Wireless World

SEPTEMBER 1954 VOL. 60 No. 9

Authority and Independence

WE have now had ample time to study the new Television Act, which became law just after our last issue appeared. The Government's plan for an "additional" television service, though somewhat involved, is not on the face of it, difficult to understand, though we must admit to doubts as to how some of the details will work out in practice.

To us, the most interesting section of the Act is that in which the Postmaster-General is given what appears to be very wide powers over the technical activities of the Independent Television Authority. In this matter, at least, there appears to be little independence and no authority! Of course, it is a fact that in Great Britain the P.M.G.'s power over every form of radio activity is sweeping; he may make regulations prescribing "the things that are to be done or are not to be done" by any one of his licensees. Of course, he may intend to keep these powers up his sleeve, and allow the I.T.A. as much technical autonomy as is enjoyed by the B.B.C. If he does not, one is tempted to ask, what is the purpose of the I.T.A.? It would surely have been less wasteful of national resources and effort to leave the *technical* means of television distribution in the hands of the B.B.C. The Government's quarrel with the B.B.C. monopoly was that it represented a monopoly in the dissemination of ideas; that objection would have been overcome much more economically by setting up a chain of transmitters operated by the B.B.C. but fed with programmes under the control of a truly independent body getting its revenue from advertisements.

The Post Office decision, announced before the new Authority came into being, that the I.T.A. transmissions were to be polarized like those of the B.B.C. in the same areas, may or may not lend colour to the idea that the P.M.G. intends to make himself responsible, not only for controlling technical policy, but for shaping it as well.

Further support for the same idea comes from the fact that one of the members of the Authority has any radio-technical qualifications or experience, and so must depend entirely on the engineering staff they may appoint or on outside advisers. And, of course, there is still another body that comes into the picture: the P.M.G.'s decisions on technical policy for both the I.T.A. and B.B.C. will be affected by the recommendations of the Television Advisory Committee.

Fortunately, there is a good deal of flexibility in the Act, and plenty of room for second thoughts. The word "may" occurs much more often than "shall" and the P.M.G. can make new regulations at short notice. Throughout all the debates, the Government has wisely kept to the principle of leaving a loophole for subsequent changes.

It is wrong to shoot the pianist who is doing his best, and still worse to shoot him before he has played a single note. The I.T.A. needs the full support of everyone concerned with radio in implementing the complicated scheme laid down in the Act. *Wireless World's* only fear is that, with so many secondary problems to overcome, attention may be distracted from the primary task of planning the long-term technical development of television.

Radio Eavesdropping

A GOOD deal of publicity has been given in the daily Press to a recent case in a London magistrate's court, where two men were charged with contravening the section of the Wireless Telegraphy Act that forbids the interception and disclosure of messages. It was stated they had listened to police and fire-service v.h.f. transmissions and passed on information so gained to news agencies and fire assessors. The defendants, who pleaded guilty and said they had no idea they were acting unlawfully, were ordered to pay £8 8s and £2 2s costs, respectively.

Newspapers, in reporting the case, made play with the fact that this was the first prosecution of its kind. That may be true enough, but no new principle is involved. Lack of secrecy has always been a skeleton in the radio cupboard and for 50 years the Postmaster-General has rightly had the power (which he has used widely) to make regulations against unauthorized interception and disclosure of messages.

The Television Act

Summary of the Main Provisions

WELL over two years ago, the Government first declared their intention of establishing a new television service, alternative to that conducted by the B.B.C. Two basic principles for the proposed scheme were affirmed by Government spokesmen; it was to be competitive and was to be financed by advertisments. Since then, many methods of attaining the desired end have been debated, only to be abandoned or modified later; even the basic principles have been watered down to some extent. Now, at last, a cut-and-dried plan has appeared in the final form of an Act of Parliament. In view of all the changes that have taken place and in spite of the vast number of words that have been written in the Press, readers may like to have a summary of those provisions of the Act most likely to affect them.

The Television Act, 1954 (H.M.S.O., price 9d) makes "provision for television broacasting services additional to those provided by the British Broadcasting Corporation, and to set up a special authority for the purpose . . . to be called the Independent Television Authority." The I.T.A. is to provide, for the period of 10 years, television services "of high quality, both as to the transmission and as to the matter transmitted," and shall be composed of a chairman, deputy chairman and eight others. These under the chairmanship of Sir Kenneth Clark have now been appointed by the Postmaster-General. They comprise an assemblage of persons distinguished in the Arts, literature, industry and the world of affairs. It is stipulated that none of them shall have any interest in an advertising agency, in the selling of radio equipment or in programme contracts. The members are to be paid, and, in addition to membership, may perform other salaried work in the Authority.

The I.T.A. is to be a "body corporate" but not a body exercising functions on behalf of the Crown. It enjoys no special privileges under the Wireless Telegraphy Act, and will need the Postmaster General's licence for its stations. The aim is that the Authority shall be financially self-supporting as soon as possible, but it may be granted by the P.M.G. up to £750,000 a year. Initial capital expenditure is to be met by a grant of up to £2M, spread over five years.

First and foremost, the function of the I.T.A. is to build and operate television broadcasting stations. It must also arrange for studios to be provided, or if need be, itself provide them. By arrangement with the P.M.G., the I.T.A. may also arrange for wired distribution of programmes through relay companies.

Provision of programmes is primarily a matter for "programme contractors," but the Authority itself may when necessary transmit its own material, in which paid advertisements may be inserted. The programme contractors will, in effect, "buy time" from the I.T.A., recouping themselves by charging fees for advertisements which will be transmitted during the intervals between items or at natural breaks in the programmes. There is to be no "sponsoring"; advertisements must not be directly associated with the programmes.

The matter of the programme contracting companies is still somewhat obscure. From our point of view, virtually all we know from the Act is that it will be the duty of the I.T.A. to secure "adequate competition" between a number of them to supply programmes. It is not known how the time of the various I.T.A. stations is to be divided between the various contractors.

Wide powers of control over the contractors are conferred by the Act on the I.T.A., who may impose heavy penalties for breach of contract. They are bound by the Act to observe certain rules as to the pay and conditions of their staff.

The Authority, in its turn, is subject to pretty drastic Government control of their day-to-day activities. The P.M.G. or any other Minister of the Crown may require them to broadcast any announcement, while the P.M.G. may at any time impose a ban on the broadcasting of "any matter or classes of matter." He also has the power to determine the hours of broadcasting, both as to maximum and minimum hours per day and as to the actual times of the transmissions.

On the technical side the Authority is subject to equally rigorous control under the powers conferred on the P.M.G. by the Act. They may be required to use "such technical measures or processes as may be specified" or to set up additional stations thought to be necessary to extend coverage.

There are a number of secondary provisions, including permission for the I.T.A. to do various things arising out of its main function and to embark on ancillary business enterprises that may be found necessary. The I.T.A. must not, however, manufacture or sell radio equipment.

The rest of the Act—in fact, the greater part of it—is concerned with detailed control of broadcast matter. An obligation is put on the Authority to see that programmes do not offend good taste or decency, do not incite to crime or lead to disorder or offend public feeling. They also have the responsibility of ensuring balanced programmes, of presenting news accurately and impartially and of showing no political bias.

Resistor and Capacitor Preferred Values

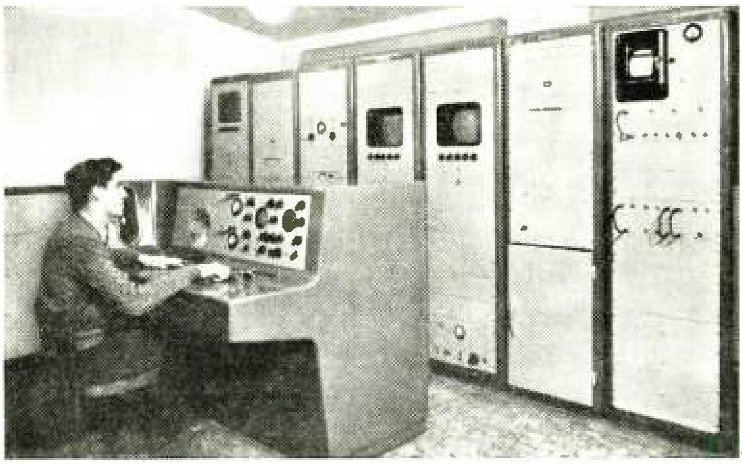
A British Standard for the preferred values and tolerances of resistors and capacitors used in telecommunications equipment is now obtainable from the British Standards Institution, 2, Park Street, London, W.1 (price 2s.)

The standard specifies a series of rounded values based on the 12th root of 10 system and with tolerances of 5, 10 and 20%. The 10% series is compiled by omitting alternate terms in the 5% series; likewise the 20% omits alternate terms in the 10% series.

While the 20% series is well known the other two are possibly not common knowledge and we give below the 5% series. Values are in ohms for resistors and in picofarads for capacitors.

Five per cent values: 1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2 and 9.1. The other two series start with 1.0 and are thus easily compiled from this list.

WORLD OF WIRELESS



Fleming Valve Jubilee

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Ionosphere Meeting

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U.S. Television

TELEVISION RELAY.—The operator-controlled diversity receiving station in Jersey where, as described last month, a wired service is distributed over the island by Rediffusion. The monitor tubes show London and Wenvoe pictures.

Jubilee of the Valve

IT WILL be fifty years on November 16th since Sir Ambrose Fleming took out the fundamental thermionic valve patent, No. 24850—"Improvements in Instruments for Detecting and Measuring Alternating Electric Currents." To mark the jubilee the I.E.E. has arranged an exhibition of historical apparatus and three lectures on the development of the valve will be given by Sir Edward Appleton, Professor G. W. O. Howe and Dr. J. Thomson.

The lectures will be given on the actual anniversary and the proceedings will be opened by the Lord President of the Council, the Marquess of Salisbury.

Ionospherists Meet

AS already announced a conference on "The Physics of the Ionosphere" is being organized by J. A. Ratcliffe, F.R.S., reader in physics at Cambridge University, in collaboration with the Physical Society. It will be held at the Cavendish Laboratory from September 6th to 9th, and will be devoted mainly to discussions of the following topics: (a) the lowest ionosphere; (b) irregularities and movements in the ionosphere; (c) the F2 layer; (d) the mathematics of wave propagation through the ionosphere.

As the conference follows the meeting of the International Scientific Radio Union at Amsterdam many foreign delegates will be among the 200 or more participating.

Abstracts of the sixty papers presented and the surveys summarizing the present position in each of the subjects discussed will be published later by the Physical Society.

U.S. Colour Television

THE cost, and more especially, the size of the three-colour tube have been cited as the main reasons for the slow "get-away" of colour television in the United States. So far colour tubes have had only comparatively small screens and have, therefore, been unacceptable to viewers who have become accustomed to 21-in and even larger monochrome screens.

Answers to both criticisms have been given by C.B.S.-Hytron who have produced a 19-in tri-colour tube at $175. The principle employed for the production of these tubes, which, it is stated, will be at the rate of 400 a day by the end of September, was briefly described in our January issue.

Radio Research

A START was recently made on the new building to be erected for the Radio Research Station of the D.S.I.R. at Ditton Park, Slough, Bucks.

Naturally everything is being done to reduce interference to a minimum. The building is over 200 yards from the nearest road, the adjoining 100 acres has been acquired to ensure isolation and as a further precaution to minimize disturbance with experimental work, the waste outlet from the building will be conveyed in a non-metallic pipe to the main district sewer.

The building has been designed specifically to meet the requirements of the Radio Research Station, of which Dr. R. L. Smith-Rose is the director with a staff of just over 100 who are at present in temporary accommodation.

Increased Exports

THE radio industry's exports during the first six months of the year increased by £2.25M compared with the same period in 1953. Of this figure £1.7M was accounted for by increased exports of communication and navigational equipment which totalled £5,974,841—approximately 46 per cent of the whole industry's exports. Increased exports are also recorded for components (£893,000), p.a. equipment and loudspeakers (£58,000) and sound reproducing gear (£38,000).

The six-months' total was £12,996,603.

Industrial Television

INCREASING use is being made by leading U.S. industrialists of closed-circuit television for nationwide sales conventions. Instead of salesmen and distributors from all over the country travelling at considerable expense to a central meeting they merely go to the studios of local television stations, which are linked with a central station where the company's executives are gathered to present their wares.

According to a report in the *Financial Times* on the activities of Box Office Television, Inc., which specializes in such "telecast conventions," Westinghouse Electric recently saved $375,000 by introducing its new receivers and appliances to 2,000 distributors through a television convention.

Valve Data

ELECTRICAL characteristics and base connections of over 2,000 British and American valves and British transistors and some 200 cathode-ray tubes are given in the latest edition of "Radio Valve Data."* The valves are classified under main headings according to their type—frequency changers, screened tetrodes, pentodes, etc. In each of these sections, they are listed under makers' names and are further classified as current, replacement or obsolete types.

Seventeen British valve manufacturers co-operated with *Wireless World* in ensuring that the information is accurate and up to date.

Additional features included in this edition are a list of equivalents, which is combined with an index, and special quality valves.

* "Radio Valve Data," fourth edition, 100 pages (11in × 8½in), published for *Wireless World* by Iliffe & Sons Ltd., price 3s 6d.

PERSONALITIES

Sir Ben Lockspeiser, F.R.S., secretary of the Department of Scientific and Industrial Research since 1949, is to receive the honorary degree of Doctor of Science at Oxford University. The presentation will precede the opening of the 116th annual meeting of the British Association for the Advancement of Science on September 1st.

E. P. B. Metcalfe, appointed engineer-in-charge of the Isle of Wight television station, which is coming into service in November, has been engineer-in-charge of the temporary Brighton station since May last year. He joined the B.B.C. in 1936 and was a maintenance engineer at various sound stations before becoming senior maintenance engineer at the Wenvoe television station in 1952.

E. J. Power, head of Murphy Radio, has been invited to become a member of the Council of the Royal College of Art. This may be taken as a tribute to the part played by his firm in industrial art; it was in the early thirties that Murphy first produced a receiver cabinet that set a new standard in functional external design.

J. P. Salter, the contributor of the article in this issue on the measurement of small voltage differences, is a senior engineer in the Armament Design Establishment of the Ministry of Supply. He served throughout the war in the Royal Artillery as an instructor in fire control (anti-aircraft radar). Before joining the Ministry of Supply for work on fuzes, on which he was engaged for six years, he was for a short time at R.R.D.E., Malvern.

C. E. Knight Clarke, who had been publicity manager for Decca Radar for two years, is now running his own business producing technical literature. Before joining Decca's he was with the G.E.C. publicity organization, where he handled the production of radio and valve technical literature. His address is 36, Denbigh Street, London, S.W.1. (Tel.: Victoria 5394.)

IN BRIEF

The increase in licensed viewers in the U.K. during the first six months of the year was 454,200. The June increase was 31,680, bringing the total to 3,411,046. The total number of **Broadcast Receiving Licences** at the end of June (including the above and 236,057 for car sets) was 13,512,275.

November 12th has been given by the B.B.C. as the date for the opening of the **Isle of Wight Television Station.** When this permanent station at Rowridge comes into service the temporary booster transmitter on Truleigh Hill, near Brighton, which has been in operation since May, 1953, will be closed down. The new station will operate in Channel 3 (56.75 and 53.25 Mc/s) and use vertical polarization as the Brighton booster has done.

The ninth **Electronics Course** covering the design, use and maintenance of electronic instruments used in nuclear physics, radio chemistry and in work with radio isotopes, will be held at the Isotope School, at Harwell, from November 1st to 5th. Physicists and electronic engineers, holding a degree or equivalent qualification, can obtain application forms from the Electronics Division, A.E.R.E., Harwell, Didcot, Berks. Attendance is limited and the fee is 12 guineas, excluding accommodation.

The operating frequency of the Lugo, Spain, **Consol Station** has been changed from 303 kc/s to 285 kc/s. The Seville station recently changed from 311 to 315 kc/s.

I.E.E. Students.—The new chairman and vice-chairman of the London Students' Section of the I.E.E. are M. C. Cubitt (Pye, Ltd.) and M. H. F. Collins (B.T-H.), respectively.

I.P.R.E.—At the inaugural meeting of the Yorkshire section of Incorporated Practical Radio Engineers (previously the Institute of Practical Radio Engineers), over 150 servicemen and traders were present. The local secretary is P. A. Senior, 5, Calverley Moor Avenue, Thornbury, Bradford, 3.

A miniature TV camera, manufactured by **Pye, Ltd.,** was used recently at the Hospital for Sick Children, Great Ormond Street, London, to enable 100 surgeons to watch a series of operations. The surgeons were attending the inaugural meeting of the British Association of Pedriatic Surgeons.

A new **Third Programme Transmitter** is to be built by the B.B.C. at Swansea, Glamorgan. Rated at 1 kW, it will operate on 1546 kc/s (194 metres).

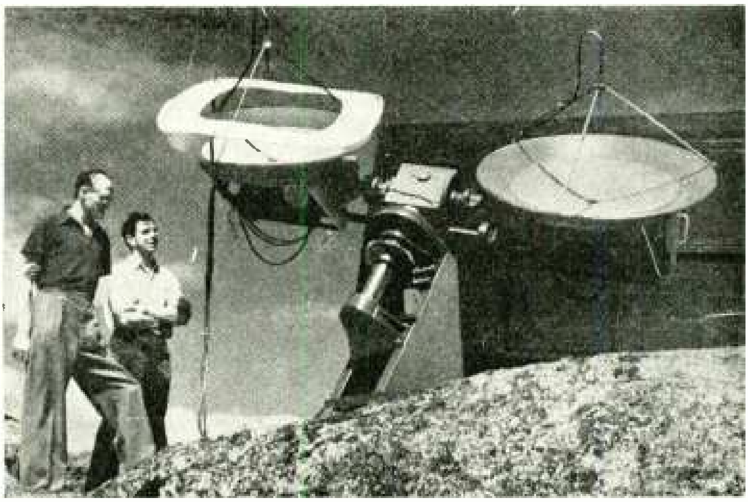
Tape Letters.—A miniature spool of 120ft of tape, weighing less than 1½ oz and, therefore, particularly suitable for recording messages for posting, has been produced by Grundig. The "Mailspool," which permits six minutes recording on each track at 3¾ in/sec, costs 6s 9d (export price 4s).

Hungarian TV.—Preparatory to planning the country's television service experimental transmissions are being radiated in Budapest. Some 200 foreign-made television receivers are said to be in use in the city for this investigation.

Indian Manufacturers.—A new class of membership—associate members—has been introduced by the Radio Manufacturers' Association of India to provide for smaller manufacturers. The member-firms constituting the R.M.A.I. committee are:—General Electric Company of India; Gramophone Company; International General Electric Company (India); Murphy Radio of India; National Ekco Radio & Engineering Company; Philips Electrical Company (India) and Radio & Electrical Manufacturing Company.

Glass being one of the many raw materials used in radio and electronics, we make no apology for drawing readers' attention to the information centre provided by the Glass Manufacturers' Federation at its new headquarters at 19, Portland Place, London, W.1.

Electronic Cooking.—The first electronic bakery in France is being set up by the French Ministry of Agriculture in Paris. It is planned to produce up to 30 tons of bread a day. Radio-frequency cooking has been used on a small scale in the United States for the commercial preparation of foodstuffs, but, according to our contemporary, *Electronics*, domestic r.f. cookers are being "home tested," and mass production at $1,000 each is planned for 1955.



ECHO OF THE ECLIPSE. Radio astronomers as well as optical astronomers were in Norway to observe the eclipse of the sun this year. The equatorially-mounted aerials shown here were set up on a peninsular near Sandefjord by an expedition from the M.o.S. Radar Research Establishment led by C. R. Ditchfield (right). Measurements of solar noise were made on a wavelength of 8 mm, the reflectors being arranged to follow the course of the sun.

"W.E." Editorials—The index to Dr. Howe's editorials in *Wireless Engineer* during the past twenty-eight years, to which we referred last month, has been prepared personally by Dr. A. J. Small, of the Department of Electrical Engineering, The University, Glasgow, W.2. We omitted to state that the index, which is obtainable direct from Dr. Small, costs 5s.

No fewer than **2,500 British Standards**, current at March 31st, are listed and briefly described in the 1954 edition of the "British Standards Yearbook." It also gives particulars of work in hand by the various Industry Standards Committees. The Yearbook is obtainable from the British Standards Institution, 2, Park Street, London, W.1, price 12s 6d.

Readers concerned with the **Transport of Goods** may like to know of the publication of the new "ABC Goods Transport Guide," published by *Motor Transport*. It includes a directory of operators of regular, long-distance road transport services and of specialist carriers. It costs 3s 6d (inc. postage).

Nottingham Central Library has issued a catalogue of some 200 books and periodicals on radio, television and radar which are available through its various branches. Journals are kept for three months, except in the case of *Wireless Engineer*, which is available from 1936, and *Wireless World* for the past six years.

EDUCATIONAL OPPORTUNITIES

The course of ten lectures on "**Crystal Valves and Transistors**" at the Borough Polytechnic, London, S.E.1, which proved so popular last year that it was run in triplicate with a total attendance of some 300, is being given in duplicate this year. The lectures, by members of the Mullard research and development staff, will be given on Tuesdays at 3.0 and 7.0 beginning on October 19th. The fee is 2 guineas. For the fourth successive year the Borough Polytechnic is also arranging a course of lectures on "The Fundamental Principles of Pulse Techniques."

A thirteen-week intensive **Course in Electronics**, designed to give those unable to take a long course an insight into the underlying principles and some of the applications of electronics, is provided by the Norwood Technical College, London, S.E.27. The college also provides a three-year full-time course in telecommunication engineering, one-year courses for the 1st and 2nd Class P.M.G. Certificates, and part-time day and evening courses in radar principles and techniques, radio and television servicing, television theory and for the Brit.I.R.E. Graduate examination.

The prospectus of **Evening Courses** arranged by the Electrical Engineering Department of The Polytechnic, Regent Street, London, W.1, includes approved telecommunications courses for the award of the Ordinary and Higher National Certificates and courses in radio and television servicing in preparation for the examination of the Radio Trades Examination Board.

Day and Evening Classes covering communication engineering (National Certificate courses), City and Guilds telecommunication engineering, and radio and television servicing, are listed in the prospectus of the Department of Electrical Engineering and Applied Physics of the South East London Technical College, Lewisham Way, S.E.4.

Amateur Classes.—We have been notified of a number of establishments providing classes during the coming session in preparation for the Radio Amateurs' Examination. Among them are the Wembley Evening Institute, Copland School, Wembley Hill, Middx. (Mondays); Ilford Literary Institute, Cranbrook Road, Ilford, Essex (Wednesdays); South East London Technical College, Lewisham Way, S.E.4 (Tuesdays); and the Grafton School, Eburne Road, Holloway, London, N.7 (Mondays). Courses commence on or after September 20th.

The recently formed Electrical Section of the **Wilmslow Guild** (Adult Education Centre), 1, Bourne Street, Wilmslow, Cheshire, is planning a series of classes of instruction in electronics. They will be held at 8.0 on Tuesdays beginning September 28th.

RADIO EXPORTS

Among the eight members of the new **Export Panel** formed by the British Standards Institution to advise on standards in relation to exports and how best B.S.I can assist export trade are J. W. Ridgeway, of Edison Swan, and Leslie Gamage, of the G.E.C.

Navigational radar equipment, radio transmitters, receivers and associated test equipment are to be supplied by **Marconi's** for five warships of the Egyptian Navy.

Radio-telephone equipment, including a 15-W fixed station, three smaller fixed stations and five mobile transmitter-receivers, has been supplied by **Pye, Ltd.**, to the Lisbon Tramway Company.

Radio equipment, including receivers, transmitters, teleprinters, terminal equipment and aerials, is listed among the products to be secured by the **Burma Purchasing Mission** to visit this country.

U.S. Enquiry.—Details of British-made industrial electronic equipment, inter-communication systems and p.a. gear are being sought by Warmington, Woodcock and Williams, Inc., 423, South 11th Street, Minneapolis, Minnesota, U.S.A. Interested manufacturers should send literature and c.i.f. prices in U.S. dollars by airmail.

Colombian Agency.—Casa Dyrma Ltda, Edificio Banco de Bogota, Oficina 632, Bogota, Colombia, have informed the British Embassy at Bogota that they are interested in acting as agents for U.K. manufacturers of electronic equipment. A long list of equipment, components and accessories is given in the announcement of this enquiry by the Export Services Branch of the Board of Trade (Ref. ESB/15127/54).

King's Dock, Singapore, has recently been equipped with a public address system by the **G.E.C.** It comprises six horn loudspeakers mounted on the lighting pylons, which are fed by two 30-W amplifiers and have a range of a quarter of a mile. Microphone points are provided at intervals around the dock.

Ekco Electronics, Ltd., have secured an order from the Carborundum Company, of Niagara Falls, New York, for a thickness gauge installation for measuring Carborundum coated abrasive products during various stages of manufacture.

Decca Radar is to be fitted in ships of the South African Navy, which, it is understood, is the twenty-sixth navy to use Decca equipment.

INDUSTRIAL NEWS

Radio manufacturers participating in the **British Trade Fair** to be held in Baghdad from October 25th to November 8th include Pye (who are planning to demonstrate closed-circuit television), B.T-H., G.E.C. and S.T.C. The fair is being organized by British Overseas Fairs, Ltd., 21, Tothill Street, London, S.W.1, on behalf of the Federation of British Industries.

The new 20,000-ton Shaw Savill liner *Southern Cross*, the first passenger ship without any cargo space, is being equipped with **Marconi Marine** transmitters, receivers, sound reproducing equipment, radar, direction finders and echometer equipment.

Coaxial telephone cables and television camera cables and accessories will be shown by **B.I. Callender's Cables** at the International Trade Fair at Leipzig (September 5th to 15th).

Marconi Marine radio-communication equipment is to be fitted in the new 3,300-ton cable ship *Recorder* which is being built for Cable & Wireless.

What is believed to be the first installation of v.h.f. radio-telephone gear in British fishing craft has been completed by **Rees Mace Marine** in two vessels of the Claydeep Fishing Company, of Grimsby.

Standard Telephones & Cables, Ltd., have erected a new factory at Southampton New Docks for the production of submarine telephone cable and repeaters.

Leevers-Rich Equipment, Ltd., has moved from Wardour Street, London, W.1, to 78, Hampstead Road, London, N.W.1 (Tel.: Euston 1481). The studios of the associated company, Leevers Rich & Company, Ltd., professional recordists, are remaining at 80, Wardour Street, where Western Electric recording equipment has recently been installed to provide a sound-on-film transcription service.

Ferguson Service.—The Birmingham service depot of Thorn Electrical Industries, Ltd., has moved to 24, Sheepcote Street, Birmingham, 15 (Tel.: Birmingham, Midland 5291).

Pam (Radio & Television), Ltd., manufacturers of domestic sound and television receivers and sound reproducing equipment, have moved from North London to 295, Regent Street, London, W.1 (Tel.: Langham 7246).

Elesco Electronics, Ltd., has been formed to sell the electronic and electrical equipment handled by Land, Speight & Company, of 73, Robertson Street, Glasgow, C.2.

Anglo-Swiss Screw Company has opened a sales office at 12, St. Ann's Square, Manchester, 2 (Tel.: Deansgate 7552).

COMMERCIAL LITERATURE

Core Laminations made by Magnetic and Electrical Alloys are now available from H. W. Forrest, 349, Haslucks Green Road, Shirley, Birmingham, who are sole distributors in England. The latest catalogue of chokes and transformers from this firm includes isolating transformers for the heaters of c.r. tubes with heater-cathode shorts.

Transformers and Chokes as specified for the Osram 912 amplifier (see p. 430) are described in a leaflet from Partridge Transformers, Tolworth, Surrey.

"Proc. L.L.L.", described as a "journal of random frequency," gives frank opinions on electronic instruments and test gear of various makes for which Livingstone Laboratories are agents. Qualities of "handleability" are assessed. No. 1, Vol. 1, from Livingstone Laboratories, Retcar Street, London, N.19.

Powder Cores and Magnets; their production and use described in a booklet "Gecalloy Low Loss Cores and Micropowder Magnets" which also gives technical specifications, performance graphs and suitable core designs for various applications. From Salford Electrical Instruments, Peel Works, Silk Street, Salford, 3, Lancs.

CLUB NEWS

Birmingham.—At the meeting of the Slade Radio Society on September 3rd, A. B. Cape, M.B.E., will speak on "The Balancing of Rotors." The subject for the meeting on September 17th is "The Possibilities of Inter-Planetary Travel," introduced by W. E. Merrill. Meetings are held on alternate Fridays at 7.45 at the Church House, High Street, Erdington. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

QRP Exhibition.—Plans are being made by the QRP Society to hold an exhibition at Walton-on-Thames on October 30th. In addition to displays of amateur-constructed gear—including television—there will be exhibits of components and commercial sound and vision receivers. Provisions are being made for the demonstration of high-fidelity equipment and radio-controlled models. The exhibition will be held in St. Mary's Parish Church Hall, admission 1s. Sec.: J. Whitehead, 92, Rydens Avenue, Walton-on-Thames, Surrey.

South Shields.—The opening meeting of the winter programme of lectures and demonstrations for members of the South Shields and District Amateur Radio Club (G3DDI) will be held at 8 on September 10th in the Trinity House Social Centre, 134, Laygate Lane, South Shields. The club is installing transmitting equipment at the South Shields annual flower show (August 26th to 29th) which will be in operation in the 20-, 40- and 80-metre bands, using the specially allocated call-sign GB3SFS. Sec.: W. Dennell (G3ATA), 12, South Frederick Street, South Shields, Co. Durham.

MEETINGS

British Institution of Radio Engineers

London Section.—"Computing Circuits in Flight Simulators," by Dr. A. E. Cutler, B.Sc. (Redifon), at 6.30 on September 29th at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.

British Sound Recording Association

London.—Presidential address by N. Leevers, B.Sc., at 7.0 on September 24th at the Royal Society of Arts, John Adam Street, London, W.C.2.

Manchester Centre.—"New Reproducing Equipment," by J. S. Holiday, at 7.30 on September 13th at the Engineers' Club, Albert Square, Manchester.

V.H.F. Broadcasting : B.B.C. Plans

COVERAGE OF FIRST NINE F.M. STATIONS

A ROUGH idea of the approximate areas to be covered by the first nine v.h.f. stations which the Government has at last sanctioned can be gained from this sketch map, based on information provided by the B.B.C. At each of the nine stations six transmitters will be installed—two in parallel for each of the three programmes to be radiated. The first station to be brought into service will be at Wrotham, Kent, where there are already two transmitters which have been used experimentally since 1950. It will be in operation next May. The other eight stations, which will be at the sites of the existing and projected television stations and will use the same masts, are to be completed by the end of 1956. Pontop Pike and Divis will be the second and third stations to be brought into operation.

Details of the frequencies to be used have not yet been announced by the B.B.C. It is, however, presumed they will be within the framework of the Plan for Band II drawn up at Stockholm in 1952, although, in fact, the U.K. was not a signatory to the Plan because at that time it was not known what method of modulation would be employed. The frequencies allocated to each of the projected transmitters in the Stockholm Plan are tabulated below. The figure in brackets is the effective radiated power in kilowatts.

The B.B.C. has already placed orders with Marconi's and S.T.C. for 64 transmitters varying from 1 to 10 kW.

	Mc/s
Wrotham, Kent [120]	89.1 91.3 93.5
Pontop Pike (Newcastle) [60]	88.5 90.7 92.9
Divis (Belfast) [60]	90.1 92.3 94.5
South Devon [60]	88.1 90.3 92.5
Meldrum, Aberdeenshire [60]	88.7 90.9 93.1
Holme Moss (Manchester) [120]	90.1 92.3 94.5
Sutton Coldfield (Birmingham) [120]	88.3 90.5 92.7
Norwich, Norfolk [120]	89.7 91.9 94.1
West Wales [60]	88.9 91.1 93.3

21st National Radio Show

STAND-TO-STAND PREVIEW OF TECHNICAL EXHIBITS

THE annual exhibition of British domestic radio equipment opens at Earls Court on August 25th. The preview of technical exhibits presented in the following pages differs from that given in the past few years in that it is a stand-to-stand report instead of a tabulated list of products. Prepared from information given to us by exhibitors, it will inevitably be incomplete in that there are bound to be a few manufacturers who will await the actual opening of the show to uncover their latest productions. Despite this, we feel that the following pages will provide a useful guide to visitors and a comprehensive survey for readers unable to attend the show.

The Radio Industry Council, which organizes the show, has again arranged for collective displays of electronic equipment. There are four such displays—two on the ground floor (marked E1 and E2 on the plan opposite) and two on the first floor (E3 and E4).

The exhibits will not, this year, be grouped together under "applications" except in the case of radio control gear. In all some twenty-five examples of applied electronics will be shown and demonstrated.

The industry, the Radio Trades Examination Board and some training establishments have co-operated in providing this year's Technical Training Display, located near the B.B.C. Studio, which, as usual, occupies a large part of the first floor. The focal point of the display is a 15-minute film on training in industry. To reach the cinema, which will hold about 50, one passes displays illustrating machine shop practice, glass manipulation, component manufacture, circuit testing, servicing and aerial techniques.

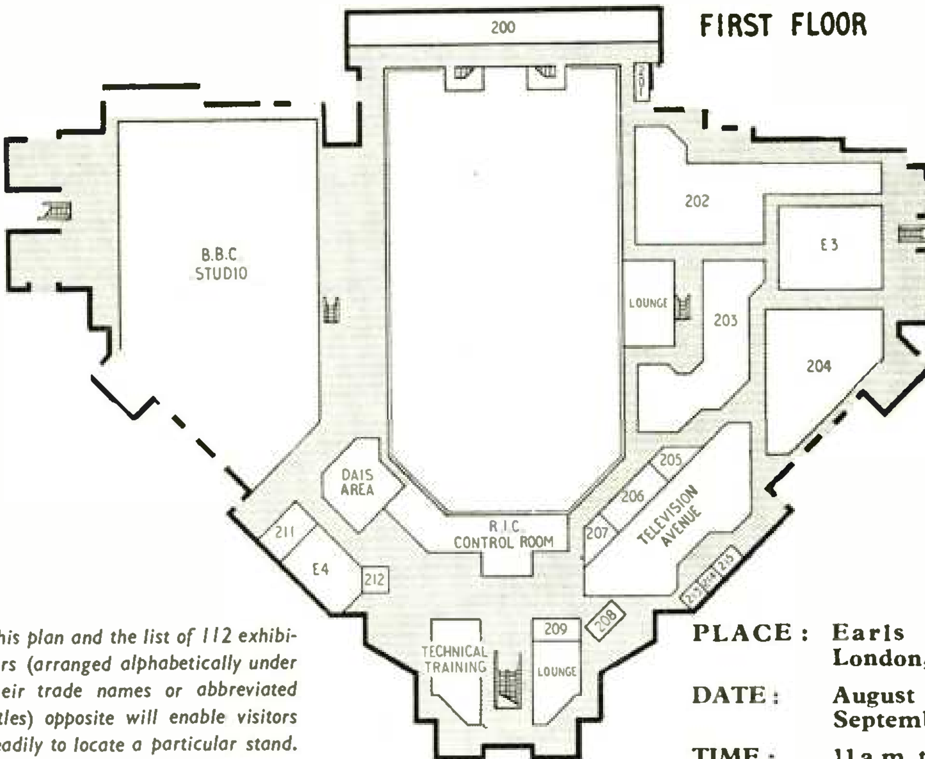
This year's television distribution system at the exhibition provides, in addition to a signal on Channel 4 (used to avoid interference from Alexandra Palace), a Band III signal superimposed on the same cable network. This signal will be a simple picture for demonstration purposes only.

ALPHABETICAL LIST OF EXHIBITORS AND GUIDE TO THE STANDS

Name	Stand
Acos	44
Aerialite	64
Alba	35
Ambassador	41
Antiference	34
Argosy	8
Army	202
Associated Technical Mftrs.	25
Avo	61
B.B.C.	200
Baird	88
Belling-Lee	67
Bernards	24
Bowmaker	47
Brimar	6
British Radio and Television	215
British Railways	43
Brown Bros.	91
Bulgin	99
Bush	86, 89 (D15)*
Chald	26
Champion	33
Channel Electronic Industries	214
Collaro	11 (D26)
Cossor	57 (D11)
Decca	39 (D28)
Defiant	106 (D13)
Domain	213
Dubilier	83
Dynatron	103
E.A.R.	49
E.M.I.	9, 73 (D21, D23)
Econasign	23 (D5)
Ediswan	37
Ekco	22, 92 (D6, D7)
Electrical and Radio Trading	32
English Electric	85 (D2)
Ever Ready	66
Ferguson	14 (D4)
Ferranti	58, 76 (D1, D30)
G.E.C.	68 (D8)
Garrard	71
Gibbs	20
Goodmans	63
H.M.V.	10 (D22)
Hobday	78
Hunt	90
Invicta	95
J.B. Cabinets	18
J-Beam Aerials	31
K.B.	70
Keith Prowse	1
Kerry's	19
Linguaphone	21
Lloyds Bank	48
Lugton	46 (D25)
M.o.S.	122
McMichael	72
Marconiphone	13 (D27)
Masteradio	62
Midland Bank	52
Mullard	56 (D3, D29)
Multicore	100 (D18)
Murphy	40 (D24)
National Provincial Bank	27
Navy	204
Nera	208
Pam	4, 84 (D19)
Peto Scott	60
Philco	36
Philips	96, 97 (D14)
Pilot	59
Plessey	28 (D9)
Practical Wireless	51
Pye	94 (D10)
R.A.F.	203
R.G.D.	93
R.S.G.B.	209
R.T.R.A.	206
Reflectograph	207
Regentone	38
Roberts	102
Rola Celestion	3
S.T.C.	82
Simon	104
Sky-Masts	30
Slingsby	50
Sobell	12
Star, The	211
Stella	55
T.C.C.	101 (D17)
Taylor	54
Telemax	81
Telequipment	80
Telerection	5
Television Society	205
Thompson, Diamond & Butcher	15
Times, The	42
Trix	65
Ultra	69
United Appeal for the Blind	201
Valradio	29
Vidor	87 (D16)
Waveforms	75
Wearite	74 (D20)
Westinghouse	2
Westminster Bank	7
White-Ibbotson	98
Whiteley Electrical	105 (D12)
Wireless & Electrical Trader	17
Wireless World and *Wireless Engineer*	45
Wolsey	16

* Demonstration rooms and offices are prefixed with "D".

FIRST FLOOR



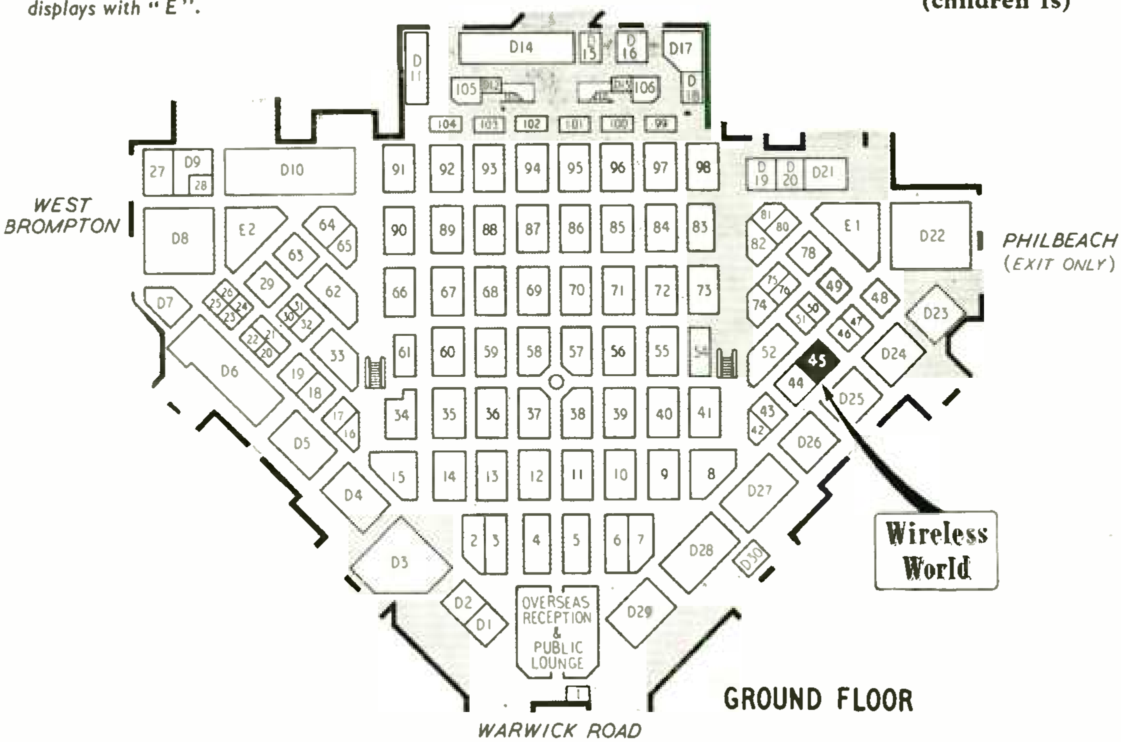
This plan and the list of 112 exhibitors (arranged alphabetically under their trade names or abbreviated titles) opposite will enable visitors readily to locate a particular stand. Demonstration rooms and offices are prefixed with "D" and electronic displays with "E".

PLACE: Earls Court, London, S.W.5

DATE: August 25th to September 4th

TIME: 11 a.m. to 10 p.m.

ADMISSION: 2s 6d (children 1s)



GROUND FLOOR

Guide to the Stands

ACOS (44)

Components employing piezoelectric crystals have always been one of the principal products of this firm. This year the "Hi-g" pickup movement, designed to track the highest record groove accelerations which are, or can be, engraved on a record, will be seen in a wide variety of types, including plug-in heads for most well-known proprietary gramophone units.

A recent addition to the range of crystal microphones is the Type MIC36 which is adaptable to a variety of applications.

Cosmocord Ltd., 700 Great Cambridge Road, Enfield, Middlesex.

AERIALITE (64)

Aerials for sound and television broadcasting and cars, with a wide range of aerial accessories and cables of various kinds, will be found on this stand. There will be two new "Aerfringe" type television aerials, one a 3-element 7.5-db gain model and the other a 4-element 11-db model. Some specimens of Band III aerials will also be available, together with other v.h.f. types.

A new "Mastatic" aerial fitted with an 18-ft whip is of the anti-interference type. Another new item is a partially air-spaced 72-ohm coaxial cable of extra low-loss qualities to meet fringe area and Band III requirements.

Aerialite Ltd., Castle Works, Stalybridge, Cheshire.

ALBA (35)

Two completely new television receivers, T321 (14in) and T324 (17in) have been added to the Alba range. These are designed for Band I and Band III and employ special valves in a 19-valve circuit using turret tuning. The specification includes a.g.c. and interference suppression on both sound and vision, frame flyback suppression, built-in aerial attenuation and a forward-facing loudspeaker.

In addition to the C114 miniature all-wave superhet and the 707 mains/battery portable radio-gramophone, the sound receiver range will include a new moderately priced 5-valve a.c./d.c. table model (3122) with built-in aerial.

A. J. Balcombe Ltd., 52-58 Tabernacle Street, London, E.C.2.

AMBASSADOR (41)

In all there will be five television models in the Ambassador programme, making use of completely redesigned chassis with turret tuners for Bands I and III stations. Sets will go out with Band I coils, and others will be supplied as additional programmes become available. The TV15CR is a combined television and sound receiver.

Four sound receivers will be shown, and two radio-gramophones, including the Viscount (Series III) with 8-waveband receiver, 3-speed record changer and storage for 200 records.

R. N. Fitton Ltd., Princess Works, Brighouse, Yorks.

ANTIFERENCE (34)

The range of television aerials made by this firm offers a wide variety of types for home and overseas requirements. Considerable emphasis is placed on the "Snapacitor" feature which permits virtual assembly at the factory and also does away with actual metal-to-metal contacts in the electrical circuitry of the aerial.

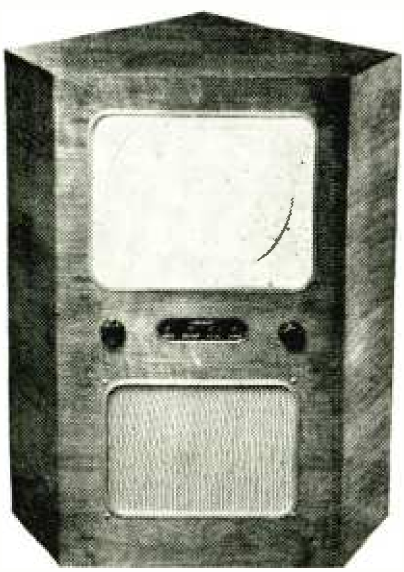
Of particular interest to overseas visitors will be the wide range of television and v.h.f. aerials for the particular frequencies and polarizations used in other countries. The pre-assembly feature is also embodied in these models.

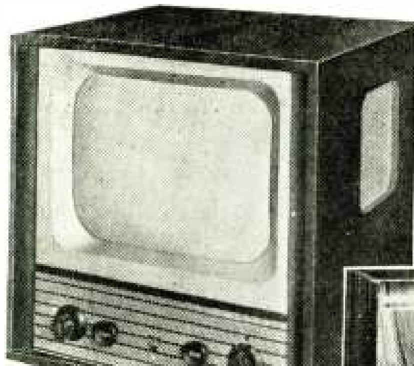
Antiference Ltd., 67 Bryanston Street, London, W.1.

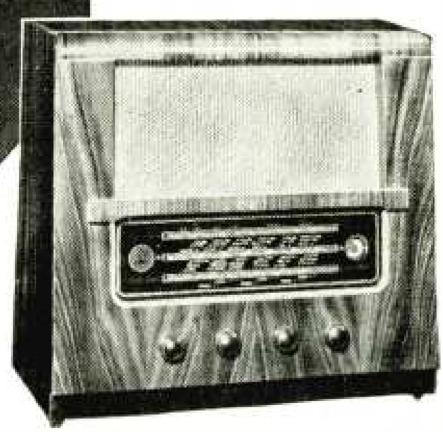
ARGOSY (8)

Three-speed automatic record changers are used in all the latest radio-gramophones to be shown by this firm, while the receiver sections cover long, medium and short waves. In each model the 10in loudspeaker is fed from a pentode capable of giving 4 watts output at less than 5% distortion. Two superhet receivers will also be shown, the five-valve TR525 and the six-valve TR626/U.

Argosy Radiovision Ltd., Argosy Works, Hertford Road, Barking, Essex.







Baird P2114 two-band receiver with 14-in tube.

Left: Ambassador corner console, TV15CC.

Right: Argosy 5-valve superhet TR525.

ARMY (202)

The space devoted to the Regular Army's exhibit is shared by the Royal Corps of Signals—the operators of its telecommunications system—and the Royal Electrical and Mechanical Engineers, responsible for the maintenance of the equipment.

An Air Support Signal Unit armoured vehicle, equipped with sets Nos. 52 and 62 and a v.h.f. transmitter-receiver, which provides direct communication between forward troops requiring air support and H.Q., will be on view. The supporting aircraft are "talked" on to the target through the v.h.f. set.

Some of the aids used in training telecommunication and radar mechanics and control equipment electricians will be displayed.

War Office, Whitehall, London, S.W.1.

ASSOCIATED TECHNICAL MANUFACTURERS (25)

Manufacturers of cables, wires and sleevings for radio and industrial purposes. Special grades of heat-resisting sleevings will be shown in addition to standard p.v.c. and polythene coverings.

Associated Technical Manufacturers Ltd., Vincent Works, New Islington, Manchester 4.

AVO (61)

While basically the existing range of Avometers and test equipment will remain largely unchanged, usefulness is being extended by the introduction of some new multipliers to cover the higher voltages now encountered in television equipment. Expected to be shown will be one extending the range of the Model 8 Avometer and other 20-kΩ/V instruments to read up to 25 kV.

In addition to test equipment coil winding machines of various kinds will be available for inspection.

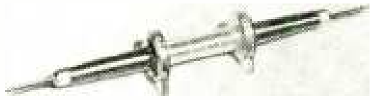
Automatic Coil Winder and Electrical Equipment Co. Ltd., Winder House, Douglas Street, London, S.W.1.

B.B.C. (200)

Working models illustrating operational processes and pieces of equipment in operation are again a feature of this stand. Among the "how it works" exhibits are a model television camera illustrating the operation of the "zoom" lens, equipment for measuring the characteristics of telephone lines, a representation of the reflection of radio waves by the ionosphere and sound recording equipment.

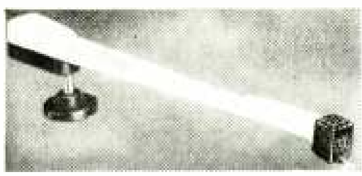
Developments in technical facilities for the production of studio and outside broadcast sound programmes will be illustrated by several new pieces of equipment and visitors will see some of the methods used in producing sound effects for programmes.

British Broadcasting Corporation, Broadcasting House, London, W.1.



Avo 25-kV multiplier for extending the range of certain Avometers.

Alba Model 3122 a.c./d.c. receiver.



Acos Type GP20 "Hi-g" crystal pickup.

Bulgin "Domino" 2-pole plug and socket.

BAIRD (88)

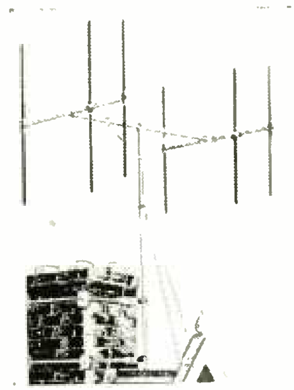
Some television receivers shown will have a turret tuner for Bands I and III. This tuner is normally fitted with coils for three Band-I channels and two Band-III channels, but up to seven further channels can be covered by extra coils. A 14-in table model and three 17-in models will be available. Single-channel sets will also be on view.

All sets can be supplied as fringe-area models, with flywheel sync and a form of vision a.g.c.

Hartley Baird Ltd., 37-39 Thurloe Street, South Kensington, London, S.W.7

BELLING-LEE (67)

Aerial equipment of all kinds, radio interference suppressors and a wide range of important items such as terminals, plugs and sockets and fuses, are the main exhibits to be found on this stand.



Belling-Lee double "Junior Multi-rod" for fringe areas.

Television aerials will include, on the one hand, simple designs for indoor use and on the other quite elaborate multi-element systems for extreme fringe-area conditions. An amplifier installed at the masthead and requiring no special cabling is another fringe-area aid to better reception. Distribution amplifiers will also be included.

There will be a new and almost miniature television interference suppressor for fitting in the mains leads of small domestic appliances; it will carry up to 2 A and is described as the "Telefilter."

Belling & Lee Ltd., Great Cambridge Road, Enfield, Middlesex.

BRIMAR (6)

Among cathode ray tubes on show will be a new 21-in tube, type C21HM, which has an improved tetrode gun assembly giving better focusing and minimum astigmatism. A 17-in self-focusing tube, type C17JM, will also be displayed. This incorporates an internal focusing electrode and so avoids the need for external focusing magnets and controls.

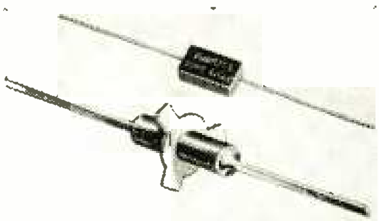
The range of valves will meet the requirements of both high-quality and economical a.m./f.m. receivers, and various circuits for these will be displayed. There will also be special quality valves at lower prices than hitherto and valves for Band III tunable television receivers.

Standard Telephones and Cables Ltd., Footscray, Sidcup, Kent.

BULGIN (99)

Connectors, signal lamps, knobs, switches and a host of other small, but quite vital, items in electronic and radio equipment comprise the main activities of this company. Among the newest items are a Lilliput lampholder no larger than a little-finger nail; miniature micro-switches which operate by almost a feather-weight touch and some new multi-pole connectors. One pattern is in the form of a strip with the plugs, or sockets, in line and self-centring;

Bush 14-in table model TV.43 with flyback suppression.



Dubilier "Hi-K" ceramic feed-through and midget moulded silvered mica Type SM22 capacitors.

another new design takes the form of a 2-pole unit (plug or socket) which can be mounted in line or stacked vertically to give almost any number of connections. They are mainly intended for inter-chassis or inter-unit connection, one part being on the chassis the other on the rack or cabinet, when the chassis is pushed home all the contacts, which are self-aligning, engage.
A. F. Bulgin & Co. Ltd., Bye-pass Road, Barking, Essex.

BUSH (86, 89)

Television receivers shown by this firm all include tuners for Bands I and III, tuning on each band being continuous with a band selector switch. All models, too, have a.g.c. on sound and a form of a.g.c. on vision, the control voltage in this case being derived from the sync-separator grid current. One model, the TV33, has flywheel synchronizing. All the sets are of the a.c./d.c. type.

Table models with 12-in, 14-in and 17-in tubes will be shown, a console with a 17-in tube and the Mobile 17, which is a floor model with a 17-in tube.

Sound-broadcast receivers will include the well-known DAC90A and a battery set introduced last year. A new set is the AC41 and an a.c./d.c. counterpart—the DAC41.

Champion "Midget" receiver, Model 825.

Collaro "54" 3-speed record changer.

A radio-gramophone with a three-speed motor and auto-changer will be shown. An exhibit of particular interest at the present time will be a v.h.f. broadcast receiver.
Bush Radio Ltd., Power Road, London, W.4.

CHALD (26)

Shown by this firm will be a new indoor television aerial in the form of a single-turn square "loop" known as the "Sqarial." It is said to give a 20—% gain over a dipole, has a back-to-front ratio of 7 db and may be expected to give satisfactory reception up to 30 to 35 miles. It is less than 3 ft square.
Chald Products Ltd., 184 Low Road, Leeds, 10.

CHANNEL (214)

Television pattern generators will be shown, one model, T1, for Band I and another, T2, for Bands I and III. Also on view will be television pre-amplifiers, multi-outlet distribution amplifiers, and t.v.i. suppression units.
Channel Electronic Products, Ltd., Burnham-on-Sea, Somerset.

CHAMPION (33)

This year Champion are concentrating on sound receivers, and in particular small portable and "midget" table models.

Model 825, a "midget" table receiver for a.c./d.c. mains, is new and will be available in a plastic cabinet with a choice of colour. Ferrite rod aerials are used in the Model 822 battery suitcase portable and in the Model 820 "Radio Revler" transportable 3-speed radio-gramophone. The larger Model 781, which is a 7-valve superhet mains-battery portable of high sensitivity, is being continued. Record playing equipment includes the portable "Revler" with crystal pickup, amplifier and 5-in loudspeaker.
Champion Electric Corporation Ltd., Drove Road, Newhaven, Sussex.

COLLARO (11)

A new record changer, Model 54, which mixes 7, 10 and 12-in records and has a constant change time, irrespective of the turntable speed, will be shown; also a new inexpensive 3-speed motor unit with turnover pickup cartridge (AC3/554).

"Transcription" units (Models 2,000 and 2010) fitted with the Collaro "Studio P" crystal pickup will be of special interest to high-quality enthusiasts.
Collaro Ltd., Ripple Works, Bye-pass Road, Barking, Essex.

COSSOR (57)

In sound broadcast receivers the most interesting exhibits on the stand will be two models capable of receiving v.h.f. as well as existing programmes. The model 523 covers three wavebands and uses seven valves, while the model 522 is a radio-gramophone with an automatic record changer.

Most of the television receivers on show will either be tunable to Bands I and III or will have facilities for the addition of a tuner unit.
A. C. Cossor Ltd., Cossor House, Highbury Grove, London, N.5.

DECCA (39)

Four television receivers with direct-viewing 14-in or 17-in tubes will be shown as well as a projection receiver (Model 1000). There will also be two television-radio-gramophones. The Model RG98 and 102 radio-gramophones have 3-waveband receivers and 3-stage audio amplifiers.

Record reproducers made by this firm include a new "Panatrope" which is an inexpensive console incorporating a Garrard RC/111 record changer with a 3-stage negative feedback amplifier giving 2½ watts. Another interesting model is the "Deccamatic II" portable player which employs a single pentode amplifier with a Collaro 3-speed motor and crystal pickup.
Decca Record Company, Ltd., 1-3 Brixton Road, London, S.W.9.

DEFIANT (106)

The five television receiver models exhibited cover both bands, being pre-set for any station in Band I and adjustable by the user to all eight channels of Band III. The

sets include a mains filter and the line time-base is completely screened.
Co-operative Wholesale Society Ltd., 1 Balloon Street, Manchester, 4.

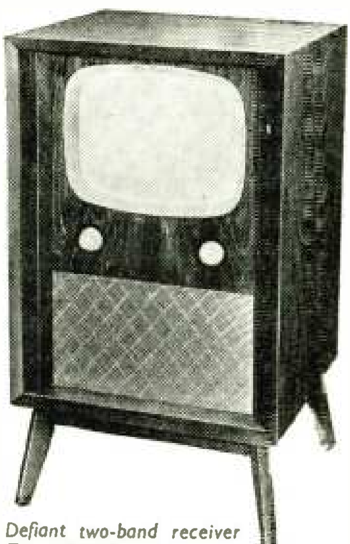
DOMAIN (213)

Television receiver tables of metal tubular construction will be on show here. They have undershelves for carrying sound receivers or record players. Equipment for dealers' showrooms will also be displayed.
Domain Products Ltd., Domain Works, Barnby Street, London, N.W.1.

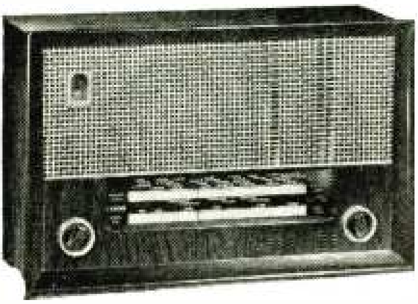
DUBILIER (83)

Capacitors, resistors, fixed and variable, and radio interference suppressors comprise the main radio parts in which this firm specializes. Miniaturization being an all-important requirement to-day, attention is being given to this aspect of design and some midget moulded silvered mica capacitors in a useful range of values are now available.

Among the ceramic dielectric capacitors interest will be focused on the "Hi-K" feed-through, stand-off and bushing styles in view of their particular suitability as r.f. by-pass capacitors in v.h.f. and Band III television receivers.



Defiant two-band receiver Type TR1755.



Dubilier will have one of the smallest insulated ½-W resistors made in the Type BTS and some pre-set "Q" type potentiometers with insulated knobs intended primarily for television sets.
Dubilier Condenser Co. (1925), Ltd., Ducon Works, Victoria Road, North Acton, London, W.3.

DYNATRON (103)

A range of large radio-gramophones will be on this stand and among them the Ether Marshal, a new model, is noteworthy for its elaborate specification. It is a 5-band set with an earthed-grid r.f. stage on short waves. There is variable selectivity and provision for the connection of an f.m. tuner. The a.f. amplifier, on a separate chassis, has a push-pull triode output stage.

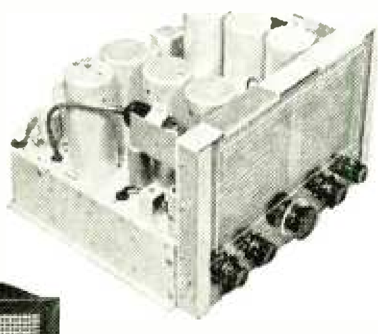
The model TV27C television receiver, for a.c. only, has a 17-in tube and a.g.c. on both sound and vision channels. There is a black-level stabilizing circuit, a black spotter, and an anti-flutter circuit.

A television "mast-head" pre-amplifier for fringe-area reception will be on view; also a range of nucleonic and electronic equipment.
Dynatron Radio Ltd., The Firs, Castle Hill, Maidenhead, Berks.

E.A.R. (49)

Portable electric gramophones are a speciality of this firm, and models are available, with three-speed turntable motors or record changers, all of which play with the lid closed. The Model A750 high-quality instrument is fitted with a 10-in × 6-in elliptical loudspeaker and separate bass and treble tone controls.

Other products of this firm include a console record reproducer with 8-watt push-pull output, a 12-watt portable a.c./d.c. amplifier for p.a. work, and a range of high-quality amplifiers for a.c. mains.
Electric Audio Reproducers Ltd., 17 Little St. Leonards, Mortlake, London, S.W.14.



Chassis of Dynatron "Ether Marshal."

Left: Cossor Model 523 a.m./f.m. receiver.

Right: Ekco 14-in table model, Type T221.

E.M.I. (9, 73)

One of the chief exhibits on these stands will be the BTR/2 tape recorder, which is available in console or transportable form and with tape speeds of either 15 and 30 or 7½ and 15in/sec. Other tape recorders on show will be the transportable TR/50 with playing times of 64, 32 and 16 minutes (according to tape speed); the "Emicorda" domestic type and the portable battery-driven model L/2 which weighs 14½ lb.

Amongst test gear displayed will be a bridge for measuring resistive and capacitive impedance in situ and a signal generator covering the B.B.C. television channels.
Electric & Musical Industries Ltd., Hayes, Middlesex.

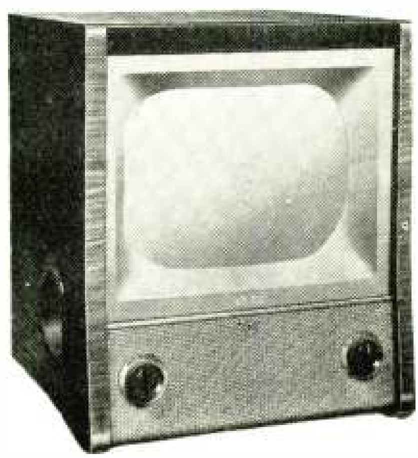
EDISWAN (37)

Aluminized cathode ray tubes will be the main feature of this stand and the range on show will include the latest 21-in rectangular type. A demonstration exhibit will show the 60 per cent increase in picture brightness obtained by aluminizing.

In valves, the 30L1 cascode double triode and the 30C1 triode pentode frequency-changer will be on view separately and as used in the Ediswan-Clix television turret tuner. This is a 12-position tuner, with pre-tuned r.f. and mixer stages, for multi-channel receivers operating in Bands I and III.
The Edison Swan Electric Co. Ltd., 155 Charing Cross Road, London, W.C.2.

EKCO (22, 92)

The television receivers exhibited will be types having either a built-in 13-channel turret tuner for Bands I and III or provision for adding such a tuner when required. The tubes range in size from 12-in to 17-in; one of the larger models is the a.c./d.c. type TC209 with flywheel sync, and a form of vision a.g.c.; spot wobble is



included and the set is unusual in including an f.m. receiver for Band II.

Among the sound-broadcast receivers, the A239 is of especial interest because it provides for f.m. reception on Band II as well as the normal a.m. bands It has a built-in Band II aerial and provision is made for the use of a tape recorder.

The New Radiotime is an a.c. set, including an electric clock which can act as an alarm or be set to switch the set on or off at predetermined times.

E. K. Cole Ltd., Southend-on-Sea, Essex.

ENGLISH ELECTRIC (85)

The "40" series of television sets have a 17-in rectangular tube operating at 14 kV and they are of the a.c./d.c. type with a barretter for the control of the heater current. A 12-channel turret tuner is included to cover Bands I and III, but, as the coils in it are changeable, it can also be used for Bands IV and V if required. There are three cabinet styles; the T40 and T41 are table models without and with doors and the C42 is a console with doors.

A tuner unit (the "Rotamatic") enables Band-III reception to be obtained on existing Band I sets. It is a 12-position turret tuner like that in the "40" series sets and it replaces the early valves in English Electric one-band sets. The output is at i.f. and connection is by plugs to the valveholders.

The English Electric Co. Ltd., Marconi House, 336-7 Strand, London, W.C.2.

EVER READY (66)

Layer-type batteries for portable receivers will be shown with miniature and sub-miniature layer types for hearing aids. There will also be a range of all-dry battery receivers, including portables and table models, and two tropicalized export receivers.

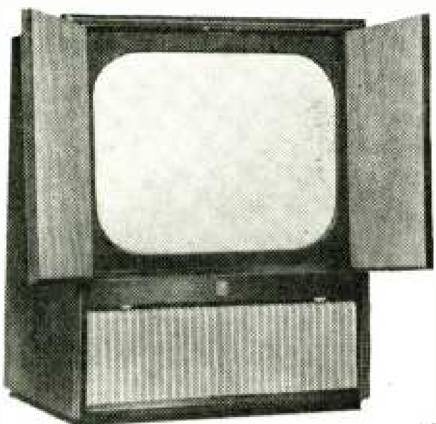
The Ever Ready Co. (Great Britain) Ltd., Hercules Place, Holloway, London, N.7.

FERGUSON (14)

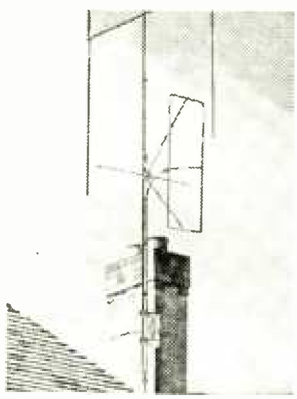
Television receivers with 12-in, 14-in and 17-in tubes will be shown. The 103T and 105T, using the larger tube sizes, have turret-switch tuners for Bands I and III; others are primarily Band I sets but have provision for the addition of a plug-in three-way tuner unit to cater for two Band III stations. Frame-flyback suppression is used on all sets and Halolight, an illuminated surround to the picture, is now fitted on four of the console models.

Among sound-broadcast receivers, there are three models which give f.m. reception on Band II as well as the normal long, medium and short wavebands. In addition to several radio-gramophones of console pattern, there is a new table model having a three-speed automatic record changer.

Thorn Electrical Industries Ltd., 105-109 Judd Street, London, W.C.1.

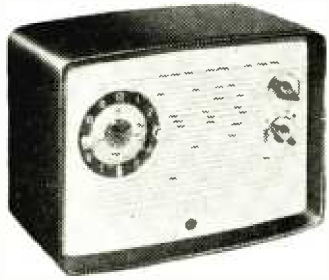


Tunable table projection receiver by Ferranti, Model 20T4.



J-Beam 3-element Band I television aerial combined with a skeleton slot for Band III.

English Electric Rotamatic tuner for Band III television.



Ekco "New Radiotime" receiver.

FERRANTI (58, 76)

An exhibit of considerable interest here will be a table projection television receiver giving a picture size of 16-in × 12-in. The receiver is permeability-tuned over the five channels of Band I. The front end of the receiver is detachable so that it can be replaced by a Band I/Band III tuner unit. Beam current a.g.c. is applied to the final vision i.f. amplifier and this ensures minimum peak white defocusing and enables the set to be operated at a high average brightness level.

Among the valves and cathode-ray tubes on view will be a new 21-in rectangular tube with a 90° deflection angle.

Ferranti Ltd., Moston, Manchester.

G.E.C. (68)

A range of new sound and television receivers will be on view. New Osram valves notable for their very high slope of 15 mA/V are the Z759 and Z359, both B9A pentodes intended as video amplifiers. The first has a 6.2 V heater and the second a 0.3 A heater. For Band III television tuners there will be the B319 double triode and the LZ319 triode pentode, while a new addition to the audio range of valves will be the N709 output pentode with an anode dissipation of 12 watts.

Among the c.r. tubes will be a development 21-in rectangular tube.

General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2.

GARRARD (71)

The record changers and gramophone turntable units shown by this firm will be seen in the new standard colour scheme of cream and brown. From a comprehensive range the retooled Model 301 "transcription" motor, the new compact RC110 and RC111 three-speed record changers and the Type GC2 and GCE3 piezo-electric pickups may be selected as worthy of closer inspection. The GC2 is a Rochelle salt crystal turnover unit with a frequency range comparable with that of separate crystal heads, and the GCE3 employs a ceramic element for use under extreme conditions of heat and humidity.

Garrard Engineering and Manufacturing Co. Ltd., Newcastle Street, Swindon, Wilts.

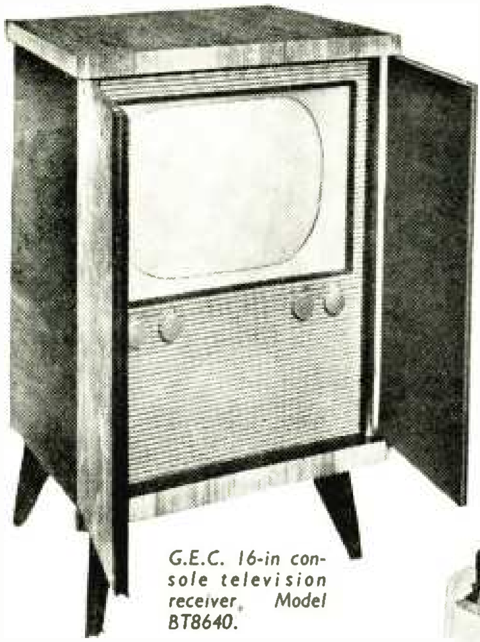
GIBBS (20)

This firm will be showing a record cabinet with a capacity of 170 records, and a range of tables suitable for television sets.

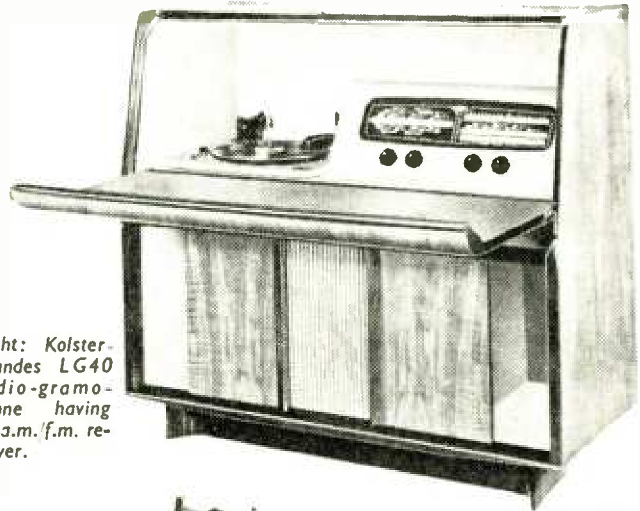
Herbert E. Gibbs Ltd., First Avenue, Montague Road, Edmonton, London, N.18.

GOODMANS (63)

This stand will be virtually a sound-proof theatre for the demonstration of high-quality reproduction, and



G.E.C. 16-in console television receiver, Model BT8640.



Right: Kolster-Brandes LG40 radio-gramophone having an a.m./f.m. receiver.

Garrard RC80M 3-speed record changer.

Hunt 50-μF 350-V wkg Type L136 miniature electrolytic.

visitors will be able to compare the results obtained with a variety of loudspeaker types and systems, including multiple units wth crossover networks. A staff of specialists will be in attendance to answer questions.

A new 12-in, 12-watt reproducer, the "Orlin III," will be shown in which the top response can be modified to give optimum performance on inputs of varying quality.

Goodmans Industries Ltd., Axiom Works, Wembley, Middlesex.

H.M.V. (10)

An important feature of this stand will be a new projection television receiver, Model 1823, with a projection tube of twice the screen area of more usual types. This gives a brighter picture than normally obtainable from such receivers. The current range of 14-in and 17-in direct-viewing sets on show will be available either as two-band versions or as Band I versions which can be modified for Band III reception when required. Three fringe-area sets incorporate a.g.c. on vision and sound, dark-scene contrast expansion, fly-back suppression and interference inversion.

Among the radiograms will be a portable and a transportable, both with a 3-speed record player on a pivoted counterbalanced desk which swings into the back of the cabinet when not in use.

Two new sound receivers will be shown. Model 1360 is a transportable in a plastic cabinet while model 1126 is a 5-valve table receiver.

The Gramophone Co. Ltd., Hayes, Middlesex.

HUNT (90)

The Supermoldseal Type W96 is a new miniature metallized-paper capacitor having a tough cast resin case which is not easily damaged by accidental contact with a hot soldering iron. Working voltages are 200, 400 and 600 d.c. and capacitance values range from 50 pF to 100,000 pF.

A new miniature single-hole fixing dry electrolytic known as the Type L136 will be shown, together with a range of low-voltage miniature electrolytics measuring 1 in long and ⅜ in in diameter, with working voltages of from 12 to 150 V d.c. and in capacitances of 1 to 50 μF.

A new development, described as the sprayed plate technique, is said to result in small bulk for a given capacitance.

A. H. Hunt (Capacitors) Ltd., Bendon Valley, Garratt Lane, Wandsworth, London, S.W.18.

INVICTA (95)

A 13-channel selector switch on the side of the cabinet will be a feature of three television sets to be displayed. These receivers, one 14-in and two 17-in, also incorporate automatic vision gain control (the black-level adjusting circuit), flywheel sync, a dark screen for daylight viewing and a built-in Band I aerial for areas of high signal strength.

A new console radiogram of small size is capable of playing L.P. records and has a receiver section covering the trawler waveband.

Invicta Radio Ltd., 100 Great Portland Street, London, W.1.

J.B. CABINETS (18)

This firm manufacture radio and and radio-gramophone cabinets for the trade and their exhibit will comprise a selection of the latest and most interesting types which have been recently produced.

J.B. Manufacturing Co. (Cabinets) Ltd., 86 Palmerston Road, Walthamstow, London, E.17.

J-BEAM AERIALS (31)

A special feature of this firm's television aerials is that the feeder is connected to one end of the main dipole via an impedance matching stub. The stub can be incorporated in the supporting mast which then becomes virtually an extension of the dipole. They will be showing also a "skeleton slot" aerial for Band III.

J-Beam Aerials Ltd., Cleveland Works, Weedon Road Industrial Estate, Northampton.

K.B. (70)

The television sets to be shown on this stand include a multi-channel turret tuner for Bands I and III. There is a table model with a 14-in tube and another with a 17-in, while the two console types have 17-in tubes. One of these has a tube with electrostatic focus, pre-set in the factory.

Adaptors to enable single-band K.B. receivers to be used on Band III are being produced.

A newcomer to the range of broadcast sound receivers is the KR20FM. This is a 6-valve set for a.c. operation which covers the usual medium and long wavebands and also the v.h.f. band. Some of the older models are still being retained, among them the FP151 a.c./d.c./battery portable.

Five radio-gramophones will be shown. Among the new types is the LG40AM/FM in which the receiver covers the f.m. band and has a push-pull output stage.

Kolster-Brandes Ltd., Footscray, Kent.

M.o.S. (212)

The main exhibit on this stand is a telemetering system for guided missiles.

Ministry of Supply, Shell Mex House Strand, London, W.C.2.

McMICHAEL (72)

The new television receivers will be available with 14-in or 17-in rectangular flat-faced tubes and in table and console models, with or without sound radio receivers. One chassis is common to all the new sets.

Special attention has been given to reliability and service accessibility. The entire chassis can be taken out of its cabinet in 1¾min and the tube in 1¼min.

These new sets will be adequately supported by a comprehensive range of sound receivers including an a.c./d.c. mains/battery portable set with a self-contained ferrite rod aerial.

McMichael Radio Ltd., 190 Strand, London, W.C.2.

MARCONIPHONE (13)

Another addition to the "Companion" range of sound receivers will be model T37DA, a 5-valve a.c./d.c. transportable covering two wavebands. There will also be a new mains/battery portable, model T36AB, in attache-case form and a new table receiver, model T38A, covering three wavebands. New radio-gramophones on show will be the model ARG40A, the ARG41A in a "contemporary" style cabinet and the TARG39A table model, all with 5-valve 3-waveband receivers.

Television receivers will also be displayed.

The Marconiphone Co. Ltd., Blyth Road, Hayes, Middlesex.

MASTERADIO (62)

To be shown for the first time at the exhibition will be a new table radiogram in a distinctively designed walnut veneered cabinet. It incorporates a 3-speed automatic record changer and covers short, medium and long waves. Also entirely new will be a portable electric gramophone known as "The Harmony" which plays 12-in records.

Television receivers will include two 17-in models with built-in Band III converters; one is a multi-channel table model, the other a console type with full-length doors. Some car radio sets will conclude an interesting display.

Masteradio Ltd., Fitzroy Place London, N.W.1.

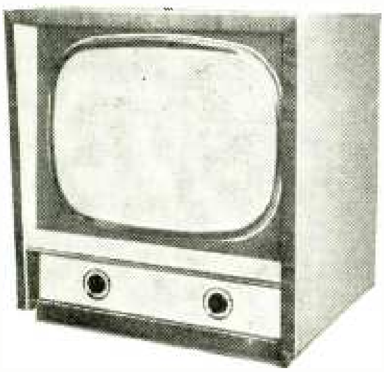
MULLARD (56)

For the amateur constructor this firm have produced a new design for a high-quality ten-watt amplifier, built around five Mullard audio valves—EF86 input, ECC83 phase-splitter, two EL84 output pentodes in push-pull and GZ30 rectifier. The response is almost flat from 10c/s to 20kc/s and harmonic distortion is below 0.4%. A booklet giving details will be available on the stand and the amplifier itself will be demonstrated in an associated room.

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

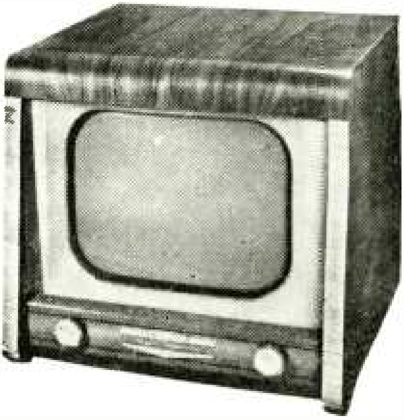
MULTICORE (100)

Designed to increase soldering speed, a 5-cored wire solder will be shown publicly for the first time. This contains a new flux (362) which in some applications permits the use of cheaper solder alloys containing less tin.

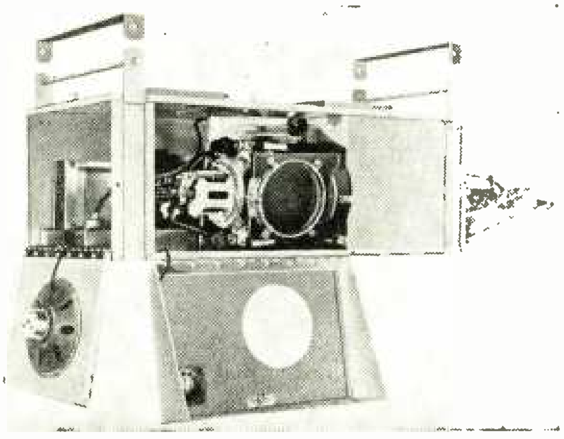


Murphy V250 two-band receiver with 17-in. tube.

Masteradio "Harmony" portable record player.



Philco 14-in. tunable television set, Model A1467.



Left: Nera front-projection television equipment for suspension from the ceiling.
Right: McMichael Model 354 mains/battery portable.

To demonstrate the large-scale use of Multicore solder in industry, the assembly and wiring of Ferguson television tuning units will be carried out.

Special soldering alloys to be shown include TLC, with a melting point of 145°C and "Consol" containing silver and having a melting point of 296°C.

Multicore Solders Ltd., Hemel Hempstead, Herts.

MURPHY (40)

This year's receivers are based on a chassis which is substantially the same for all models, the chassis differences between the 14-in V240 and the 17-in V250 being mainly the provision of higher voltages for the tube of the latter. Fringe-area models have flywheel sync, a gated a.g.c. circuit and a special noise limiter.

Provision is made in all models for Band-I and Band-III reception by means of a 12-channel turret tuner, the r.f. stage being of the cascode type. A direct-drive line-scan circuit is used.

Among sound-broadcast receivers, the new V198 and A212 will be shown. The V198 is an a.c./d.c. set with a built-in ferrite-cored aerial covering medium and long wavebands. The A212 is a larger table model for a.c. mains only and including one s.w. band. It has an internal plate aerial and provision for an external aerial.

Murphy Radio Ltd., Welwyn Garden City, Herts.

NAVY (204)

Operational conditions for under-water television are simulated by the provision of a large glass-sided tank on the ground floor, in which the camera is suspended, while the remote control and monitoring gear is in the gallery. Training exhibits are being provided by the two Naval electrical schools—H.M.S. Collingwood and H.M.S. Ariel—and the R.N.V.(W)R. Examples of radio communication equipment, electronic control and navigational gear and facsimile apparatus used in the Navy are being provided by Marconi's, Pye, Redifon, Muirhead, Decca, Murphy and G.E.C. for display and demonstration on this stand.

Admiralty, Whitehall, London, S.W.1.

NERA (208)

This firm will be showing projection television equipment for picture sizes ranging from 30in to 84in. A projector for ceiling mounting is designed to give a picture 4ft by 3ft.

A 12-channel converter for Nera receivers will also be shown.

Nera of England Ltd., Jeffries Passage, High Street, Guildford, Surrey.

PAM (4, 84)

Five television models will be shown, all for a.c./d.c. operation and with 13-channel tuners. A form of a.g.c. is provided in all but the cheapest 12-in Model T954.

Two table model sound receivers (955a and 965) employ basically the same 4-waveband chassis, which is also used in the Model 966RG radio-gramophone.

The Model 610 wide-range record player has a push-pull output driving an 8-in loudspeaker. The table cabinet is designed to reinforce the bass response when the lid is closed and the loudspeaker aperture is designed to give wide-angle diffusion of high frequencies.

Pam (Radio and Television) Ltd., 295, Regent Street, London, W.1.

PETO SCOTT (60)

The television receivers shown by this firm are designed primarily as Band-I sets with a switch change-over to an alternative tuner, which is physically a separate unit, for Band III. The tuner has a cascode r.f. stage and tuning is continuous by the adjustment of ganged cores to the coils. The circuit arrangement avoids any switching in r.f. circuits.

Among the sound equipment to be shown is a table-model receiver including one s.w. band, the R54, an automatic 3-speed record changer radio-gramophone and a record reproducer with auto-changer.

Peto Scott Electrical Instruments Ltd. Addlestone Road, Weybridge, Surrey.

PHILCO (36)

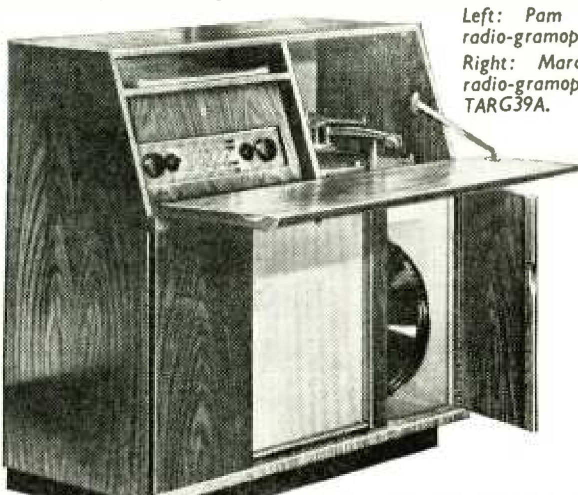
Among the new television sets to be shown is a 14-in table model incorporating a turret tuner for reception of Band-III programmes. It has a.g.c. and noise suppression on both vision and sound channels. Similar facilities are offered by a 17-in model, with the additional feature of a removable front to the cabinet which allows the tube and mask to be cleaned.

Three sound receivers on view are notable for having all metal parts and components fully tropicalized so that they can be operated in kitchens, etc., without fear of deterioration from steam and damp.

Philco (Great Britain) Ltd., Romford Road, Chigwell, Essex.

PHILIPS (96, 97)

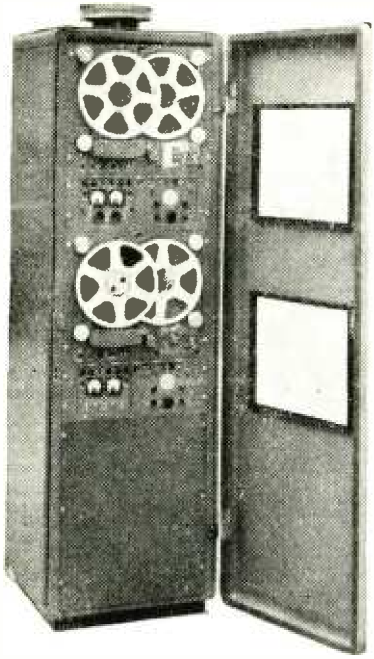
Of most topical interest on these stands will be an a.m./f.m. table receiver, Model 543A. It uses 7 valves and is designed for a.c. mains only. Another new exhibit will be a 5-valve receiver which also acts as



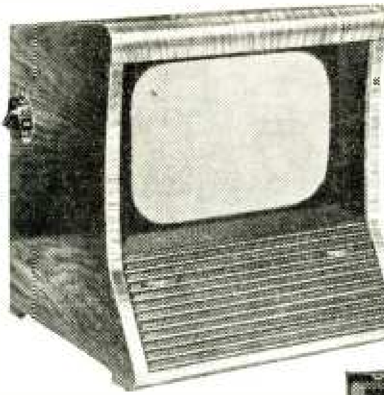
Left: Pam Model 966/RG radio-gramophone.

Right: Marconiphone table radio-gramophone, Model TARG39A.

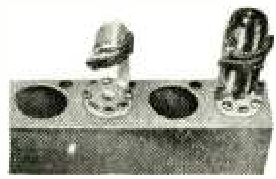
Right: Mullard range of valves for a.m./f.m. receivers.



Simon dual tape monitoring equipment.

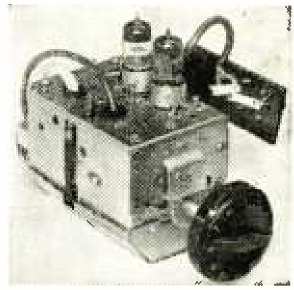


Pye 13-channel receiver, Model VT4.

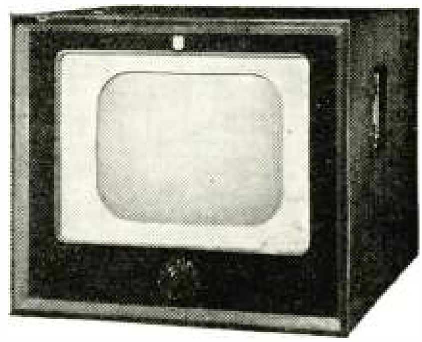


Plessey valveholder clip for mounting sub-miniature valves.

Germanium junction power rectifiers by S.T.C.



Pilot 13-channel Turret Tuner.



Philips 14-in. tunable television set, Model 1446U.

an alarm clock and will switch itself on and off at pre-set times. It is pre-set tuned for four stations, three medium-wave and one long-wave.

Amongst radio-gramophones and record players will be a new portable record player, Model AG2121, incorporating a 3-valve amplifier and, in the lid, a 7-in loudspeaker.

Two new table television receivers, one 14-in and the other 17-in, will incorporate a turret tuner for reception of B.B.C. and Band-III programmes.

Philips Electrical Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

PILOT (59)

Five television sets to be shown by this firm will all have provision for plugging in a tuner for reception of alternative programmes. Two are 14-in models and three are 17-in models. The 12-position tuner is a turret type covering 13 channels and costs 6 guineas. It has a dual control knob, with a numbered inner section for selecting the channel and an outer rim for fine oscillator tuning.

Among the sound broadcast receivers will be a new battery/mains portable (a.c./d.c.) in attaché-case form. It has a Ferroxcube built-in rod aerial and a 6in×4in elliptical speaker.

Pilot Radio Ltd., Park Royal Road, London, N.W.10.

PLESSEY (28)

This firm manufactures an extensive range of components, accessories and complete radio assemblies for the trade; their exhibit will consist of some of the newer and more interesting items now in production. A novel development is some special clips for sub-miniature valves, one is for chassis mounting like a valve-holder, the other holds two valves and can be fixed in any position. A strip switch for a.m./f.m. sets will also be shown.

Plessey Co. Ltd., Vicarage Lane, Ilford, Essex.

PYE (94)

One of the latest television receivers to be shown by this firm will be the 13-channel Model VT4. This is a 14-in table receiver with a tilted-forward screen, and the 12-position channel selection switch covers the five B.B.C. channels in Band I and channels 7 to 13 in Band III (channel 6 being brought in by oscillator trimmer tuning when required). The receiver also incorporates vision a.g.c., flywheel sync, vision interference inversion and frame fly-back suppression.

High-quality sound reproduction equipment will also be on view.

Pye Ltd., Radio Works, Cambridge.

R.A.F. (203)

Inspection and repair of v.h.f. airborne equipment as undertaken in the workshops of the Maintenance Command of the R.A.F. is to be demonstrated. Radio's part in weather forecasting will be illustrated in a typical Meteorological Forecasting Office set-up on the stand. Visitors will also see the complex assembly of radio and electronic equipment now carried in modern jet aircraft.

Air Ministry, Whitehall Gardens, London, S.W.1.

R.G.D. (93)

Four table-model and two console receivers comprise the R.G.D. television programme together with a combined television and radio-gramophone (Model C55). An improved synchronizing circuit ("Synchrolock") is a feature of the 17-valve circuit.

Twin 6½-in loudspeakers and a push-pull output stage are used in the "Two-Ten" table model radio-gramophone which takes its place with the R.G.D. console models. The "One-Ten" sound receiver is a 6-valve, 3-waveband model with push-pull output.

Radio Gramophone Development Company Ltd., Eastern Avenue West, Mawneys, Romford, Essex.

R.S.G.B. (209)

A wide variety of modern amateur-constructed sound and vision transmitting and receiving equipment will be seen on the R.S.G.B. stand. The emphasis is on equipment for use in the recently formed Radio Amateur

Emergency Network. V.H.F. and u.h.f. gear, some transistor transmitters and s.s.b. transmitting and receiving equipment will also be displayed. Historic amateur equipment and a clandestine receiver constructed in a prisoner-of-war camp will be seen.
Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.1.

REFLECTOGRAPH (207)

An ingenious continuously variable drive mechanism forms the basis of the magnetic tape recorders made by this firm. In addition to standard portable domestic recorders, a number of scientific and industrial machines will be shown. For some of these (Series P) a frequency response of 80 c/s to 15 kc/s ± 3 db is claimed at 7½in/sec.

Two systems of recording very low frequencies have been developed, one of which (Model PLF2), employing a differential pulse-code system, is capable of recording down to zero frequency and is independent of tape speed.
Rudman Darlington (Electronics) Ltd., Wednesfield, Staffs.

REGENTONE (38)

Sound receivers and radio-gramophones include the "Multi 99" table radio-gramophone incorporating a B.S.R. "Monarch" record changer. This model is also available in console form.

Three portable gramophones in tough-fibre cases are designed for hard use. They are the RP2 record player for feeding the pickup terminals of any broadcast receiver, the HG2 "Handy-Gram" with built-in amplifier and loudspeaker, and an automatic record changer version (AHG2).

Regentone television sets are being re-designed in detail and will be shown in new cabinets.
Regentone Radio and Television Ltd., Eastern Avenue West, Mawneys, Romford, Essex.

ROBERTS (102)

Portable sound broadcast receivers are associated with the name of this firm and in the current range Model RP4 (battery) and RMB (a.c. mains/battery) are now available in "rexine" covered cabinets. Models CR (a.c. mains/battery), BR (battery) and MR (a.c. mains) can be obtained in a wide range of colours.
Roberts Radio Company Ltd., Creek Road. East Molesey, Surrey.

ROLA CELESTION (3)

A loudspeaker designed to be operated under conditions of extremely high or low atmospheric pressure, and capable of surviving complete immersion in water is indicative of the wide field of activities of this firm. All sizes from 2½in to 18in diameter are available, including elliptical types and other special designs for receiver manufacturers. A wide range of output transformers, including hermetically sealed types for tropical climates will be shown.

Public address loudspeakers and line-matching transformers, under the Truvox marque, for powers from 3 to 120 watts also form part of this exhibit.
Rola Cèlestion Ltd., Ferry Works, Thames Ditton, Surrey.

S.T.C. (82)

Asymmetric resistors (working on a rectifier principle) suitable for digital computors will be shown under construction and as used in an electronic accounting machine. Also on view will be metal rectifiers for h.t. and e.h.t. supplies; battery charging rectifiers; high voltage aluminium rectifiers for aircraft power supplies; germanium junction power rectifiers and a germanium junction photocell suitable for direct operation of relays.
Standard Telephones and Cables Ltd., Connaught House, Aldwych, London, W.C.2.

SIMON (104)

Some fine examples of engineering construction will be seen in the professional and domestic magnetic tape recorders made by this firm. The long-duration tape monitors for recording air traffic control messages and the Model SP/1 portable recorder with 10-watt output are of great technical interest.
Simon Equipment Ltd., 48-50 George Street, Portman Square, London, W.1.

SKY-MASTS (30)

The design and erection of aerial masts and complete aerial installations constitute the main activities of this company and their exhibit will show in model and in actual form some of the more interesting types they produce.
Sky-Masts, Beadon Garage, Beadon Road, London, W.6.

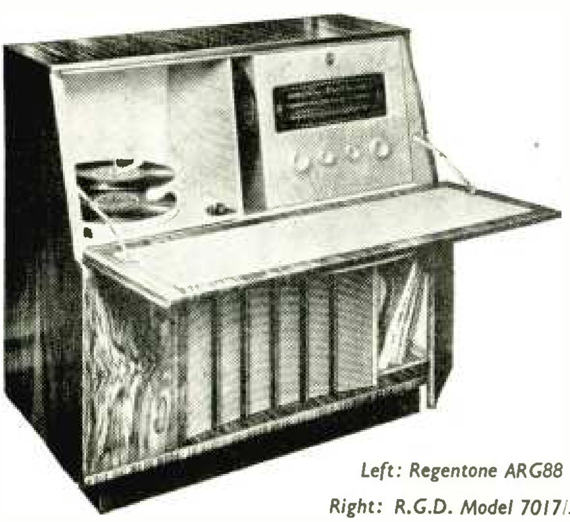
SOBELL (12)

Sound-broadcast, television receivers and radio-gramophones will be displayed on this stand. Most of the last include automatic record changers and all have three-speed motors and employ crystal pickups. The sound receivers have provision for a pickup and an external loudspeaker.

Most television sets include turret tuners for Bands I and III; the 12-in model, which does not, has provision for a Band-III adaptor. A form of a.g.c. is included in the sets and flyback suppression is fitted. The models include 12-in, 14-in and 17-in types and all are for a.c./d.c. operation.
Sobell Industries Ltd., Langley Park, Slough, Bucks.

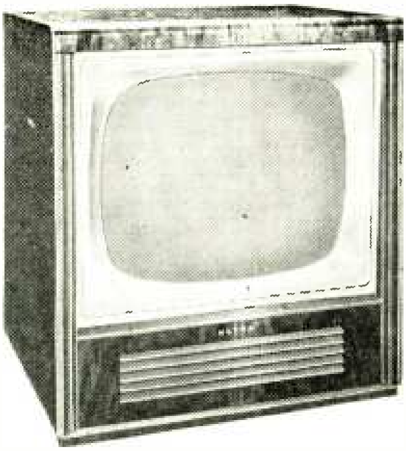
STELLA (55)

Four new table television receivers will be shown with provision for re-



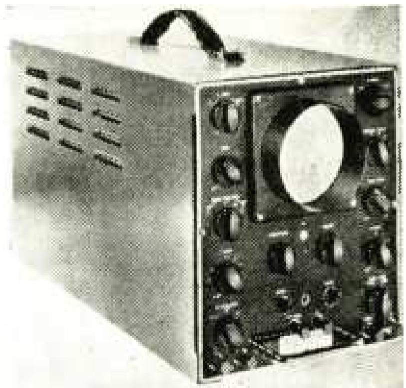
Left: Regentone ARG88 radio-gramophone.

Right: R.G.D. Model 7017/3C television receiver.

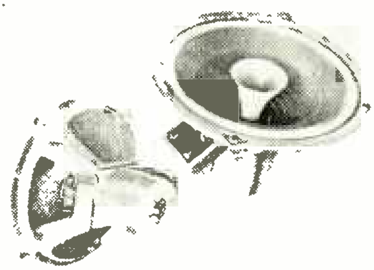


Ultra 17-in. table model, type V.9-17.

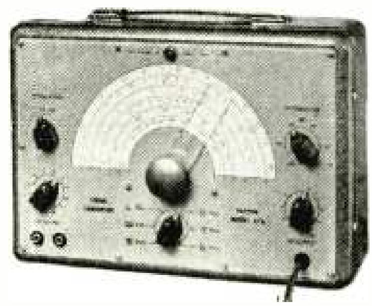
Vidor "Lady Margaret" handbag-size portable, but with 5-in. loudspeaker.



Telequipment oscilloscope Type 520 with 4-in. flat-faced tube.



Whiteley concentric Duplex loudspeaker.



Taylor Model 67A signal generator.

Waveforms type 405 television signal generator.

ception of Band-III programmes. The ST8314U 14-in model and ST8317U 17-in model are designed to incorporate a tuner when the programmes become available, while the 14-in model 6414U and 17-in model 6417U already include the tuners and have fine tuning and pre-set sensitivity controls for each channel.

An important feature of the model 102A sound receiver is bass compensation for low positions on the volume control. Also on view will be a portable record player with a pick-up needle pressure of less than one-third of an ounce.

Stella Radio & Television Co. Ltd., Oxford House, 9-15 Oxford Street London, W.1.

T.C.C. (101)

Among the many capacitors shown by T.C.C. this year will be six new ceramic types for incorporating in Band III television converters and in multi-channel dual-band tuners. Some are known as "Hi-K" and some "Low-K," the former being fairly large-capacitance bypass types for soldering into punched holes in the chassis. They take the form of lead-through, bushing and stand-off types. The "Low-K" are mostly pre-set variables with very small capacitance sweep; 0.5 to 3 pF and 1 to 5 pF are typical.

Electrolytic capacitors with very high insulation resistance are now included in the T.C.C. range and these are suitable for inter-valve a.f. couplings. A feature this year of the T.C.C. exhibit will be a demonstration of power-factor correction.

Telegraph Condenser Co. Ltd., Wales Farm Road, North Acton, London, W.3.

TAYLOR (54)

Some entirely new models of test apparatus are being introduced on this occasion; one is a 100-kc/s to 240-Mc/s signal generator known as Model 67A. Internal modulation at 400 c/s is provided.

Another interesting test set is the Model 92A; this is a television sweep oscillator covering 0-250 Mc/s and with a frequency deviation, or sweep, variable from ± 1.5 to ± 15 Mc/s.

Other new items include a d.c. valve voltmeter covering 1 to 1,000 V with an input impedance of 25 MΩ and a 10-c/s to 100-kc/s RC oscillator.

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

TELEMAX (81)

Two models of front-projection television receiver are being shown by this firm. The 2352 gives a 4-ft by 3-ft picture and is self-contained; the new CT1 is in two units, camouflaged as normal articles of furniture.

There will be a direct-view receiver, with a 17-in tube and a 12-channel tuner, which is unusual in being combined with a record player.

The exhibit will include a Band-III converter and an insulation test set covering 150 V to 10 kV

Telemechanics Ltd., 3 Newman Yard, Newman Street, London, W.1.

TELEQUIPMENT (80)

Television test apparatus is the speciality of this firm, who this year will show a 625-line Monoscope equipment which provides a complete video signal and synchronizing pulses to C.C.I.R. standards. Models for 405 and 525 lines have been available for some time.

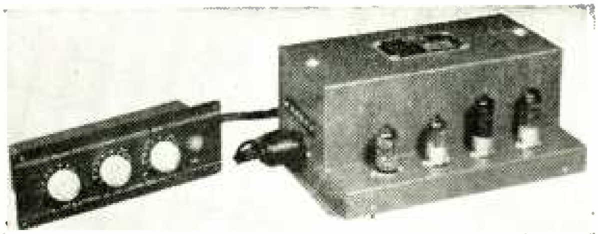
Specially designed for television work is the Type 520 oscilloscope embodying a 4-in flat-faced tube and a "Y" amplifier of exceptional performance. The "X" amplifier gives an expansion up to 5 screen diameters.

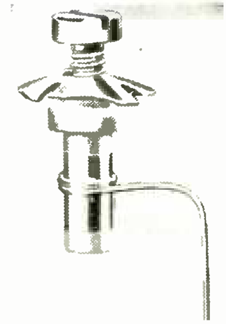
Telequipment Ltd., 1319A High Road, Whetstone, London, N.20.

TELERECTION (5)

Considerable thought has been given by Telerection to the problems involved in the design of multi-band television aerials and while final designs cannot very well be produced before all the facts of Band-III television are known, they will be showing some examples of how the problems can be tackled for both the semi-local and fringe area viewers.

Telerection Ltd., Antenna Works, St. Paul's, Cheltenham, Glos.





Left: Trix T41 domestic high-quality amplifier. Centre: Valradio tuner covering Bands I, II and III. Right: T.C.C. ceramic trimmer for use in TV tuners.

TELEVISION SOCIETY (205)

The equipment to be displayed has been chosen to illustrate the various aspects of television engineering covered by the papers read at the society's meetings. Reprints of some of the papers read during the past session will be available.

Television Society, 164 Shaftesbury Avenue, London, W.C.2.

TRIX (65)

Amplifiers and auxiliary equipment for every class of sound reproduction from portable "crooner" outfits to rack-mounted large-scale p.a. installations are made by this firm. Designed for high-quality music reproduction in the home, the Model T41 amplifier, with a power output of 3-4 watts, is of special interest. A separate control unit is provided with independent bass and treble controls and there are two inputs for use with pickups of all types giving maximum output for 3 mV and 130 mV.

Trix Electrical Company Ltd., 1-5 Maple Place, Tottenham Court Road, London, W.1.

ULTRA (69)

Receivers embodying tubes of from 12-in to 17-in will be exhibited. Because of the particular mask shape adopted, a somewhat bigger picture than is usual for the tube size is claimed. The tuning system has a switch channel selector giving a choice of one Band-I and two Band-III stations, the Band-III tuner being a separate unit.

In addition to a range of sound-broadcast receivers, a radio-gramophone will be on view. This is the ARG891 which includes space for record storage. A model for f.m. reception is available.

Ultra Electric Ltd., Western Avenue, Acton, London, W.3.

VALRADIO (29)

Reception of f.m. transmissions in Band II, as well as television transmissions in Bands I and III, is possible with the new multi-channel tuner to be shown by this firm. It uses a PCC84 cascode r.f. amplifier and a PCF80 frequency changer and covers 40-100 Mc/s in four steps and 170-225 Mc/s in two steps. Continuous tuning is provided over each step by ganged iron-dust cores and brass slugs in the coils.

Incorporating this tuner will be a new projection television set, giving a picture of 27in × 20¾in on a screen in the lid.

Valradio Ltd., New Chapel Road, High Street, Feltham, Middlesex.

VIDOR (87)

No fewer than five different portable sets will be shown this year; one, the "Lady Margaret," is entirely new and although no larger than a lady's handbag (8 × 8 × 4 in) it incorporates a 4-valve receiver, takes a 90-V battery and boasts a 5-in loudspeaker; the weight is 6¼ lb only.

Provision is made in the latest 14-in and 17-in television receivers for internally fitting a Band-III converter.

A special feature will be made of export type receivers, the batteries being protected against humidity and extremes of temperature.

Dry batteries of some 370 different types, ranging from those for torches to special models for nucleonic equipment, will be shown.

Vidor Ltd., West Street, Erith, Kent.

WAVEFORMS (75)

A new television signal generator will be on this stand. The Radar 405 provides an r.f. signal, tunable over Bands I and III, which is modulated by the correct sync pulses and a selection of test patterns. The sound and vision outputs are independently tunable and can be used together. The output is adjustable from 10 μV to 10 mV.

A more elaborate instrument, the type W90, will also be shown, together with a range of other test apparatus.

Waveforms Ltd., Radar Works, Truro Road, London, N.22.

WEARITE (74)

Principal interest on this stand centres on the Ferrograph magnetic tape recorder, which is available in many forms for scientific and industrial research as well as for domestic and professional sound recording.

A special version (2A/NH) of the Model 2A recorder will be shown, with tape speeds of 7½ and 15in/sec instead of 3¾ and 7½ in/sec. Another interesting version is the YDC with simultaneous dual-track recording for comparative analysis or stereophonic recording.

Wright and Weaire Ltd., 131 Sloane Street, London, S.W.1.

WESTINGHOUSE (2)

Tubular e.h.t. rectifiers will be prominent on this stand and the normal range will cover d.c. outputs of up to 15kV in single units with current outputs of between 100 μA and 8 mA. Copper-oxide instrument rectifiers, "Westectors" and germanium diodes will also be on view.

Westinghouse Brake & Signal Co. Ltd., 82 York Way, King's Cross, London, N.1.

WHITE-IBBOTSON (98)

Large-screen projection television receivers will be shown on this stand. The 4836 gives a picture 4ft × 3ft and is available in front- or back-projection forms. The 2418 and 2015 are rear-projection types and give pictures of 24in by 18in and 20in by 15in respectively.

Vision and waveform monitors will also be shown.

White-Ibbotson Ltd., Mortimer House, 37-41 Mortimer Street, London, W.1.

WHITELEY ELECTRICAL (105)

The cambric cone, introduced last year, has now been applied to the 12-in concentric Duplex and other loudspeakers in the high-quality range. A new dismountable "bass reflex" cabinet, which can be easily assembled, has been introduced for use with the 10-in and 12-in high-quality loudspeakers. Extension loudspeaker units with volume controls and optional push-button remote control will also be shown.

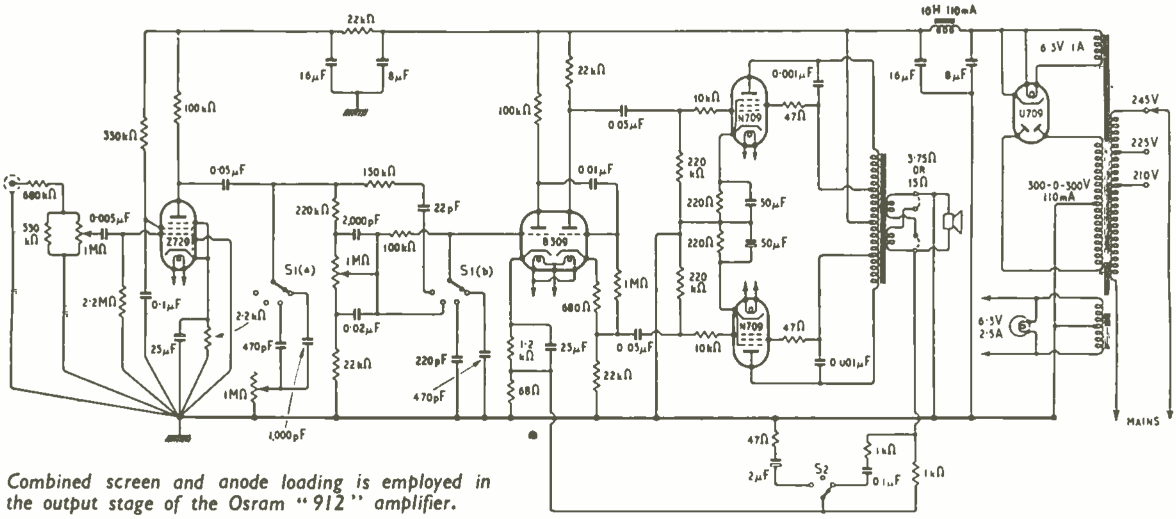
Sound reproduction is by no means the only activity of this firm, and the exhibit will also provide examples of a wide variety of components, including amplifiers, wavemeters, a.m. and f.m. transmitters.

Whiteley Electrical Radio Company Ltd., Mansfield, Notts.

WOLSEY (16)

To be shown this year will be a new "X" type television aerial with a "delta" matching section incorporated in one of the Vs formed by the crossed dipoles. Appropriately named the "Deltex" aerial it is said to give better matching between aerial and feeder. As neither dipole need be split and insulated at the centre it results in a far stronger construction. Like all other Wolsey aerials the "Deltex" is pre-assembled to simplify erection.

Wolsey Television Ltd., 43-45 Knight's Hill, West Norwood, London, S.E.27.



Combined screen and anode loading is employed in the output stage of the Osram "912" amplifier.

HIGH-QUALITY SOUND REPRODUCER

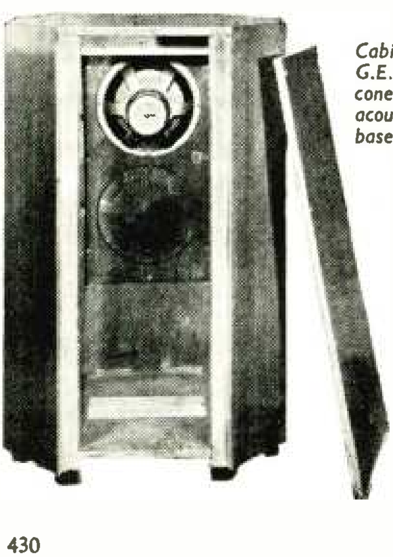
Osram "912" Amplifier and G.E.C. Metal-Cone Loudspeaker

NOW that the G.E.C. "F.R." metal-cone loudspeaker is in quantity production, the makers have decided to issue a design for an amplifier which will ensure that its full capabilities are realized. This design will be published as a booklet (price 3s 6d), which will also give details of a recommended cabinet for the loudspeaker.

The circuit type number "912" indicates that the frequency range is 9 octaves (30 c/s-16 kc/s) and that the power output is 12 watts. The first stage is a Z729 low-noise pentode, followed by a B309 double triode in which one triode acts as the second a.f. stage and the other as a phase splitter.

Two N709 pentodes in push-pull have the output load distributed between anodes and cathodes, thus giving a compromise between pentode and triode operation as far as efficiency and harmonic distortion are concerned.

Feedback is applied over the last three stages and can be modified by a switched RC network in the feedback loop to give a flat response or one with an approximately 5 db level lift or drop from about 3,000 c/s upwards. This is described as a "presence" control and when "in" has the effect of transporting the listener to the front seats of the concert hall where the ratio of high to low frequencies is higher than, say, at the back of the hall, where the increased proportion of reverberation and high-frequency absorption tend to depress this ratio. The device is admittedly artificial but the effects are more realistic than those which would be obtained with normal sloping tone control characteristics. Normal tone control is, of course, provided (between the first and second stage) to cope with variations in recording and pickup characteristics.



Cabinet designed by G.E.C. for the metal-cone loudspeaker. The acoustic vent is in the base.

The "F.R." metal-cone loudspeaker* in addition to its low non-linearity distortion is capable of a very uniform and extended frequency response when housed in a suitable enclosure. A very rigid cabinet of octagonal section has been developed in which unwanted panel resonances are suppressed, only the single Helmhotz resonance being applied at or near the fundamental cone resonance to control the impedance rise and extend the low-frequency response. The vent is situated in the centre of the cabinet, which is raised from the floor by four supports, the height of which tunes the acoustic resonance, since the air mass between the floor and base is in radial vibration. It is conceivable that, with this arrangement the resistive damping is increased. However this may be, the result is a remarkably smooth and full bass response down to 30 c/s which adds no trace of coloration to the reproduction of speech.

* See *Wireless World* Nov. and Dec. 1952.

Combination F.M./A.M. Receivers

Design Factors of Sets for the New B.B.C. Service

By G. H. RUSSELL,
Assoc.Brit.I.R.E.

FREQUENCY modulation broadcasting is to commence in this country in the near future. Special combination receivers will have to be provided for the reception of both the f.m. transmissions in the v.h.f. Band II, and the a.m. transmissions which will continue to be radiated in the medium and long broadcast bands.

The standards of f.m. transmission will be similar to those prevailing in America and Germany; 100 per cent modulation will correspond to 75 kc/s deviation, maximum modulation frequency will be 15 kc/s, and pre-emphasis corresponding to a time constant of 50 μ secs will be used. The nominal channel separation will be 200 kc/s, and judging from a preliminary list of stations it would appear that stations serving the same area will be separated by 2.2 Mc/s. Generally, the minimum field strength in towns may be expected to be in the region of 800 μV/metre, and in country districts about 250 μV/metre.

Translating this information into receiver requirements, we arrive at the following design data. The receiver should be tuneable over the whole of Band II; that is, 87.5 to 100 Mc/s, although initially only 88-95 Mc/s will be available for the f.m. service. Regardless of the modulation frequencies involved, the bandwidth will have to be made considerably greater than that theoretically required, to allow for oscillator drift; -3 db at ± 100 kc/s should be regarded as a minimum. In this respect, it is safer to err on the liberal side as the distortion produced on a f.m. receiver by mistuning is at least as great as that obtained on selective a.m. receivers. Taking into account the "capture effect" and the distribution of stations, a selectivity characteristic of -3 db at ± 150 kc/s would probably make a good compromise.

As the vast majority of these receivers will undoubtedly be used with the inevitable "piece of wire" acting as an aerial, a sensitivity of the order of 10 μV will almost certainly be required. Sensitivity in f.m. receivers means not only that the standard 50-mW output is obtained with a given r.f. input signal 30 per cent modulated, but also that the receiver limits satisfactorily with the same input. If satisfactory limiting requires a greater input than that required to produce standard output, it is this figure that expresses the true sensitivity of the receiver. Satisfactory limiting may be defined as that which produces an f.m. to a.m. ratio of not less than 30 db. For preference the figure should be in the region of 40 db. The f.m. to a.m. ratio expresses the difference in the output of a receiver produced by injecting consecutively (at the centre frequency) f.m. and a.m. signals both 30 per cent modulated. It is as well to point out here that the majority of f.m./a.m. signal generators available in this country to date show a distressing tendency to change frequency when the system of modulation is changed. As 100 per cent modulation corresponds to 75 kc/s deviation, it should be clear that 30 per cent modulation corresponds to 22.5 kc/s deviation.

General Considerations.—From the foregoing, the outline of the combination f.m./a.m. receiver becomes apparent. First, two tuners are required; one to tune the long- and medium-wave broadcast bands, and the other to tune the v.h.f. band. For obvious reasons these should be controlled by a single knob. Secondly, two separate intermediate frequency amplifier chains are required; one for the broadcast bands which will embody the usual selective amplifier operating at a frequency of about 470 kc/s, and the other a relatively wide-band amplifier operating at a considerably higher frequency. Thirdly, in all but a few cases, two detectors are required—one for a.m. and one for f.m. demodulation, the latter including, or being preceded by, some form of amplitude limiting. Fourthly, a method of switching both the wavebands and the systems must be devised.

In all but the most expensive receivers, the short waveband, which has been a feature of the majority of our receivers since the mid-thirties, may now be expected to disappear. In western Germany, where over 90 f.m. stations give almost complete coverage, even the long waveband has disappeared from what may be termed the standard receiver. This may eventually be expected to happen here when complete f.m. coverage is attained, but until then a long waveband will have to be provided in our receivers for the reception of Droitwich.

Due to the use of a higher value of intermediate frequency and the need for a considerably wider bandwidth, more stages of amplification are needed for f.m. than for broadcast reception. The usual method of obtaining this is to use the heptode section of the broadcast frequency changer as an extra i.f. amplifier, together with a second i.f. stage using a valve with a higher slope than is usual in broadcast receivers. A special series of valves has been made available for combination receivers. The Mullard range includes the ECH81 triode-heptode, the EF85 variable-mu pentode with a mutual conductance of 6 mA/V, and the EABC80 triple-diode triode. With the latter, two diodes are used for the f.m. demodulator and the third for detection and a.g.c. on the broadcast bands.

Delayed a.g.c. cannot be provided with this arrangement, but as a great deal more gain can be obtained from the i.f. amplifier than is usual in broadcast receivers, this should be of little consequence. Alternatively, a separate germanium diode could be fitted. A.G.C. is not generally used with f.m. receivers as minor variations in amplitude do not affect the receiver output, and the lack of a.g.c. provides extra limiting with large inputs. Both the ECH81 and EF85 are operated with relatively large screen resistors (22 kΩ and 56 kΩ respectively) which make it almost impossible to exceed the maximum permissible dissipation. With standard 470-kc/s i.f. transformers, the

EF85 stage gain will be far too high and instability will result unless this is reduced to manageable proportions. This can be achieved either by using i.f. transformers with a suitably low dynamic resistance or, possibly more simply, by switching in a supplementary cathode resistance. The conversion conductance of the ECH81 is 775 µA/V, and the mutual conductance of the heptode section is 2.4 mA/V when it is used as a straightforward amplifier.

V.H.F. Tuning Unit.—As the heptode section of the ECH81 is used as an i.f. amplifier for v.h.f. reception, it clearly cannot be used as a frequency changer at these frequencies. It is, furthermore, undesirable that it should be so used, as at v.h.f. it would give very poor gain in comparison with other methods. It would also require switching at v.h.f. which is something to be avoided as far as possible.

The v.h.f. mixer is therefore almost invariably a separate valve; triodes and pentodes being equally popular. Both types are usually employed as self-oscillating mixers; a circuit which gives a high conversion gain. In Germany, a triode self-oscillating mixer (EC92) is much favoured, but as the Germans tend to use this without a stage of r.f. amplification, oscillator radiation is a problem. To minimize this, the valve is used in a form of bridge circuit the function of which is to cancel out the oscillator voltages at the aerial. Its efficacy, however, seems somewhat limited, as one German receiver employing this circuit which the author tested showed 300 mV to be present across the correctly terminated aerial sockets. It is understood that this is by no means uncommon. As German receivers use an i.f. of 10.7 Mc/s and make use of the whole of Band II, it can be seen that the oscillator frequency actually falls within the band. It can only be assumed that this fact was taken into account when frequencies were allocated.

There can be no doubt that in this country such a practice would be frowned upon, and an r.f. stage should be regarded as a necessity. For the same reason, the use of a super-regenerative type of receiver is almost out of the question. Its high efficiency and apparent simplicity make it appear an attractive proposition, but as it makes use of a pulsed oscillator it could be placed under the heading of "small power transmitters." The power radiated by these oscillators is so high that it is doubtful whether an r.f. stage would provide adequate protection. To return to the r.f. stage, here again a choice between triodes and pentodes can be made; the triode being earthed-grid connected. As receiver noise is of little moment in f.m. receivers, the choice between triodes and pentodes for the mixer or r.f. amplifier is purely a matter of convenience. The choice is usually made by balancing amplification against cost.

Either permeability or capacitive tuning can be used; the latter being more convenient from a mechanical design standpoint. Tuning capacitors made specially for these receivers are now available. If permeability tuning is used, the r.f. stage can be pre-set tuned to the centre of the band to avoid alignment problems. Little is lost by so doing. One advantage of not having externally controlled signal frequency tuning is that the inter-valve circuit capacitance can be kept low, permitting a higher LC ratio to be obtained. A unit similar to that published in *Wireless World* recently[1], but designed for use on Band II, with an aerial step-up transformer and a 1:1 i.f. transformer, will give a gain from the aerial input to the secondary of the i.f. transformer considerably in excess of 100. One last word about the usefulness of the r.f. stage. Quite apart from the fact that it isolates the oscillator, it is well worth the extra cost because a well-designed stage will provide appreciable rejection of spurious responses as well as worthwhile gain.

I.F. Amplifier.—A typical i.f. amplifier for a combination a.m./f.m. receiver is shown in Fig. 1. As can be seen, system switching takes place at intermediate and audio frequency. Great care must be taken with the layout of the switch wiring, and particularly the relative positions of the grid and anode wires. German designers tend to use a slider switch which runs almost the whole length of the chassis in some cases. This enables the switching of each stage to be carried out as close to the valve as

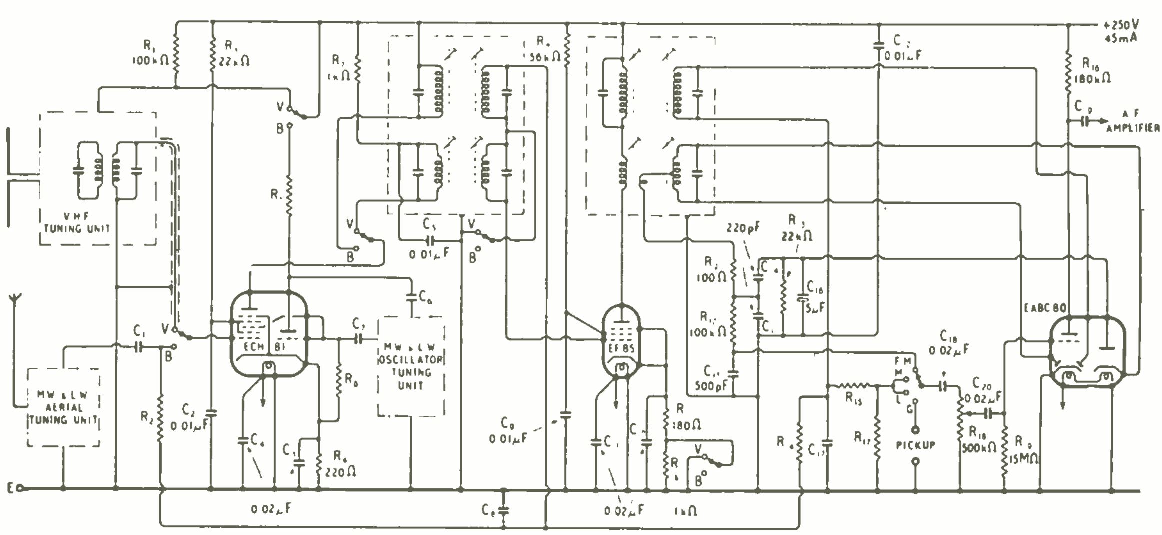


Fig. 1. Circuit diagram of i.f. amplifier and detectors for combination a.m./f.m. receiver. "V" indicates switch position for f.m. reception and "B" that for medium- and long-wave reception.

possible. This type of switching is facilitated in German receivers by the fact that only a two-position switch is necessary. British receivers will be complicated by the necessity for incorporating a long waveband. Nevertheless, a similar arrangement will probably be necessary for switching the ECH81 anode and the EF85 grid and cathode. Care must also be taken with the output lead of the v.h.f. unit. It may not always be possible to place the output connections of the unit close to the switch, and if the connecting lead is more than an inch or two long it must be screened. Low-capacitance screened lead should be used and the i.f. transformer secondary tuning capacitance reduced accordingly.

The necessity for switching the ECH81 anode and the EF85 grid may not at first be clear. The reason for switching the ECH81 anode is that many frequencies are present at the anode of a mixer, and the presence of two circuits tuned to different frequencies in the output could cause undesirable effects. One obvious one is the possibility of unwanted signals passing through the wrong channel and reaching the audio section through leakage across the switch. The switch in the EF85 grid circuit is intended primarily to short-circuit the a.g.c. line when using the higher i.f. in order to prevent stray coupling between the i.f. stages. It incidentally performs the additional function of short-circuiting the secondary of the first 470-kc/s i.f. transformer which results in slightly improved v.h.f. sensitivity.

The reason for R_1 may also appear obscure. It is included in order to comply with the valve manufacturer's requirements which do not tolerate operating high-slope valves with their heaters on but with no high tension. Nevertheless, it is desirable to stop the v.h.f. unit operating when the receiver is being used for broadcast reception, and R_1 covers both requirements by reducing the h.t. to some 20 volts.

The f.m. discriminator is a ratio detector of the unbalanced variety; R_{13} is the load and C_{16} the stabilizing capacitor. R_{12} and C_{13} form the de-emphasis circuit. It will be noticed that grid current biasing is used with the EABC80 triode. This is preferable because it enables the cathode to be taken directly to chassis potential. As this cathode is common to one of the ratio detector diodes, this circuit reduces the possibility of unbalance in the detector. It incidentally shows a slight saving in cost over the cathode biasing arrangement. The distortion introduced by this stage is remarkably low and no fears need be felt on this score.

F.M. Detector.—There are many forms of f.m. detector, most of which are only of academic interest to domestic receiver designers as they are either very inefficient, or they require additional valves to act as limiters. Information on these can be obtained from the literature and it is proposed to confine this section to a discussion of two types only.

Until 1947, limiting in f.m. receivers was nearly always provided by two saturated amplifiers preceding the discriminator. That tended to make these receivers rather expensive. It would not be far from the truth to state that if a simpler solution to the limiting problem had not been found, f.m. broadcasting on a large scale would have been made impossible through the lack of listeners. Combination receivers are expensive enough without the additional cost of two extra stages! In fact, two solutions were found; the nonode valve and the ratio detector.

The nonode valve, designated EQ80 in this country, is a "gating" valve. Two voltages having a phase angle between them of 90 deg are applied to the third and fifth grids. The voltages at the first and second grids are held constant and anode current can only flow when both the third and fifth grids are positive. As in a pentode, if the first and second grid voltages are held constant, the electron current is likewise constant. Therefore, in the nonode valve any change in anode current will be solely a function of the phase difference of the voltages at the third and fifth grids. If this phase difference is made to vary in accordance with an f.m. signal, the valve will convert changes in frequency to changes in amplitude, and the valve will become an f.m. demodulator. As the electron current is constant, the valve will not respond to changes in amplitude of the input signal and limiting is therefore automatic. There is, however, one serious

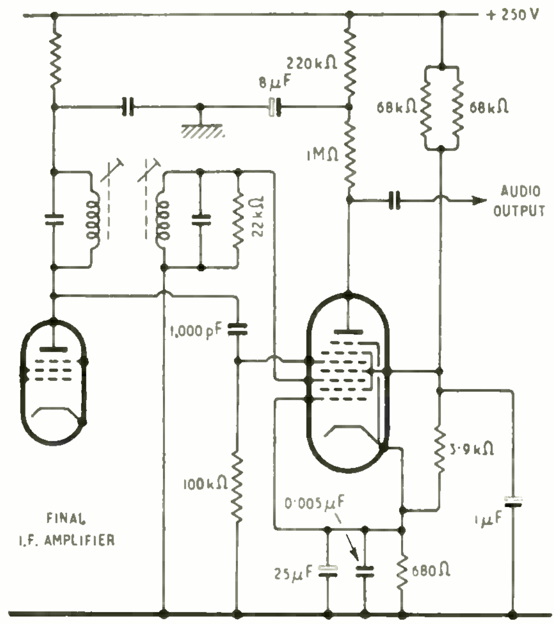


Fig. 2. Typical circuit of a nonode f.m. detector.

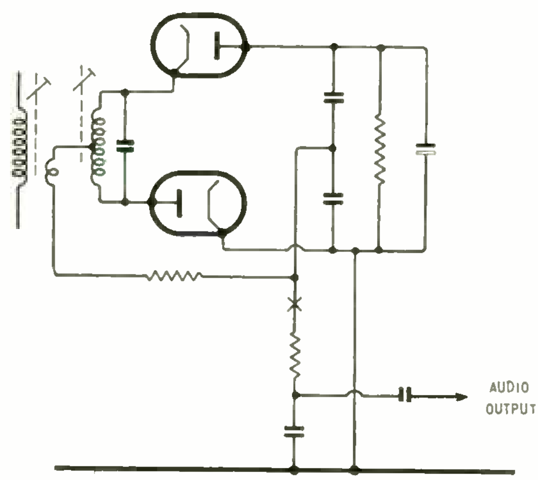


Fig. 3. Circuit diagram of ratio detector.

drawback. For efficient limiting, over 11 volts peak is required at grids 3 and 5, and as the phase difference is usually obtained by means of a transformer, something of the order of 23 volts peak must be provided across the primary. Needless to say, at the intermediate frequencies generally used in f.m. receivers this is difficult to obtain, and the saving on the conventional phase detector with two limiters is probably one valve. Nevertheless, once limiting does take place, the results are excellent. A typical circuit is shown in Fig. 2.

It is not proposed to go into any detailed description of the operation of the ratio detector, as this has been dealt with elsewhere[2]. The circuit is shown in Fig. 3. As can be seen, it bears a resemblance to the conventional phase detector but with two major differences. The diodes here are connected in series and the resultant voltage developed across the load resistance is stabilized by means of a large capacitor. This capacitor holds the amplitude constant and limiting is therefore automatic. Satisfactory limiting can be obtained with about 6 volts input. As the loading is heavy, a form of matching is used between the primary and secondary of the discriminator transformer. Possibly the most important factor in the design of the ratio detector is what the designers have termed the S/P ratio; that is, the ratio of secondary to primary voltage. On this depends whether the detector will limit satisfactorily, if at all. After all other parameters have been fixed, the S/P ratio becomes a function of the coupling between the primary and the secondary, and therefore between the primary and the tertiary.

An easy method of adjusting the coupling is during alignment. A d.c. meter (low loading) is placed across the stabilizing capacitor and an unmodulated signal is injected into the receiver. All i.f. circuits except the secondary of the discriminator transformer are adjusted for maximum d.c. output. The meter is then transferred to the audio take-off point (point X in Fig. 3) and the secondary of the discriminator transformer is adjusted to give a d.c. voltage half of that which was obtained across the stabilizing capacitor. The primary may then require a slight re-adjustment after which the secondary setting should be checked. This process should be repeated until no further adjustment is necessary. The signal is then amplitude modulated and the point of maximum limiting should occur within about 10 kc/s of the alignment frequency. If it does not, the position of the tertiary winding should be adjusted with relation to the primary. The alignment process must then be repeated. The whole process must be repeated as often as is necessary until the point of minimum a.m. response does fall within about 10 kc/s of the alignment frequency. If it does not occur anywhere within the permissible range of adjustment of the tertiary winding (that is, between the top and bottom of the primary winding) the transformer has been incorrectly designed. It will be noted that it is not absolutely necessary to use an f.m. signal generator to align this detector. The need for such a generator will only arise if some obscure fault develops, or for more involved tests.

The ratio detector has enjoyed great popularity both in America and in Germany, and will no doubt become just as popular here. It is simple, reasonably sensitive, and f.m./a.m. ratios of 40 db and more can be obtained in practice with quite low inputs. It has another advantage in that the sideband responses are small and it tends to limit even on random noise. The result of this is extraordinarily low interstation noise. This is a great advantage in domestic receivers as it is doubtful whether most people would appreciate the colossal din, common with receivers using other types of detector, that occurs when tuning from one station to another.

Intermediate Frequency.—The choice of an intermediate frequency is, as usual, a difficult one. The designers of the ratio detector chose 10.7 Mc/s as being the highest frequency that would give a reasonably high gain per stage. Unfortunately, this frequency has the drawback of causing the fundamental oscillator frequency to fall in Band II, and the second harmonic to fall in the middle of Band III. In spite of this, 10.7 Mc/s has virtually become standard in both America and Germany.

The same considerations hold good for this country. Although initially an i.f. of 10.7 Mc/s may not cause the oscillator to interfere with broadcast reception in Band II, it will almost certainly affect the public services operating in Band II and to the commercial television services in Band III. It is highly debatable whether radiation in mass-production receivers can be kept within the limits laid down by B.R.E.M.A. The radiation problem is further complicated in f.m. receivers by the fact that the majority will not be used with a matched aerial. The piece of wire that will probably stand proxy for an aerial will almost certainly increase the nuisance value of the receiver. For this reason it is suggested that the oscillator voltage at the aerial socket should be measured without the usual terminating resistance.

Any frequency above 12.5 Mc/s will keep the oscillator out of Band II, but to keep its second harmonic out of Band III requires an i.f. above 20 Mc/s. For the same stability margin this frequency will only give half the gain per stage that can be obtained with 10.7 Mc/s. Even so, the sensitivity of the receiver should be adequate, and the higher frequency has advantages to offer. It will give increased protection from spurious responses; an important point when it is remembered that television stations in Band III could cause interference due to the oscillator second harmonic. Another advantage is that the farther removed the signal frequency is from the oscillator, the greater will be the protection against radiation given by the signal-tuned circuits. A minor advantage is that it makes the design of a receiver with a pre-set tuned r.f. stage easier by keeping the oscillator frequency well away from the centre of the band.

The Pseudo F.M. Receiver.—It will have become quite clear by now that combination f.m./a.m. receivers are going to be somewhat more expensive than the standard 4+1 domestic receiver we have been used to. In the circumstances, it was only to be expected that attempts would be made to produce something considerably cheaper—if only for use in high signal strength areas. It is well known that f.m. signals can be received on an a.m. receiver by the simple expedient of tuning down the slope of the selectivity characteristic[3]. This is often referred to as slope-detection. This form of detection has many drawbacks. It is very inefficient, it provides no limiting, and it gives two tuning points for each station. The use of it is only justified by its simplicity and cheapness.

A receiver using a slope-detector for f.m. reception has been produced in Germany; the circuit is shown in Fig. 4. It can be seen that the receiver consists of three valves plus rectifier. The first valve is a v.h.f. triode (EC92) used as a self-oscillating mixer

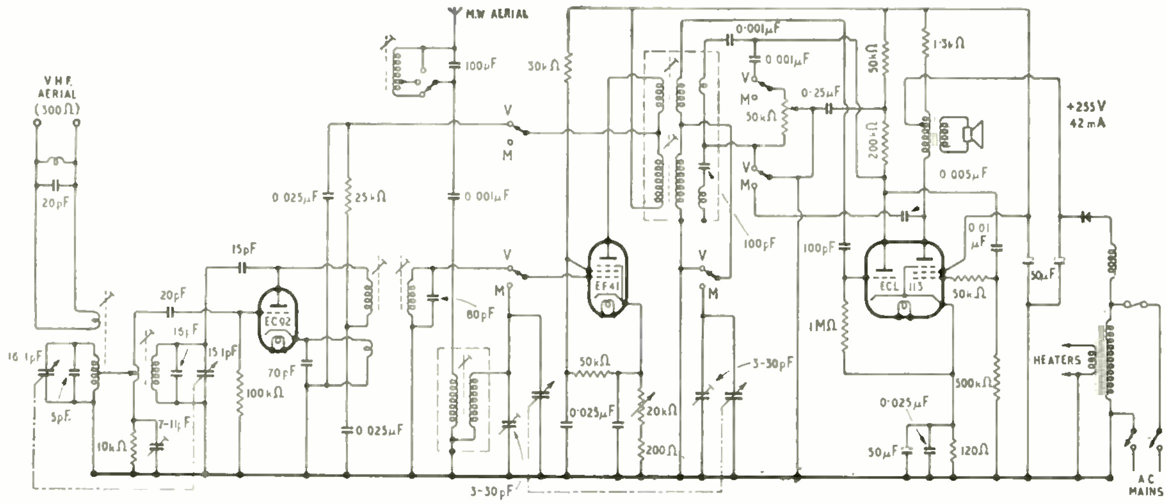


Fig. 4. Circuit diagram of German Grundig f.m. a.m. receiver, Model No. 810, showing use of slope-detector for f.m. demodulation. "V" indicates switch position for v.h.f. and "M" that for medium-wave reception.

on v.h.f. only. It incidentally illustrates the typical way in which this valve is used. The second valve (EF41) does service as an i.f. amplifier on v.h.f. and an r.f. amplifier on medium waves. The final valve (ECL113) is a triode-pentode, the triode section acting as a leaky-grid detector on both bands, the pentode being the audio output valve. Volume is controlled by a variable resistance in the cathode of the EF41, and a potentiometer in the anode circuit of the detector provides a reaction control on medium waves and a tone control on f.m. Whether for f.m. or a.m. reception, this receiver is only suitable for use in high field strength areas, and it is not known what success it has had.

This receiver has no r.f. stage, nor does it provide any form of limiting. As far as this country is concerned, such a circuit might conceivably fill a temporary need as a converter, but as a receiver it should surely be rejected. Quite apart from the ethics of the case, it is doubtful whether such a receiver would be capable of any better performance on f.m. than the standard broadcast receiver gives on medium and long waves.

Audio Amplifier.—The B.B.C. has stated that it is introducing v.h.f. broadcasting, "not as a complete substitute for long and medium wavelengths but as a powerful reinforcement of the sound services." We may therefore take it that fidelity will only be a secondary consideration. Taking into account the high-frequency attenuation of land-lines and the frequency response of studio equipment, it will only be on rare occasions that full advantage will be taken of the upper modulation frequency limit of 15 kc/s. This, however, need not make us downcast, as reception in many places will be considerably better than that which is obtainable on medium and long waves. It is suggested that in combination receivers the distortion level should not be higher than 2 per cent at the maximum rated output, and should preferably be of the order of 1 per cent. To attain these figures will require a substantial amount of negative feedback with a consequent reduction in amplification. The amount of feedback that has to be used may be so great as to reduce the sensitivity of the receiver to a level which is below that required. In this case, it may be thought

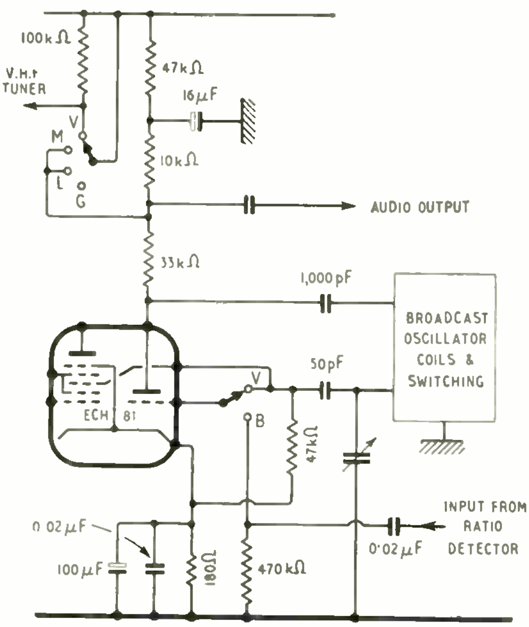


Fig. 5. Circuit diagram showing the method by which the triode section of the ECH81 can be used as an audio amplifier on v.h.f. without detriment to its function as an oscillator on medium and long waves.

worth while to use the otherwise idle triode in the ECH81 as an extra audio amplifier on v.h.f. The method by which this may be done is shown in Fig. 5. Hum is the greatest problem here, and extra smoothing must be used in the anode supply. Even then, full use of the valve cannot be made, and it will be noticed that only one-quarter of the anode load is used. This keeps the hum level low and enables the stage to give a useful power gain of over six times.

Results.—Three receivers comprising an EF80 preset tuned r.f. stage, EF80 self-oscillating mixer, ECH81 i.f. and a.f. amplifiers, EF85 i.f. amplifier, EABC80 ratio detector and a.f. amplifier, EL85 power amplifier and EZ80 mains rectifier, used in a similar manner to that described in this article, had sensitivities of 3, 4 and 9 μV respectively, and f.m./a.m. ratios of between 36 and 40 db at these signal levels. The intermediate frequency was 19.5 Mc/s. Bass boost at 80 c/s was between 4 and 5 db with reference to 400 c/s, and the frequency response with pre-emphasis was level up to 8 kc/s. Overall distortion at 1.5 watts output was in the region of 2 per cent.

Conclusions.—It was mentioned in the "Second Report of the Television Advisory Committee, 1952," that the additional cost of incorporating v.h.f. in new receivers will be of the order of 30 per cent. It was also stated that the additional cost would be greater unless the receivers were mass-produced. Whether these receivers can be produced on anything like the scale of the 4+1 receiver will depend on two factors. The first is the speed with which the B.B.C. are able to erect the stations, and the second is whether the ordinary man-in-the-street is going to think it worth while to spend that extra 30 per cent on his receiver. If demand is great enough, we may be well on the way to building up a thriving industry in a.m./f.m. receivers. In this case, it may be possible to reduce the 30 per cent substantially, and that will justify all the arguments that have been made in favour of f.m. broadcasting.

References

[1] Russell, G. H., "Band III Convertor," *Wireless World*, Vol. 60, No. 5, May, 1954, p. 211.

[2] Seeley, S. W., Avins, J., "The Ratio Detector," *RCA Review*, June, 1947.

[3] Sturley, K. R., "Radio Receiver Design," Part II, Chapman and Hall, 1947, p. 335.

Colour Television Tests

By J. FRANKLIN

IF any television experimenters in London happened to have their sets running after programme hours during July they may have been lucky enough to see some strange things on the screen. The things in question, which I saw quite by chance on my receiver, were orderly patterns of white dots on a synchronized, but otherwise blank, raster. Sometimes the patterns had a bar or several bars across them and at other times they were quite plain.

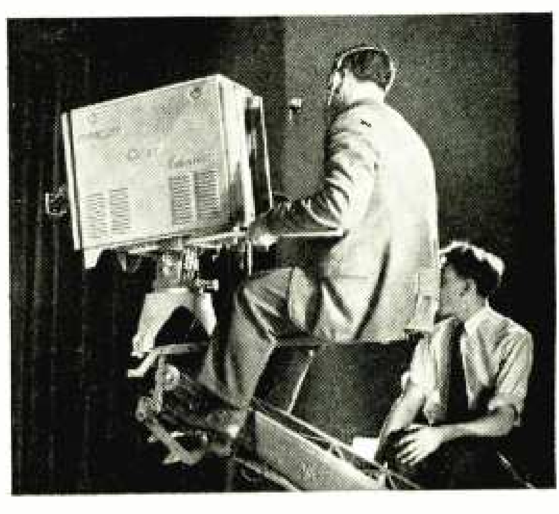
Having been following developments in colour television pretty closely, I realized immediately that the B.B.C. were transmitting a sub-carrier frequency on the main 45-Mc/s carrier wave from Alexandra Palace—a sub-carrier such as would be used for conveying colour information in a compatible colour television system of the N.T.S.C. type. As is generally known, this sub-carrier in the N.T.S.C. system enables the colour information to be transmitted within the same video band as the monochrome signal, and its frequency is chosen so that the colour sidebands are interleaved between the monochrome sidebands.

The great problem which British television people seem to be faced with at the moment is whether or not we can adapt the N.T.S.C. type of colour system to our existing 405-line standards. And this depends to some extent on whether the system is compatible enough. In short, is the presence of a sub-carrier and its resultant pattern on the screen going to cause too much deterioration of our pictures? I imagine that the B.B.C. were attempting to answer this question by arranging a series of test transmissions of a sub-carrier signal so that observations could be made on typical receivers. An interesting problem here is: what is the best frequency for the sub-carrier?

In the June issue of *Wireless World* a report was given of a British version of the N.T.S.C. colour television system developed by Marconi's, and in this the sub-carrier used was approximately 2.66 Mc/s. I therefore assumed that the B.B.C. were transmitting something comparable with this. Tests with an absorption wavemeter, however, showed the frequency to be more like 2.8 Mc/s, or perhaps slightly under. This higher frequency, of course, would give a finer and less visible dot pattern on the screen than in the Marconi system, and I personally found that I could not see the dots when I moved to a distance of about 4-5 feet from the screen.

On the other hand, the higher the sub-carrier frequency the more likely is the colour signal to interfere with the sound channel of the system. I presume that the bars I saw on the screen were a form of modulation on the sub-carrier to test for this effect (probably square-wave modulation). There was, in fact, a perceptible low-frequency noise in the loudspeaker when these bars appeared, but it did not strike me as being particularly obtrusive. No doubt the amount of this interference would vary with different receivers.

Presumably some organized observations were made on these test transmissions, apart from the clandestine ones such as my own, and it will be interesting to see the results when they are eventually published.



Colour television camera used with the Marconi system referred to in the article. It has only two pick-up tubes (one for high-definition monochrome information and the other for low-definition colour) and is notable for its small size.

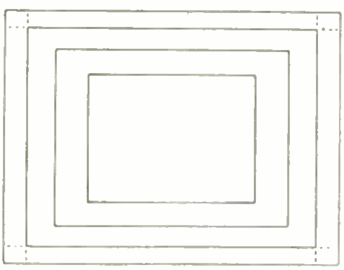
LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents

"*Why Lines?*"

THE "Lissajous" scanning system proposed by F. P. Hughes (your August issue), if it earns full marks for originality surely merits none for practicability.

If one inscribes three similar and symmetrical rectangles within the screen so that the smallest is one quarter of the whole screen area, and the area between each rectangle and the next larger is also one quarter of screen area, it is clear that with B.B.C. standards the spot will be in each of the four equal areas for approximately 22 per cent of total transmission time, the remainder being lost to synchronizing pulses, etc. With "Lissajous" scanning the spot will be 11 per cent of transmission time in the central area, 14 per cent in the next area as one moves outward, 19 per cent in the next and 56 per cent in the outmost fringe. Moreover the spot will take as long in total to scan the four small rectangles in the corners (comprising together 1.8 per cent of screen area) as it does to scan the important centre area. In fact the transmission time wasted on the edges and corners of the picture will be very much greater than that "wasted" in sync. pulses in conventional systems and definition in the important central area will be equivalent to a 30 per cent cut in line number and 50 per cent in bandwidth as compared with the conventional.



Even more serious would be the consequences of the timebase waveform departing in the slightest degree from purity. As the screen is being scanned equally from left to right and from right to left any phase drift will shift half the picture elements one way and the other half in the opposite direction. At screen centre a drift of 0.001 c/s will cause the picture elements to separate by approximately 0.006 of the total picture width, giving a "defocus" effect equivalent to complete loss of the one-megacycle bands on the test card. Similar loss of definition, but varying in complex fashion from place to place on the screen, would result from 0.6 per cent of *total* harmonic distortion. As these results would be additive on some parts of the screen, it would probably be necessary to specify tolerances of not more than 0.0002 c/s max. phase drift and 0.1 per cent total harmonic distortion for the timebase oscillators. Such a specification is probably not unattainable, but the cost and complication would obviously be prohibitive.

Teddington, Middx. S. HOSKING TAYLER.

Why A.G.C.?

I SEE from p. 40 of the August issue that "Diallist" proposes to build a modified version of my midget sensitive t.r.f. receiver (described in the April issue) without a.g.c. A.G.C., he maintains, is unnecessary because the receiver is intended only for reception of local stations which, in his locality, are free of fading. Surely "Diallist" isn't under the impression that a.g.c. is used only to combat fading? It has another merit, equally important; namely, that it ensures equal volume from all signals. This fully justifies its inclusion in a local-station receiver. "Diallist" is indeed fortunate if all his local transmissions are of equal strength and, if they are not, he will need to reset the volume control after each tuning adjustment. The inclusion of a.g.c. avoids this, making operation easier and prolonging the life of the volume control potentiometer.

Although it may not apply in this particular case, a.g.c. is sometimes used to avoid the application of large signals to the detector. Such protection may be necessary if the detector overloads easily (as anode bend detectors do) or if the detector may be damaged by large signals (as some crystals are).

J. L. OSBOURNE.

Ionic or Iontic?

PEOPLE speaking languages of Anglo-Saxon or Latin origin employ, generally successfully, a great number of technical and scientific terms derived from the Greek. Occasionally, though, in the process of adaptation, there is a regrettable loss of clarity and precision.

An example of successful use is the word *ion*, which is the neuter present participle of a Greek verb meaning "to go." But non-Greek technologists, in coining derivatives and compounds of this useful word, have introduced error and confusion. *Ionic order* (architectural), *Ionic school* (philosophic), etc., refer to the ancient Greek land *Ionia*. *Ionic* is a synonym of *Ionian*; therefore, *ionic bombardment* might (and should, by the rules of language) refer, say, to a naval action off the Ionian Islands! The mythological Greek priestess Io ('Iω), sweetheart of Zeus, who gave her name to these islands, bore no relation whatever to the electrically charged atoms, molecules or radicals in which the radio engineer is interested. She also had nothing to do with the new radio-active isotope *ionium*.

To avoid confusion, derivatives of *ion* should be formed from the genitive *iontos* (*ιοντος* which gives us the root *iont-*, or sometimes, for the sake of euphony, *ionto-*.

The correct practice has already been adopted by the medical profession in the word *iontophoresis* (introduction of ions into human tissues). Radio technologists and physicists should, I suggest, follow suit by changing, for example, ionize into *iontize*, ionosphere into *iontosphere*, ionium into *iontium*, etc.

DIONYSIUS J. BATAIMIS.
Hellenic National Broadcasting Institute,
Athens.

Electronics and Automation

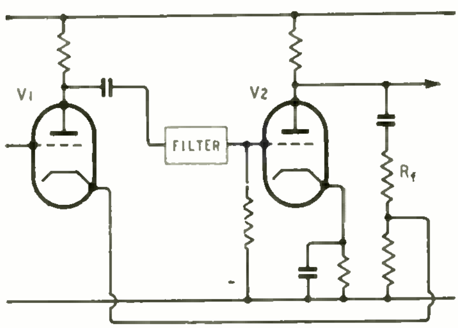
IN your report on a debate at the Brit. I.R.E. Convention ("Industrial Electronics," *Wireless World*, August, 1954, p. 358) you mention a discussion on the possibilities of flexible machines which could be programmed for different tasks as required: these would in fact be something like the original concept of a Robot; i.e., a mechanical substitute for a human being. One attempt to mechanize a production process in terms of "replacing human labour" has convinced me that this is a wrong approach. Human labour is very flexible and fairly cheap (especially if female) and a machine to carry out precisely an adjustment such as tuning a circuit to resonance, which at present is done by hand, is prohibitively complex. Not least of the difficulties is that of making the robot connect automatically with the appropriate part of different models of equipment.

The future of "automation" (factory production with the minimum of labour) lies mainly in the development of appropriate manufacturing techniques, such as printed circuitry in radio and electronics, and the pressed-steel body in place of the coach-built body in the automobile industry. The future of industrial electronics lies in doing things which the average human operator *cannot* do successfully. This applies particularly to fast-moving flow production; e.g., colour printing, textile manufacture, continuous steel strip mills, but it is also beginning to find application in precision machine tools. Whenever the quickness of the machine deceives the eye, or the potential accuracy of the machine is greater than that of human hand and eye, there may be an essential job for electronics.

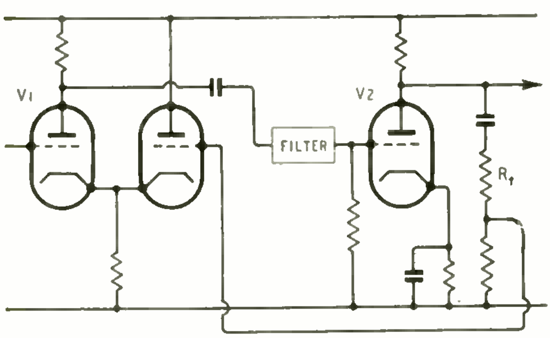
Birmingham. D. A. BELL.

Feedback Circuits

THE well-known feedback circuit (diagram (a)) is fully discussed in "Radio Designer's Handbook," p. 334. However, one soon finds out when trying to apply the circuit that either the anode load of V_2 becomes inordinately low or that the cathode load of V_1 becomes inordinately high with anything more than a small feed-



(a)



(b)

back ratio. These snags disappear when the feedback is applied to the grid of a cathode follower which is direct coupled to V_1 (diagram (b)). It is possible to vary the feedback between wide limits without upsetting the working characteristics of either V_1 or V_2.

I am using this circuit in a pre-amplifier with a parallel-T whistle filter between V_1 and V_2. Coupled to a Baxandall tone control (*Wireless World*, Oct. 1952) the whole arrangement works very well, is silent, stable and, judged by ear, of high fidelity.

It is possible that this circuit may be discussed somewhere in the literature and if one of your readers could enlighten me I would be grateful.

Burgess Hill, Sussex. A. V. SLATER.

Vector Diagram Conventions

IN his July article, "Cathode Ray" has advocated that certain conventions should be adopted to ensure that there should be only one correct voltage vector diagram to correspond to any given circuit diagram. The suggested conventions involve the addition and placing of vectors in an order uniquely determined by the circuit configuration. The conventions thus imply a slight restriction on the commutative law of addition of vectors, and also on the usual understanding of a graphical vector as having length and direction but no defined position.

In my view, although it is desirable in every problem to establish a defined relationship between the sign convention for the circuit diagram and the sign convention for the vector diagram, it is undesirable to extend this to "a perfect tie-up between circuit and vector diagrams" in the rigid one-to-one manner that has been advocated by "Cathode Ray."

"Cathode Ray" has invited his readers to point out any flaw in the system which might account for its lack of general acceptance since it was first proposed in 1951. It is possible that this may reside in the restriction to which the diagrams are subject when an attempt is made to develop them into vector loci. For example, with reference to Fig. 14 of the July article, and considering a constant current condition, diagram (a) would provide the most convenient basis for a locus to illustrate the variation of E and V with variation of ωL, R_1 and R_2 being constant. On the other hand, diagram (b) would be more convenient if R_2 were to be varied with R_1 and ωL held constant, while diagram (c) would be more convenient if R_1 were to be varied with R_2 and ωL held constant. To justify these alternative forms of vector diagram, "Cathode Ray" would have to redraw his circuit diagram to match each case, thus attributing undue importance to the cyclic order of the components in a circuit in which the only really significant fact is that the components are connected in series.

Bangor, N. Wales. DAVID MORRIS.

FURTHER EDUCATION

Radio Courses Available

IF the proposal put forward by the Parliamentary and Scientific Committee in a memorandum on higher technological education* is adopted, some twenty of the existing technical colleges will be granted charters and become Royal Chartered Colleges of Technology, with the right to award degrees in technology. They would provide for advanced full-time "sandwich" and part-time day and evening courses, post-graduate courses and full-time and part-time research.

These are, of course, purely recommendations. Facilities for further technological education do already exist even if some of them are inadequate. We have secured from the Ministry of Education a list of further education establishments providing classes in radio and allied subjects. The term "further education," by the way, is used for establishments providing classes for those whose whole-time formal education has ended.

On the opposite page is tabulated some 150 further education establishments in England† (grouped under counties) providing courses in telecommunications (col. A), radio theory, transmission and marine wireless (B), radio servicing (C), and television servicing (D). The letters used in these columns indicate full-time courses (F), part-time day courses (P) and evening courses (E).

* "Memorandum on Higher Technological Education," Parliamentary & Scientific Committee, 31, Palace Street, London, S.W.1, price 2s.

† It is hoped to give similar details for Scotland and Wales next month.

	A	B	C	D
Bedfordshire				
Bedford, N. Beds. C.F.E.	P E			
Berkshire				
Maidenhead, E. Berks. C.F.E.	E		E	
Newbury, S. Berks. C.F.E.	E			
Reading T.C.	P E			
Buckinghamshire				
Bletchley E.I.	E			
High Wycombe C.F.E.	E			
Slough C.F.E.	E			
Wolverton T.I.	E			
Cambridgeshire				
Cambridge T.C.	E	P E	P E	
Cheshire				
Crewe T.C.			E	
Stockport C.F.E.	E		P E	
Cornwall				
Redruth, Cornwall T.C.	P E		P	
Cumberland				
Carlisle T.C.	E	E		
Derbyshire				
Derby T.C.	P E		P E	E
Devonshire				
Barnstaple, N. Devon T.C.	P E			
Exeter, Central T.C.	P E		E	E
Plymouth & Devonport Mun. T.C.	P E	E	P E	E
Tiverton Science & Tech. School	E			
Torquay, S. Devon T.C.	P E	E		
Dorsetshire				
Weymouth, S. Dorset T.C.	E		E	
Durham				
Darlington T.C.	P E			
South Shields Marine & T.C.		F E	E	
Stockton-on-Tees T.I.		E		
West Hartlepool T.C.	P E		E	E
Essex				
Chelmsford, Mid-Essex T.C.		P E		
Colchester, Ardleigh House C.F.E.	P			
,, N.E. Essex T.C.	E	E		
Dagenham, S.E. Essex T.C.	P E	E	E	
Southend-on-Sea Mun. T.C	E	P	P E	E
Gloucestershire				
Bristol C.T.	E	E		
Cheltenham, N. Glos. T.C.	E	E	E	
Gloucester T.C.	E	E		
Stroud & Dist. T.C.	E			
Hampshire				
Aldershot E.I.	E			
Bournemouth Mun. C.T.	P E	E	E	
Farnborough T.C.	E			
Portsmouth Mun. Coll.	P E	E	P E	
Southampton University	P E	F P E	P E	P E
Herefordshire				
Hereford C.F.E.	P E		E	
Hertfordshire				
Hatfield T.C.	E		P E	
Letchworth, N. Herts. T.C.			E	
St. Albans C.F.E.	E			
Watford, S. Herts. C.F.E.	P			
Kent				
Beckenham T.I.	P			
Canterbury T.C.	P E		E	
Dartford T.C.	P E	E	E	
Dover T.C.	E			
Faversham E.I.		E		
Folkestone T.C.	E			
Gillingham, Medway T.C.	P E		P E	
Gravesend T.C.			E	
Ramsgate, Thanet T.C.	E			
Tunbridge Wells, W. Kent T.C.	P E			
Lancashire				
Blackburn Mun. T.C.	E	E	P E	E
Blackpool T.C.	P E		E	
Bolton Mun. T.C.	E		P E	
Bootle Mun. T.C.	P E			
Lancaster & Morecambe C.F.E.	E			
Liverpool C.T.	E	E		
,, Old Swan T.I.	E			
,, Riversdale T.C.	P		P E	E
,, Walton T.C.	P			
Manchester, Openshaw T.C.	P E		P E	E
Oldham, Mun. T.C.			P E	
Preston, Harris Inst.	E	E	E	
Salford, Royal T.C.	P E		E	E
Stretford, Metrovick School		P		
Wigan & Dist. Mining & T.C.	P E	E		
Leicestershire				
Leicester C.T.	P E	E	P E	P E
Melton Mowbray T.C.	E			
Lincolnshire				
Grantham T.C.	E			
Grimsby C.F.E.			P E	
Lincoln T.C.			E	E
London				
Acton T.C.	E	P E	E	
Battersea Polytechnic	E			
Deptford, S.E. London Day College	P			
Deptford S.E. London T. C.	P E	E		E
Ealing T.C.	P			
East Ham T.C.	P E			
Finsbury, Northampton Polytechnic	P E	E		
Hammersmith Day College	P			
Hendon T.C.	P E	E		
Holborn, Kingsway Day College	P			
Holloway, Northern Polytechnic	F E	P	P E	E
Kingsbury E.I.	E			
Norwood T.C.	F E		E	P E
Poplar T.C.			E	
St. Marylebone, The Polytechnic	E	E	E	E
Southgate T.I.	E			
Southwark, Borough Polytechnic	P E	P E	P E	E
Walthamstow, S.W. Essex T.C.	E	E		
Wandsworth T.C.	P E	E		
West Ham C.T.	E	E		
Willesden T. C.	P E	E		
Wimbledon T.C.	P E	E	E	
Woolwich Day College	P			
,, Polytechnic	P E	E		
Middlesex				
Enfield T.C.	P E	E	E	
Isleworth, Spring Grove Polytechnic	P E	E		
Southall T.C.	E	E	P	E
Norfolk				
King's Lynn T.I.	E	E		
N. Walsham E.I.	E			
Norwich City College	P E			
Northamptonshire				
Kettering T.I.	E			
Wellingborough T.C.		E	E	
Northumberland				
Newcastle, Rutherford C.T.	P E	E	P E	E
Nottinghamshire				
Nottingham & Dist. T.C.	P E	E	P E	E
Oxfordshire				
Oxford C.T.	E	P		
Shropshire				
Bridgenorth E.I.	E			
Oswestry T.I.	P			
Shrewsbury T.C.	P E		E	
Somerset				
Bath T.C.	P		E	
Burnham T.I.	E			
Taunton T.C.	E		E	
Weston-Super-Mare, School of Science	E			
Staffordshire				
Burton-on-Trent T.C.	E	E	E	
Stafford, County T.C.	E	E		
Stoke-on-Trent, N. Staffs. T.C	P E		P	
Walsall T.C.		E	P	
Wolverhampton & Staffs. T.C.	P E		F P E	E
,, Wulfrun C.F.E.	P E		P E	
Suffolk				
Lowestoft T.I.	P E		E	
Surrey				
Croydon Polytechnic	P E	P E	P E	
Guildford, County T.C.	E			
Kingston T.C.		E		
Mitcham E.I.	E			
New Malden West E.I.	E			
Richmond T.I.			P E	
Weybridge, Brooklands T.C.			E	
Sussex				
Brighton Mun. T.C.	P E			
,, Preston T.I.	E	P E		
Crowborough E.I.	E			
Hastings T.I.	E	E		
Warwickshire				
Birmingham, Bournville Day College	P			
,, Bournville & Northfield T.I.				E
,, C.T.	P E	E	P E	E
Coventry T.C.	P	E		
Westmorland				
Kendal, Allen T.I.	E			
Wiltshire				
Chippenham, N.W. Wilts. C.F.E.	E	E	E	
Malmesbury F.E. Inst.	E			
Salisbury & S. Wilts. C.F.E.			E	
Worcestershire				
Bromsgrove Tech. School		E		
Worcester, Victoria Inst.	E			
Yorkshire				
Barnsley Mining & T.C.		E	E	
Bradford, Hanson T.I.	P			
,, T.C.	P E	E	E	E
Doncaster T.C.	E	E	P	
Huddersfield T.C.	P	E	P E	E
Kingston-upon-Hull Mun. T.C.	P E	F E		
Leeds C.T.	E		E	E
Middlesbrough, Constantine T.C.	P E	E		
Rotherham T.C.			P	
Scarborough T.I.	E			
Sheffield C.T.	P E	E		
,, University		E		
York T.C.	P E			

C.T. College of Technology; T.C. Technical College; T.I. Technical Institute; E.I. Evening Institute; C.F.E. College of Further Education

Ferrite Rod Aerials

Underlying Principles and Basic Design Formulæ

By W. A. EVERDEN,* G.I.Mech.E.

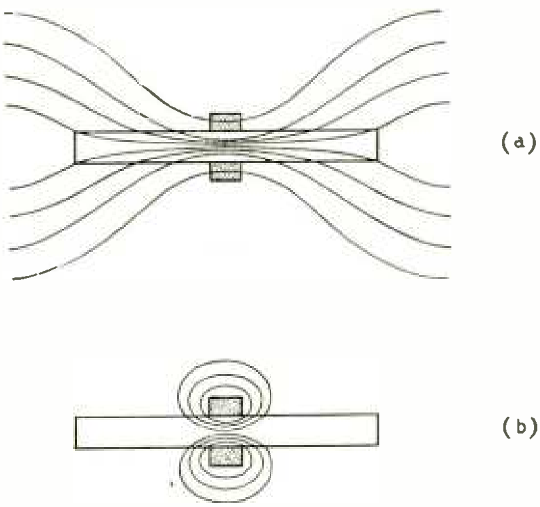


Fig. 1. The effective permeability $\bar{\mu}$ of the rod to an external field (a), must be distinguished from the permeability μ_c relative to the coil (b).

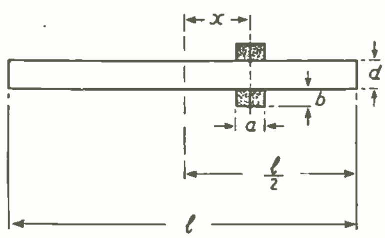


Fig. 2. Relevant physical dimensions of an aerial rod and coil.

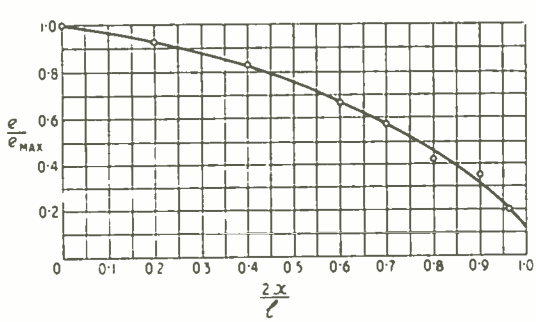


Fig. 3. Distribution of e.m.f. (e/e_{max}) induced in a coil as a function of its distance 2x/l from the midpoint of an aerial rod.

WITH the introduction of the nickel-zinc grades of Ferroxcube with their high material permeabilities and low losses many new fields of application have been opened up. Not the least important of these is the replacement of bulky frame aerials by relatively small rods and coils. All aerial rod designs in this article are based on Ferroxcube rods in grade B2, which has an initial permeability of approximately 200 and a resistivity of 10^5 ohm-cm. Its loss factor $\tan\delta/\mu$ at 0.5 Mc/s being 90×10^{-6}.

It should not be assumed that rod aerials, as they have come to be known, can only replace frames or indoor systems; with a rod of larger proportions than those discussed in this article, a signal voltage comparable with that of an outdoor aerial in combination with a normal input circuit can be approached. Interference which is now so prevalent all over the long and medium wavebands can often be reduced by the directional effect inherent in these assemblies.

Although the advantages of such a system are immediately evident, the design of a suitable assembly is rather complex, due mainly to the lack of practical design data on open-ended coils. An attempt will be made in this article to combine all necessary data on this form of aerial into workable formulæ, and to present examples of the manner in which ferrites can be used in practical aerial systems.

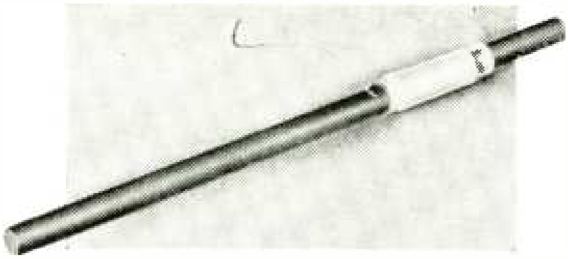
Before analysing the physical properties of rod aerials it may be worth while to discuss the relative merits of inductive and capacitive aerials, as the basis of comparison may not be immediately obvious.

Inductive and Capacitive Aerials

The efficiency of any type of aerial is usually judged from the voltage delivered to the grid of the first valve. With an average domestic aerial of dimensions under a half wavelength, used in conjunction with a matching transformer, the voltage is proportional to the product of the field intensity (vectorially) in volts per metre, the effective height (*h*) in metres and the transformer ratio (N).

With inductive aerials, including rod aerials, the voltage at the first grid is mainly determined by the product of the effective height (*h*) and the aerial circuit quality factor (Q). No direct comparison should be made between these two types of aerial. However, a comparison can be made between the products of effective height (*h*) and transformer ratio (N) of the capacitive aerial against the effective height and quality factor Q of the latter.

* Mullard. Ltd. (Components Division).



Experimental ferrite rod aerial for frequencies of the order of 1 Mc/s.

Basic Design Data

Frame Aerials.—At the input to any aerial the field concentration and frequency of the transmitter signal are usually known. A loop of n turns enclosing a part of the radiated field will then have induced in it an e.m.f. of

$$e_1 = \Phi \omega n . 10^{-8} \quad \ldots \quad (1)$$
$$= Ba \omega n . 10^{-8} \text{ volts} \quad \ldots \quad (2)$$

where the cross-sectional area of the loop is a sq. cm., the flux $\Phi = Ba$ and the flux density B is in gauss.

If Q is the input circuit quality factor, then the voltage becomes e_1Q, denoted e_0, and is applied to the grid of the first valve. Therefore

$$e_0 = QBa \omega n . 10^{-8} \text{ volts} \quad \ldots \quad (3)$$

Rod Aerials.—The main purpose of a high-permeability ferromagnetic core is to increase the flux density B within the closed loop. For satisfactory operation this should take the form of a rod so that the flux may be concentrated within the turns of the coil (Fig. 1(a)).

By redesigning the aerial coil and inserting a ferromagnetic core, the effective permeability of the enclosed medium to an external field is increased. This effective permeability μ' is much lower and should not be confused with the initial permeability μ_0 of the core material as measured in a closed magnetic circuit. The output voltage now becomes:

$$e_0 = \mu' QBa \omega n . 10^{-8} \text{ volts} \quad \ldots \quad (4)$$

The calculations of μ' will not be dealt with here, as it is fully covered in the literature[1]; it is only necessary to say that μ' can never exceed μ_0, and depends mainly upon the physical dimensions of the core. This can be seen from Fig. (5).

It has often been argued that a flat plate of ferromagnetic material would be more suitable for this application than a small-diameter rod, but experiments leading to the computing of Fig. 5 have shown that the flux density inside a plate at right angles to the magnetizing field differs very little from that of the magnetizing field. This can be shown if we take a plate of Ferroxcube with an initial permeability of 200 and dimensions $l = 114$ mm, $d = 6.3$ mm. The l/d ratio then becomes 0.055 and from Fig. 5 we obtain an effective permeability μ', which is for practical purposes unity.

With the introduction of a ferromagnetic core, the aerial system becomes considerably modified. So far we have been considering it primarily in relation to the external field, but it is also part of a tuned circuit and must have a specific value of inductance L. From this it should be evident that the increased permeability necessarily involves a reduction in both a and n, and therefore equation (4) must be developed, to contain L as a parameter. It is thus obvious that the physical size of the coil may be reduced to one not very much larger than that of the core. With the introduction of any ferromagnetic core, the inductance L increases by a factor L_c/L_a, where L_c is the inductance with ferromagnetic core and L_a is the inductance with an air core. This is often termed the coil permeability μ_c and differs considerably from μ' (see Fig. 1).

At this stage all coils will be shown diagrammatically as being short pile-wound coils. The designing of the most efficient coil will be dealt with later. The inductance of an air-cored coil of the form shown in Fig. 2 is given by the following formulæ:

$$L = n^2 d \phi . 10^{-8} \text{ henrys} \quad \ldots \quad (5)$$

where ϕ is a constant which depends on the dimensional ratios a/d and b/d of the coil.

The ratio of the external and internal reluctance paths of an air-cored coil mainly determines this value of inductance. It can be assumed that this ratio of reluctance within the coil to that outside the coil is 10 : 1. Thus approximately 1/11th of the circuit reluctance is outside the coil. For a coil where a ferromagnetic core is introduced the reluctance of the magnetic path inside the coil can be neglected compared with the external path.

If we now continue the assumption given above it is evident that the inductance ratio of a coil with a

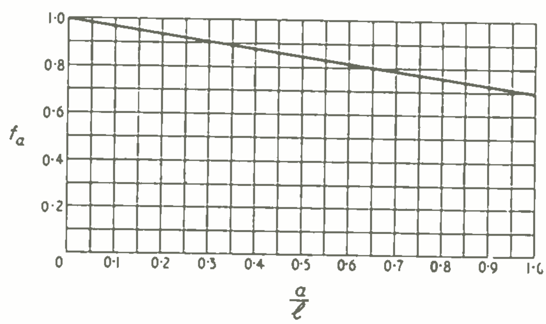


Fig. 4. Ratio of mean to maximum flux density (f_a) as a function of coil length relative to the length of the core.

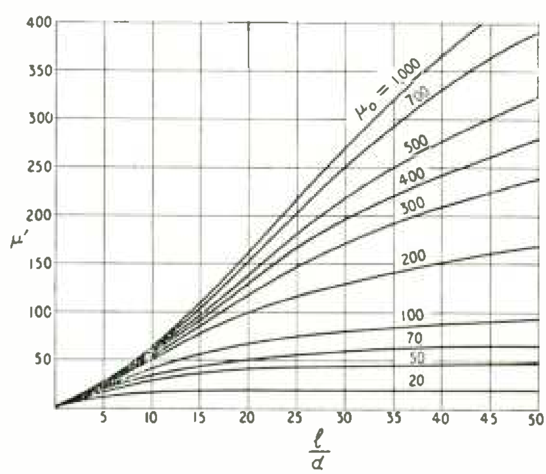


Fig. 5. Effective permeability of rod in an external field as a function of the ratio l/d with initial permeability as a parameter.

[1] See for example "Demagnetizing Factors of Rods" by R. M. Bozorth and D. M. Chapin, *J. Appl. Phys.*, Vol. 13, p. 321, 1942.

ferromagnetic core to that of an air-cored coil will be approximately 11 : 1.

It can be shown that for a short-section coil of the type shown in Fig. 2 the effective coil permeability μ_c is usually between 5 and 15. With a ferromagnetic core the inductance will be:

$$L = n^2 d\phi\mu_c . 10^{-8} \text{ henrys} \quad .. \quad .. \quad .. \quad (6)$$

By substituting in equations (4) and (6) we obtain:

$$e_0 = QBa\omega\mu' \sqrt{\left(\frac{L}{d\phi\mu_c'}\right)} . 10^{-4} \text{ volts} \quad .. \quad (7)$$

Equation (7) thus shows that a high value of output volts e_0 can be obtained by the optimum choice of the effective values μ' and μ_c. These factors can be controlled during the design stage.

Control of Rod Permeability.—If a ferromagnetic rod is placed in a uniform magnetic field B, the field is distorted towards the centre of the rod. The maximum flux density is at the centre and decreases towards the two ends. The rod permeability μ' is of the ratio of *maximum* flux density with the rod in position, to that of the original field flux density B. For rods with large l/d ratios having reasonably high material permeabilities the flux distribution along the rod is almost parabolic. The curve of Fig. 3 shows this effect in terms of the ratio of induced e.m.f.'s for a grade B2 Ferroxcube rod 200 mm long and 8 mm diameter. From this curve it can be seen that equation (4) only holds when the coil is placed at the centre of the rod, where the flux density is maximum. The ratio of the mean to maximum flux density has been termed the averaging factor f_a and a curve, derived from Fig. 3 by integration, showing the dependence of f_a on the relative length of coil and rod for a symmetrical arrangement is given in Fig. 4. For a very short coil, $f_a = 1$ and for a coil surrounding the entire length of the rod it is 0.7.

Fig. 5 shows μ' plotted as a function of the initial permeability μ_0 and the ratio l/d. To obtain a high value of effective permeability μ' the ratio l/d and the initial permeability μ_0 must be high. As a first approximation, μ' may be assumed proportional to the ratio l/d, say

$$\mu' = \alpha \frac{l}{d} \quad .. \quad .. \quad .. \quad .. \quad .. \quad (8)$$

From equations (7) and (8), and substituting $a = \frac{\pi d^2}{4}$ we get

$$e_0 = QB\omega\alpha \frac{\pi l}{4} \sqrt{\frac{dL}{\phi\mu_c}} . 10^{-4} \text{ volts} \quad .. \quad .. \quad (9)$$

Circuit Quality Factor (Q).—The circuit quality factor Q is, of course, one of the main considerations. The reason for this is that an optimum Q value not only determines the output voltage e_0 but also the circuit selectivity. It would seem that as high a Q as possible would be an advantage, but tests have shown that if a Q value greatly in excess of 200 at 1 Mc/s is used, severe sideband cutting is experienced.

Influence of Q on Signal/Noise Ratio.—When calculating the effective Q of the circuit the effect of valve input impedance must not be overlooked. To account for this, our quality factor will now be denoted as Q′. The circuit quality factor Q′ also has an influence upon the signal/noise ratio e_0/V_n.

It can be proved that a given noise voltage (V_n) does not in any way depend on the value of Q′ but is directly proportional to the frequency. By looking at either equation (3) or (4) it can be seen that e_0 is proportional to the frequency and quality factor, therefore e_0/V_n will not be subject to the frequency but will be proportional to the quality factor.

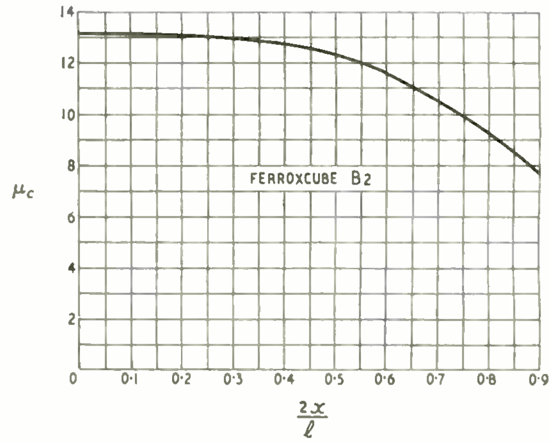


Fig. 6. Measured values of μ_c plotted as a function of distance 2x/l from centre of rod.

From this statement it can be seen that a high value of Q would be an advantage in respect of signal/noise ratio.

Temperature Coefficient.—The temperature coefficient of open-ended coils using Ferroxcube cores is a subject by itself and is extensively dealt with elsewhere.[2] It should suffice to say that at normal ambient temperature the permeability of Ferroxcube has a small positive temperature coefficient which, in this type of application, produces a positive temperature coefficient of inductance of approximately 0.4×10^{-4} (°C.). This variation of inductance can in turn influence the shape of the tracking curve.

Mechanical Mounting.—Wherever possible the rod should be mounted above or to one side of the chassis so that the additional losses introduced due to the proximity of any metal-cased components are reduced to a minimum. In order to ensure optimum performance it is also advantageous to keep the length of the rod almost the same as that of the chassis, otherwise the latter will have a screening effect, thus lowering the obtainable grid voltage.

A general method of mounting is to extend small plastic brackets from the end of the chassis and insert the rod between rubber grommets so that any vibration or torsion that may be set up during transportation is absorbed. Tag boards and soldering lugs should be mounted away from the actual coil, otherwise a reduction of Q of as much as 20% at 1 Mc/s (299.8 metres) may result. This loss and any other which may be set up due to metal objects, is proportional to the square of the frequency.

Adjustment of Inductance.—Two methods of adjustment are now in general use, the more popular being to slide the coil along the rod until the required value of inductance is obtained. This will be found to be most critical as the centre line of rod is approached. The second method is that of removing or spacing of end turns, and is used where the coil is wound directly on the core.

Material Tolerances.—Mechanical tolerances on

[2] *Electronic Application Bulletin*, Vol. 13, No. 6. Tolerances and temperature coefficient of coils with Ferroxcube slugs.

the dimensions of Ferroxcube B2 are ± 3% on diameter and ± 4% on length, and the value of initial permeability μ_0 is generally quoted on ring specimens as being > 200. The combined effect of these tolerances can cause a spread in μ_c of ± 5% when measured with a given coil in a fixed position, e.g., in the middle of the rod. For most rods and an average coil the required inductance should be designed at a point where $2x/l = 0.45$. Fig. 6 shows that for starting value $2x = 0.45$ a displacement of the coil to a position where $2x/l = 0.2$ or 0.6 will be sufficient to compensate for a spread in μ_c of ± 5%.

Effective Height.—The factor known as the effective height has already been discussed in so far as it affects the comparative merits of inductive and capacitive aerials. As already explained it is common to express the field intensity in volts/metre and the performance of an aerial as the effective height.

The effective height of a loop aerial is usually expressed as:

$$h = \frac{2\pi A n}{\lambda} \cdot 10^{-4} \text{ (metres)} \quad \ldots \quad (10)$$

where A is the mean area of the loop in cm² and λ is the wavelength in metres. If a ferromagnetic rod is now introduced having a permeability μ' equation (10) becomes:

$$h = \frac{2\pi A \pi f_a \mu'}{\lambda} \cdot 10^{-4} \text{ (metres)} \quad \ldots \quad (11)$$

where f_a is derived from Fig. 4, A is the mean area of the coil in cm² and λ is the wavelength in metres.

Coil Design.—First let us decide what is going to be the main design parameter, i.e., maximum output voltage or a high value of Q. If a high value of e_0 is aimed at, the Q value will more often than not be poor, and if a high Q value is the main requirement then the grid voltage may well be below avarage. Because most radio engineers are continually striving to achieve better selectivity we will consider first a design with a predetermined Q value.

Most of the information which has so far been published on this subject has treated the problem on the basis of a fixed frequency of 1 Mc/s. Experiments have shown us that the value of Q increases with the rod diameter, but from an economic standpoint the optimum value occurs at about 200-210 on a 5/16in diameter rod 8in long in Ferroxcube grade B2.

If we take this value of Q as a general figure and design our coil around a rod 5/16in dia. × 8in long this will form a basis for all further designs. A coil whose length is relatively small has been chosen so

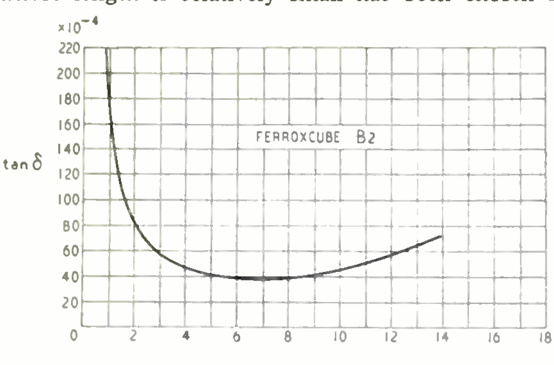


Fig. 7. Total losses plotted as a function of μ_c.

that the value of temperature coefficient can be kept within reasonable limits. It will be found that due to the manufacturing tolerances essential with most ferrite materials, the coil will have to be moved toward one end of the rod to obtain the required value of Q. Assuming an inductance of 197 μH for the medium-wave coil and a coil permeability of 13, the theoretical position of the coil from the centre line of the rod can be obtained from Fig. 6.

If we now take the reciprocal of our quality factor, i.e., $1/Q = \tan\delta = 50 \times 10^{-4}$ we see from Fig. 7 that this value of Q can be obtained with a coil permeability of 11. If this value of permeability is accepted the new position of the coil, with reference to the centre line of the rod can be found by referring to Fig. 6 to be $2x/l = 0.6$.

The decrease in coil permeability must now be compensated for by an increase in the number of turns, in this particular case by multiplying by the ratio of 1 : 1.1 where it will be found that the required number of turns will increase from 27 to 30.

Due to the displacement of the coil, the flux distribution will decrease as shown in Fig. 3, for $2x/l = 0.6$ the decrease of $e/e_{max} = 0.68$.

Converting physical dimensions into cm and taking $n = 30, f_a = 1$ and $\mu' = 117$, the effective height is

$$h = \frac{2\pi \times 0.5 \times 30 \times 1 \times 117 \times 0.68}{299.8} \cdot 10^{-4}$$
$$= 0.0025 \text{ metre}$$

The overall performance, $hQ = 0.0025 \times 200 = 0.5$.

If this value is compared with that of the second design it will be found that the increase of Q was obtained at the expense of overall performance.

From laboratory tests it has been determined that short thick rods should be employed where exceptionally high values of Q are required, i.e. say 9/16in × 4in long. A typical design for a medium- and long-wave aerial coil utilizing the core stated above would be 50 turns of 9/40 litz wound approximately ¾in from one end, this forming the medium wave section with 120 turns of 9/40 litz wound on the opposite end and used in conjunction with the medium wave coil for the long wave reception. A multi-turn coupling coil is sometimes found to be necessary between the two windings, when coupling to an external aerial

With an assembly of these dimensions, and taking $n = 50$, $f_a = 1$, $\mu' = 40$ and $e/e_{max} = 0.75$, the effective height is

$$h = \frac{2\pi \times 1.54 \times 50 \times 1 \times 40 \times 0.75}{299.8} \cdot 10^{-4}$$
$$= 0.00484 \text{ metre}$$

and the overall performance $hQ = 0.00484 \times 250 = 1.21$ where a Q of 250 is applicable for this type of rod.

Let us now consider a design where the voltage applied to the grid of the first valve becomes a main consideration. This design is again based on the same Ferroxcube rod as the first example, i.e 5/16in dia. × 8in long.

The initial or toroidal permeability of Ferroxcube grade B2 is given as 200; knowing this and the l/d ratio we can find μ' from Fig. 5, i.e. 117. The coil effective permeability factor $\phi\mu_c$, on the other hand, can be determined from Fig. 8, which is a curve of measured values of $\phi\mu_c$ plotted as a function of a/l. The quality factor will be $Q = 10^4/62 = 161$.

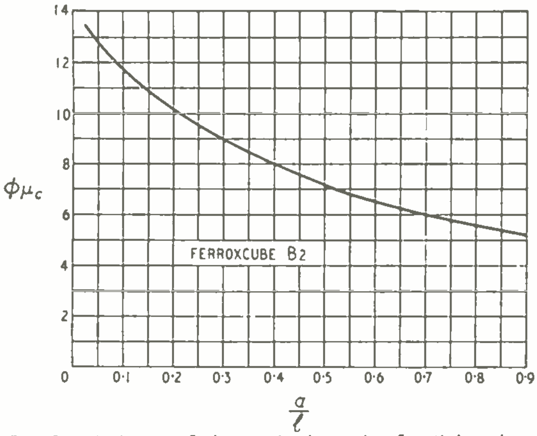


Fig. 8. Variation of $\phi\mu_c$ with the ratio of coil length to rod length.

With this information it is now possible to calculate the effective height, inductance, etc., of the aerial. As already explained, the value of f_a for the short type of coil used is practically unity.

Therefore the effective height is

$$h = \frac{2\pi \times 0.5 \cdot 27 \times 117}{299.8} \cdot 10^{-4} = 0.0033 \text{ metre}$$

and the overall performance of the aerial system will be

$hQ = 0.0033 \times 161 = 0.532.$

For proof that a higher overall performance can be obtained by increasing the value of the l/d ratio the above example has only to be re-calculated with an l/d ratio of say 40. The objection here being that the rod would be difficult to manufacture by normal processing and hence not an economical proposition.

From Fig. 8 the effect of increasing the length of the coil can be seen, the slope between unity and $a/l = 0.5$ is reasonably flat and between 0.5 and zero extremely sharp. Therefore there is little benefit to be gained in increasing the ratio of a/l above 0.5 as the price of a decrease of $\phi\mu_c$ would be considerable increase in both losses and temperature coefficient.

Variation in Coil Performance.—Recent tests on the size, shape and wire diameter of which medium wave coils are wound have proven rather interesting and will be summarized as follows. For reasons already explained, short-length single-layer coils have, up to now, been used, positioned towards one end of the ferrite rod. If we now spread-wind, or progressively wave-wind over approximately 2–3in of the rod length, keeping the ratio a/l less than 0.5, it will be found that the quality factor will drop by approximately 25%, i.e. from 200–210 to 150–160. The pick-up voltage will, however, increase. Therefore, before finally deciding upon the type of coil necessary for a particular circuit, the main parameter of selectivity or sensitivity should be decided upon. If a long loosely wound coil is used then the value of $\phi\mu_c$ will increase, which in turn will decrease the value of inductance, so that the number of turns must be increased to compensate for this loss.

The effects of temperature coefficient on the type of coil described influence the overall performance of the aerial by very little and can be more or less neglected.

Effect of Winding Wire.—For close wound coils the Q values vary greatly both with wire diameter and type. For instance, with solid wire 25 s.w.g. the Q value is approximately 100, whereas with the same coil wound from 9/40 litz the quality factor increases to 270. It is worth noting that the input voltage increases with a decreasing wire gauge and is a maximum with litz. On the other hand, with long spread windings the quality factor remains almost constant with the type and wire gauge, the circuit voltage following the same trend.

Up to now we have only considered the effects of various types of coil on the quality factor, but it is of importance to take into account the effects of variations in the coil upon the inductance.

1. The maximum variation of inductance as a function of frequency is ± 1%, and does not depend upon the coil dimensions.

2. As already pointed out, by increasing the length of the coil we also increase the value of μ_c and decrease the true value of inductance. Therefore for a constant inductance, the number of turns must be increased, but this in turn decreases the value of Q.

3. The type of wire used does not influence the value of inductance but can greatly effect the quality factor.

All coils so far described have a diameter which only exceeds the diameter of the rod by the thickness of the coil former which is usually of brown paper or very thin presspahn. To find what influence this increase in diameter has upon the circuit quality factor a series of measurements were taken with an increasing diameter of coil former and keeping the length of the coil and number of turns the same.

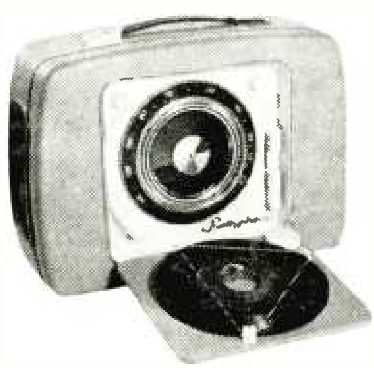
Coil Diameter (mm)	*Quality Factor* (Q)
8	203
9.5	227
12	233
14	224
20	216
28	205

All measurements were taken at 1 Mc/s.

Miniature Radio-Gramophone

WEIGHING only 10 lb, the "Babyphon" portable radio-gramophone is operated entirely from batteries—90-V h.t. and two 1.5-V cells being required for the valves and four 1.5-V cells for the special turntable motor. This is designed for 45 r.p.m. 7-in records and a speed control is provided to compensate for battery voltage variation. The miniature pickup is fitted with a sapphire stylus.

In the receiver, which covers medium waves only, four low-consumption (0.025-A) valves are used, in conjunction with a ferrite rod aerial. The circular tuning dial is concentric with the record turntable. Storage is provided for five records in the lid.



The price of this instrument, which is of German manufacture, is £32 9s 11d (including tax, but without batteries) and the distributors in the United Kingdom are G-A Distributors (Whitehall), Ltd., 29, Whitehall, London, S.W.1. A mains feeder unit is available and costs £4 4s.

Filters Without Fears

2.—Tchebycheff: a Name to Conjure With

By THOMAS RODDAM

LAST month I embarked on the task of persuading the reader that if he kept his nerve when confronted by a cumbersome algebraic expression there was no reason why he should not plunge into the exact theory of filter design without any fear of finding himself embroiled with the higher mathematics. As we shall see later, there are many problems where the classical theory is virtually useless. This is not because there is anything wrong with the classical theory itself, but is simply because the classical theory assumes that you have a lot of filter between the two ends, so that the end effects are relatively small correction terms. Where the filter is nearly all end, the direct approach is both easier and better. Moreover, the algebraic approach is balanced in regard to effort: a simple filter is easy to design, a complicated filter is extremely tedious.

The first stage of the process, which is always based on the low-pass filter, is to calculate the ratio of generator voltage to load assuming that we have a resistive generator, a resistive load, and n reactances in between. The n reactances, consisting of alternate shunt capacitances and serial inductances, form a low-pass filter of the nth order, and the standard way of calculating the currents and voltages is by means of Maxwell's circulating currents. Although I worked in terms of voltage, the whole treatment can be carried out in terms of current: often, indeed, it is desirable to work with current at one end and voltage at the other. For example, a pentode working into a valve grid suggests that we consider the input current/output voltage ratio; a triode working into a transistor emitter would best be treated by considering the input voltage/output current ratio: all we need to consider really is the ratio of input quantity/output quantity with and without the filter network. The ratio of those two ratios is the insertion loss.

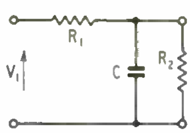
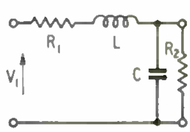
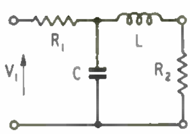
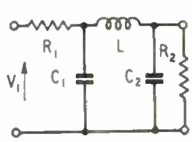
The first article expressed this ratio of ratios in the form $|N|^2$, where the insertion loss in decibels is $10 \log |N|^2$. We found that for the class of network we are considering, $|N|^2$ took the general form.

$$a_0 + a_1\,\omega^2 + a_2\,\omega^4 + \;..\; a_n\,\omega^{2n}$$

where n is the order of the network. The coefficients a_0, a_1 .. a_n depend on the resistances, capacitances and inductances and some of the results are displayed in Table I. Since a low-pass filter has no insertion loss at zero frequency, the term a_0 is actually unity as you will see by looking at the table.

We then went on to the problem of choosing the element values. For a low-pass filter the insertion loss should be small if ω is less than some particular value ω_1, and large if ω is greater than some other value ω_2 ($\omega_2 > \omega_1$, of course). If ω is less than unity, ω^4 is smaller than ω^2, ω^6 smaller than ω^4, and so on. Near $\omega = 0$, therefore, the general form of

TABLE I

	NETWORK	N
1st ORDER		$1+j\omega C\frac{R_1R_2}{R_1+R_2}=1+j\omega CR$ $R=R_1R_2/(R_1+R_2)$
2nd ORDER		$1+j\omega(CR_p+\frac{L}{R_s})-\omega^2LCk$ $k=R_2/(R_1+R_2)$
		$1+j\omega(CR_p+\frac{L}{R_s})-\omega^2LCk'$ $k'=R_1/(R_1+R_2)$ $R_s=R_1+R_2$ $R_p=R_1R_2/(R_1+R_2)$
3rd ORDER		$1+j\omega\left[(C_1+C_2)R_p+\frac{L}{R_s}\right]-\omega^2\frac{L}{R_s}(C_1R_1+C_2R_2)-j\omega^3LC_1C_2R_p$ $R_s=R_1+R_2$ $R_p=R_1R_2/(R_1+R_2)$

Summary of insertion coefficients for basic low-loss filter structures

$|N|^2$ is very close to $a_0 + a_1\,\omega^2$, so that we can keep $|N|^2$ small by taking $a_1 = 0$. Then we transfer our attention to $a_0 + a_2\omega^4$, and by similar reasoning we can arrive at the Butterworth function $(a_0 + a_n\,\omega^{2n})$ which keeps very close to a_0 for small values of ω and then tips up sharply and smoothly. This gives us a maximal flatness, critically coupled, transitionally coupled response: there may even be some more names for it. Even more attractive, it gives a form which is fairly easy to work with.

The only problem is whether the Butterworth response is the most efficient one. There are three regions in a filter characteristic: the pass band, the transition region and the stop band. The transition region is that range of frequencies where there is too much attenuation for the signal to be useful, and too little attenuation to prevent it being a nuisance. Fig. 1, which shows the Butterworth function of the second order $(1 + x^4)$, indicates that if we regard the pass band as the region in which we can satisfy a $\pm\frac{1}{2}$ db condition, and the stop band as the region in which we have more than 20 db attenuation, the ratio of ω_2/ω_1 is about 4.7.

It is very tempting to see whether we cannot do something to improve this state of affairs. Tchebycheff, in St. Petersburg in 1875, published a paper discussing what are now known as the Tchebycheff polynomials, which are exactly what we need. There is, by the way, the usual difference of opinion about the correct way to spell this name, which in some post-war writing appears as Chebyshev, which conforms with the post-revolutionary alphabet. But the polynomials are always written as $T_n(x)$ and I see no reason for allowing foreign politics to confuse us.

I do not propose to delve into the mathematics of the Tchebycheff polynomials because we shall have all the mathematics we can stand before we reach the end. All we need to know is that these polynomials oscillate up and down within prescribed limits for values of x between -1 and $+1$, and then increase steadily. Curves showing this pass-band behaviour are given in Fig. 2, which shows the first five Tchebycheff polynomials. You will perhaps recognize the shape in the region $-1 \leqslant x \leqslant 1$ as that of the Lissajous figures of the same order and the appropriate phase conditions. It is not surprising, therefore, to find that the even polynomials, which are the only ones which concern us, are given by the equations:

$$\omega = \omega_c \sin \Phi$$
$$T_n = \cos n\,\Phi$$

These two equations are given by Darlington, but other writers prefer:

$$\omega = \omega_c \cos \Phi$$
$$T_n = \cos n\,\Phi$$

For our purposes there is yet a third form, which is much more convenient. The even polynomials are:

$$T_2(x) = 2x^2 - 1$$
$$T_4(x) = 8x^4 - 8x^2 + 1$$
$$T_6(x) = 32x^6 - 48x^4 + 18x^2 - 1$$
$$T_8(x) = 128x^8 - 256x^6 + 160x^4 - 32x^2 + 1$$

In the region we are considering as the pass band, $0 \leqslant x \leqslant 1$, these functions oscillate between a maximum value of $+1$ and a minimum value of -1. For $x \gg 1$ the highest order term takes control, and off they go, getting larger as x^n so that the asymptote has a slope of $10n$ db/decade or $3n$ db/octave. A third order filter, for example, which we shall see is associated with $T_6(x)$, cuts off at the rate of 18 db/octave.

How can we make use of these polynomials? We have an insertion loss function $|N| = a_0 + a_1x^2 + a_2x^4 + \ldots a_nx^{2n}$ where x, of course, is either ω or ω/ω_0, whatever ω_0 might be. We want this function to be within the limits $1 \leqslant |N|^2 \leqslant 1 + t$ or $1 - t \leqslant |N|^2 \leqslant 1$ over a range of frequencies, the pass band. To fix our ideas, let us work with the second order filter. We have to consider the Tchebycheff polynomial $T_4(x) = 8x^4 - 8x^2 + 1$. At $x = 0$ $T_4(0) = 1$. At $x = 1$, $T_4(1) = 1$. At $x = 0.71$, $T_4(0.71) = -1$. For values of $x > 1$, $T_4(x)$ increases rapidly. We therefore take a function

$$1 - t + t\,T_4(x)$$

which lies between 1 and $1\text{-}2t$ for all positive values of x less than unity. The response is then $\pm\frac{1}{2}$ 10 log $(1\text{-}2t)$ decibels. Let us take as our permitted tolerance ± 0.625 db, for which we find $t = 0.125$. I have chosen this rather odd tolerance to make the arithmetic easier. Now we have the function

$$1 - 0.125 + 0.125\,(8x^4 - 8x^2 + 1) = 1 - x^2 + x^4$$

The response of the second order filter is,

$$|N|^2 = 1 + \omega^2\left[\left(CR_p + \frac{L}{R_s}\right)^2 - 2LCk\right] + \omega^4L^2C^2k^2$$

In this expression,

$$R_p = R_1R_2/(R_1 + R_2)$$
$$R_s = R_1 + R_2$$
$$k = R_2/(R_1 + R_2)$$

Last month I worked out in detail the conditions for a

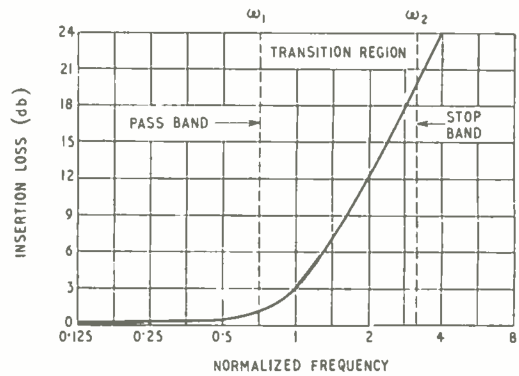


Fig. 1. Butterworth response of second order. The pass band is defined as the region in which the response is within ±0.5 db, the stop band as the region in which the insertion loss exceeds 20 db.

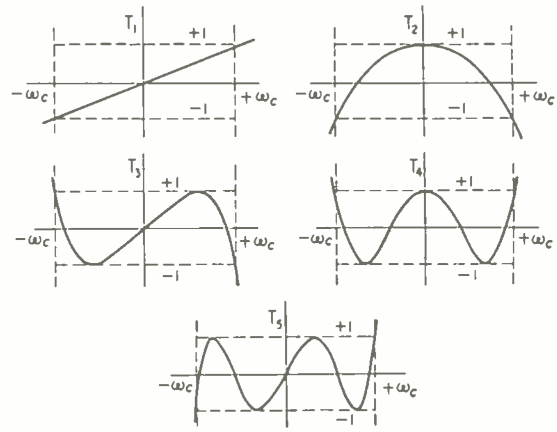


Fig. 2. Form of the first five Tchebycheff polynomials.

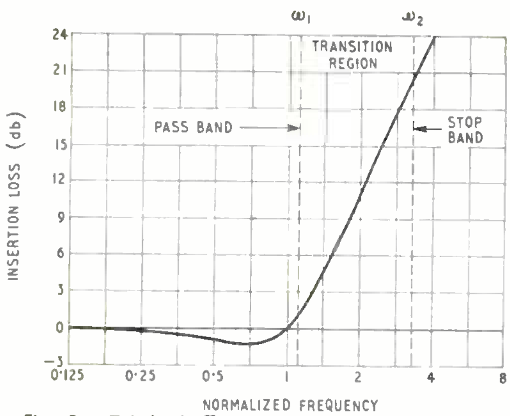


Fig. 3. Tchebycheff response of second order. The pass band is defined as the region in which the response is ±0.625 db, and the stop band as the region in which the insertion loss exceeds 20 db.

Butterworth response with $k = \frac{1}{2}$, corresponding to $R_1 = R_2$. If you try to get a Tchebycheff response under these conditions, you find that you need a negative resistance somewhere in the circuit. We can, however, take $R_2 = \infty$, so that $k = 1$. Then

$$|N|^2 = 1 + \omega^2 \; [(CR_1)^2 - 2LC] + \omega^4 L^2C^2$$

We now compare this with the form

$$1 - x^2 + x^4$$

For identity we must have

$$x^4 = \omega^4 L^2 C^2$$
$$x^2 = (2LC - C^2R_1^2)\,\omega^2$$

It is not very hard to reach the equation

$$\omega^2 LC = (2LC - C^2R_1^2)\,\omega^2$$

so that
$$C^2R_1^2 = LC$$
$$L = CR_1^2$$

which we must compare with the condition for a Butterworth response,

$$L = \tfrac{1}{2}\,CR_1^2$$

To see what we have gained by this change, let us look at Fig. 3 and compare it with Fig. 1. The small bump, less than $1\frac{1}{2}$ db, at a normalized frequency of 0.7, has reduced the ratio ω_2/ω_1, from about 4.7 to about 3.3. Another way of expressing this result is that for the same stop-band response the ±0.6 db pass band is increased from 0.7 to 1.

Most important of all, we have made full use of one piece of information, the permitted tolerance in the pass band. There is nearly always some inefficiency in a circuit which can be designed without using one of the vital parameters.

We should, I suppose, complete our calculations for the example. At $\omega^2 LC = x^2 = 1$, the edge of the pass band is reached. This, of course, means that $\omega_0^2\, LC = 1$. Then as $L = CR_1^2$

$$L = R_1/\omega_0$$
$$C = 1/\omega_0 R_1$$

The other case of $k = 1$, with $R_1 = 0$, leads us to $L = CR_2^2$ instead of $L_{(B)} = \frac{1}{2}\, CR_2^2$, with

$$L = R_2/\omega_0$$
$$C = 1/\omega_0 R_2$$

This particular example is, I must confess, deceptively simple. The reason is that the choice of $t = 0.125$ got rid of all the awkward numbers. If we had decided to adopt ±0.5 db. as our design criterion we should have been working with the function

$$1 - 0.8x^2 + 0.8\,x^4$$

which, although theoretically no harder, leads us to

$$0.8\,x^4 = \omega^4 L^2 C^2$$

giving $\quad 0.894\,x^2 = \omega^2 LC$

and $\quad 0.8\,x^2 = (2LC - C^2R_1^2)\,\omega^2$

or $\quad 1.12\,\omega^2 LC = (2LC - C^2R_1^2)\,\omega^2$

$$C^2R_1^2 = 0.88\,LC$$
$$L = 1.137\,CR_1^2$$

Of course, there is no more mathematics, really, but the actual arithmetic is more tedious. It is interesting to notice here that the new value of ω_0 is $0.945\,(LC)^{\frac{1}{2}}$, so that by tightening the tolerance from ±0.625 db to ±0.5 db we have cut the pass band down by just over 5%. We may, perhaps, come back to this matter later.

The third order filter is related to the Tchebycheff polynomial of the sixth order, $T_6(x)$. For $x = 0$, $T_6\,(x) = -1$, so that we consider

$$1 + t + t\,.\,T_6\,(x)$$

which oscillates between 1 and $1 + 2t$. The expression we arrive at is therefore

$$1 + 18t\,x^2 - 48t\,x^4 + 32t\,x^6$$

Any value of t is going to make this look pretty alarming, and it is this sort of arithmetic which gives network design a bad name. A little investigation shows, however, that if we take $t = 1/16$, so that the response is to be within ±0.25 db, and then take as our function $1 + x^2 - 3x^4 + 2x^6$, we shall not be too much in error. In the special case when $R_2 = \infty$, we can pick up the expression quoted in the previous article and simplify it to:

$$|N|^2 = 1 + \omega^2[(C_1 - C_2)R_1]^2 + \omega^4[-2LC_1C_2(C_1 + C_2)R_1] + \omega^6 L^2C_1^2C_2^2R_1^2$$

and the conditions for this Tchebycheff response become

$$\omega^6 L^2 C_1^2 C_2^2 R_1^2 = 2\,x^6$$
$$2\,\omega^4 LC_1C_2\,(C_1 + C_2)R_1 = 3\,x^4$$
$$\omega^2\,(C_1 + C_2)^2\,R_1^2 = x^2$$

I am not going to solve these equations for L, C_1 and C_2, though they do not present insuperable difficulties. You will realize, however, that if we had not cheated in our writing of the polynomial, if we had taken t as, say, 0.1, and if we had chosen $R_2 = 3R_1$, the equations might have been rather grim.

Fortunately, there is a much more advanced approach to this problem, and this leads, as is not unusual, to a rather simpler arithmetical process. If you want to know the amount of £100 at 5% after 17 years, you do not write down a long table:

£100
£105
£110 5s and so on

You know that the answer is $100\,(1.05)^{16} = 100$ antilog (16 log 1.05). If you deal a lot with money you will not even do this: you will look the answer up in tables.

There are tables which give the values of the elements in second and third order Tchebycheff low-pass filter, for response tolerances up to ±0.5 db. They are given in chapter 12 of "Filter Design Data," by J. H. Mole (E. & F.N. Spon, 1952). With the aid of these tables the use of the Tchebycheff response becomes a matter of no greater complexity than the use of the Butterworth response. The only trouble is that you must be satisfied, in the third order case, to work with either equal resistances at both ends, or with one end open-circuited.

Perhaps we should just look back. The ordinary processes of the application of Maxwell's circulating currents have led us to an expression for the insertion loss of a network

$$20 \log \left[\left(\frac{\text{V or I in}}{\text{V or I out}} \right)_{\substack{\text{with} \\ \text{network}}} \Big/ \left(\frac{\text{V or I in}}{\text{V or I out}} \right)_{\substack{\text{without} \\ \text{net-} \\ \text{work}}} \right]$$

$$= 10 \log |N|^2$$

where

$$|N|^2 = 1 + a_1 \omega^2 + a_2 \omega^4 \, .. \, a_n \omega^{2n}$$

We have then sought a function of the same form which represents the frequency characteristic of a low-pass filter. Such a function, which we can call a filter function, is

$$F(x) = 1 + \alpha_1 \omega^2 + \alpha_2 \omega^4 + \, .. \, \alpha_n \omega^{2n}$$

If our network is to have this characteristic, obviously

$$\alpha_1 x^2 = a_1 \omega^2$$
$$\alpha_2 x^4 = a_2 \omega^4$$

and so on.

Two basic kinds of filter function, the Butterworth and the Tchebycheff, have been discussed, and we have seen how we can solve this set of simultaneous equations to find the reactances required. We have also seen that in the simple form we have used, the Tchebycheff equations become very cumbersome. It's a good thing we can dodge the hard work by looking up the answers in tables. We have not yet decided whether the Tchebycheff response is always worth while, or what price we must pay for a flatter response. These are matters of very great interest, but they will occupy more space than I can demand here.

The phase characteristics of filters are often of interest, and it must be noted that we have all the information for plotting these characteristics. From the results in part I we can see that the insertion phase shift is:

1st order $\theta = \arc\tan \omega CR$

2nd order

$$\theta = \arctan \frac{\omega(CR_p + L/R_s)}{1 - \omega^2 LCK}$$

3rd order

$$\theta = \arctan \frac{\omega \left\{ \left[(C_1 + C_2) R_p + \frac{L}{R_s} \right] - \omega^2 LC_1C_2 R_p \right\}}{1 - \omega^2 \frac{L}{R_s} \left(C_1R_1 + C_2 R_2 \right)}$$

Into these expressions we can now substitute the values we have found for the responses we consider. This may become one of the factors which settles our final choice of response.

Acknowledgment. Fig. 2 is adapted from Fig. 2 of " Network Synthesis Using Tchebycheff Polynomial Series " by S. Darlington, *B.S.T.J.* Vol. 31, p. 613 July 1952.

***Correction**: In the first part of this article it is regretted that the curves of Figs. 4 and 6 on pages 369 and 370 of the August issue became transposed.*

Ultrasonic Developments

Techniques Revealed at Oxford and Manchester

PROBABLY the most familiar ultrasonic device to radio technical people is the ultrasonic flaw detector, which works on an echo-sounding principle and uses electronic circuitry somewhat akin to radar. While this idea has become well established it has not been allowed to stagnate, any more than has radar, and recently some interesting variants and developments of the original theme have come to light. One or two were described in papers read at the recent Brit. I.R.E. Convention on industrial electronics at Oxford, while others were on show as actual apparatus at the Ninth Annual Exhibition of Electronic Devices organized by the Institution of Electronics (North-West Branch) at the Manchester College of Technology.

A fairly straightforward application of the flaw-detector principle was an equipment for obtaining echo patterns from the living human brain, the idea being to detect abnormal structures such as cerebral tumours. This was shown at Manchester by the Department of Physics of the Royal Cancer Hospital (see Fig. 1). The ultrasonic waves are generated by a quartz crystal which is pulsed by a thyratron discharge at a repetition rate of 50 c/s and produces a series of damped wave trains at a frequency of 1.25 Mc/s. When the crystal transducer is applied to the patient's cranium a beam of ultrasonic energy about $\pm 4^\circ$ wide passes through the brain until it encounters an internal surface differing in elasticity or density, and then some of the energy is reflected back. The crystal also acts as a pick-up device, in between the times it is being pulsed by the thyratron, and it receives the burst of reflected energy and converts it back into an electrical signal. This is then amplified and applied to the Y plates of a cathode-ray oscillograph, which has a time-base locked to the 50-c/s thyratron pulse generator. The original transmitted pulse appears at the left-hand edge of the time-base sweep (since it is fed back into the receiver amplifier) while the returned pulse appears farther along to the right, the actual distance between them indicating the distance of the internal reflecting surface from the cranium.

The time-base of the oscillograph will show echoes from surfaces up to 20cm away, and it has been possible to calibrate it in centimetres by using a water tank and immersed reflecting surface in place of the patient's head, for the velocity of the ultrasonic waves in water is very little different from their velocity in brain tissue (a depressing thought!). Since the transmitted pulse is applied straight back to the receiving amplifier, however, this amplifier is paralysed for a short while and as a result echoes from less than 3-4cm away do not appear on the oscillograph.

With an amplifier gain of something like 100 db the equipment is extremely sensitive, and an echo with a

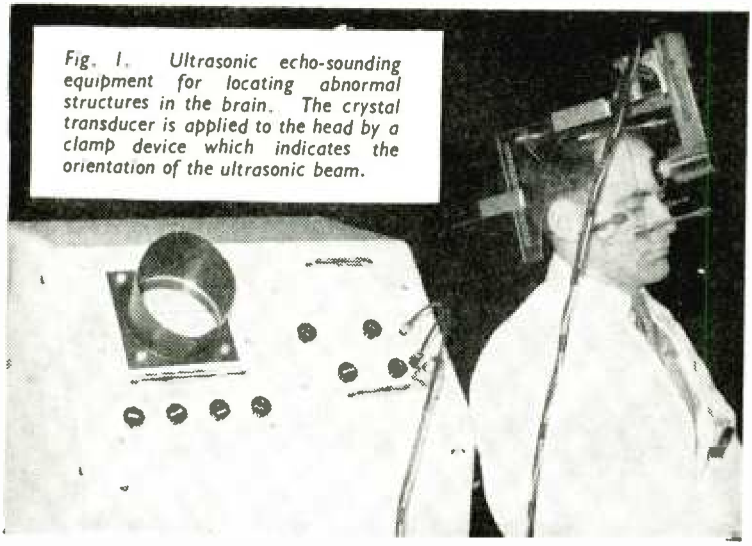


Fig. 1. Ultrasonic echo-sounding equipment for locating abnormal structures in the brain. The crystal transducer is applied to the head by a clamp device which indicates the orientation of the ultrasonic beam.

high signal-to-noise ratio can be obtained in a tank of water from a glass fibre of less than 0.001in in diameter. Particles and bubbles in the water, too small to be seen, can also be shown up clearly. As for the accuracy of location, a resolution of 20 microns is claimed for the equipment.

When the *Wireless World* reporter was invited to try the apparatus on his own head he was somewhat reluctant, having heard of the emulsifying and cavitation effects produced by ultrasonic waves. It appears, however, that there is no danger of the brain becoming addled, as the average power used is only about 10 microwatts.

One problem in ultrasonic flaw detection which is providing a great deal of food for thought is that of launching the ultrasonic wave into the material at an oblique angle—or more particularly at a variable angle so that the material may be scanned for flaws. Normally, of course, the beam simply travels in at right angles to the surface from the point where the transducer is applied. One approach to the problem has been the use of suitably shaped blocks of glass or Perspex between the transducer and the work. The lower surface of the block, in contact with the work, is made flat, while the upper surface is curved so that the transducer (also suitably curved to fit) may be slid round it in an arc. In this way a steerable beam is obtained, but the method is still rather slow and cumbersome.

A rather ingenious system of beam steering and scanning which the National Physical Laboratory has tried out was described by G. Bradfield at the Brit.I.R.E. Convention. This works on the principle of causing the ultrasonic wave to be launched from one side of the transducer slightly before or after it starts from the other side. The result is an inclined wave front (the actual inclination depending on the time lag) and the beam travels obliquely from the crystal instead of at right angles to its surface. A comparable situation in Nature is that of sea waves coming in at an oblique angle to a beach, so that they break at one end of the beach somewhat later than at the other end —though here, of course, the waves are arriving instead of departing.

To achieve this effect a barium titanate transducer is used and is divided into a number of sections by grooves (Fig. 2). Each section is then fed from a corresponding section of an LC delay line into which a short 2½-Mc/s electrical wave-train is injected. (Actually the barium titanate sections themselves form part of the capacitive elements of the line.) As a result the ultrasonic wave is launched from the "injection" end straight away and from the other end a fraction of a microsecond later. Using a 0.235-μsec delay line the wave-front is given an inclination of 4° from normal and with a 0.47-μsec line it has an inclination of 8°. This gives two beam angles in, say, an "easterly" direction, and by injecting the 2½-Mc/s signal into the other end of the line the same angles of inclination can be obtained in a "westerly" direction. Thus, with the normal propagation of the beam straight into the material, there are five beam angles available altogether.

A rotating switch enables any one of these five beam angles to be selected, but in practice it is arranged to sweep through them in rapid succession so that the returning echoes along the beams can be displayed almost simultaneously on a cathode-ray tube. In this way the material is scanned in a similar fashion to radar and the range and bearing of the echoes can be presented either in B-scope form (Cartesian co-ordinates) or as a p.p.i. display.

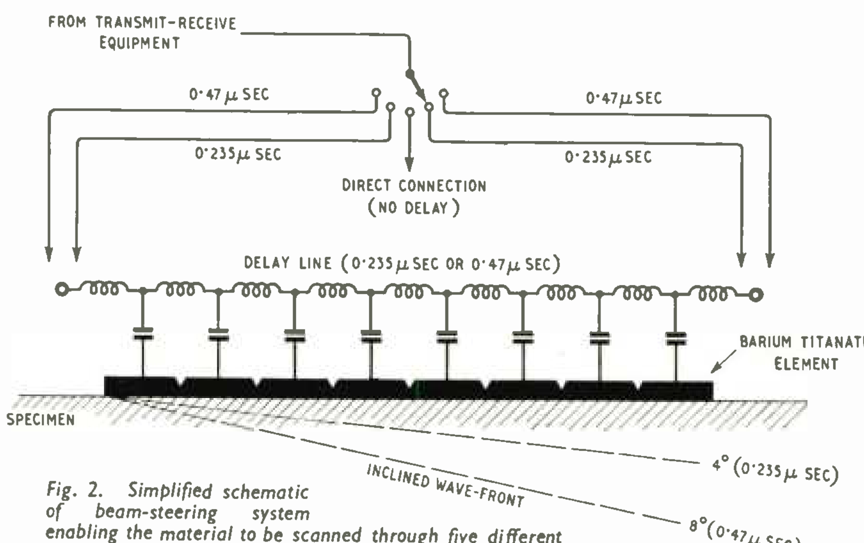


Fig. 2. Simplified schematic of beam-steering system enabling the material to be scanned through five different angles. The flaw-detector equipment can be connected to either end of the transducer delay line.

Fig. 3. Portable thickness gauge working on a mechanical resonance principle, with quartz crystal transducer in front.

Another ultrasonic examining device with cathode-ray tube presentation was mentioned by F. Gutman at Oxford. This is an ultrasonic microscope developed by the Russian scientist Sokolov for detecting and studying objects in opaque media. Here, a beam of ultrasonic waves is reflected from the object under examination and is focused and collected on a plate of piezoelectric material which is mounted in a cathode-ray tube. Secondary electrons are produced from the plate by the action of the electron beam and their path is modified by the piezoelectric charges caused by the ultrasonic waves. An image is then obtained by the usual television method. A magnification of several thousand is claimed for this instrument.

Thickness Measurement

Ultrasonic techniques are also being used a great deal nowadays for gauging the thickness of materials, and, as they generally utilize reflection of the waves, they are particularly valuable when only one surface of the material is accessible. The reflection, however, is not used in the same direct way as in the flaw detector. An ultrasonic generator is applied to one surface of the material and the reflected waves returning from the far side intersect with the outgoing beam to produce standing waves. At a certain frequency (determined by the thickness of the material and the velocity of the waves in it) a resonance condition occurs, and from this frequency the thickness can be calculated. The mechanical resonance also occurs at harmonics of this fundamental frequency.

To put the principle into practice it is therefore necessary to be able to vary the frequency of the ultrasonic generator and to obtain an indication of the mechanical resonance. The first is easily done with a variable frequency oscillator, while the resonance indication is obtained from the fact that the internal damping of the material at resonance puts a load on the oscillator; this can be detected by an increase of anode current in the oscillator valve.

Unfortunately, this increase of anode current is not always enough to give a good indication. One way of overcoming the trouble was described by F. M. Savage at Oxford, and the improved technique has been used in a commercial instrument which was exhibited at Manchester (see Fig. 3). The oscillator is frequency-modulated over a small deviation range by a motor-driven capacitor. Then, when the oscillator is tuned (by a permeability control) to the mechanical resonance frequency of the material, pulses of anode current are produced as the oscillator frequency is swung back and forth through this point. These pulses are at an audio frequency rate (determined by the motor-driven capacitor) and they are amplified, rectified and applied to a meter and to a pair of headphones. Resonance is then indicated by an increase in the meter reading or by an audible note.

Padding capacitors are placed in series with the motor-driven capacitor so that modulated bands of various widths can be chosen. Narrow bands provide maximum selectivity and accuracy while the wider bands are used when the material has a rough surface or is of variable thickness. The oscillator covers a range of 0.75 Mc/s to 2 Mc/s and this enables the same crystal transducer to be used for all frequencies with very little loss of sensitivity. If only the fundamental resonance indications were used the thickness measurement range would be of the same order as the frequency range (just over 2 to 1), but by using harmonic resonance indications as well this range can be extended to about 1,000 to 1.

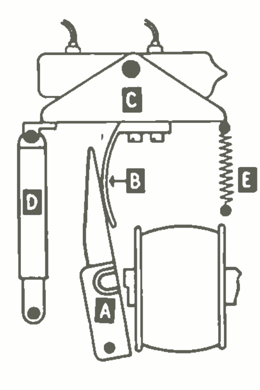
MERCURY SWITCHES

THE Tiltray mercury switch is operated by a built-in relay, but the design is a little unusual in that the mercury elements are carried by a tilting tray pivoted in such a way that it ensures a smooth surgeless flow of mercury from one contact to the other. In certain operating sequences this could be important.

How this is achieved is shown in the schematic diagram reproduced here. The armature A moves the tilting tray C carrying the mercury capsules by what is called a variable ratio one-tooth gearing, consisting of an extension of the armature A and a curved finger B. This slows down the movement of the tray as the armature accelerates towards the coil. Acceleration of the tray is further retarded by the action of the pneumatic damper D and the return spring E.

Mercury switches find many applications in circuits where heavy currents flow, and they are especially useful where inductive loads are involved as quite high inductive surges can be handled safely since the energy is released in a mercury-vapour arc and there is no high-voltage build up.

Tiltray mercury switches are made by Besson and Robinson, Ltd., 6, Government Buildings, Kidbrook Park Road, London, S.E.3, and can be arranged for switching three circuits of up to 60 A each in a single compact unit; the operating power is ½ to 2 W d.c. or 5-15 VA a.c.



Schematic diagram of the Besson and Robinson Tiltray mercury switch.

Measuring Small Voltage Changes

Simplified Method Using Polystyrene Film Capacitors and Electrometer Valves

By J. P. SALTER, A.M.I.E.E.*

A PROBLEM that arises quite frequently in development work is the accurate measurement of small changes in the d.c. level of relatively high voltages. The change of level may be produced deliberately by an adjustment made elsewhere in the circuit, or it may develop over a matter of minutes as a result of slow changes in circuit constants.

A change of, say, 0.1 V at a 300-V level would be imperceptible on a voltmeter; the rate of change would be too slow for normal a.c. techniques to be employed; and the application of manually adjusted backing-off voltages is fraught with danger to the meter on which the change is to be read.

The development of the polystyrene film capacitor and the low grid conductance of modern electrometer valves enables this problem to be solved very simply. Fig 1 shows the basic circuit where C_1 and V_1 are the capacitor and the electrometer valve respectively, and S_1 is a polystyrene-insulated switch. So long as the switch is closed the valve and the difference meter are protected from any changes of d.c. level at the input. When a measurement is required the switch is opened and, as the capacitor is already charged to the correct backing-off voltage, only difference voltages are transferred to the metering system. The potential across the capacitor can change only as a result of internal leakage, of leakage across the switch, of leakage or grid current in the valve, or of electrification effects in the dielectric.

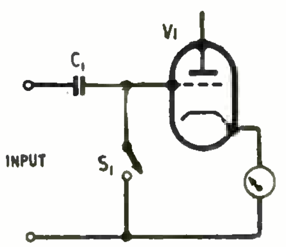


Fig. 1. Basic circuit used for measuring very small voltage changes.

The insulation resistance of good types of polystyrene film capacitor is so high that their time constants are measurable in terms of years, and in this application both internal leakage and electrification effects can be ignored entirely. On most types of relay the supporting insulant of one of the contacts can be replaced by polystyrene without difficulty. The grid conductance of the valve can be kept acceptably small by choice of valve and operating potentials.

The system has many advantages. Backing off is automatic, is independent of polarity, and is independent of input level within the operating range of the capacitor. Since leakage in the capacitor can be ignored, a direct calibration check against any voltage standard of suitable range can be carried out at zero-voltage level, and drift in the instrument itself over any desired period can be checked simply by shorting the input and opening the switch.

Polystyrene film capacitors are now generally available in values up to 0.2 μF with quite a modest ratio of volume to capitance. A single 0.2-μF capacitor is sufficient for most applications, but there are occasions when, in order to be able to use a more familiar type of valve such as the EF37A or the ME1400, it may be worth while using a number in parallel to provide, say, 1 μF. Various voltage ratings are available, and capacitors rated at 350 V working at 65°C (1,000-V d.c. test) have operated very satisfactorily at a 500- to 600-V level when mounted in such a position that they remain substantially at room temperature.

Practical Circuit

In considering the layout of the instrument, there is only one lead whose insulation is vital; that connecting the grid, the capacitor, and one contact of the switch. The use of a length of polythene-insulated coaxial cable for this lead and the adoption of a simple "guard" system[1] will reduce leakage to negligible proportions. For the guard system, the mounting clip for the capacitor, the outer conductor of the cable, the framework of the switch (preferably relay-operated), and the metalizing of the electrometer valve, should all be connected to the earthy input lead.

The characteristics of electrometer valves and of general purpose valves which can be pressed into use in this role have been the subject of a number of articles of recent years[2], and little need be added here. The electrode potentials are so chosen that normal grid current is almost completely suppressed, and the "reverse" grid current which flows is predominantly the result of ionisation of free gas molecules by the electrons flowing to the other electrodes. The gas pressure varies somewhat from one type of valve to another, and from valve to valve within any one type, but there is little the user can do about it other than to avoid any careless maltreatment which might result in the release of further gas from the electrodes.

The choice of a valve for this application depends mainly on the range of difference voltages to be measured, on the time interval over which the measurement is to extend, and on the accuracy demanded. By reducing the anode voltage to some 5-10 V, and by adjusting one's methods to deal with

* Ministry of Supply.

[1] Scroggie, M G "Measuring High Resistance," *Wireless World*, June 1952

[2] Scroggie, M. G "A Valve Megohmmeter," *Wireless World*, November 1953.

values of g_m and μ as low as 15 μA/V and unity respectively, grid currents of 10^{-13}A and below can be achieved without much difficulty, but the range of input and output voltage tends to become somewhat limited. It is advisable, therefore, to be content to achieve a grid current no lower than is really necessary for the particular application in mind. The arithmetic is quite simple; one assumes a constant charging rate for the capacitor and employs $VC = Q = it$ (volts, farads, amps and seconds) to calculate the grid current that would result in the development of an acceptably small error voltage across the chosen capacitor during the time needed to complete the measurement.

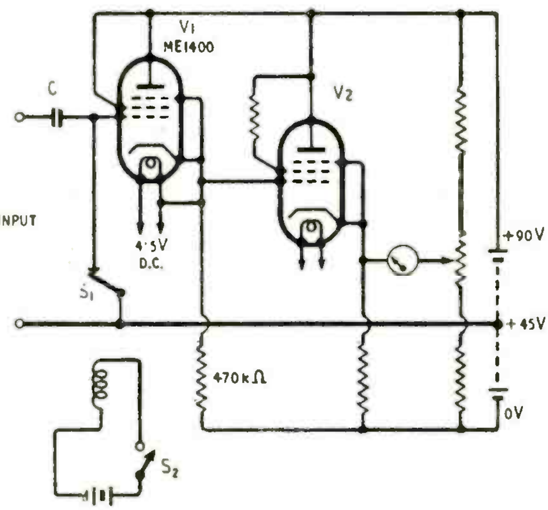


Fig. 2. Simple form of measuring set using battery operation.

As an example of what can be achieved using quite conventional circuitry, we can take the case of the ME1400. Strapped as a triode, the electrode potentials recommended by the makers are 4.5 V on the heater, 45 V on the anode, and -2 V bias on the grid. Under these conditions the valve has a μ of 20 and a g_m of 300 μA/V, whilst the anode current is about 100 μA and the grid current is around 6 $\mu\mu$A. The grid can be swung about half a volt each side of the recommended operating point without approaching too close to anode current cut-off on the one hand or the commencement of normal grid current on the other. The grid current is reduced by a factor of three, or thereabouts, at the peak of the negative swing, and is increased by a similar factor at the peak of the positive swing.

With such a limited grid base there are obvious advantages in adopting the cathode follower technique. The required conditions will be met by the use of 90 V h.t. and a 470-kΩ cathode load. Using such a value of cathode load, the gain of the system will approximate to $\mu/(\mu+1)$ and only $1/\mu$ of the input voltage will appear between grid and cathode. A change of level at the input not exceeding 10 V, of either polarity, could therefore be handled satisfactorily.

If we use a 1-μF capacitor and take 6 $\mu\mu$A as being a representative value of grid current for small excursions, we obtain a leakage rate ($V/t = i/C$) of 6 μV per second or 22 mV per hour. If the error due to this leakage is not to exceed say 1 per cent, we should have about three minutes in which to complete a difference measurement of 0.1 V, or about half an hour for one of 1 V. For a 10-volt measurement

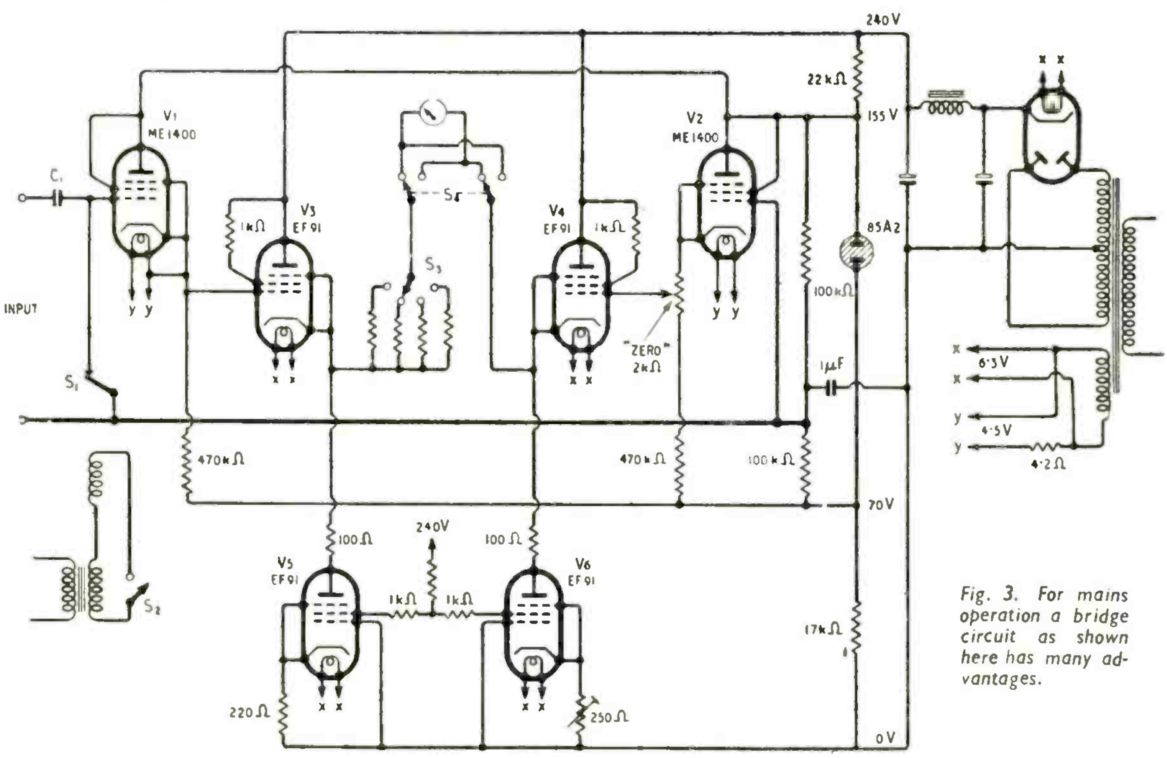


Fig. 3. For mains operation a bridge circuit as shown here has many advantages.

(taking the positive-going input as being the worst case) the leakage rate would increase to about 70 mV per hour, giving us an hour and a half for the same percentage error.

Periods such as these are quite long enough for the completion of most tests in which the change to be measured is the result of a change in the effective value of a component (e.g., a thermal change), and it is only in the more specialized applications that it is worth employing one of the more esoteric types of electrometer valve. In fact, for applications where the change of voltage level develops more or less concurrently with the making of some adjustment elsewhere in the circuit, as, for example, when one is examining the response of a stabilized power pack to changes of load or of input voltage, we could safely use a single 0.2-μF capacitor and still have a large margin in hand for stray leakages. In the same way, there are occasions when it would be in the nature of an extravagance to employ an electrometer valve at all and when the average EF37A would do the job quite satisfactorily if used in the circuit described.

The design of the metering portion of the instrument is largely a matter of personal choice. Although the valve is operating as a cathode follower in the arrangement described, the output impedance is not particularly low and it is not really satisfactory to feed even a 25-μA meter movement direct from the cathode. The simplest form of practical circuit is probably that shown in Fig. 2, in which V_2 is any convenient valve of reasonable slope. An unbalanced circuit such as this is very vulnerable to both l.t. and h.t. variations, and is best suited to battery operation, particularly as the current requirements are small.

Mains Operation

For mains operation, the use of a Bridge circuit such as that shown in Fig. 3 makes the provision of stabilized h.t. and l.t. unnecessary for most applications. Pentode loading of the cathode followers V_3 and V_4 provides them with high impedance cathode loads through which they can be fed with 8 or 9 mA apiece at the expense of a very modest voltage drop. This keeps up their g_m and permits the use of a robust meter. With correct adjustment of the preset variable resistor which provides the bias for V_6 the bridge will remain balanced over quite a wide variation of mains voltage.

Since the change to be measured may be of either polarity, a centre-zero meter or a change-over switch for the meter should be provided, and voltage ranges of 0.25, 1.0, 2.5, and 10 volts f.s.d. can be provided by the use of a range switch and series resistors suitable to the meter employed. The use of a relay-operated switch for S_1 simplifies the control of surface leakages and permits the linking of other events to the opening of the switch. Where the power supplies are unstabilized and the relay is a.c.-operated, it is advisable to feed the relay coil from a separate transformer. For general use it is desirable to include in the instrument a suitable resistor in series with the input terminal; this will limit the charging current when the instrument is first attached to a high voltage point.

Hay G. A. "Receiving Valves Suitable for Electrometer Use." *Electronic Engineering*, July 1951

Yarwood, J. and Le Croisette, D. H. "D.C Amplifiers," *Electronic Engineering*, January 1954.

Infra-red Analysis

Mervyn-NPL infra-red spectrometer for chemical analysis and process control.

THE selective absorption of electromagnetic waves by organic and other liquids and gases is becoming increasingly important as a rapid method of analysis in the petroleum, chemical and many other industries. Wavelengths of the order of 3μ (3×10^{-3}mm) in the infra-red region of the spectrum are generally used, and a curve is plotted showing how the absorption varies with wavelength. From this and a knowledge of the absorption characteristics of pure substances, an analysis of mixtures can be made.

The first essential is the production of a "monochromatic" source of radiation of variable frequency, and in the past this was provided by a refracting prism and an expensive auxiliary optical system. Recently the National Physical Laboratory have developed an efficient method of making diffraction gratings, based on a method originated by Sir Thomas Merton, which produces comparable resolution at a fraction of the cost.

Mervyn Instruments, Copse Road, St. John's, Woking, Surrey, have undertaken the commercial production of an infra-red spectrometer using the Merton-NPL grating. The source of radiation is a Nernst filament lamp and the beam is interrupted 800 times per second. After absorption in the specimen under test, the beam passes to a lead selenide photocell, the output of which is amplified and recorded on a chart.

To achieve accuracy comparable with a balanced double-beam null method of measurement, a high degree of overall stability is required. In the Mervyn instrument this is achieved by continuously monitoring the source of radiation and the sensitivity of the detector and applying any variations to the amplifier in the form of gain control. Compensation for the wavelength-dependent characteristics of the source, the grating filter and the detector is effected continuously, as the spectrum is transversed, by an adjustable shaped cam.

Magnetic Tape Spools

DIMENSIONS of spools for nominal tape lengths of 300, 600, 1,200 and 1,750ft are given (with tolerances) in a new specification (B.S.2478:1954) obtainable from the British Standards Institution, 2, Park Street, London, W.1, price 2s. These spools are for domestic and commercial recording, as distinct from those used in broadcasting studios.

Other matters touched on by this specification include the width of safety lane and the direction of recording in dual track tapes. It is recommended that if the tape moves from left to right with the active side away from the observer, the upper track should be in use.

TRANSFORMERS for Low and High Frequencies

By "CATHODE RAY"

Demonstrating Their Differences by "General" Vector Diagrams

NOW that we have spent two issues studying vector diagrams—and I hope the time has not been wasted—we should be better equipped to tackle problems like the one an Australian reader put to me some while ago. He asked for an explanation of the fact that in critically-coupled r.f. transformers, such as those often used in i.f. amplifiers and f.m. discriminators, the voltage across the secondary is 90° out of phase with the voltage across the primary. He says that the textbooks (and "Cathode Ray"!) gloss over this part of the story.

Well, I can't easily forget that when dealing with the discriminator stage in f.m. receivers a few years ago I tripped up over this very thing, so it is some comfort to be told that it is a difficult point. One catch, perhaps, is that in ordinary low frequency transformers the secondary voltage is in phase with the primary voltage, or very nearly so, and it is easy to assume the same thing holds for transformers in general.

A clue can be given quickly by saying that the r.f. transformer is very loose-coupled and normally works in the condition of resonance, whereas the ordinary power transformer is very close-coupled and non-resonant. To get a complete picture, however, there is nothing for it but to pull out our small but trusty kit of basic principles and get to work.

Probably the best approach is to start with a theoretically perfect 100% coupled transformer and see what happens as the coupling is loosened. If you like we can start with something simpler still—a single winding on an iron core, as in Fig. 1. When this is connected to an a.c. generator, as in Fig. 2(a), the alternating current that flows through the coil produces an alternating magnetic flux in the core. Because the current is the direct cause of the flux, the flux is in phase with the current.

The alternations of flux generate an e.m.f. ("the e.m.f. of self-induction") in the coil, proportional to the rate of flux variation, and always tending to oppose its cause—the variation of current. According to the current notation explained last month, I_{JK} means the current whose positive direction in Fig. 2(a) is clockwise around the circuit. At the start of the current cycle, as shown in Fig. 2(b), the current is increasing at its greatest rate, so this induces the maximum e.m.f. tending to oppose the increase of current, and therefore anticlockwise at this moment. To keep the current increasing, notwithstanding this opposition, it is necessary for the generator to be exerting an equal e.m.f. clockwise (we are neglecting the resistance of the coil). Whether one looks at it from the point of view of the coil or the generator, *b* must be maximum positive with respect to *a*. So V_{ab} (which, using the "potential-rise" convention, means the voltage change on moving from *a* to *b*) is peak positive, as shown. In the familiar words of the text-books, the current lags the applied e.m.f. by 90°. The information given in Fig. 2(b) is much more conveniently portrayed in Fig. 2(c), which is the general vector diagram for Fig. 2(a). (The whole point of going over this very elementary stuff is really to remind ourselves of the conventions explained in detail in the last two issues.)

It would make no difference in principle if the wire we used for this coil happened to be composed of two strands. Nor would it make any appreciable difference whether the strands were insulated

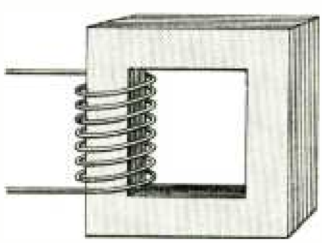


Fig. 1. The starting point—a single iron-cored coil.

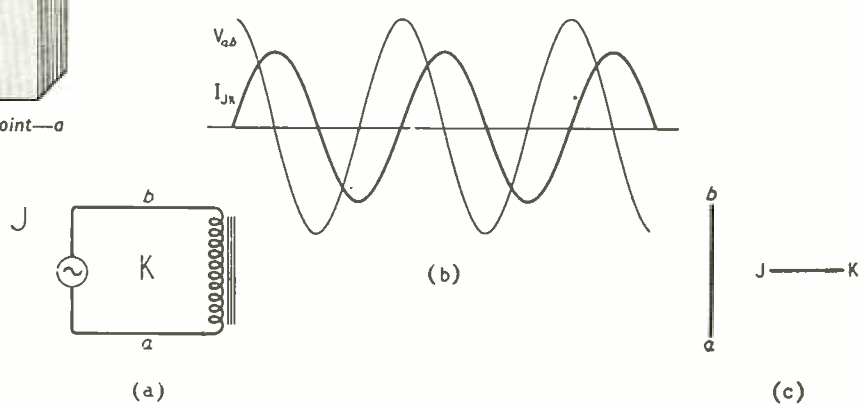


Fig. 2. (a) s the lettered circuit diagram for the coil connected to an a.c. generator; (b) is the waveform diagram; and (c) the general vector diagram—ab for voltage and JK for current.

or not. The flux causing the e.m.f. would link both strands practically equally, and if one strand happened to become disconnected from the generator, the same voltage, in the same phase, would exist between the ends of the disconnected strand as between the ends of the connected strand. Fig. 3 shows an enlarged view of the separated strands, with the disconnected one dotted to distinguish it. What we have now is a virtually 100%-coupled transformer, and there can be no doubt that the secondary e.m.f. V_{cd} (Fig. 4) is in phase with the primary e.m.f. V_{ab}.

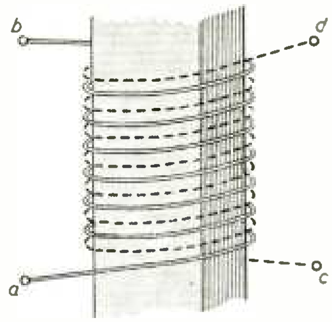


Fig. 3. The result of separating the two strands of the wire with which the coil in Fig. 1 is wound.

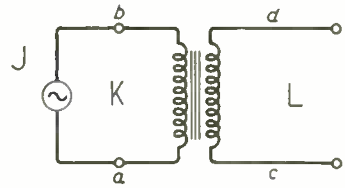


Fig. 4. Circuit diagram of the close-coupled 1 : 1 transformer formed by separation of strands as in Fig. 3.

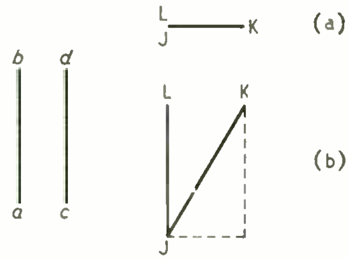


Fig. 5. Voltage diagram for Fig. 4; and current diagrams, (a) unloaded, (b) with resistance load.

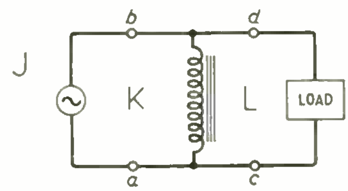


Fig. 6. For analysis the double-wound transformer as in Fig. 4 can be replaced by the original single wound coil.

Now consider what happens when a resistance load is connected across the secondary. Being a resistance, it passes current (I_{JL}) in phase with V_{cd}. This current of course has to flow through the secondary winding, and in doing so it creates an alternating magnetic flux—a quite unchangeable result, like the law of the Medes and Persians, only more so. Yet it can't be allowed! The generator is still applying the same e.m.f. as before (we assume) and this must be exactly balanced by the e.m.f. generated in the primary by the alternating magnetic flux. That flux was just right before I_{JL} started to flow, so it can't still be right when another lot of flux is being caused. There is only one way out of this deadlock; the way of the Persian monarch Ahasuerus when his wife convinced him that a law he had made under the influence of a sinister courtier was wrong. He couldn't rescind it, but he could issue another that would neutralize it. Nothing can be done to prevent I_{JL} exerting its magnetizing influence, but this influence can be exactly neutralized and the *status quo* restored if the generator supplies a primary current that creates an equal and opposite flux. This current is of course in addition to the original magnetizing current needed to induce the back e.m.f.

100% Coupling

It is time we brought our vector diagram up to date. Because it is induced by the same flux as the primary e.m.f., the secondary e.m.f. is represented in Fig. 5 by *cd*, an exact duplicate of *ab*. The current diagram at (a) applies before the secondary was loaded; the fact that I_{JL} was then zero is shown by the distance J to L being zero. After connecting the resistance load the current I_{JL} is represented at (b) by JL in phase with *cd*. The current effective for causing magnetic flux is the total current crossed on moving from L to K ($I_{LK} = I_{LJ} + I_{JK}$), and this can only be kept the same as in (a) by raising K to the new position shown at (b); that is to say, by adding the vertical dotted portion (equal to JL) to the original horizontal portion.

The fact that there is no actual connection between meshes K and L is appropriately represented by leaving K and L without a direct connecting line in Fig. 5(b), but the distance from K to L does nevertheless correctly represent the total current in the two windings lying between meshes K and L. This logical interpretation of vector diagrams constructed on this plan is particularly helpful in transformers, for it shows the net magnetizing current, irrespective of the individual currents flowing through the windings. The sign of the currents is automatically taken care of, provided that the circuit diagram is drawn so that the coils are wound in the same direction—see Fig. 4—and have equal numbers of turns. (This is covered by the normal practice with transformer vector diagrams, of working in volts per turn and ampere-turns, rather than total volts and amps, so as to avoid vectors of absurdly different lengths.) It is easy enough to take separate account of unequal turns, by multiplying or dividing by the turns ratio as required.

In Fig. 5(b) the primary current I_{JK} lags the applied e.m.f. V_{ab} much less than the original 90°. Power transformers are usually designed so as to make the magnetizing current (I_{LK} here) small compared with the other part of the primary current needed on account of full load. That other part has the same phase relative to the e.m.f. applied to the primary as the secondary current has to the e.m.f. given by the secondary. For instance, if the secondary is loaded by a capacitor, a leading current is added to the magnetizing current in the primary.

On the equal-turns-ratio assumption, if *a* in Fig. 4 is joined to *c*, *d* is at the same potential as *b* and can be joined to it without making any difference. We have, in effect, reverted to our single-winding two-strand coil, and the load current can be regarded as going straight from generator to load, only the magnetizing current flowing via the coil, which is no more than an inductive shunt (Fig. 6). This " distinction without a difference " would be represented in Fig. 5 by making *cd* coincide with *ab*, and joining L directly to K.

The next step is to take account of the resistances of the windings. These can be shown separately from

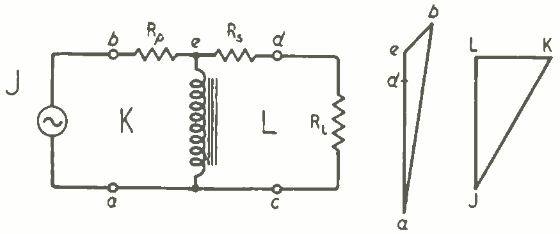


Fig. 7. Circuit of 1 : 1 transformer with resistive load, and corresponding vector diagram; account being taken of the primary and secondary coil resistances.

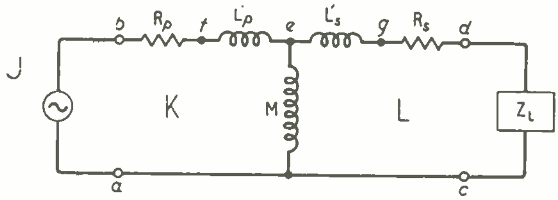


Fig. 8. Elaboration of the transformer equivalent circuit to take account of incomplete magnetic coupling.

the coils, as if they were resistors in series with the primary and secondary coils. In the Fig. 6 representation they are also in series with one another, so if the magnetizing current were small enough to neglect they could be lumped together as one resistance; but as we don't know whether we shall always be justified in neglecting the magnetizing current we shall keep them separate. Fig. 7 shows the modified diagrams. Since R_s and R_L form a simple potential divider, the potential of *d* is part of the way down from *e* to *a*, and on the assumption that R_s is small compared with R_L it is shown only a little way below *e* in the voltage diagram. The voltage V_{eb} across R_p must be in phase with the current flowing through it, however, so *eb* must be drawn parallel to JK. The result is that the phase angle between primary current and generator voltage is slightly reduced. But the more important practical effect of these resistances is to make the secondary terminal voltage V_{ad} less than the primary terminal voltage V_{ab}.

Leakage Inductance

And now we come to the point of this enquiry: to see what happens when the coupling between the two windings is not 100%. It never quite is, of course, in any actual transformer. If the windings are separate they cannot coincide, so at least a small amount of the flux caused by the primary current fails to link with the secondary winding. One of the objects of using a closed iron core is to make the magnetic path around both coils so easy that very little flux will take short cuts. With care, the leakage flux (as it is called) can be reduced to less than 1% of the whole, so a very good approximation can be made to the theoretical fully-coupled transformer—at least at low frequencies. At high frequencies it is much more difficult, for several reasons: the iron core loses much of its permeability, and very close coupling of the windings tends to cause excessive stray capacitance and loss. Fortunately, very close coupling is seldom wanted in r.f. transformers.

The effect of the magnetic leakage in a transformer is the same as if the inductance of each winding were divided into two parts: one part common to both windings as in Fig. 7, to represent the flux that links both; and the other completely uncoupled, to represent the leakage flux. Putting two and two together we get—*three*, as in Fig. 8 (since one inductance in each winding is common to both).

Let us remember that inductance is the name given to the flux-making ability of any part of the circuit. This ability is reckoned as the number of volts the flux would generate if the current in that part of the circuit were made to change at the rate of 1 amp. per sec. When an alternating current of 1 amp. (r.m.s. value) is made to flow, the r.m.s. value of its rate of change is $2\pi f$ amps per sec, so the back voltage generated by an inductance L is $2\pi f$L. To drive the 1 amp against the back voltage, an equal e.m.f. must be applied. The number of volts needed to drive 1 amp. through a resistance equals the resistance in ohms; by analogy, $2\pi f$L is the reactance in ohms of the inductance L.

So the effect of leakage flux L'_p in the primary winding is similar to that of the resistance R_p, except for the usual 90° difference in phase. And the same for L'_s. The inductance common to both windings is the mutual inductance, M. And the coefficient of coupling, usually denoted by *k*, is equal to $M \sqrt{} (L_p L_s)$, where L_p and L_s are the *total* primary and secondary inductances. This formula applies whatever the ratio of the transformer, but if the ratio is 1 : 1, so that $L_p = L_s$, then $k = M\ L_p = M/L_s$, and $L_p = L'_p + M$ and $L_s = L'_s + M$. When $L_p = M$, then $L'_p = 0$ and $k = 1$, which means that the coupling is 100%.

Before we go on to loose-coupled transformers, shall we just draw the general vector diagram for a loaded power transformer with appreciable leakage, on the basis of Fig. 8. Although this case is a " must " in every book and course on electrical engineering, so that one would have thought that by now a standard technique would have been arrived at, there is still the utmost chaos. Some teachers draw an upward arrow alongside the generator and another upward arrow alongside the primary (to represent the back e.m.f. opposing it); some show the primary arrow pointing downward, in the same circuital direction: some show both arrows pointing both ways; some draw two primary voltage vectors pointing in opposite directions; some in the same direction; and so on. No wonder that when a certain teacher tested a class by asking what, in Fig. 3, would be the polarity of the voltage from *c* to *d* relative to that from *a* to *b*, 11 said the same and 12 said the opposite ! *

It is usually easiest to work backward from the load to the generator. So the first vector to draw in Fig. 9 is *ad*, representing the output terminal voltage V_{ad}. The nature of the load Z_L is unspecified, but a mixed power load is generally somewhat inductive, so we draw the load current vector JL slightly lagging on *ad*. (If we take the e.m.f. applied to Z_L in the direction *ad*, that is to say clockwise, the corresponding direction of current is downwards, that is to say in the direction JL.) Now that we have the phase of I_{JL} we can draw *dg* in phase with it to represent the drop in the secondary resistance, and *ge* leading 90°, for the drop in the secondary leakage inductance. That gives us *ae*, representing the e.m.f. induced in the

* J. E. Parton, *Bulletin of Electrical Engineering Education*, No. 7 (Nov. 1951), page 22.

transformer. The current needed to create the flux to induce it is I_{LK}, which (since it passes wholly through inductance, M) lags V_{ae} by 90°, and LK is therefore drawn accordingly. (To be quite correct it should be slightly less than 90°, to allow for core losses.) If we like we may mark this vector "Φ," to show that it also represents Φ_{LK}. I_{JK}, the primary current, is of course $I_{JL} + I_{LK}$, so we join J straight to K to represent it. This shows its phase, enabling us to draw *ef* and *fb*, and so finally to arrive at V_{ab}, the generator voltage needed to maintain the assumed load conditions.

If you have a book on electrical engineering handy, look up its vector diagram for the equivalent transformer circuit, Fig. 8, and compare it with Fig. 9 for clarity and ease of construction.

Just to exercise this new simplicity you might care to redraw Fig. 9 for a highly capacitive load, making JL turn well to anticlockwise of *ad*. Then you will demonstrate the untruth of the axiom that the part cannot be greater than the whole. But, of course, being radio men, familiar with the workings of tuned circuits, we see nothing new or surprising in this. It is quite normal for the current in one branch of a parallel tuned circuit to be very much greater than the whole current fed in.

Tuned Transformers

This thought makes a convenient bridge to the loose-coupled tuned r.f. transformer. Its equivalent circuit, Fig. 10, is almost the same as Fig. 8, except for the capacitance in series with the primary, and the explicitly capacitive load. But the proportions of L and M are vastly different. In the power transformer, nearly all the inductance is mutual, L'_p and L'_s being just minor leakage. In the r.f. transformer, nearly all the inductance is L′, M being relatively tiny. The condition for "critical" coupling—the coupling between two resonant circuits giving the greatest secondary voltage—is that the reactance of M $(= 2\pi fM) = R$. (So that we don't become involved in complications right at the start, we are assuming that the two tuned circuits are identical.) Now since the reactance of the whole primary or secondary, $2\pi f(L' + M)$, is Q times R, M is 1 Q of the whole inductance of either coil—and a typical value for Q is 100. It may seem queer that the biggest output voltage is obtained with something like 1% coupling; it might be expected that it would be with 100%. But close coupling throws the two circuits out of tune and largely destroys their magnification. Any closer than critical coupling makes the single resonant peak divide into two, and it is the deepening hollow between them that makes the output at the original resonant frequency drop.

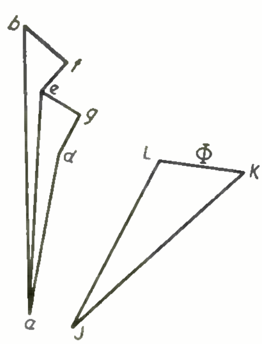


Fig. 9. Vector diagram corresponding to Fig. 8, for a transformer having comparatively little magnetic leakage.

Just before drawing the complete vector diagram for Fig. 10 it may be a good thing to take note of the characteristic shape of the diagram for a single tuned circuit, as shown in Fig. 11(a). The current in a series tuned circuit is a maximum at resonance, so we make JL fairly long. But R in a good tuned circuit is relatively small, so notwithstanding the maximum current we draw a short line *dg* in phase with JL. The voltages across C and L are Q times as great however; V_{ge} leading and V_{ad} lagging the current by 90°. (Even if we had made *dg* quite small, a Q of 100 or more would put *a* and *e* well off the paper—and probably off the desk as well!—so a somewhat lower Q will have to do.) The result is a long thin rectangle, with *a* and *e* so placed as to show that V_{ae}, the injected e.m.f., is equal to and in phase with V_{dg}. This picture fits all that one knows about series resonant circuits—I needn't go into all the details. The only point to note is that if R and L in the circuit changed places the voltage diagram would be as in Fig. 11(*c*). Seeing that in reality R and L are mixed up together, it is purely a matter of choice which order we show them in the equivalent circuit; personally I think (b) is a clearer and more recognizable picture than (c).

We already have a good start towards the vector diagram for the coupled circuits, of which Fig. 10 is the equivalent circuit. As you see, I cunningly lettered Fig. 11 so that it corresponds with the secondary, the "generator" being M, which induces the necessary e.m.f. There is one other important difference however: the reactance of L′ is not exactly equal and opposite to that of C, for L′ is L less M. Now we have made the reactance of M equal to R, so the amount by which *eg* must be shortened is equal to *dg*, representing the drop across R (Fig. 12). The vector *ae* is now the diagonal of a square instead of one of its sides, so is $\sqrt{2}$ times as long as before;

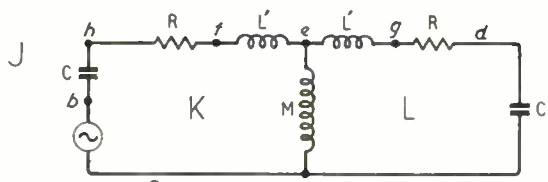


Fig. 10. Modification of Fig. 8 equivalent to a loose-coupled tuned r.f. transformer with identical primary and secondary coils.

Fig. 11. (a) is a single tuned circuit; (b) the corresponding vector diagram; and (c) the modified form of the voltage diagram if L and R in (a) changed places.

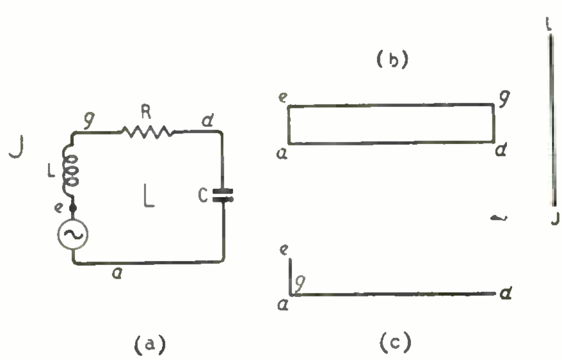
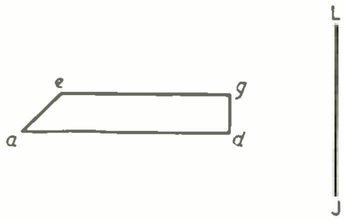


Fig. 12. Vector diagram for secondary circuit only of Fig. 10 at resonance.



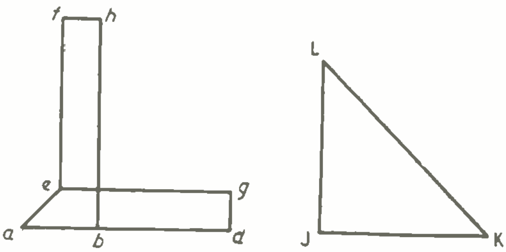


Fig. 13. Complete vector diagram for Fig. 10, at the resonant frequency.

and its phase is 45° behind. The current through M is therefore $\sqrt{2}$ times I_{JL} (it includes I_{JK} as well), and of course 90° behind V_{ca}. So we know the length and direction of KL, which we draw accordingly, Fig. 13. This gives us I_{JK}, the primary current, and we can now proceed to complete the diagram by drawing first *ef*, 90° ahead of JK, and equal to *eg* (for JK = JL); then *fh* in phase; then finally *hb* 90° behind JK, and equal to *ad*.

This complete picture has been arrived at without any deep thought, just by following exactly the same rules as for previous examples—the three fundamental phase relationships (for R, L and C) and the two prescribed rotations for voltage and current. Apart from following these rules correctly, there has been no need to worry about which way arrows should point, or whether we have the vectors in the right directions. And the diagram is simplicity itself to interpret. We see at once the two slim rectangles representing the two tuned circuits, and that they are at right angles to one another, showing that the voltages across them are 90° out of phase—which was what we set out to do. We see that the primary current is in phase with the injected e.m.f., which therefore sees a resistance load (as of course it should, at resonance). Since *fh* and *dg* are only half as long as *ab*, we see that the primary and secondary currents and the voltages across the circuits are half what the same input e.m.f. would produce across a single tuned circuit with the same characteristics. (If you are not quite sure about this, take away the secondary L, R and C from Fig. 10 and draw the voltage diagram for what is left. It should be a rectangle standing on *ab*, twice as tall as *bh*).

If you have become intrigued by all this you probably won't be kept from going on with it, drawing diagrams for less and more coupling than critical, and in doing so will learn (or confirm) quite a lot about coupled circuits. So far, I haven't come across a conventional vector diagram for critically-coupled tuned circuits. Perhaps it is such an unintelligible mess that no one dared publish it!

BOOKS RECEIVED

Microwave Theory and Techniques, by H. J. Reich, P. F. Ordnung, H. L. Krauss and J. G. Skalnik. Text-book for advanced students covering basic field and electron motion theory and its application in the design and operation of practical microwave generators, amplifiers, waveguides and radiators Pp. 901+XIII; Figs. 602. Price 75s. Macmillan and Company, St. Martin's Street, London, W.C.2.

Grundlage der Verstärkertechnik, by Hans Bartels. Revised and enlarged fourth edition of a monograph on the design of feedback amplifiers and their auxiliary stages, with an extensive bibliography. Pp. 279+XII; Figs. 181. Price DM20. S. Hirzel Verlag, Stuttgart, Germany.

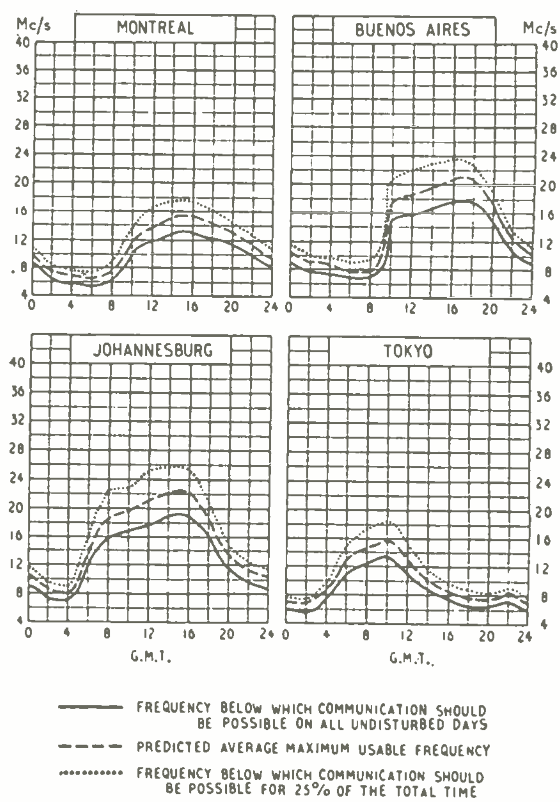
Electrical Measuring Instrument Practice by E. H. W. Banner, M.S.E., M.I.E.E., F.Inst.P. Survey of the types and designs of pointer instruments and recorders and their uses, including applications to the measurement of non-electrical quantities. Pp. 130; Figs. 50. Price 15s. United Trade Press, 9 Gough Square, London, E.C.4.

Short-wave Conditions

Predictions for September

THE full-line curves given here indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during September.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.



Neon Timers

Simple Circuits Based on CR Time Constants

By B. T. GILLING

IN radio work neon tubes are used mainly as voltage stabilizers and occasionally as saw-tooth generators, but they also have a very useful field of application as interval timers. Two different types of timers have recently been built by the writer and they are described below as examples of what can be done and also as exercises in simple relay switching. A very good article on relays by T. Dawson appeared in the January, 1953, issue of *Wireless World* and this should be consulted.

The basic neon timer circuit is shown in Fig. 1(a). A large capacitor is charged slowly from a high voltage through a high-value resistor. The voltage across the capacitor will rise until it reaches the striking voltage of the neon, which will fire and discharge the capacitor until the extinguishing voltage of the neon is reached. The relay in series with the neon will operate and close its contacts and this will complete the discharge of the capacitor. The relay will then drop off, opening its contacts, and the whole operation will recommence. This cycle of events will continue as long as the high voltage is applied. A small resistor of a hundred ohms or so is connected in series with the contacts to prevent a too rapid discharge of the capacitor with consequent sparking.

A disadvantage of this circuit is that only the small portion of the charge of the capacitor between the striking and extinguishing voltages of the neon flows through the relay coil, the rest being dissipated in the series resistor. The circuit can be rearranged as Fig.

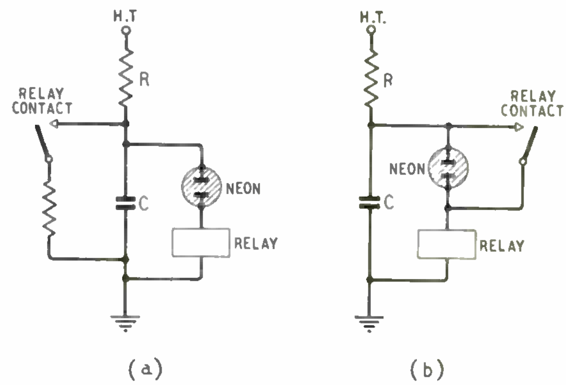
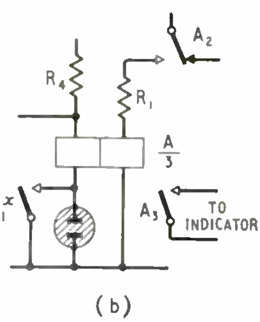
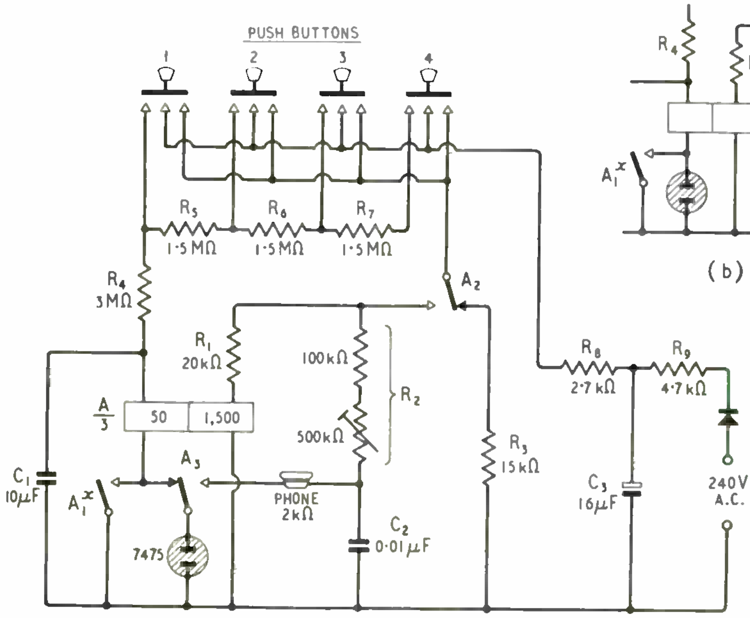


Fig. 1 Above. Basic neon timer circuit (a), with improved arrangement (b) giving a more positive action.

1(b) to overcome this. When the neon strikes the relay operates and its contacts short-circuit the neon; the capacitor then discharges through the relay and a more positive action is achieved. This latter method in a slightly modified form is used in both of the instruments to be described.

The first one is an interval indicator, shown in Fig. 2. The object of this instrument is to give an audible indication at the end of any half minute from one to two-and-a-half minutes. It was developed to time the operations of a cleaning machine used by watch repairers in which the parts to be cleaned are immersed in different fluids for set times. It is push-button operated for simplicity of working and uses one relay. This relay has windings of 50 and 1,500 ohms and three sets of contacts, two being change-overs and the third a single make which is arranged to close at low spring pressure before the others start to move. The operation is as follows. Assume that push-button 1 is pressed. C_1 will charge through R_4. When the neon strikes





(a)

Fig. 2 (Left). Circuit of interval indicator giving an audible note at the end of any half minute from one to two-and-a-half. x indicates early operation.

the current through the 50-ohm coil will cause the relay to start to operate and A_1 will close, short-circuiting the neon. The entire remaining charge in the capacitor will then flow through the coil, causing the relay to operate completely. A_2 will change over, locking up the relay through its 1,500-ohm coil and R_1. A_3 will change over, transferring the neon to the oscillator circuit R_2C_2 and a note will be heard in the telephone earpiece. This note is adjusted by the variable portion of R_2 and will continue until any one of the projecting buttons is pressed, releasing the operated button. The supply voltage is thus removed, the relay drops off and the instrument is ready to be operated again.

The values of the resistors in the high voltage circuit, R_7, R_8, R_9, are chosen to give an operating value of 150 volts at the push buttons, R_3 being chosen to pass the same current as the holding and tone generating circuits combined. In this instrument, close accuracy of timing was not essential and so no attempt was made to stabilize the high voltage. The values of the capacitor and resistors in the charging circuit give times of 1, 1½, 2 and 2½ minutes. This depends on the value of the high voltage and it may be necessary to alter the value of R_8 to obtain exact timing on an individual instrument.

A Post Office type 3000 relay is used and the values of the windings are not critical. The first coil will work at any value up to 1,000 ohms, and provided appropriate alterations are made to R_1 any high resistance value will suit the second coil. A point to bear in mind is that the second coil has only to hold the armature after it has been operated, therefore a very much lower value of current is called for than would be needed had the relay to be operated by this winding.

The method of generating the indicating signal is a simple one calling for the minimum of additional components but the circuit can be rearranged as shown in Fig. 2(b) to switch in an external indicator, either sound or light.

The second instrument (Fig. 3) was designed to switch on the lamp of a photographic enlarger for any predetermined time with close accuracy. It is operated by a telephone key-switch having a central off, one locking and one non-locking position. Two relays are used, one having a 50-ohm coil and a change-over contact. The other has a 2,000-ohm coil and three contact sets, two make contacts and a change-over. It is a two-step relay, the first step being controlled by B_1 which closes at light spring pressure before the other two sets move.

The operation is as follows. The key-switch is pressed in its non-locking position, closing its contacts K_1 K_2, the contacts K_2 being adjusted to close a fraction before K_1. Relay B will operate, but as K_2 has put R_4 in shunt with its coil there is only sufficient power to close B_1. This state of affairs will continue until the key-switch is released. The shunt is then removed and full current passed through the relay over B_1, operating the relay fully. B_3 closes, connecting the enlarger lamp across the mains. B_2 changes over, connecting the resistor R_1 to the capacitor, which starts to charge. When the neon strikes relay A operates. A_1 changes over, disconnecting relay B which drops off and the enlarger lamp is extinguished. B_2 changes over, disconnecting the charging circuit and completely discharging the capacitor through R_2, and the apparatus is ready to be used again.

The locking position of the key-switch is to enable the enlarger lamp to be switched on permanently for setting-up and focusing operations. The high voltage supply is stabilized by a tube, type VR150/30, and an accuracy better than 5 per cent is obtained from one exposure to another. R_1, which is the time control, can be a variable resistor of 2 MΩ calibrated in seconds, but a preferable method is to use a Yaxley type switch with fixed resistors so chosen that each step increases the time by one half of the previous one. Resistor values for this are given in Table I.

A Post Office type 3000 relay is used for B and since differences in spring pressure and armature clearance will alter its characteristics the values of R_3 and R_4 may need modification. The method of setting up is as follows. With R_4 disconnected a value for R_3 is found which will give a good positive action to the relay when the key-switch is depressed. This

TABLE I

The resistance values are selected to give an increase of approximately one half per step in a ratio series familiar to photographers as f numbers.

Seconds	1	1.4	2	2.8	4	5.6	8	11	16	22	32	45
Kilohms	62.5	25	37.5	50	75	100	150	190	310	400	600	800

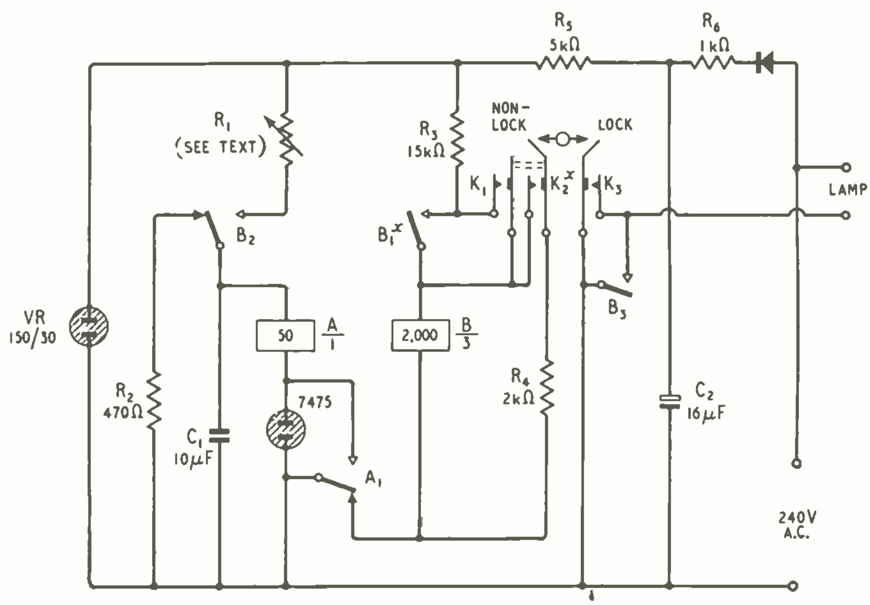


Fig. 3. Timer for switching on a mains circuit for any predetermined time with close accuracy.

value is wired in circuit and a variable resistor connected in place of R_4. A value for this is found which will allow the relay to operate only to close B_1 when the key-switch is operated. Finding the value of these resistors in this way also permits the use of relay coils having a resistance other than 2,000 ohms. Relay A is a Post Office type 600 and its resistance is not critical; values of up to 1,000 ohms can be made to work.

In the examples shown the high voltage supply is obtained directly from the mains. This is a simple and efficient method but it must be very strongly emphasized that either the instrument must be in a case made entirely of insulating materials with no metallic controls exposed, or, if a metal case is used, no wiring must be allowed to come into contact with it and it must be securely earthed. Rectification is by a small 24-section selenium unit and smoothing is of the simplest, consisting of resistor and a single 16-μF capacitor in each case. The maximum current drawn in either is less than 20mA.

A point of importance to be observed in all timers is that the charging capacitor must be of high-grade paper construction with very low leakage and, in fact, all parts associated with the charging part of the circuit must be of the highest insulation.

Training in Television Servicing

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

Special Apparatus for Practical Demonstrations

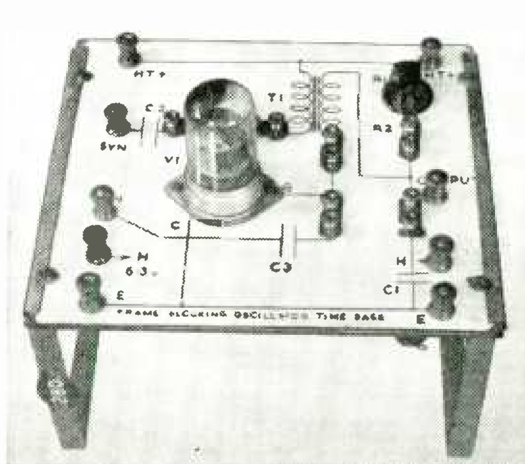


Fig. 1. Experiment board of frame blocking oscillator.

IN the training of television service technicians there are a number of problems which do not occur in most other subjects. The course is essentially a craft type and the people normally attending such courses have a limited academic background, so that the subject must be dealt with in as simple and as practical a manner as possible. Unfortunately, a modern television set is a complicated piece of equipment and is tending to become more so with the introduction of efficiency diodes, Band III, etc. It is extremely difficult to explain the operation of many television circuits without going into mathematics and complicated circuit theory. Although a television servicing technician is only required to repair sets and not design them, the author finds it difficult to understand how a satisfactory repair can be made without at least an elementary knowledge of how the circuit operates and, what is equally important, what will happen under various fault conditions. It is, of course, possible to cure many faults by a trial and error method, but this may be very time-consuming and expensive. Experience of typical faults on particular models is, of course, most valuable but is something which cannot be easily taught.

In view of the difficulties of explaining many circuits the author considers that practical demonstrations are the ideal way and essential to the teaching of this subject. This idea is used to a great extent at Bradford Technical College, where the course consists of two nights per week for a period of two years. One night is devoted to lectures and demonstrations and the other night to practical work by the students themselves. Turning to the practical work, this is divided into two types, (a) experiments on simple circuits, (b) actual fault finding on commercial television receivers. The work done during the first year of the course consists of type (a). For this purpose a number of experiment boards have been constructed, each board consisting of a simple circuit of a section of a television receiver, e.g., a time base or a synchronizing separator. These boards are designed so that they may be used for three purposes:—

1. Experiments on the general operation of the circuit. Voltages, waveforms, etc.
2. The effect of faults on the general operation of the circuit and on the voltage readings and waveforms.
3. The actual location of faults on these circuits.

A typical board is shown in Fig. 1. The "board" consists of hardboard covered with drawing paper on one side. The circuit is drawn on this paper which is then covered with celluloid or, rather better but more expensive, Perspex. More recently a transparent plastic covering has been used which can be secured to the paper by heat. The components of the circuit are fastened to the back of the board and are con-

* Bradford Technical College.

nected to small terminals which are located in the correct positions on the circuit diagram. In series with most components are connected two terminals which are normally joined together by a link. By removing the link the component is effectively open circuited. The board is most useful to show the operation of the circuit, and voltage readings and oscillograph waveforms may be taken at various points. Since these are taken at points on an actual circuit diagram it is easy to see just what voltage is being measured. By removing the links, one at a time, the effect of open-circuited components can be seen on both voltage readings and oscillograph waveforms. The effect of short circuits may be seen by connecting appropriate terminals together.

Fault Finding Scheme

In order that the same board may be used for actual fault finding the links are of special construction. They are made of a sandwich of Leatheroid and copper foil (cemented with Bostik) and are used with the Leatheroid upwards. For fault finding, a number of dummy links are available which are constructed in a similar manner but a slot is cut in the copper foil so that, although the circuit is not completed, the link appears the same as normal. Short circuits may be placed on the circuit by shorting links fitted with crocodile clips on the underside of the board, the students being instructed not to turn the board over. From the point of view of fault finding these boards have the advantage that they can be used repeatedly, whereas when soldered connections are broken and remade to place faults on circuits the apparatus soon becomes useless, owing to damage to components, soldering tags, etc.

In order to operate these boards a coaxial cable is fed to each position in the room. Each position may be supplied with any of the following:—

1. B.B.C. signal from aerial.
2. R.F., modulated with test pattern.
3. Video signal of test pattern.
4. Composite synchronizing pulses.
5. Line pulses.
6. Frame pulses.

The last four are fed through an amplifier and cathode follower unit on each position so that the output may be varied in amplitude and either polarity may be obtained by means of a switch. These supplies and boards have been found invaluable for demonstrations and save much time in connecting up circuits when wishing to give demonstrations. If much connecting up is required in order to give a demonstration the general result is that the demonstration does not get shown.

At present 33 such boards are available and it is hoped to make more in the near future. For the second part of the practical work a number of commercial television receivers are available and also two sets constructed at the college. One is a normal circuit (largely *Wireless World* design) arranged with separate chassis for the various sections while the other is a projection set. Faults of various types are placed on these sets and the students get experience in locating them.

Apart from the normal equipment of cathode-ray oscillographs, valve voltmeters, signal generators, etc., a number of special pieces of equipment are available which are most useful. The first is a commercial oscillograph with d.c. amplifiers and an X trace which can be expanded to approximately five times the screen diameter. This is invaluable for showing the operation of d.c. restorers and of circuits where the d.c. component is important.

The second is a television waveform display apparatus which was constructed at the College and is described in more detail elsewhere.[1] The apparatus is essentially a special cathode ray oscillograph arranged so that the waveform of 2 to 250 lines of a television picture may be shown. The lines can be varied so that any selected ones may be shown and a pulse is available for brightening the corresponding lines on a picture on a normal receiver. This is particularly useful for showing the operation of synchronizing separators, which are almost impossible to demonstrate on a normal cathode-ray oscillograph. Fig. 2(a) shows the frame synchronizing period on even frames taken on the signal from the pattern generator, while (b) shows the effect of integration of the frame pulses. In this the build-up of voltage can easily be seen but it is quite impossible to show anything of this nature on an ordinary oscillograph since the frame synchronizing pulses occupy only a small fraction of the total frame time. The apparatus can, of course, be used with advantage for fault finding.

Camera Equipment

Recently a complete television camera has been constructed to help in clarifying some of the mysteries of the camera side of television, which cannot normally be seen by students outside the London area. The camera itself consists of a Pye Staticon miniature pick-up tube with a two-valve pre-amplifier, a cathode follower and a pulse amplifier. It also contains an electronic view-finder with corresponding time bases and video amplifier. The camera is fed from a control unit which is mounted on two racks. These contain the power supplies, video amplifiers, time bases, pulse generator and monitor tube. The signal from the pre-amplifier is fed by coaxial cable to the video amplifier on this control unit. After amplification and frequency-response correction, the signal is fed to a clamp circuit to set the black level, and then to a blanking amplifier which suppresses the signal for the required periods. The synchronizing signal is then added to give a complete video waveform. The control unit also contains a small r.f. oscillator and amplifier which is modulated

[1] Patchett, G. N "A Television Waveform Display Apparatus," *Electronic Engineering*, May and June, 1953.

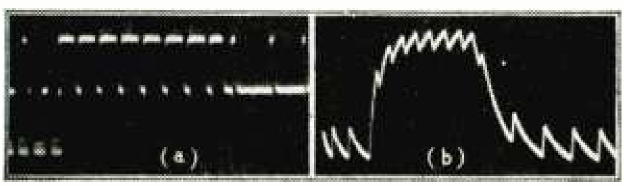


Fig. 2. (a) Video signal of pattern generator during even frame synchronizing period. Negative picture signal. (b) The effect of integrating the synchronizing pulses during the frame synchronizing period. Positive pulses.

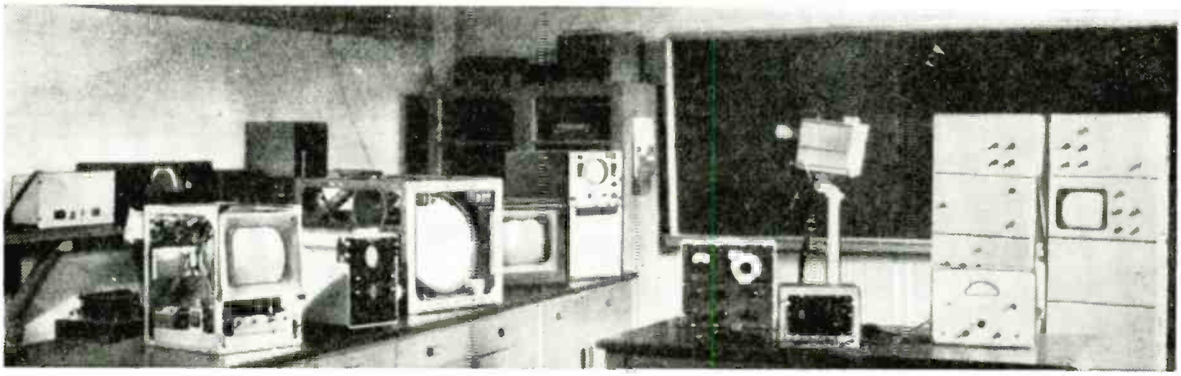


Fig. 3. A corner of the television servicing laboratory at Bradford Technical College, showing camera and control unit.

with this video signal so that the camera may be used to operate a normal commercial set.

The camera is most useful for showing effects of d.c. component, definition, etc., which are difficult to show on a normal pattern-generator signal. It is designed to give a correct B.B.C. synchronizing signal and will resolve at least the 2-Mc/s bars on Test Card C. Built into the same control unit is a monoscope which enables a Test Card C pattern to be produced when required. Some further work is required on this section to give complete satisfaction but it will be a most useful addition as this signal is not available (apart from a few minutes) during normal class time.

Fig. 3 is a general view of part of the laboratory with the television camera control unit and other apparatus.

Although much time and effort have been devoted to this work it is felt that it is well worth while if it enables students to obtain a better understanding of the working of a television receiver. With the introduction of more channels and, at some later date, colour, the complexity of the television receiver will increase and it will be even more difficult to give satisfactory training. The servicing trade is already short of technicians and it will become more important to have highly skilled people available as more sets are installed and as their complexity increases.

MODERN AIRFIELD RADIO

A NEW civil airport near Dungeness, known as Ferryfield, opened recently by Silver City Airways, is said to be the first airfield in the world planned especially to deal with the transport of vehicles, as distinct from passengers or freight. It will eventually replace the cross-channel car ferry now operating from Lympne.

Its interest from our standpoint is that, being a new airport, it has no legacy of existing radio facilities that must be integrated with new services and the whole radio and radar installation has been planned from the ground up, so to speak.

First and foremost is the air-to-ground communication; this is carried out primarily on two v.h.f. channels in the 118- to 132-Mc/s aircraft band by means of modified T1131 crystal-controlled transmitters of 50 watts telephony rating and four Marconi HR82 receivers. Two transmitters and receivers are in service and two on stand-by. There are also two h.f. transmitters (one operational and one stand-by) for single spot-frequency operation in the 2- to 25-Mc/s band. They are rated at 250 watts telephony and 350 watts c.w. telegraphy and have been installed to handle long-distance communications in connection with charter work. There are two h.f. receivers of Racal design.

Two aids to navigation are provided; one is a v.h.f. direction finder operating on the null-signal aural

The flying controller's desk at Ferryfield is typical of the type now installed at civil airports. Facing the controller is a panel of instruments giving wind velocity, time and barometric pressure information. On the left is a recessed loudspeaker to which all receivers are connected, and on the extreme left is the runway's lighting control. Convenient to the controller's left hand is a panel carrying switches and indicator lights for remote control of all radio services. A hand telephone set is in a recess below.

principle and employing a pair of rotatable dipoles with switched reflectors to give "sense." Bearings are taken on the normal R/T transmissions from the aircraft. The other navaid is a Decca 424 radar with the scanner and radio-frequency head located about 400 to 500 yds from the control tower. The i.f. signal is "piped" to the tower where, in a room fitted with tinted glass windows, are two c.r. tube display units, with separate i.f. receivers to allow for independent operation. Thus one can cover the distant approaches out to 25 miles or so, while the other can give an expanded picture of aircraft movement within a mile or two of the airfield.

Radio-telephone facilities are provided in this room to enable aircraft to be "talked down" to within visual distance of the runways under conditions of poor visibility. Here is located also the v.h.f. direction finder so that all the radio navigational aids are conveniently to hand.

Not yet installed, but planned, is a v.h.f. radio-telephone system for keeping in touch with all airport vehicles. It, and all the other radio services, will be operated from the controller's console as is now customary practice at all airfields, large and small.

The radio and other airport equipment at Ferryfield was planned and installed by Racal, Ltd., and, of course, is approved by the Ministry of Transport and Civil Aviation.

International Technical Questions

PROFESSOR BALTH. VAN DER POL, director of the International Radio Consultative Committee (C.C.I.R.), has sent us a copy of Volume I of the Proceedings of the VIIth Plenary Assembly of the Committee which was held in London last September. Engineers and technicians interested in the international aspects of technical radio questions will find the book (which is available in English and French) of considerable interest.

Volume I contains the full text of 90 recommendations, reports and resolutions adopted by the assembly. It also gives full details of the study programmes and questions which will be investigated during the three years before the next assembly, to be held in Warsaw in 1956. These investigations are carried out by the study groups of each of the member countries of the International Telecommunication Union of which the C.C.I.R. is a permanent organ. It is as a result of the papers submitted by these national study groups that the recommendations and further study programmes are arranged.

As the book also contains the texts of those reports, etc., adopted at the previous two plenary assemblies which are still valid, it forms a complete collection of the current C.C.I.R. documents.

Some idea of the diversity of subjects covered in this 406-page book may be gained from the following summary of some of the entries in the 20-page index:—

Propagation: Ionospheric, tropospheric and ground-wave.

Receivers: Noise and sensitivity; selectivity; frequency stability; choice of i.f.

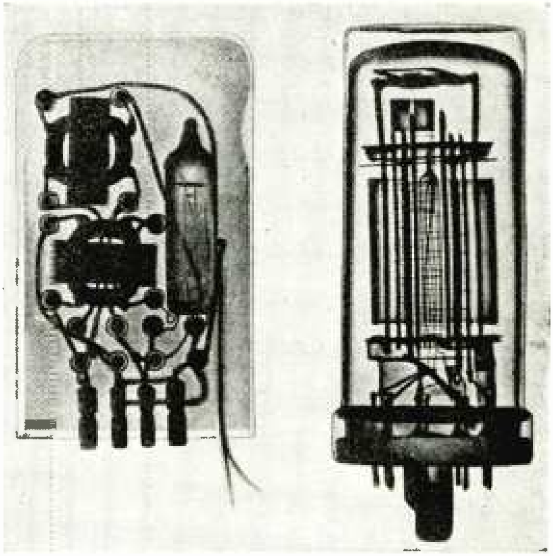
Recording: Standards for sound on discs, film and tape.

Television: Recording, polarization, standards conversion, picture and sound modulation, combining monochrome and colour.

Two further volumes covering the reports of the study group chairmen and the director (Vol. II), and the minutes of the plenary assembly (Vol. III) will be published later.

Volume I is obtainable from the Publications Department, International Telecommunication Union, Palais Wilson, Geneva, Switzerland, price 23.10 Swiss francs.

ELECTROSTATIC RADIOGRAPHY



THIS picture shows an x-ray image of a valve and a potted circuit obtained by a new process called xeroradiography which dispenses with ordinary photographic techniques. The method is cheap because the plates can be used over and over again and is very quick—the radiograph being ready in less than a minute from the time of exposure.

In place of the ordinary photographic plate a thin film of selenium on a conductive backing plate is used, and this is charged electrostatically. On exposure to the x-rays the charge is modified according to the pattern of the object being radiographed, so that an electrostatic image is obtained. This image is then made visible by spraying on to the plate a very thin film of charged powder, which adheres in accordance with the charge distribution. For re-use it is only necessary to wipe the plate clean and recharge.

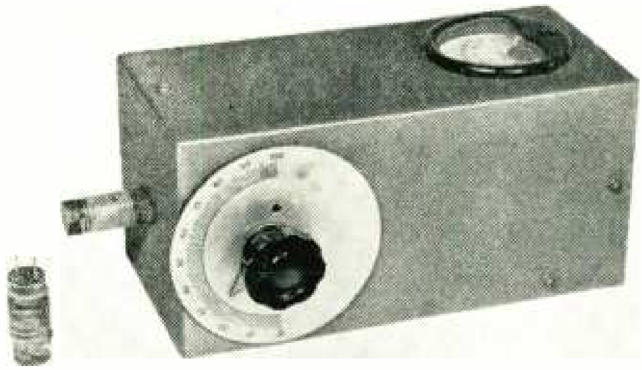
The method has been developed by Ferranti, who say that it is possible to obtain pictures with an even finer grain than in conventional x-ray photographs.

Problem Picture

What is it? Clue: the external form is strictly functional. No, it is not a r.f.-heated pressure cooker, but the latest transmitter-receiver for ships' lifeboats, made by Marconi Marine.

The "Salvita" set, as it is called, is waterproof—indeed, submersible—and is powered by a hand-driven generator. It complies with the latest Government specification, and operates on 500 kc/s and 8.364 Mc/s.

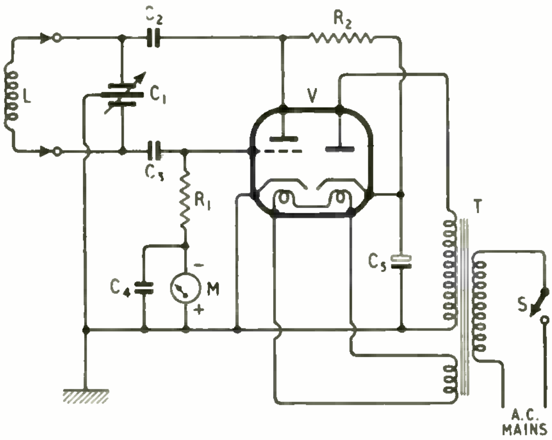
COMPACT GRID-DIP OSCILLATOR



By G. P. ANDERSON
(*Amateur Radio Station G2QY*)

A Useful Method of Finding the Resonance Frequency of Coils and Circuits

DURING recent years the increasing appreciation of the value of the grid-dip oscillator as an item of test gear has been reflected in the number of articles published describing different varieties of the species. The only excuse the present writer has for offering yet another contribution on the subject lies in the use of a triode-diode v.h.f. mixer valve as an oscillator and mains h.t. rectifier.



Circuit diagram of the grid-dip oscillator described in the text.

Basically the GDO comprises an oscillating valve tunable over the desired frequency range, and including a meter to show the rectified current flowing in the grid circuit. The oscillator coil is usually placed on the outside of the unit in order to permit it to be brought near to the circuit under test. When the test circuit and the GDO are tuned to the same frequency, power is absorbed from the oscillator causing the grid current to fall; hence its name.

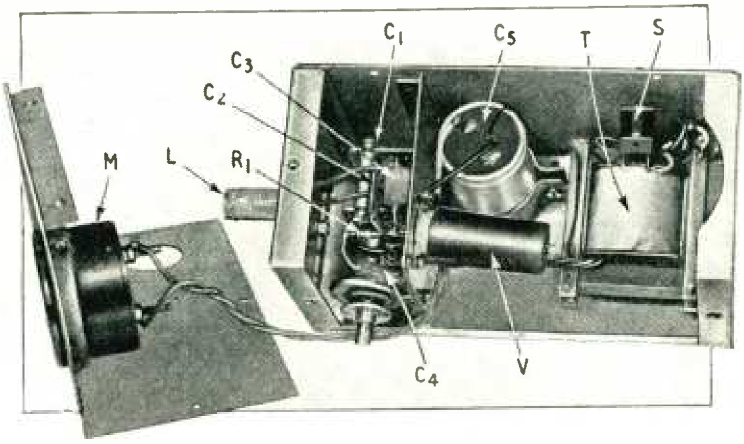
An examination of the makers' characteristics for the diode part of the Mullard EAC91 shows that it is designed with limiting values of 50 volts between heater and cathode, and a cathode current of 5 mA. Using the triode section as an oscillator with approximately 50 volts h.t., the current taken is well within this limit, and the valve may be made to oscillate easily up to frequencies of the order of 220 Mc/s, using components suitable for operation at lower frequencies as well. The particular model shown in the photographs is designed to cover the range from 5 to 160 Mc/s with seven coils, which are arranged to plug in to the end of the unit.

The mains transformer may be quite small as it supplies about 2 watts only, and the smoothing shown in the circuit diagram, comprising C_5 (32 μF) and R_2 (10 kΩ), is adequate for the purpose. The

LIST OF COMPONENTS

C_1	20 + 20 pF variable
$C_{2, 3, 4}$	100 pF silvered mica
C_5	32 μF 50 V wkg.
R_1	22 kΩ ¼ W
R_2	10 kΩ ½ W
V	EAC91 (Mullard)
A	250 μA meter
L	See table
T	Mains transformer; secondaries 50 V at 5 mA, 6.3 V at 0.3 A.

On the right the layout of the parts inside the box is shown with the top and one side removed.



signal produced, if listened to in a receiver, is modulated very deeply with 50 c/s, but this is no disadvantage in using the instrument; it is in fact very useful for identifying the signal when accurate frequency checking is desired.

The model shown is built into a box measuring 7×3¼×3¼in, which is a convenient size for holding in the hand. It could be made smaller, but was originally built as a companion to a self-contained battery model, which used one triode of a 3A5 in a similar oscillator circuit, driven by hearing aid batteries. The only external difference was in the replacement of the mains toggle switch by a spring-loaded push button, conveniently placed for thumb operation. This switch was fitted in the heater circuit in order to prevent the batteries being run down unnecessarily.

Details of the coils, and the approximate ranges covered, are shown in the table. If use at the upper end of the range only is contemplated a smaller capacitor at C_1 permitting a different layout to secure shorter leads in the oscillator circuit would probably enable the GDO to be used at even higher frequencies. In passing it may be mentioned that tests have been carried out with 120 volts applied to the rectifier without any signs of distress; with the heater left unearthed, this voltage does not appear across the heater and cathode, but only between the two cathodes, and, of course, the cathode and anode of the diode.

For completeness, a few notes on the use of the GDO may be added. Each range should be calibrated, conveniently by comparison with a suitable receiver, but it should be kept in mind that such calibration is only approximate, since coupling to a tuned circuit tends to "pull" the oscillator. In use the coil of the GDO should be brought near to the circuit under test, and the tuning condenser varied until a decrease in grid current is indicated. The coupling should then be reduced, by moving the GDO away, until the smallest observable "dip" is obtained; in this way, the "pulling" of the oscillator frequency is reduced to a minimum. If more accurate knowledge of the frequency than is given by the GDO calibration is required, the oscillator frequency may be checked on a receiver, maintaining meanwhile the coupling to the circuit under test.

Apart from the obvious uses in adjusting tuned circuits in receivers, transmitters and such like, the GDO may also be used to find the resonant frequencies of aerials, guy-wires, etc.

COIL TABLE

Coil	Approx. Freq. Range	Turns	Winding Length	Wire
A	5–9 Mc/s	68½	¾in	36 s.w.g. enamel
B	9–15 ,,	39½	,,	28 ,,
C	14–24 ,,	24½	,,	24 ,,
D	23–40 ,,	15½	,,	22 ,,
E	37–63 ,,	8½	,,	20 ,,
F	60–110 ,,	5½	½in	20 ,,
G	100–160 ,,	1½	¼in	20 ,,

The coils are each wound on 1-in lengths of ½-in diameter Paxolin rod, and are terminated on two 20 s.w.g. tinned copper wires inserted in the ends, spaced to suit the socket on the grid-dip oscillator. In the original model, the socket is a diode valveholder (Base Type B3G).

FITTING CAR RADIO

IN order to encourage radio dealers not having facilities for handling motor cars to take a more lively interest in car radio, Pye Telecommunications are organizing fitting depôts throughout the country to which dealers can send their customers for skilled and prompt fitting of the latest Pye car radio receiver. At the time of writing depôts are functioning in Birmingham, Cambridge and Manchester.

To facilitate speedy installation in the widest possible range of cars the new set is made in three separate parts; radio tuner, combined output and power unit and loudspeaker respectively. The first and last only need be in the body of the car and space can generally be found somewhere under the bonnet for the power unit, where, incidentally, it will be within easy reach of the battery in most cases.

The tuner is a complete three-valve, two-waveband superhet less output stage, and is designed to have a reasonably small frontal area so that it can be accommodated conveniently in the space provided on the dash board, or immediately below without obstructing either the driver or passenger.

Tuning and the combined volume/on-off controls are fitted with normal type knobs and disposed on either side of a rectangular dial, while the tone control and wave-change switch have disc-shaped "dollies" for finger or thumb operation and are let into the lower part of the dial. There are separate scales for medium and long waves with illumination for night-time operation. The price of the new set, including aerial, purchase tax and fitting fee is £28.

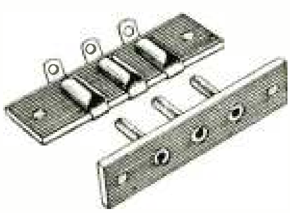
Right: To facilitate installation the new Pye car radio receiver is broken down into the three units shown here.

Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

Strip Connectors

THE plug and socket connector illustrated is one of a new range introduced by Bulgin for the electrical interconnection of individual items of a larger equipment. A typical application would be where several chassis are mounted in a rack or a cabinet and slide in and out on guide rails for maintenance and servicing. The socket part can be fixed to the back of the chassis and the plug part (or vice versa) on the back of the rack or cabinet. When the chassis are pushed fully home the two parts mate together and the electrical interconnections are automatically made. To ensure correct alignment of the pins and sockets, individual sockets are allowed a free lateral movement of ±5 deg.



Bulgin 3-way plug and socket strip connector.

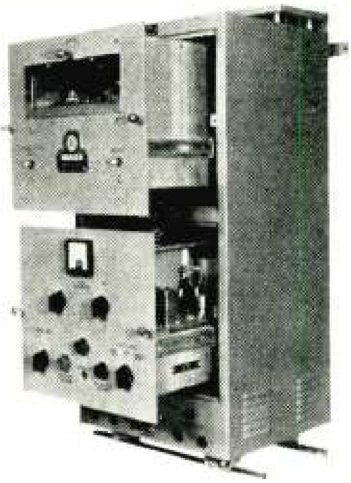
Plugs and sockets are mounted on strips of good-quality bakelized material, the pin spacing being $\frac{7}{16}$ in. Pins are hollow and the leads are secured by tip soldering as in the older-type valve pins. Sockets are fabricated from resilient metal strips, bent to shape, and have integral soldering tags.

These new connectors are available in 3- to 6-, 8-, 10- and 12-way types and prices range from 1s 1½d for a 3-way plug and socket to 3s 6d for a 12-way.

The makers are A. F. Bulgin and Co., Ltd., Bye Pass Road, Barking, Essex.

Auto-alarm Receiver

THE "Seaguard" auto-alarm receiver is intended to take the place of the ship's radio officer when he goes off duty. It maintains a constant watch on the marine distress frequency of 500 kc/s, and, in the event of a distress signal conforming to the international standard of 12 four-second dashes at one-second intervals being received, operates an alarm. In order to allow for slight mis-tuning of the caller's transmitter the Seaguard receiver is pre-tuned for reception over the band 490 to 510 kc/s.



Marconi Marine Seaguard auto-alarm equipment with chassis withdrawn for inspection.

A receiver of high sensitivity is employed and elaborate precautions are taken to ensure that only a genuine distress signal of the agreed form will actuate the alarm mechanism, which comes into operation after the fourth dash of correct duration and spacing.

The Seaguard consists of two main units, receiver and power supply, both housed in a single cabinet with draw-out chassis for servicing. A built-in meter provides means for checking all valve feed currents and failure of either unit is indicated by one of two lamps lighting up; also the alarm bells ring.

The equipment is supplied by the Marconi International Marine Communication Co., Ltd., Marconi House, Chelmsford, Essex.

NON-FERROUS METALS

ELECTRICAL, physical and mechanical properties of non-ferrous metals and alloys are given in the 472-page "Metal Industry Handbook and Directory, 1954," which also includes summaries of relevant British Standard specifications, compositions and melting points of solders and a classified directory of products. The volume, which is in its 43rd year of publication, is published by the Louis Cassier Company, Ltd., Dorset House, Stamford Street, London. S.E.1, price 21s.

RANDOM RADIATIONS

By "DIALLIST"

Sporadic E

YOU'VE probably had your whack of television interference by sporadic E reflections at one time or another in the course of the present summer (*sic*). "Clouds" of intense ionization, forming sporadically in the E-layer and capable of propagating long-distance interference with our TV services were forecast as most likely to occur in the daytime between May and August by T. W. Bennington,* whose work is well known to *Wireless World* readers. His forecast has been amply borne out by what happened this year. At one time or another from early May onwards severe modulated r.f. interference during daylight has been reported from many parts of the country. Unless there's some interesting event, sporting or otherwise, on tap, I don't often use my receiver during the afternoon. Hence it wasn't until early in July that I saw sporadic E interference in full swing. It began more or less mildly with the appearance of a number of faint whitish lines on the screen. They were not stationary, but jittered about, sloping now from left to right and now from right to left between the top and bottom of the screen. The lines grew rapidly more obvious and "greys" appeared between the "whites.' Meantime, they became steadier and less inclined this way or that. Watching them was very trying to the eyes, but I was too fascinated to switch off. So far as I remember, the next development was sudden: the lines became alternate black and white vertical bars of equal width, covering the entire screen. They were at one time so steady that I could count them: 24 black bars, with jagged edges indicating modulation.

Long-Range TV

TELEVISION is full of surprises. If you were asked what were the chances of obtaining consistently good pictures at a seaside town, 70 odd miles from the nearest transmitter and with huge hilly areas inland, you'd probably reply without hesitation that they were not very bright. That's certainly what I should have said about Torquay—if I hadn't just returned from a visit to friends who live there and seen for myself the quite excellent pictures that they regularly have on their screen. Good reception is rare in the more low-lying parts of the town; but, given an efficient receiver and a high 3- or 4-element Yagi array, pictures in the higher parts are very nearly up to the standard of those obtainable in a normal service area. When you think of Torquay you are apt to picture it as lying under the shadow of Dartmoor. You might even feel that the direct path from Wenvoe must pass over Exmoor as well. Take a look at the map and you'll see that a straight line between the two places doesn't cross either: there are, in fact, few natural obstacles in the way of a metre-wave transmission.

A.G.C.

Almost the only fly in the ointment in this part of South Devon is slow, and sometimes not so slow, fading. My host had done a good deal towards minimizing the effects of this by rigging up a remote-control arrangement for the contrast. With this he could keep the picture-level more or less steady; but I couldn't help feeling that this job of work should have been done in the receiver itself by means of effective a.g.c. It is not only in places far from a transmitter that receivers have to cope with signal variations big enough to be a nuisance to the viewer. I am glad to see that an increasing number of manufacturers are including a form of a.g.c. in their sets. What a boon it will be if it is really effective against aeroplane flutter; for this form of interference is becoming more and more frequent with the increasing number of planes in the air.

The F.M. Scheme

THOUGH the first stage of the B.B.C.'s plan for v.h.f. broadcasting provides for only nine stations, it will cover a good 75 per cent of the homes of this country. The idea is to turn every TV station eventually into a combined television and sound broadcaster This means that the provision of interference-free sound broadcasting will go forward hand in hand with steadily improving television coverage. Since it should be possible to share much of the building, maintenance and running costs

* *B.B.C. Quarterly*, Autumn 1953.

between the two services this should make for a considerable saving in expense. A saving in manpower, too; for the number of engineers and technicians needed to run a "combined" transmitting station should be quite a bit smaller than that called for by two completely separate outfits. Although we may not be the first country to have a nation-wide high-fidelity sound service we shall, I believe, be the first to demonstrate the economies of combined sound broadcasting and television stations.

AWARDS TO AUTHORS

AUTHORS of a dozen or more papers on radio and allied subjects read before the Institution of Electrical Engineers last session, or accepted for publication during the session, are to be awarded premiums by the Institution.

The Duddell Premium (£20) goes to G. W. Barnes (R.A.E., Farnborough), for his paper "A Single-Sideband Controlled-Carrier System for Aircraft Communication," the Blumlein-Browne-Willans Premium (£20) to G. Dawson, K. G. Hodgson and R. A. Meers (all of S.T.C.), and L. L. Hall and J. H. H. Merriman (P.O.), for "The Manchester-Kirk o'Shotts Television Radio Relay System," the Ambrose Fleming Premium (£10) to Dr. M. M. Z. Kharadly (Imperial College), and Dr. Willis Jackson, F.R.S. (Metrovick), for "The Properties of Artificial Dielectrics Comprising Arrays of Conducting Elements," the Fahie Premium (£10) to T. Hayton, C. J. Hughes and R. L. Saunders (all of C. & W.), for "Telegraph Codes and Code Convertors" and the Heaviside Premium (£10) to J. F. Coales (Cambridge University), for "The Application of Information Theory to Data-Transmission Systems and the Possible Use of Binary Coding to Increase Channel Capacity." A £10 Premium will also be awarded to Dr. A. L. Cullen (University College, London), for "The Excitation of Plane Surface Waves."

Premiums valued at £5 will be given to the following authors for the papers quoted: E. D. Daniel and Dr. P. E. Axon (B.B.C.), for "The Influence of Some Head and Tape Constants on the Signal Recorded on a Magnetic Tape" and "The Reproduction of Signals Recorded on Magnetic Tape"; Dr. E. A. O'Donnell Roberts (Mullard), for "A Study of Some of the Properties of Materials Affecting Valve Reliability"; Dr. J. A. Saxton and B. N. Harden (Radio Research Station, Slough), for "Basic Ground-Wave Propagation Characteristics in the 50-800 Mc/s Band" and "Ground-Wave Field Strength Surveys at 100 and 600 Mc/s"; J. Brown (Imperial College), for "Artificial Dielectrics Having Refractive Indices less than Unity"; Dr. A. Talbot (Imperial College), for "A New Method of Synthesis of Reactance Networks"; and E. Green (Marconi's), for "Synthesis of Ladder Networks to give Butterworth or Chebyshev Response in the Pass Band."

UNBIASED

By FREE GRID

Teleoptics

I HAVE been reading with very great interest an article in the June issue of the French journal *Télévision* in which the author, Gaston Muller, puts forward some very original ideas. He is, like myself, afflicted with a divine discontent, as, indeed, is F. P. Hughes, who wrote "Why Lines?" in last month's *Wireless World*.

Muller criticizes the use of scanning in television; the picture is transmitted piecemeal and not in one complete whole as in the long-range TV system employed by the moon and other heavenly bodies.

Although the viewer thinks he sees a complete picture it is in reality a mere illusion—like marriage, where one gets to know the real personality of ones partner bit by bit instead of all at once. As things are at present the marriage between electronics and optics, which produces as its offspring the television picture on our screens, is rather an unsatisfactory one from Muller's point of view. The offspring, by means of the scanning process, grows up gradually into a fully fledged adult over a period of time in the same way as an infant in the biological world. M. Muller wants the offspring to arrive in the world like Venus as a ready-made adult with none of this time-wasting growing business.

He describes his proposed remedy for this unsatisfactory state of affairs at considerable length, but admits that practical details are likely to prove very formidable. It is these tiresome practical details that are holding up a teleoptical scheme of my own as I want to provide every room in my house with television, using one set only.

As you cannot just couple up an extension c.r.t. as you can a loudspeaker I propose to mount my set on the roof next to my masthead pre-amplifier and to distribute the picture optically. I intend to use a small projector-type c.r.t. in the set and by an elaboration of the optical arrangement used in a binocular microscope, coupled with the necessary number of periscopes, I shall be able to beam the picture down each chimney of my house. It doesn't look as if we are going to get any coal next winter and I don't like to think of the chimneys as being entirely useless.

In the empty grate of each room, there will be a prism or inclined mirror to throw the image forward on to the back of a translucent screen standing in the position occupied by the normal fire screen. In this way television will be available in each room and the occupants will be able to gather in a half-circle round the fireplace as has been the habit of families for generations past.

Optical television distribution.

The Etch and the Itch

ONE sometimes comes up against the problem of replacing a defunct valve, on which the etched type number is indecipherable, in a receiver about which no technical information is available.

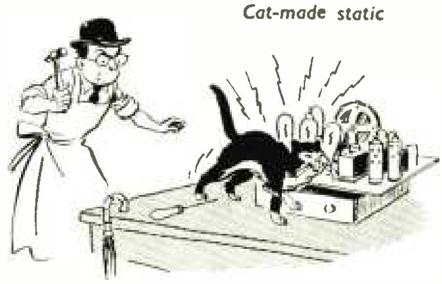
In a recent issue of the American journal *Radio-Electronics* a gallant attempt is made to solve this problem by suggesting various things which may be done to enable the faint and elusive type number to be read. All depend on the fact that the etching process causes a slight roughening of the glass over the actual etched area. Among other things suggested is that the valve be rubbed on your hair; the rough etched area of the glass collects more of the natural scalp oil than the rest and so shows up. But those of us who have dry scalps need not despair. All we need do is to stick the valve in the refrigerator and when it is really cool take it out and breathe on it; and we shall find that the resultant condensation has collected more readily on the rough etch than elsewhere.

These suggested remedies are all very well in their way, but I am surprised at a technical journal like *Radio-Electronics* having any truck with such non-electronic methods. I must confess, however, that I only discovered the correct method myself by chance.

One day I had on my laboratory table the chassis of a set which I had picked up cheaply in the Petticoat Lane of radio. I was having trouble in deciphering the valve numbers and had left the room for a few moments in search of a valve data book and when I returned I noticed the cat rubbing itself against the valves and other components of the up-ended chassis.

There was nothing abnormal about all this, of course, but when I reached the chassis I noticed that the etching stood out boldly amid the dust which had gathered on the rest of each valve. The explanation is simple. When glass is rubbed with a piece of catskin it becomes electrified and readily attracts particles of dust. But there had been a much greater degree of friction between the itching skin of the cat and the rough area of the etching, and, therefore, a greater electrical charge with the result that the dust had been attracted there to a much greater extent than elsewhere on the glass envelope of each valve.

Cat-made static



Mobile Phone Boxes

EACH YEAR there is an outcry from punters at the shortage of 'phone boxes at Newmarket, Epsom and other racing centres, to give people a chance of getting on to their London bookmakers for the later events in the programme after they have lost all their hard cash to the ready-money course bookmakers in the earlier races.

The usual excuse of the G.P.O. is that the capital outlay in building dozens of telephone kiosks which would be used for only a few days in the year would not be justified. Have they never heard of such things as radio waves, or are the officials in charge of the telephone department totally lacking in imagination?

I see no reason at all why temporary 'phone boxes made of wood and canvas should not be dumped down where needed, each containing a battery-powered radio unit for linking with a similar installation on the roof of the local telephone exchange. Such temporary boxes, with their complete freedom from connecting cables, could be readily moved by a suitably equipped pantechnicon from course to course as required.