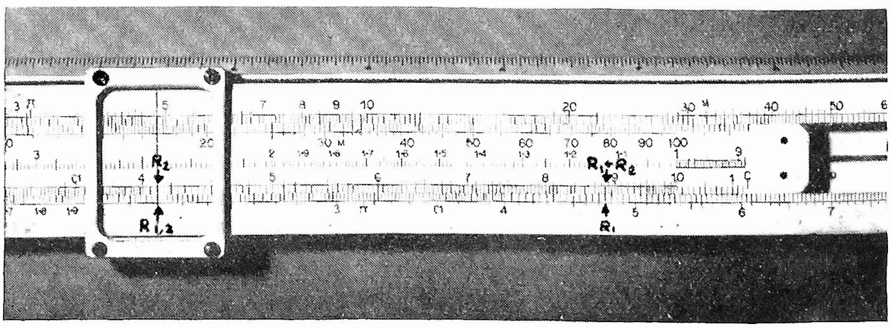



**Fig. 3. Slide rule setting for calculating parallel resistances**

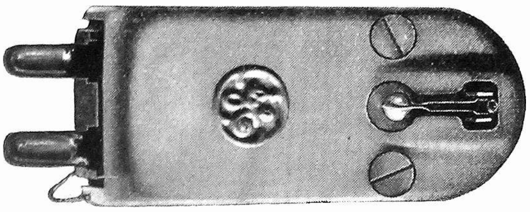


Fig. 1. Underside of Pickup

# The G.E. Variable Reluctance Pick-Up

By ALAN DOUGLAS

RECENT research into the preferred forms of gramophone pickup for accurate translation of the recorded matter has led to several very interesting designs.

Analysis of the alternative existing types suggests that while all have some special merit, all suffer from the defects inherent to an interchangeable stylus. These are: (a) loss in transmission of the higher frequencies due to radiation from the needle, (b) standing waves set up on the needle due to its own natural frequency, (c) cross modulation of the armature or active element due to flexure in some plane other than that of the recording (unavoidable where there is any rake on the needle), (d) general loss of energy from the groove due to the irregular frequency transmission characteristics of the needle. In addition, the damping may cause mutilation of the signal in one way or another.

The G.E.* variable reluctance pickup is designed to overcome most of these defects. Fig. 1 shows the underside of the unit with the stylus/armature assembly and pole pieces. The sapphire or diamond stylus is incredibly small and stiff, less than 1/16th in length and having an included angle of 50° with a tip radius of 0.003 in., this form represents the maximum possible stiffness. Owing to the density of sapphire, with its absence of grain, there is no internal loss in the stylus. The dynamic mass of the stylus is 8 by $10^{-3}$ gm, and it is mounted vertically.

* The General Electric Co. of America.

The armature is a small ring of iron into which the sapphire is spun, and is anchored at the end to a strip of steel which is flexibly attached to a post on the body of the pickup. The small resonance in the suspension is damped by a piece of plastic material in tension, and this is effective while still transmitting frequencies up to 15 Kc/s. The total suspension compliance is only 0.87 by $10^{-6}$ cm. The design is so contrived that only lateral vibrations are transmitted to the stylus; there is no response to the vertical noise components on the record. Under these circumstances, a small pressure only is required for the unit to track satisfactorily; between ¾ oz. and 1¼ oz. The pickup is less than 1¾ in. long by ¾ in. wide.

Fig. 2 shows the signal coils and pole pieces. The wide air gap gives substantially uniform velocity-frequency characteristics, which can be readily compensated as required. The double coil construction is so designed as to reduce mains hum. The inductance of the system is 240 millihenries at 1,000 c/s.

As might be expected, the output is very small; this, of course, is common to all high quality microphones. A test frequency record at 1,000 c/s. shows that 11 mV is obtained under a stimulus of 4.8 cm/sec. Thus some preamplification is desirable.

Fig. 3 shows a suitable circuit for this purpose. The input shunt resistor of 6,800 ohms can be varied to control the frequency response. A higher value will increase the H.F. response, while a lower value will reduce it. Note that a low anode voltage is desirable. The filter circuit of 27 K and 0.01 μF produces an attenuation at 50 c/s.; it is intended to reduce the rumble from automatic record changers. A slight improvement in response may be effected by shunting the 0.01 μF condenser by a resistance of 180 K ohms. The gain with a 6SC7 valve is 35 db. at 1,000 c/s.

Results from this reproducer suggest that it represents the greatest advance in faithful reproduction so far attained. There is no "needle talk" and the surface noise from a good pressing is negligible.

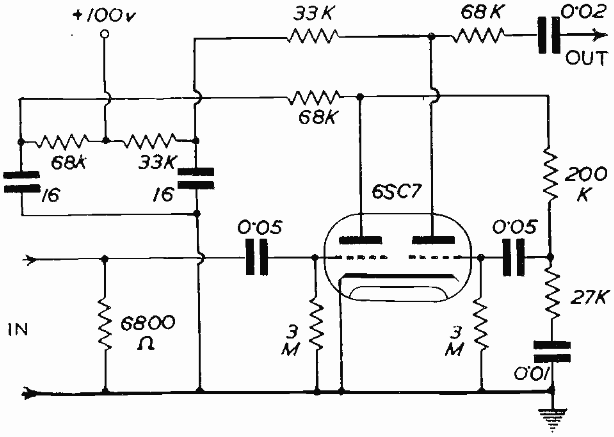



Fig. 3. Suitable circuit for pre-amplifier

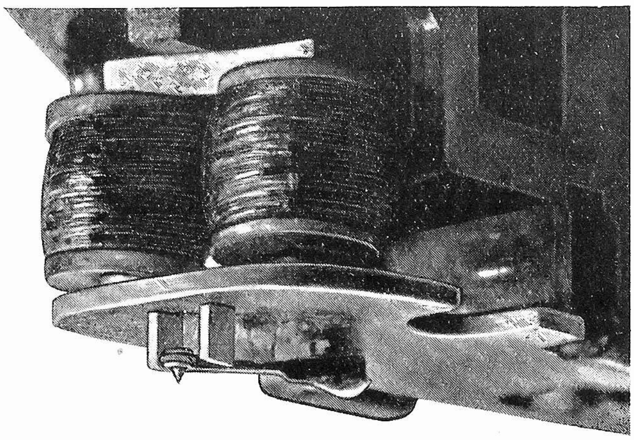


Fig. 2. Enlarged view of coils and pole pieces

# A Direct Reading Impedance Meter

By N. H. CROWHURST

FOR precision measurements, the various bridge circuits available may be used to compute accurately any resistance, reactance, or complex impedance. But for a considerable amount of work, the "Ohmmeter" type of instrument gives a quick check of resistance values which is far less cumbersome than the use of a bridge, and with careful calibration can give readings within about 2 to 5 per cent. The instrument here described applies the same principle to the measurement of complex impedances, or referred resistances, as transferred by a transformer, and has proved to be a very useful instrument.

## Principle of the Ohmmeter

Fig. 1 shows the basic circuits of two types of ohmmeter. In each case the reading is basically a comparison between the internal resistance, *R*, and the external resistance to be measured.

In the case of the circuit shown at (a), the circuit is arranged so that short circuiting of the external terminals produces full scale deflection of the movement, which becomes the zero of the scale calibration. Introduction of resistance between the terminals reduces the less deflection, and the scale is calibrated to give an indication of the value of resistance connected.

In the case of the circuit shown at (b), the movement is arranged as a voltmeter, which gives full-scale deflection when the external terminals are open circuited. Connexion of an external resistance produces a drop in voltage across the movement, the internal resistance *R* and the external resistance acting as a potentiometer. Again the scale is calibrated in terms of the external resistance connected, but zero will in this case correspond with zero deflection.

In each case an external resistance equal to *R* (actually equal to the effective internal resistance, including the movement) will produce a half-scale deflection, and the scale for the type of Fig. 1b is the inverse of that for that at 1a.

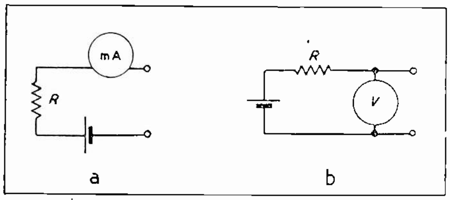



Fig. 1. Basic circuits of two types of ohmmeter

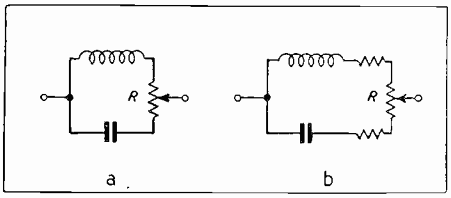



Fig. 2. Constant impedance variable phase circuit

## Application to Impedance Meter

If the movement is arranged to indicate A.C., the same scale calibration will hold, provided that both internal and external resistances are, in fact, pure resistances. But if one of them is somewhat reactive, the reading is modified by the fact that the voltage across each are not now arithmetically equal in sum to the applied E.M.F., but it is their vector sum which makes the total.

But if some arrangement can be made so that the internal and external impedance have the same phase, the indication given may still be a comparison between the two. It thus appears that a network, the impedance of which can be maintained constant while its phase is varied to correspond with that of the external impedance, is required to replace *R* of Fig. 1.

## Variable Phase Device

Fig. 2 shows a circuit which provides an impedance capable of being varied in phase, while maintaining almost constant value at the frequency for which it is designed. The values are chosen so that the impedance at each end setting is equal to that at the centre setting. Under these conditions, using pure reactances, as shown in Fig. 2a, the impedance can be varied in phase from approximately 70.5° inductive to 70.5° capacitative, while the variation in impedance value is as shown in Fig. 3. The total variation in impedance is about 6 per cent. of

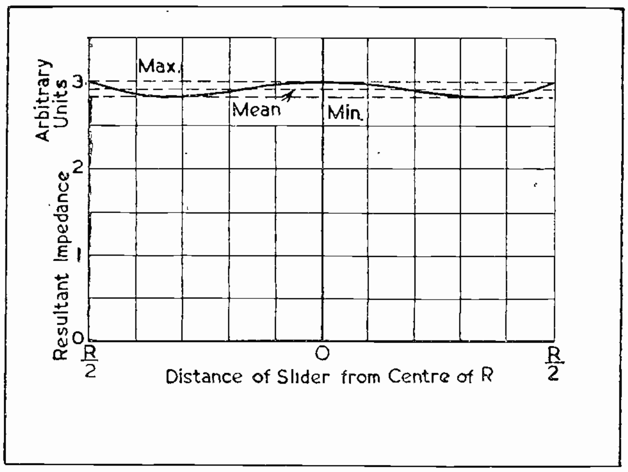



Fig. 3. Variation of impedance with R of Fig. 2

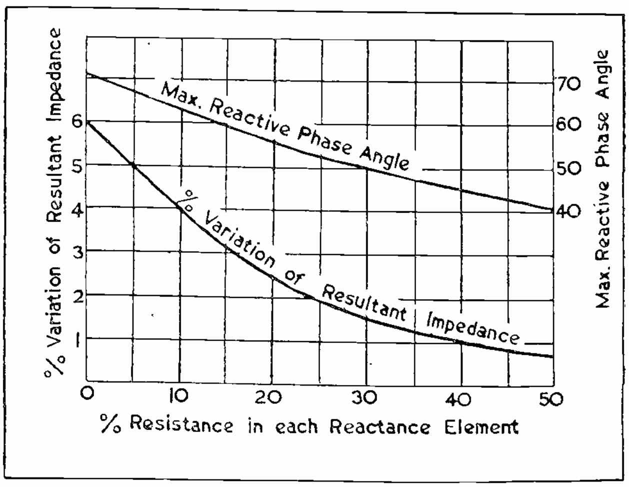



Fig. 4. Variation of impedance with series variable resistance

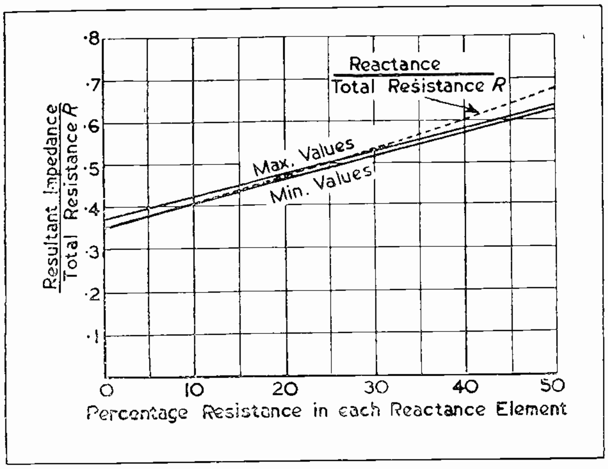



Fig 5. Curves of impedance against percentage resistance
The dotted curve gives the impedance in terms of *R*

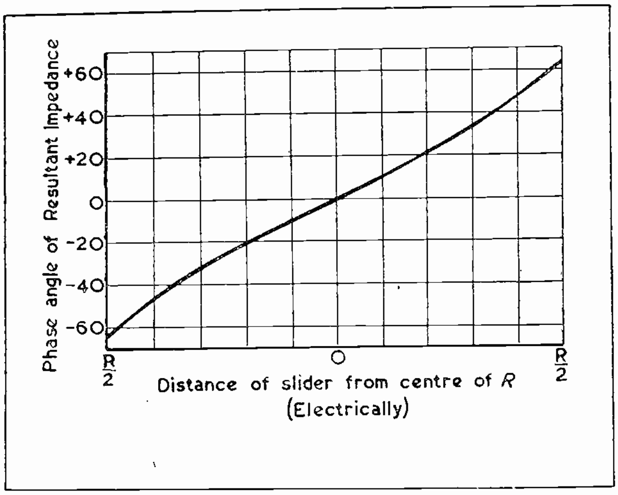



Fig. 7. Calibration curve of phase angle against slider distance

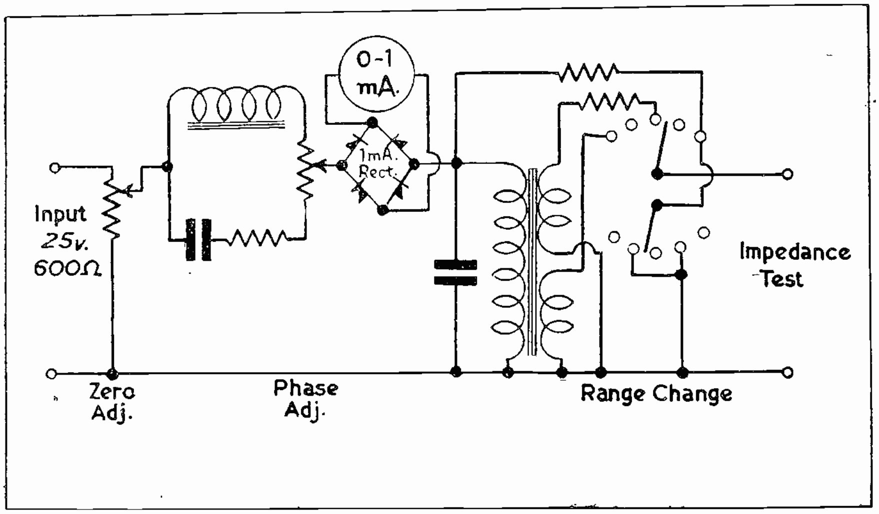



Fig. 6. Complete circuit of impedance meter

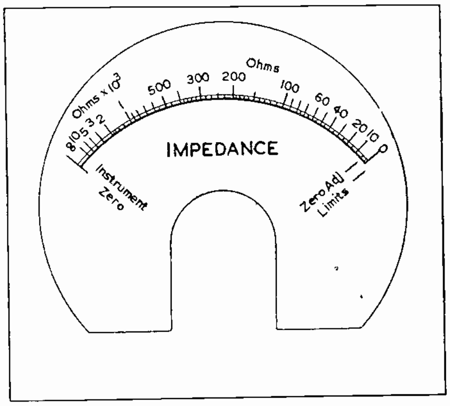



Fig. 8. Scale of impedance meter

its mean value, which means that it is always within plus or minus 3 per cent. of this value.

In practice, the inductance will not be a pure reactance. This fact can be turned to advantage in improving the accuracy of the device. If an inductance of known resistance is used, and an equal fixed resistance is inserted in series with the condenser element, the degree of phase variation is reduced. By readjusting the relative values so that the impedance at each end setting is still equal to that at the centre setting, the variation of impedance over the range is also reduced. These reductions are plotted in Fig. 4, in terms of the resistance in series with each reactance, expressed as a percentage of the reactance.

It will be noted that up to between 10 and 20 per cent. resistance introduced into each reactance results in considerable reduction in impedance variation, with much less reduction in phase range. Fig. 5 shows the values of reactance required in terms of the total value of the variable resistance, *R*, for the various percentages of resistance in the reactance elements. The dotted line gives the values of resultant impedance in terms of the variable, *R*.

### Practical Circuit

Fig. 6 is the complete circuit of an instrument employing this principle, capable of giving readings within about 2 per cent. over an impedance range from 0.2 ohm to 0.2 megohm, allowing for a phase variation from $-63°$ to $+63°$. Relative readings are obtainable for values beyond these limits to 0.05 ohm and 1 megohm.

The circuit is designed around a phase varying resistance of 50,000 ohms. If a stock resistance is used, the value should be accurately measured, and the circuit values and calibration should be adjusted to correspond with the actual resistance. A linear type resistance is best, because it provides an approximately linear phase calibration (*see* Fig. 7), and also there will be a minimum variation in total resistance due to the small portion short-circuited by the slider.

The reactances have a series resistance of 10 per cent. of their reactance value. For the inductance, which is iron cored, this means that the total loss referred as a series resistance must be 10 per cent. of the inductance at the operating frequency. In the case of the condenser, an external resistance is included in series. From Fig. 5 the value of reactance required under this condition is 0.405 times the total variable resistance—if the resistance is accurately 50,000 ohms, the reactance values require to be 20,250 ohms, and the series resistance 2,025 ohms. The mean value of the variable phase impedance will be 0.415 times the total variable resistance (*see* Fig. 5). For 50,000 ohms this will be 20,750 ohms.

The input is via a 600 ohms potentiometer, which serves as a zero adjustment. The instrument consists of a 1 milliamp movement, with an instrument rectifier. Using a sinusoidal input (which is essential to the accuracy of the instrument) the instrument will require 1.11 mA for full-scale deflection. This means that about 23 volts R.M.S. will be required to produce full-scale deflection on short circuit. An oscillator designed to give an output of 1 watt into 600 ohms will produce nearly 25 volts across the input potentiometer. The slider being near to the top, if the source impedance of the oscillator output is low, the impedance added to the instrument by the input arrangement will be much lower than 600 ohms.

The range change transformer provides a step down of 10/1 and 100/1, to give reduction in impedance readings of 100/1 and 10,000/1 respectively. The primary is tuned by a condenser so that the impedance presented in shunt is a maximum, and is resistive. The simplest method of finding the value is to use series tuning across the output of an oscillator of low output impedance, and measure the volts across the primary. Adjust the value of capacity so that the resonance occurs at the required operating frequency, when the oscillator output is adjusted so that this resonant voltage is about 23 volts. This will ensure greatest accuracy at the upper end of the scale (lowest deflection), where it would have most effect.

Series resistances are included with the direct connexion position and one secondary, which are adjusted so that the maximum deflection (zero impedance) is the same on all ranges. This enables the range switch to be used without intermediate use of the zero adjustment.

### Method of Calibration

To ensure maximum overall accuracy, the instrument scale should indicate the mean value of impedance from which an equal variation may occur in either direction. The use of actual resistances to calibrate would result in the calibration at one extreme value. For this reason the method adopted is to calibrate the instrument in terms of angular deflection for various values of A.C. current. From these values a scale is calculated, making allowance for the effect of the transformer shunt impedance at one end, and the total series impedance (composed of the instrument and referred series losses in addition to the phase-changing impedance) in limiting the range. Fig. 8 shows a typical scale produced in this way. The values are for the middle range, using 10/1 transformer ratio, so that the same scale may be used with a multiplying factor of 100 for the direct range, and with a dividing factor of 100 for the lowest range.

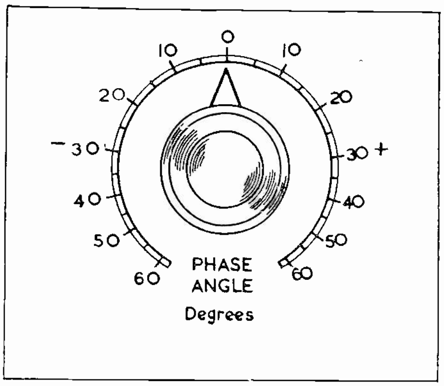



Fig. 9. Scale of phase angle adjustment

Fig. 7 shows the variation of phase in terms of the fraction of $R$ by which the slider is removed from the centre (electrically). If the resistance is exactly linear, and the total rotation 300°, the resulting phase scale will be as at Fig. 9. To produce an accurate calibration here, the actual value of $R$ for various angles of rotation is plotted, and the resulting law applied to the electrical law of Fig. 7 to obtain the scale.

### Method of Use

Two adjustments are required to calibrate the completed instrument to prepare it for use: for frequency and voltage input.

With the range switch in position 2 or 4 (each of which provides a zero check) the frequency of the oscillator should be trimmed, and the setting of the 600 ohm input potentiometer adjusted, so that rotation of the phase-changing potentiometer from one end to the other causes the instrument needle to move symmetrically between the " limit " marks by the zero end of the scale, in a way similar to the variation shown in Fig. 3.

To obtain a reading of an impedance connected, the phase potentiometer should be rotated to find the position of maximum impedance indication (minimum deflection). The scale reading will then indicate the value of impedance, and the setting of the phase change potentiometer the phase of the connected impedance at the operating frequency of the instrument.

If a reading falls outside the limits from 20 ohms to 2,000 ohms, an adjoining range should be used to bring it within these limits, unless an extreme range is already being used, in which case the accuracy of the reading will not be within the specified limits if the impedance is appreciably reactive.

### Details of Windings

*Inductance.*—This consists of a winding of 5,500 turns of 46 S.W.G. enamelled wire on a bobbin to fit a core composed of a square stack (7/16 in.) of No. 21 Mumetal laminations. The laminations are assembled with a gap, which is adjusted to give an inductance of the correct reactance at the working frequency. Suggested working frequencies for audio frequency work are 600 or 1,000 cycles.

*Range-changing Transformer.*—This is wound using a core of laminations of the waste-free type with a ¾ in. centre limb (M.E.A. No. 35; Sankeys No. 70; G. L. Scott No. 120) square section. If possible, Mumetal should be used. The calibration given is with a transformer using Mumetal. The use of an alternative transformer iron will reduce the shunt impedance, and restrict the top end of the scale (the space between the movement zero and infinity impedance will be increased, *see* Fig. 8). Windings in order as follows:—

1st secondary, 240 turns 28 S.W.G. enam. copper wire.

Primary, 2,400 turns 38 S.W.G. enam. copper wire.

2nd secondary, 24 turns 18 S.W.G. wire.

Turns should be accurately counted, as accuracy on the two lower ranges depends on this. The method of tuning the primary is described in the section under the heading Practical Circuit.

# A Phase Discriminator for Frequency-Modulation Reception

By F. G. NEWALL and J. G. SPENCER*

## Introduction

THE discriminator circuit described in this article† has been developed for use in F.M. receivers. Compared with other discriminator circuits it not only produces a bigger output voltage, which is sufficient to drive a normal output valve, but it is also easier to align, all the test equipment needed for the purpose being an unmodulated oscillator and a milliammeter. These advantages are of considerable practical significance, the ease of alignment especially being a most valuable feature from the point of view of the serviceman and the home constructor whose test equipment is limited.

The operation of the circuit depends upon two principles. First, that a parallel-tuned circuit has a phase-frequency characteristic that is sensibly linear over one quarter of its bandwidth, where the bandwidth is defined as the difference between the frequencies for which the phase angle is $\pi/4$ radians. Secondly, that valves having three or more grids can be used as multiplicative mixers, the anode current of a three-grid valve, for example, containing a term that is the product of the voltages applied to the first and third grids. Thus, if voltages $A \sin(\omega t \pm \pi/2)$ and $B \sin(\omega t + \theta)$ are applied to the first and third grids, the anode current will contain the term:

$$KAB\ (\sin \omega t \pm \pi/2) \times \sin(\omega t + \theta)$$

which simplifies to:

$$\tfrac{1}{2}KAB.\sin\theta + \sin(2\omega t + \theta)$$

where $A$, $B$ and $K$ are constants.

The significant term in this expression is $\frac{1}{2}KAB.\sin\theta$; for, if the angle $\theta$ is made linearly proportional to the deviation of $\omega$ from a mean value $\omega_0$, and if the maximum value of $\theta$ is restricted to 0.25 radians (up to which $\sin\theta \simeq \theta$), the output will contain a term that is proportional to the deviation of $\omega$ from $\omega_0$.

In this discriminator circuit the voltage $A \sin(\omega t \pm \pi/2)$ is developed across a capacitor supplied with a current varying as $\sin \omega t$. The other voltage, $B \sin(\omega t + \theta)$, is obtained by feeding the same current through a parallel $LC$ circuit, which is tuned to resonance at $\omega_0$, and which has a bandwidth four times that of the maximum deviation of $\omega$ from $\omega_0$. This figure for the bandwidth is chosen in order to keep the frequency deviation well within the linear part of the phase-frequency characteristic and to keep the amplitude $B$ sensibly constant.

* Engineering Research Department, B.B.C.
† Patent application No. 19804/48.

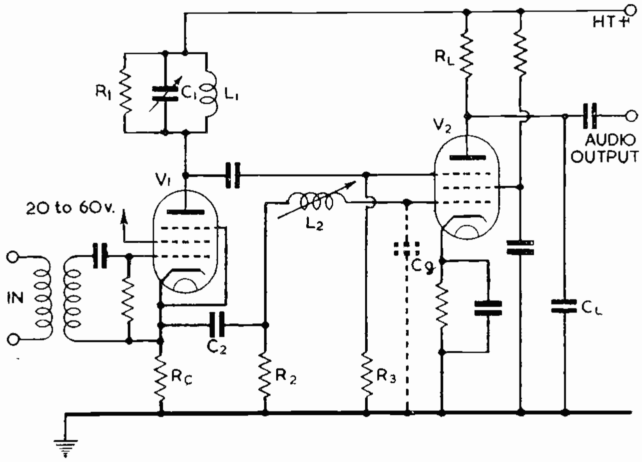
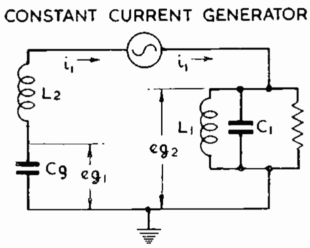



Fig. 1 (right). Circuit diagram of Discriminator

Fig. 2 (below). Simplified $V_1$ circuit




## Discriminator Circuit

The circuit diagram of the discriminator is shown in Fig. 1. $V_1$ is a high slope H.F. pentode, operating as a grid-current limiter, with reduced screen-grid voltage to shorten the grid base. The anode circuit of $V_1$ is a parallel-tuned circuit consisting of $R_1$, $L_1$ and $C_1$, in parallel with the stray capacitance between the anode of $V_1$ and earth and between the suppressor grid of $V_2$ and earth. The voltage on $V_2$ suppressor grid has a phase angle $\theta$ with respect to the anode current of $V_1$, $\theta$ being zero at the mean frequency $\omega_0$ and varying with deviations of $\omega$ from $\omega_0$.

The cathode circuit of $V_1$ consists of a series-tuned circuit $L_2$ and $C_2$ in series with the capacitance to earth of $V_2$ control grid. $C_2$ isolates the control grid of $V_2$ from the D.C. voltage on $V_1$ cathode. $R_c$ and $R_2$ are high resistances, completing the D.C. cathode and grid circuits of $V_1$ and $V_2$ respectively. The resistance $R_c$ must be higher than the impedance of the series-tuned circuit $C_2$, $C_g$, $L_2$ but not so high that the voltage drop across it reduces the anode to cathode voltage of $V_1$ below the point at which $V_1$ operates properly as a grid-current limiter. $R_2$ should be high in value, its maximum value being determined by the maximum D.C. resistance permissible in the grid circuit of $V_2$. As most of the alternating current in the anode-cathode circuit of $V_1$ flows through the series-tuned circuit composed of $L_2$, $C_2$, $C_g$, the voltage across $C_g$ which is applied to the control grid of $V_2$, is in quadrature with the anode-cathode current of $V_1$. This relation holds true for all values of $\omega$.

The circuit of $V_1$ in Fig. 1 can be simplified to that of Fig. 2, in which the valve $V_1$ is replaced by a constant-current generator. This current is denoted by $i_1$. The voltage $e_{g1}$ which represents the voltage drop across $C_g(V_2)$ in Fig. 1 is equal to $\frac{i_1}{j\omega C_g}$ and is therefore fixed at $\pi/2$ out of phase with $i_1$. The amplitude of $e_{g1}$ varies inversely with $\omega$, but, since the maximum variation of $\omega$ is a very small percentage of $\omega_0$ this amplitude variation is not serious.

The phase relation between $e_{g2}$ and $i_1$ can be represented by the angle $\theta$. $\theta$ is zero when the angular frequency of $i_1$ is $\omega_0$ and varies as $\omega$ deviates from $\omega_0$. The bandwidth of the parallel-tuned circuit at the anode of $V_1$ is such that the maximum value of $\theta$ does not exceed $\pm$ 0.25 radians. Over this range $\sin\theta$ is, with reasonable accuracy, proportional to the deviation of $\omega$ from $\omega_o$.

If $i_1$ has an instantaneous value proportional to $\sin \omega t$, the voltage $e_{g1}$ can be represented by $A \sin(\omega t - \pi/2)$, and the voltage $e_{g2}$ by $B \sin(\omega t + \theta)$. The anode current of $V_2$ will contain the product of these two voltages, *i.e.*,

$$\frac{KAB}{2}\sin\theta + \frac{KAB}{2}\sin(2\omega t + \theta)$$

Since $\sin\theta$ is proportional to the deviation of $\omega$ from $\omega_o$, the first term in this expression is the wanted one. The second term represents the second harmonic of the input signal, which is eliminated in the output circuit by the capacitor $C_L$. The components $R_L$ and $C_L$ may conveniently be chosen to provide whatever amount of de-emphasis is required in the discriminator. Audio-frequency feedback can be applied to either grid of the mixer, if desired.

### Results

The discriminator circuit of Fig. 1 has been tested with various mixing valves, using a mean frequency of 1 Mc/s. and a deviation of $\pm$ 15Kc/s. The peak audio-frequency output ranged from 8 to 10 volts, which is ample to drive a normal output stage in a receiver. These results agreed closely with the calculated values. The discriminator may be aligned very easily by first resonating the two tuned circuits $L_1C_1$ and $L_2C_2$. Then with an unmodulated oscillator connected to the receiver I.F. input, and a milliammeter in the anode circuit of $V_2$, a final re-adjustment may be made on the circuit $L_1C_1$ until no change is observed in the D.C. milliameter as the unmodulated carrier is switched on and off. A deviation in the frequency of the unmodulated oscillator will now cause a proportionate change in milliammeter reading.

### Design Data

$f_o$ = mid-frequency of I.F. amplifier.
$\Delta f$ = maximum deviation frequency.
$\omega_o = 2\pi f_o$
$\Delta\omega = 2\pi\Delta f$

then

$$L_1 = \frac{1}{\omega_o^2(C_1 + C_s)} \qquad (1)$$

where $C_s$ is the total stray capacity from the anode of $V_2$ to earth.

$$R_1 = \frac{L_1/C}{8\Delta\omega \, . \, L_1 - r_{L1}} \qquad (2)$$

where $r_{L1}$ = series resistance of $L_1$

$$C = (C_1 + C_s)$$

Now

$$C_2 >> C_g$$

where $C_g$ is the first grid to earth capacity of $V_2$.

$$L_2 = \frac{1}{\omega_o^2 C_g} \qquad (3)$$

$$R_c >> \sqrt{(2\Delta\omega L_2)^2 + r_{L2}^2} \qquad (4)$$

where $r_{L2}$ = series resistance of $L_2$

$$R_2 >> R_c$$
$$R_3 >> R_1$$

The audio output voltage of the discriminator can be calculated from the following formula.

$$V_{a\ peak} = \frac{g_m^2 e^2 R_1 \omega_o^2 L_1^2 G R_L}{16\,\omega\, C_g r_{L1}\left(R_1 + \dfrac{\omega_o^2 L_1^2}{r_{L1}}\right)} \text{ volts} \qquad (5)$$

where $g_m$ = mutual conductance of limiter valve $V_1$
$e$ = grid base of limiter $V_1$ (*i.e.*, cut-off voltage)
$R_L$ = anode resistance of $V_2$
$G$ = D.C. change of anode current in $V_2$ when a sinusoidal voltage of one volt peak is supplied to the two grids $G_1$ and $G_3$ connected in parallel.

This, of course, assumes that the signal is larger than the grid base of $V_1$ or is, in fact, being limited by $V_1$.

The grid circuit of the limiter $V_1$ must be returned to cathode and not to earth, in order that it shall behave as a limiter.

# Moisture Control for Electronic Equipment

THE problems of damage and breakdown to electronic equipment caused through the intake of moisture are too well known to require elaboration and frequently the expense of effecting a cure is considerable. In the case of new designs moisture can be kept out by hermetically sealing the units, but at the expense of a considerable increase in dimensions, especially if a large wattage has to be dissipated.

In the case of existing apparatus some other means must be found of preventing the entrance of moisture.

The mechanism of moisture deposition may be briefly explained: Air may be saturated with moisture vapour, the amount of water vapour in a cubic foot of air rising with increase in temperature. Dew point is the temperature at which moisture will be deposited if the air is gradually cooled down. At 100 per cent saturation it is the same as the air temperature, but as the degree of saturation is reduced so will the dew point fall. Thus, there will be no trouble from moisture unless the temperature falls below the dew point of the air.

The method adopted to overcome these troubles is to dry the air so that its dew point is much lower than any expected operating temperature. When a continuous stream of ventilating air is not required this can be done by the use of a breather dryer. As the name implies, as the apparatus warms up in service, air can be breathed out, but air sucked in again on cooling is properly dried to a low dew point. Units of this type are usually very small even when the protected volume is large and tropical conditions are encountered.

In experimental work it is frequently essential that apparatus be filled with a perfectly dry gas and for this purpose units can be provided to dry air and most other gases to dew points as low as 80° C.

Suitable drying units are made by Edmonds McKenzie & Co. All employ as the drying element a solid absorbent such as silica gel or activated alumina, a material of high efficiency which is capable of being regenerated many times without any detectable deteriorations.

*—Edmonds McKenzie and Co.,*
*40 Francis Road, Purbrook,*
*Hants.*

# The Electronic Engineering Televisor

THE ELECTRONIC ENGINEERING Modern Home-built Televisor was first demonstrated in the autumn of 1947 and has proved one of the most popular of home-constructed receivers, several thousand having been built since that date. The basic soundness of its design has been shown by the very few difficulties which have been encountered in its construction and the small number of modifications which have had to be made to the original design data.

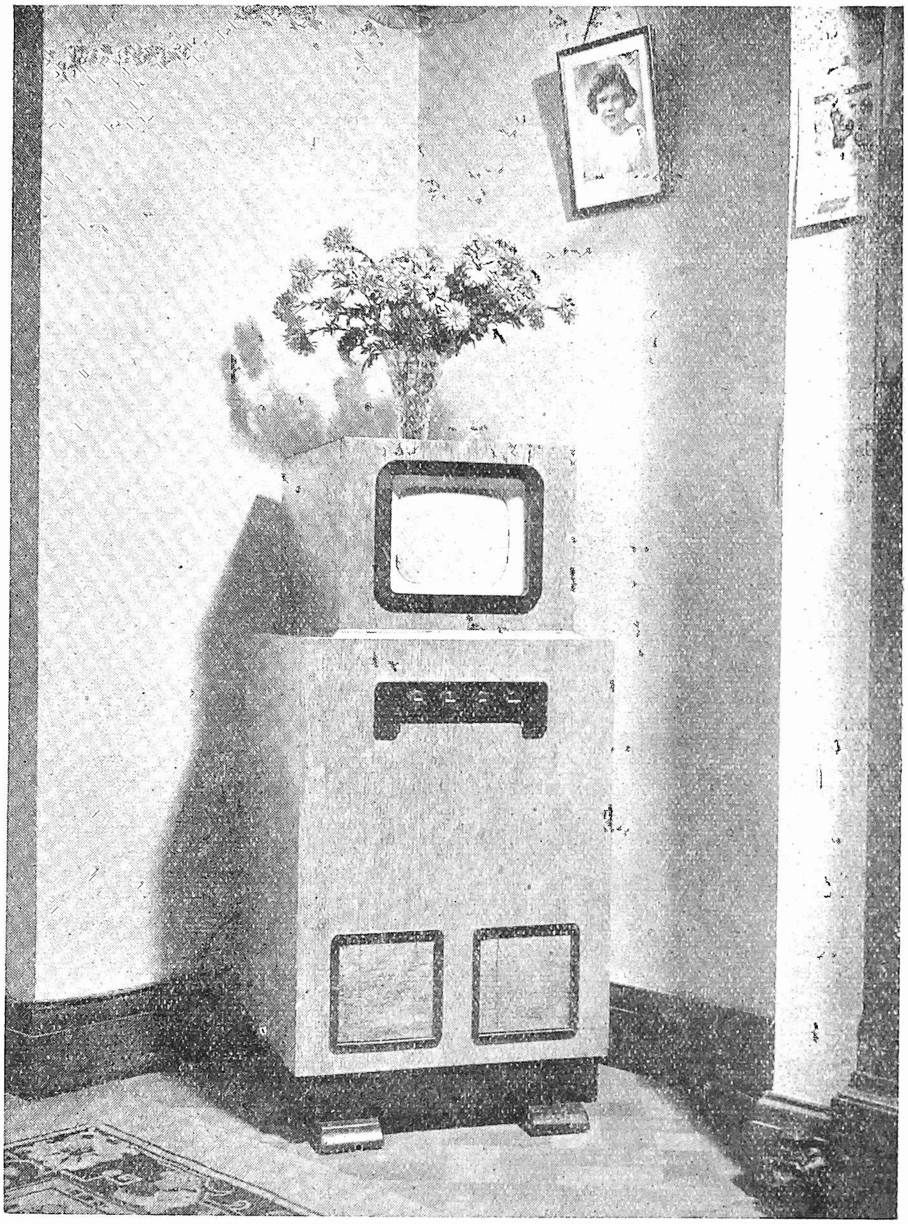
For the benefit of those who have already purchased the instruction book, a list of these modifications is given below, together with references to later articles which have been published in ELECTRONIC ENGINEERING. The modifications are all included in the 3rd Edition of the booklet which is now available, and owners of earlier editions are advised to mark their copies with the alterations and additions.

**Amendments to Booklet (1st and 2nd Editions)**

| Page No. | Fig. No. | Correction |
|---|---|---|
| 17 | 2 | Alter V.7 in photograph to V.6. |
| 25 | 6 | Alter R.22 in list from 4.7K to 5K. |
| 37 | 14 | Alter V.8, V.9, V.10 to V.9, V.10, V.11 respectively. |
| — | 15 | Add another choke (Ch.8) to the wiring below the two already shown. |
| 43 | 19 | Alter C.50 from 0.002 μF. to 0.005 μF. and in the text above. |
| 45 | 20 | Alter R.73 from 0.27 M to 0.22M.<br>R.78 from 150 to 120.<br>R.79 from 7.5K to 6K.<br>C.62 from 8 μF. to 16 μF.<br>and in the text where mentioned. |
| 46 | — | Alter "S.912" to "S.914." |
| 51 | 23b | Alter C.66a and b to 32 μF. 450 V wkg. |
| 55 | 25 | Alter C.68 in photograph to C.64. Alter R.97 in photograph to R.92 and insert R.97 between Ch.9 and C.66. |
| 57 | 27 | Add under figure: Pins 5, 6 and 7 in the Mullard 22-7 should not be used for anchoring points. |
| 60 | — | Add: . . . approximately $\frac{3}{8}$ in. thick . . . after "felt pad" (line 7 from top). |
| 69 | — | Alter components list as follows, under Capacitors:<br>2 71,50 0.005 μF.<br>1 49 0.002 μF.<br>1 66 32-32 μF., 450 V wkg. (Type No. CE.29.PE.) |

The remaining components in the list should be checked against the modified values given above and the necessary corrections made.

If it is required to improve the linearity at the commencement of the frame scan, a capacitor of approximately 2.0 μF. may be connected across the cathode bias resistor R.78.



A home-constructed "Televisor" housed in a cabinet designed and made by a reader, Mr. R. C. Rolfe. The twin speaker grilles have been included for symmetry, and two speakers would improve the quality of reproduction

—*Photo by A. R. Tanner*

## Alternative Components

In addition to those specified in the list of components, additional manufacturers have been approved as suppliers of satisfactory alternative components. Constructors are advised in their own interests to make sure that their components have been tested and approved by the designers of the Televisor, and the Editorial staff will be pleased to give information in doubtful cases.

A list of approved suppliers was given in the December issue, 1948, p. 407, and additional lists will be issued from time to time.

## Additional Notes

Answers to some of the more common queries will be found in articles in ELECTRONIC ENGINEERING of the following dates:

November 1947.—Using a 12 in. Tube; Feeder Tubes; Connexion of R.5 to H.T. line.

January 1948, p. 25.—Coil Data; Choke L.8; Alternative Valve Types; Power Consumption; Precautions in Wiring; Chassis Drawing Correction.

Suitable circuits for interference suppression on both sound and vision channels were given in the August 1948 issue, p. 253.

# Electronic Equipment

A monthly record of British electronic apparatus, components, and accessories, compiled from information supplied by the manufacturers.

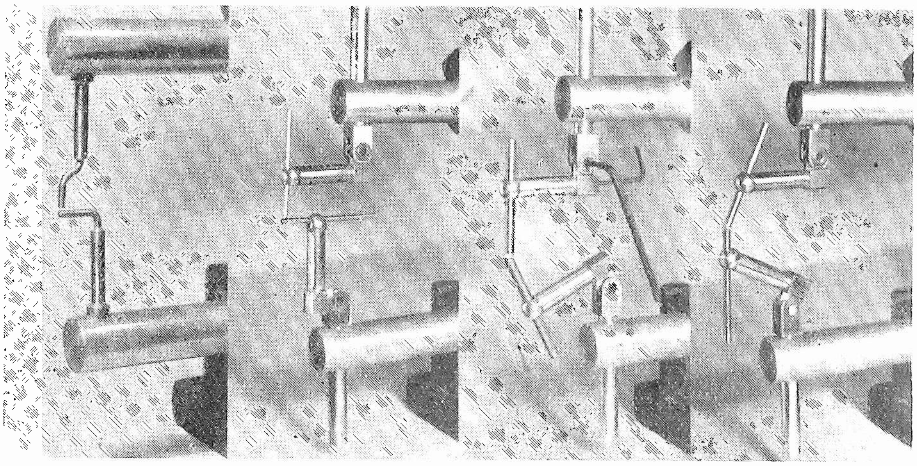
### Spot Welding Electrodes and Holders

TO minimise the trouble and expense of machining small welding electrodes from copper rod, a series of miniature electrodes and holders has been introduced by Johnson Matthey & Co.

The miniature holder consists of a $\frac{5}{16}$ in. diameter stake terminating in a hinge clamp capable of locking the electrode holder at any desired angle from vertically upwards through 180 deg. to the vertically downwards position. The holder is tubular in construction to provide access to the electrode clamping screw in the socket head. Two types of holder are available, the vertical type, providing for electrodes to be clamped at 90 deg. to the holder, and the angle type, designed to give improved access in confined spaces, clamping thr electrode at $112\frac{1}{2}$ deg. to the holder. Foue sizes of electrode, $\frac{1}{16}$ in., $\frac{3}{32}$ in., $\frac{1}{8}$ in. and $\frac{5}{32}$ in. in diameter are also stocked, each $1\frac{3}{4}$ in. long. One end is cut square while the other is chamfered at $67\frac{1}{2}$ deg. to the axis.

The photographs show (left to right) a conventional pair of electrodes bent up from copper rod, a pair of Mallory miniature holders and electrodes designed to replace them, and two typical set-ups using swivelling holders. These are now available from stock.

*Johnson Matthey and Co.,*
*73 Hatton Garden, E.C.1.*



### Dynatron Nucleonic Equipment

THE photographs below show two units of the four which comprise the nucleonic equipment supplied by Dynatron Radio Ltd. to approved research organisations under Government licence.

The complete equipment contains a Scaling Unit, Type SC.200, a power unit for Geiger counters, and a monitor oscilloscope fitted with a cathode follower probe unit.

The scaling unit (not shown) embodies the following technical features:

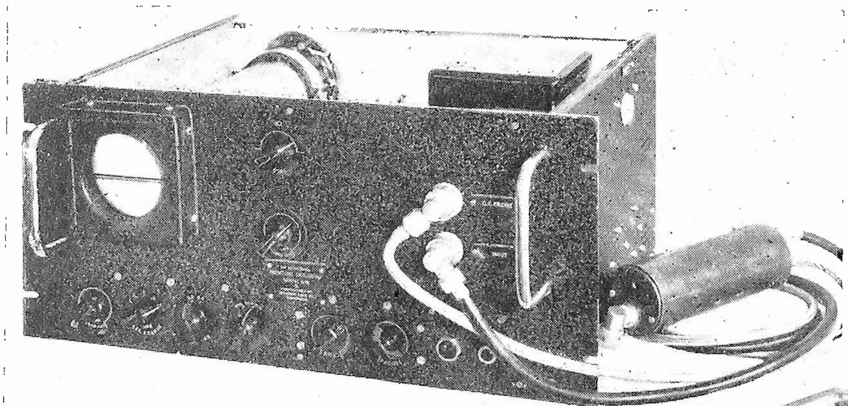
*Counting :* Indications are given by means of neon lamps up to 100, with a maximum average rate of counting of 500 pulses-per second.

*Sensitivity :* The unit operates from a 5V minimum pulse of either polarity with a pulse separation of 6$\mu$S., or alternatively, with a 3V minimum pulse with a paralysis time adjustable up to 1 mS.

The power unit (below) provides a stable output voltage up to 4,000 volts in four ranges, 175—500, 350—1,000, 700—2,000 and 1,400—4,000, the desired range being selected by means of a 4-way switch and the output voltage continuously varied by a control on the front panel. A further calibrated control gives a vernier adjustment up to 10 per cent of the maximum voltage on the selected range. Output voltage can be made positive or negative with respect to chassis.

Currents of up to 50$\mu$A may be drawn and stabilisation of 1 per cent still maintained.

Panel dimensions : Width 19 in. ; height $8\frac{3}{4}$ in. ; depth 14 in. ; weight 48 lb. ; Price complete, £75.



### The Test Oscilloscope Monitor, Type M.200

THE oscilloscope shown above provides facilities not given by the usual laboratory oscilloscope and has the advantage of being rack panel mounted uniform with the remainder of the equipment. Technical features are as follows—*Amplifier :* Gain controlled by switch on front panel to give fixed gains of $\times 2$ or $\times 4$. Frequency response within 1.5db up to 3 Mc/s. *Time Base :* May be triggered from + 10 volts or − 20 volts pulse with sweep speeds continuously variable from 15 micro-seconds up to 10 milli-seconds by means of five range switch and fine control.

*Dynatron Radio Ltd.,*
*Maidenhead, Berks.*

## Two-Channel Electronic Switch

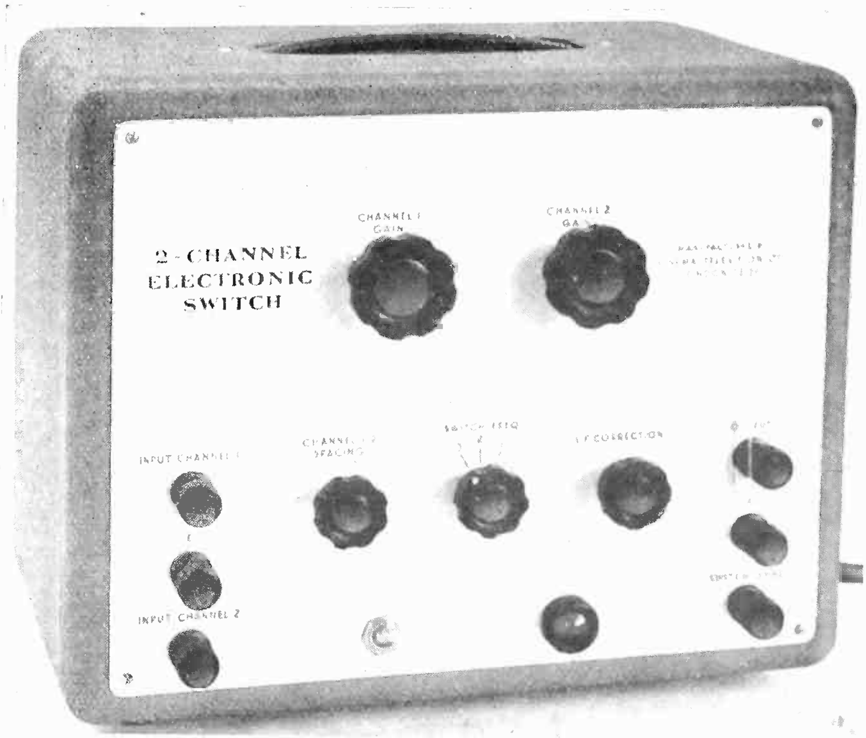
THIS instrument enables two signals to be examined together on any standard single beam oscilloscope.

The unit includes two switched amplifiers, the signals to be examined being applied one to each amplifier. The output has a composite waveform consisting of a square wave with the signals superimposed on alternate half-cycles of the square wave.

This composite waveform is applied to the " Y " amplifier of a cathode ray oscilloscope and both the signals will appear on the screen one above the other. The time base should be synchronised with one of the signals. If it is synchronised with the square wave the composite output wave form is observed.

The equipment is available in two forms : Type " A " mounted on a standard 19 inch rack mounting panel, and Type " B," as illustrated a self contained unit. Price, £38 10 0. Delivery, ex stock.

*Cinema-Television Ltd., Lower Sydenham, S.E.26.*




## The Mullard Selective Amplifier

THE Mullard Selective Amplifier type GSA1 has been designed as an A.C. bridge amplifier to be used in conjunction with a suitable indicator for the detection of harmonics and other unwanted tones. The frequency range of 16 c/s. to 200 Kc/s. is covered in five ranges. The response is 20db. down at approximately 1.25*f*. and 0.8*f*. and 40 db. down at 2*f*. and 0.5*f* ; where *f* is the frequency to which the amplifier is tuned.

The unit is built for normal rack mounting and has a 19 in. by 7 in. panel and a depth of 10½ in. It is subdivided into two units, one containing the amplifier circuit and the other the power supply and rectifier together with a ripple smoothing valve. Price : £82.

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

## Push-Pull Power Tetrode

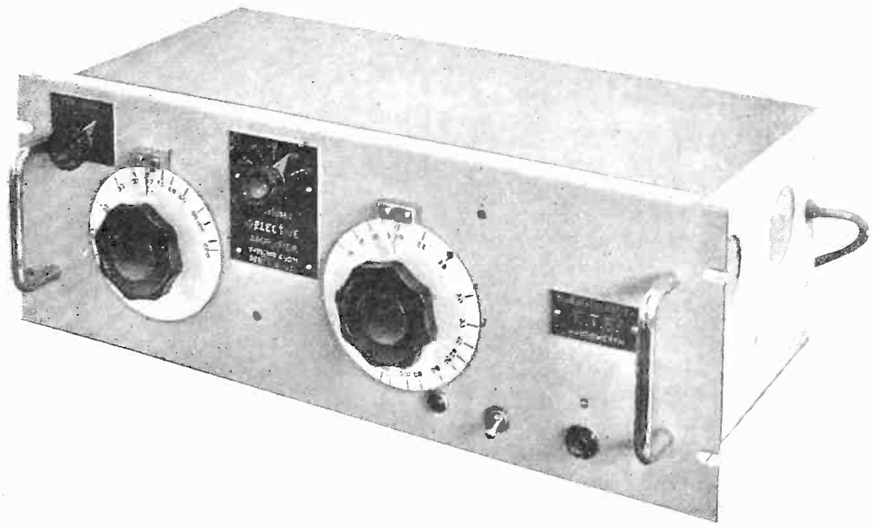
THE push-pull power tetrode, QV07-40, has been specially designed to give stable and efficient performance at very high frequencies and should, therefore, prove of interest to those amateurs intending to use the new 144-146 Mc/s band. A particularly interesting feature of this valve is that neutralisation is not usually necessary and, another important feature is that it requires only a very low driving power.

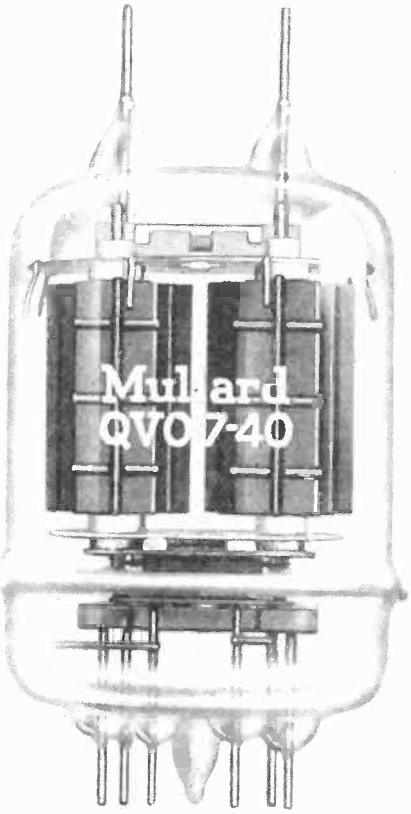
This valve is directly equivalent to the American type 829B. The list price is £7 10s.

*Mullard Electronic Products Ltd.*

## Midget Electric Motors

Messrs. Henry Hughes Ltd. have asked us to state that the midget motors described in last month's issue are only obtainable in quantity and are not for individual sale.





# CORRESPONDENCE

## Demagnetisation of Valves

DEAR SIR,—My attention has been drawn to the letter from Dr. Grey Walter and his colleagues in your July issue, in which he points out that a considerable reduction in the ripple voltage appearing in the anode circuit of pentode valves, could be brought about by demagnetisation of the valve electrodes.

We observed the same effect during the course of unpublished work in these laboratories in 1935, during a general investigation of the causes of hum due to running the heaters of receiving valves on A.C., and arriving at a logical qualitative explanation.

The primary effect of the magnetic field of the heater, in the usual type of receiving valve assembly is to cause lateral deflections of the electrons in a direction at right angles to that of the grid winding wires. Most of the deflection takes place close to the cathode, where the magnetic field is strongest and the electrons have their lowest velocity. This lateral deflection causes increased space charge and therefore reduction of anode current. In a negative grid triode, this periodic variation of space charge is the major effect, and is equivalent to a small applied grid voltage.

In a tetrode or pentode, however, a further effect arises, in that the lateral deflections will cause a periodic variation in the distribution of the current between screen and anode. That such a variation takes place may readily be demonstrated by the increase of ripple present in the anode circuit in the pentode connexion as compared with the triode connexion, and even more effectively by the fact that the ripple current in the screen circuit is almost equal in amplitude and of opposite phase to that in the anode circuit. A large measure of variability will occur from valve to valve dependent on how the individual beams of electrons which come from between the control grid turns strike the screen in the absence of the magnetic field. The order of increase of ripple over the triode connexion may be five to twenty times.

The above may be called the normal tetrode ripple. To explain the abnormal ripple when the electrodes (chiefly anode), become magnetised, it may be noted that some of the distribution variation will occur, not at the screen grid surface, but at the edges of the anode where electrons may shoot past and return by long paths to the screen. The anode design is usually a compromise in order to minimise this effect while still keeping the anode earth capacitance as small as possible.

If now the electrodes are magnetised, small steady deflections will be superimposed on the normal electron trajectories, and the number of electrons that shoot past the anode edges may be very considerably increased. Correspondingly, the variation in their number due to the magnetic field of the heater is increased and gives rise to the large observed ripple. The alternative possibility that the anode magnetisation is directly affected by the heater field no doubt contributes slightly to the abnormal effect, but is considered to be of secondary importance.

Among the experimental results leading to the above theory may be quoted the following:

(a) The effect is larger in variable—mu types of valve than in straight-mu types, presumably due to the increased spreading of the electron beams caused by increased space charge density at the gap in the grid of the former.

(b) The open type of construction used in glass envelope valves causes some increase in ripple as compared with the corresponding external anode type, since no distribution can occur at the anode of the latter.

(c) The use of iron instead of nickel for the valve anodes gives rise to an increase of ripple.

As the ripple voltage in the screen circuit is of approximately equal magnitude and opposite phase to that in the anode circuit, while the signal current is smaller in magnitude and of the same phase, it should be possible by circuit means to make use of the screen ripple to neutralise the anode ripple. In practice, however, it would be far simpler to use a triode amplifier instead of the pentode, and make up for the loss of gain by increased amplification at larger signal level.

W. H. ALDOUS

(Research Staff of the M.O. Valve Co. at the G.E.C. Research Laboratories, Wembley, England).

## References

DEAR SIR,—With a view to solving the simpler problem of storing references I have adopted a system of indexing all articles in ELECTRONIC ENGINEERING and other periodicals to which I subscribe, on cards under their Universal Decimal Classification numbers. Now, with cards completed for some sixty monthly issues and with many back numbers awaiting attention, the system is already proving valuable, as the card index can be searched far more rapidly than any monthly or annual indexes. At present it certainly does not yield reference to the world's scientific publications, but it is recommended as worthy of adoption by other readers, as it does reveal the contents of one's own bookshelf.

We now have, in B.S.1000, Volume 4, Part 2, an excellent English edition of the U.D.C. as applied to ELECTRONIC ENGINEERING, so that index cards can be rapidly made out and the appropriate number added. However, the allocation of numbers might well be performed by editorial staffs, and the writer would suggest that if these were printed with each important contribution in ELECTRONIC ENGINEERING this valuable periodical would be further enhanced.

I shall be grateful if you will give this suggestion your consideration and perhaps investigate whether it would be supported by other readers. L. C. BRANSON.

*Would it ?—Ed.*

## Scanning Circuits

DEAR SIR,—With respect to the article by Mr. C. H. Banthorpe in your November issue and in particular the last paragraph concerning cathode coupled multi-vibrators, we would like to say that this firm has been using this type of line and frame oscillator in its television receivers for the past fifteen months.

We agree with Mr. Banthorpe's remarks on the merits of the type of oscillator and would like to add that the oscillator will lock so readily that the picture remains absolutely steady over most of the range of the frequency control potentiometers.

pp. Felgate Radio, Ltd.
J. MANNERS

For McCarthy Radio.

# NOTES FROM THE INDUSTRY

### R.C.M.F. Exhibition 1949

The Sixth Annual Private Exhibition of British Components, Valves and Test Gear for Radio, Television, Electronic and Telecommunication Industries will be held in the Great Hall, Grosvenor House, Park Lane, London, W.1., during the period Tuesday, March 1, to Thursday, March 3, 1949, daily from 10 a.m. to 6 p.m.

Admission is by invitation only as in previous years. Applications for tickets and further information can be obtained from the Secretary, Radio Component Manufacturers Federation, 22 Surrey Street, Strand, London, W.C.2.

### Radiolympia 1949

The Radio Industry Council announces that the 16th National Radio Exhibition ("Radiolympia") will be held at Olympia, London, from Wednesday, September 28, to Saturday, October 8, 1949. There will be a pre-view with admission by invitation only on Tuesday, September 27.

Intending visitors from overseas are asked to inform the Radio Industry Council, 59 Russell Square, London, W.C.1.

### New Amateur Bands

The G.P.O. has advised the Radio Society of Great Britain that as from January 1, 1949, a number of new bands will become available to U.K. amateurs.

All bands in current use, with the exception of the band 58.5-60 Mc/s., will continue to be allocated. In addition to the bands,

144-145 Mc/s.
1,215-1,300 Mc/s.
5,650-5,850 Mc/s.
10,000-10,500 Mc/s.

will become available.

Frequency modulation as well as amplitude modulation will be permitted on all bands from 420 Mc/s. upwards and on all these bands as well as on the 144-146 Mc/s. band an input power of 25 watts will be permitted.

### Television Output Up

The production of television receivers in October 1948 was 12,037, and in September 11,854, according to figures issued by the Radio Industry Council. The average monthly rate of production has been 6,430 in 1948 compared with 2,300 in 1947. One of the limiting factors in production has been the cathode ray tube, but manufacturers have recently been able to speed up production and it is hoped to make it possible to issue 200,000 receivers next year. The total of licences issued up to October 31, was 73,800.

### Pye Television and Road Safety

The Police and Pye Ltd., co-operated recently in a Road Safety Exhibition in Cambridge. Television cameras picked up an actual street scene and the signals were fed through 1,500 ft. of cable to receivers in the exhibition. As cases of "jay walking" and dangerous driving were observed on the screens a police commentary was given to viewers.

### "World Radio Handbook for Listeners"

Published by O. Lund Johansen of Copenhagen the Third Edition (November 1948-May 1949) of this reference book gives invaluable information to help in the identification of the principle broadcasting stations of the world. The name, call-sign, frequency, interval-signal of each station is given together with the address, details of its leading personalities and programme schedules. Copies (price 6s. 6d.) are distributed in this country by: *Wm. Dawson & Sons, Ltd., Cannon House, Macklin Street, London, W.C.2.*

### New Transmitter Condenser

Messrs. Stratton and Co. ("Eddy stone") announce the release of a new transmitting condenser Cat. No. 612. It is a split-stator of rigid construction with ceramic end plates, having a capacitance of 50 pF. per section. It is particularly suitable for transmitters working on the 28 and 14 Mc. bands. and is priced at 32s. 6d. It is supplied with a comprehensive set of accessories for mounting in a variety of positions.

### Antiference Ltd.

#### NOTICE

Attention has been drawn to the fact that one or more concerns are offering for sale an item described as the "World's Finest Antiferance Device." Use of the word "Antiferance" in connexion with anti-static devices is in the view of Antiference, Ltd., a clear infringement since it sufficiently resembles their Trade Name and Registered Trade Mark "Antiference." Consequently they will immediately instruct their solicitors to issue against any infringer a writ for damages.

Antiference, Ltd.. would be obliged if any of our readers would send to them literature in their possession making use of the words "Antiferance" or "Antiference" and not to their certain knowledge issued by *Antiference, Ltd.*, 67 *Bryanston Street, London, W.1.*

### Correction

Mr. D. McMullan was incorrectly described (Dec., 1948, p. 392) as being with the Cavendish Laboratory, Cambridge. He is at the Cambridge University Engineering Laboratory and the work for the article in question was done before joining the laboratory.

## Publications Received

"Glossary of Terms Used in Waveguide Technique." Supplement No. 1 (1948) to British Standard 204:1943, price 2s. net, post free. Obtainable from *British Standards Insitution, 24/28 Victoria Street, London, S.W.1.*

"Marconi Broadcasting." A well illustrated 12-page survey of recent Marconi transmitting equipment, issued by *Marconi's Wireless Telegraph Co., Ltd., Chelmsford.*

"Ediswan Special Purpose Valves." Publication No. R.1338 issued by *The Edison Swan Electric Co., Ltd.*, 155 *Charing Cross Road, London, W.C.2.*

"Precision Measuring Instruments," a catalogue of their current range. *H. Tinsley and Co., Ltd., Werndee Hall, South Norwood, S.E.25.*

"Some Electrical Instruments of Precision." Leaflet on their products issued by: *Doran Instrument Co., Ltd., Wallbridge Works, Stroud, Glos.*

"High Vacuum Equipment." A booklet dealing briefly with this range of equipment issued by: *W. Edwards and Co. (London), Ltd., Kangley Bridge Road, Lower Sydenham, London, S.E.26.*

Piezo Crystals and Constant Temperature Oven. Two leaflets issued by *Piezo Crystals, Ltd., "Hadresham," Outwood, Redhill, Surrey.*

Telcon Metals. Publication No. M44 relating to Transformer and Choke Laminations in Mumetal, Radiometal and Rhometal. *The Telegraph Construction and Maintenance Co., Ltd.*, 22 *Old Broad Street, London, E.C.2.*

A new catalogue of "Douglas" and "Macadie" coil winding machines and accessories giving illustrations and descriptions not only of machines which have been produced for a number of years, but also of a large number of new models. *The Automatic Coil Winder and Electrical Equipment Co., Ltd., Winder House, Douglas Street, London, S.W.1.*

"Radio Measuretests" a 36-page booklet on the determination of radio receiver performance with particular reference to instruments specially designed for the purpose by *Marconi Instruments Ltd., St. Albans, Herts.* from whom any Radio Engineer, writing on business notepaper, may have a copy.

"Loud Speaking Key Controlled Intercommunication Telephone Equipment." A leaflet No. 1001/1 issued by *Automatic Telephone and Electric Co., Ltd., Strowger Works, Liverpool, 7.*

# BOOK

## High Vacua, Principles, Production and Measurement

Swami Jnananandra. (D. Van Nostrand, Inc., New York—Macmillan and Company, Ltd., London). XIII + 310 pp. with 134 illustrations. 1947. Price 30s. net.

THE ever increasing importance of high vacua in electronic, chemical, pharmaceutical and optical engineering attracts the interest of wider and wider circles in their principle, their production and their measurement. Although perhaps no fundamental developments with exception of the advent of new working fluids for diffusion pumps have appeared since the first comprehensive textbooks have been published about 25 years ago and since Yarwood's little monograph (this journal *16*, 82, 1943) any new addition to the literature of this field is welcome.

About one quarter of Dr. Jnananandra's book is devoted to a lucid survey of the principles of the kinetic gas theory the laws of which naturally form the basis of the science and technique of high vacua. This survey forms the first chapter and it contains among other things a brief account of Maxwell's calculation of the distribution of molecular velocities so important in explaining the phenomena in a diffusion pump.

The second chapter, after an introduction dealing briefly with pumping speed, gives a description of pumps with and without piston. A brief paragraph of the section dealing with piston pumps describes electromagnetic pumps designed especially for such cases in which vacua uncontaminated by oil vapour are required. The section on molecular pumps contains also the modern designs due to Siegbahn. A large number of diffusion pumps is described and illustrated among them Dolejsek's three-stage paraffin pump. From the table comparing the performance of vacuum pumps it appears that the most recent designs for very large pumping speeds are not taken into consideration. As highest pumping speed 250 $l$/sec at $10^{-4}$ mm. Hg is mentioned for a multiple-nozzle pump worked with Apiezon "B" oil while actually pumps with a speed of 5,000 $l$/sec at $2 \times 10^{-4}$ mm. Hg have been described in modern literature. No mention is made of silicone oils used as working fluids. Also performance curves for the various pumps are not given.

The third chapter is devoted to high vacuum gauges. In the section dealing with McLeod gauges a reference to tilting types is missing which, in the form of the "Vacustat," afford a very handy though perhaps not too accurate instrument and, in the form of the Flosdorf gauge, lend themselves to a modification suitable as registering instrument. A welcome feature of Dr. Jnananandra's book is the section on "phlegmatic liquid-filled" gauges. While gauges based on radiometer action, thermoconductivity and viscosity are adequately dealt with, a reference to the Philips gauge and to the "Alphatron" is missing in the section on ionisation gauges.

The fourth chapter deals with the technique of high vacua including the tubing and joints for assembling complete vacuum systems, the waxes, cements and greases and a somewhat brief paragraph on leak hunting. Especially in this direction much development work was done in recent years reference to which is missing. Cutoffs, valves and cold traps are also dealt with in this chapter.

Under the heading preparatory operations for vacuum work chapter five gives a brief account on cleaning the apparatus and the theories of, and practices for eliminating, adsorbed and occluded gases.

The sixth and final chapter deals with gettering and similar physico-chemical methods for producing or improving high vacua.

The book is well produced and, in spite of the few objections raised above, deserves to find a place on the book shelves of laboratories and workers in the high vacuum field.

R. NEUMANN

## Vacuum Tubes

By Karl R. Spangenberg, xvii -- 860, McGraw-Hill, 1948. 30s. net.

THE post-war years have witnessed the publication of a succession of books, mainly of American origin, which purport to describe the developments which took place in radio physics and radio engineering between the years of 1939 and 1945. Of these the volumes of the Radiation Laboratory Series are typical; descriptions with little or no commentary, making the minimum of discrimination between the finished research which adds a stone to the scientific edifice, and the unfinished, sometimes abortive experiment which is part of the rubble of war-time building.

A few books of the more old-fashioned didactic type are now beginning to appear, and of these Professor Spangenberg's work is an interesting example. In "Vacuum Tubes" the scientific basis of the subject is adequately laid by a teacher who has shown considerable discrimination in selecting his topics. Only well-tested theories which add to our understanding of vacuum physics have been included, and there is none of the apparent aimlessness which is bound

# REVIEWS

to characterise the factual accounts of war work. As a consequence, the reviewer found this book a pleasure to read. That he also found it instructive suggests that it contains much that has not been adequately recorded in other works of the same nature.

In his introduction, after quoting phenomenally large figures for the numbers of electronic equipments in U.S.A., the author concludes that "there are many vacuum tubes in use" and suggests that "they must be of some importance." The succeeding 21 chapters should convince the reader of this. It should also give him a most refreshing course in all branches of applied physics, for Professor Spangenberg does not hesitate to go back to first principles when the argument warrants it, nor does he gloss over the detailed techniques required for the study of problems in valve design. For example, Chapters 4, 19, and 21 could be transferred *en bloc* to any standard work on modern pure physics. Their subjects are, respectively, Electron Emission, Photo Electric Tubes and High-Vacuum Practice. On the other hand, Chapters 7, 9, 10 and 11 constitute an exhaustive and illuminating account of the analysis of "standard" valves, the titles being "The Electrostatic Field of a Triode," "Triode Characteristics," "Tetrodes" and "Pentodes." The result is that the book is a rich mine of information on almost all aspects of the subject, and yet the mode of presentation gives a pedagogic continuity.

In a book of this magnitude one expects to meet a few errors. On page 45 it is stated that during the activation of an oxide emitter, "copious oxygen is evolved." Surely one should read "carbon dioxide" for "oxygen." On page 169 the figure showing the potential distribution in a plane-electrode diode is misleading. The student might continue under a misapprehension until page 191. In this case the presentation might be improved. There is a misprint in the legend of Fig. 14.2 on page 395, and the description of "sealing glass to other materials" on page 796 *et. seq.* is not detailed enough to be of any real value to the technician. But these are minor blemishes in what must be regarded as a most excellent treatise. The book can be unreservedly recommended to all serious students of "vacuum tubes" who will find that the dry humour with which it is punctuated does nothing to detract from its value.

J. THOMSON

## Pulse Generators

G. N. Glasoe, J. V. Lebacqz and others. Massachusetts Institute of Technology. Radiation Laboratory Series. Vol. 5. 741 pp. Price 54s.

WAR generally brings considerable technological advances but it is often at the cost of fundamental research. "Pulse Generators" emphasises the truth of this statement for it discloses no fundamental development; it is a valuable record, well documented and liberally illustrated, of the application of known principles in the radar field. The principal authors are university teachers, and their practical experience in teaching has been used to such good effect that any one with a graduate's knowledge of radio engineering can gain a full understanding of the principles and practice of pulse generation for modulating magnetron radar transmitters. Inevitably a number of instances of recapitulation occur and the designer of pulse equipment may well prefer the I.E.E. Radiolocation Convention papers* on Pulse Modulators, which contain as much practical information in a more succinct form. Reference to these publications has not been found in the book but acknowledgment is made at many places to the contributions of British scientists.

The book is divided into three parts; the first of approximately 150 pages, describes the hard valve pulser which is triggered by a pulse applied to its grid and which partially discharges a storage capacitor through the load. The next 300 pages of Part II are devoted to the Line-Type Pulser, which may use a spark-gap or thyratron valve to discharge a charged artificial line into the load. Pulse Transformer Design is the subject of Part III, which is practically the same length as Part I. There are two appendices on Pulse Measuring Techniques and Equivalent Pulse Duration and Amplitude. A list of symbols is also included and against each is placed the page on which the symbol first appears.

There are 15 chapters, of which the first is an excellent introduction to the problems associated with the types of pulse generators that were developed. A final section sets out in tabular form the advantages and disadvantages of the two types of pulse modulator. Part I begins at Chapter 2 with a discussion of the power supply and the storage capacitor which are the sources of pulse energy. The method of coupling to the magnetron load, which is shown to be equivalent to a biased diode, is considered, and the advantages of using a transformer are outlined. The third chapter lists the properties of the ideal switching valve and shows how far these can be fulfilled by the triode or tetrode. The receiving

* Proceedings of the Radiolocation Convention. *J.I.E.E.*, Vol. 93, Part IIIA, Nos. 5, 6 and 7.

# BOOK REVIEWS *(continued)*

valve engineer will find himself on familiar ground here for most of the problems encountered with oxide-coated cathode valves are described. Chapter 4 deals with the various types of driver circuit needed to trigger the final pulser valve. The driver stage does not generate the initial pulse but is itself triggered, and three types are described. These are the Bootstrap (a valve with its load in the cathode to H.T. negative lead), the blocking oscillator or more correctly termed regenerative driver, for it is quiescent until triggered by the initiating pulse, and the multivibrator biased to be inoperative until triggered. Chapter 5, which concludes Part I, contains full descriptions of three types of pulse modulators, two of which had wide application during the war. One is a light-weight airborn pulser of 0.144 MW power output and the other is part of a ground station radar equipment with a pulse power output of 1 MW. The very complete circuit diagrams will be invaluable to any institution, which has acquired American ex-Army UHF radar apparatus.

Chapter 6, the first of Part II, analyses the pulse forming network and stresses the difficulty of obtaining very steep leading and trailing pulse edges from equivalent lines with lumped con stants. Guillemin's important contribution to the design of the sections of equivalent line is described and illustrated by numerical examples. The construction and testing of the coils and capacitors making up the sections of the line are fully discussed. The subject of Chapter 7 is the discharge circuit for the line network, i.e., the switch and the load and it is shown that the matching of load to line is not critical. Its effect on pulse shape, regulation and efficiency is also considered. Chapter 8 covers the three types of switch, the rotary and fixed spark gaps and the hydrogen thyratron. Circuit design for either d.c. or a.c. methods of charging the line is examined in Chapter 9, and the performance of the pulser and the various factors affecting it are given in Chapter 10. Part II concludes in Chapter 11 on particular apparatus treated in as full detail as those described in Chapter 5.

Part III has four chapters on pulse transformer design. Chapter 12 is a general introduction to transformer theory and Chapter 13 shows how this theory must be modified to meet the needs of pulse waveforms. The effect of transformer parameters on the leading and trailing edges and the top of the pulse is examined in Chapter 14. The final chapter considers the properties of suitable core materials. This part seemed less satisfactorily written than the others largely because a clear distinction is not made between the essential and less essential points of detail. In the reviewer's opinion Melville's paper* on the same subject gives a better picture of the problems of pulse transformer design and their method of solution.

Outstanding features of the book are the large number of oscilloscope traces used to illustrate pulser performance and the way in which theoretical analyses are followed by practical examples giving typical component values. The book should be in the reference library of every organisation concerned with radio and most designers of pulse equipment will wish to have their own copy. Its esoteric character will restrict its sale among radio engineers whose work is unconnected with pulse modulators for radar equipment.

K. R. STURLEY

* Melville, W. S. The Theory and Design of High Pulse Transformers. Proceedings of the Radiolocation Convention. *J.I.E.E.*, Vol. 93, Part IIIA. No. 6, p. 1063.



## Antenna Manual

Woodrow Smith (Editors and Engineers, Ltd., Santa Barbara. California, U.S.A.) 306 pp. Price 25s.

THE author of this book has restricted himself to a non-mathematical account of antennae and has omitted the usual references one expects to find in technical works. As a result the book will appeal far more to the radio amateur than to the professional engineer. The emphasis on the amateur's requirements is also shown by the fact that short and ultra-short wave antennae are dealt with in greater detail than other types.

A quarter of the book is taken up by the first chapter which is devoted to a discussion of the propagation of radio waves; but since a consideration of the propagation conditions is almost inseparably linked up with the design of an antenna system, this forms a valuable addition to the book.

The book continues with quite an extensive description of transmission lines dealt with from a practical point of view. This is followed by chapters dealing with antenna systems at various frequencies, one on measuring equipment and techniques, and finally a chapter on antennae for navigational aids. Actually the last chapter contains very little beyond a short discussion of D.F. antennae, for the material presented on radar antennae is too sketchy to be of any engineering value.

So far the review has been concerned only with the scope of the book. It must now be added that both the writing and presentation of the information are excellent throughout the book. Moreover, the author has succeeded in introducing many of the "finer points" of the subject without in any way obscuring the main issues. It can be stated therefore that many radio enthusiasts will welcome the publication of this book.

H. PAUL WILLIAMS

## Great Circle Projection Map

Copies are obtainable from the Publishers of "Wireless World," Dorset House, Stamford Street, London, S.E.1, at 2s. 6d. (by post 3s.)

THE *Wireless World* Great Circle Projection Map was first drawn by the late J. St. Vincent Pletts at the time when world-wide radio communication was just beginning. Since then, the map has become an essential part of the equipment of every station concerned with long-range communication.

The map gives the true bearing and distance "as the radio wave travels" to any part of the British Isles. Nothing more elaborate than a rule with inches divided decimally is needed for making measurements.

# JANUARY MEETINGS

## The Institution of Electrical Engineers

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

### Radio Section

Date: January 11. Time: 5.30 p.m.
Lecture: "Double-Ratio A.C. Bridge with Inductively Coupled Ratio Arms."
By: H. A. M. Clark, B.Sc.(Eng.), and P. B. Vanderlyn.
Lecture: "A Direct-Capacitance Aircraft Altimeter."
By: W. L. Watton, B.Sc., and M. E. Pemberton.

*This is a joint meeting with the Measurements Section.*

Date: January 12. Time: 5.30 p.m.
Lecture: "Some Aspects of Design of Balanced Rectifier Modulators for Precision Applications."
and
"The Effects of an Unwanted Signal Mixed with a Carrier Supply of Ring-and-Cowan Modulators."
By: D. G. Tucker, D.Sc., Ph.D.

Date: January 18. Time: 5.30 p.m.
Discussion on: "Should British Universities consider the Establishment of Special Degrees in Radio?"
Opened by: Professor E. B. Moullin, M.A., Sc.D.

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

### Cambridge Radio Group

Date: January 11. Time: 6 p.m.
Held at: The Cambridgeshire Technical College.
Lecture: "The Testing of Communication-Type Receivers."
By: W. J. Bray, M.Sc.(Eng.), and W. R. H. Lowry, B.Sc.

*Hon. Sec.: H. G. Booker, Cavendish Laboratory, Cambridge.*

### North-Western Radio Group

Date: January 19. Time: 6.30 p.m.
Held at: The Engineers' Club, Albert Square, Manchester.
Lecture: "Three-Dimensional Cathode-Ray-Tube Displays."
By: E. Parker, M.A., and P. R. Wall, B.Sc.(Eng.).

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

### North Staffordshire Sub-Centre

Date: January 10. Time: 7 p.m.
Held at: King Edward Grammar School, Stafford.
Lecture: "Some Projects favourable to Direct-Current Transmission, and the Role of the British Electrical Industry in Relation thereto."
By: F. J. Erroll, M.A., M.P., and The Lord Forrester, M.A.

*Hon. Secretary: R. G. Kitchenn, Post Office Engineering Dept., Central Training School, Duncan Hall, Stone, Staffs.*

### South Midland Centre

Date: January 25. Time: 6 p.m.
Held at: The Town Hall, Birmingham.
Lecture: Faraday Lecture on "Television."
By: Sir Noel Ashbridge, B.Sc.(Eng.).

*Hon. Secretary: H. Hooper, British Electricity Authority, 53 Wake Green Road, Moseley, Birmingham, 13.*

### South Midland Radio Group

Date: January 24. Time: 6 p.m.
Held at: The James Watt Memorial Institute, Great Charles Street, Birmingham.
Lecture: "Television Developments."
By: K. R. Sturley, Ph.D.

*Hon. Secretary: H. G. Foster, Electrical Engineering Dept., The University, Edgbaston, Birmingham, 5.*

### Western Centre

Date: January 10. Time: 5 p.m.
Held at: South Wales Institute of Engineers, Park Place, Cardiff.
Lecture: "A Resumé of the V.H.F. Point-to-Point Communication."
By: F. Hollinghurst, B.Sc.(Eng.), and C. W. Sowton, B.Sc.

Date: January 19. Time: 6.30 p.m.
Held at: Victoria Rooms, Bristol.
Faraday Lecture: "Television."
By: Sir Noel Ashbridge, B.Sc.(Eng.).

*Hon. Secretary: J. Vaughan Harries, 28 St. Mary Street, Cardiff.*

## The Institute of Physics

### London and Home Counties Branch

Date: January 12. Time: 5.30 p.m.
Held at: The Institute of Physics, 47 Belgrave Square, S.W.1.
Lecture: "The History of the Fundamental Concepts of Electricity."
By: Dr. N. H. de V. Heathcote.

*Hon. Secretary: Dr. H. L. Penman, Rothamsted Experimental Station, Harpenden, Herts.*

## British Sound Recording Association

Date: January 28. Time: 7 p.m.
Held at: The Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2.
Lecture: "Gramophone Record Processing."
By: E. D. Parchment.

*Hon. Secretary: R. W. Lowden, "Wayford," Napoleon Avenue, Farnborough, Hants.*

## R.S.G.B.

Date: January 28. Time: 6.30 p.m.
Held at: The Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2.
Adjourned Annual General Meeting.

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

## Brit. I.R.E.

### London Section

Date: January 20. Time: 6 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.
Lecture: "Developing an Indicator Unit for $H_2S$ Equipment."
By: R. T. Croft.

*The Secretary: 9 Bedford Square, London, W.C.1.*

### South Midlands Section

Date: January 27. Time: 7 p.m.
Held at: The Technical College, The Butts, Coventry.
Lecture: "Telecommunications in Turkey."
By: A. E. Harrold.

*Secretary: C. Stokes, 6 Esterton Close, Coventry.*

### Merseyside Section

Date: January 5. Time: 6.45 p.m.
Held at: The Incorporated Accountants' Hall, Derby Square, Liverpool, 2.
Lecture: "Television Receiver Design Technique."
By: W. Jones.

*Secretary: J. Gledhill, 123 Portelet Road, Liverpool, 13.*

### North-Western Section

Date: January 6. Time: 6.45 p.m.
Held at: College of Technology, Sackville Street, Manchester, 1.
Presidential Address.
By: L. H. Bedford, O.B.E., M.A.

*Secretary: G. T. Y. Stennett, 123, Parrs Wood Road South, East Didsbury, Manchester, 20.*

## The Television Society

### Midlands Centre

Date: January 4. Time: 7 p.m.
Held at: The Chamber of Commerce, New Street, Birmingham.
Lecture: "Television Applications other than Entertainment."
By: Dr. W. Summer.

*Hon. Lecture Secretary: Dr. W. Summer, 169 Mary Vale Road, Bourneville, Birmingham, 30.*

## The Royal Photographic Society

### Scientific and Technical Group

Date: January 11. Time: 7 p.m.
Held at: 16 Princes Gate, S.W.7.
Lecture: "Picture Telegraphy."
By: J. Bell, M.Sc., M.I.E.E.

Date: January 13. Time: 7 p.m.
Held at: 16 Princes Gate, S.W.17.
A Symposium: "Utilisation of Government Surplus Photographic Equipment."

Date: January 20. Time: 7 p.m.
Held at: 16 Princes Gate, S.W.17.
Lecture: "The Kinephotomicrography of the Living Cell."
By: Dr. A. Hughes.

*The Secretary: 16 Princes Gate, S.W.7.*

# ABSTRACTS OF ELECTRONIC LITERATURE

## CIRCUITS

### Very-High-Frequency Single-Channel Receiver

(*W. C. Lane and T. C. Clark*)

Increased traffic at the major airports and the greater coverage required of airline *en route* communications have shown the need for an improved very-high-frequency crystal-controlled ground-station receiver with high rejection of unwanted signals and good sensitivity. The receiver designed for these requirements operates on a single pretuned frequency in the range of 118 to 136 megacycles per second, and employs a 14-tube superheterodyne circuit, incorporating automatic-volume-control, squelch, and noise-limiter circuits. Low cost, small size, high quality, performance, and an easily serviceable unit were the points stressed in this design. Field tests indicate the effectiveness of the design.

—*Elect. Comm.*, June, 1948, p.132.

### Simplified Automatic Stabilisation of a Frequency-Modulated Oscillator

(*J. L. Hollis*)

A frequency-modulated exciter which incorporates a quartz-crystal discriminator for centre-frequency stabilisation of the modulated oscillator is described. The unit was designed as the exciter for a frequency-modulated broadcast transmitter.

The frequency-stabilising circuits are the unique portion and are described in detail. Circuit simplicity is attained by operating the discriminator at the modulated-oscillator frequency, thus eliminating heterodyning and mixing circuits. A special bridge circuit, operating on the modulator bias, maintains the average frequency at the mid-point of the discriminator. Performance and stability of a completed unit are briefly discussed.

—*Proc. I.R.E.*, September, 1948, p.1,164.

### Distributed Amplification

(*E. L. Ginzton, W. R. Hewlett, J. H. Jasberg and J. D. Noe*)

This paper presents a new principle in wide-band amplifier design. It is shown that, by an appropriate distribution of ordinary electron tubes along artificial transmission lines, it is possible to obtain amplification over much greater bandwidths than would be possible with ordinary circuits. The ordinary concept of "maximum bandwidth-gain product" does not apply to this distributed amplifier. The high-frequency limit of the distributed amplifier appears to be determined by the grid-loading effects.

The distributed amplifier provides means for designing amplifiers either of the low-pass or band-pass types. The low-pass amplifiers can be made to have a uniform frequency response from dc to frequencies as high as several hundred Mc/s. using commercially available tubes.

The general design considerations included in this paper are: The effect of improper termination of transmission lines; methods for controlling the frequency response and phase characteristic; the design which provides the required gain with fewest possible number of tubes; and a discussion of high-frequency limitations. The noise factor of the amplifier is evaluated.

Practical amplifiers, designed according to the principles described in this paper, have been built and have verified the theoretical predictions. Experimental work will be described in a forthcoming paper.

—*Proc. I.R.E.*, August, 1948, p.956.

### A Phase-Shift Oscillator with Wide-Range Tuning

(*G. Willoner and F. Tihelka*)

A new audio oscillator of the phase-shift type is discussed. The oscillator can cover continuously the entire audio-frequency range, and tuning is achieved by varying but one element of the feedback network. The theory of the new principle and a description of the oscillator are given.

—*Proc. I.R.E.*, September, 1948, p.1,096.

### A Broad-Band High-Level Modulator

(*R. J. Rockwell*)

A class-B modulator has been devised to assure a broad pass band having uniform gain with quite low distortion and noise level. Unique features include (1) a cathode follower, (2) no modulation transformer, and (3) broad-band feedback.

—*Proc. I.R.E.*, September, 1948, p.1,160.

## C. R. TUBES

### Some New Aspects of High-Speed Oscillography

(*D. M. Mackay*)

In Part I it is shown that conventional deflexion systems do not enable the possibilities of the cathode-ray tube to be fully realised. By a modification to the shape of deflector plates, it is theoretically possible, under suitable conditions, to expand the time scale obtainable with a given time-base generator up to infinity. The geometry of the deflected electron beam is examined, and an expression derived relating the shape of the effective time-base voltage wave-form, the time scale, and the shape of the Y-plates. In Part II, several practical factors, which cause various forms of trace distortion, are examined, and possible ways of overcoming a number of these difficulties are described.

—*Phys. Soc. Proc.*, September, 1948, p.235.*

### Spectral Power Distribution of Cathode-Ray Phosphors

(*R. M. Bowie and A. E. Martin*)

This paper embodies some of the results of a study undertaken because of the lack of substantial agreement among colorimetric determinations made from cathode-ray-tube screens by television manufacturers in the United States. The ICI (International Commission on Illumination) system of colour specification is described, and is applied to the visible light produced by cathode-ray screens. A survey was made of the principal colorimetric methods now in use by television manufacturers. These methods have been evaluated in terms of how closely their inherent characteristics meet the criteria of the 1931 ICI Standard Observer. The necessity for standardisation of colorimetric measuring equipment is pointed out. Suggestions are offered as to the manner in which such standardisation might be achieved.

—*Proc. I.R.E.*, August, 1948, p.1,023.

## THEORY

### Some Notes on Noise Theory and its Application to Input Circuit Design

(*W. A. Harris*)

The mechanism by which noise is produced in an electron tube and is relation between induced grid noise and plate noise are discussed. An equivalent circuit with noise generators supplying voltages and currents to simulate noise derived from the plate current of a tube, from the grid by passage of this current, and from the input circuit is then analysed to determine the optimum noise factor obtainable under various conditions. The frequency for which the quantity $R_{eg}\, g_{in}$ is unity is seen to be an appropriate figure of merit for the noise produced by an electron tube. The frequencies corresponding to chosen values for the noise factor are presented for several receiving tube types. The paper concludes with a discussion of the circuit requirements which must be satisfied in order to obtain noise factors approximating the theoretical values.

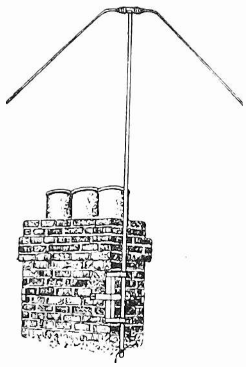
—*R.C.A. Review*, September, 1948, p.406.

* Abstracts supplied by the courtesy of Metropolitan-Vickers Electrical Co. Ltd. Trafford Park, Manchester

# BELLING-LEE

## 'QUIZ' (No. 17)

***Answers to some of the questions we are continually asked by letter and telephone***



*Showing the "Belling-Lee" L.606 Inverted "V."*

**Question 43** (requested many times). *Can we have further technical information regarding your inverted "V" television aerial?* (*1)

**Answer 43.** This inverted "V" aerial was designed, in the first place, for indoor use in vicinities where the field strength was sufficiently intense to dispense with outdoor aerials. Apart from the symmetrical manner in which this aerial fits in with the roof shape, the bending of each element to an angle of 45 deg. introduces a valuable technical feature, namely, the independence of the aerial upon the angle of polarisation of the incident signal wave.

There is naturally some loss of signal, the terminal voltage at the mid-point being 6db less than that from a single vertical half-wave di-pole. Since the aerial is only intended for use under conditions of high field strength this loss is quite unimportant. In addition to this non-polarising feature the aerial is directional, possessing sharp minima at right angles to its plane. This property is of very great use in removing a "ghost" due to the multi-path transmission, or for eliminating interference from electronic heating or diathermy apparatus.

As regards the limits of distance (from the transmitter) at which the inverted "V" aerial can be expected to work satisfactorily, a great deal obviously depends upon the amount of local screening. Experience indicates that, in suburban districts, a distance up to five miles can usually be relied upon. If the aerial is mounted out of doors at a height of about 40 feet, the above distance can be doubled.

The aerial is designed to be connected to a twin balanced feeder of 80 ohms nominal characteristic impedance (*2) but co-axial feeder (*3) may be used with negligible difference in results. Due to the partial folding of the elements, the bandwidth of the aerial is somewhat greater than that of the conventional dipole using elements of the same diameters, and is more than adequate for both the sound and vision channels as at present transmitted.

| | | |
|---|---|---|
| *1 L.605. | Inverted "V" for attic mounting | **£2 10 0** |
| L.606. | Inverted "V" for chimney mounting | **£4 12 6** |

Regd. Design No. 836593 Patent applied for.

*2 Balanced twin L.336. **7½d.** per yard } extra.
*3 Co-axial L.600. **1/6** per yard }

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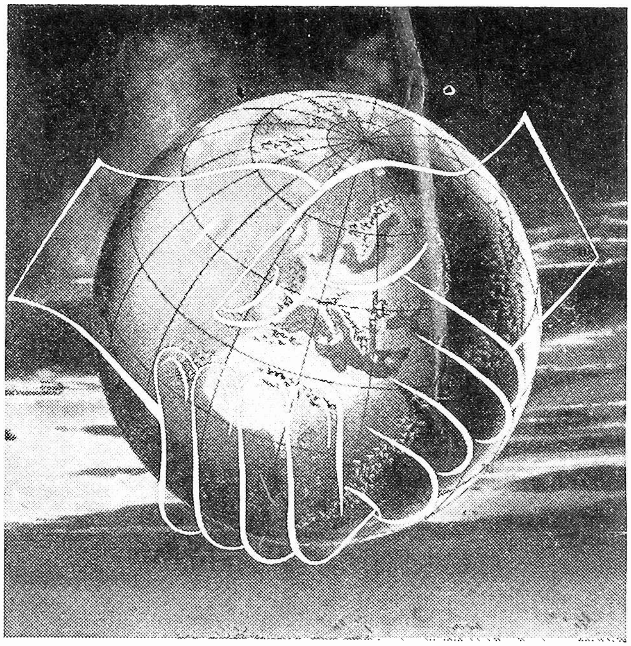

## Plans for a neighbourly world

Marconi's first wireless messages did more than enable nation to speak to nation. They drew closer the world's boundaries, quickened the tempo of existence and turned distant acquaintances into next-door neighbours. Broadcasting has helped still further to increase our knowledge of our neighbours ; wireless navigational aids and radar have brought greater safety and faster travel between Continents. And so Marconi's will continue to pioneer. Their engineers are busy today on developments which will make the world a closer community tomorrow.

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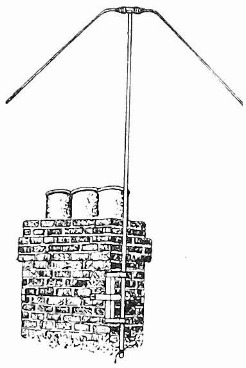
# BELLING-LEE

## 'QUIZ' (No. 17)

***Answers to some of the questions we are continually asked by letter and telephone***



*Showing the "Belling-Lee" L.606 Inverted "V."*

**Question 43** (requested many times). *Can we have further technical information regarding your inverted "V" television aerial?* (*1)

**Answer 43.** This inverted "V" aerial was designed, in the first place, for indoor use in vicinities where the field strength was sufficiently intense to dispense with outdoor aerials. Apart from the symmetrical manner in which this aerial fits in with the roof shape, the bending of each element to an angle of 45 deg. introduces a valuable technical feature, namely, the independence of the aerial upon the angle of polarisation of the incident signal wave.

There is naturally some loss of signal, the terminal voltage at the mid-point being 6db less than that from a single vertical half-wave di-pole. Since the aerial is only intended for use under conditions of high field strength this loss is quite unimportant. In addition to this non-polarising feature the aerial is directional, possessing sharp minima at right angles to its plane. This property is of very great use in removing a "ghost" due to the multi-path transmission, or for eliminating interference from electronic heating or diathermy apparatus.

As regards the limits of distance (from the transmitter) at which the inverted "V" aerial can be expected to work satisfactorily, a great deal obviously depends upon the amount of local screening. Experience indicates that, in suburban districts, a distance up to five miles can usually be relied upon. If the aerial is mounted out of doors at a height of about 40 feet, the above distance can be doubled.

The aerial is designed to be connected to a twin balanced feeder of 80 ohms nominal characteristic impedance (*2) but co-axial feeder (*3) may be used with negligible difference in results. Due to the partial folding of the elements, the bandwidth of the aerial is somewhat greater than that of the conventional dipole using elements of the same diameters, and is more than adequate for both the sound and vision channels as at present transmitted.

*1 L.605. Inverted "V" for attic mounting **£2 10 0**
L.606. Inverted "V" for chimney mounting **£4 12 6**
Regd. Design No. 836593 Patent applied for.

*2 Balanced twin L.336. **7½d.** per yard } extra.
*3 Co-axial L.600. **1/6** per yard }

TO BE CONTINUED . . .

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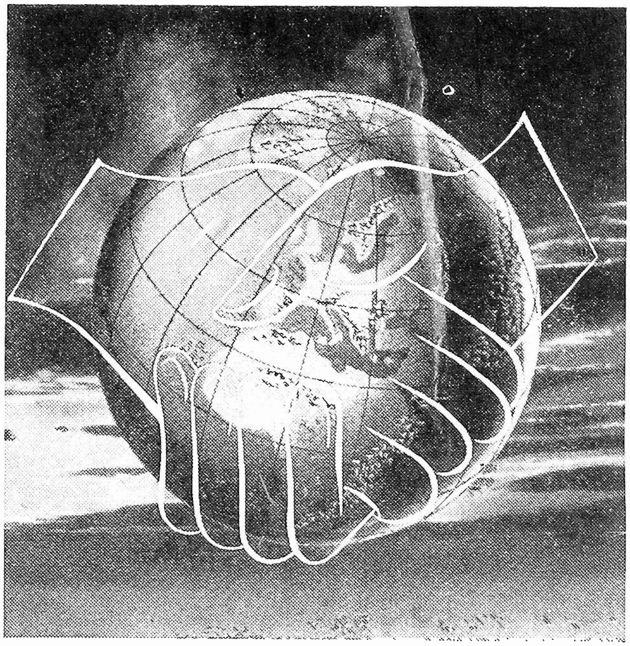

# Plans for a neighbourly world

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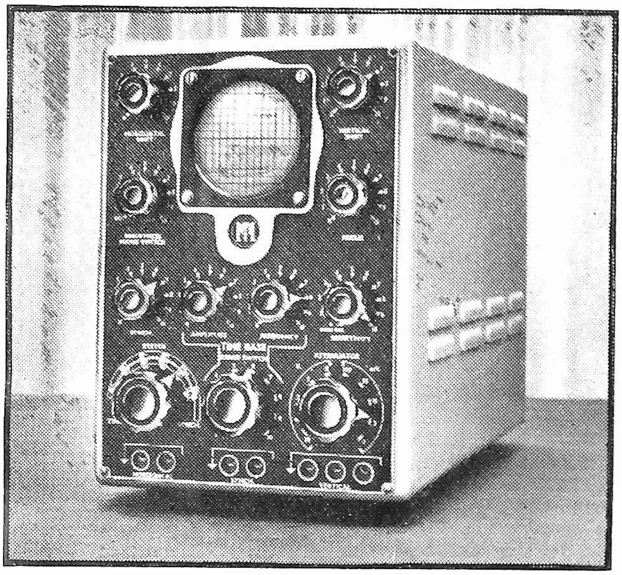
# Measurement by Mullard



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Time base frequency 0.25—16,000 c/s.
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Amplifier sensitivity (Max. Gain) 1 mV.rms/cm.
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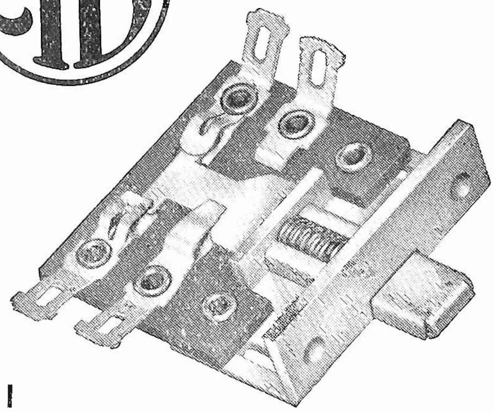





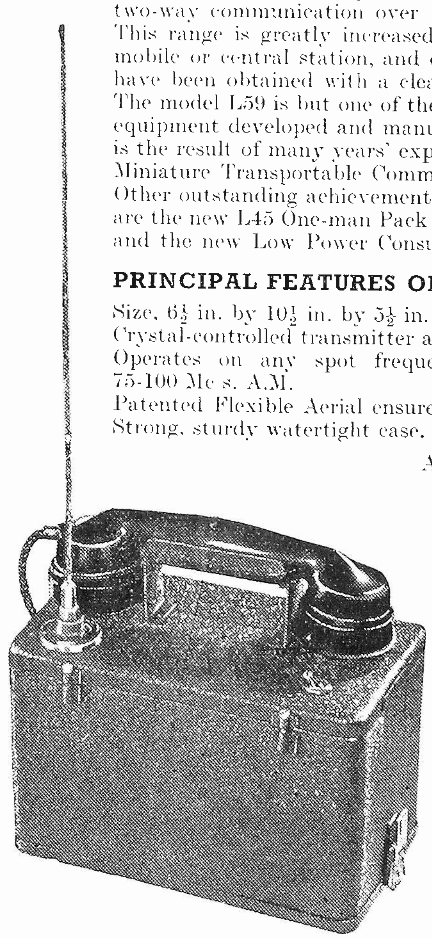

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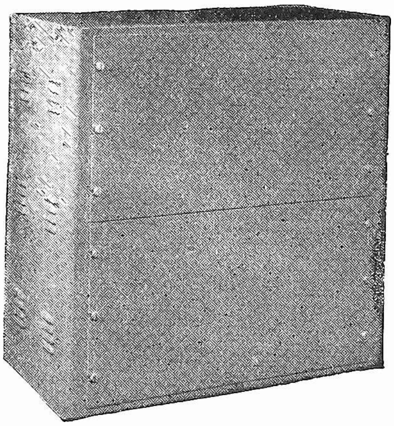

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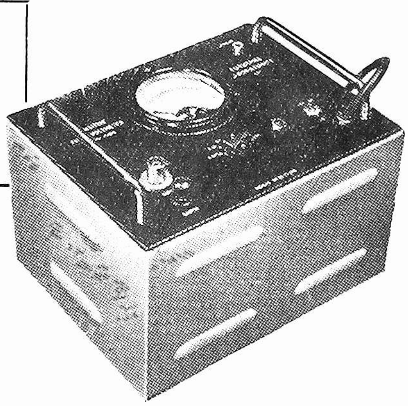

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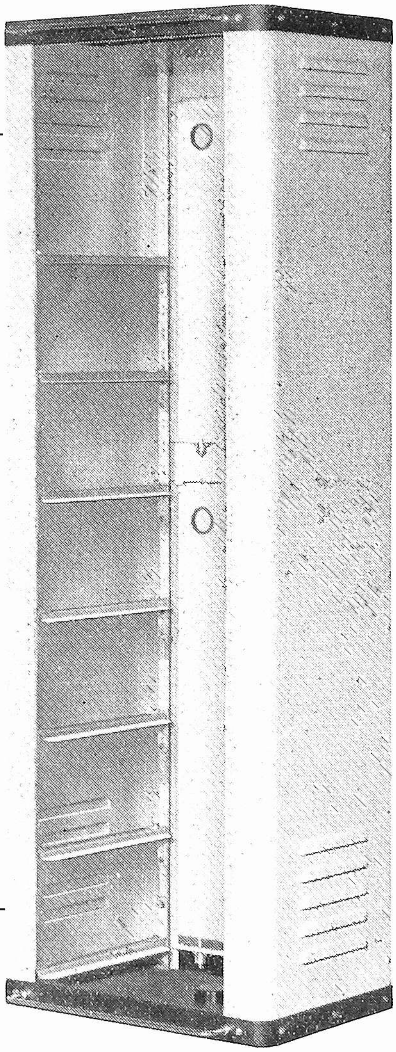

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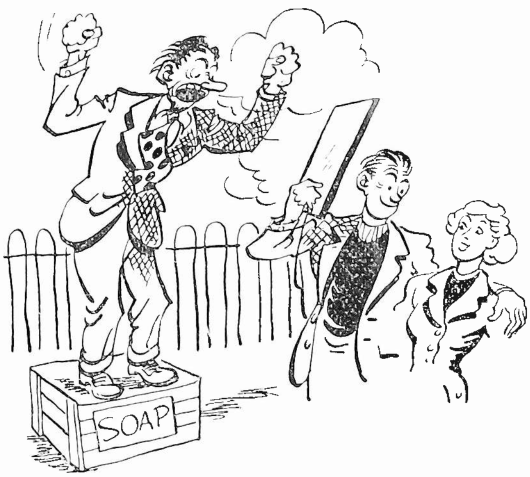


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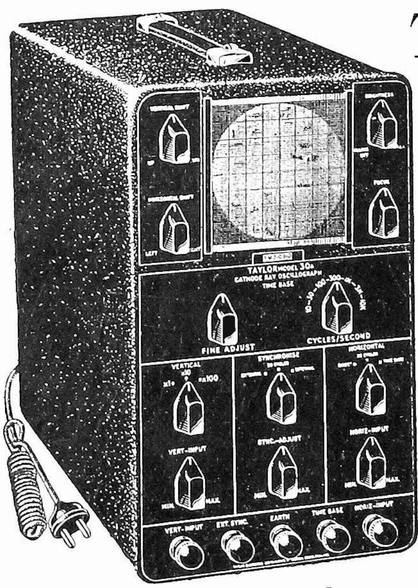


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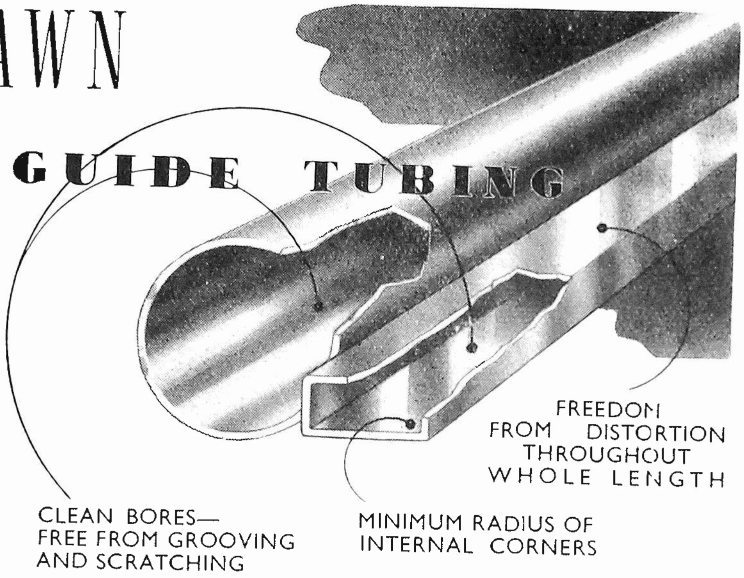


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| M | 3N | 0.003 µF | 350 V. ,, | 2/3 |
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| CP | 33S | 0.01 µF | 500 V. ,, | 1/10 |
| CP | 34S | 0.02 µF | 500 V. ,, | 1/10 |
| CP | 37S | 0.05 µF | 500 V. ,, | 2/1 |
| CP | 31N | 0.005 µF | 350 V. ,, | 1/8 |
| CP | 32N | 0.01 µF | 350 V. ,, | 1/8 |
| CP | 33N | 0.02 µF | 350 V. ,, | 1/9 |
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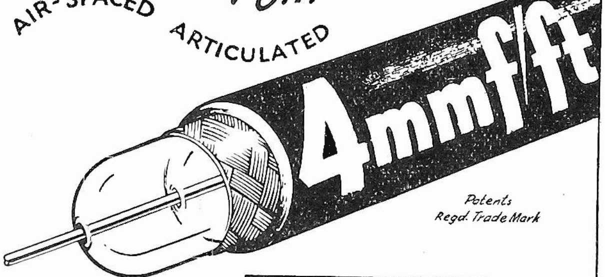


Patents
Regd. Trade Mark

THE LOWEST EVER CAPACITANCE OR ATTENUATION

*IMMEDIATE DELIVERIES FOR HOME & EXPORT*

*Write or cable for data sheets or deliveries to the Originators of flexible air spaced RF Cables*

| LOW ATTEN TYPES. | IMPED OHMS | ATTEN. db/100ft at 100 Mc/s. | LOADING Kw. | O.D." |
|---|---|---|---|---|
| A 1 | 74 | 1.7 | 0.11 | 0.36 |
| A 2 | 74 | 1.3 | 0.24 | 0.44 |
| A34 | 73 | 0.6 | 1.5 | 0.88 |

HIGH POWER FLEXIBLE

| LOW CAPAC TYPES. | CAPAC mmf/ft | IMPED. OHMS. | ATTEN. db/100ft 100Mc/s. | O.D." |
|---|---|---|---|---|
| C 1 | 7.3 | 150 | 2.5 | 0.36 |
| P.C.1 | 10.2 | 132 | 3.1 | 0.36 |
| C 11 | 6.3 | 173 | 3.2 | 0.36 |
| C 2 | 6.3 | 171 | 2.15 | 0.44 |
| C22 | 5.5 | 184 | 2.8 | 0.44 |
| C 3 | 5.4 | 197 | 1.9 | 0.64 |
| C33 | 4.8 | 220 | 2.4 | 0.64 |
| C44 | 4.1 | 252 | 2.1 | 1.03 |

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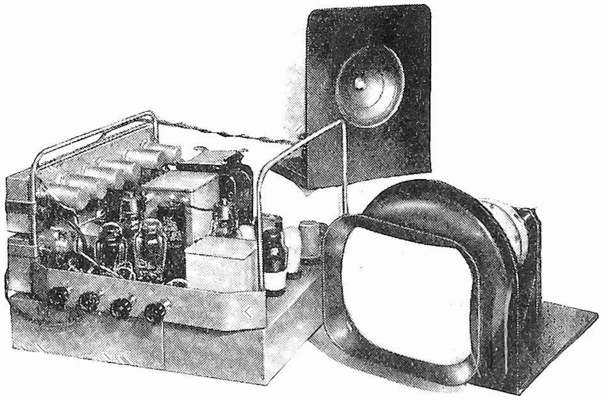
Cables: TRANSRAD, LONDON

Electronic Engineering

## HOME BUILT TELEVISOR



A specially built model

NOW ON VIEW

All components — brand new and exactly as specified by "Electronic Engineering" —are available from stock.

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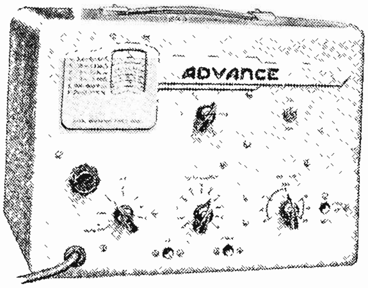
The "Advance" Type E Signal Generator places an instrument of laboratory class within the financial scope of every radio service engineer and experimenter.

The discerning engineer will appreciate its accuracy and stability, its **exceptionally wide range** which covers all frequencies required for radio and television receivers and its accurate attenuating system which enables sensitivity measurements to be made on highly sensitive receivers up to 60 Mc/s. Send for fully descriptive pamphlet.




**Range:** 100 Kc/s—60 Mc/s on fundamentals.
**Accuracy:** Guaranteed within ± 1%.
**Attenuation:** Constant impedance system embodying a matched 75 ohms transmission line.
**Stray Field** Less than 3 microvolts at 60 megacycles.
**Illuminated Dial:** Total scale length 30".
**Power Supply:** 110-210-230 volts.
**Dimensions:** 13" × 10½" × 7¼" deep.
**Weight:** 15 lbs.

The **Advance** Type E Signal Generator

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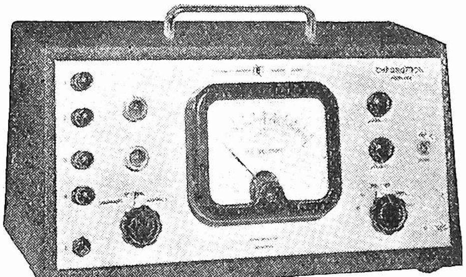


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MODEL 25A ... 0 — 1 Second
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IN SIX RANGES

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*(Available for Ship's stores use and Export free of Purchase Tax.)*

## GRAMOPHONE MOTORS

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**"Connoisseur"** A.C.-operated motor, on mounting plate with on/off switch and speed regulator. Heavy cast non-magnetic turntable. This motor fulfils the long-felt need for SILENT AND STABLE REVOLUTION. Design gives absolute minimum induced hum and is suitable for use with modern low-output pick-ups....................£13 5s. 0d. Plus £5 14s. 10d. Purchase Tax.

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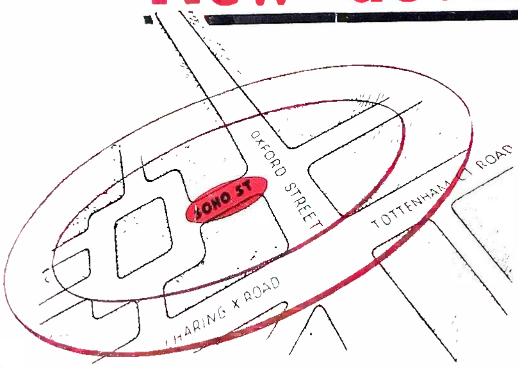
**Collaro AC37.** Similar to AC47, but with mounting plate and auto-stop.................................................£5 2s. 0d. Plus £2 4s. 2d. Purchase Tax.

**Collaro RP49.** A popularly-priced general purpose unit on mounting plate and *complete with pick-up*.......................£4 0s. 0d. Plus £1 14s. 8d. Purchase Tax.

# New developments at WEBB'S




*FOR ALL HIGH-GRADE ELECTRONIC APPARATUS*

## TEST APPARATUS

**Eddystone Crystal Calibrator.** An indispensible item for accurate calibration of receivers, etc., and for checking accuracy of signal generators. Gives "markers" every 1,000 Kc/s. or 100 Kc/s., the 100 Kc/s. harmonics being usable up to 30 Mc/s., and the 1,000 Kc/s. up to 60 Mc/s. Two separate vacuum-mounted crystals, accuracy .01 per cent. A.C. operated 210/230 volts. Extremely compact design, size 4½" × 3½" × 3". Cat. No. 690....£12 0s. 0d.

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**Industrial Electronics Oscilloscope, Model 1200.** Employs 2¾" tube in a completely self-contained unit. Push-pull D.C. connected amplifiers on both axes. Sensitivity 100 mV. per cm. Frequency response sensibly level from zero to 50 Kc/s., and useful up to 500 Kc/s. Time base 5 cycles to 20 Kc/s. in 4 steps. The X amplifier allows expansion of the time base up to approximately 8 diameter. Instantaneous shift and positive sync. operation. Size 9½" × 8" × 7".....................£32 0s. 0d.

**Wayne Kerr Component Bridge B101.** An A.C. operated instrument for the direct measurement of L. C. & R. with a general accuracy of ±2 per cent, falling away slightly at scale extremes. Capacity, 0/500 microfarads in 8 ranges. Resistances, 0/500 megohms in 8 ranges. Inductance, 0/5,000 henries in four ranges (min. 100 m/henries). Comparator: for comparison of components—scale directly calibrated in percentages up to ±10 per cent. Leakages, 0/1.5 microamps in 10 microamp steps. General: direct indication of power factor and Q is available on most ranges, and a selection of polarising voltages is available for application to electrolytics prior to measurement. Size, 14" × 10½" × 9¼".......................£27 6s. 0d.

**Taylor Model 30A Oscillograph.** A general purpose instrument using a 3½" tube and push-pull amplifier for vertical plates coverage. Audio frequency range, with useful amplification up to 100 Kc/s. Linear horizontal timebase with coarse and fine frequency controls 10 to 10,000 Kc/s. A.C. operated 110 or 200/250 volts £29 10s. 0d.

**Cossor Oscillograph Model 1035.** The newly-developed version of Cossor's famous "Double Beam Scope." The facilities offered by this versatile instrument create for it a wider field of applications than any other transportable oscillograph................£82 10s. 0d.

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