Kelly

Electronic Engineering

Incorporating ... ELECTRONICS, TELEVISION & SHORT WAVE WORLD

VOL. 20 No. 242 APRIL 1948 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.

SITUATIONS VACANT

cancies advertised are restricted to persons or employ-nts excepted from the provisions of the Control of gagement Order, 1947.

RRANTI LIMITED require for Vacuum Physics boratory Physicists or Engineers, graduates or with uivalent qualifications, preferably with experience of ctronic vacuum work or U.H.F. valves. Application ms from Personnel Manager, Ferranti Limited, rry Road Edinburgh, 5.

RAUGHTSMEN required for jig and tool drawing ice. Must be familiar with electronic equipment istruction. Manchester area. Apply, giving full rticulars of experience, qualifications and salary uired, to Box 213, E.E.

IGINEERS required for employment on develop-nt of radar, communication and electronic iipment. Applicants must possess a degree in gineering or its equivalent. Salary £400 to £600 annum, according to qualifications. Reply, stating , experience, training and qualifications, etc., to ssor Radar Ltd., Wren Mill, Chadderton, Nr. lham, Lancs.

SIGNER-DRAUGHTSMAN required for factory rthern area. Must be conversant with radar and io equipment construction. Reply, stating age, details of experience, training and salary required, Box 214, E.E.

SENIOR RADIO DEVELOPMENT ENGINEER required by the South Western Division of a leading dio Company. Candidates should have had practical perience in radar work and be capable of controlling tions developing radar and atomic energy electronic iipment. Commencing salary will be £600 upwards, ording to qualifications and experience. Housing ommodation is likely to be made available in the ar future to the person appointed. Full details ould be submitted immediately.

e Company is also appointing a Junior Development gineer (Inter. B.Sc. or equivalent). Candidates this post must have had practical experience in ilar and communications equipment design. The nmencing salary will be £350/£400, with every ospect and facility for advancement. Full details qualifications and previous experience in writing Box 212, E.E.

IGINEERS required for employment on mechanical sign of radar, communication and electronic equip-nt. Applicants must possess a degree in engineering its equivalent, and be capable of producing designs itable for small and mass scale production. Write ting age, details of experience, training and alifications, etc., to Cossor Radar Ltd., Wren Mill, adderton, Nr. Oldham, Lancs.

EVELOPMENT ENGINEERS required by radio anufacturers in Essex for work on centimetric waves. ndidates should possess a University Degree, eferably with telecommunications as a subject. ge 25-35. Salary according to age and experience. ply, quoting Ref. 91, to Box 215, E.E.

ESEARCH DEPARTMENT of Instrument-making n in N.E. London, requires graduate in physics or gineering with good communications experience, rticularly in acoustics and electronics, including the sign of amplifiers for outputs up to 2 KW. Write, ing age, experience and salary required, to Box 224, E.

ADIO SENIOR Assembly Foreman required, anchester area, must be capable of controlling male d female labour, experienced in assembly belt layout d familiar with A.I.D. requirements. Apply, stating e, experience and salary required, to Box 223, E.E.

ENIOR RADIO Development Engineers, with perience of light electrical engineering, required by rge manufacturer. Suitable applicants would be uired to travel abroad and knowledge of languages d commercial experience would be an advantage. ate full details of experience, age and salary required Box 222, E.E.

ADIO MANUFACTURERS, West London strict, have vacancies for Senior Development gineers and Laboratory Assistants for work on sign and development of telecommunication equip-ent and broadcast receivers. For the senior posts, at ast five years' practical experience in this class of ork is essential. Write, stating age, qualifications, perience and salary required, to Box 229, E.E.

A LARGE MANUFACTURING Company in the South of England requires an electrical engineer and physicist to take charge of microwave development work. Suitable applicants must have experience of this work and adequate technical knowledge. Reply, stating qualifications, experience, age and salary required, to Box 230, E.E.

REQUIRED MACHINE SHOP Superintendent by Radar and Radio Company, Manchester area; must be capable of supervising the production of components for assembly lines. Knowledge of machine, press and fitting operations essential. Apply, giving full particulars of experience and salary, etc., to Box 228, E.E.

PLANNING ENGINEERS required by Radar and Electronic Equipment Company, Manchester area; must have served general engineering apprenticeship and be capable of developing and planning all machine shop, fitting and assembly operations. Apply, stating age, experience and salary required, to Box 227, E.E.

TRANSFORMER DEPARTMENT Superintendent required by Radar and Radio Equipment Company, North Manchester area; must be capable of controlling labour, be conversant with all operations of coil winding, impregnation and assembly. Reply, giving details of age, experience and salary required, to Box 226, E.E.

SENIOR RADIO ENGINEER required for large industrial concern operating in the Middle East. Applicants should have had at least seven years' experience in technical installation, operation and maintenance of M/F., H/F. and VH/F. communication transmitters, superhet receivers and high-speed W/T systems. A knowledge of carrier current technique advantageous. Age not over 35, Secondary School education. Attractive salary plus generous allowance in local currency. Free passage out and home, medical attention, kit allowance and furnished bachelor accommodation. Write, giving age and full particulars of qualifications and experience, quoting Department F.96, to Box 1076 at 191, Gresham House, E.C.2.

ASSISTANT PHYSICIST, preferably with some electronic knowledge, required for work on waveguide systems. Mathematical and academic qualifications essential, practical experience and mechanical ability an advantage. Age 20 to 30. Salary, £350 to £450 per annum. Write Box N. 5862, A.K. Advtg., 212a, Shaftesbury Avenue, W.C.2.

ASSISTANT ELECTRONIC ENGINEER required for Radar laboratory. Mathematical qualifications and some previous experience necessary. Age 20 to 30. Salary, £350 to £450 per annum. Write Box N. 5866, A.K. Advtg., 212a, Shaftesbury Avenue, W.C.2.

E.M.I. INSTITUTES (associated with H.M.V., Marconiphone, etc.) require a Lecturer in Radio Communications. Science degree (or equivalent) and good practical outlook essential. Commencing salary about £300, according to age, qualifications and experience. Cost-of-living bonus 29s. 6d. extra per week in addition to superannuation benefits. Apply giving fullest possible particulars to Principal, E.M.I. Institutes, 43, Grove Park Road; London, W.4.

LEADING COMPONENT Manufacturers require the services of a graduate radio engineer to carry out research and development programmes in connection with electronic components, fuses and suppressors. Good background in general physics and some inventive ability essential. Salary will be in accordance with qualifications and experience but will not exceed £500 per annum. Give full details of age, education and experience. Box 232, E.E.

DEPUTY DIVISION HEAD required for laboratory responsible for development of carrier current telephone and multi-channel telegraph equipment. Replies from those with suitable experience should give qualifications and salary expected. Permanent and pensionable position with good prospects. Box 233, E.E.

SIEMENS BROTHERS & CO., LTD., Ref. 235, Woolwich, S.E.18, invite applications for posts as Senior Engineers in the line telephone transmission laboratory. Suitably qualified applicants only should write, stating details of experience and salary required.

SUPERINTENDENT required to take charge of radar and radio assembly department, Electronic Equipment Company, Manchester area; must be familiar with A.I.D. requirements, and capable of controlling labour on track and bench assembly. Reply, giving full particulars of age, experience, qualifications and salary required, to Box 225, E.E.

PHILIPS' MITCHAM WORKS have vacancies in their domestic receiver development laboratories for technical assistants. Applicants should be between the ages of 20 and 30, and be graduates (engineering with radio or telecommunications) of a recognised University or hold qualifications exempting from I.E.E. examination. The work will involve a study of the problems of mass production of components and complete receivers, and successful candidates will be expected to work with a minimum of supervision, and to take responsibility for the preparation of receivers and associated components for production. Some experience of production is an advantage. Salary according to qualifications. Write for application form to the Personnel Manager, Mitcham Works, Ltd., New Road, Mitcham Junction, Surrey, quoting reference "C.1."

VALVES AND ELECTRONIC VACUUM TUBES. Production Engineer required to take charge of small production unit. Experience on similar work essential. Good salary and prospects for experienced man. Apply Personnel Manager, Ferranti, Ferry Road, Edinburgh.

THE RESEARCH LABORATORIES of Elliott Brothers (London) Limited have a vacancy for an experienced electronic circuit research engineer. Applicants must have qualifications of degree standard and research experience of general circuit techniques, preferably those relating to pulse methods.
The successful applicant will be required to take charge of small groups concerned with advanced circuit techniques. Age 25-30. Salary, £500 to £800, according to qualifications. Application to be made to the Research Director, Research Laboratories of Elliott Brothers (London) Limited, Elstree Way, Borehamwood, Herts.

E.M.I. ENGINEERING Development Limited, Hayes, Middlesex, invite applications from junior and intermediate engineers, age 25 to 30, with engineering degree or the equivalent, and practical design experience. Specific vacancies on radar development include the following work: (a) design of 30-100 Mc.I.F. amplifiers; (b) transformers for higher frequency power supply; (c) special problems on radar presentation. There are several other interesting vacancies for physicists and engineers. Inclusive salary £400 to £550, according to age and qualifications. Write, giving full details and interests, to Personnel Department.

RADIO ENGINEER, preferably aged 25-30, with an Honours degree or equivalent qualifications, and with experience in circuitry and advanced development work, is required for research in the field of telecommunications. Apply by letter only to The Director, Research Laboratories of the General Electric Co., Ltd., North Wembley, Middlesex, stating age, academic record and experience.

RADIO SERVICE ENGINEERS for works and field, primarily in London area, well-known company, excellent prospects. Applicants should have comprehensive knowledge radio servicing and minimum of two/three years retail or industrial experience in repair work. 5-day, 44-hour week. Wages according to experience and at prevailing levels. Apply, stating age, full details experience, wages required. Box 241, E.E.

ELECTRONIC DEVELOPMENT ENGINEER. Well-known North London firm requires good engineers interested in electronic design and instrument work. Sound theoretical knowledge and wide experience of low-frequency circuits in particular are essential. Vacancies for senior assistants with academic qualifications, commencing salary up to £500 per annum and junior with Nat. Cert., Inter. B.Sc., or C. and G. III Commencing salary up to £350 per annum. Write, stating qualifications, experience, age and salary required, to Box 242, E.E.

DRAUGHTSMEN. North London firm requires good draughtsmen. (a) Designer with sound training and wide experience, including instrument and tool work for preference, commencing salary up to £475 per annum. (b) Young man with initiative and preferably some knowledge of electrical layout and circuit diagrams. (A.E.S.D. rate.) Much interesting development work for the right men. Write, stating qualifications, experience, age and salary required, to Box 243, E.E.

INDEX TO ADVERTISERS

SEE **PAGE 32**

CLASSIFIED ANNOUNCEMENTS (Cont'd.)

TECHNICAL ASSISTANT required for radio and lines project section. Age 21-26 years. Experience in communication and radio engineering essential, together with ability to write descriptions of such equipment. Minimum qualifications City and Guilds Radio, Part 3. Apply in writing to E.T.E. Ltd. (Radio Laboratory), Brathway Road, Wandsworth, London, S.W.18, stating experience, age and salary required.

ASSISTANT (TECHNICAL) required for cathode-ray tube department. Must have technical knowledge and be prepared to do practical work. Some knowledge and experience of electronic tube and high vacuum technique desirable. Apply Personnel Department, The Edison Swan Electric Co., Ltd., Cosmos Works, Brimsdown, Enfield, giving full particulars, age, etc.

RADIO ENGINEERS required for design and test of latest type radio transmitters and receivers. Technical standard preferably up to City and Guilds final, or equivalent. Opening offers good prospects. London area. Apply in confidence giving age, details of education, experience and salary required to Box 247, E.E.

THE MULLARD RADIO VALVE CO. require designer draughtsman for special purpose machinery in connection with electric lamps and radio valves. Only those men capable of seeing jobs through to conclusion need apply. Jig and tool draughtsmen should note that their experience is not sufficient to warrant application for one of these positions. Good salary and prospects for the right men. Apply in the first instance to the Works Personnel Officer, The Mullard Radio Valve Co., Ltd., New Road, Mitcham Junction, Surrey, for a form of application and quote the reference "J.a."

OFFICE JUNIOR wanted for the Head Office of this journal; good opportunity for alert youth or girl leaving school; hours 9.30 to 5, no Saturdays. Written applications to Staff Manager, Morgan Brothers (Publishers) Limited, 28 Essex Street, London, W.C.2.

ELECTRICAL COMPONENTS MANUFACTURERS require young man with good electrical training, preferably with Higher National Certificate or equivalent, for development work on television components. Write giving full details and stating remuneration required to Box 248, E.E.

ASSISTANT ENGINEER for laboratory development of radio communication receivers. University degree or equivalent and industrial experience of receiver measurements essential. Applicants should state salary required. Apply Ref. 715, Siemens Brothers and Co., Ltd., Woolwich, S.E.18.

LOW POWER radio transmitter design engineer required. Qualifications engineering or physics degree or equivalent and industrial experience of transmitter design. Salary according to qualifications and experience. Pensionable position on permanent staff. Box 249, E.E.

ASSISTANT ENGINEER for design and development of subscribers telephone instruments required. Applicants should have university degree or equivalent and have had previous experience of acoustic measurements. Salary will be paid in accordance with experience and qualifications. Box 250, E.E.

SITUATIONS WANTED

LIGHT ELECTRO-MECHANICAL Engineer would advise in the design of relays, motors, etc., and all electro-magnetic equipment. Also acoustics and industrial electronics. University and industrial qualifications. Box 234, E.E.

RADIO ENGINEER, extensive practical experience, seeks progressive responsible position, London area. Conversant telephone, telegraph equipment, domestic receivers, other radio electrical fields. Accustomed controlling staff. Box 240, E.E.

DEVELOPMENT ENGINEER, 35, B.Sc.(Eng.), wide experience in audio technique and electronics, now in London, seeks position involving development or research in or near country. Box 239, E.E.

ENGINEER, 33, City and Guilds Final Grade in Telecommunications and Technical Electricity, now studying for Higher National Certificate, seeks change. Box 238, E.E.

ENGINEER, Oxford Graduate with ten years' experience of light current engineering, seeks executive position in London area or south-east where initiative and administrative ability are essential additions to a wide technical background. Box 236, E.E.

ENGINEER, Bristol area, prepared to act as part-time technical representative or agent. Box 235, E.E.

RADIO AND ELECTRONIC Engineer, desiring change, requires position of responsibility, fully experienced in television and radio frequency heating. Box 237, E.E.

ROYAL AIR FORCE Technical Signals (Radar) Officer, 7 years' experience of airborne and ground communication and radar equipments; single (26), available soon. Seeks progressive position. good prospects essential. Hard work and long hours no object with reasonable salary. Box 231 ,E.E.

PHYSICIST, B.Sc., F.Inst.P. 38, experienced in electronic engineering and vacuum practice, is available for research in thermionics, vacuum physics applications, or instruments. Box 221, E.E.

BUSINESS OPPORTUNITIES

GENTLEMAN, opening business New Zealand shortly, desires agencies for industrial goods, radio and electrical components, etc. Write West, 46, Boileau Road, Barnes, S.W.13 (Phone: RIVerside 1044).

EDUCATIONAL

COMPLETE CORRESPONDENCE COURSE covering Amateur and C. and G.I. Examinations, consisting of 12 lessons. Send for particulars. Everyman's Correspondence College, 72, St. Stephen's House, Westminster, S.W.1.

SERVICE

FACILITIES AVAILABLE for radio assembly work on amplifiers, radar and small radio chassis. Prompt deliveries, first-class work. Write R. T. M. C. Ltd., 141, Little Ealing Lane, W.5 (EALing 6962).

LOUDSPEAKERS—We carry on. Sinclair Speakers, 12, Pembroke Street, N.1.

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

FACTORY HAS TECHNICAL Staff and capacity available for manufacturing scientific or other articles in glass. Box 163, E.E.

TELEVISION ENGINEERS. Here is something you cannot manage without. Wide band television pattern Generator. The only way to check vision and sound receivers satisfactorily. Full details apply W. B. Martin, Television Engineers, 206-208, Lower Parliament Street, Nottingham.

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.

WEBB'S Radio Map of the World enables you to locate any station heard. Size 40 in. by 30 in. 2-colour heavy Art Paper, 4/6, post 6d. Limited supply on Linen, 10/6, post 6d.—Webb's Radio, 14, Soho Street, London, W.1. 'Phone GERrard 2089.

MORSE Practice Equipment for Class-room or Individual Tuition. Keys Audio Oscillators for both battery or main operation. Webb's Radio, 14, Soho Street, London, W.1. 'Phone: GERrard 2089.

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).

FOR SALE

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

EX-R.A.F. Loran Indicators with 5 in. electrostatic c.r.t. with time base. 26 valves including 6SN7, 6H6, 6SJ7 and calibrated 100 Kc. crystal, suitable for conversion to oscillograph, £10. Box 220, E.E.

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.

MASTS. First-class aerial masts, new, unused and crated. A.M. type 23. 78 feet high when erected. A few are offered at 17 gns. each, carr. paid nearest railway station in G.B. for quick sale. Telephone TUDor 5277 or write BM/RXBF, London, W.C.1.

THE MORDAUNT DUPLEX REPRODUCER, as used in the ENOCK instrument, is now available separately. Folded horn bass unit and new high note reflector of original design, giving exceptionally smooth response from 40-20,000 c.p.s. Even distribution over a wide angle. Reproduction has an "atmosphere" and realism hitherto unattainable. Price (ex works), 98 Gns. Please send for full particulars, or better still, let us arrange for a demonstration. Joseph Enock Ltd., 273a, High Street, Brentford, Middlesex (EALing 8103).

TEST METERS, Triplett, 10-5,000 volt A.C./D.C., 10-500 mA D.C., 3,000-250,000 ohms resistance, Government surplus, £5 10s. Ball-type microphones, 15 ohms coil, £5 2s. 6d. Hand M.C. Microphones with 40 yards screened lead and jack plug, £4 10s. Cabinets, car radio, pierced for speaker, few only, 12s. 6d. Speakers, P.M., 2½ in., 18s. Tuning Condensers, twin 400 pf with spindle 1 in. long, ⅜ in. dia., 5s. Twin 480 pf with 2½ in. drive drum, 7s. 6d. Small Mica Condensers, 0.01-0.0005 mfd., parcel of 50 for 10s. 6d; High Voltage Condensers, 0.01 mfd. 5,000 v., 1s. 6d.; 0.02 mfd., 8,000 v., 2s. 6d.; 1 mfd., 1,200 v., 3s. 6d.; 0.1 mfd., 2,500 v., 1s. 3d.; 0.25 mfd., 2,000 v., 1s. 3d.; 0.1 mfd., 1,200 v., 1s.; 2 mfd., 1,000 v., 3s. 6d.; 4 mfd., 1,000 v., 6s. EA50 valve holders, 3s. per dozen. Heavy Duty Chokes, 350 ohm, 150 mA, 12s. 6d.; 150 ohm, 200 mA, 14s. 6d.; 2,000 ohm, 300 mA, 16s. 6d.; 100 ohm, 500 mA, 22s. 6d.; 100 ohm, 700 mA, 35s. Vibrators, 6 volt 4-pin UX, 8s. 6d. Flexible insulated shaft couplings, ¼ in. spindles, 1s. 3d. Write for list of these and many other bargains. Joseph Enock Ltd., 273a, High Street, Brentford, Middlesex (EALing 8103).

A DIAMOND STYLUS, due to its permanence, never changes its shape and is therefore the only possible solution where consistent, high quality reproduction is required. This is only one of the reasons why the ENOCK pick-up is capable of such an unusually fine performance. Light-weight moving coil. Weight at needle point, ⅜ oz. Price £33 13s. 9d., including tax. Full particulars from Joseph Enock Limited, 273a, High Street, Brentford, Middlesex (EALing 8103).

NEW ARMOUR MAGNETIC Steel Recording Wire on standard spools, in maker's sealed tins. 60 minutes' speech or 30 minutes' music playing time. £3. Harris, Strouds, Pangbourne, Berks.

EVERSHED 500 v. Bridge-Megger, 4-dial plus Varley test, £35. Also Wee-Meggers (in leather case), 500 v., £8 10s.; 250 v., £7 10s. Generator-driven ohmmeters, 0-5 or 0-10,000, £3 15s. "Megger" ohmmeter, battery model, 2-range, 0-1,000, 0-200K., £5. Box 244, E.E.

VALVES, 1T4, 6s 6d.; 3A5, 10s.; 813, 110s. All new, boxed. Box 245, E.E.

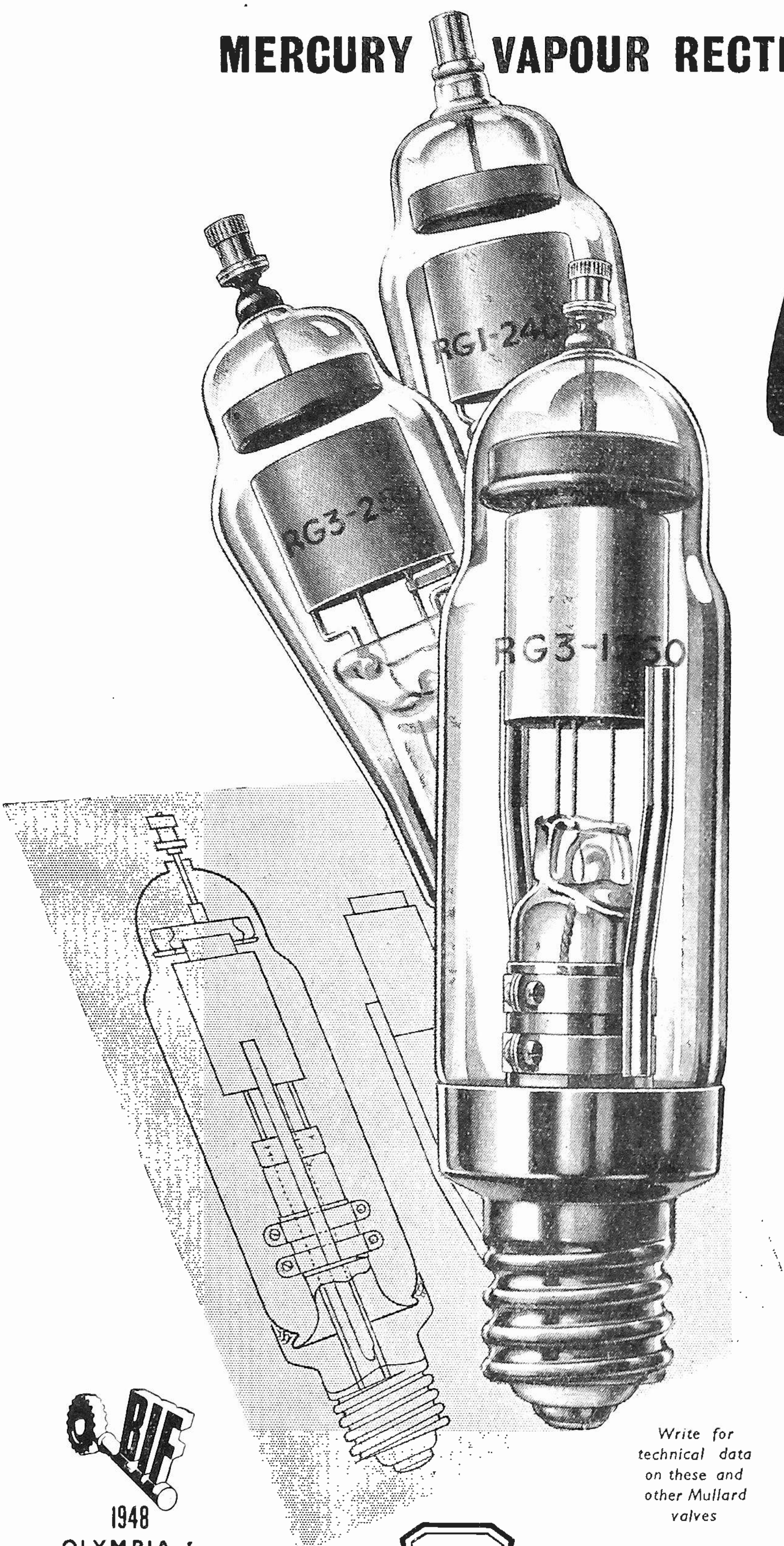
JOURNAL APPLIED PHYSICS from October, 1939, to December, 1942, less February, 1940, June, October, November and December, 1941. 34 copies, immaculate, £4.
Cambridge-Grassot Fluxmeter, used once only, £20 Box 246, E.E.

WANTED

I WILL BUY a metal detector to detect at 10 feet below ground. Write to Felix Rovira S., P.O. Box 1305, Caracas, Venezuela.

MERCURY VAPOUR RECTIFIERS WITH AN ASSURED

Long Life



These three Mullard rectifiers owe their reputation for dependability to closely controlled manufacturing processes. Below are some of the reasons why more and more designers are specifying the " RG " range.

Stable Emission. The special double spiral filaments are so designed that the emissive coating is firmly keyed to the wire.

Long Life. The use of zirconium to eliminate " foreign " gases reduces positive ion bombardment of the cathode.

High Voltage Tests. All valves are subjected to rigorous back-arc tests.

RG1-240A

Peak Inverse Voltage	4,700 V max.
Mean Anode Current	250 mA max.
Two Valves in a Single-Phase Full-Wave Circuit will give 1,500 Volts at 500 mA.	
Filament Voltage	4.0 V
Filament Current	2.7 A

RG3-250

Peak Inverse Voltage	10,000 V max.
Mean Anode Current	250 mA max.
Two Valves in a Single-Phase Full-Wave Circuit will give 3,150 Volts at 500 mA.	
Filament Voltage	2.5 V
Filament Current	5.0 A

RG3-1250

Peak Inverse Voltage	13,000 V max.
Mean Anode Current	1.25 A max.
Two Valves in a Single-Phase Full-Wave Circuit will give 4,140 Volts at 2.5 amps.	
Filament Voltage	4.0 V
Filament Current	7.0 A

Write for technical data on these and other Mullard valves

Mullard

THERMIONIC VALVES & ELECTRON TUBES

THE MULLARD WIRELESS SERVICE CO. LTD., TRANSMITTING & INDUSTRIAL VALVE DEPT., CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2

BIF 1948
OLYMPIA & EARLS COURT
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SEE OUR EXHIBIT
Stand No. H.45

Mullard

MVT20

MAZDA

for

DEPENDABILITY

SP61*

RATING:

Heater Voltage	6.3
Heater Current (amps)	0.6
Maximum Anode Voltage	250
Maximum Screen Voltage	250
‡Mutual Conductance (ma/V)	8.5

‡ Taken at Va=200: Vs=200: Vg=1.5

GENERAL:

The SP61 is a high slope screened H.F. Pentode designed for use on A.C. mains in the H.F. and I.F. stages of a Television receiver.

Other uses are:

1. Video amplifier in circuits where the capacity across the output load is low.
2. Frequency changer in conjunction with a separate oscillator valve such as the P61.
3. Certain classes of audio amplification work where gains of over 150 can be realised.

The valve is fully metallised and is fitted with a Mazda octal base.

★ *Also made with 4v. heater and known as SP41*

LIST PRICE 10/6 (plus 3/5d. purchase tax)

P61†

RATING:

Heater Voltage	6.3
Heater Current (amps)	0.6
Maximum Anode Voltage	250
§Mutual Conductance (ma/V)	8.0
§Amplification Factor	17
Maximum Peak Anode Current (mA)	30
Maximum Anode Dissipation (watts)	4.0

§ Taken at Va=100: Vg=0

GENERAL:

The P61 is a triode and has been primarily designed for use as an oscillator in television receivers. It may also be used as an oscillator in all-wave receivers where a single valve frequency changer is not employed.

The valve is fully metallised and is fitted with a Mazda octal base.

† *Also made with 4v. heater and known as P41*

LIST PRICE 9/6 (plus 3/1d. purchase tax)

THE EDISON SWAN ELECTRIC COMPANY LIMITED

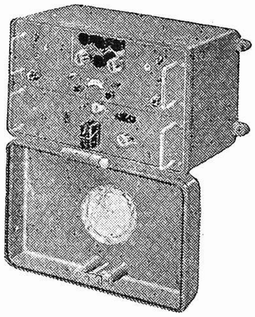
RADIO DIVISION

155 CHARING CROSS ROAD, LONDON, W.C.2

R.M.57

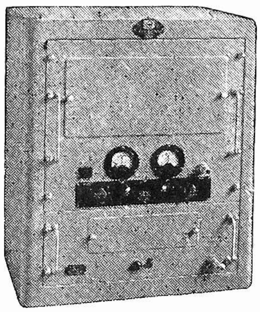
Announcing... SIX ENTIRELY NEW ELECTRONIC INSTRUMENTS

by CINEMA-TELEVISION LIMITED



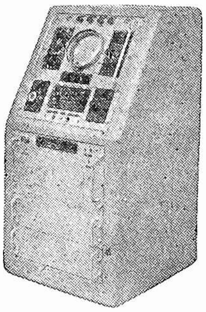
INDUSTRIAL ELECTRONIC METAL DETECTOR

An automatic inspection equipment for the detection of ferrous and non-ferrous metal particles of all kinds in non-metallic substances such as foodstuffs, plastics, textiles, tobacco, timber, pharmaceutical products, etc.



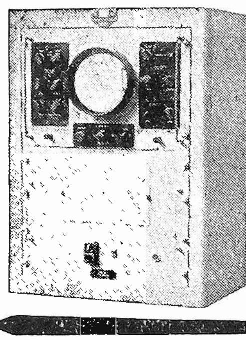
STANDARD ELECTRONIC COUNTER

A high speed electronic counter of particular appeal to the industrialist. Facilities are provided for batching, selective counting etc., the maximum counting-speed for the equipment being 30,000 per minute.



UNIVERSAL OSCILLOSCOPE

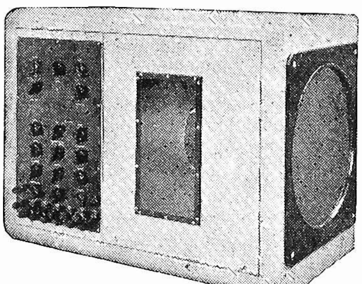
A unique instrument meeting fully the requirements of the serious users of oscilloscopes for laboratory and industrial purposes, arranged to permit readily the assembly of suitable units to fulfil every application. Complete range of units is available, e.g. stabilised time base, A.C. and D.C. amplifiers, 5 beam switch unit etc.



LABORATORY OSCILLOSCOPE

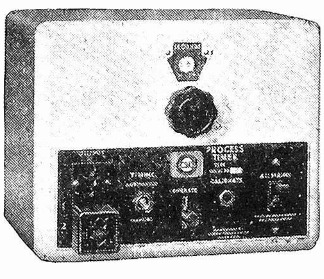
A high grade 6″ screen oscilloscope expressly designed for laboratory use, incorporating hard valve linear time base, 3 megacycle "Y" amplifier and 1 megacycle "X" amplifier. Cupboard and trolley are available if required.

DEMONSTRATION OSCILLOSCOPE FOR LECTURE PURPOSES



Demonstrator and student alike will acclaim the features of this equipment — 15″ tube with glare removing filter, 2 beam switch for simultaneous delineation of two recurrent wave forms, or their "addition" to produce a single resultant trace. Provision is made for setting up from rear of instrument

PROCESS TIMER



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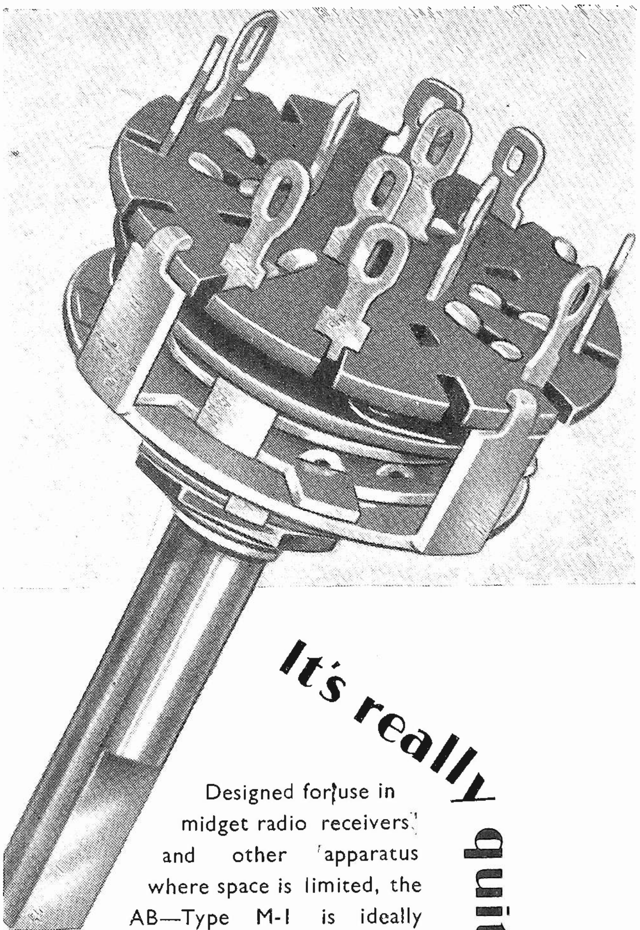

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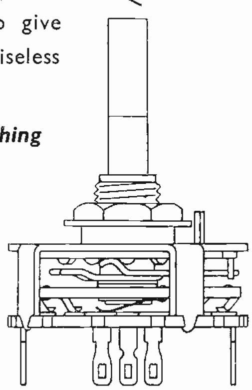

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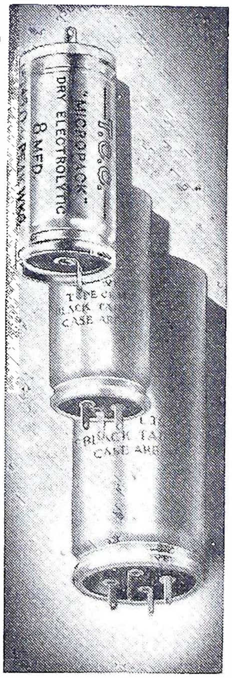

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2000	12	2¾	1¾	CE23B	12/-	24	200	2¼	1	CE25G	4/6
						32	200	2¾	1	CE26G	5/6
25	25	1¾	½	CE32C	2/9						
50	25	1¾	¾	CE18C	3/-	2	350	1¾	⅝	CE17L	3/-
500	25	2¾	1⅜	CE10C	8/6	4	350	1¾	¾	CE18L	3/3
1000	25	2¾	1¾	CE23C	12/-	8	350	2¼	¾	CE11L	3/9
						16	350	2¾	1	CE26L	4/9
12	50	1¾	½	CE32D	2/9	30	350	2¼	1⅜	CE29L	6/6
25	50	1¾	¾	CE18D	3/-	40	350	2¾	1⅜	CE10L	7/6
50	50	1¾	1	CE24D	4/-						
100	50	2¾	1	CE26D	5/6	1	450	1¾	½	CE32P	2/9
250	50	2¾	1⅜	CE10D	8/6	2	450	1¾	¾	CE18P	3/3
500	50	2¾	1¾	CE23D	12/-	4	450	2¼	¾	CE11P	3/9
						8	450	2¼	1	CE19P	4/6
250	100	2¾	1¾	CE23E	12/-	16	450	2¼	1⅜	CE29P	6/-
						24	450	2¾	1⅜	CE10P	7/6
8	150	1¾	¾	CE18F	3/-	32	450	4½	1⅜	CE37P	10/-
16	150	2¼	¾	CE11F	3/3						
32	150	2¼	1	CE19F	4/6						
						4	500	2¾	1	CE13P	4/9
2	200	1¼	½	CE31G	2/9	8	500	2¾	1⅜	CE10P	6/6
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20–20	150	2⅞	1	CE35F	6/6	24–8	350	2⅞	1⅜	CE28L	8/6
*32–24	150	2⅜	1	CE34F	7/6	24–16	350	2⅞	1⅜	CE28L	9/-
*50–30	150	2⅞	1	CE35F	8/6	30–30	350	4½	1⅜	CE37L	12/-
						32–16	350	4½	1⅜	CE37L	11/-
16–16	275	2⅜	1⅜	CE27H	7/-						
25–25	275	2⅞	1⅜	CE28H	9/-	4–4	450	2⅜	1	CE34P	6/-
						8–8	450	2⅜	1⅜	CE27P	7/6
8–8	350	2⅞	1	CE35L	6/-	16–8	450	2⅞	1⅜	CE28P	9/-
16–8	350	2⅜	1⅜	CE27L	7/6	16–16	450	4½	1⅜	CE37P	11/-
16–16	350	2⅞	1⅜	CE28L	9/-	24–16	450	4½	1⅜	CE37P	12/-

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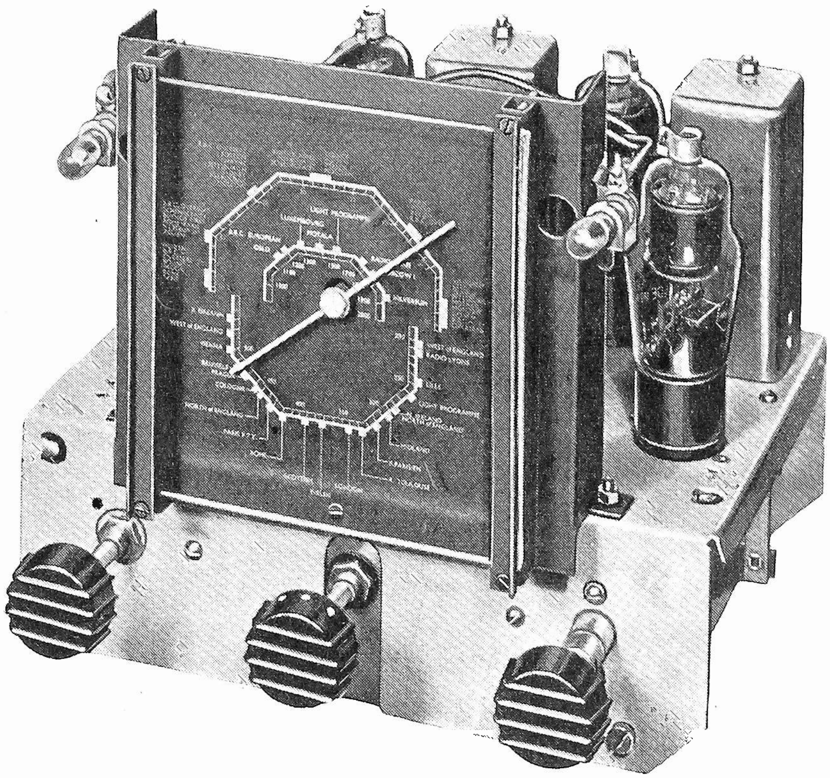

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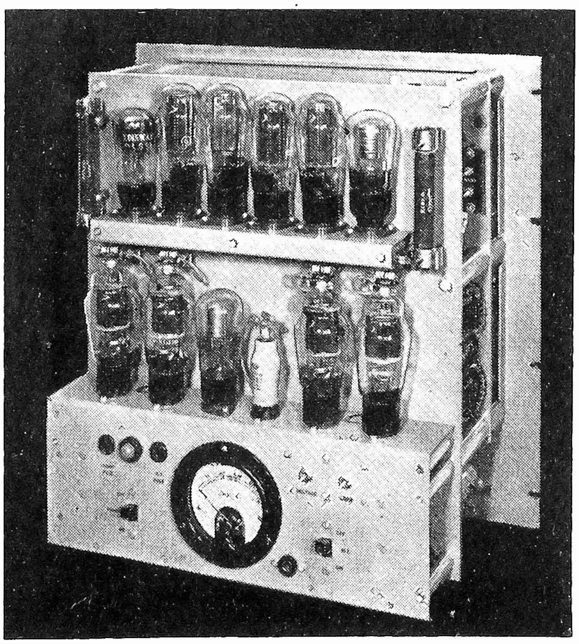

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CONTENTS

American Radio

Some facts and figures

MR. BOND GEDDES, Vice-President and General Manager of the American Radio Manufacturers' Association, recently gave evidence before a House of Representatives' Committee on the state of the American radio industry. A summary of his statement is given here.* The figures given show the rapid expansion of the American radio industry in the years immediately following the war, and will be interesting news to many engaged in the corresponding industry in Britain.

The American R.M.A. comprises about 325 principal manufacturers of all types of radio and electronic equipment, including 193 set makers (as compared with 57 pre-war), and of these about 65 are major firms.

The factory employment is estimated at 300,000, and in addition there are 1,500 radio distributors and wholesalers and 35,000-50,000 dealers. With 40,000-50,000 servicemen, the total industry employs about half a million. The average hourly wage for all types of labour, skilled and unskilled is now $1.19 (4s. 6d.) against $0.68 (2s. 8d.) pre-war.

* Reproduced with acknowledgements to *Radio News* magazine, March 1948.

Radio business in America is composed mainly of scores of small parts suppliers and set makers on a modest scale. It is highly competitive, to the point of being "cut-throat," and only about 50 of the 290 manufacturers in the Association in 1927 have survived. Conditions to-day are at their competitive peak, owing to the entrance of many new firms into the business.

Radio set ownership among the American people is estimated (according to the F.C.C. Report) at 73,000,000. There is at least one radio in 91 per cent. of homes, and the average home ownership is two sets.

In 1947 the industry had a record production of 18 million sets of all types compared with the previous record of 16 million in 1946, the first post-war year of full production. The estimated value of this production is $1,271,100,000 or about £254,300,000.

F.M.

A year ago the F.C.C. predicted that there would be more than 700 F.M. stations on the air by the end of 1947. Actually there are 379 stations in operation. Largely as a result of the inability to secure network music on F.M. broadcast programmes, the industry's 1947 production was only 1,150,000 receivers, or less than half the anticipated figure.

Television

The production of television receivers in the last five years has totalled 183,000, but nearly all this quantity has been produced in 1947. Estimates give a total of 500,000 receivers to be made in 1948, with a value of nearly $250,000,000. The rapid growth of post-war television is shown by the following figures:

Year	Sets made	Value in dollars (Millions)
1940	1342	0.427
1941	389	0.152
1942	953	0.176
1946	5367	2.050
1947	175,000	102.000

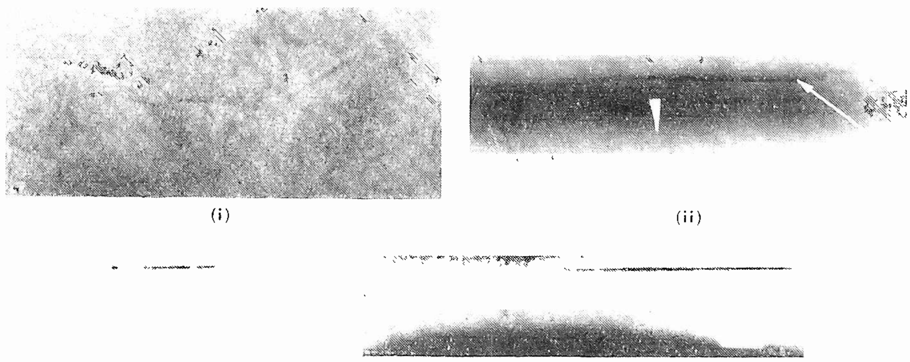
The Detection of Cracks
by X-Rays and Gamma Rays

By C. CROXSON, B.Sc., F.Inst.P.*

Based on a lecture given at a Symposium on "Methods of Crack Detection," July, 1947, arranged by the Industrial Radiology Group of the Institute of Physics.

THE applications of radiology surveyed in this paper cover a remarkably wide field, embracing metals and non-metals, magnetic and non-magnetic metals and alloys, and thicknesses ranging from a few hundredths of an inch in spot welds to 4 in. or more of steel, and equivalent thicknesses of other materials. The results are, unlike those of some other methods, not affected by looseness of structure in metallic castings or by inhomogeneities in the material, and the method can be used both for the investigation of cracks which are visible on the surface and also for the detection of those which are wholly internal. The most common applications are probably to steel castings and welds, in thicknesses ranging from ½ in. to 2 in.

In view of this wide field, no more than passing mention can be made of many defects which, though not strictly cracks, have crack-like characteristics; these include laminations in rolled plates, lack of fusion in welds, fish eyes in welds, badly fitting rivets, fine gaps between the walls of containers and their contents, microporosity in magnesium alloy castings, and dendritic formations in steel and non-ferrous alloys. Some of the crack-like appearances which have been seen in radiographs are shown in Fig. 1, and none of these is a genuine crack.†



(i) (ii) (iii) (iv)

Fig. 1. Radiographs of some crack-like defects

(i) Dendritic structure in cast tin-bronze (gamma rays)
(ii) Internal flaws in steel forging (X-rays)
(iii) Lack of fusion in weld (X-rays)
(iv) Small pipe in 1¾ in. dia. gunmetal rod (X-rays)

Geometrical Characteristics of Cracks

One outstanding characteristic of cracks is their great diversity; another is that they tend to emerge nearly normal to the surface when not wholly internal. The emergence is often obscured in castings by the surface layer of scale: in steel forgings a crack may be so fine as to be invisible even on a polished surface, viewed with a hand lens. The ends of a crack taper to disappearance, which is a useful fact in radiographic interpretation.

The liability of a crack to extend is one reason why the defect is regarded so seriously. Repair was formerly considered to be unsafe but it is nowadays a commonplace under radiographic supervision. Radiography may, of course, prove a suspected crack to be nothing more than a shallow surface defect.

General Radiographic Technique

There is very little published work on the radiography of cracks, and much more investigation is needed. One rather discouraging factor is the difficulty of assessing the mechanical significance of a crack by correlating radiographic results with practical experience. This, however, need not prevent systematic work on technique.

The radiographic conditions are clearly much the same as for the recording of fine detail but are modified by the geometry of the crack, which may not inaptly be described as "length without breadth." The controlling factors in producing a good radiograph are contrast and definition. Little need be said about the former except that high contrast is secured by reducing the tube voltage as much as possible without prolonging the exposure time unreasonably, and provided that adequate protection can be given against the effects of scattered radiation. Gamma rays are equivalent as regards contrast to very high voltage X-rays and are of comparatively low sensitivity for flaw detection especially for thicknesses below one inch of steel.

Sharp definition is achieved by placing the film as close as possible to the specimen, by ensuring good contact between film and intensifying screens, and by choosing a distance between the focus of the X-ray tube and the specimen such that the penumbra is imperceptible. Experimental work at Woolwich has shown that penumbral unsharpness is not so detrimental as might be supposed when one considers the small width of a crack, and a slight broadening of a fine image by penumbra may even enhance its perceptibility. The penumbral width need not be reduced below 0.01 in., a value which is readily attainable: incidentally, tube distances can often be reduced without loss of diagnostic value from those normally employed especially in the

* Armament Research Department, Ministry of Supply.

† All the radiographs in this paper are reproduced as they appear in the original films, that is, they are so-called radiographic "negatives."

radiography of thin specimens.

It has been found, on the other hand, that graininess in the photographic film is very detrimental and breaks up the image so that the latter becomes merged in the background. The experiments have shown a progressive improvement in sensitivity as the graininess is reduced, other factors being maintained constant, and for critical radiography the use of fine grain high contrast film with metal intensifying screens is essential. For maximum sensitivity, the film should be exposed to a density of about 2 reached by development for 3 or 4 minutes in a standard MQ developer. The pronounced graininess of gamma radiographs is probably at least as serious a factor as the inherently low contrast of gamma rays in producing the lower sensitivity as compared with X-ray radiographs.

Projective enlargement has been introduced in Germany to overcome the effects of grain. The method, as shown in Fig. 2, is to project an enlarged radiographic image on to the film by placing the film a considerable distance from the object, so that the image details are large compared with the grain. Berthold[1] states that an appreciable improvement results from an enlargement of 2 or more. While this is true for standard film, the author has found that no added resolution can be perceived by projective enlargement on to fine detail film, even when using an X-ray tube with a focus of only 0.3 mm. diameter. There appears therefore to be little advantage in projective enlargement, provided that fine grain films are used.

When the above conditions are observed, radiography is undoubtedly a very sensitive method of detection if the crack is oriented in line with the rays. The factor of orientation was investigated by Warren[2] for artificial "cracks" in steel 1 in. thick using X-rays, and some additional results have since been published by Berthold.[3] Warren found that the angular deviation through which a crack remains discernible depends on its width, and is in fact practically proportional to the width. Paradoxically, with a "deep" crack ($\frac{1}{4}$ in.) such that the oblique view is a band of sensible width the depth dimension does not appear to enter into the discernibility, which is, however, sensitive to change of angle. With a shallow

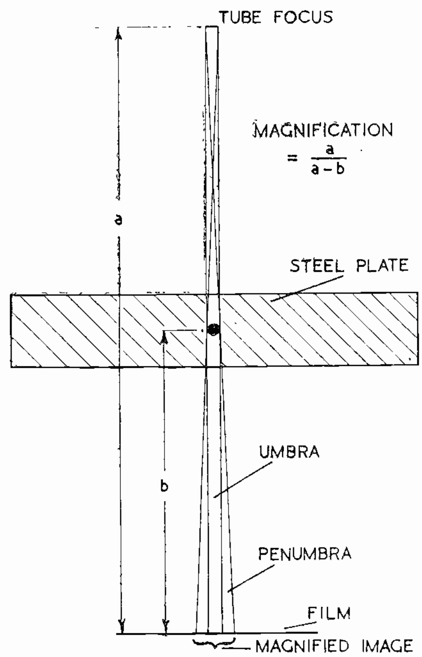


Fig. 2. Projective enlargement to minimise the effects of graininess

crack (1/16th in.) such that a change in the projected width of the trace is not noticeable to general observation, the discernibility is unaffected by change of angle and the intensity of the image is proportional, not to the width, but to the cross-section of the crack. This fact is attributed to the inability of the unaided eye to distinguish between the two elements of width and intensity when the image is very fine. It follows that the radiographic appearance is not a dependable guide in estimating the probable depth or width; a crack 0.005 in. wide and 1/16th in. deep looks much the same as a crack 0.001 in. wide and $\frac{1}{4}$ in. deep in a radiograph. Berthold's results[3] for cracks $\frac{1}{4}$ in. deep in $1\frac{1}{2}$ in. of steel show that a crack 0.01 in. wide can be seen when inclined as much as 30° to the X-ray beam, and this partially explains the ready detection of relatively broad cracks such as hot tears.

Very little information is available as to the dimensions of the smallest cracks which can be detected. Certainly cracks a few tenthousandths of an inch, that is 10 microns or less, in width can be found in steel up to about $\frac{1}{2}$ in. in thickness. The criterion, however, is not entirely a dimensional one, so much depends on orientation and on variation in direction as the crack wanders through the metal; what really matters is whether the radiological method is successful in practice. For this purpose the applications to metal castings, forgings and welds will be briefly surveyed in turn.

Metal Castings

Perhaps the commonest type of crack occurring in castings is the hot tear, which in a large casting may extend to a length of two feet or more. Hot tears usually break through to the surface over some part of their length, but it is frequently found that they do not penetrate the surface skin of metal, and thus escape detection by visual surface examination; an example of this is shown in Fig. 3.

The direction of a hot tear can generally be inferred with sufficient accuracy and so long as there is accessibility to the part for which examination is required, little difficulty is to be anticipated either in detecting or diagnosing the defect. The problem of accessibility is illustrated in Fig. 4, and the examination of this casting was only possible by the use of gamma rays. The practical question is perhaps not so much to detect a crack as to find its full extent, and to ensure a sound repair by excavating and welding. Excavation of a crack without radiological verification is a common but a most unsatisfactory practice. The ends of a crack in a rough excavation are easily burred over by a chipping tool when, as shown in Fig. 5 there may be serious unsuspected cracks left in the metal. Furthermore one crack may be successfully cleared only to leave other completely separate cracks buried at a greater depth in the metal wall. In the majority of castings dealt with in the author's experience the radiographs have shown further excavation to be necessary, although apparently clear to surface examination.

If a broad, deep crack is oriented very obliquely to the X-ray beam a pseudo-multiple appearance may result from the changes in direction as it wanders through the metal, only the portions which are in line with the rays (or nearly so) giving a trace on the film. This changing direction partially explains the difficulty often experienced in the interpretation of stereoscopic radiographs: the two exposures forming the stereoscopic pair record different portions of the crack (*see* Fig. 6), and it is little wonder that these will not combine to give a three-dimensional result. In spite of this,

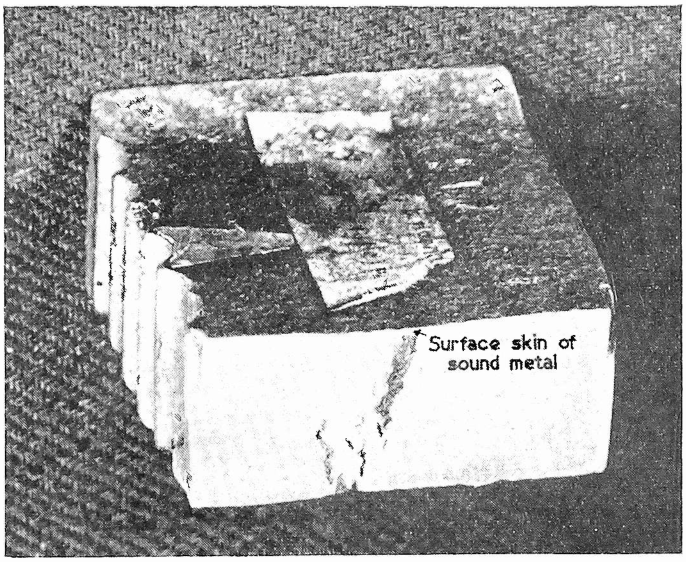
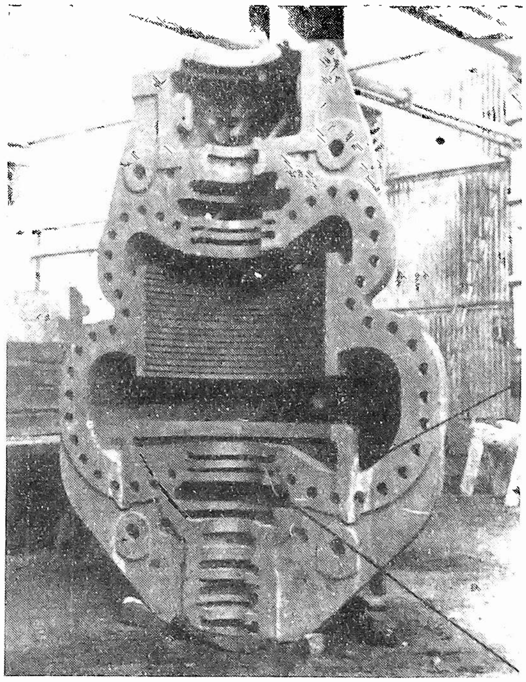


Fig. 3. Photograph of typical hot tears in portion of steel casting $\frac{11}{16}$ in. thick



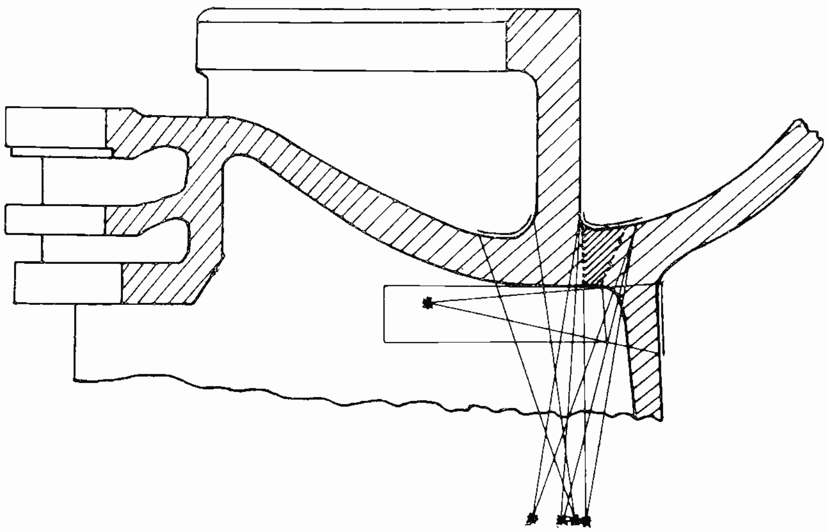


Fig. 4. H.P. turbine casting, and sketch showing section of welded region after removal of cracks

however, tube-shift exposures made on a single film can be used to locate and find the depth of a crack with sufficient accuracy to determine the best method of excavation. This has been done on many occasions with gamma rays, using fast salt screens, the exposure time with a 240 mgm. source of radium being of the order of 5 minutes for $1\frac{1}{2}$ in. of steel.

Another type of defect found in steel castings is intercrystalline cracking. As a casting defect this is fortunately rare: fortunate because such cracking has a serious effect on the strength of the material and also because cracks of this kind can, at a first glance, be mistaken for relatively harmless shrinkage porosity.

A defect occasionally found, chiefly in non-ferrous alloys, may be conveniently described as a "negative" crack. This is formed by a crack becoming filled with solder, lead paint, or other dense material and thus producing a light instead of a dark image in the radiographic film: an example is shown in Fig. 7.

Two instances will serve to illustrate the application of radiography to castings. The first concerns a turbine casting in which a crack had been found during machining, and which was returned to the foundry and repaired without the aid of radiography. On return to the engineering firm it failed a second time on water pressure test. Radiography disclosed an extensive and complex system of cracks but the casting, almost fully machined and very expensive was ultimately satisfactorily repaired and passed into service.

The second example concerns some particularly vital castings which after ten years' service, were all found to be cracked. The replacement castings in store, and new ones specially made to the same design, were then examined and found to be cracked in the same regions. The completely redesigned component was thoroughly vetted by radiography of the pilot casting and more than 70 castings of the new type, each weighing about 10 tons, have since given yeoman service at a critical period in our history.

It can be stated that suspected cracks, unsuspected cracks, and incompletely excavated cracks, have been detected or located by means of X-rays or gamma rays and satisfactorily repaired in literally hundreds of the heaviest and most valuable steel castings. In the author's opinion the radiological method is reliable and indeed invaluable as applied to castings, and he has never heard of an authentic instance of a crack in a casting being missed by X-rays and subsequently disclosed by failure of the casting.

Forgings and Processed Materials

Compared with hot tears cracks in forgings are usually short, straight, planar and very fine. They may arise consequent on heat treatment, they may be due to local concentrations of stress (notch effect) or to corrosion, fatigue, stress corrosion and so on. In general a crack in a forging involves rejection, and repair by welding is not permissible because it may not be possible to follow up with the required heat treatment.

The problem is mostly to determine whether a more or less faint surface mark is a genuine crack or a shallow defect of little or no significance. Owing to the small width and depth critical radiography is necessary for detection. It would be assumed that the crack emerges normally to the surface, and if it is not detected on this assumption the area must be searched by means of successive exposures in which the inclination of the rays is varied in steps of about 5° on either side of the normal. The appearance of a crack will change markedly with a small shift of the X-ray tube while that of a forged-out inclusion remains almost unaltered.

The changing width of the image of an approximately plane, deep crack with the position of the X-ray tube enables, very often, a surprisingly accurate estimate of depth to be made, but it is impossible to be certain what accuracy is being attained in a particular specimen without sectioning the material. The table below gives some actual results obtained with six cracks in a forged steel tube, $1\frac{3}{8}$ in. wall, which was subsequently sectioned.

No. of Crack	DEPTH from Radiograph	DEPTH from Section	WIDTH from Radiograph	WIDTH from Section
1	·06	·05	·008	·011
2	·06	·04	·007	·010
3	·08	·07	·007	·010
4	·11	·10	·003$_7$	·004$_5$
5	·07	·08	·004	·005
6	·18	·17	·003	·004

Snowflakes are well known defects most commonly found in alloy steel forgings. They are in general wholly internal and of very varying direction. When they occur, as they usually do, in considerable numbers there is every prospect of detecting a substantial proportion of them if the radiographic technique is good. Nevertheless, radiography of itself can scarcely be relied upon to give a complete picture.

Bare mention only can be made of

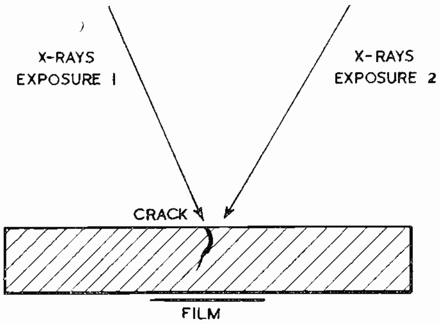


Fig. 6. Sketch illustrating how the different portions of a wandering crack are recorded in a stereoscopic pair of radiographs

cracks in riveted plates for the detection of which no special technique is required, and of corrosion defects in the inner surfaces of boilers and the like. Access to both sides of the material is essential and may be difficult, but the non-destructive value of the method is lost if the suspected area has to be cut out before the examination can proceed. It is usually possible, however, to find a radiographer small enough and sufficiently altruistic to crawl through a man-hole and set up the necessary exposures.

Some of the most difficult problems in radiography are the examinations of cylindrical rods or pipes, and circumferential butt welds of small diameter. The examination of a restricted area is fairly straightforward, but a 100

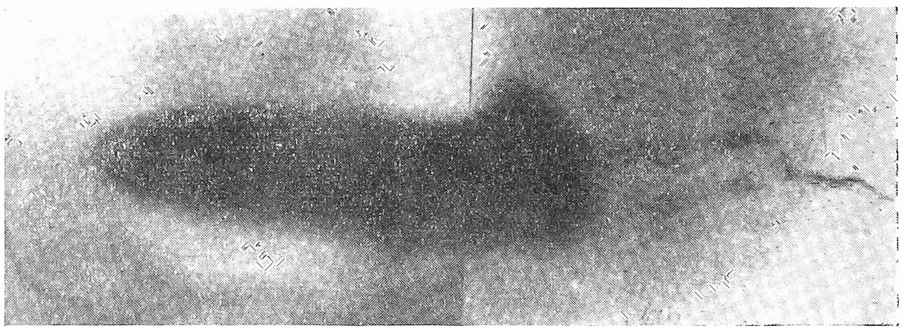
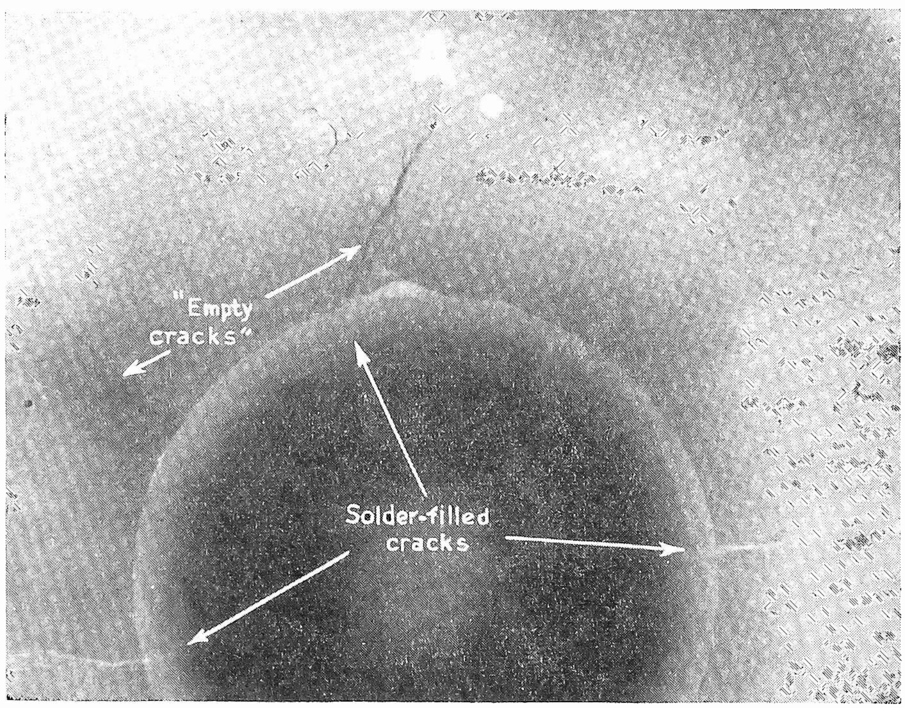


Fig. 5 (above). Composite radiograph (gamma rays) showing hot tears not completely removed by large excavation in centre

Fig. 7 (below). Radiograph (X-rays) showing normal and solder-filled cracks in cast bronze



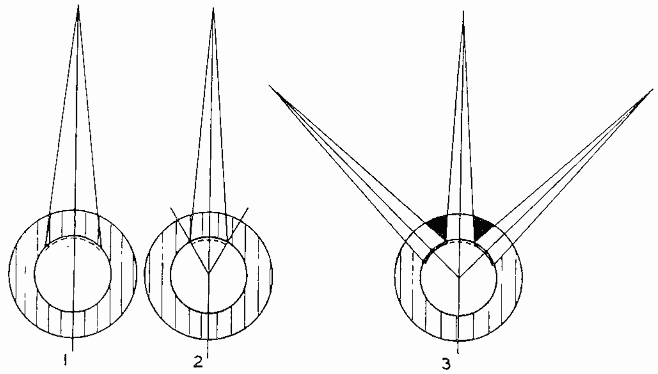


Fig. 8. Limiting factors in the radiography of pipes and cylinders

(1) Increase of thickness with increasing obliquity of X-rays

(2) Decreasing sensitivity with increase of angle between the rays and the normal to the metal surface

(3) Large parts of metal not examined unless considerable overlap allowed

per cent. examination of a specimen of small diameter relatively to the wall thickness is often required and this is much more difficult. A full treatment of the problem is outside the scope of this paper, but briefly there are three factors which restrict the application of X-rays to the radiography of a metal wall which is convex to the X-ray tube (*see* Fig. 8):—

(i) The increasing thickness of metal to be penetrated as the obliquity of the radiation increases towards the edges of the field.

(ii) The decreasing sensitivity as the angle between the direction of irradiation and the normal to the surface increases, the crack being assumed radial.

(iii) The large amount of overlap required between adjacent exposures to cover the whole periphery, especially of a thick walled specimen of small diameter.

Analysis shows that (ii) is the major factor, and if high sensitivity is to be attained only a very small sector can be covered per exposure. The maximum length of arc on the inner surface is given by

$$l = 0.35\ (d - t)r/(d + r)$$

where r is the internal radius, t the wall thickness, and d the source-to-film distance. For a tube of 4 in. external diameter and $\frac{1}{2}$ in. wall thickness the length must not exceed approximately $\frac{1}{2}$ an inch to ensure the detection of a radial crack 0.001 in. in width. Thus about twenty exposures would be required to cover the whole periphery which is quite impracticable. Insofar as there is any departure from this technique so are the results inferior to those attainable with a flat plate. Two methods are known in which these disadvantages may be overcome:—

(1) *Panoramic Rotational Radiographs.*

This method was described by Warren[2] in 1935, and was also subsequently referred to by Berthold[3]; it is shown diagrammatically in Fig. 9. A film is placed round the whole of the inner periphery in close contact with the metal surface. The rays pass through a slit $\frac{1}{2}$ mm. wide in a lead plate placed close to the cylinder, and between it and the X-ray tube; the cylinder is kept in continuous rotation during the exposure. This is a sensitive and easily applied method, but the exposure times are necessarily long, as each element of the cylinder is only exposed for a small fraction of the total time.

(2) *Film round the outside of a cylinder, source of rays inside.*

This method can be used for cylinders of a foot or more in diameter into which an X-ray tube can be inserted. Long anode tubes have a limited application for this purpose and a tube operating at 250 kV with a focus smaller than $\frac{1}{2}$ mm. would be most useful. Extensive use is now made of gamma rays, and small radon seeds of high intensity and $\frac{1}{2}$ mm. or less in width will give sharp definition in pipes down to 3 in. diameter; the poor contrast results, however, in a loss of sensitivity especially in wall thicknesses below 1 in. of steel. The length of pipe which can be examined per exposure is much restricted with a small source-to-film distance, but this is of little consequence in the examination of butt welded joints.[4] This common application has the disadvantage that root cracks are on the inner surface, that is the surface remote from the film, which is the worst position for detection. On the other hand the set-up is a good one for detecting lack of side fusion in a weld with V or U joint preparation.

Scattered radiation must receive due and respectful attention and one of the many curious effects of scatter, this time a beneficent one, is known in the A.R.D. as the stencil effect. Where a defect emerges on the film side of a thick specimen the radiographic image is partially built up by a wash of soft, scattered radiation falling upon the final cracked layer from widely differing directions and giving a considerably enhanced image if the film is in close contact with the cracked surface. This ultra sensitivity rapidly decreases to normal value for a defect embedded $\frac{1}{8}$ to $\frac{1}{4}$ in. below the surface. Neeff[5] pointed out that in general increased contrast results from placing the film up to an inch or so away from the metal surface. This does not hold, however, for an emergent defect on the inner surface because of the stencil effect and it is preferable to use a flexible cassette or wrapper with the film wedged in close contact with the surface as shown in Fig. 10 rather than a metal cassette placed along a chord—suitable precautions being taken, of course, to avoid pressure marks.

It will be seen that the radiography of fine cracks in forgings requires very good technique. The method is considered to be a reliable one in the hands of an experienced radiologist but it may not always be possible to give a definite diagnosis.

Welds

Much of the foregoing applies to welds and the radiography of all grade 1 welds in pressure vessels and the like is now required by inspecting authorities. Since cracking is the defect most likely to cause failure if present, its detection was taken to form the basis of a specification prepared for another Service Department in 1941. This specification covered technique and acceptance limits for radiographic examination of fusion welded pressure vessels. It is understood that somewhat similar recommendations for general industrial use has already been published by another authority concerned with welding.[5]

The surfaces of grade 1 welds are as a rule ground smooth and therefore critical radiography is possible; this is also true of welded repairs in high-grade castings. Radiography is also used for the examination of fillet welds in fabricated structures. The difficulty with these is the rapid change of thickness in the metal section and there is also the difficulty of detecting lack of fusion and cracks situated along the toes (*see* Fig. 11).

These cracks are mostly similar in character to hot tears in castings and are readily detected in butt welded joints. In the repair of a casting it may be necessary to fill an excavation in the form of a slot in the wall, and cracks tend to occur in the first run of welding bridging the gap in the metal; it is preferable therefore in radiographing the repair to place the film adjacent to the side where the original first run of welding was made; (incidentally, it is better to avoid piercing the wall during the excavation if at all possible). Failure occasionally occurs by the "springing" of a weld when cold, and such a crack tends to be fine, so that fine-grain high-contrast film should be used for such an examination.

The application of X-rays to spot welds has been described in a comprehensive series of papers by McMaster and his co-workers.[6] The low voltages (10 to 40 KV) and short focus-film distances employed for the radiography of the very thin material give rise to a rather specialised technique, but the detection and interpretation of the cracks appear to be readily achieved, and stereoscopic methods have been used with success even in these small thicknesses.

The most difficult problem with welds is the detection of short fine cracks occurring as root cracks, basal cracks, crater cracks, and cracks associated with inclusions. These are difficult not only because of their shortness, but because of their random orientation which makes detection very uncertain: and it is sometimes, in a thin weld, almost impossible to distinguish between a small crack and a slag "stringer." This is a limitation which must be accepted, but it seems questionable whether it is a really serious one. When it is remembered that the radiography of welded boiler drums has been in operation for about 15 years without any failure, so far as is known, and remembering the radiography of the Boulder Dam pipe line in America and of many welded bridge structures and the like in Europe the practical value of the method can hardly be doubted.[7]

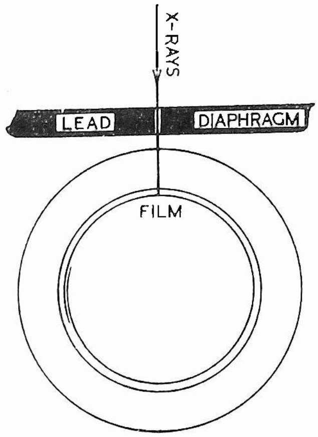


Fig. 9. Sketch illustrating the method of producing a Panoramic Rotational Radiograph

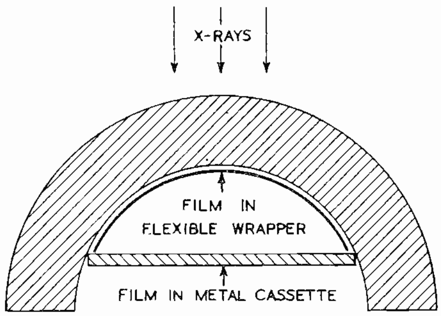


Fig. 10. Sketch illustrating the alternatives of flat or curved films in the radiography of a cylinder

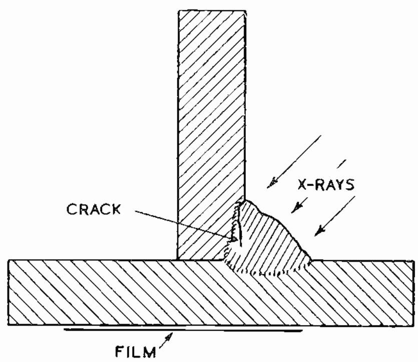


Fig. 11. Crack in toe of fillet weld. Note changing thickness of metal across the welded corner

Conclusions

The main points which have emerged from this brief survey are as follows:—

(1) The basic principles of radiographic technique are known, but much more investigation is necessary to find how the discernibility of cracks varies in materials of different thicknesses and densities.

(2) The circumferential radiography of tubes and cylinders, an important industrial application, needs more attention than is perhaps generally realised and a thorough knowledge of technique is required especially for pipes and cylinders of small diameter.

(3) The radiological method can be considered sound and reliable with relatively few limitations. Limitations there must be since there are limits to what X-rays can reveal, but the practical criterion is whether it is possible for potentially serious cracks to escape detection by radiology. To this the author would say no in the case of hot tears and cracks in castings; also in forgings provided that good technique is used. In welds it is possible that small cracks would escape detection but these would appear to be of little practical significance.

(4) The increasingly widespread opinion that gamma rays are in all circumstances an efficient and a simple substitute for X-rays should be corrected before it becomes firmly established in industrial circles. The chief value of the gamma ray method is that it can be used to give a general picture in positions which are inaccessible to X-ray apparatus. There ought to be no doubt whatever that X-rays should be used for preference on every occasion when a critical examination is required.

(5) Finally, some of the most interesting applications of X-rays for the radiologist are to the various crack-like defects mentioned in the introduction. Further discussion of these must be deferred, but it can be said that radiological methods have been successfully used in the detection of all the defects enumerated.

Acknowledgements

Grateful acknowledgement is made by the author to his colleagues, in particular to Mr. W. J. Wiltshire, G.M., and Mr. J. W. Avery, for contributions to the subject matter and for helpful criticism and advice.

The paper is published by permission of the Chief Scientist, Ministry of Supply.

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2 Warren. *B.J.R*, 8. 1935. 235.
3 Berthold. *Atlas der zerstorüngsfreien Prüfrerfahren* 1937.
4 Dawson. *J.Sci.Inst.* 23 1946. 138.
5 Neeff. *Zeit. f tech. Phys.* 6. 1925. 208.
6 McMaster and others. *Welding J.* 25. 1946. 707, 851. 26. 1947. 121, etc.
7 Rhoades. *Welding J.* 26. 1947. 497.

A Direct Reading Indicator for Electronic Counters

By G. T. BAKER, M.Sc.*

ELECTRONIC counters are being applied to an increasing number of industrial functions. Two fundamental requirements of such counters, as distinct from their laboratory equivalents, are robustness and ease of reading. In most applications, a binary indication would be a serious disadvantage, and some form of decade counter is essential. Of the several types of decade available, that constructed from four "scale-of-two" stages[1] is probably the most suitable. A counting rate of, say, 50 Kc/s. is ample for most industrial requirements, and if sufficient positive and bias potentials are allowed, this circuit can be constructed with wide tolerance components, and is stable over a considerable range of operating conditions.

Indication is, however, more difficult on this circuit than on others. The four neon tubes arrangement[1] is simple, but leads to errors when used by a semi-skilled operator on repetition work. Grosdoff[2] shows a system using ten neon tubes, one for each integer. Like the current summation arrangements, this system is somewhat marginal, and involves a control over the plate potentials which nullifies one of the main advantages of the circuit.

* Automatic Telephone and Electric Co., Ltd.

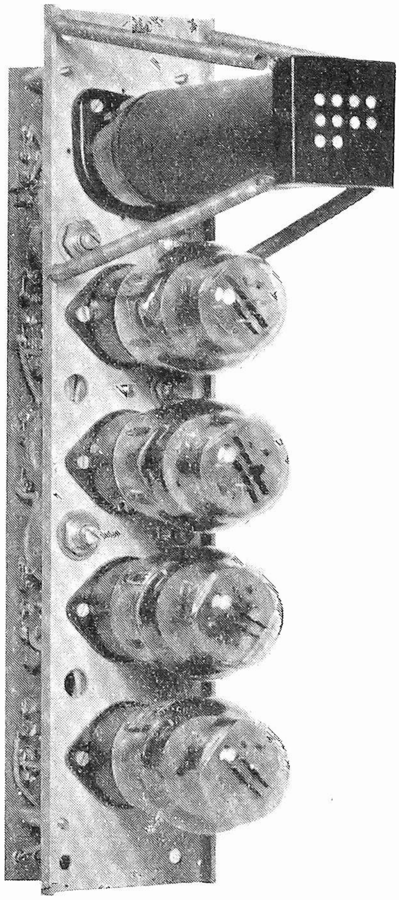

Fig. 4. Typical decade with indicator in position

Regener[3] discloses a method whereby the count is indicated by the position of the spot on a cathode-ray tube. This he uses in conjunction with a ring-type counter, but the same instrument applies more readily to the 4 × 2S type of decade. The following notes describe a simple and robust indicator, which can be read with such speed and certainty as to make it very suitable for industrial instruments.

In Fig. 1, each of the vertical elements represents a binary stage, the short thick strokes indicating the anodes. It is assumed that the four lower valves are conducting in the resting or zero position. Deflection plates X_2 and Y_2 of the tube are virtually at the full positive potential, but plates X_1 and Y_1 being connected to conducting load resistors, are more negative by an amount, say V. This potential across each pair of plates displaces the spot upwards and to the left, *i.e.*, to the position occupied by "0" in Fig. 2.

When the counter receives the first impulse, conduction is transposed in the first stage, and X_1 and X_2 are now at the same potential. The spot moves into a neutral or undeflected position horizontally, thus indicating "1." The next impulse restores the potential on X_1, but also transposes the second stage. The potentiometers forming the load resistors are so adjusted that the potential on the X_2 plate is equal to $2V$. Consequently this plate is now the more negative by an amount V, and the spot moves an equal distance to the right to indicate "2." The third impulse

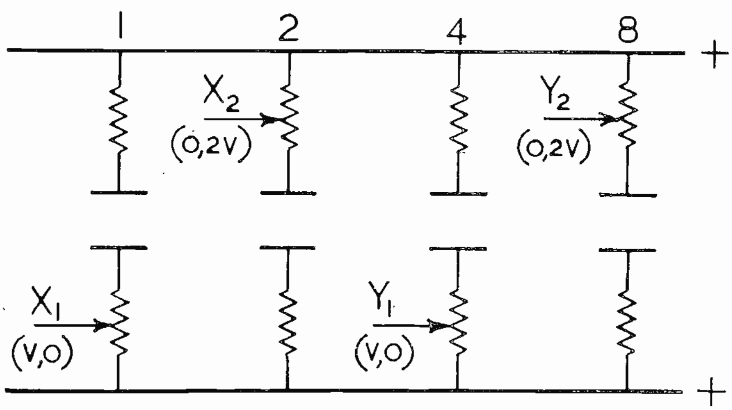

Fig. 1. (above) Plate connexions

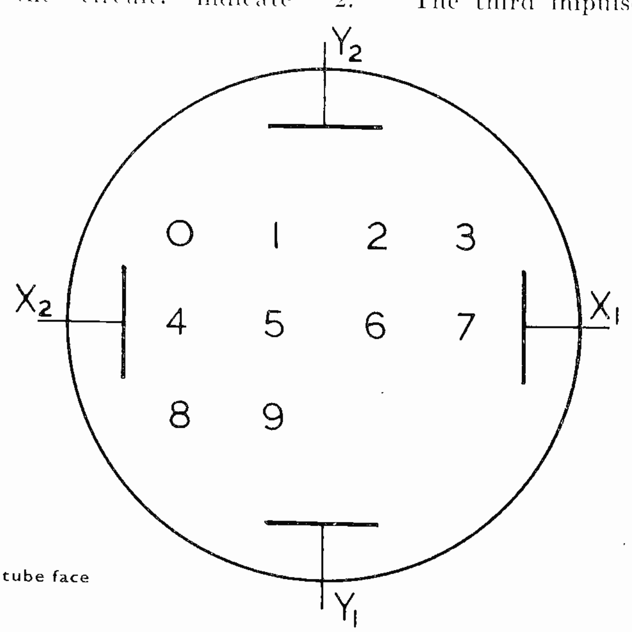

Fig. 2. (right) Layout of scale for tube face

again transposes the first stage to remove the potential V from X_1. X_2 is now more negative by $2V$, and the spot moves one step further to the right to indicate "3."

On the fourth impulse, the third binary stage is actuated, and the negative potential V is removed from Y_1. The spot drops to the vertical mid-position, but since the first two stages have been reset, the horizontal displacement is similar to "O," and the spot indicates the integer "4." Further impulses re-operate the first two stages as before, and the spot moves horizontally to "5," "6" and "7." At the eighth impulse, the third stage restores, but the operation of the last stage produces a potential $2V$ upon Y_2, making this plate the more negative by V. The spot drops one step below the mid-position and the locating of "8" and "9" will be obvious. At the tenth impulse the system re-sets to zero.

It will be noted that Fig. 2 shows the scale symmetrical about a vertical axis whereas the above description suggests that the frame should be displaced to the right. The symmetry is achieved by providing a standing potential upon X_1, which can be obtained by connecting the plate to a potential divider system as shown in Fig. 3. Resistances R_1 and R_2 are so chosen that the system is displaced one half step to the left, *i.e.*, the potentials applied to plate X_1 are not V and zero but 1.5 V and 0.5 V. To reduce the wattage, and so economise on the control potentiometers, it is advisable to make these of high resistance, *e.g.*, 2 megohm, and to bridge the potentiometers by a fixed resistors equal to the required anode load. In this case, the positive side of the X_1 potentiometer is connected to the shift divider system of Fig. 3, and the deflection plate is connected directly to the sliding arm.

The type of scale depends on the finish of the instrument. A simple method is to draw the figures on a piece of tracing cloth or detail paper, and to gum this on the face of the tube. The spot shines through and illuminates the integer corresponding to the state of the count. It is an advantage to draw each character in reverse and to attach the scale so that the figures touch the screen. The unwanted numbers are less obtrusive and the contrast is increased. A somewhat more elaborate arrangement uses a small metal cap or mask to hold the tracing cloth against the face of the tube. Holes correspond to the position of the integers, and the body of the tube is coated with black paint to exclude back light. (Fig. 4).

The beam should be de-focused somewhat to illuminate the body of the character, and to prolong the life of the screen. When designing an instrument incorporating this type of indicator, it is desirable to have a separate control on the beam, either by a toggle switch or a push button. This can act either by disconnecting the positive supply to the tube or by applying a more negative potential to the grid or brilliance electrode. In some cases the beam control can be effected automatically, *e.g.*, in timing instruments, the key controlling the timing cycle can also control the tube illumination. With these precautions, it is possible to use a fairly high beam current and to dispense with adjustable values for the

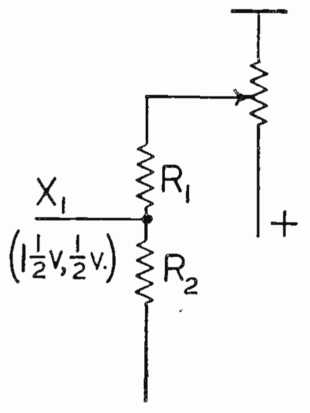

Fig. 3. Arrangement of shift circuit

focusing and brilliancy potentials, since a wide tolerance can be permitted. When a number of decades are conjoined to form a multi-digit counter, a single divider chain is sufficient to provide the intermediate potentials for all the tubes.

The tubes can be of the small monitoring type. A quite effective scale is obtained on an inch diameter screen, the character size and separation being approximately equal to that of a 2.5 in. straight scale. Efficient operation of the decade counter requires some 400-500 volts, which is sufficient to operate a small tube. The indicator should therefore add but little to complexity of the circuit.

References

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[3] Regener, *Rev. Sci. Inst.*, May 1946, p.185.

D

Printed Circuits

THE illustrations below show successive stages in making an amplifier from a printed circuit.

—*M. Lorant.*

Steatite plate after drilling and firing.

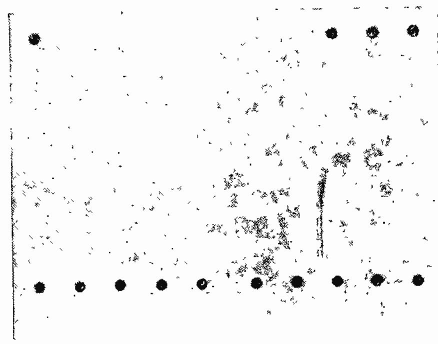
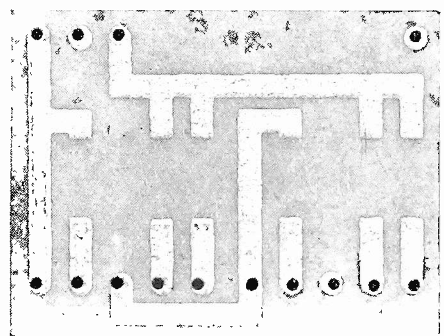
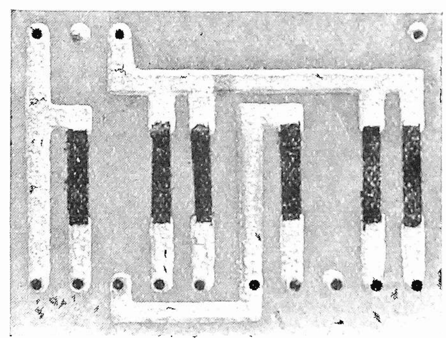


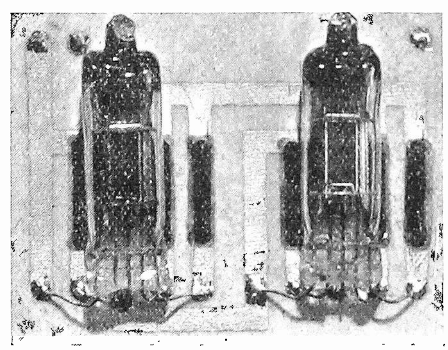
Plate with circuit wiring deposited



Resistor strips added



Miniature valves soldered direct to the wiring, making a 2-stage amplifier



The R.C.M.F. Exhibition

The fifth annual exhibition of British Radio, Television, and Electronic Components was held at Grosvenor House, Park Lane, on March 2–4, 1948. A selection of the newer and more important exhibits is given below. Further information can be obtained from the firms named.

Aerials

The "Arnine" aerial is a folded dipole which, together with its supporting insulators, is embedded in polythene. This firm also exhibited aerials suitable for car radio and television.

—*Antiference, Ltd.*
67, *Bryanston Street, W.*1.

Attenuators

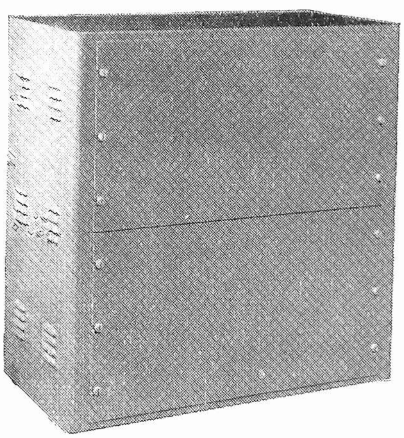
Variable and fixed attenuators, screened and unscreened, with stud switching and one-hole fixing. Dials calibrated in db. can be supplied. Slider type heavy-duty faders will dissipate over 1 KW and work at 125° C.

—*Painton & Co.*
Kingsthorpe, Northampton.

Cabinets

Instrument cases, standard rack and panel assemblies.

—*Alfred Imhof, Ltd.*
*New Oxford Street, W.C.*1.
—*Labgear, Ltd.*
Fair Street, Cambridge.
—*Weymouth Mnfg. Co., Ltd.*
Crescent Street, Weymouth.



2-panel instrument case by Imhof

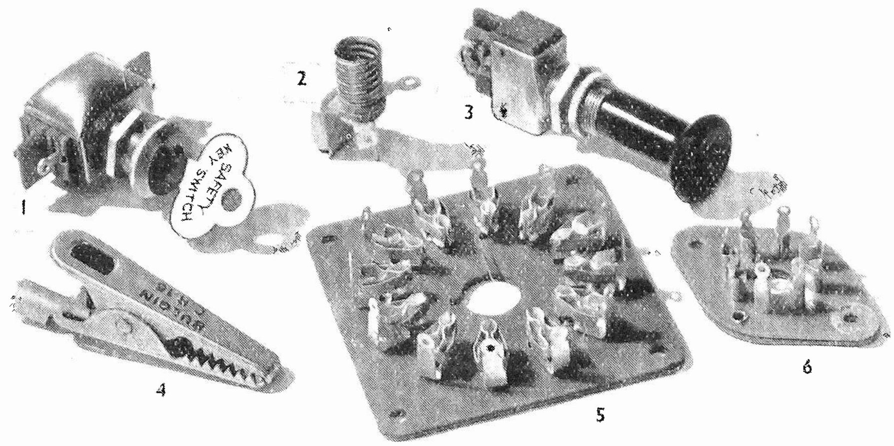
Capacitors

Silvered mica capacitors of small size in a wide range of specifications and tolerances, with unusual stability.

—*Stability Radio Components, Ltd.*
*Central Street, E.C.*1.

A range of silvered ceramic capacitors is shown by *Fulham Electrical Components, Ltd.*, an associate of the *London Electrical Mnfg. Co., Ltd.*

459, *Fulham Road, S.W.*10.



Some of the new Bulgin components: 1. Key switch. 2. Clip-on lamp socket. 3. Push switch for dashboards. 4. Large crocodile clip with identifying disk. 5. Cathode ray tube socket. 6. Valve socket.
—*A. F. Bulgin & Co., Barking*

Silvered mica capacitors, including twin capacitors for use as end-plates in I.F. transformers, and lead-through capacitors for by-passing in television receivers up to 300 pF (*see* illustration).

—*United Insulator Co., Ltd.*
Toutley Works, Wokingham.

Tubular Paper

Paper capacitors for fluorescent lighting, and hermetically sealed types for tropical use.

—*Ferranti, Ltd.*
Hollinwood, Lancs.

Complete range in aluminium containers or wax-dipped bakelite tubes.

—*Static Condenser Co., Ltd.*
Oakcroft Road, Tolworth.

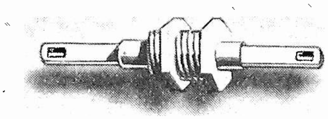
Metallised Paper

A special range of miniature metallised paper capacitors possessing self-healing properties.

—*A. H. Hunt, Ltd.*
*Garratt Lane, S.W.*18.

A new addition to the "Cathodray" range of capacitors is a 0.0005 μF type rated at 25 KV for use in projection-type television receivers.

—*Telegraph Condenser Co., Ltd.*
*North Acton, W.*3.



Lead-through capacitor—*United Insulator Co.*

Capacitors—Pre-set and Variable

Air-dielectric and "postage-stamp" trimmers in strips up to six units.

—*Wingrove & Rogers, Ltd.*
*Broadway Court, Broadway, S.W.*1.

Complete range of variable transmitting capacitors and trimmers.

—*S. Bird & Sons (Cyldon), Ltd.*
Cambridge Road, Enfield.

New range of variable capacitors for transmitters, etc.

—*Labgear, Ltd.*

A capacitor designed for use in high Q circuits. Its lightness and small size make it suitable either for use within a coil can, or for fixing on the chassis, in conjunction with the mounting plate. Two sizes: 2-8 pF. and 3-30 pF.

—*Mullard Wireless Service, Ltd.*
*Century House, W.C.*2.

Electrolytic Capacitors

In addition to standard types in aluminium cans, with neoprene seals, special types for A.C. starters can be supplied.

—*Daly (Condensers), Ltd.*
*The Green, W.*5.

"Drilitic" dry electrolytic capacitors can now be supplied in metal cans or tubular cases. A full range is available of comparatively small dimensions.

—*Dubilier Condenser Co., Ltd.*
N. Acton, W.3.

Cathode Ray Tube Accessories

Holders and sockets are supplied by *Belling & Lee, Ltd., Carr Fastener Co., Ltd.*, and Messrs. *British Mechanical Productions, Ltd., (Clix).* Shields from *Magnetic & Electrical Alloys, Ltd.*, and *Telegraph Construction & Maintenance, Ltd.* Masks for television and other purposes from *Long & Hambly, Ltd., High Wycombe.*

Coil Packs

A new 3-band midget coil pack, and an 8-range band-spread coil pack with wave-band scale lamp switching.

—*Weymouth Radio Mnfg. Co.*

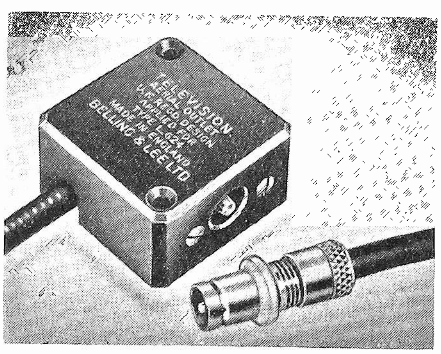
E.H.T. Rectifiers

A new range of high-voltage metal rectifiers has been specially developed to meet the growing demand for a small, compact metal rectifier to provide E.H.T. in many forms of equipment where the current demand is unlikely to exceed about 0.5 mA. D.C.

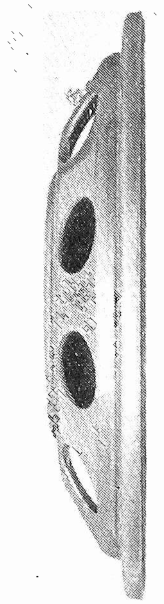
Rectifiers Type 36EHT are tubular in construction; the outside diameter is 7/16 in. throughout the range. Tag connectors are provided at the ends, in place of the more usual nut and bolt connectors.

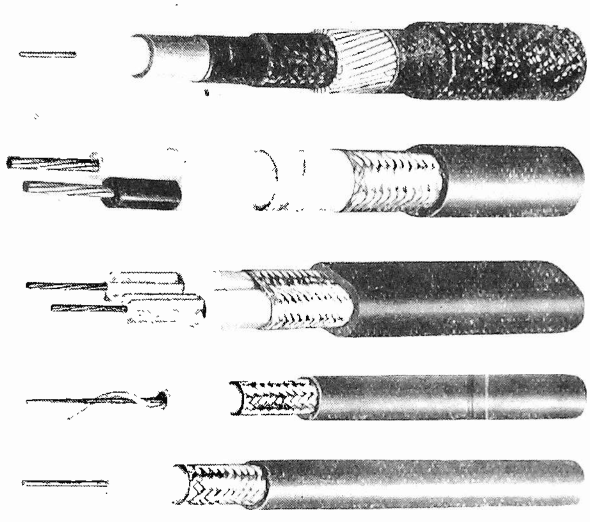
Type 36EHT rectifiers are particularly suitable for use in voltage multiplying circuits such as voltage doublers, triplers, etc., owing to their small size and low forward resistance, and they will operate very effectively as pulse rectifiers to derive E.H.T. from the flyback pulse, which occurs at the line scanning output transformer of a television receiver.

—*Westinghouse Brake & Signal Co., Ltd.*
York Way, N.1.



New television outlet box—*Belling & Lee*





Left: The "Disc" loudspeaker, described in col. i.
Above: Types of low loss polythene cable exhibited by B. I. Callender's Cables Ltd.—72 *Fleet Street, E.C.4.*

Disk Loudspeaker

An entirely new form of design is shown in the "Disc" loudspeaker manufactured by the British Communication Corporation. It is claimed to be both weight-saving and space-saving and comparable in performance with any other high-quality speaker. The thickness of the 5 in. model is only $\frac{7}{8}$ in., and that of the $2\frac{1}{2}$ in. model $\frac{5}{8}$ in. The 5 in. model handles 3 W peak and the $2\frac{1}{2}$ in. model $\frac{1}{2}$ W peak. The magnet is of Alcomax, with a cadmium-plated pot housing. The chassis is of stamped hard aluminium.

—*British Communications Corporation.*
Gordon Avenue, Stanmore.

Gramophone Motors

A new type of record player in which a record placed on the turntable is automatically played on closing the lid of the cabinet. The pickup runs on a tracking rod to give true tracking, and is prevented from damage by an interlock which prevents the motor from starting when no record is on the turntable.

- *Garrard Engineering Co.*
Swindon, Wilts.

Hearing Aids

A special range of miniature components for hearing aids.

—*E. Shipton & Co.*
Ferndown, Northwood Hills.

H.F. Cables

In addition to feeders for domestic radio and television receivers, two Telcothene insulated transmission lines have been introduced with surge impedance of 300 ohm and 150 ohm.

Special double-screened and anti-microphonic cables are also to be seen.

—*Telegraph Construction Co.,*
22, Old Broad Street, E.C.2.

Metals

The same firm is able to give good delivery of Telcon thermostatic bimetals, which are employed in delay switches, instrument temperature compensating devices and other components.

Magnets

Sintered Alnico magnets are identical with the cast metal, but permit small complex shapes to be readily moulded.

Sintered and drawn tungsten and molybdenum wire is also available.

—*Murex, Ltd., Rainham, Essex.*

Pick-ups

The Ferranti Ribbon gramophone pick-up is a precision instrument designed to reproduce lateral recordings of standard groove shape with the highest fidelity, and with negligible groove wear.

To enable rapid and accurate control of the pick-up to be obtained without fear of damage due to momentary lapses, an automatic placing mechanism is provided in the base. The pick-up may be placed on, or removed from, a 10 in. or 12 in. record simply by pressing the appropriate button.

—*Ferranti, Ltd.*

Also shown: 3 types of pick-up, the "Concert" moving-coil with linear response from 40-16,000 c/s., the "Ferrocoil" with higher output and a response from 50-12,500 c/s., and the "Ribbon," a pick-up having exceptionally light weight in the moving system.

—*Truvox Engineering Co., Exhibition Grounds, Wembley.*

Plugs and Connectors

A new 2-pin plug L.607PG suitable for L.336 balanced twin feeder carries two "O.Z." contacts and a removable "fouling pin" to prevent insertion into a 2 amp. mains socket. Reversible or non-reversible when used with the appropriate sockets. The socket panel carries two sockets and either 1 slot or 2 slots to take the "fouling pin."

A co-axial outlet box will be available for our new range of television and car radio co-axial plugs and sockets, all of which are now in production. They include single and twin right-angle, line coupling and through chassis connectors, the standard plug and chassis socket and a modified version for larger diameter.

—*Belling & Lee, Ltd.*

Temperature Indicators

A new item shown for the first time, is a Multicore Kit for determining bit temperatures. Of special interest to planning engineers and works managers, this kit comprises five different Multicore Indicator Wires which melt at temperatures recommended for the appropriate Ersin Multicore alloys and enables it to be determined simply whether or not a soldering iron has the requisite bit temperature. Previously, such tests could be undertaken only with expensive pyrometers of special design.

—*Multicore Solders, Ltd., Albemarle Street, W.1.*

Vibrators

A new synchronous vibrator and vibrator power pack which have been specially designed to ensure low current consumption for 2 volt working.

The power pack, which has been designed as a self-contained replaceable unit is extremely small and measures only 4 in. by 4 in. by 2½ in. high and provides an H.T. supply of 90 V, 10 milliamps and a negative bias of 6 V. This can, of course, be varied to suit customers' specific requirements with an upper limit of 6 watts D.C. energy.

—*The Plessey Co., Ltd., Ilford.*

Measuring and Test Instruments

Signal Generator.

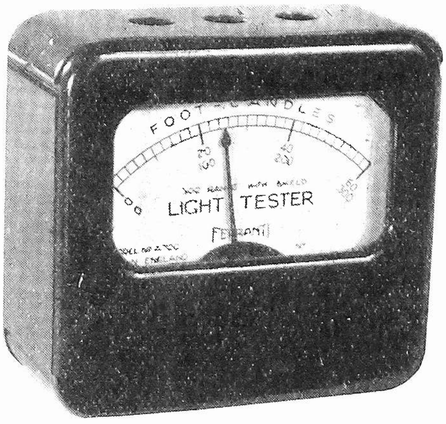
The Signal Generator Type B.4 is an entirely new substandard signal generator designed to cover two frequency ranges:

Model A, 100 Kc/s. to 70 Mc/s. and Model B, 30 Kc/s. to 30 Mc/s. Both the modulation depth and the carrier output of the instrument are monitored by a crystal voltmeter.

The generator, which is small in size and light in weight, may also be externally modulated. Radiation is negligible—less than 1 μV at all frequencies.

Audio Generator Type F.

This instrument is a particularly flexible power source at audio frequencies for measurements on the frequency characteristics of transformers, filters, transmission lines, amplifiers and loudspeakers. The



Ferranti Light Tester. The instrument employs a selenium cell and has 2 ranges—0-60 ft. candles without shield, and 0-300 ft. candles with shield.

frequency scale approximates to logarithmic and a high quality drive is provided. The output is monitored by a rectifier type output meter.

The use of a well-designed negative feedback network gives the instrument an almost level response over the complete range 100 cycles to 10,000 cycles.

—*Advance Components, Ltd., Shernhall Street, E.17.*

Four New Dawe Instruments

The following new instruments shown by Dawe Instruments, Ltd.

(1) A combined stroboscope and flash unit for industrial high speed analysis and photography.

(2) Sound level measurements over the full range of hearing.

(3) Resistance-tuned oscillators extending to 0.1 c/s.

(4) An electronic tachometer which requires no connection with the device under measurement.

—*Harlequin Avenue, Brentford.*

Resistance and Capacity Bridge

A small portable bridge designed for the quick checking, with fair accuracy, of resistors and capacitors including electrolytics. It consists of a pair of ratio-arms and a number of standard resistors and condensers selected by a switch. The bridge is balanced by variation of the ratio arms, a calibrated potentiometer. Provision is also incorporated for checking the leakage of electrolytic condensers. The leakage current is arranged to charge a condenser which after an interval discharges through a neon tube. The rate of flashing of the neon is then a measure of the leakage current of the condenser under test.

"Q" Meters

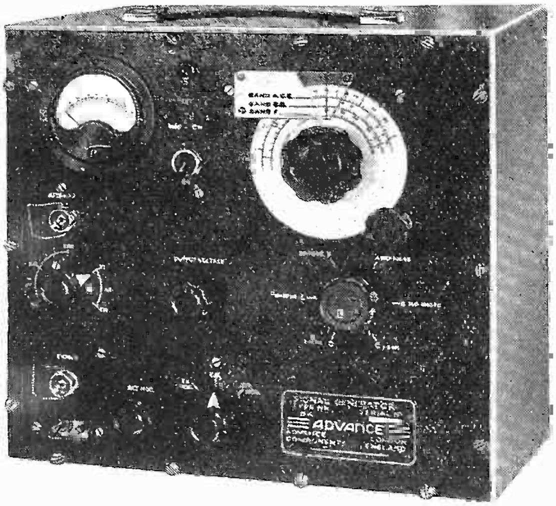
These two instruments operate on an entirely new principle which eliminates the "injection" resistance and they are capable of a high degree of accuracy up to extremely high frequencies. They cover the whole of the frequency range where the "Q" of coils is likely to be required, capacity can also be measured and with a simple calculation loss measurements of dielectrics may also be carried out. The low frequency model covers the range 25 Kc/s. to 50 Mc/s. and the high frequency model 15 Mc/s. to 150 Mc/s. In both instruments the degree of error is constant at all frequencies except at the extreme high frequency end.

—*Salford Electrical Instruments, Ltd., Salford, Lancs.*

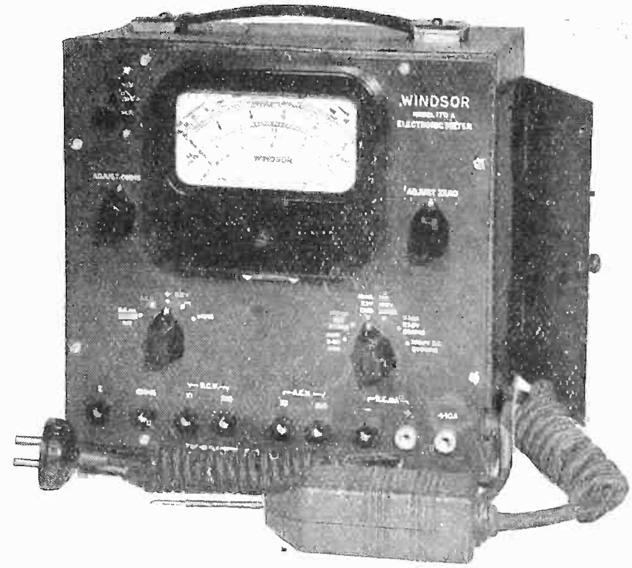
Pick-up Test Oscillograph

This equipment has been designed for the production testing of gramophone pick-ups. An output from a low-frequency oscillator covering the spectrum 0-10 Kc/s. is fed to the pick-up under test, and the response curve from the pick-up is traced on a cathode-ray tube. In order to get a continuous picture the oscillator is deviated at a recurrence frequency of 1 c/s., and a tube with the necessary after-glow is provided. A jig for mounting the test sample is supplied.

The low frequency oscillator, which is of the beat frequency type, carries a frequency calibration. The variable oscillator of the B.F.O. is driven by a synchronous motor, but



" Advance " Signal Generator with six waveband ranges, Type B.4



Taylor " Windsor " Valve Voltmeter for universal measurements

a friction device is provided with a manual control to enable the oscillator to be set at any frequency in the spectrum. Provision for viewing the wave-form from the pick-up is given by a built-in time base.

—*The Plessey Co., Ltd.*

Electronic Meter

This instrument is an A.C. mains-operated valve voltmeter enabling readings to be taken of A.C. voltages from 0.1 to 250 volts at frequencies up to 200 Mc/s. and up to 2,500 volts at audio frequencies.

D.C. voltage measurements from 50 millivolts to 10,000 volts are available and the input impedance on D.C. volt ranges is 10 megohms on the lower ranges and 100 megohms on the higher ranges.

Resistance measurements can also be made from 1 ohm to 2,000 megohms in six ranges and D.C. current measurements are available from 2 microamps to 10 amperes.

Model 170A. Provisional price £22 10s.

Combined Electronic Meter and Universal Multi-Range Voltmeter

This instrument has the same specification as the Model 170A but in addition the instrument can be used as a Universal Meter having a sensitivity of 10,000 ohms per volt D.C. and 1,000 ohms per volt A.C.

Model 180A. Provisional price £27 10s.

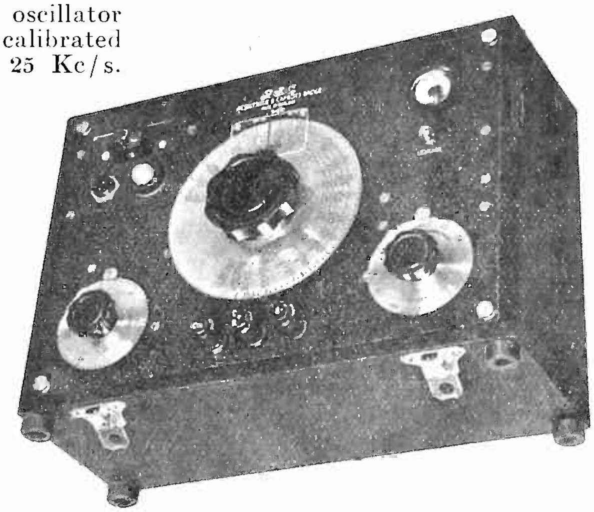
Wobbulator Model 55A

Curve tracing facilities are provided by this unit which is used with a signal generator and C.R. oscillograph such as the Taylor 65B and 30A respectively. The mean frequency of the wobbulated oscillator is 4 Mc/s. with directly calibrated incremental tuning of ± 25 Kc/s. for bandwidth measurement. A continuously variable amplitude of frequency sweep is provided by a potentiometer feeding the reactor valve which is controlled by the time base voltage from the C.R. oscillograph. The dimensions are $12\frac{1}{2}$ in. × $8\frac{1}{2}$ in. × 6 in.

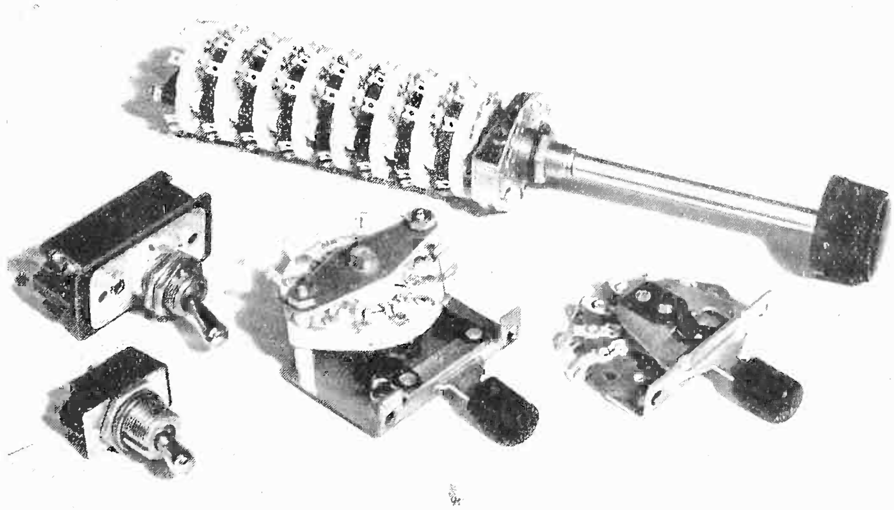
Price £14 14s.

—*Taylor Electrical Instruments, Ltd.*

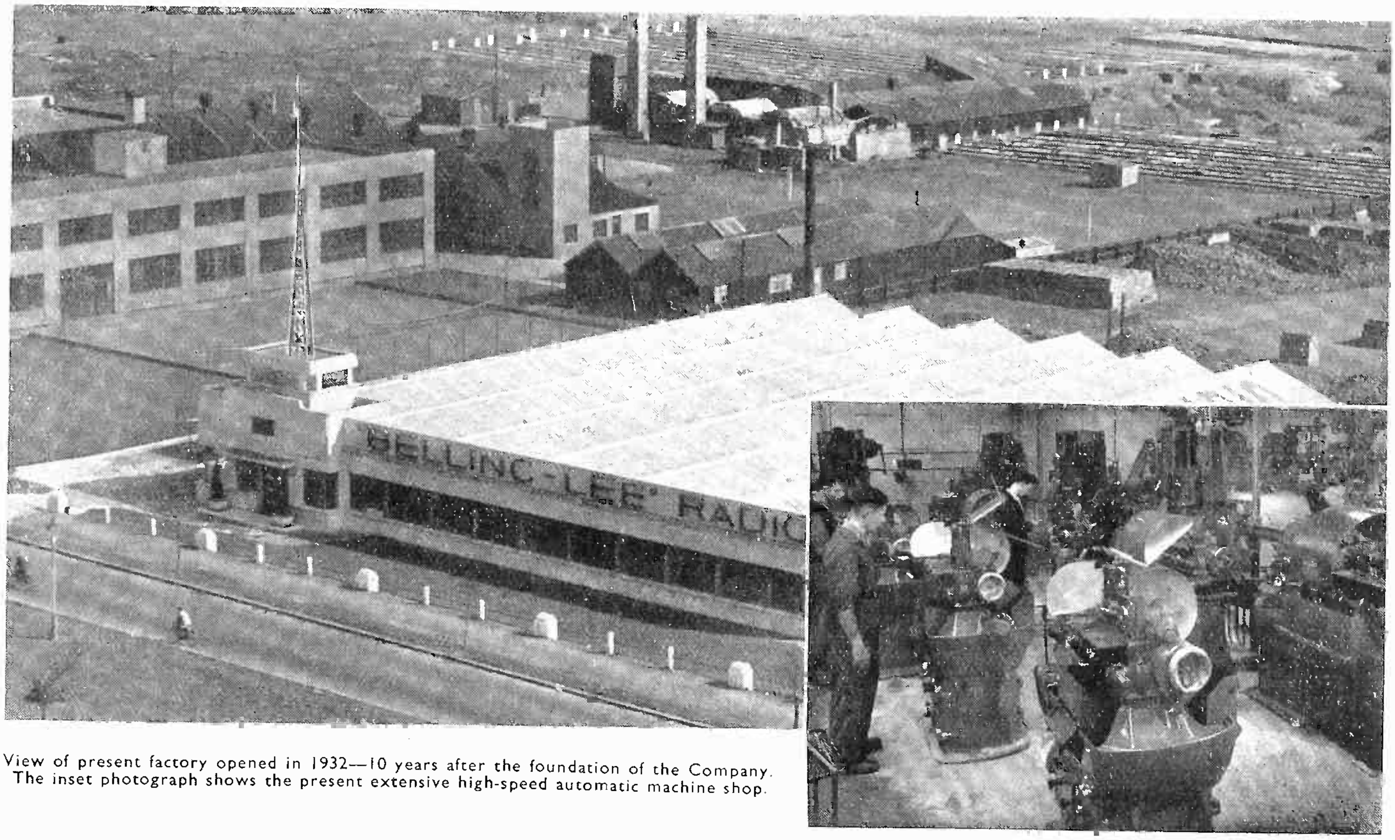
Further items are unavoidably held over and will be described later.



G.E.C. Resistance-Capacity Bridge



New " Oak " rotary switches of small diameter, with ceramic wafers. The toggle switches are Cutler-Hammer type made under licence. *British N.S.F. Co. Ltd., Keighley, Yorks.*



View of present factory opened in 1932—10 years after the foundation of the Company. The inset photograph shows the present extensive high-speed automatic machine shop.

25 Years of Component Making

Belling & Lee Silver Jubilee

BELLING & LEE, LTD., now embarking on their second quarter-century in the radio and electrical industry was first registered as a company in 1922. The British Broadcasting Company had also started in the November of that year, and for the first two years of its existence the firm of "Belling-Lee" made radio receivers in a small factory of 2,000 square feet at Queensway, Ponders End.

The pitfalls of receiver manufacture in the early days soon convinced the small company that a "safe" line in receivers was required, and a simple crystal set was produced and sold at 25s., the production being 300 sets per week.

One by one the components were designed and tooled for making in the factory, until the only components purchased outside were the aerial and earth terminals. Then, in 1924, a combination of ideas produced the first indicating terminal with a head that did not come off and an engraved marking on it. A further improvement in 1925 produced the terminal which made the name of "Belling-Lee" as component manufacturers—the "B" type, with non-removable head and non-rotating indications.

At 9d. each these were in enormous demand in the home constructor market, some sets having as many as 20 terminals with different labels. The "B" type terminal has persisted to the present day with only minor modifications, and is still a best-selling line.

Other small components followed in quick succession—fuseholders and fuses, wander plugs, multi-contact plugs, and special valveholders.

In 1933 the problem of interference in radio reception was becoming acute and development of interference suppressors was undertaken. One thing led to another, and from the simple suppressor unit mounted on a meter board came a complete noise reduction service with anti-interference aerials as well as suppressors. An improved anti-interference aerial, the "Eliminoise" was marketed in 1936 and later came the "Skyrod," a vertical rod aerial of neat appearance and superior effective height.

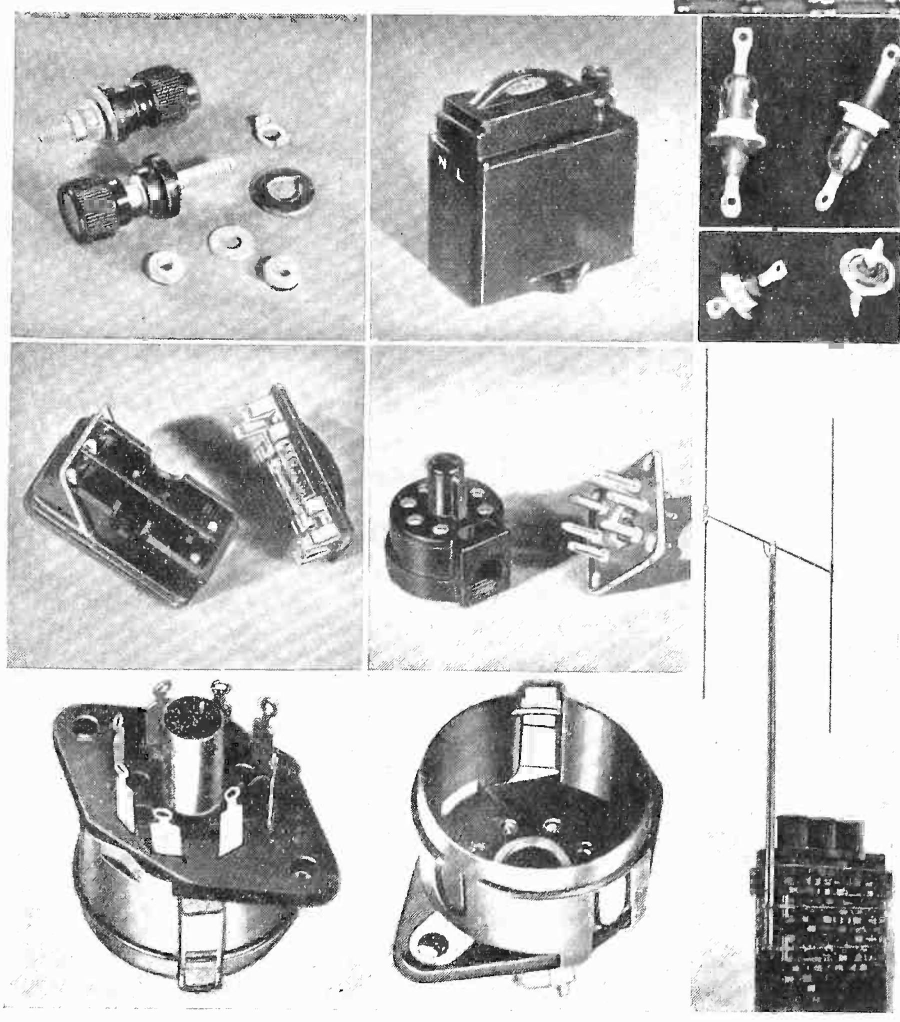
The same year (1937) saw the beginning of television broadcasting, and with the additional designs of television dipoles the firm in 1939 had reached a position where aerials were the largest part of the manufacture, with smaller components as a steady and useful background.

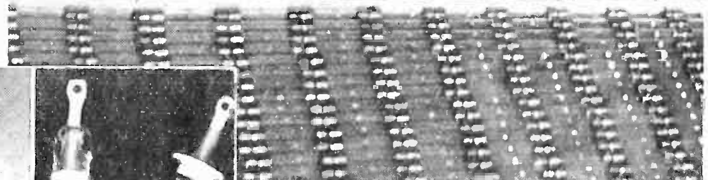
In 1932 the company had outgrown its works in Queensway, having already covered four separate factory premises, and it moved to a new modern factory on the Cambridge Arterial Road covering 22,000 sq. ft. At the outbreak of war in 1939 this new factory was turned over entirely to war material and components for radar and Service radio equipment, and the output of small components became astronomical. Even the original moulded terminal exceeded its records of home constructor days, and many of the well-known types of component were exported to the U.S. Signal Corps.

Extensions to the factory were added until the present area covers over 60,000 sq. ft. In this area is one of the largest plating plants in the country, capable of finishing single aerial sections of 25 ft. in length. The plant includes polythene moulding presses, pressure die-casting and glass moulding machines, and high-speed automatic presses producing 36,000 valveholder contacts an hour. The normal complement of the production units is 16,000,000 piece parts.

The organisation not only produces aerials and equipment but also instals them, with teams of skilled riggers and construction technicians

The illustration below shows old and new developments of the "B" type terminal and its modern counterparts in high voltage glass hermetic seals, the original meter-board suppressor and the well-known dipole and reflector Viewrod. The twin safety fuseholder is a 1929 design practically unaltered ; the multi-connector is typical of a range including 5, 7 and 10 pin types with panel pins or socket. These incorporate the O-Z low contact resistance, heavy current construction plug pin, and finally the new valveholder for B8A type valves





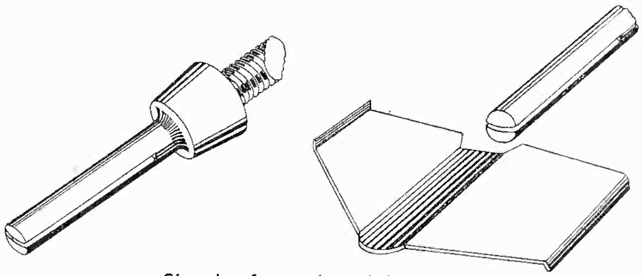
Soldering ends of fuse wire to caps. Note how the wire is threaded through a succession of fuse tubes

backed by a technical service department of high standard. The research department, in addition to carrying out development work, has a range of standard equipment for testing and checking under carefully controlled conditions and can simulate tropical or arctic surroundings if required.

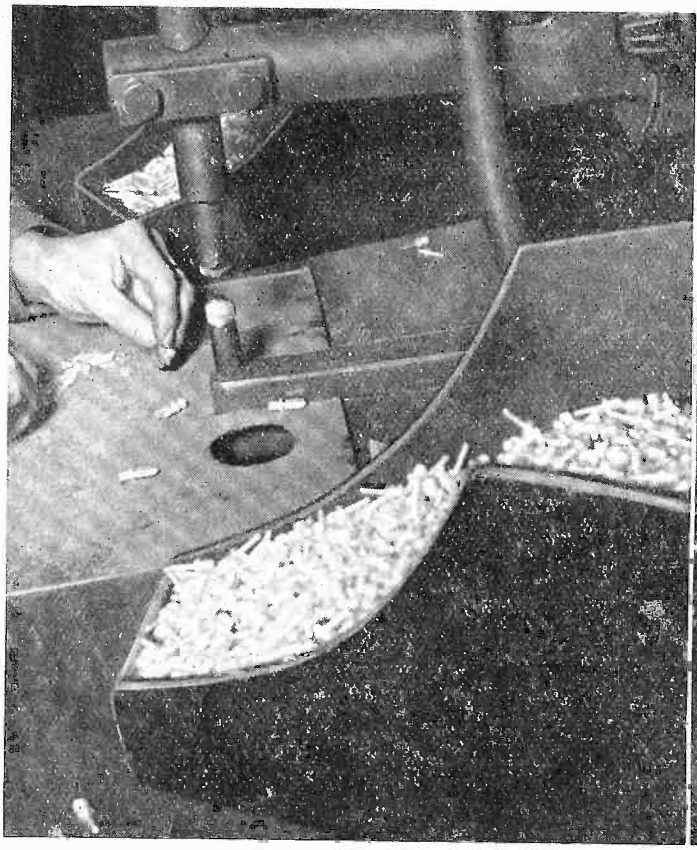
Fuses

Fuses are manufactured to B.S. Specification with ratings from 50 mA to 20 A. As shown in the illustration, after the glass tubes have been fitted with caps bored to receive the wire, it is threaded through a number of tubes in turn, soldered to the caps and the surplus is then trimmed off. For the lower current fuses wire of as small a diameter as .001 in. is successfully employed.

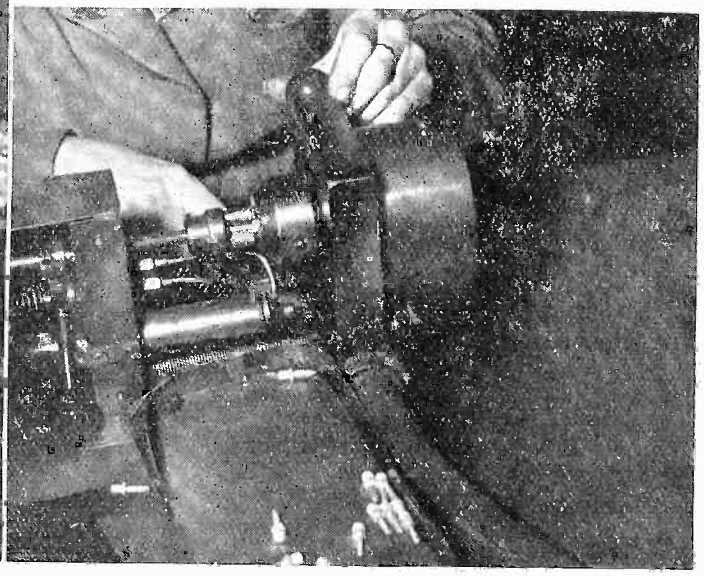
A special form of construction is used in the "Magnickel" fuse which is designed to provide delay action on heavy overloads of short duration. This fuse employs a fine nickel filament to which a special



Showing formation of O-Z plug



Welding leaf contacts into O-Z plugs



Rolling the leaf into shape after welding

Below : **Aerial packing department, seen through a row of aerials ready for packing**

—Behr-Hunot photos

magnesium deposit is attached. When an overload persists the magnesium ignites and ruptures the nickel fuse wire. On a 75 per cent. overload which is maintained it will blow within a minute.

O-Z Plugs

The problem of making good contact between a split plug and a socket has always presented difficulties, especially where a good contact area is required. The type of plug known as O-Z was developed and patented with the object of ensuring good contact in sockets of varying dimensions and depths. It is formed from a slotted plug into which is welded a phosphor-bronze leaf contact which is afterwards formed into a Z-shaped curve. The springiness of the leaf enables the plug to fit securely into a cylindrical socket and gives exceedingly low contact resistance. It is thus possible to carry heavier currents without overheating ; for example, a slotted plug of $\frac{1}{8}$ in. nominal diameter would be rated at 2 amperes, whereas an O-Z plug of the same diameter would be under-rated at 5 amperes.

It is the intention of the company to employ this type of plug throughout the range of components, and it is at present available in four sizes.

The photographs show the formation of the contact spring from the flat leaf, the principle of assembly being shown in the diagram.

Thermal Cut-outs

Among the later developments are thermal cut-outs for small motor protection and delay switches for rectifier heating. Applications for these delay switches have been found in fluorescent lighting and in electric train door control, and cut-outs are frequently used in circuits where an ordinary fuse is liable to blow on a momentary surge.

The thermal cut-out is assembled from over 25 piece parts under motion study conditions in a little over a minute. The switch itself contains a bimetallic element inserted in a mechanical toggle-link action which gives a quick break on overload. A follow-through contact ensures that the movement has accelerated to maximum speed at the moment of breaking circuit, and the same toggle action ensures quick make on resetting the cut-out.

Each switch is tested on an electronic timer and is then tested in a temperature-controlled oven with its individual thermocouple. This accurate control enables a cut-out to be made with the precision of a high-grade instrument at a cost which permits its use in relatively low-priced machines. An important advantage of the device is that it provides a double safeguard if mounted near the windings of machines, as the switch can be thermally operated by the temperature of the winding in addition to overload current.

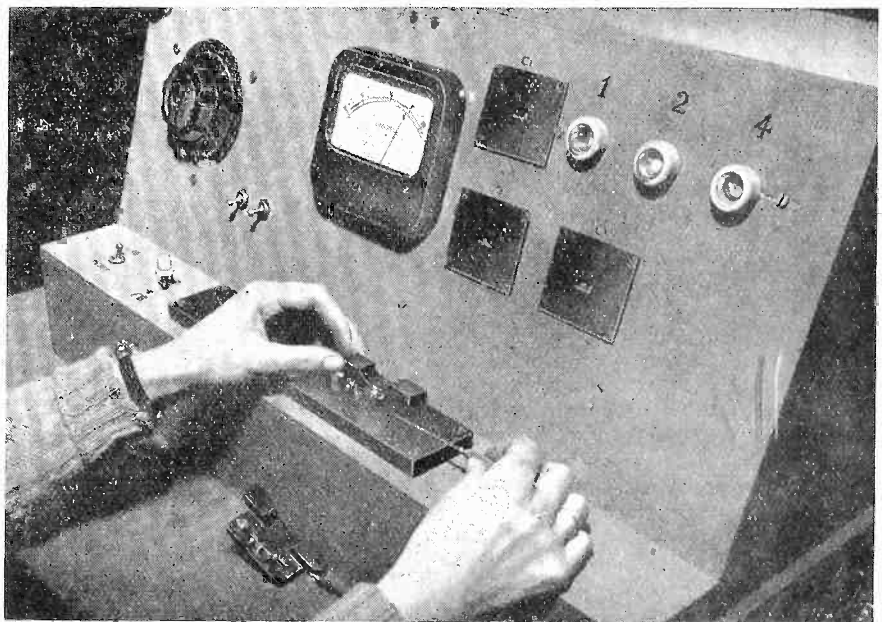
Aerials

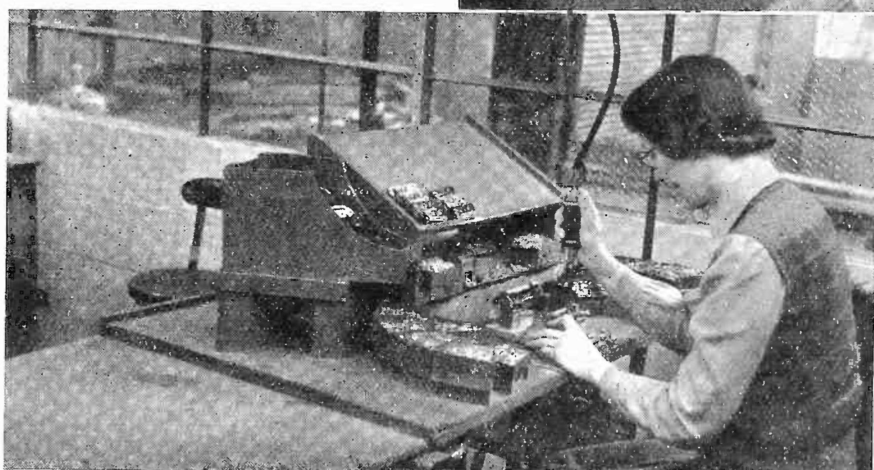
The standard H-type television aerial, which is widely used in the reception area, is shown in the illustration being packed for dispatch. A recent addition to the range is the "inverted-V" television aerial, which can be installed in a loft as well as outside the building. The appearance of what is considered by some as an unsightly rod is avoided, but the range of the V-aerial is restricted to 5 miles from the station when indoors and 10 miles outdoors.

Other Belling-Lee activities in aerial construction cover airborne radar and radio aerials, matching units and filters, and pre-fab. aerials for the new housing programme. There is also a complete aerial kit for amateur transmitters.

Acknowledgement

The photographs illustrating this article were taken by permission of Belling-Lee, Ltd., who also supplied the information on which the article is based.





The Manufacture of Thermal Cut-outs

An electronic timer for controlling cut-out operation on current overload in a fixed time. The panels C1 C2 C3 are electronic counters in seconds and neon lamps indicate eights of seconds

Centre: A motion-studied layout for cut-out assembly employing pneumatic spanner for speed and uniformity of nut tightening

Each cut-out is tested with an individual thermocouple in one of the small ovens shown below

—*Behr-Hunot photos*

High Vacuum Pumps

Their History and Development

By R. NEUMANN, Dipl. Ing., A.M.I.Mech.E.

Part 4 — Diffusion Pump Design

THERE exists an enormous number of different designs of diffusion pumps and only very few typical examples can be dealt with here. Perhaps the best way of approach is to discuss briefly the different elements of design and then to give a few illustrations of pumps actually manufactured or having special features which might be useful in future development.

The principal parts of an ordinary diffusion pump are the boiler or evaporator with its heating appliance, the tube leading from the boiler to the pump chamber, the diffusion slit or nozzle, the condensating or cooling arrangement, the connexions from the recipient to the pump chamber and from the latter to the backing pump. Certain accessories as the cold traps necessary with mercury pumps for obtaining very high vacua and the baffles required mainly in oil pumps shall be dealt with separately.

In many cases the evaporator is simply formed by the lowest part of the cylindrical pump chamber, but frequently—especially in pumps made of glass or quartz—the evaporator has the form of a bulb so that the boiling surface is increased. This enlargement of the boiling surface is also employed in some all-metal pumps, *e.g.*, if they are of the fractionating type. In Hickman's horizontal design the boiler is a more or less V-shaped annex fastened lengthwise to the pump chamber. In a recent design developed by the National Research Corporation the boiler acts on the fire tube principle.[101]* It consists of a short horizontal or vertical tube mounted underneath the U-shaped pumping chamber and connected to it by a vapour uptake and a return flow pipe. In some cases it is gas-heated. But in general—except for small laboratory pumps—electrical heating is preferably used as the current may be readily adjusted to the requirements of operation and may be easily measured. The exact adjustment of the temperature of the boiler is the more important with oil diffusion pumps as there is a comparatively narrow range between the temperature at which vapour production for efficient working of the pump is obtained and the temperature at which cracking takes place.

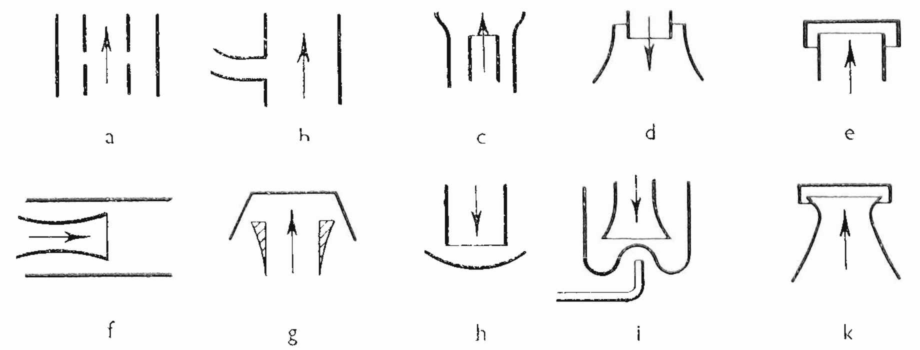


Fig. 20. Typical nozzles of diffusion pumps

a Gaede's slit. *b* Williams' orifice. *c* Langmuir's nozzle. *d* Langmuir's "goose-neck" nozzle. *e* Langmuir's "umbrella" nozzle. *f* Crawford's nozzle. *g* Kaye's design. *h* Pilow's design *i* Brill's design. *k* Embree jet.

Cylindrical or flat heating units are most generally applied, but also various other arrangements have been proposed, *i.e.*, mercury are heating,[105] induction heating,[106] the latter also with high frequency current. To increase the speed of starting the pump the boiler may be heated for a short period with excess heat.[107]

Small and light electric heating elements with a minimum heat capacity are recommended by Hickman, *e.g.*, nichrome wire windings on split mica circles, preferably immersed in the pump fluid. With synthetic oils used in fractionating pumps the optimal depth of the liquid is 3-5 mm., not higher as the quantity of decomposition products liberated is proportional to the quantity of pump filling, and not too shallow lest a vapour layer would isolate the liquid from the very hot wall and decomposition would be accelerated.

The natural flow of the vapour from the horizontal surface of the working fluid in the boiler is upwards. In the first designs of diffusion pumps, Gaede's as well as Langmuir's, this upward flow was not deflected and the vapour flowed in a vertical tube to the diffusion slit or the orifice. Considerations of design showed that a downwards flow of the vapour has some advantages in avoiding the extra work spent for taking care of falling drops of condensed fluid. This led first to the "goose neck" type of pu in which the tube, leading from the boiler to the pump chamber, is shaped like an inverted U and then to the "umbrella" or "mushroom" type in which the vapour is led upwards in a central tube and deflected by a cowl at its upper end. This design is the one most commonly used in modern pumps, specially in those of metal construction, but is also used to a large extent in glass pumps, although for these either the original undeflected flow or a more or less horizontal flow is frequently met with. For fractionating pumps Hickman prefers the horizontal design as the boiler area is independent of the jet diameter, as the precise distribution of the heat input can be more easil regulated, as the arrangement of the boiler underneath the pump chamber leaves two free ends, one for the small fore-vacuum and one for the large fine-vacuum connec-

* National Research Corporation of Boston and Cambridge, U.S.A., and Daniel Varney, Ltd., of Hillington, Glasgow, and 6, Cromwell Place, London, have now formed conjointly British American Research, Ltd., who are producing all the National Research Corporation's products in Daniel Varney's Glasgow Works.

Siegbahn's molecular pumps mentioned in the February issue are manufactured by LKB-Produkter Fabriksaktiebolag, Stockholm.

tion, and as the fractionating unit may thus serve as a straight pipe between the mechanical pump and the vessel to be exhausted.

As we saw, the narrow diffusion slit used in Gaede's first design was soon discarded. In the mushroom type an annular nozzle is formed by the upper end or the sides of the uptake tube and the cylindrical or conical inner surface of the cowl. Where the sides of the cowl are made conical, use is made of a principle first proposed by Crawford[108] who applied the experiences gained in steam turbine designs by Laval to the shaping of the nozzle of the diffusion pump. This divergent nozzle causes the vapour to leave the admitting tube as a nearly parallel jet of very high speed. Various proposals were made to make these nozzles adjustable.[109] But it may be safely stated that, in spite of Gaede's objections to its theory, the ordinary divergent nozzle—either circular or annular—is now the one most widely accepted, though it has not quite replaced the cowl with cylindrical side walls.

A recent development of the annular divergent nozzle is the Embree jet[110] extensively used in the pumps of Distillation Products Inc. It is a mushroom nozzle in which the vapour is allowed to expand towards the centre of the pump. With such a jet a Ho-coefficient of over 30 per cent. has been obtained. Fig. 20 gives a comparison of some typical kinds of nozzles used in diffusion pumps.

For the condensing or cooling systems natural or enforced air cooling and water cooling are employed. While in small glass type diffusion pumps natural air cooling may be sufficient, for larger type pumps a small electric fan or a gentle stream of air from a laboratory line may be used for providing the necessary circulation of the cooling medium. This stream of air is preferably directed towards the outer wall of the pump near the jet. The cooling action may be improved by copper wire coiled and looped around the tubes on small glass pumps, or by cooling ribs on metal pumps (*e.g.*, VMF series, Distillation Products Inc.)[87]

For water cooling, either only the outer walls of the pump chamber, or also the inner parts of the nozzle or its opposite walls, are cooled.[71,110a] Jacket cooling with or without a spiral water channel (*e.g.*, Metrovac) or special cooling

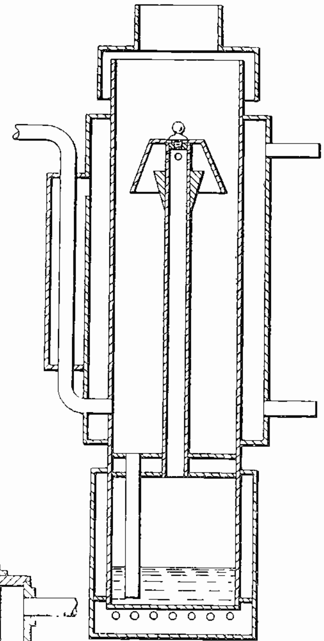


Fig. 23. Kaye's diffusion pump

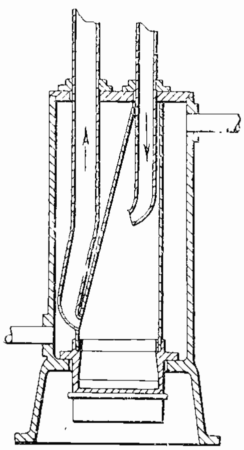


Fig. 21. Brown Boveri's Mercury diffusion pump

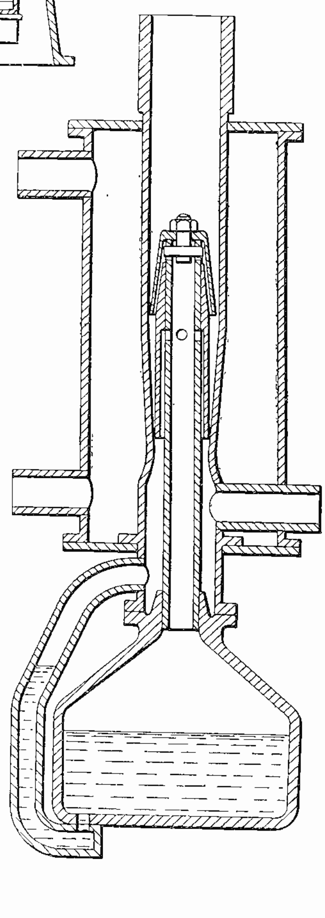


Fig. 22. Philips' diffusion pump

tubes wound around the walls of the pump chamber (Dist. Prod. Inc., Litton) are employed in the various designs. In Bancroft's design these are hard welded to the condenser tube.[111]

According to a proposal by Krämer the cooler may be arranged as a self-contained vessel, its walls contacting the walls of the pump. Preferably it consists of two half cylindrical parts, surrounding the pump and flanged together.[112]

The connexion between pump chamber and the vessel to be evacuated should be as short as possible and of largest possible cross-section. If shutters cannot be avoided, they must be of a type with least possible obstruction to gas flow. The same applies also to the connexion to the fore-pump, although to a lesser degree.

Perhaps the simplest design suitable for a mercury pump used in connection with mercury arc rectifiers and therefore requiring a final pressure of not much less than 10^{-3} mm. Hg is shown in Fig. 21 (Brown Boveri).[113] The "slit" is here replaced by the orifice of the high vacuum admission pipe in a similar manner as in Williams's design.[114] Other designs by Brown Boveri[115] show concentric uptake tubes and may be considered as predecessors to the fractionating pumps later developed. A specially compact pump in which the central tube and the diffusion jets can easily be removed for inspection and cleaning was designed by van der Poel (Philips) and is shown in Fig. 22.[116]

The same advantageous feature is incorporated in Kaye's pump (Fig. 23).[117] Kaye's design is used in the series of mercury diffusion pumps manufactured by W. Edwards & Co., and a typical example of this pump is shown in Fig. 24. While these latter pumps are the principal representatives of mercury diffusion metal pumps in this country, oil diffusion metal pumps are mainly manufactured by Metropolitan-Vickers Electrical Co.[118] Fig. 25 shows a section of a two-stage pump. The pump for higher suction speeds shown in Fig. 26 uses a smaller two-stage pump as a "booster." A similar booster is also used in Edwards' Type 120, which until recently was the largest capacity pump (180 l/s) available here according to manufacturers' catalogues. It has now been replaced

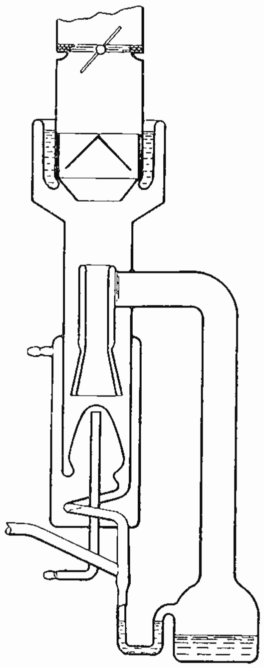
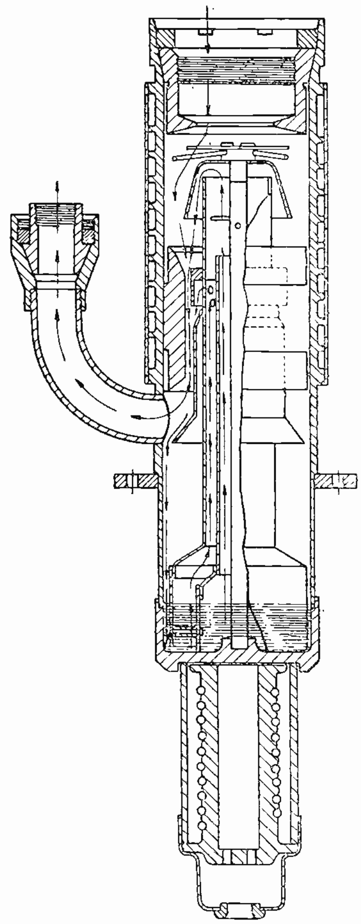


Fig. 29. Bull's high-speed pump



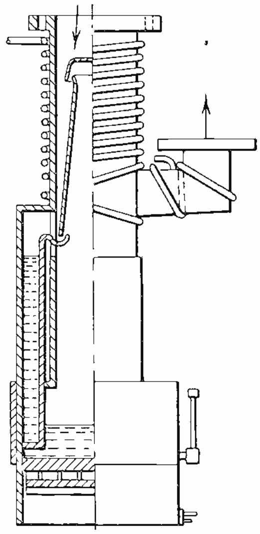


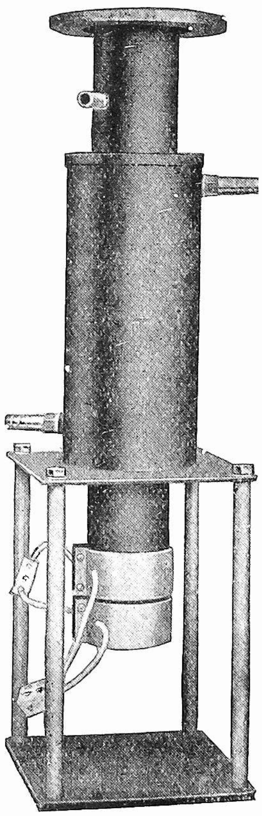
Fig. 25 (*centre left*). Metropolitan-Vickers' 2-stage oil diffusion pump, Type O.3B.

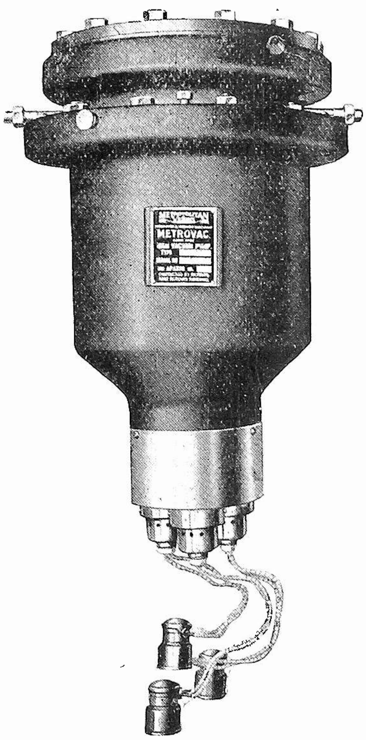
Fig. 26 (*centre, below*). Metropolitan-Vickers' pump Type O.4B.

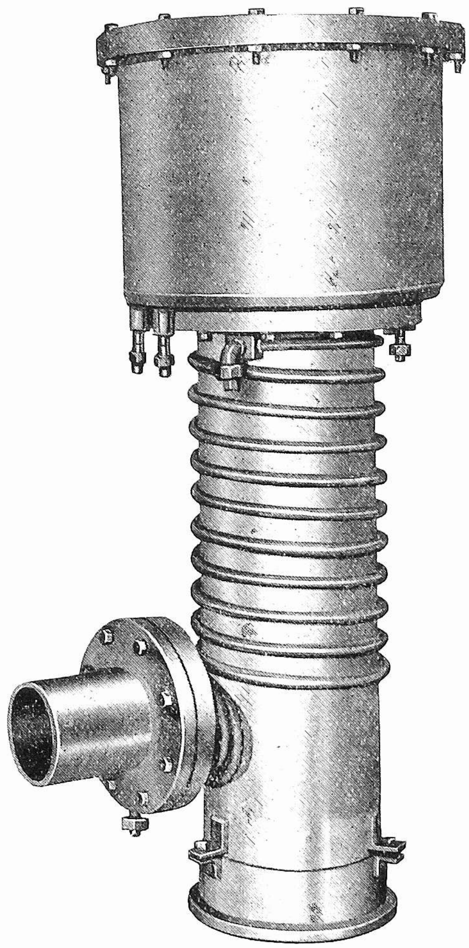
Fig. 28 (*above*). Westinghouse oil booster pump

Fig. 27 (*below*). Metropolitan-Vickers' pump, Type O.83B, with baffle

Fig. 24. Edwards' mercury diffusion pump







by the pump 6MD500 working without a booster and attaining a pumping speed of 500 l/s over a wide pressure range. This is a Hg diffusion pump. The Metrovick oil diffusion pump shown in Fig. 26 and working with a booster is now replaced by one of the models exhibited for the first time at the Physical Society's 31st Exhibition of Scientific Instruments and Apparatus, April, 1947. The types 0203B, 083B, 063B and 043B with diameters of 20 in., 8 in., 6 in., 4 in. and speeds of approximately 3,500, 500, 300 and 120 l/sec. at 10^{-4} mm. Hg were exhibited. Of these the type 083B is shown in Fig. 27.

While it is quite customary to use the combination of box pump and single diffusion pump as main pumping outfit, booster pumps between these two units are frequently applied for obtaining larger speeds. They may operate against exhaust pressures as high as 2 mm. for oil diffusion pumps and 25 mm. for mercury diffusion pumps. The maximum exhaust pressure of a diffusion pump should be as high as possible as the efficiency and speed of the box pump increases with increasing intake pressure.

A 6 in. booster oil diffusion pump was, for instance, developed by Westinghouse for use on the atomic bomb project, for which about the largest pumps so far designed have been built, especially for the seperation of isotopes. The booster is built with an electrically heated expanded boiler with large evaporating and heater contact surface. Fins welded to the boiler platter facilitate the heat transfer. A single jet is used which best prevents back streaming of air molecules. An external oil return leads the condensed oil back to the boiler. The booster weighs about 150 pounds.[119] Fig. 28 shows a section through this booster pump.

A high speed mercury diffusion pump designed by Bull with annular Crawford nozzle and condenser with inside and outside water cooling is shown in Fig. 29.[120] Inside and outside water cooling is also used in the design of P. Alexander.[71]

(To be concluded)

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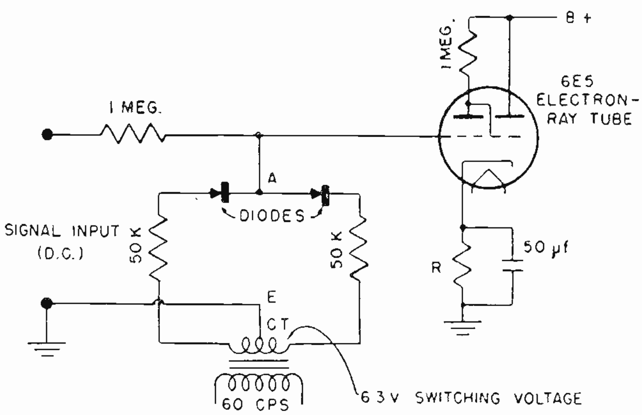
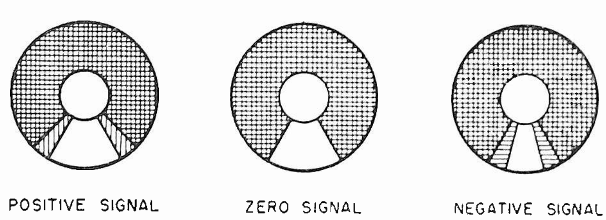
Magic Eye Tubes as Polarity Indicators

THE use of electron-tube tuning indicators for balance or null detectors is well known. For instrument work, however, a balance indicator capable of greater precision is frequently desired. By means of a special circuit M. L. Greenough has adapted a conventional "magic eye" tube of the variable shadow angle type, such as the 6E5, 6U5, and 6N5, to furnish a polarity-sensitive indication. Although this circuit was developed for instrument application it may be of value for adapting a conventional tuning eye to balance indication in FM discriminators.

The obvious method of making the "magic eye" tube polarity-responsive is to bias the deflection grid to produce some arbitrarily chosen reference angle, which is marked on the scale over the tube. Positive or negative signals then cause an increase or a decrease of this shadow angle. The disadvantages of instability of the reference angle, which is greatly dependent upon the supply voltages, and parallax of observation may be avoided by repeatedly switching the signal on and off at a rate fast enough to prevent visible flicker. By this means two shadow angles are maintained on the tube screen itself. One corresponding to zero input, appears half the time, and during the remaining time the angle is that due to the amplitude of the applied signal. Zero signal input is indicated when the edges of these angles coincide.





Typical patterns are obtained for positive zero, and negative signals. There appears to be a half-illuminated angular sector whose width is proportional to the deflection signal, and which lies on one or the other side of a reference line as determined by signal polarity. The switching voltage is conveniently obtained from an L.T. winding on the transformer, as shown in the diagram.—*National Bureau of Standards Technical Bulletin.*

The Cathode-Follower

By E. PARKER, M.A., A.M.I.E.E.

Part 4 — *Appendices*

Appendices I and II are mainly of theoretical interest, but the remainder contain results of considerable practical value. Except that Appendix V must follow Appendix IV, the appendices can be read in any order ; they refer exclusively to the linear or "idealised" theory of Sections 1–9.

APPENDIX I.

The Principal Formulae Expressed in terms of R_a.

FOR the sake of completeness the principal formulae of Sections 1 to 5, inclusive, are re-stated below in terms of R_a. As mentioned in Section 1, the writer believes them to be *less* convenient than the forms given in the main text. Each "R_a" form is, of course, obtained from the corresponding "R_m" form (whose number is given in brackets) by the substitutions $R_m = 1/g_m = R_a/\mu$.

The Basic Triode Equation:

$$I = \frac{V_a + \mu V_g}{R_a} \quad \ldots\ldots\ldots\ldots\ldots (1.1)$$

The "Degenerate" Triode Equation:

$$I = D \times \frac{V_{ht} + \mu V_i}{R_a} \quad \ldots\ldots\ldots\ldots\ldots (2.2)$$

$$\text{where } D = \frac{R_a}{R_a + (\mu + 1)R_c} \quad \ldots\ldots (2.3)$$

$$\simeq \frac{R_a}{R_a + \mu R_c} \quad \ldots\ldots\ldots\ldots (2.4)$$

The Cathode-Follower Current Equations:

$$I = \frac{V_{ht} + \mu V_i}{R_a + (\mu + 1)R_c} \quad \ldots\ldots (3.2)$$

$$\simeq \frac{V_{ht} + \mu V_i}{R_a + \mu R_c} \quad \ldots\ldots\ldots\ldots (3.3)$$

$$\text{and } \Delta I \simeq \frac{\mu \Delta V_i}{R_a + \mu R_c} \quad \ldots\ldots\ldots\ldots\ldots (3.4)$$

The Cathode-Follower Voltage Equations:

$$V_o = \frac{R_c}{R_a + (\mu + 1)R_c}(V_{ht} + \mu V_i) \quad \ldots\ldots (4.1)$$

$$\simeq \frac{R_c}{R_a + \mu R_c}(V_{ht} + \mu V_i) \quad \ldots (4.2)$$

$$\text{and } \Delta V_o \simeq \frac{\mu R_c}{R_a + \mu R_c}\Delta V_i \quad \ldots (4.5)$$

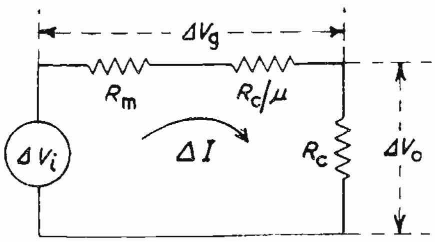


Fig. 24. Equivalent potentiometer

APPENDIX II

Further Consideration of the Equivalent Circuits

A.2.1. The Exact Equivalent Circuits

The exact equivalent circuits, like the approximate equivalent circuits (*see* paragraph 5.2) are obtained most directly from Equation (2.1), which, with a slight notational change, can be written:

$$I.R_m = V_i + V_{ht}/\mu - (\mu + 1)V_o/\mu$$

(It will be recalled that this was a fundamental relationship derived directly from the basic triode Equation (1.2).) Re-arranging, the above equation becomes:

$$V_o = \frac{\mu}{\mu + 1}V_i + \frac{1}{\mu + 1}V_{ht} - \frac{\mu}{\mu + 1}R_m.I \quad \ldots (A.2.1)$$

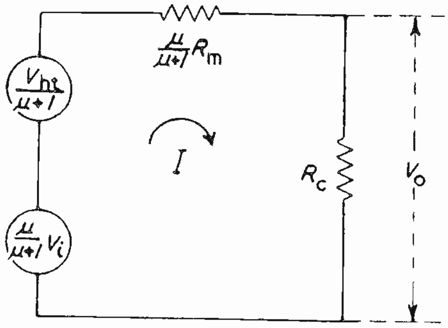


Fig. 22. Equivalent D.C. circuit of cathode follower

The exact equivalent D.C. circuit is therefore as shown in Fig. 22. The corresponding exact A.C. equation is:

$$\Delta V_o = \frac{\mu}{\mu + 1}\Delta V_i - \frac{\mu}{\mu + 1}R_m.\Delta I \quad \ldots (A.2.2)$$

and the *exact equivalent* A.C. *circuit* is that shown in Fig. 23. In particular, the *exact output impedance* is $[\mu/(\mu+1)]R_m$ and the *exact inherent amplification* (amplification under "no load" conditions) is $\mu/(\mu+1)$. This last result has been found previously in paragraph 4.3.1.

The above expression:

$$[\mu/(\mu + 1)]R_m$$

for the exact output impedance may

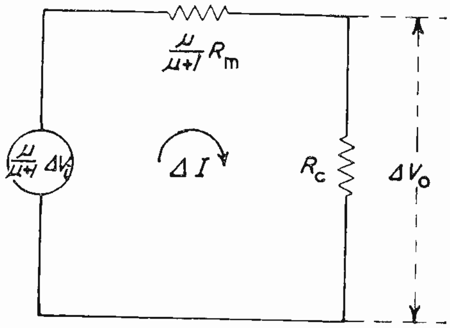


Fig. 23. Equivalent A.C. circuit of cathode follower

be re-written as $1/(1/R_m + 1/R_a)$—set μR_m for R_a and work backwards—which shows that *the exact output impedance is equal to the mutual resistance R_m in parallel with the anode resistance R_a*. (Compare the approximate result given in paragraph 5.6.) The exact statement corresponding to the last sentence of paragraph 5.6 is that the output impedance of the stage as a whole is Z, where:

$$\frac{1}{Z} = \frac{1}{R_m} + \frac{1}{R_a} + \frac{1}{R_c}$$

These accurate expressions involving R_a are, of course, mainly of academic interest since $1/R_a$ is almost always negligible compared with $1/R_m$. The results of paragraph 5.6 are the practical ones.

A.2.2. The Equivalent Potentiometer

An alternative way of writing Equation (A.2.2) is as follows:—

$$[(\mu + 1)/\mu]\Delta V_o = \Delta V_i - R_m.\Delta I$$

or, re-arranging,

$$\Delta V_o = \Delta V_i - R_m\Delta I - \Delta V_o/\mu.$$

Writing $R_c.\Delta I$ for ΔV_o in the *right-hand side only* gives immediately:

$$\Delta V_o = \Delta V_i - (R_m + R_c/\mu)\Delta I$$

which establishes the alternative equivalent circuit of Fig. 24. This is not an equivalent circuit in the usual sense of the term since the "internal impedance," viz., $R_m + R_c/\mu$, is not independent of the load but it does give some information that cannot easily be derived from the conventional equivalent circuit of Fig. 23. The significant difference between the two circuits is that the "input voltage" in the circuit of Fig. 24 appears explicitly as ΔV_i without any multiplying factor (which it does not in the circuit of Fig. 23), so that the voltage across the "internal impedance" of the new circuit is precisely $\Delta V_i - \Delta V_o$, i.e., ΔV_g. In other words, the new circuit relates ΔV_i, ΔV_g, ΔV_o, in the manner of a simple potentiometer, a relationship which is sometimes very convenient. For example, it can be used to provide an alternative proof of the results of Section 7 on maximum input and outputs (*see* paragraph A.2.3 below). To distinguish it from the circuit of Fig. 23 the circuit of Fig. 24 will be called the "*Equivalent Potentiometer*."

A.2.2.1. It should be noted in connection with the last paragraph that the equivalent circuit of Fig. 9, which also appears to have ΔV_i and ΔV_o at the ends of its internal impedance, does *not* (in general) have ΔV_g across this impedance since the ΔV_o there is only approximate. Comparison between Figs. 9 and 24 shows, in fact, that this will be so only if $R_c/\mu << R_m$, *i.e.*, if $R_c << R_a$.

A.2.3. Example. The Results of Section 7 Proved by Use of the Equivalent Potentiometer

Let the Δ appearing in Fig. 24 denote the change from cut-off to the grid current point on the characteristic. Then clearly $\Delta I = I_m$, $\Delta V_o = V_m$ and $\Delta V_g = V_{ht}/\mu$ (the "idealised" grid-base, V_{GB}), while ΔV_i is the maximum permissible peak-to-peak input voltage. Fig. 24 then becomes Fig. 25, and from the latter it follows that

$$I_m = (V_{ht}/\mu)(R_m + R_c/\mu)$$

which equals $V_{ht}/(R_a + R_c)$, and that

$$V_m = [R_c/(R_m + R_c/\mu)][V_{ht}/\mu]$$

which equals $[R_c/(R_a + R_c)]V_{ht}$.

The maximum peak-to-peak input voltage is $V_m + V_{ht}/\mu$. These are the previously established results of Section 7.

A.2.4. The Equivalent Potentiometer Established Verbally

The reasoning which established the equivalent potentiometer can be put into almost completely verbal form as follows. Let an (incremental) input voltage ΔV_i produce a change ΔI in output current. This causes a rise $R_c.\Delta I$ in cathode voltage, which, in effect, *directly* reduces the input voltage by an amount $R_c.\Delta I$. It also has an *indirect* effect, in that it causes a drop $R_c.\Delta I$ in the anode voltage, and this, by the definition of μ, is equivalent to a change $R_c.\Delta I/\mu$ in the grid voltage. Hence the *effective input voltage* is

$$\Delta V_i - R_c.\Delta I - R_c\Delta I/\mu,$$

and this expression times g_m must therefore equal ΔI. Replacing g_m by $1/R_m$ then leads immediately to the result $\Delta V_i = (R_c + R_c/\mu + R_m)\Delta I$ which establishes the circuit of Fig. 24.

If the last equation is multiplied through by $\mu/(\mu + 1)$, the exact equivalent A.C. circuit of Fig. 23 is also established.

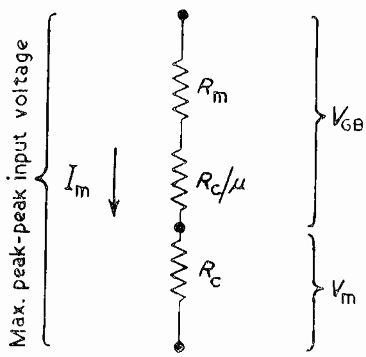


Fig. 25. Mnemonic circuit (exact) for maximum input and output in terms of V_{GB} ($=V_{ht}/\mu$)

APPENDIX III

The Case $R_c << R_a$

A.3.1. Maximum Outputs

The results of Section 7 on maximum outputs are capable of some simplification when R_c is much less than R_a. This includes the important case of a cathode-follower feeding a low impedance transmission line. For Equations (7.2) and (7.1) become, respectively, $I \cong V_{ht}/R_a$, which equals I_1 (from Section 8), and $V_m \cong (R_c/R_a)V_{ht}$ which equals I_1R_c. In words, the maximum output current is practically independent of R_c and equal to I_1, for all values of $R_c << R_a$, while the maximum output voltage increases directly with R_c. Geometrically (refer to Fig. 26), the R_c-lines for values of $R_c << R_a$ make only small angles with the current axis and so the maximum output currents differ little from I_1 while the maximum output voltages are proportional to R_c. These results are, of course, self-evident when it is recalled that with small values of R_c there can be no appreciable change in the anode voltage.

From the equation $V_m \cong I_1R_c$ of the previous paragraph it is possible, however, to write down a very convenient expression for V_m in terms of the "*idealised*" *grid-base*, V_{GB} (*see* Fig. 26), of the valve. For, from this figure, $I_1 = g_mV_{GB} = V_{GB}/R_m$ and so

$$V_m \cong \frac{R_c}{R_m} \times V_{GB} \quad \ldots\ldots \quad \ldots \quad (A.3.1)$$

A.3.2. Maximum Peak-to-Peak Input

The input necessary to swing the valve from its "idealised" cut-off point to its full output is greater than V_m by the grid-base itself (*see* Fig. 26), *i.e., the maximum peak-to-peak input voltage* is $V_m + V_{GB}$ which is equal approximately to:

$$\left(\frac{R_c}{R_m} + 1\right) V_{GB} \quad \ldots\ldots\ldots\ldots \quad (A.3.2)$$

A.3.3. Conclusions

Equations (A.3.1) and (A.3.2) can be remembered from the simple mnemonic circuit of Fig. 27 which is what Fig. 25 becomes under the condition $R_c << \mu R_m$ of the present appendix. But an even simpler statement of the results (A.3.1) and (A.3.2) is the following:

> *A cathode-follower with a cathode resistance equal to $N \times R_m$ and yet small compared with R_a has an effective grid-base $(N + 1) \times V_{GB}$ and a maximum output voltage $N \times V_{GB}$.*

It follows further that the *gain* is $N/(N + 1)$ but this result holds whether R_c is small compared with R_a or not. It was, in fact, proved in paragraph 4.3.

A.3.4. It will be seen from Fig. 26 that the peak-to-peak input necessary to swing the valve from *true* cut-off to full current exceeds $(N + 1)V_{GB}$ by an amount AA'. But if the valve is worked only on the linear part of its characteristic, $(N + 1)V_{GB}$ remains a very good approximation to the input swing required, while the *peak-to-peak* outputs will in this case be less than V_m, I_m by the minimum D.C. cathode voltage and current, respectively, that the condition of linear working will permit.

APPENDIX IV

The Voltage Across R_m in the Approximate Equivalent A.C. Circuit of Fig. 9.

This voltage has the very important property that:

Its product with the mutual conductance is equal to ΔI (A.4.1)

In other words, it is the "*effective input voltage*" to the valve. The proof of the statement (A.4.1) is self-evident since from the circuit of Fig. 9 the "voltage across R_m" is $R_m.\Delta I$ and this multiplied by g_m is ΔI.

The actual value of the "effective input voltage" in terms of the true input voltage ΔV_i follows at once from Fig. 9. It is $R_m/(R_c + R_m)$ times ΔV_i. Mathematically, of course, this is exactly the same result as was found in Section 2 where the input voltage was supposed unaltered by degeneration but where the *mutual conductance* was supposed reduced to an effective value $R_m/(R_c + R_m)$ times g_m. The change of viewpoint regarding the equivalent circuit itself should also be noted. In section 5 the "voltage across R_m" was the voltage uselessly dropped across the internal impedance of the cathode-follower, while the voltage across R_c was the useful "output" voltage. Now, the "voltage across R_m" is regarded as the significant voltage and the voltage across R_c is ignored. The reason for the new viewpoint is as follows. When the equivalent circuit of Section 5 had been established, the basic theory of the cathode-follower was essentially complete and there was no need for a theorem about the effective input voltage, but when the value of the current through the valve is required *for its own sake* (*i.e.*, not as a step on the way to finding the cathode voltage), as in the next appendix, the theorem (A.4.1) is very convenient. It is, in other words, a useful corollary to cathode-follower theory rather than a fundamental part of it.

It should be noted that although the "voltage across R_m" has been shown to be the "effective input voltage" to the valve, this is not the same thing as saying that it is the grid voltage ΔV_g. It is ΔV_g modified to take into account the change in anode voltage that has occurred. Only if $R_c << R_a$ (*see* para. A.2.2.1) is it the *actual* grid voltage ΔV_g.

A similar theorem clearly exists in connexion with the approximate equivalent D.C. circuit of Figure 8.

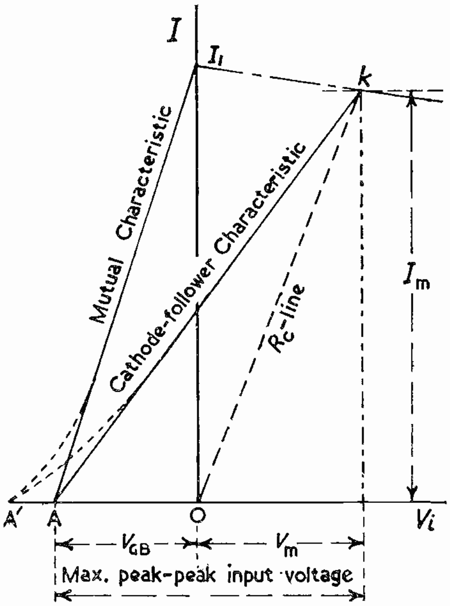


Fig. 26 Illustrating the case where R_c is much less than R_a

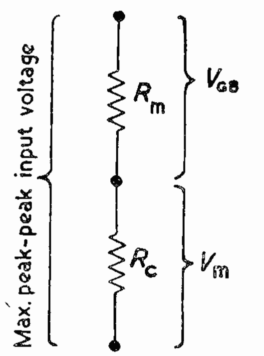


Fig. 27 Mnemonic circuit for maximum input and output voltages in terms of V_{GB} when $R_c \ll R_a$

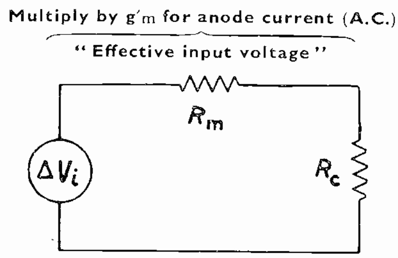


Fig. 28 Approximate equivalent circuit for tetrode or pentode amplifier with cathode degeneration

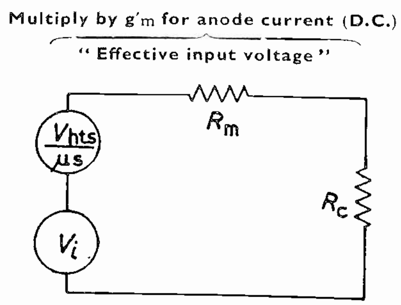


Fig. 29. Approximate equivalent D.C. circuit to the above

APPENDIX V

The Tetrode or Pentode Amplifier with Cathode Degeneration

A.5.1. Introduction

A great deal of the theory of the cathode-follower can clearly be applied to a tetrode amplifier with cathode degeneration, since such a valve is, of necessity, a cathode-follower at the same time. (The term "tetrode" is to be taken to include "pentode" in the present appendix.) When the cathode current has been found by cathode-follower theory it is only necessary to know the division of this current between the anode and screen, and the anode current and stage gain are then known.

For this simple extension of cathode-follower theory to be valid, it is necessary to make the assumption (a customary one) that the anode resistance of a tetrode is very large. The external anode load can then be supposed *zero* so far as the cathode current is concerned. It is also convenient (though not essential) to assume a fixed screen voltage relative to H.T. negative. With these assumptions, the "grid input"/"cathode output" relationships of the valve clearly obey cathode-follower rules exactly, and in particular the equivalent circuits and their associated formulae can be used with only notational changes.

There is, however, a simpler and more elegant approach making the same assumptions but using the "effective input voltage" theorem of the previous appendix. This theorem holds for a tetrode just as it did for a triode provided that R_m is now defined specifically as the grid-*cathode* transresistance. (In a triode the grid-*cathode* and grid-*anode* transresistances were the same so that the distinction never had to be made.) In the tetrode case the theorem can be stated most conveniently as follows:

The "voltage across R_m" is the "effective input voltage" to the valve and, in particular, its product with the grid-anode transconductance is equal to the anode current.

This is illustrated in Fig. 28 where the symbol g_m' is introduced to represent the grid-*anode* transconductance. The corresponding D.C. circuit is shown in Fig. 29 (*see* para. A.5 for explanation of symbols). The rigorous proof of the foregoing statements is left to the reader, as also is the proof of some of the miscellaneous examples which follow.

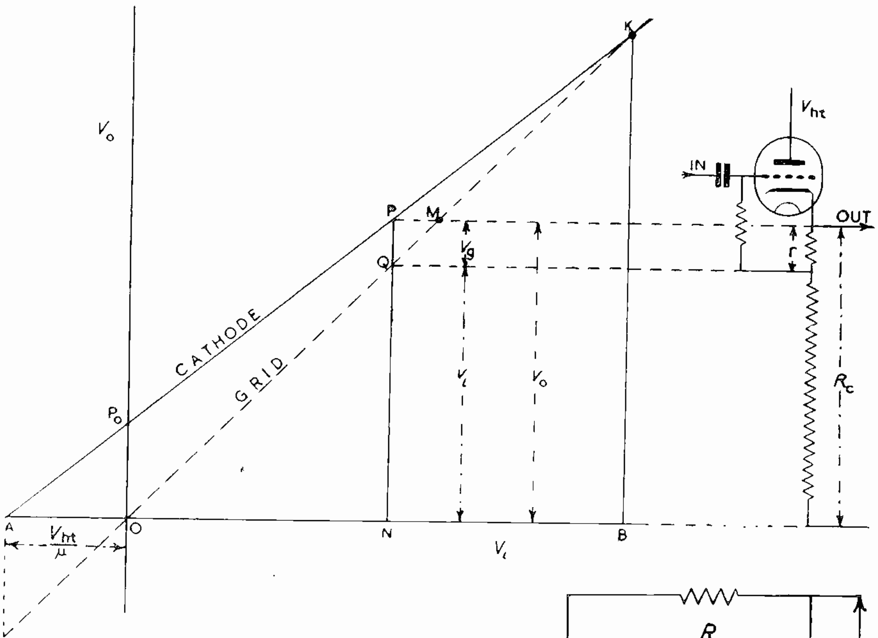


Fig. 30. Nomogram for determining biasing conditions

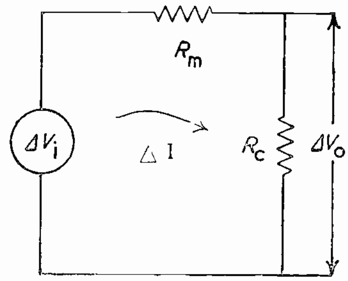


Fig. 9. Repeated from Part I, for convenience in reading Appendix IV

In practice, R_m can, of course, be taken as either the grid-cathode *or* grid-anode transresistance unless a very accurate result is required.

A.5.2. The Stage Gain

Fig. 28 shows that the " effective input voltage " is $R_m/(R_m + R_c)$ of the actual input voltage, from which it follows that the stage gain also is $R_m/(R_m + R_c)$ of what it would have been without degeneration. *In the notation of paragraph A.3.3, the stage gain is reduced by a factor* $1/(N + 1)$. If the anode load resistance is R_L, the stage gain is, in full, $g_m' R_L \times R_m/(R_m + R_c)$.

A.5.3. The Stage Gain when $R_c >> R_m$.

In this case, the last formula of the preceding paragraph becomes $g_m' R_L \times R_m/R_c$, approximately. This can be written as $(R_L/R_c) \times g_m'/g_m$ (where g_m is the grid-*cathode* transconductance) which is $R_L/R_c \times$ the *ratio of the anode current to the cathode current*. This result could have been obtained by recalling that when $R_c >> R_m$ the cathode voltage follows the grid voltage almost exactly so that the stage gain is, in effect, the anode voltage divided by the cathode voltage.

If the screen current can be neglected, the expression for the stage gain simplifies still further to R_L/R_c.

A.5.4. Maximum Anode Current and Input Voltage when $R_c << R_a$

The results of Appendix III applied to a tetrode amplifier with cathode degeneration give that the maximum available anode current remains unaffected (to a first approximation) by the introduction of a cathode resistance small compared with R_a, while the maximum permissible A.C. input is increased by a factor $N + 1$ (where $R_c = NR_m$).

A.5.5. Maximum Anode Current and Input Voltage for any R_c.

The anode current equation of a *tetrode* has the form (*cf*. Equation (1.1)).

$$I_a = \frac{V_s + \mu_s V_g}{R_s} \quad \text{.............} \quad (A.5.1)$$

where V_s is *the* D.C. *voltage of the screen relative to the cathode*. It has this form because the anode current in a tetrode depends on the grid and screen voltages in just the same way as the anode current in a triode depends on the grid and anode voltages. In the above equation R_s is *the " screen voltage/anode current transresistance "* and may be found from the published characteristics as *the screen voltage divided by the corresponding anode current at* $V_g = 0$. The constant μ_s is the " grid/screen amplification factor " and is the ratio of any screen voltage to the corresponding (idealised) grid-base.

If the screen current can be neglected, the maximum available valve current (*i.e.*, cathode *or* anode current) can easily be shown to be

$$I_m = \frac{V_{hts}}{R_s + R_c} \quad \text{..............} \quad (A.5.2)$$

where V_{hts} is *the* D.C. *voltage of the screen relative to* H.T. *negative*. (This result is obtained most simply by an argument exactly analogous to that of paragraph 7.4.) The corresponding value of V_m is $[R_c/(R_s + R_c)]V_{hts}$, which is therefore the *maximum permissible positive input voltage*. (V_m must no longer be described as the maximum output voltage since the output is now being taken from the anode, not from the cathode.)

A.5.5.1. If the screen current *cannot* be neglected, a modification of the same argument shows that the above equation for I_m still holds provided that R_c is replaced by R_c/λ, and that the equation for V_m still holds if R_s is replaced by λR_s, where λ is the ratio of the anode current to the cathode current.

A.5.5.2. *Maximum Permissible Anode Load.* The value of I_m given in Equation (A.5.2) above will not be realisable in practice if the anode supply voltage V_{ht} is so low or the anode load resistance R_L so large that the anode " bottoms " before this current is reached. An (approximate) necessary condition for the realisability of this value of I_m is clearly $(R_L + R_c)I_m < V_{ht}$. For linear working, the difference between these two quantities (*i.e.*, the anode-to-cathode voltage) should not be allowed to fall below a certain figure (often about 80 volts). If $V_{ht} = V_{hts}$, the above condition becomes (by Equation (A.5.2)) simply $R_L < R_s$. Corresponding conditions taking the screen current into account can be worked out if required.

(*Continued on p.* 131)

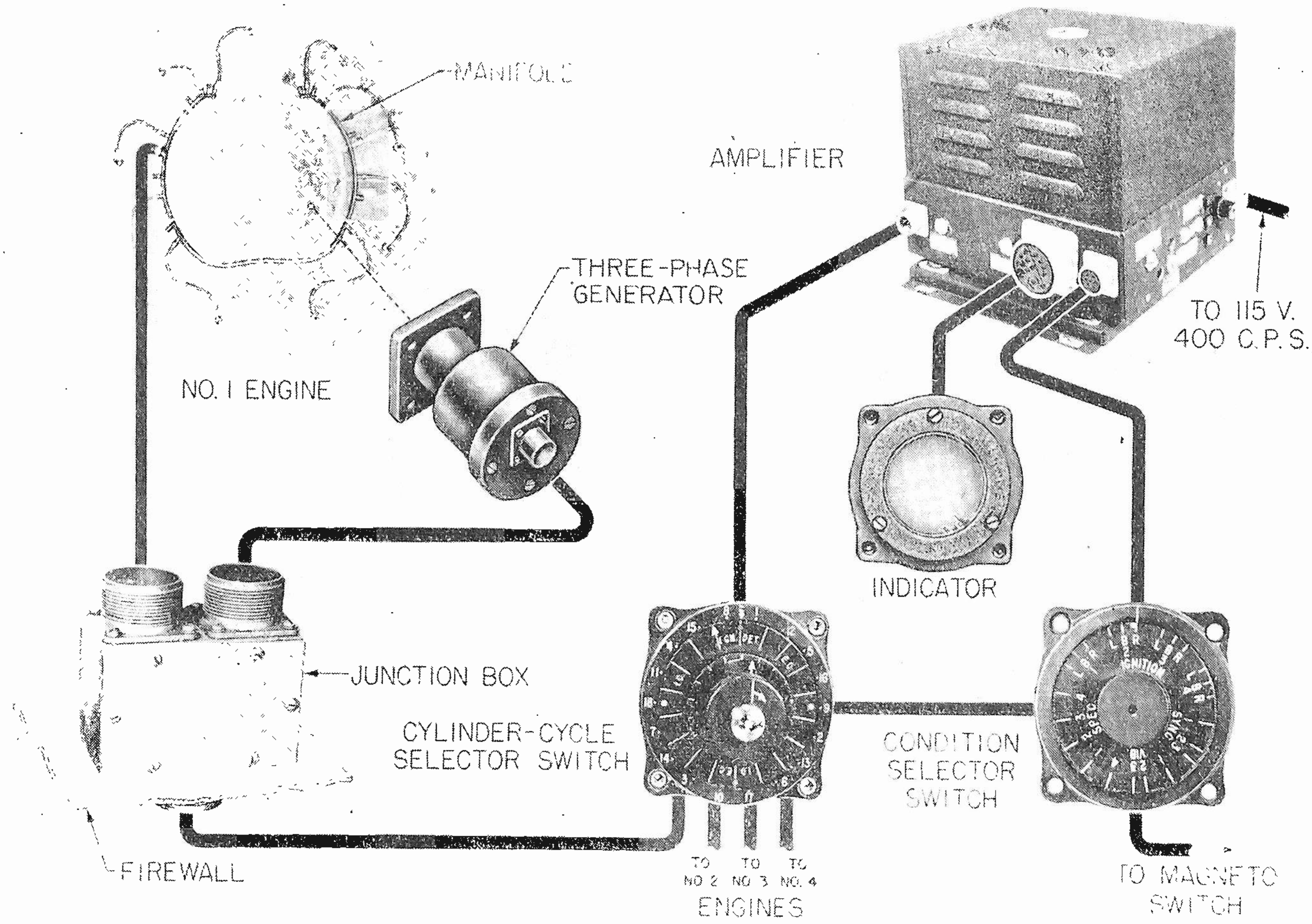


Fig. 1. Diagram of the complete analyser system

A New Cathode-Ray Engine Analyser

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

THE application of the cathode-ray tube to the analysis of internal combustion engine problems is not new, but the engine analyser of the American Sperry Gyroscope Company is believed to be the first instance of this type of analysis being made the basis of a standard flight instrument for aircraft.

Although the design is broad enough to permit the presentation of various aspects of the aircraft's performance the primary purpose of the equipment, as developed, is to present traces related to the engine ignition system and to the mechanical vibration associated with individual cylinders.

To display traces representing the ignition system the varying voltage at the magneto switch in the primary circuit is applied directly to the vertical deflection circuit of the cathode-ray tube, though care is taken to ensure that the analyser cannot vary the performance of the ignition system.

For vibration traces, magnetostriction pickup units are screwed into each cylinder and the voltages generated are applied to the vertical deflection plates, after amplification.

Of particular interest is the method of synchronising the oscilloscope time-base with the engine so that variation in the speed of the latter does not change the display conditions. It is done by driving a small three-phase generator from the auxiliary tachometer drive of the engine so that the output voltage alternates synchronously with the engine rotation. This voltage is used to trigger the cathode-ray tube time-base and the sweep can be initiated just before the firing of any desired cylinder.

Fig. 1 shows a diagram of the complete analyser system.

Ignition Patterns

Fig. 2 illustrates a typical normal pattern for the engine and ignition named and consists of two damped high frequency oscillations superimposed on a low frequency oscillation. The trace is started when the contact-breaker points separate. The firing of the charge accompanies the arc associated with the first high frequency burst and the second oscillation arises because of the electrical reaction of the ignition system. The voltage developed by this is smaller but by that time there are highly ionised gases between the sparking plug points and so a second discharge can easily occur.

An ignition pattern due to a fouled sparking plug is illustrated in Fig. 3. It appears as a pattern which varies in a dancing manner between perfectly normal and a trace with the second oscillation almost obliterated (the sign of a short circuited secondary or short circuit to frame). Magnetos mis-timed can be shown on the analyser by two methods. In method 1, shown in Fig. 4, there is dependence on an induced pattern picked up from the advanced plug when the single pattern from the retarded one is being displayed. The induced pattern, shown quite clearly in the oscillogram, is a small oscillation before the start of the main pattern, the distance between them being proportional to the angular mis-timing.

The second method of detecting mistiming depends on the fact that if two normal patterns are displayed simultaneously they must be perfectly superimposed if the two sparking plugs fire at precisely the same instant.

Other distinct ignition patterns include small and large plug gaps, open circuited secondary (Fig. 5), short circuited primary capacitor and engine "hunting," even if only slight.

Vibration Patterns

The normal vibration pattern shows the four main engine noises as four large-amplitude spaced pips corresponding to:

1. The exhaust valve closing.
2. Fuel being injected.
3. The inlet valve closing.
4. Combustion.

If there are any spurious mechanical effects their presence will be shown by additional pips.

If a valve is seating badly its corresponding pip will be missing or much reduced in amplitude, while incorrect valve timing will be betrayed by the pip being displaced to the left or right of its normal position.

Two switches incorporate all the analyser controls; a Condition Selector to choose the engine, magneto and kind of pattern (vibration or ignition) to be examined; and a Cylinder Selector to choose the individual cylinder or sparking plug and portion of the engine cycle. A push button in the middle of the Cylinder Selector can be used to display the patterns of all cylinders simultaneously, in a row and starting with any particular cylinder.

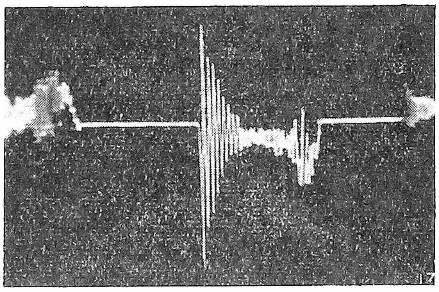


Fig. 2. Normal pattern at 1,700 r.p.m. Wright "Cyclone 18" engine. No capacitor in magneto secondary circuit

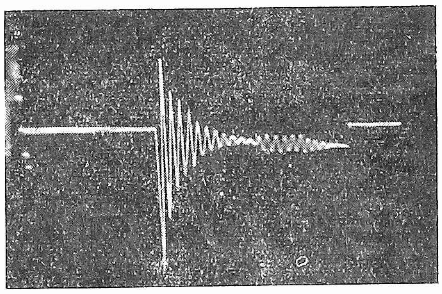


Fig. 3. Fouled sparking plug

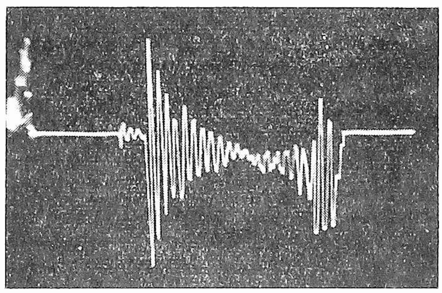


Fig. 4. Magneto mis-timed. (Method 1)

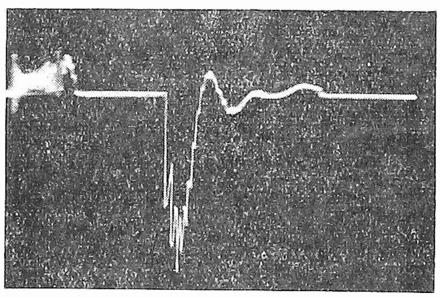


Fig 5. Open circuited secondary

The analyser is built for operation at 115 volts, 400 c/s., draws 0.6 ampere and has 13 valves in the amplifier. The oscilloscope tube is 3 in. in diameter, fluoresces green and has medium afterglow.

For ignition patterns only in a 4-engined machine, the total analyser weight is only 38 lb. without cables, but if vibration patterns are wanted the weight increases to 112 lb.

The Cathode-Follower

(*Continued from p. 129*)

APPENDIX VI
A Note on Biasing

A.6.1. General.

A common way of giving the input signal to a cathode-follower a *positive* bias with respect to H.T. negative is to return the grid-leak of the valve to a tapping on the cathode resistance (*see* the circuit part of Fig. 30). The position of the tapping-point on the cathode resistance and the position of the working-point on the characteristic are related as follows.

Let P be the working-point on the cathode-follower voltage characteristic and let the ordinate PQN be drawn as shown (in the graph of Fig. 30). Then by the theory of Section 6, PQ/QN is equal to the (numerical) value of the ratio V_g/V_i at this working-point. But since there is no current in the grid-leak, V_g/V_i is (numerically) the ratio into which the cathode resistance is divided by the tapping-point. Hence this latter ratio is equal to PQ/QN whose value can be measured from the graph.

This method of determining the tapping-point corresponding to a given working-point is illustrated in Fig. 30 where the circuit symbol for the cathode-resistance R_c has been drawn equal in length to the ordinate PN and in the position shown, while horizontal lines have been drawn through P and Q cutting this symbol at the cathode terminal and the tapping point respectively.

Clearly a cathode-follower *current* characteristic with its associated R_c-line will serve equally well in this construction since the current graph differs only from the voltage graph in having a different vertical scale.

A.6.2. Mid-point Biasing

In Fig. 30, if $AP = PK$, then $NP = \frac{1}{2}BK = \frac{1}{2}V_m$, and $QP = PM = \frac{1}{2}AO = \frac{1}{2}V_{ht}/\mu$

Hence $QP/NP = V_{ht}/\mu V_m$

$= (R_a + R_c)/\mu R_c$, from Eq. (7.1).

But from what has been said above, $QP/NP = r/R_c$ (Fig. 30). Hence

$$r = (R_a + R_c)/\mu = R_m + R_c/\mu$$

This, then, is the condition for mid-point biasing. If $R_c << R_a$, the condition reduces to $r = R_m$.

The Synchrodyne — *Correspondence*

Communication Receivers

Dear Sir,—I have studied the articles on the Synchrodyne receiver in March, July, August and September issues of Electronic Engineering. I have a great interest in that subject, especially since I have started working on the problem of selective demodulation before I had the chance to get acquainted with the publications. I admit that I did not get far before the articles made clear to me the advantages of the discriminative properties of the synchronised oscillator.

In the last article in the September issue of Electronic Engineering you leave as an unsolved question to be solved by the reader the use of the Synchrodyne principle in a communication receiver. I have worked out this type of a receiver and I should like to notify you about the innovations employed in it.

The main difference between the "High Sensitivity Circuit" as described in the article and my design, which I call the Super-Synchrodyne Communication Receiver, lies in the voltage amplification prior to demodulation. As already the name of my design shows, the R.F. amplification stages are replaced by the mixer and I.F. amplifier of a superhet type. I found that this arrangement has the following advantages:

1. The rate of voltage amplifications per stage is much higher than in case of a periodic R.F. amplification. I presume that the voltage gain of the A.F. part is limited to the value which can be obtained by two pentode stages, since higher amplification requires expensive screening and precautions against parasitic oscillations. Therefore I believe that the I.F. stages of a sensitive receiver give us the most economic voltage amplification.

2. Standard mixer stage will permit the reception of all frequency bands.

3. The parameters of the synchronised oscillator can be fixed since it is working on a constant frequency. Its synchronising and discriminative action will not depend upon the frequency of the received signal. Furthermore, the fact that the synchronised oscillator works on a fixed frequency is also very helpful in suppressing the tuning-in "howl."

4. In order to increase the frequency discrimination of the receiver the synchronising element of the oscillator may be coupled to the I.F. amplifier through a high selectivity circuit, which elements will have fixed values.

You will probably object to the point that the I.F. amplification will bring a frequency discrimination in the signal part, while you intend to concentrate it only on the demodulator circuit. Theoretically it is certainly true, but in practice the highest modulating frequency of an A.M. transmitter is 9 Kc/s., so if the I.F. channel will pass a 20 Kc/s. band it will not influence the fidelity of the receiver to any extent. At the same time this small frequency discrimination of the I.F. amplifier would be sufficient to keep the strong signals of local stations from overloading the amplifier.

A further innovation in my design is the arrangement of the ring demodulator as illustrated in the diagram. The values of L and C are chosen so that the demodulator circuit can be regarded as a parallel resonant circuit tuned to I.F. if viewed from the last I.F. tank circuit, to which it is coupled. At the same time it behaves like two series resonant circuits in parallel if viewed from the oscillator side. This arrangement of the ring demodulator means a high impedance coupler to the last I.F. stage.

The task of the oscillator voltage is to switch on and off the rectifiers. The smaller the voltage drop on the circuit impedance as compared with the drop on the rectifier internal resistance the more efficiently is the oscillator voltage used. In the arrangement as described above the current of the oscillator passes through the low impedance of the series resonant circuit and the internal resistance of the rectifier and the voltage drop on the last is much higher than in the case of an untuned circuit. The relatively small loading of the I.F. amplifier and efficient use of oscillator voltage are the advantages of the here described tuned ring demodulator.

In my design I took advantage of a relatively simple selectivity control of a receiver using the synchrodyne demodulation system. I placed several m-derived low pass filters with different cut-off frequencies in the A.F. part of the receiver and by simply switching one of them I got the required selectivity of the receiver. This way of controlling the selectivity seems to me to be one of the great advantages of the synchrodyne system since they are accomplished by much simpler means and the selectivity curve approached nearer the ideal rectangle form than in a normal communication receiver using detector demodulation.—Yours faithfully,

Edwin Langberg.

Prague.

Patent Note

Dear Sir,—In the February issue of Electronic Engineering we note in Dr. Tucker's article the suggestion of using a "reactor valve." It does not appear to be generally known that this circuit is a British invention, being the subject of Patents 443,423 and 450,136, owned by this company, and we should be obliged if you would print a note pointing this out in your next issue.—Yours faithfully,

p.p. Murphy Radio, Limited.
(G.F. Hawkins)
Electronics Division.

Correction

In Fig. 6 of the article on The Synchrodyne (page 54, February issue), C_5 and R_7 should be connected to earth and not to the feedback circuit as shown.

Television Bandwidth

Sir,—With regard to correspondence in your February issue on the subject of Television Bandwidth.

We are under the impression that the British system uses an aspect ratio of 5 : 4 for the picture. Therefore, the aspect ratio of the transmitted raster, including horizontal and vertical blanking, is 5.882 : 4.301, assuming 15 per cent. horizontal blanking and 7 per cent. vertical blanking.

Now, using this aspect ratio in the accepted bandwidth formula: $(l^2RP)/2$ where l = number of lines (405), R = aspect ratio (5.882 : 4.301), P = picture frequency (25).

$$\text{Bandwidth} = \tfrac{1}{2}(164025 \times 1.367 \times 25) = 2.802 \text{ Mc/s.}$$

This is the bandwidth required to transmit a picture containing 377 lines with an aspect ratio of 5 : 4, assuming equal horizontal and vertical definition.—Yours faithfully,

J. E. Rich, L. F. Odell.
Nightingale Lane, S.W.12.

APRIL MEETINGS

Institution of Electrical Engineers

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

Ordinary Meeting

Date: April 22. Time: 5.30 p.m.
The Thirty-Ninth Kelvin Lecture:
"The Nervous System as an Electrical Instrument."
By: B. H. C. Matthews, C.B.E., M.A., Sc.D., F.R.S.

Radio Section

Convention on "Scientific Radio."
Date: April 7.
Subjects:
"Standards and Measurements."
"Propagation."
Date: April 8.
Subjects:
"Radio Noise."
"Radio Physics."
Date: April 13. Time: 5.30 p.m.
Discussion on: "Future Trends in the Design of Receiving Aerials."
Opened by: E. M. Lee, B.Sc.

Installation Section

Date: April 15. Time: 5.30 p.m.
Lecture: "The Flash Tube and its Applications."
By: J. N. Aldington, B.Sc., Ph.D., and A. J. Meadowcroft.

Informal Meeting

Date: April 26. Time: 5.30 p.m.
Discussion on "Industrial Applications of Photo-Electric Cells."
Opened by: F. Baxendale, B.Sc.(Eng.).
The Secretary: I.E.E., Savoy Place, W.C.2.

Cambridge Radio Group

Date: April 6. Time: 6 p.m.
Held at: Cambridge Technical College.
Lecture: "Television Camera Tubes."
By: F. H. Townsend.
Date: April 27. Time: 8.15 p.m.
Held at: Cavendish Laboratory.
Lecture: "Tropospheric Propagation."
By: H. G. Booker.
Hon. Secretary: J. E. Curran, University Engineering Laboratory, Trumpington Street, Cambridge.

North-Western Radio Group

Date: April 7. Time 6.30 p.m.
Held at: Engineers' Club, Albert Square, Manchester.
Lecture: "Pulse Communication."
By: D. Cooke, B.A., Z. Jelonek, A. J. Oxford, B.Sc., E. Fitch, B.Sc.
Asst. Secretary: A. L. Green, 241 Brantingham Road, Chorlton-cum-Hardy, Manchester 2.

North-Eastern Centre

Date: April 5. Time: 6.30 p.m.
Held at: Neville Hall, Newcastle-on-Tyne.
Lecture: "The Design and Construction of a New Electron Microscope."
By: M. E. Haine, B.Sc.
Hon. Secretary: E. C. Rippon, c/o. C. A. Parsons and Co., Ltd., Heaton Works, Newcastle-on-Tyne, 6.

Institute of Physics

Electronics Group

Date: April 20. Time: 5.30 p.m.
Held at: The Institute of Physics, 47 Belgrave Square, S.W.1.
Lecture: "Long-Wave Infra-Red Detectors."
By: C. J. Milner, M.A., Ph.D.,
Hon. Secretary: A. J. Maddock, B.S.I.R.A., "Sira," Southill Road, Elmstead Woods, Chislehurst, Kent.

Electron Microscopy Group

Date: April 6 and 7.
Spring Conference.
Held at: The Physics Department, King's College, W.C.2.
Hon. Secretary: Dr. V. E. Cosslett, Cavendish Laboratory, Cambridge.

X-Ray Analysis Group

Date: April 13 and 14.
Conference.
Held at: The Royal Institution, Albemarle Street, W.1.
Hon. Secretary: J. N. Kellar, A.Inst.P., Cavendish Laboratory, Cambridge.

Scottish Branch

Date: April 13. Time: 7 p.m.
Held at: The Department of Natural Philosophy of the University, Glasgow.
Lecture: "Electronics in Peace and War."
By: Sir Robert Watson-Watt, C.B., F.R.S.
Hon. Secretary: J. M. A. Lenihan, F.Inst.P., Natural Philosophy Department, The University, Glasgow, 2.

Manchester and District Branch

Date: April 30. Time: 7 p.m.
Held at: New Physics Theatre, The University, Manchester.
Branch Annual Meeting followed by:
Lecture: "Superconductivity."
By: Dr. D. Shoenberg.
Hon. Secretary: Dr. F. A. Vick, Physics Department, The University, Manchester, 13.

British Sound Recording Association

All meetings are held at the Royal Society of Arts, John Adam Street, London W.C.2.
Date: April 23. Time: 7 p.m.
Lecture: "Quality Factors in Film Recording."
By: B. C. Sewell.
Hon. Secretary: R. W. Lowden, Napoleon Avenue, Farnborough.

British Kinematograph Society

Date: April 14. Time: 7.15 p.m.
Held at: The Gaumont-British Theatre, Film House, Wardour Street, W.1.
Lecture: "Colour Vision and the Film Industry."
By: W. D. Wright, A.R.C.S., D.Sc.
Secretary: R. Howard Cricks, Dean House, 2 Dean Street, London, W.1.

The Television Society

Meetings will be held at The Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2.

Programme Group

Date: April 21. Time: 7 p.m.
Lecture: "Production Problems in Television Outside Broadcasts."
By: C. I. Orr-Ewing, O.B.E., B.A., A.M.I.E.E.
Lecture Secretary: T. M. C. Lance, 25 Albemarle Road, Beckenham, Kent.

Constructors' Group

Date: April 14. Time: 7 p.m.
Lecture: "Radio Frequency E.H.T. Supplies."
By: K. G. Macleod.
Group Secretary: A. E. Sarson, 22 Union Road, Bromley, Kent.

Institution of Electronics

Date: April 30. Time: 6.30 p.m.
Held at: Reynolds Hall, College of Technology, Manchester.
Lecture: "The Application of Electronics to Vibration Research."
By: D. M. Corke (de Havilland Propellors, Ltd.).
Hon. Secretary: Leslie F. Berry, 105 Birch Avenue, Chadderton, Lancs.

Brit. I.R.E.

London Section

All meetings are held at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.
Date: April 8. Time: 6 p.m.
Lecture: "High Fidelity Recording and Reproduction."
By: W. S. Barrell and G. F. Dutton, Ph.D.
The Publications Officer, 9 Bedford Square, London, W.C.1.

North-Eastern Section

Date: April 14. Time: 6 p.m.
Held at: Neville Hall, Westgate Road, Newcastle-on-Tyne.
Lecture: "The Pulse Signal."
By: Prof. M. G. Say, Ph.D., M.Sc.
Secretary: M. A. Boardman, 20 Princes Avenue, Gosforth.

North Western Section

Date: April 8. Time: 6.45 p.m.
Held at: The College of Technology (Reynolds Hall), Manchester.
Lecture: "Factors Governing the Performance of I.F. Amplifiers."
By: H. Stibbe and K. G. Lockyer.
Hon. Secretary: B. E. P. Ritson, 38 Parswood Court, East Didsbury, Manchester, 20.

Scottish Section

Date: April 21. Time: 6.45 p.m.
Held at: The Institution of Engineers and Shipbuilders in Scotland, Elmbank Crescent, Glasgow, C.2.
Lecture: "The Physical Applications of Micro-Waves."
By: J. B. Birks, B.A.
Local Secretary: A. M. Turnbull, 68 Lauderdale Gardens, Glasgow, W.2.

BOOK

Radio Technik, Theorie und Praxis

(Radio Technique, Theory and Practice), 216 pages. By Dr. J. Durrwang, (B. Wepf and Cie., Basel, Switzerland, 1947.)

WRITTEN for the serious minded amateur and service man, this book makes interesting reading. Although written in German, the English reader who masters this language will find it sometimes difficult to understand certain passages of the text, because the way of expressing a thought in Swiss-German is different from the German the English reader is used to.

The subject of the book is divided in 18 chapters the general headings of which are:

Fundamentals of A.C. and D.C. theory; capacitors; inductors; resonance; electron valves; rectifiers; principles of electro-acoustics; L.F. amplifiers; electro-acoustic transformers; principles of Wireless Telephony; H.F. generators (transmitters); transmission aerials and transmission; radiation; operation of receivers; television technique; ultra-short, decimetre, and centimetre waves.

The author shows with great skill how a very good insight into the problems and phenomena of radio can be given without resorting to the use of mathematical formulae, and introduces mechanical models when explaining electrical phenomena. He clearly has a deep knowledge of technical matters in addition to teaching experience.

There are but a few minor slips which may be pointed out here, not so much to criticise as for the benefit of the English reader who perhaps might take them in unawares.

On p. 22 the terms alternating voltage (*Wechselspannung*) and alternating current (*Wechselström*) are used rather loosely. On p. 32, some unnecessary complication is introduced by using the same letter "e" once for a voltage and then for the charge of a capacitor. The alternating current in Fig. 32 is designated by the letter "J" whereas it is "I" in Fig. 33a and in the text and "i" in Fig. 33a. The transformer coils are marked once S_1 for the primary and S_2 for the secondary (Fig. 35) and then P and S respectively in Fig. 36.

In the elaboration of the formula for the inductive voltage on page 40 the formula should read correctly:

$$e = -k \frac{d}{dt} F_0 \sin \omega t$$

The wording of line 9 from the bottom of page 52 is incorrect and conveys to the reader the erroneous idea that the oscillator circuit (*Schwingkreis*) is D, whereas in fact the author should have written ". . . . *so wird der Verlustfaktor D des Schwingkreises* . . . ."

Inconsequence of symbolism may also be found in the formula on p. 64 for the mutual conductance S (*Steilheit*) viz:

$S = \dfrac{\triangle J_A}{\triangle E_G}$ while in Fig. 58 the same quantity is written $S = \dfrac{\triangle J}{\triangle V}$. (Incidentally, the "J" should be "I"). For enlightenment of the English reader the Barkhausen formula $S.d.R_i = 1$ on p. 66 reads in English and American textbooks $g_m.R_a = \mu$.

"*Fadingausgleich*" on p. 73, in German textbooks "*Schwundausgleich,*" is "A.V.C."

On p. 87 the statement about overtones is incomplete as the author omits to point out that the difference between, for instance, the "c" as played on the piano and the same sound as produced on a clarinet, is not only a matter of different amplitudes, but also of a different sound spectrum of the harmonics.

W. SUMMER

Electrical Engineering

By W. Purse, M.I.E.E., M.I.Mech.E. 104 pp. (Southern Editorial Syndicate) 5s.

THIS little book reviews, for all young people contemplating an electrical engineering career, the many different branches they can enter, the types of training that will be necessary and the prospects they may hope to find.

In a long chapter on Foundation Studies, the author emphasises the importance of joining the Institution of Electrical Engineers and eventually qualifying for Associate Membership. He then refers to the courses offered at some of the Universities and Technical Colleges, and their cost. The most valuable part of this chapter, if not indeed of the whole book, is that devoted to Works Training. Full information is given about the system of apprentice training available in the works of most of the large electrical engineering firms. There is also an account of the training facilities offered by the Post Office and the B.B.C. This information will be found most helpful to students, parents, teachers and all who are called upon to advise young people in their preparation for entry into any branch of electrical engineering.

The reader is guided as to which branch to adopt by a chapter devoted to a description of the classes of engineers required in communications, generation, transmission, distribution, transport, mining, electrical installation, contracting, consulting engineering, technical journalism and teaching. The author advises his reader to aim high, and to make sure of promotion by

REVIEWS

keeping himself in the "electrical public eye."

Mr. Purse is justly proud of the developments of the past and confident of even greater improvements and inventions in the future. Every youthful aspirant to electrical engineering is bound to feel some of what the author calls "unrestrained enthusiasm for my profession," and moreover he will find in this book a guide to the achievement of his goal.

M. J. Butt

Microwave Technique

Published by the Radio Society of Great Britain, Price 2s.

IN some 54 pages this booklet gives an admirable introduction to the principles and practice of radio techniques used in the frequency range 3,000-30,000 Mc/s. The characteristics of resonant cavities, wave-guides, disc seal grounded-grid triode valves, velocity modulation valves such as the reflex klystron oscillator and the travelling wave amplifier tube, magnetrons and crystal valves are briefly but clearly described. Block schematics of typical S.H.F. transmitters and receivers for communication purposes are given and directional aerials such as the paraboloid reflector, horn and slot types are referred to. The final chapter discusses the measurement of frequency, power and standing wave ratio. A useful bibliography is included. The booklet represents good value and is confidently recommended to the amateur who is a newcomer to the field of micro-wave radio.

W. J. Bray

High Frequency Measuring Techniques Using Transmission Lines

By E. N. Phillips, W. G. Sterns, N. J. Gamara (Research Staff, Collins Radio, Iowa, U.S.A.) Published by John F. Rider, New York.

THIS pamphlet of some 58 pages describes the use of a slotted co-axial transmission line with a travelling probe for the measurement of wave-length, impedance, velocity of propagation and attenuation in the U.H.F. range. A collection is given of the formulae required to convert from the standing wave ratio and probe position data derived from the line to the quantity it is desired to measure, together with many numerical examples illustrating the application of the formulae and the accuracy obtainable in practice. Although somewhat specialised in character and limited in scope the booklet can be recommended to those concerned with this particular phase of U.H.F. measurement technique.

W. J. Bray

Electro-Technology for National Certificate—Vol. I

By H. Teasdale and E. C. Walton. 325 pp. 193 figs. (The English Universities Press Ltd. 9s. 6d. net).

THIS is the first of a set of three volumes intended for the use of students preparing for the Ordinary National Certificate in Electrical Engineering, the course for which is normally taken by part-time instruction over a period of three years. The authors explain that the subject matter in the three volumes is arranged to correspond very roughly with the work done in the three years of the course.

It is somewhat difficult adequately to review volume one without a knowledge of the contents of the other volumes but it can be stated at once that the standard set is in many respects higher than would be normally expected from a first year student.

The contents include chapters on the electric circuit, resistance, electrical energy and its conversion into heat, electro-chemistry, accumulators, magnetic fields, motor and dynamo effects, electrostatics. The presentation of the subject matter is clear and logical. There are specimen numerical examples worked out and included in the text and an excellent selection of examples at the end of each chapter. As will have been noted the subject of indicating instruments is not dealt with as a separate chapter but the working and description of various types are treated in the appropriate chapter: thus the moving coil and moving iron instruments appear in the chapter dealing with motor and dynamo effects. This method of approach has much to recommend it.

The reviewer has, in his opinion, one major criticism to offer which concerns the frequent appearance of photographs of apparatus that have little or no educational value. To give only a few examples: on page 125 is a picture of a carbon filament lamp, on page 118 are two illustrations of arc furnaces with sensibly no detail, on page 131 a porcelain fuse-holder and on pages 58 and 59 photographs of variable resistors which the student will himself handle in the laboratory. The majority of these photographs might well be omitted which would effect a decrease in the bulk of the book and possibly the price, and incidentally produce a saving in paper.

There is nothing but praise for the production of the book, the line diagrams being excellent and the appearance of the next volume will be eagerly awaited.

W. H. Date

ABSTRACTS OF ELECTRONIC LITERATURE

MEASUREMENT

Recorder and Timer for Short Intervals
(W. H. Bliss)

Designed to meet the needs of nucleonic research, this interval timer measures and records intervals up to 16 microseconds with an accuracy of 0.25 microsecond. Intervals to be measured may occur at random and be widely separated.

—*Electronics*, November, 1947, p.127.

Visual Photometer for After-glow tests on C.R.T. Screens
(W. G. White)

The photometer described was developed to enable a quick check on the decay characteristics of cathode-ray tube screens to be made. The method employed is to measure with a stop-watch the time taken for the screen brightness to decay from one level to another. In the design, more importance has been attached to the convenience of testing by semi-skilled factory operators than to high accuracy. The low field brightness of the photometer and imperfect colour matching both tend to increase the variability of the measurements, but this limitation is kept within reasonable bounds by the novel arrangement of a swinging neutral filter which ensures the same level of brightness for both the initial and final balance. The results of statistical tests are given from which the coefficient of variation is shown to be of the order of 16 per cent. for each of four screens tested.

—*Jour. Sci. Inst.*, January, 1948, p.1.

An Improved Intermodulation Measuring System
(G. W. Read and R. R. Scoville)

This paper describes a new intermodulation analyser of improved design and also a two-signal generator for use with the analyser. The equipment is intended for measuring distortion in audio-frequency systems by means of paired signals which may be selected in several combinations from 40 to 12,000 cycles per second. This equipment has been found to be particularly useful in determining optimum processing conditions for variable-density recording, but is also useful in any field where audio-frequencies are employed.

—*Jour. S. M. P. E.*, February, 1948, p.162.

Portable Ultrasonic Thickness Gauge
(N. G. Branson)

The "Audigauge" described is stated to differ from other thickness-measuring equipment in that it is portable and uses an audible signal to indicate resonance. A frequency-modulated oscillator provides an audible indication of plate current peaks when the oscillator is tuned to the fundamental or harmonic thickness resonance of the material under test. The indicating dial shows steel thickness directly; and the thickness of empty or full pipes and tanks, or metal sheets is measured quickly to a claimed accuracy of 1 per cent.

—*Electronics*, January, 1948, p.88.*

A Photo-electric method for determining colour balance of 16mm. Kodachrome Duplicating Printers
(P. S. Aex)

It has been necessary in the past to control the colour balance and exposure of 16 mm. duplicating printers by making actual test prints at frequent intervals. A large amount of footage could be risked during the time required for processing the test prints. A method is described by which it is possible to check the balance of the printer instantly by means of tri-colour readings with a photronic cell.

—*Jour. S.M.P.E.*, November, 1947, p.425.

C. R. TUBES

Improvements in the Construction of C.R. Tubes
(J. de Gier and A. P. van Rooy)

The use of flat glass base with chrome iron pins has long been known in the manufacture of radio valves. By applying this construction to cathode-ray tubes more space has become available and it has thus been possible to introduce some improvements of an electron-optical nature without having to make the tube any larger. Furthermore, a new technique has been developed for the mounting of the electrodes which ensures better centreing. As a result a sharper light spot is obtained, particularly at the edge of the screen. These improvements have been incorporated in a new oscillograph tube, type DG 7-3, which also has an electric screening that prevents the two pairs of deflecting plates affecting each other electrically at high frequencies.

—*Philips Technical Review*. Vol. 9, No. 6, p.180.

The Optics of Three-Electrode Electron Guns
(S. G. Ellis)

This paper is concerned primarily with the electron guns employed in electron microscopy. The position of the image of the cathode, the magnification, and the divergence of the beam leaving the anode are calculated for a three-electrode electron gun with plane electrodes and circular apertures both for zero and battery bias. The simplifying assumption is made that the electrostatic lenses are thin. The results are compared with the experiments of Johannson. The extension of the results to the gun used in the transmission electron microscope is considered with the aid of electrolytic trough measurements. The case of a gun biased by a cathode resistor is also discussed.

—*J. App. Phys.*, October, 1947, p.879.*

Producing Curves on an Oscilloscope
(H. E. Webking)

Stepping circuit switches grid voltage after each characteristic curve is traced on cathode-ray oscilloscope. In this way a complete family of curves is automatically produced. Equipment makes possible rapid and detailed studies of all factors affecting tube operation.

—*Electronics*, November, 1947, p.129.

THERMIONIC DEVICES

The i,V Characteristics of the Coating of Oxide Cathodes During Short-time Thermionic Emission
(R. Loosjes and H. J. Vink)

The potential differences existing across an oxide coating during short-time emission (condenser discharge with an "RC-time" of 10^{-4} sec.) were measured.

For this purpose a new measuring method was worked out. Using this method it was found that at current densities of about 5-10 A/cm^2 remarkably high potential differences exist across the oxide coating (50-200 V) at the normal working temperatures (900-1,100° K) at which the experiments were carried out.

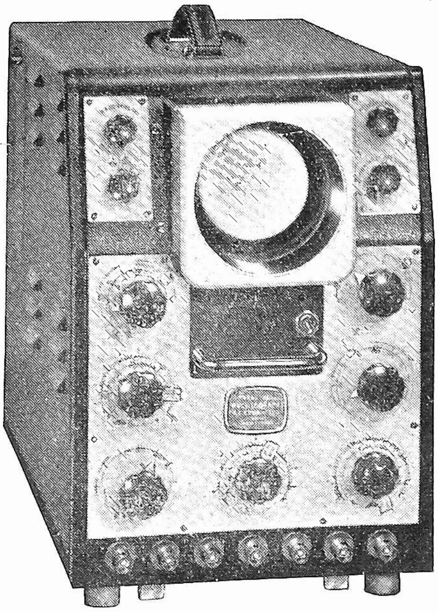
—*Philips Research Reports*, June, 1947, p.190.

An Improved Method for coupling valves at Ultra-short waves
(A. van Weel)

A method for coupling two electron valves, or one valve with an antenna is described, by which method the difficulties to the finite inductance of the internal electrode leads of a valve can be eliminated up to very high frequencies. In addition to this the new system provides a very simple way to realise matching of the valve impedance.

—*Philips Research Reports*, April, 1947, p.126.

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



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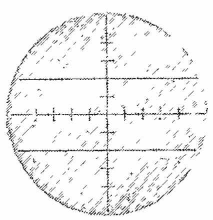
is designed specifically for industrial use where the main interest is in the observation and measurement of low frequency phenomena. Its presentation is generally similar to that of Model 1035 and a comprehensive specification includes 4 kv. tube operation for transient recording.



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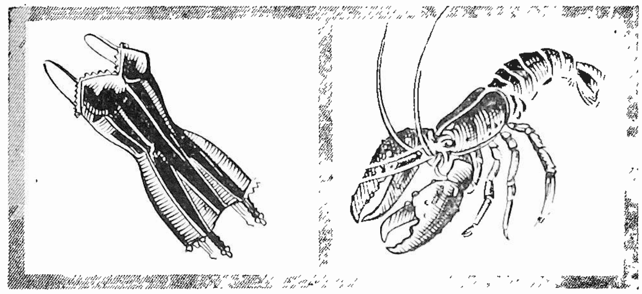

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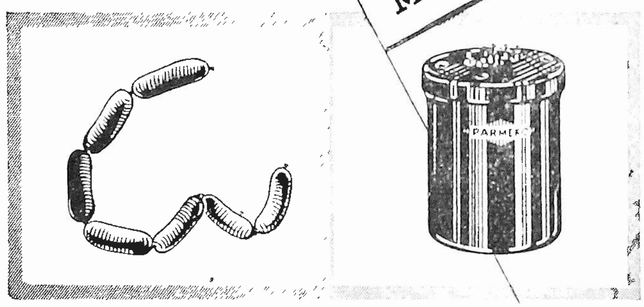

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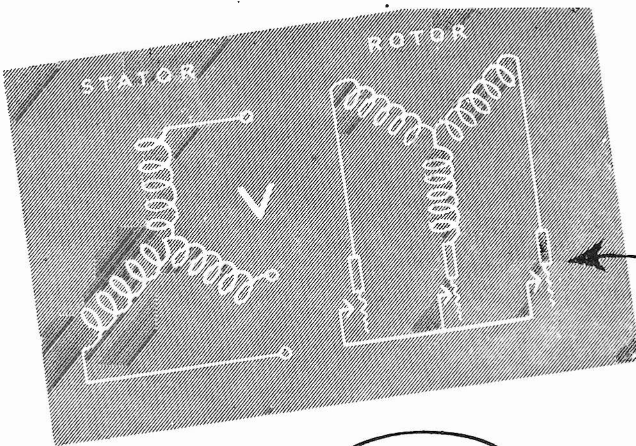

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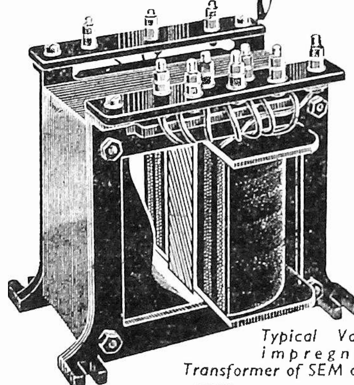

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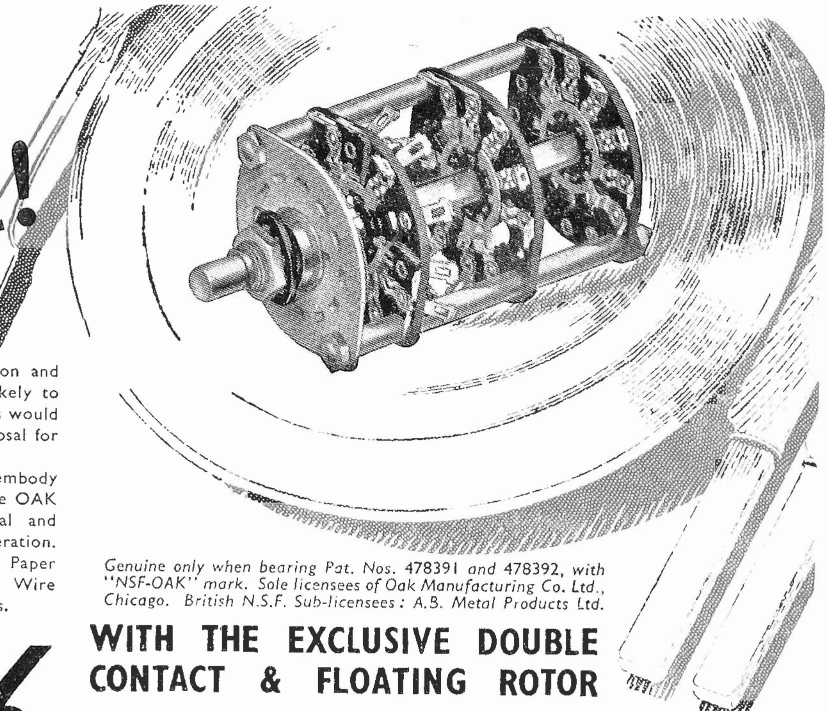

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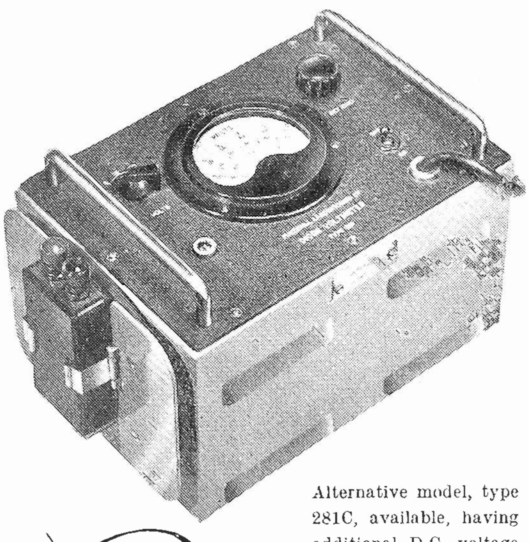

Alternative model, type 281C, available, having additional D.C. voltage range to 300 volts.

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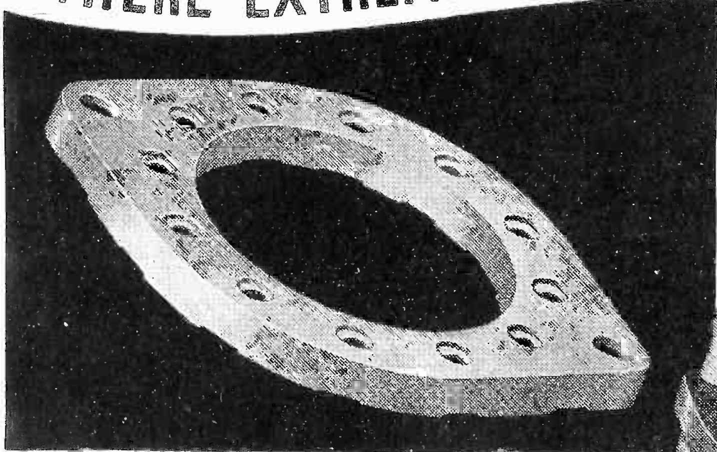

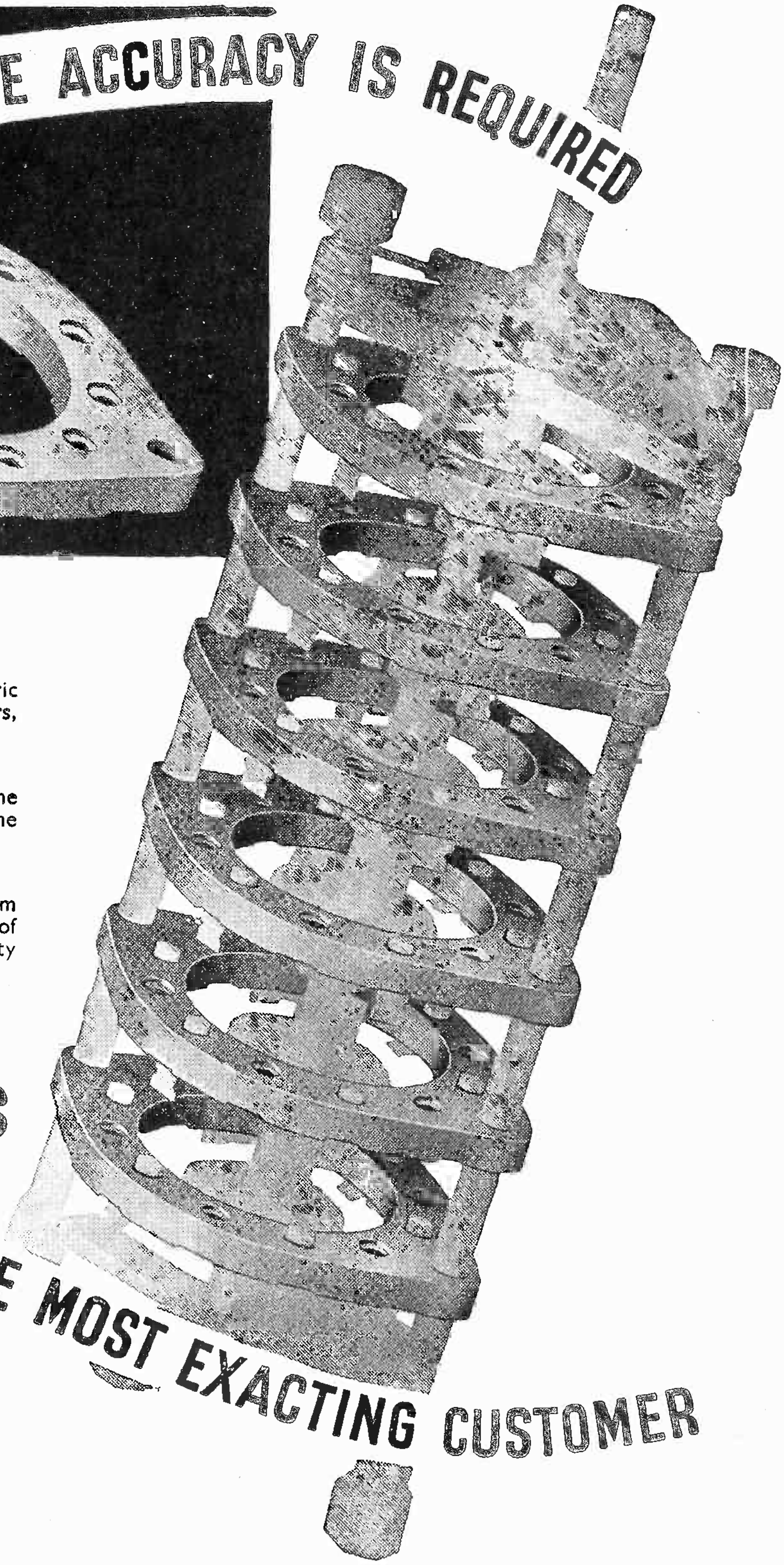

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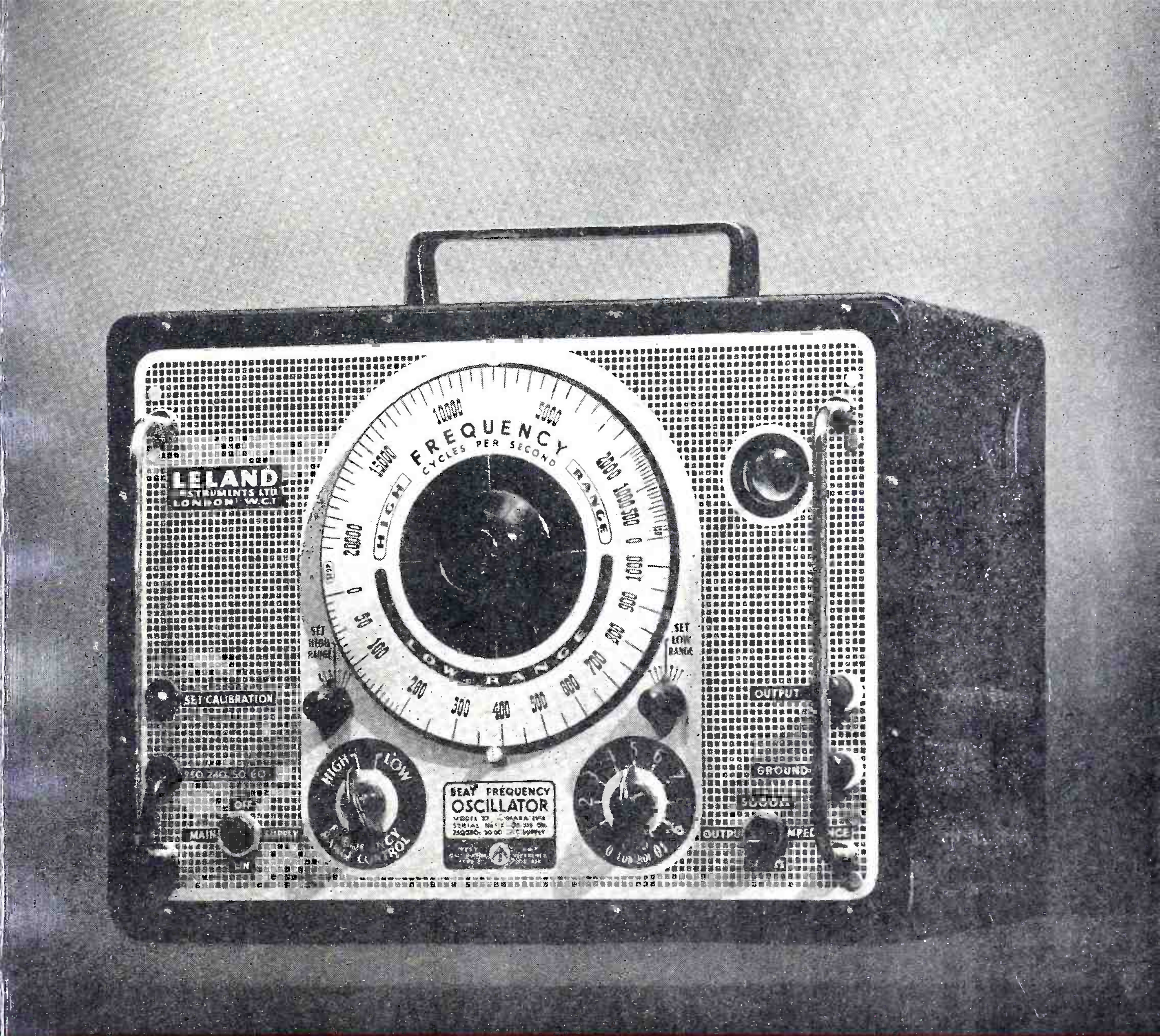
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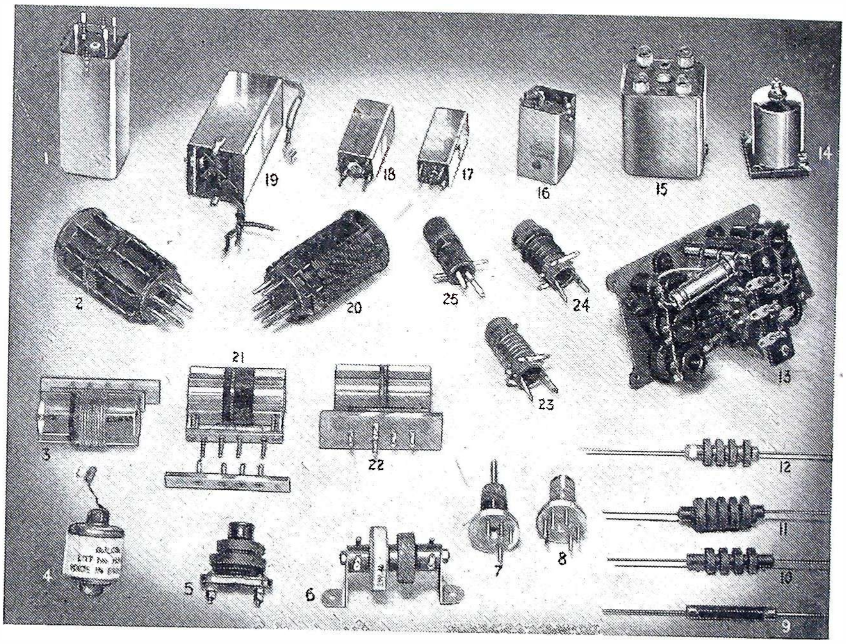

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