Wireless World

RADIO, ELECTRONICS, TELEVISION

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To facilitate reference, the month of issue as well as the page number is given.

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Wireless World

JANUARY 1955 VOL. 61 No. 1

A New Master?

IT must have sounded revolutionary to suggest, as we did last month, that the time had at last come to relieve the Post Office of some of its powers of control over radio. The present system has survived without basic change for over 50 years; we all tend to be conservative in these matters; the more surprising, therefore, that hardly any real objection has been raised against our proposals. Indeed, most of the criticisms have urged something more drastic, in some cases going so far as to say *all* executive and administrative power should be transferred to an independent body. Anyway, it seems clear that none of the radio interests are fully satisfied with the present position. Dissatisfaction has also been expressed in the House of Commons, where C. Ian Orr-Ewing said it would be wise to try to take the responsibility of frequency allocations from the Post Office and leave it to an independent body.

What kind of body should replace the G.P.O. as the controlling authority? When this kind of question crops up the Federal Communications Commission of the U.S.A. always comes to mind, and we have spent some time studying its history and constitution. The F.C.C. is "an independent Federal establishment" responsible to Congress. It is administered by seven Commissioners appointed by the President. Commissioners hold office normally for seven years. Not more than four Commissioners may be members of the same political party.

What does the F.C.C. do? Roughly, it exercises all the licensing and controlling functions over radio that come under the G.P.O. in this country. In addition, it regulates internal and external wire communications, but does not license U.S. Government stations. Frequency allocations for these are made by an inter-departmental committee with which the F.C.C., however, works in close collaboration. Technical functions of the F.C.C. include the maintenance of a laboratory dealing with such things as studying propagation and investigating interference; the operation of over 20 monitoring stations, the holding of technical examinations for operators and the inspection of stations. Administrative functions include the regulation of telegraph and telephone charges and the assumption of at least some responsibility for the content of broadcast programmes.

For the year 1951 (the latest for which a report is available) the F.C.C. was run by a total staff of 1,205 persons. The number of transmitters licensed numbered 425,000. For all this the cost was $6,600,000, which does not seem high, allowing for the vast size of the country and the large number of stations. It should also be remembered that much of the work of the F.C.C. is brought about by the intensely competitive nature of American radio. Taking everything into account, a safe guess is that a "B.C.C." would be far less costly than its American prototype.

Can the F.C.C. model be fitted with a right-hand drive for use in this country? We can see no insuperable difficulties, though we must admit some of the organizational problems involved are rather outside our province. For instance, which of the Ministers would replace the Postmaster-General in assuming responsibility in Parliament for radio matters? Not, we should hope, the head of any of those Ministries which are large users—and, it is to be feared, often prodigal users—of radio channels.

In the interest of economy the sale of broadcast receiving licences, the tracking-down of "pirates" and the investigation of interference with broadcast reception should remain in the hands of the Post Office. Such tasks as the allocation of channels and licensing of stations, monitoring, inspection and the examination and licensing of operators should be transferred to the new controlling body.

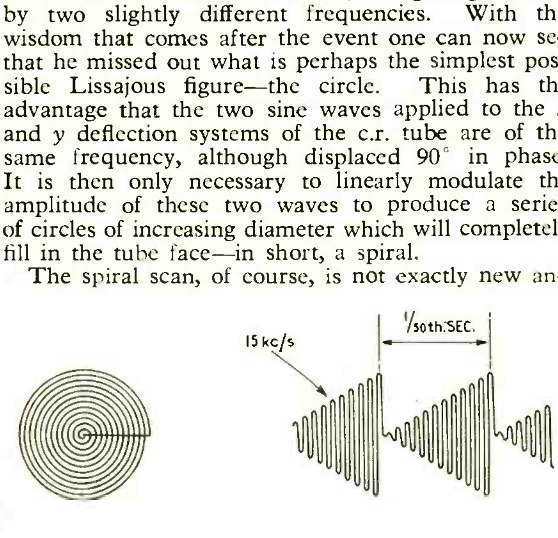
All but the most fervent of revolutionaries are apt to have some doubts when a sweeping change is proposed. Is it worth while passing over from the known to the unknown? Our thoughts go back to a talk with an American visitor a year or two ago. After we had explained in some detail the way British radio was controlled, he said, "I see; near enough, then, F.C.C. is American for G.P.O." To make a change for the sake of a new set of initial letters would indeed be foolish, but there are in fact real differences. The G.P.O. is both an interested party and it is tied up with politics.

SPIRAL SCANNING

Simple Method for Industrial Television Equipment

WHEN F. P. Hughes conducted his public search in the pages of *Wireless World* for the Simplest Possible Scan* he started with a point, proceeded to a line and ended with a Lissajous figure generated by two slightly different frequencies. With the wisdom that comes after the event one can now see that he missed out what is perhaps the simplest possible Lissajous figure—the circle. This has the advantage that the two sine waves applied to the x and y deflection systems of the c.r. tube are of the same frequency, although displaced 90° in phase. It is then only necessary to linearly modulate the amplitude of these two waves to produce a series of circles of increasing diameter which will completely fill in the tube face—in short, a spiral.

The spiral scan, of course, is not exactly new and has been used in oscillography for a good many years, but it is to the credit of the French firm Laboratoires Derveaux that they have successfully adapted it to television purposes. A description of the industrial television equipment they have developed on this principle is given in *Toute la Radio* for November, 1954. The scanning waveform, shown at (b) of the diagram, is a 15-kc/s sine wave modulated with a 50-c/s sawtooth (to produce the variation in circle diameter). One such signal is applied to the horizontal deflector coils of the camera tube and receiving c.r. tube and another one, 90° displaced in phase, to the vertical deflector coils. Each "tooth" of the sawtooth waveform contains 300 cycles of the 15-kc/s sine wave, so this means that one complete sweep of the spiral, from the centre of the tube to the outside, involves 300 revolutions of the spot. If the tube face is bisected by an imaginary line this gives the equivalent of 600 lines in a conventional raster.



(a) (b)

Form of the spiral scan is shown at (a) while (b) is the waveform used to produce it

Of course, the two components of the scanning waveform have to be kept in very strict phase and frequency relationship, so the 50-c/s sawtooth is produced by frequency dividing from the 15-kc/s source. Brightness modulation is applied to the receiving c.r. tube in the normal way. In addition it is necessary to apply a brightness correction waveform (of sawtooth form) to compensate for the fact that the spot has a lower "tracking" speed in the centre and the trace is consequently brighter there than at the outside of the spiral.

This variation in the speed of the spot, as it describes circles of increasing circumference, brings up an interesting point about definition. In the centre of the picture, where information is scanned and transmitted at low speed, the bandwidth required for the system is considerably less than at the outside, where the picture information is being scanned at high speed. In practice, using a fixed and limited bandwidth, this means that the definition will be higher in the centre than at the outside. However, Laboratoires Derveaux say that this is actually an advantage because the centre of interest of a television picture is generally in the centre of the tube.

In its utilization of time for the transmission of picture information the system is very efficient. Very little time is wasted on flyback (only one per "frame" instead of several hundreds) and none at all on transmitting sync pulses. The only synchronization that is necessary is to keep the transmitter and receiver 15-kc/s sine waves (which are derived from the same source) in correct phase relationship with each other. This adjustment is done by a simple phase-shifting network. Incorrect phasing merely results in the received picture being turned round out of the horizontal. Another incidental advantage of having no sync pulses is that if an r.f. carrier is used for transmission it can be modulated completely by the picture waveform.

The circular shape of the complete picture makes it unsuitable for domestic television, but this does not matter so much in industrial television. In fact it might be considered something of an advantage, in so far as it gives better utilization of lenses, pick-up tubes and cathode ray tubes, most of which are circular in form.

* "Why Lines?" by F. P. Hughes. *Wireless World*, August 1954.

STYLI BY THE MILLION

Mass Production of Sapphire Points

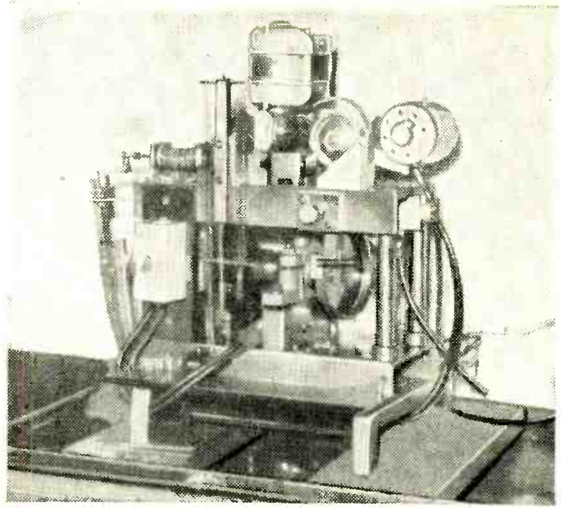
FOR a gramophone pickup stylus to function satisfactorily it must be shaped to close limits to conform with the groove section of the particular type of record with which it is to be used. The first sapphire styli were produced by the same basic techniques as those used by precious stone cutters, which accounted for their high price.

To meet the enormously increased demand and at the same time to bring down prices, Sapphire Bearings, Ltd., in collaboration with the Union Carbide Corporation of America, have developed radically new manufacturing methods in which quality is maintained, but costs are much reduced.

The slicing of the synthetic sapphire "boule" and the production of the "rondel" or cylindrical shank follow normal practice, but the formation of the conical point is carried out on a centreless grinder of

Left : Untouched photomicrograph of stylus tip (standard finish).

Right : Diamond-wheel point grinding machine used in the production of "Windsor" sapphire styli.



special design in which a sintered diamond grinding wheel revolving at 22,000 r.p.m. takes the place of the more usual lap, which must be continually re-dressed with diamond powder by skilled operatives.

After the formation of the cone, which is taken right up to a sharp point, the styli are subjected to a "tumbling" process in batches of 10,000 to 20,000 in a diamond powder medium. Details of this process are not disclosed, but the result is a symmetrical spherical point which will pass the closest examination.

Inspection probably accounts for the major part of the cost of these styli, and every one is examined for flaws and to check that its dimensions fall within prescribed limits. Binocular microscopes of the latest design and projection shadowgraphs are used for this purpose. A further inspection is made after the styli have been mounted in their shanks or pickup movements (some of the leading pickup manufacturers entrust this work to the stylus makers).

The surface finish of the sapphire after "tumbling" is of a high order and satisfies all ordinary requirements. An even higher polish can be obtained by fusion of the surface in an oxy-acetylene flame, and this "super" finish may be expected to give a correspondingly lower surface noise on records whose grooves are in mint condition.

Both standard and flame-polished types of stylus are available under the trade name of "Windsor" and cost 2s 6d and 5s 6d each respectively.

In a new factory to be opened next year it is expected that production will be at the rate of 20 million a year.

Commercial Literature

Radar Plotting Aid; the "Locatorgraph." An illustrated booklet explaining how it can be used in various ways, with worked examples, available from Marconi Marine, Chelmsford, Essex, price 4s 6d.

Solderless Connections; a system involving many different types of crimped wire terminations, with special tools for attaching them, described in an illustrated brochure from Aircraft-Marine Products, 2100 Paxton Street, Harrisburg, Pa., U.S.A.

Spring Alloy for high-temperature working (up to about 800° C), impervious to rust and corrosion. Leaflet giving the properties of Nimonic 90 from Henry Wiggin & Company, Wiggin Street, Birmingham, 16.

Tape Recording Accessories; foot switch for dictating; telephone pick-up device (attached by suction cup); stethoscope earphones; single-earpiece headphones; a small crystal set mounted on a jack for reception of radio programmes. Leaflets from Truvox, 15 Lyon Road, Harrow, Middlesex.

Low-voltage Stabilizer, with a range of 1-15V d.c. and 0-25A. Regulation: a load current of 2.5A causes a voltage drop not exceeding 5mV. Stability: a ± 10 per cent mains voltage change causes an output change of less than ± 5 mV. Specification on a leaflet from Servomex Controls, Crowborough Hill, Jarvis Brook, Sussex.

Voltmeters, ammeters, wattmeters, including moving-coil, moving-iron and dynamometer types, mainly for use on industrial switchboards. Latest catalogue from Measuring Instruments (Pullin), Electrin Works, Winchester Street, Acton, London, W.3.

Valve Retainers; booklet of tables giving the type of retainers needed for most valves in common use, from Electrothermal Engineering, 270 Neville Road, London, E.7. Distribution is restricted to equipment manufacturers.

Tape Recorders; transportable model in wooden cabinet, giving high-quality reproduction; a smaller portable model weighing 35 lb; a tape deck (used in both) with two speeds, 7½in and 3¾in per second. Leaflets from Lee Products (Great Britain), Elpico House, Great Eastern Street, London, E.C.2.

R.F. High-voltage Generators for cathode-ray tube supplies and other purposes. Several models giving variable outputs over ranges between 5kV and 50kV. Output currents from 0.25mA to 1mA. An illustrated brochure from Teleonics (Communications), 196 Dawes Road, London, S.W.6.

Signal Strength Meter for television, consisting of r.f. amplifier, germanium diode and meter, with three ranges covering 0-10 mV altogether. Model supplied for each channel in Band I. Descriptive leaflet from Radio-Aids, 29 Market Street, Watford, Herts.

Communications Receiver, originally designed for Admiralty, with frequency range of 60kc/s to 31Mc/s divided into eight bands. Reception of a.m., c.w. and m.c.w. with either single or double superhet circuit, depending on frequency. Specification and description from Pye Telecommunications, Ditton Works, Newmarket Road, Cambridge.

Nickel-Copper Alloy "Monel" with strong resistance to corrosion. Data sheet giving physical and mechanical properties from Henry Wiggin & Company, Wiggin Street, Birmingham, 16.

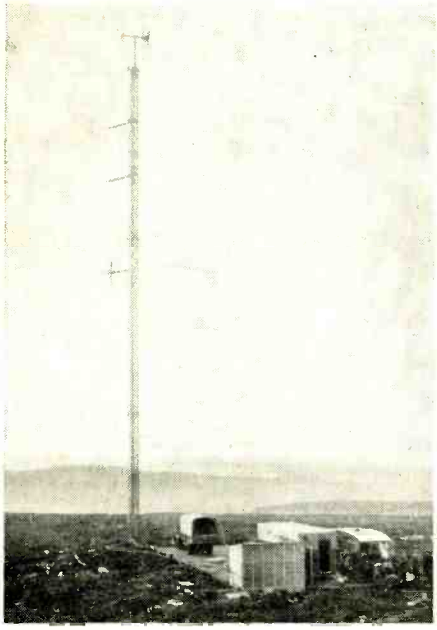
R.F. Tuner, 3-valve 4-waveband superhet, for feeding high-quality amplifiers. Output 1 volt maximum at infinite impedance. Also two new amplifiers, one for use with tape recorders. Leaflets from Lee Products, Elpico House, Great Eastern Street, London, E.C.2.

Electronic Manufacturing Facilities available in the Manchester area outlined in an illustrated booklet from the factory of F. C. Robinson & Partners at Councillor Lane, Cheadle, Cheshire.

Electronic Instruments for electrical, acoustic, radioactive, vibration, strain-gauge and electro-chemical measurements. An illustrated catalogue (in English) from the Danish company Brüel and Kjaer, available from the London office of Rocke International, 59 Union Street, London, S.E.1.

Component Storage Trays for assembly of electronic equipment in factories. Plastic mouldings designed suitably for interlocking, stacking and labelling. Leaflet from Precision Components (Barnet), 13, Byng Road, Barnet, Herts.

WORLD OF WIRELESS



MOBILE television transmitter and temporary 150-ft mast at N. Hessary Tor, S. Devon

Organizational, Personal and Industrial Notes and News

A Restrictive Practice?

VALVES and cathode-ray tubes are to come under the scrutiny of the Monopolies and Restrictive Practices Commission. The supply of these accessories is to be investigated by the Commission which has been asked to "report about both the facts of the matter and their bearing on the public interest."

Any person or organization wishing to offer evidence should write to the secretary of the Monopolies and Restrictive Practices Commission, 3, Cornwall Terrace, Regent's Park, London, N.W.1.

I.T.A. News

FREQUENCIES for the first three stations to be opened by the Independent Television Authority have now been announced. Birmingham will operate in Channel 8 (189.75 Mc/s vision, 186.25 Mc/s sound) and the transmitters for the London and Manchester areas in Channel 9 (194.75 Mc/s vision, 191.25 Mc/s sound). The frequencies of the London transmitter will be offset by 6.75 kc/s (vision) and 20 kc/s (sound).

Although Channels 8 and 9 were allocated to British stations in the Stockholm V.H.F. Broadcasting Plan the allocations were not made to transmitters in London, Manchester and Birmingham. It must, however, be remembered that the plan provides for the use of eight channels in Band III, only two of which will be available for television until such time as the present users of the band are accommodated elsewhere.

In addition to the appointment of P. A. T. Bevan as chief engineer (see Personalities) the I.T.A. has appointed Major-General D. A. L. Wade and Brigadier R. H. O. Coryton as assistants to the chief engineer. General Wade was, until recently, telecommunications attaché in Washington, and Brigadier Coryton chief signal officer, Northern Army Group.

National Radio Show

THE period chosen for this year's Earls Court exhibition is approximately the same as last year—August 24th to September 3rd. The Radio Industry Council, which organizes the show with the co-operation of its constituent associations covering the various sections of the industry, is again arranging for a preview for overseas visitors and invited guests on August 23rd.

Television Society Exhibition

IN addition to some 30 manufacturers and research organizations, exhibitors at the Television Society's Exhibition will include a number of members. The exhibition, which will be held in the gymnasium, University College, Gower Street, London, W.C.1, on January 6th, 7th and 8th, is concerned with television research rather than domestic reception and amongst the equipment to be seen will be standards conversion gear for international television exchanges.

Admission on the first day (6-9 p.m.) is limited to members and the Press. Tickets for the other two days (noon to 9 p.m. and 10 a.m. to 7 p.m., respectively) are obtainable free from the society, 164, Shaftesbury Avenue, London, W.C.2.

Ambulance Radio

ACCORDING to figures given by the Minister of Health in reply to a question in the House of Commons, 20 of the 63 county health departments use mobile radio in the operation of their ambulance services. Of the 83 county boroughs, 42 have installed mobile radio equipment. It might be added that this is in spite of the fact that ambulances come under the "private mobile radio" category and have to pay £3 per annum for each transmitter, whereas fire services and police pay only £2 per annum for each fixed station irrespective of the number of mobile transmitters operating in the network.

PERSONALITIES

Professor G. W. O. Howe, D.Sc., M.I.E.E., has been awarded the Fellowship of the American Institute of Radio Engineers "for his pioneering work in radio and his outstanding contributions to engineering education." Dr. Howe retired in 1946 from the James Watt chair of electrical engineering at Glasgow University, where he had been for 25 years, and was awarded an emeritus professorship. For fifteen years prior to going to the university he was lecturer and assistant professor at Imperial College, London. Dr. Howe has been technical editor of our sister journal *Wireless Engineer* for nearly 30 years. Incidentally a 75-page index to his editorials in *Wireless Engineer* from January, 1926, to May, 1954, has been prepared by Dr. A. J. Small of Glasgow University.*

T. E. Goldup, C.B.E., M.I.E.E., has also been awarded the Fellowship of the I.R.E. "for his pioneering achievements in the design and development of thermionic tubes and his contributions to the technical and administrative counsels of the British radio industry." He joined the research staff of the Royal Navy Signal School, Portsmouth, in 1914, where from 1918 to 1923 he was senior experimental officer. He is now a director of Mullard's, which he joined in 1923 as an assistant in the valve laboratory.

Dr. A. G. Touch, M.A., D.Phil., the new director of electronics research and development at the Ministry of Supply, was a member of the Watson Watt radar team at Bawdsey research station from 1936 to 1940. For his contribution to the development of metre-wave AI and ASV he received an award from the Royal Commission on Awards to Inventors. Before joining the civil service he was at Clarendon Laboratory, Oxford. From 1941 to 1947 Dr. Touch was liaison officer with the British Joint Services Mission in Washington, where he was concerned with the development and production of airborne radio and radar equipment. For five years after his return from Washington he was superintendent, Armament and Instrument Experimental Unit, Martlesham Heath, Suffolk, and for the past two years has been deputy to the director, **Air Comdre. W. G. Pretty,** C.B.E., whom he is now succeeding. Air Comdre. Pretty was for two years in the Air Ministry directorate of signals, was deputy director (radar) at the Air Ministry and after a tour of duty as chief signals officer, Fighter Command, assumed the directorship at the Ministry of Supply, which he is now relinquishing The new deputy director, electronics research and development (air) is **Air Comdre. C. A. Bell.**

John Clarricoats, G6CL, has completed 25 years as secretary of the Radio Society of Great Britain. To mark the occasion, the retiring president, A. O. Milne, made a presentation, for which over £150 was collected from members.

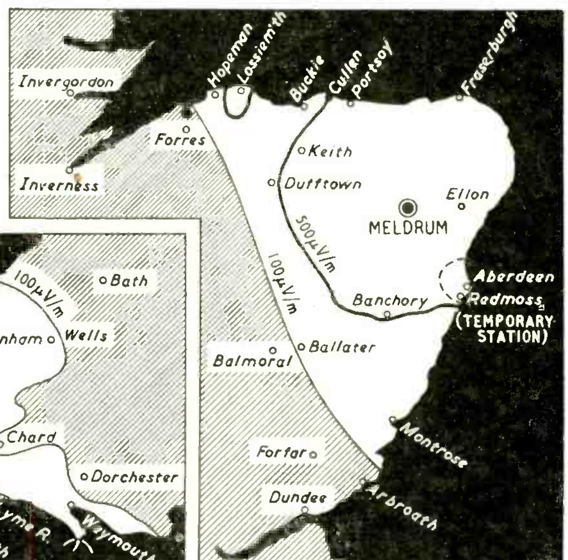
W. I. Flack, Assoc.I.E.E., who is well known as the designer of the View Master television receiver and Soundmaster tape recorder, is to concentrate on printed circuitry for the Telegraph Condenser Company.

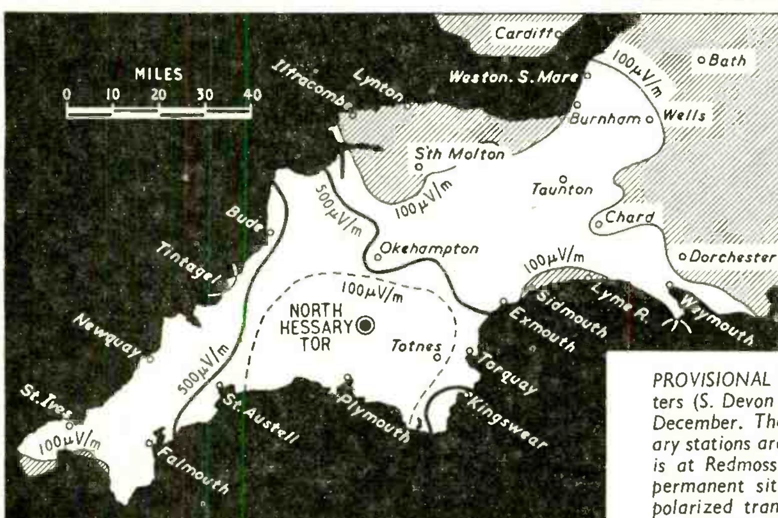
* Obtainable from Dr. Small, price 5s.

P. A. T. Bevan, B.Sc., M.I.E.E., whose appointment as chief engineer of the Independent Television Authority was announced early in December, was for 20 years with the B.B.C. where he had latterly been a senior member of the Planning and Installation Department of the Engineering Division. He graduated in engineering at Cardiff University and was for three years a graduate apprentice at the B.T-H. Rugby works. At the B.B.C. he has been mainly concerned with the development of v.h.f. television and sound transmitters. Mr. Bevan is the author of a number of papers, for one of which he received the I. E. E. Duddell premium and has, since 1949, been a member of the editorial advisory board of *Wireless Engineer.*

C. R. Jephcott, A.M.I.E.E., has been appointed engineer-in-charge of the B.B.C.'s temporary television transmitting station at North Hessary Tor, South Devon. He joined the corporation in 1935 at the Droitwich station, where six years later he became a senior maintenance engineer. In 1946 he transferred to the short-wave transmitter at Skelton, Cumberland, where he has been a senior maintenance engineer until taking up his new appointment.

S. W. Wain has retired from the position of deputy engineer-in-charge of the Post Office radio station, Leafield, which he has held since 1942. During his 34 years at the Post Office he has also served at Bodmin, Rugby and Portishead stations. He is succeeded at Leafield by **E. G. H. Middleditch,** who has been in the Post Office since 1923. Mr. Middleditch went to the engineer-in-chief's office at headquarters in 1935 and during the war





PROVISIONAL field-strength contours for the two transmitters (S. Devon and N.E. Scotland) opened by the B.B.C. in December. The service contours (100µV/m) of the temporary stations are shown dotted. Scotland's temporary station is at Redmoss, near Aberdeen, some 25 miles from the permanent site at Meldrum. The station's horizontally polarized tranmissions are radiated in Channel 4. The N. Hessary Tor mobile transmitter, which radiates in Channel 2 (carriers offset), is pictured on the opposite page.

SIR ANTHONY EDEN, guest of honour at the Radio Industry Council annual dinner, is seen talking to Sir Kenneth Clark, chairman of I.T.A. On his right is Sir Ian Jacob, director-general, B.B.C.

was given the task of providing emergency radio-telephone installations and mobile multi-channel R/T stations for the War Office.

Clifford Sanctuary, who has gone to Canada to take charge of the engineering side of the recently formed Decca Radar (Canada) company, has been associated with radar since he joined the Bawdsey research station in 1939. Two years later he joined the R.A.F. and was concerned with the installation of CH radar stations and OBOE. He joined the Decca Navigator Company in 1946 and transferred to the research labs of Decca Radar in 1951.

A. J. Brunker, B.Sc.(Eng.), A.M.I.E.E., who before joining E. K. Cole, Ltd., in 1947, was deputy director (radio production) at the Ministry of Supply, has become the company's chief engineer. He has relinquished the position of general export manager but retains his directorship in the subsidiary company, Ekco Electronics.

Walter M. York, who, as an executive director of E. K. Cole, already controls Ekco publicity and the company's heating division, will, in addition, now direct the export of radio, television, plastics and ciné equipment.

F. H. McCrea has been elected chairman of the Dubilier Condenser Company in succession to the late W. H. Goodman, who formed the original Dubilier company in 1912. Mr. McCrea has just completed 25 years' service with the company and was appointed managing director in 1939, a position which he still holds.

G. Johnson, author of the article in this issue on a transistor d.c. amplifier, was concerned with the development of prototype gunnery radar at A.S.R.E. during the war, after which he was for a time senior inspecting officer at Ferranti's. In 1948 he became interested in electro-physiology and went to Hurstwood Park Hospital, Haywards Heath, to organize the new department of applied electro-physiology of which he is now in charge. He is honorary secretary of the Electrophysiological Technologists' Association and a council member of the EEG Society (electroencephalographic).

WHAT THEY SAY

Industry and P.O. Control.—"There is a strong door that shuts us out from discussions on frequency allocations"—G. Darnley Smith speaking at the Radio Industry Council dinner.

Are we so Boring?—"I do not want to weary the House with a quotation from *Wireless World* . . ."—C. R. Hobson, M.P., speaking in the House of Commons on November 23rd.

IN BRIEF

4,000,000 TV Licences.—Within the first few days of December the four-millionth television licence was issued. The number of television licences current in the United Kingdom at the end of November was 3,999,624, an increase of 157,956 during the month. The total number of receiving licences, including 250,256 for car receivers, was 13,794,195.

Television I.F.—The report on the choice of intermediate frequencies for television receivers prepared by the European Broadcasting Union, to which G. H. Russell referred in our July issue, is now available in English. The report, the full title of which is "The E.B.U. Enquiry Concerning the Choice of Intermediate Frequencies for Domestic Television Receivers and Related Questions" (Tech. 3062-E) can be obtained from the Union Européenne de Radiodiffusion, 4, rue de la Vallée, Brussels, Belgium, price 70 Belgian francs, including postage.

R.S.G.B. Membership.—A regrettable but expected drop in membership as a result of the necessary increase in subscription rates is recorded in the annual report of the Radio Society of Great Britain. Comparative figures given in the report show a 13 per cent decrease during the year ended June 30th, 1954. The respective figures for 1953 and 1954 are 11,190 and 9,735.

U.S. Colour TV.—Over 130 stations in the U.S.A. are now equipped to rebroadcast network colour transmissions and, according to data given in *Television Digest,* 40 of these will have three-colour film cameras by the end of January. A few stations are already equipped for live colour transmissions.

Solder Standard.—BS441:1954 "Rosin Cored Solder Wire, Activated and Non-Activated" is a revision of the standard "Cored-solder, Rosin Filled," published in 1932 and now includes methods of activating the rosin core. It costs 3s and is obtainable from British Standards Institution, 2, Park Street, London, W.1.

Component Testing.—Conditions and procedure for climatic and durability testing for components are given in BS2011:1954 "Basic Climatic and Durability Tests for Components for Radio and Allied Electronic Equipment." Based upon the Radio Industry Council specification RIC11 and the Services specification RCS11, the standard describes tests which will form the basis of the tests to be included in individual standards for specific components. Price 5s.

The **French Components Show** will be held at the Port de Versailles, Paris, from March 11th to 15th.

Germany's Radio Show, which, like its British counterpart, covers sound and vision reception and gramophone reproduction, will be held from August 26th to September 4th in Düsseldorf.

Luxembourg TV.—The operators of Radio Luxembourg have been granted the monopoly of television in the Duchy. Commercial programmes will be radiated by the 819-line station on 189.26 Mc/s vision and 194.75 Mc/s sound when the service starts early this year.

Monte Carlo TV.—Using the French definition of 819 lines the Monte Carlo television transmitter has a directional aerial array which concentrates energy along a narrow stretch of the Rivieria coast. Its sponsored programmes are receivable from San Remo, Italy, to St. Raphael, France.

E.B.U. Headquarters.—Having moved its receiving centre from the outer suburbs of Brussels to an interference-free site at Jurbise-Masnuy (see *W.W.*, September, 1953), the European Broadcasting Union has transferred its offices nearer the centre of the city. The new address is 4, rue de la Vallée, Brussels.

"Velocity of Radio Waves."—The velocity of light given in Dr. Smith-Rose's article (December, page 590) should, of course, have been 3×10^5 km/sec.

A course of 20 lectures on the applications of **Pulse Technique** in communications, radar and computor circuits will be given on Tuesdays, beginning January 11th, from 7.0-9.0 at the Kingston Technical College, Fassett Road, Kingston-upon-Thames. The fee is 3 guineas.

The presentation of technical information is naturally of particular interest to *Wireless World* and we, therefore, draw readers' attention to the course of five weekly lectures on the **Writing of Technical Reports** at the Borough Polytechnic, Borough Road, London, S.E.1. The lecturer is Geoffrey Parr, and the course, for which the fee is one guinea, begins on January 20th at 6.30.

The one-full-day-per-week course on Band II (f.m.) and Band III (television) reception, which ran from September to the end of the year at the **Northern Polytechnic,** Holloway, London, N.7, will be repeated on Mondays from 9.30 to 4.30, commencing January 10th. The fee for the three-months course is £2.

The recent presentation of awards to trainees in Cossor's electronic engineering **Apprenticeship Scheme** afforded an opportunity to record that 112 student apprentices have entered the scheme since its inception in 1947.

BUSINESS NOTES

Aveley Electric, Ltd., of 44, Tottenham Court Road, London, W.1 (Tel.: Langham 7097), have been formed to act as representatives and agents for Rohde and Schwarz, of Munich, manufacturers of communication and laboratory measuring equipment. Eventually the company plans to manufacture some of the instruments in the Rohde and Schwarz range and a factory is under construction in Aveley, Essex. The directors are R. F. Parker, B.Sc., J. I. Brown, A.M.Brit.I.R.E., and A. C. Judd, A.C.A.

Mobile radio equipment has been supplied by **Marconi's** to the North of Scotland Hydro-Electric Board to facilitate the repair and maintenance of the new power transmission line which runs between Fort Augustus and Speyside and is the highest in the U.K. The equipment has been installed in small buildings containing repair gear near the top of Corrieyairack Pass.

The **General Electric Company,** which, some months ago, installed mobile radio equipment for the rescue service of the N.W. Division of the National Coal Board, has now supplied similar installations for four other divisions.

It is announced by **Decca Radar** that over 3,500 ships, operated by more than 840 companies, navies and ministries throughout the world, have been equipped with Decca radar since the company started five years ago.

Learning a foreign language by "almost unconscious assimilation" with the aid of gramophone records is the principle of Assimil, which has been introduced into this country by **E.M.I. Institutes.** There are 20 double-sided records in the complete course, details of which are obtainable from 10, Pembridge Square, London, W.2.

A. K. Fans, Ltd., of 20, Upper Park Road, London, N.W.3 (Tel.: Primrose 5969), announce that A. W. Dean, who was with Marconi's, has joined the company and that they have taken over further factory space at 352, Goswell Road, London, E.C.1.

The complete television studio and equipment which **Pye** installed at the recent British Trade Fair in Baghdad is to be purchased by the Iraq government and re-erected on a site belonging to the country's broadcasting authority. It is anticipated that initially the station will be used for educational purposes.

Underwater television equipment is being supplied by Pye to the expedition which is endeavouring to locate the wreck of the *General Grant*, sunk off the Lord Auckland Islands, south of New Zealand, in 1866 with a cargo of 9½ tons of unrefined gold.

Medium- and short-wave transmitters, complete aerial systems and studio equipment are to be installed by **Redifon** at Piura for the Peruvian broadcasting organization Radio Nacional.

Cossor airfield control radar (Mark VI) has been installed at Zurich airport. A feature of this 450-kW surveillance radar equipment is the cancellation of permanent echoes, which is particularly important at Zurich where the Alps give heavy responses.

All-wave broadcast receiving equipment, gramophone amplifiers and loudspeakers are being supplied by **Pye Marine** for 20 trawlers being built at Lowestoft for the Soviet Union.

A $2.5M contract awarded to the **General Electric Company** for extensions to the telephone system of Haiti, in the Caribbean, includes the provision of v.h.f. radio relay equipment where the terrain makes the use of lines uneconomic.

Public address and intercom equipment has been installed by **Hadley Sound Equipments,** of Smethwick, at both the Renfrew (Glasgow) and Ringway (Manchester) airports.

Australian Agency.—The Sydney, N.S.W., firm of L. D. Beston (Aust.) Proprietary, Ltd., 387, Kent Street, would like to act as representatives of a U.K. manufacturer of television receiving aerials. Interested manufacturers should write directly to the company and are advised to send a copy of the correspondence to the U.K. Trade Commissioner, 39-49, Martin Place, Sydney, N.S.W.

Agency for a three-valve, all-dry, long- and medium-wave set made by a U.K. manufacturer not already represented in Ceylon is sought by Hentleys, Ltd., P.O. Box 670, Mackinnon Building, York Street, Colombo. Manufacturers should write direct to Hentleys but are invited to send copies of their correspondence to the U.K. Trade Commissioner, P.O. Box 745, Hong Kong Bank Building, Fort, Colombo.

NEW ADDRESSES

F. C. Robinson and Partners, manufacturers of electronic measuring and control equipment, have moved their head office and sales and service departments from Deansgate to 122, Seymour Grove, Old Trafford, Manchester, 16 (Tel.: Chorlton 5366). The factory is in Councillor Lane, Cheadle, Cheshire.

Furzehill Laboratories have transferred their head office and sales and designs departments to 57, Clarendon Road, Watford (Tel.: Gadebrook 4686). The production and purchasing departments are still at the works in Shenley Road, Boreham Wood, Herts (Tel.: Elstree 1137).

The Rectifier Division of **Standard Telephones and Cables** has moved from Boreham Wood, Herts, to a new factory in Edinburgh Way, Harlow, Essex (Tel.: Harlow 26811).

The London district office and service depot of the **Edison Swan Electric Company** is now at 10-12, Euston Buildings, N.W.1 (Tel.. Euston 6072). The company's head office will remain at 155, Charing Cross Road, W.C.2.

The Manchester office of **Elliott Brothers (London), Ltd.,** is now at 32, Deansgate, Manchester, 3 (Tel.: Blackfriars 7752).

A new branch office at 270, Corporation Street, Birmingham (Tel.: Central 6191), has been opened by the **Telegraph Construction and Maintenance Company.** The branch manager is J. H. Barham, Assoc.I.E.E.

Philips have opened new showrooms and a branch office at 47-49, Victoria Street, Bristol, Glos. (Tel.: Bristol 20307).

The address of the Middlesbrough district office of **British Insulated Callender's Construction Company** is now 55-57, Borough Road (Tel.: Middlesbrough 43644).

Gramophone and Microphone

THE pre-amplifier described in this article is intended primarily for use with the 10-watt amplifier described by the author in 1948,[1] and its h.t. supply of approximately 20 mA at 300 V may be obtained from this power amplifier with complete freedom from motor-boating troubles. If desired, however, the pre-amplifier may be built with its own power pack, and may then be employed for feeding any high-quality power amplifier requiring a sine-wave input not exceeding 4 V r.m.s., at high impedance, for full output.

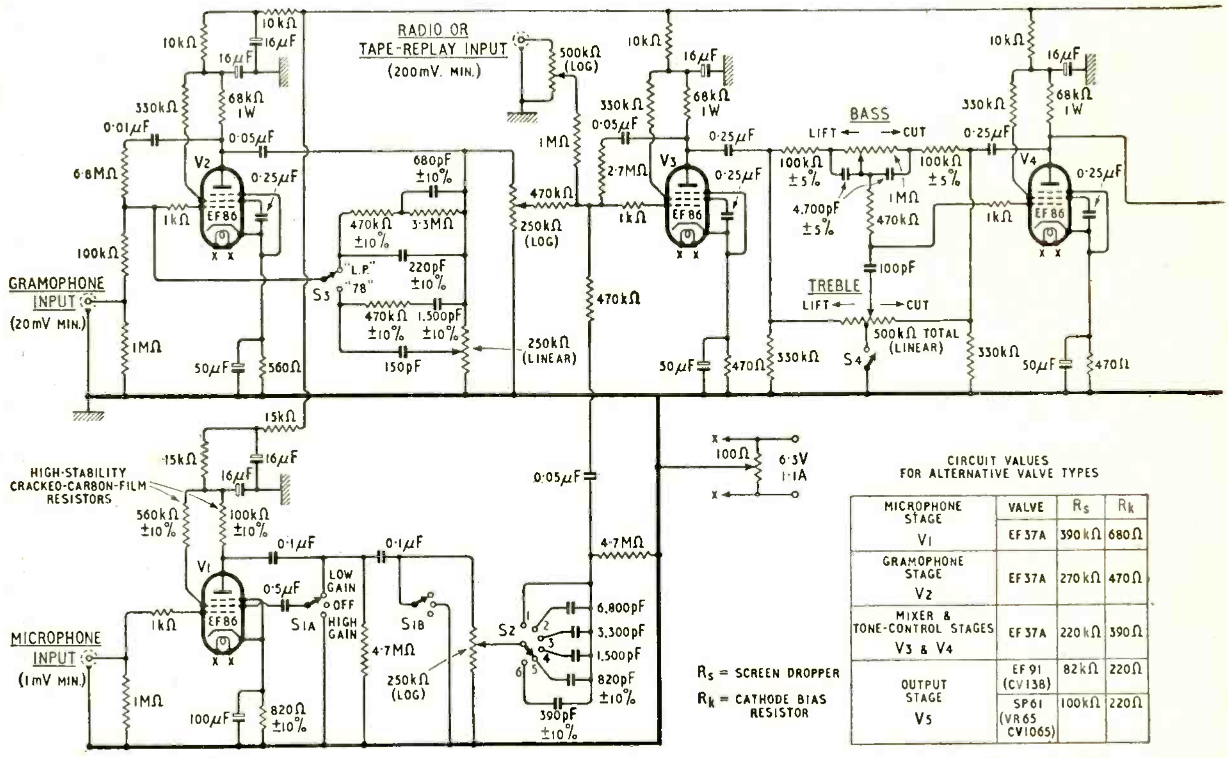
Separate input stages and gain controls are employed for the gramophone and microphone inputs, followed by a mixing circuit, making the pre-amplifier suitable for applications such as stage sound effects, recording, etc., where, for example, an effects record may be mixed in to provide a background to the spoken words of a play. If required, several microphone channels may be incorporated, whereas readers interested only in high-quality record reproduction may include only the gramophone channel.

The full output of 4 V r.m.s. may be obtained, with a total harmonic distortion not exceeding 0.1 per cent, for sine-wave signal inputs ranging from 1 mV to about 50 mV on the microphone channel, and from 20 mV to 1 volt on the gramophone channel. Full provision is made for recording-characteristic equalization, scratch filtering and microphone bass-cut, the writer's continuously adjustable tone-control circuit[2] being employed, in addition to the above, to provide adjustable compensation to suit room acoustics, loudspeaker characteristics, etc.

The equipment as described uses Noval-based miniature valves; but certain other valves may be employed if desired, and the slight changes in circuit values then necessary are indicated below Fig. 1. The Noval type appears to be becoming established as the preferred series in British commercial practice, combining excellent electrical characteristics with conveniently small size and satisfactorily robust construction.

Microphone Input Stage.—Experience with high-quality ribbon microphones has shown that, for general purposes, the maximum gain available on microphone channels should be sufficient to enable the following amplifier to be fully loaded when a sine-wave signal of about 1 mV r.m.s. is applied to the input valve grid. An EF86 low-hum, low-microphony pentode, under the operating conditions employed in the present equipment, gives a gain of approximately 90 without negative feedback, and its harmonic distortion is less than 0.1 per cent provided the input does not exceed about 10 mV r.m.s.

However, even a low-sensitivity high-quality microphone may sometimes give a signal in excess of 10 mV —for example, when placed near to a piano or an orchestra—so that the distortion introduced by such a pentode stage will then be greater than 0.1 per cent



	VALVE	R_s	R_k
MICROPHONE STAGE V1	EF37A	390kΩ	680Ω
GRAMOPHONE STAGE V2	EF37A	270kΩ	470Ω
MIXER & TONE-CONTROL STAGES V3 & V4	EF37A	220kΩ	390Ω
OUTPUT STAGE V5	EF91 (CV138)	82kΩ	220Ω
	SP61 (VR65 CV1065)	100kΩ	220Ω

Fig. 1. Complete circuit of pre-amplifier. All resistors ½ watt ± 20%, except where otherwise specified. All capacitors (other than electrolytic) ± 20% except where otherwise specified. Mullard valve type EF86 may be directly replaced by Osram Z729; other alternatives require circuit changes as shown in the inset table.

Pre-Amplifier

By P. J. BAXANDALL, B.Sc.(Eng.)

Versatile Design with Facilities for Mixing Several Inputs

unless the gain control is placed between the microphone and the grid. The disadvantage of having the gain control in this latter position is that the actual amplifier is operating at full gain all the time, resulting in unnecessarily high noise and hum levels under average conditions of use.

The problem is, therefore, to reduce the gain in such a way that low distortion is obtained without sacrificing signal-to-noise ratio, and the solution adopted in the present design is to place the gain-control potentiometer after the input stage and arrange that the valve may be switched to operate effectively as a triode instead of as a pentode when large signals are to be handled. Under triode conditions, an input of about 3 mV r.m.s. is required to give full output at the maximum-gain setting of the potentiometer, and the distortion does not exceed 0.1 per cent until the input reaches about 50 mV r.m.s. Thus, provided the switch is never used in the "pentode" position when sufficient gain can readily be obtained in the "triode" position, the distortion will never exceed 0.1 per cent for any value of input up to 50 mV—a value unlikely to be exceeded with a high-quality microphone.

The gain following the above input stage must be sufficient to give 4 V r.m.s. output from the pre-

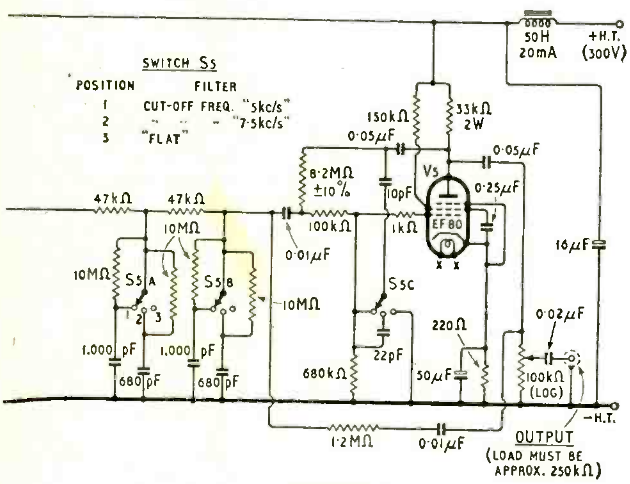


TABLE I

Number of contact on switch S2	Approximate frequency for 3 db attenuation.	Approximate distance from ideal ribbon microphone for perfect bass compensation.
1	—	—
2	50 c/s	3 ft
3	100 c/s	18 in
4	200 c/s	10 in
5	400 c/s	5 in
6	800 c/s	2.5 in

amplifier for a microphone stage output of 90 mV r.m.s.; with the mixing circuit employed, the noise level at the pre-amplifier output, with the input stages faded right down, is then approximately 70 db below 4 V r.m.s., which is highly satisfactory.

The above system has been adopted, instead of one of the feedback arrangements used in high-grade broadcasting equipment, for the following reasons:—

(a) Shunt-feedback methods,[3] if optimum signal-to-noise ratio is to be obtained, require the feedback circuit, microphone and input transformer to be designed to work in conjunction with one another, whereas in a versatile design, intended for amateur construction, it seems desirable to have an input circuit which will suit any available microphone with or without input transformer.

(b) Feedback obtained by inserting resistance in the cathode lead[4, 5] is liable to lead to unnecessarily high hum levels, unless a d.c. heater supply is used or other expensive precautions are taken.

(c) Circuits involving more than one stage[5, 6], special feedback transformers,[6] or ganged stud-type potentiometers,[4] are regarded as undesirably expensive for amateur use.

Though a single-knob gain-control system is certainly more convenient than the combination of potentiometer and switch used in the present design, it is thought that most amateurs will be prepared to sacrifice a small amount of simplicity of control in order to obtain a very high-grade performance economically.

In most circumstances the gain switch can be set, before commencing operations, to the position appropriate to the sensitivity of the microphone and the likely intensity of the sound, and it will not require altering during the performance. The gain-switching circuit has been so arranged, however, that no switch clicks are heard even if the switch is operated, as may occasionally be necessary, without first fading the input stage down. The switch (S1 in Fig. 1) must be of the make-before-break variety, to ensure that section S1B maintains a short circuit across the gain control during the whole of the time that section S1A is effecting the change-over from triode to pentode or vice versa.

On measuring the input capacitance of the microphone stage, including the input socket, values of approximately 30 pF and 70 pF were obtained under pentode and triode conditions respectively. The higher value under triode conditions is due to Miller effect, involving the screen-grid to control-grid capacitance. A capacitance of 70 pF, shunted across the secondary of a microphone transformer, will produce an appreciable effect on the high-frequency response only if the secondary impedance is well in excess of 50 kΩ; since such transformers are very rare, no trouble arising from input capacitance is likely to be experienced in practice.

A switch S2 is included (see Fig. 1) to enable various degrees of bass cut to be introduced on the microphone channel. This is a very desirable feature, particularly when using a ribbon microphone under fairly close-speaking conditions, since the curved wave-front reaching the microphone then causes a considerable increase in the relative output at low frequencies[7]. Table I on the preceding page gives, for each setting of the switch, the approximate frequency at which an attenuation of 3 db occurs, and the approximate distance from an ideal ribbon microphone at which the compensation for spherical wave propagation is theoretically perfect.

Gramophone Input Stage.—Equalization for recording characteristics[8] is obtained by means of negative-feedback networks associated with V2 in Fig. 1, it being assumed that the pickup employed gives a constant output for constant stylus velocity at all frequencies.*

In the "LP" position of the switch S3, the measured response curve of the gramophone stage is as shown in Fig. 2 (broken-line curve), and is suitable for equalizing microgroove records of both British and American origin. A little extra bass lift may sometimes be required, however, particularly with R.C.A. records, but this can readily be applied by means of the main tone control circuit. The "LP" setting may also be used for American 78 r.p.m. records.

* The best moving-iron, moving-coil and ribbon pickups approximate closely to this ideal.

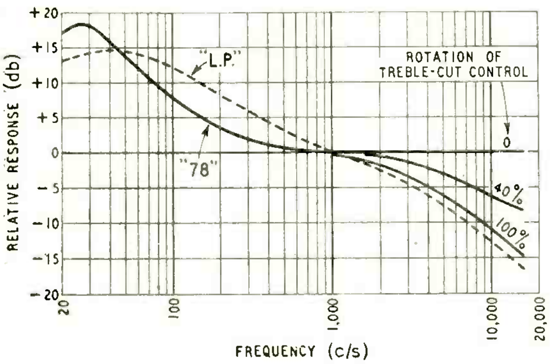
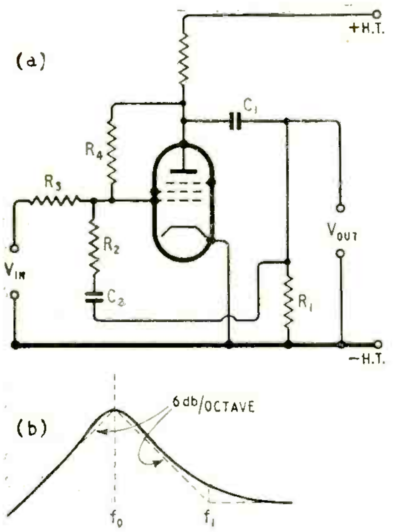


Fig. 2. Measured response curves for gramophone input stage (all components within 5% of values shown in Fig. 1).

The full-line curves in Fig. 2 are obtained on the "78" setting of S3; fixed bass equalization, which is accurately the inverse of the E.M.I. recording characteristic, is provided, and the treble equalization is adjustable by means of a potentiometer. With the potentiometer at approximately 40 per cent rotation from the maximum-treble end, assuming a linear element, the treble attenuation is nominally correct for equalizing the high-frequency pre-emphasis on Decca "ffrr" records. Other settings may be used to give the best audible results with records of various makes and conditions.

It will be seen that the "78" bass-equalization curve shown in Fig. 2 rises at a rate approaching 6 db/octave down to about 35 c/s, below which it changes over fairly rapidly to a similar rate of fall. This latter feature, which provides a useful measure of turntable rumble filtering, is achieved by including two a.c. couplings in the feedback loop used for bass equalization, instead of only one as is more usually the case[9]. The basic theory involved is the same as for the high-pass filter, and is considered later in this article. The practical design formulæ are given in Fig. 3, which also shows the circuit freed from irrelevant details such as grid bias, screen supply, etc.

A low-pass filter, to be described later, is included in the last stage of the pre-amplifier, and will frequently be employed as a scratch filter when using the equipment for reproducing gramophone records only. When mixing a gramophone recording with live speech from a microphone, however, it is often preferable not to limit the frequency range of the microphone contribution, so that the low-pass filter cannot then be employed; but since conditions are not very critical when the gramophone channel is used merely to provide a background effect, scratch filtering is likely to be necessary only with 78 r.p.m. records and can be provided adequately well by means of the adjustable treble-cut control associated with the gramophone input stage. By placing the low-pass filter at the output end of the pre-amplifier, instead



Practical Design Procedure :—

(i) Choose arbitrary value for R_1 (at least 100kΩ)

(ii) Make R_2 several times R_1

(iii) Determine C_2 from :— $C_2 = \frac{1}{2\pi f_1 R_2}$

(iv) Determine C_1 from :— $C_1 = \frac{1}{2\pi R_1}\left(\frac{1}{Qf_0} - \frac{1}{f_1}\right)$

(v) Determine R_4 from :— $R_4 = R_2\left[\frac{Q^2(C_1R_1+C_2R_2)^2}{C_1R_1C_2R_2} - 1\right]$

(vi) Determine R_3 from :— $R_3 = \frac{R_2\,R_4}{R_2+R_4} \div \left[\text{Required value of } V_{OUT}/V_{IN} \text{ at H.F.}\right]$

Note :— The formulae apply accurately only when the actual valve gain is much higher than the value of $\frac{|V_{OUT}|}{|V_{IN}|}$ at f_0. In practice R_4 may be made higher than the calculated value, to compensate for finite valve gain.

Fig. 3. (a) Circuit used for gramophone bass equalization, omitting irrelevant details. (b) Frequency response obtained when $Q=1$.

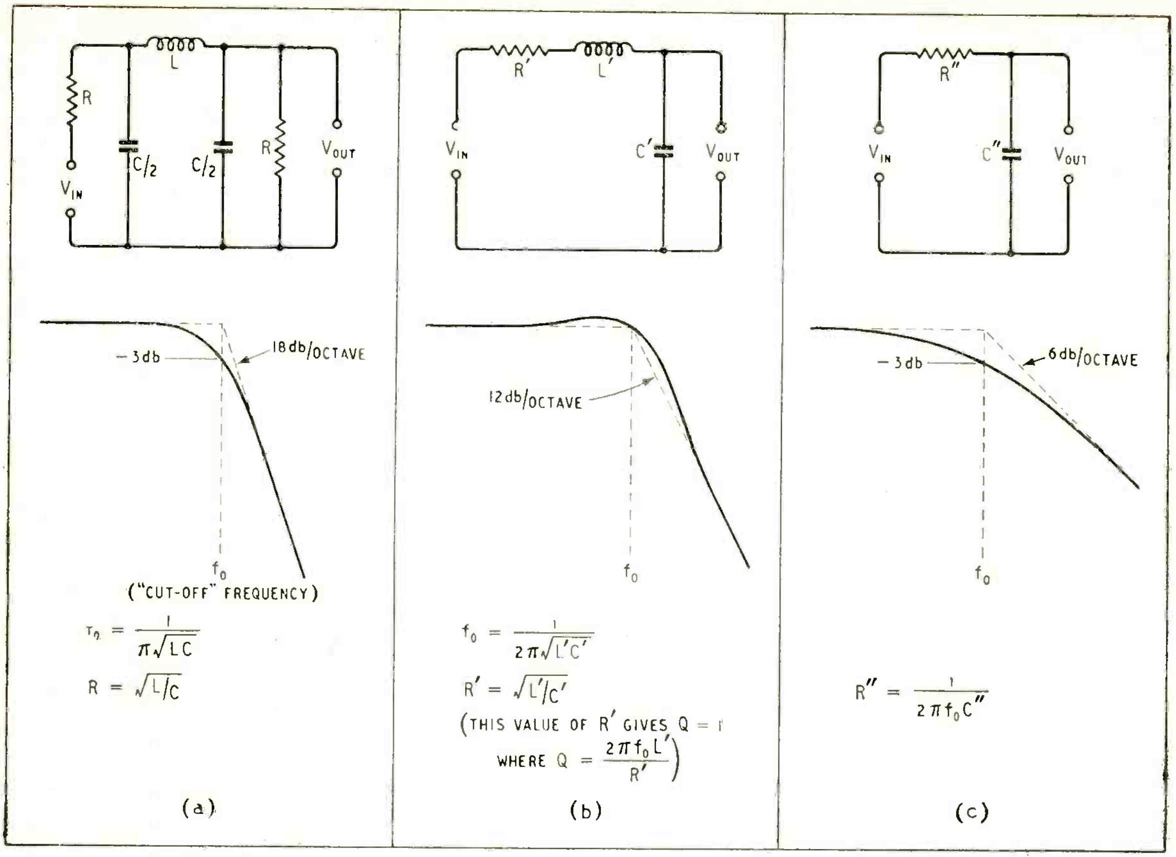


Fig. 4. The constant-k, π-section low-pass filter shown at (a) has the same response (to both sine-waves and transients) as that given by circuits (b) and (c) in cascade, assuming that (c) does not appreciably load (b).

of making it part of the gramophone stage, it becomes available for use on radio programmes, the radio input being fed to the mixer circuit in a similar manner to the microphone and gramophone inputs. A further consideration is that if a crystal pickup is used, the gramophone input stage may be omitted altogether, a suitable passive equalizing network[10] being connected between the pickup and the gramophone gain control;* the low-pass filter is, however, still available under these conditions. (An alternative method of using a crystal pickup, such as the Cosmocord GP20 "Hi-g," is to shunt the pickup with a series combination of two resistors, of values about 220 kΩ and 22 kΩ, the voltage drop across the 22 kΩ resistor being applied to the input of the gramophone stage shown in Fig. 1. The correct value of shunt resistance makes the crystal pickup have a response approximately the same as that of a moving-iron or moving-coil pickup.)

Mixer Stage.—An anode-follower or virtual-earth type of mixer[2] is employed, because it possesses the following desirable features:—

(a) The gain on one input channel is almost independent of the gain-control settings on the other input channels.

(b) The circuit is economical, enabling several inputs to be mixed with a single valve whilst also providing a useful amount of gain—just over four times in the present case.

(c) The non-linearity distortion is low, due to the negative feedback.

(d) The output impedance is low, also because of the negative feedback, making the circuit suitable for feeding the tone-control.

Tone-control Stage.—The tone-control circuit is almost exactly as previously published[2], but an EF86 valve is used in place of the high-slope valve originally specified, in order to secure reliable freedom from microphony and hum. The signal output from the tone-control valve, for a final output from the pre-amplifier of 4 V, is 400 mV; under these conditions, the non-linearity distortion introduced by the tone-control stage is much less than 0.1 per cent despite the low-slope valve employed.

With the switch S4 in the "open" position, the alternative treble-response curves, as shown dotted in Fig. 8 of the previous article[2], may be obtained. A resistor of 330 kΩ is connected to earth from each end of the treble-control potentiometer, to provide a d.c. return path from the grid to earth when S4 is opened—a requirement inadvertently overlooked when the original article was written, but soon pointed out by several readers! Whether this facility for obtaining the alternative response curves is included, is a matter for personal choice, and some constructors may prefer to omit it.

* The values of the gain control potentiometer and the mixer input resistor may be advantageously increased to 500 kΩ and 1 MΩ respectively.

Output Stage.—The output stage provides a voltage gain of approximately 10, and has associated with it feedback circuits giving high-pass and low-pass filter characteristics.

The high-pass filter, which has a fixed cut-off frequency of about 30 c/s, reduces tendencies for the main amplifier and/or loudspeaker to be overloaded by sub-audio frequency inputs caused by turntable rumble, or, on the microphone channel, floor vibration and the effects of wind on the microphone. This filter also substantially reduces the amount of h.t. decoupling necessary for obtaining complete freedom from motor-boating troubles when the pre-amplifier is fed from the main amplifier h.t. supply. Full bass lift may, in fact, be applied at maximum gain settings without causing instability, though this combination is unlikely to be needed in normal use.

The low-pass filter, as already mentioned, is primarily for reducing scratch and distortion on the gramophone channel, and cut-off frequencies of 5kc/s and 7.5kc/s may be selected by means of switch S5, a third position of which cuts the filter out.

It is sometimes said that filters using resistors and capacitors only, in suitable feedback circuits, give better transient response than can be obtained with passive filters which include inductors. In general, however, this notion is quite incorrect, and any filter employing feedback principles may, in fact, be shown to be equivalent, in both frequency response and transient response, to a particular passive filter using inductors. The feedback filters employed in the present equipment are equivalent to, or "simulate," simple constant-*k* filters[11] with one π (or T) section and resistive terminations, the rate of cut-off tending to 18 db/octave.

Considering first the low-pass filter, the basic circuit to be stimulated is that shown in Fig. 4 (a), and the first fact utilized in deriving the equivalent feedback circuit is that the response of the basic circuit is exactly the same as that of the two circuits shown in Fig. 4 (b) and (c) in cascade, provided that the component values are correctly chosen and that circuit (c) does not appreciably load circuit (b)*. It is the normal practice to make R in Fig. 4 (a) equal to $\sqrt{L/C}$; to simulate this condition, the circuit of Fig. 4 (b) must series-resonate at the nominal cut-off frequency of the filter, with a Q of unity at resonance, and circuit (c) must have a response which is 3 db down at the cut-off frequency. Thus, provided a feedback circuit can be found, which has the same kind of response as the Fig. 4 (b) circuit, it is then only necessary to add a "sample lag," as shown in Fig. 4 (c), to make it simulate the filter of Fig. 4 (a).

The main characteristics of the Fig. 4 (b) type of circuit are:—

(a) Level response at low frequencies.

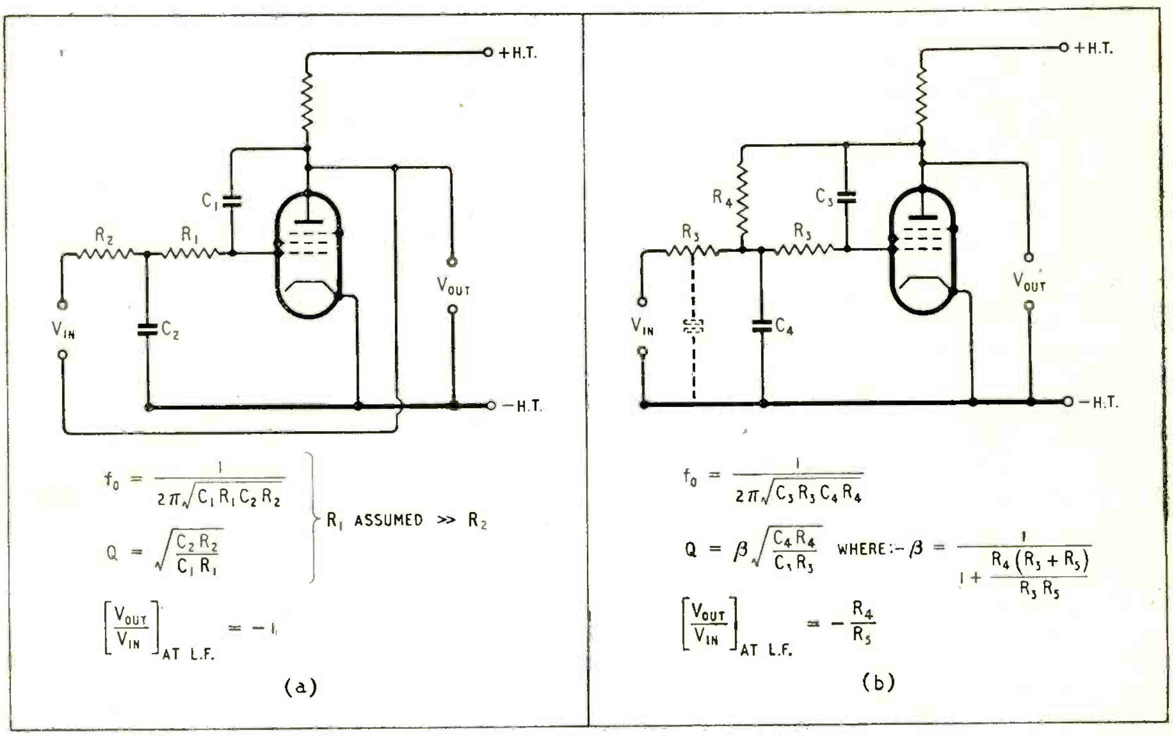
(b) A peak in the response near to the resonant frequency—unless the Q is very low.

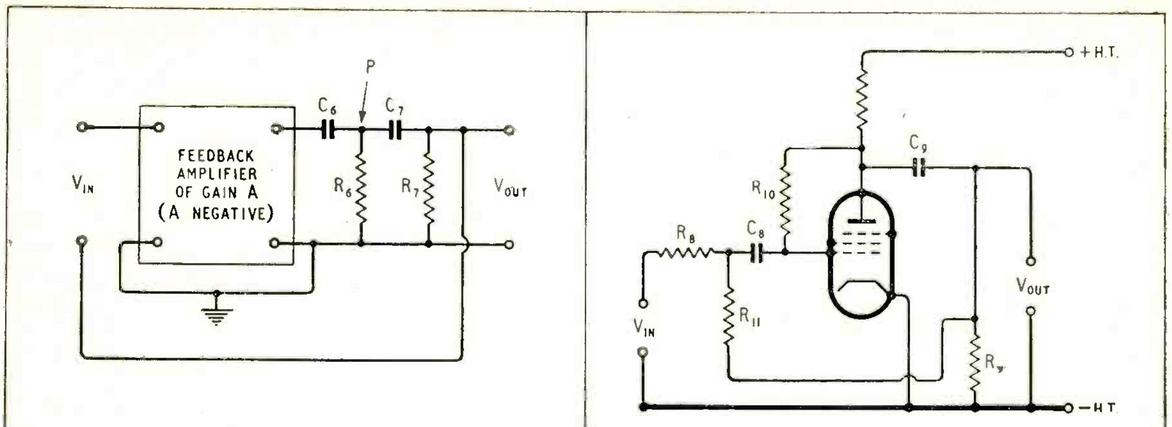
(c) A rate of attenuation tending to 12 db/octave at frequencies well above resonance.

The above are also the main characteristics of a negative-feedback amplifier having two simple lags in the forward path, and it is actually found that the equation relating input and output voltages for such an amplifier is of exactly the same form as that for the Fig. 4 (b) circuit. Alternatively, one of the simple

* The latter condition may be satisfied by making circuit (c) of much higher impedance than circuit (b), or by interposing an isolating stage, such as a cathode follower, between the two circuits.

Fig. 5. Feedback circuits simulating the circuit of Fig. 4 (b). The formulæ apply accurately only when the actual valve gain is much higher than the gain given by the above circuits at low frequencies. The capacitor shown dotted above provides the additional lag required for simulating Fig. 4 (a) instead of Fig. 4 (b).





$$T_1 = C_6 R_6, \quad T_2 = C_7 R_7 \quad \} R_7 \gg R_6$$

$$\left[\frac{V_{OUT}}{V_{IN}}\right]_{\text{AT H.F.}} = \frac{A}{1 - A}$$

(a)

$$T_1 = C_8 \times \frac{R_8 R_{11}}{R_8 + R_{11}}, \quad T_2 = C_9 R_9, \quad A = -\frac{R_{10}}{R_{11}} \quad \} R_{11} \gg R_9$$

$$\left[\frac{V_{OUT}}{V_{IN}}\right]_{\text{AT H.F.}} = \frac{R_{10} R_{11}}{R_8 (R_{10} + R_{11})}$$

(b)

FOR BOTH THE ABOVE CIRCUITS:— $f_0 = \dfrac{1}{2\pi\sqrt{T_1 T_2 (1 - A)}}$

$$Q = \sqrt{1 - A} \times \frac{\sqrt{T_1 T_2}}{T_1 + T_2}$$

Fig. 6. Feedback circuits simulating Fig. 4 (b) with L′ and C′ interchanged. For simulating a constant-k, high-pass filter with $R = \sqrt{L/C}$ terminations, Q is made unity and a passive a.c. coupling, —3db at f_0, is added externally to the above circuits.

lags may be replaced by a Miller integrator,[12] leading to the circuit shown in Fig. 5 (a); this arrangement has the advantage that its performance is almost independent of the actual valve gain, provided the latter is high enough. The necessity for a "floating" signal-input source may be avoided by employing the modified circuit shown in Fig. 5 (b). The capacitor shown dotted in Fig. 5 (b) provides the additional lag required for simulating the circuit of Fig. 4 (a) rather than that of Fig. 4 (b),* and is placed before the valve (instead of after it) in order to enable the low output impedance of the feedback circuit to be utilized for feeding the cable connecting the pre-amplifier to the main amplifier—the cable capacitance may be as much as 200pF without materially affecting the performance.

On referring to the complete circuit diagram, Fig. 1, it will be seen that the low-pass filter circuit of Fig. 5 (b) is that employed in the actual equipment, though a little effort may be needed to disentangle the low-pass filter from the high-pass filter, the latter being achieved by feedback round the same valve!

* The above method of providing the additional lag actually results in slight departures from the simple theory, because the extra capacitor affects, to some extent the operation of the other lag, involving C4; but perfectly satisfactory results may be obtained in practice by suitable choice of component values. Ref. (13) gives an ingenious solution of this complication.

In the high-pass filter, a feedback circuit is used to simulate a series tuned circuit like that shown in Fig. 4 (b) but with L′ and C′ interchanged. This is followed by a circuit as shown in Fig. 4 (c) but with C″ and R″ interchanged, the combination of these circuits simulating a constant-*k* high-pass filter with a rate of attenuation tending to 18 db/octave below cut-off. The basic system used for simulating the series tuned circuit is shown in Fig. 6 (a), and involves a feedback loop having two a.c. couplings in the for-

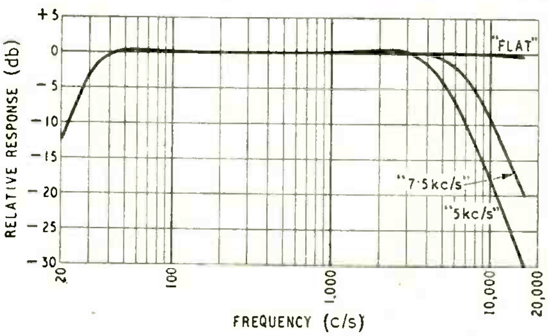


Fig. 7. Measured response curves for output stage in Fig. 1 (all components as marked, within ±5%).

ward path, the forward gain being stabilized by non-frequency-dependent internal feedback. The arrangement is the same in principle as that used for bass equalization and rumble-reduction in the gramophone stage, except that in the gramophone application the output is taken from the point "P." The practical circuit evolved from Fig. 6 (a) is shown in Fig. 6 (b), in which irrelevant details have been omitted for clarity, and it will be seen that one of the time constants in the feedback loop comes before the valve and one after. Non-linearity distortion is considerably reduced by this means.

Fig. 7 gives the results of measurements on the complete output stage, with component values as shown in Fig. 1.

(To be concluded)

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[12] "The Miller Integrator" by B. H. Briggs, *Electronic Engineering*, Aug., Sept. and Oct. 1948.

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Dates for Your *Wireless World* Diary

INDIVIDUAL announcements have already been made of the dates of many of this year's exhibitions, but for the convenience of readers we give below a list of the principal shows in 1955.

Television Society Exhibition — **Jan. 6-8**
University College, Gower St., London, W.C.1.

Components Show (R.E.C.M.F.) — **April 19-21**
Grosvenor House, Park Lane, London, W.1.

Physical Society Exhibition — **April 25 & 28**
New Royal Horticultural Hall, Westminster, London, S.W.1.

Association of Public Address Engineers Exhibition — **April 27 & 28**
Horseshoe Hotel, Tottenham Court Rd., London, W.1.

Northern Radio Show — **May 4-14**
City Hall, Manchester.

British Sound Recording Association Exhibition — **May 21 & 22**
Waldorf Hotel, Aldwych, London, W.C.2.

British Plastics Exhibition — **June 1-11**
National Hall, Olympia, London, W.14.

National Radio Show — **Aug. 24-Sept. 3**
Earls Court, Fulham, London, S.W.5.

Farnborough Air Show (S.B.A.C.) — **Sept. 5-11**
Farnborough, Hants.

NEW ACOUSTICS LABORATORY

A NEW wing has been added to the laboratory of Goodmans Industries, Ltd., at Wembley for research and development in the production of loudspeakers, microphones and other electro-acoustic devices.

The main feature of the new extension is an echo-free room with a volume of 4,500 cu ft lined with glass fibre wedges 8in square at the base and 3ft long. The whole room floats on rubber supports and although a main line railway is only 100ft away, structurally borne vibrations are negligible. The unusually deep lagging presents problems in the design of the door, which must, of course, be similarly treated. These problems have been solved by mounting the door on vertical guides and raising it electrically into a tower on the roof of the building when access to the room is required.

In addition to normal frequency response curves, measurements of "hang-over" transients are also made by a tone pulse technique, and this has proved useful in investigating cabinet as well as loudspeaker performance.

Auxiliary equipment includes a high-speed level recorder (1,000 db/sec), electrical and acoustical standards and instruments for measurement of compliance and other mechanical parameters.

The services of the laboratory are available to set manufacturers for testing prototype designs and ensuring that harmonious acoustic relations exist between loudspeaker and cabinet.

Goodmans Industries acoustics laboratory, showing in the background the entrance to the echo-free chamber.

Education and Training

Can We be Satisfied with the Results?

By FRANCIS REECE

THE tremendous demand for radio engineers and technicians is reflected in the many advertisements which appear not only in the technical press, but also in the lay press. There has been no easing of the shortage of manpower over the past ten years, and it may be assumed that this is a serious handicap to a fast developing industry.

Why is there such a shortage when the importance of technical education is so widely appreciated and public interest in technology in this country is greater than ever before?

It is popular to criticize the lethargy of the younger generation. Be that as it may, employers cannot complain at the number of young men who are sufficiently attracted towards employment in the radio field to embark upon long and arduous courses of instruction. In fact, there has been a very large increase in the number of candidates taking the examinations of the City and Guilds of London Institute, the Institution of Electrical Engineers, and the British Institution of Radio Engineers.

Whilst, however, large numbers of students undertake courses of study, comparatively few successfully complete the courses. Every technical college reports that at the end of each academic year a number of students give up their courses either because of their waning interest or an inability to assimilate the work. One London technical college has reported, for example, that 50 students started on the first year of an Ordinary National Certificate course, but by the end of the third year only 25 actually attempted the final examination leading to the award of the certificate. Of that 25, only 5 went on to attempt the Higher National Certificate. Similar figures have been given in respect of courses in preparation for the City and Guilds Full Technological Certificate and other examinations.

These facts are of supreme importance in estimating the future number of engineers, as distinct from technicians, likely to enter the radio industry. The bulk of the engineers already employed and certainly the majority of future engineers, will come from the technical colleges with a Higher National Certificate or having directly passed the examinations of the I.E.E. or the Brit.I.R.E.

A Popular Misconception

It is a popular misconception that engineers have necessarily to be university graduates. The majority of the engineering staff of any firm or Government organization have not had the advantage of a university education. Indeed, the number of graduates securing degrees in the appropriate engineering faculties. could not possibly meet the present enormous demand for junior and senior development and research engineers. Moreover, the number of engineering degrees awarded in Great Britain has decreased in the last two years. Thus, in the main, industry must look to the technical colleges to provide the majority of men for whom there is at present such a demand.

It may be argued that much of the trouble lies in preliminary education. The minimum level of basic education laid down by the professional institutions is the Common Preliminary Examination conducted by the Engineering Joint Examination Board. This requires success in English, mathematics, elementary physics and a foreign language, and exemption is granted from it to the boy (or girl) who has obtained a pass in these subjects in the General Certificate of Education at the ordinary level.

Unfortunately, figures are not available to indicate how many grammar school boys enter the engineering profession, including the radio industry. Apart from this source many of the engineers of the future will receive their basic education in the secondary modern schools. It is, however, a deplorable fact that very few of these schools train their pupils for the General Certificate of Education even in two or three subjects.

Under the provision of the 1944 Education Act children not admitted to either grammar or secondary modern schools finish their education in the secondary technical schools. For the purpose of these notes such pupils need not enter into our reckoning, although doubtless many of them are ultimately engaged in engineering in an unskilled capacity or as craftsmen or mechanics. A few may have the tenacity to carry on with part-time studies to qualify for better positions.

Is Basic Education to Blame?

The bulk of students taking the Ordinary National Certificate or similar courses at a technical college come now from the secondary modern schools and have not had the advantage of a grammar school education. It may well be that this lack of basic education accounts for the large wastage now being experienced in second and subsequent years of technical college courses.

The question may, therefore, be asked as to whether the eight years working of the new Education Act is in any way responsible for the very high percentage of failures in the C. and G., I.E.E., and Brit.I.R.E. examinations. Whatever the reasons, the fact is that since the war the number of young students attracted to the radio engineering career has steadily increased. In 1953, for example, the C. and G. had a record entry of over 30,000 candidates for their various examinations in telecommunications. Of this number only 394 succeeded in obtaining an Intermediate Certificate, 139 were awarded a Final Certificate, and 67 obtained the Full Technological Certificate in Telecommunications Engineering (Radio).

Success in the Full Technological Certificate examination in telecommunications only secures partial exemption from the appropriate professional examinations of the I.E.E. and the Brit.I.R.E. The younger engineer usually looks forward to qualifying for membership of one of these professional bodies. Some consideration must therefore be given to the experience of these institutions in assessing the technical qualifications of their prospective members, whether by direct examination or by granting exemption.

According to the last annual report of the Brit.I.R.E. the results of its own examination are very disappointing. Whilst the number of entries is now over 1,000 a year, fewer than 6% of the candidates pass the graduateship examination.

The I.E.E. runs a different scheme of examination but it is sufficient for our purpose to consider the results of its Section B, which includes the optional subject of radio communication. The I.E.E. does not distinguish between candidates taking radio communication and the electricity supply subjects in its summary of results, but in 1953 it had 722 candidates writing the Section B subjects, of which only 152 succeeded. Thus, although the percentage of success may vary between the three examining bodies mentioned, the over-all result must be disappointing to both the entrants and those who are looking for an increased entry to the engineering ranks of the radio industry.

Varying Standards of Instruction

It is true, of course, that apprentices, trainees and others may meet the requirements of their individual firms by obtaining National Certificates. In 1953 over 7,500 Higher and Ordinary National Certificates (Electrical Engineering) were awarded, but figures are not available to show how many of these certificates were in respect of radio or telecommunication subjects. The pass standard required for National Certificates seems to be a little lower than that required for success in external examinations, but an important additional requirement is that the candidate's course work is also taken into account. Furthermore, the radio content of a course for the H.N.C. varies according to the college. There are all too few colleges in Great Britain able to offer a course leading to a Higher National Certificate in radio subjects. Indeed, the I.E.E. issued a memorandum in 1950 which stated that only 20 such colleges were offering approved courses in radio and telecommunications engineering (including line communication).

Courses in preparation for National Certificates or the examinations of the C. and G., I.E.E. or Brit.I.R.E. are the first steps which must be taken for qualification as an engineer by a candidate not having the advantage of a university education. Only from these sources can the industry recruit the type of engineer who, graduating through the technician and junior ranks, can undertake responsibility for development and production. Such experience must be coupled with proper training for ultimate employment in senior positions.

A Select Committee has recently issued a report in regard to the manpower requirement of the Royal Air Force. The shortage is particularly acute in the electronic field. Thus the Services now add their claim upon the too few people available to industry.

Surely the first step towards solving this problem is for the Ministry of Education, the C. and G. and the engineering institutions concerned, to make a detailed investigation as to the reasons for the poor results in their examinations and the National Certificate scheme. If the answer is that the calibre of the candidates is too low because of the inadequacy of basic education, then the Ministry of Education has it in its power to alter the application of the 1944 Education Act. The present writer suggests, however, that the failure lies not so much with basic education as with the inadequacy of subsequent technical instruction. Various reports, including one issued by the Parliamentary and Scientific Committee, have suggested that there is a shortage of properly qualified lecturers and that the colleges are handicapped in not possessing suitable equipment. There has also been little progress with the proposal that lecturers should have better opportunity to secure industrial experience with corresponding release of industrial engineers to undertake part-time teaching.

A further factor in trying to produce better results is the need to overcome the reluctance of some colleges to provide courses specifically designed for the radio engineer. Many of the existing syllabuses were drafted for the training of the electrical engineer. The addition of one subject in radio in the final year of a course for the H.N.C. is not generally thought to be sufficient to meet the needs of a rapidly expanding industry.

The third possibility is to consider whether the examining bodies demand too high a standard. Everyone would welcome these various bodies reconciling their differences of opinion. If they did so the technical colleges would be greatly helped in the arrangement of their courses. Concerted and agreed opinion would also influence training at the grammar school level.

Pros and Cons of Specialization

The C. and G. has always been primarily concerned with the training of the mechanic and technician. In more recent years, however, it has developed these interests to a more advanced level for the radio and telecommunications engineer. To this extent they are encouraging specialization.

On the other hand the I.E.E. does not fully subscribe to any degree of specialization, as will be seen from a perusal of its examination syllabus. This, however, does not necessarily account for its slightly better percentage of examination successes when compared with those recorded by the C. and G. and the Brit.I.R.E. In general the I.E.E. insists on a broader education in general engineering, with emphasis upon practical laboratory work.

Rather naturally perhaps the Brit.I.R.E. appears to subscribe to the policy of specialization. The tendency is to attach more importance to physics than would normally be followed in an O.N.C. course; possibly the main criticism of the Brit.I.R.E. is that it encourages specialization within two years of starting a general engineering course. This insistence upon specialization in depth might therefore account for the small percentage of successes in its graduateship examination.

In only one respect does the National Certificate examination scheme and the examinations of the two institutions agree—that of insisting upon some system of approved courses requiring actual attendance and the provision of suitable laboratory work. In the case of the C. and G. there is no insistence on the satisfactory completion of an approved course. The candidate alone decides when he will take the examination and the temptation to "have a go" may account for many of the failures. The Brit.I.R.E. appears to have realized that this factor contributes to the low percentages of success and is now insisting that candidates for the examination must provide evidence of supervised course work.

There is much discussion on the proper way of using an engineer once he has been recruited. The unskilled worker, the mechanic, and the technician are all needed by the industry. The future development, and the grasping of opportunities at hand in the radio industry, will be lost unless the engineer is recruited at the right age and with the requisite basic education.

It is not the function of this article to discuss the opportunities which are available to the properly trained young engineer. It is true that unfavourable comparison is very often made with the returns available elsewhere to unskilled labour. Nevertheless the interest of a comparatively new and growing art continues to attract large numbers of young men. The fact that they fail to achieve their goal must reflect on the education and training that they receive.

Education and training will continue to be a subject in which industry must take an increasing part. As employers, however, they are not alone in this responsibility for the same story of shortage of radio and electronic engineers is to be found in the Civil Service, the Navy, the Army, and the Air Force. Even the B.B.C., with its own internal system of training, is continually advertising vacancies for radio engineers.

Last year the Radio Industry Council published a most useful pamphlet "Careers in Radio and Electronics" dealing with the need and the opportunities for the young engineer in the radio industry. The booklet was a further indication of industry's realization that it has a very important part to play in the training of the engineer of the future. Certainly, the opportunities available within the industry for "sandwich" courses and other methods of part-time study, coupled with experience, are a great advance upon the facilities available to the pre-war student.

The R.I.C. estimated that up to 3,000 boys a year can be absorbed by the industry. No account was taken, however, of the demand for radio engineers outside the industry, and the developments already mentioned, including the Services' requirement, probably means that at least double this number is required every year if all demands are to be reasonably satisfied. All the more reason, therefore, to ensure that available material is properly trained and not wasted. The first essential is to retain the interest of the student in the early years of his technical training. Unless this problem is tackled, the tendency must be for the younger man to take advantage of the opportunities in other fields, to the subsequent detriment of future development in the radio industry.

Can we, therefore, be satisfied with the results achieved by our present method of technical education?

PUBLICATION DATE

***Wireless World* will in future appear on the fourth Tuesday of the Month preceding that for which it is dated. The February issue will therefore be published on 25th January.**

Radio Officers' Training

Colleges Providing Courses

THE particulars included in the lists of further education establishments published in our September and October issues last year were provided by the Ministry of Education and included only those colleges, etc., which come under the direct control of the Ministry. They do not, therefore, include the privately operated wireless schools throughout the country which provide training for prospective radio officers. The following establishments in the United Kingdom are licensed by the P.M.G. to use transmitting equipment for instruction purposes.

Bridlington
North Eastern School of Wireless Telegraphy, Radio House, Shaftesbury Road, Bridlington, Yorks.

Grimsby
Grimsby Nautical School, Orwell Street, Grimsby, Lincs.

Hull
Municipal Technical College, Park Street, Hull, Yorks.

Leamington Spa
Midland Wireless School, 2, Myton Croft, Myton Road, Leamington, Warwicks.

Liverpool
Riversdale Technical College, Riversdale Road, Liverpool, 19.
Wireless College, 6, Princes Road, Liverpool, 8.

London
British School of Telegraphy, 179, Clapham Road, London, S.W.9
Wireless School, Radio House, 21, Manor Gardens, Holloway, London, N.7.
London Telegraph Training College, Morse House, 20, Penywern Road, Earls Court, London, S.W.5.
Norwood Technical College, Knight's Hill, W. Norwood, London, S.E.27.

Manchester
Wireless Telegraph College, 25, John Dalton Street, Manchester.
College of International Marine Radiotelegraphic Communication, Overseas House, Brook's Bar, Manchester, 16.

Plymouth
Plymouth and Devonport Technical College, Tavistock Road, Plymouth, Devon

Preston
Northern Counties Wireless School, 91, Lancaster Road, Preston, Lancs.

Southampton
The University, Southampton.
Air Service Training School of Radio and Radar, Hamble, Hants.

South Shields
Marine School, Ocean Road, South Shields, Co. Durham.

SCOTLAND

Aberdeen
Marine Radio College, 56, Union Street, Aberdeen.

Edinburgh
Edinburgh Wireless College, 17, Gayfield Square, Edinburgh, 1, Midlothian.
Leith Nautical College, Leith, Edinburgh, 6, Midlothian.

Glasgow
Glasgow Wireless College, 26, Newton Place, Glasgow, C.3, Lanarks.

Greenock
Watt Memorial School, Dalrymple Street, Greenock, Renfrews.

WALES

Cardiff
Cardiff Wireless College, 1, Stuart Street, Docks, Cardiff, Glam.

Colwyn Bay
Wireless College, East Parade, Colwyn Bay, Denbighshire.

NORTHERN IRELAND

Belfast
Marine Radio College, Orlington House, 2, Eglantine Avenue, Lisburn Road, Belfast.

"Special Quality" Valves:

Improvements in Electrical Characteristics as Well as in Reliability

By E. G. ROWE,* M.Sc., A.C.G.I., D.I.C., P. WELCH* and W. W. WRIGHT,* B.Sc., A.Inst.P.

IN our company, we started work on reliable valves in early 1949 because of complaints about valve failures in an automatic pilot equipment. We then expanded our efforts in order to help our Radio Division to produce equipment which would successfully pass flight trials. The real impetus, however, was provided by the Services, who later in the same year placed large-scale development contracts for the design of reliable valves to be plug-in replacements for types on the Preferred List.

Our work showed that whilst human errors in manufacture played a part in producing failures, the basic valve designs needed attention. The major problem was that most valves had loose structures which gave rise to noise and characteristic instability, whilst some had structures of such dimensions that low frequency resonances were inevitable. Fig. 1 shows the proportions of noise output contributed by the various valve components.

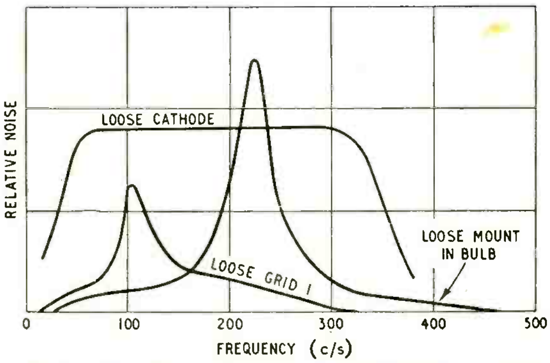


Fig. 1. Contribution of various parts of the valve structure to noise output.

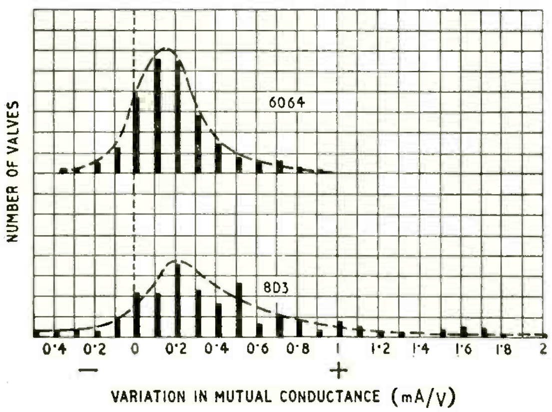


Fig. 2. Comparison of mutual inductance spread between type 8D3 and its special-quality equivalent, 6064, in 500 hours static life test.

Some manufacturers tended to take panic measures on the principle that if more struts were added to the valve structures then they would be bound to be more reliable, but our view has always been that a more scientific approach would pay dividends, even though it might take longer in actual time. Our philosophy was that before a valve design was considered suitable for production it had to be analysed for noise, and a resonance search test equipment designed by Dr. H. Moss proved invaluable for this purpose. Its disadvantage was that valves had to be made up first and then tested, but since then we have devised empirical formulae to forecast in advance whether the individual components would produce objectionable resonances. Thus this particular piece of test gear has now become a routine checking instrument only.

Cathode Poisoning

The most serious cause of valve failures, other than short life catastrophes, was found to be the evolution of gas, resulting in cathode poisoning. The cause of this was traced to frictional movement between the mica insulators and the valve envelope and components, and the elimination of this has been the most important contribution to valve longevity under conditions of vibration and shock.

The techniques used to overcome such troubles, and the results obtained, have already been described in *Wireless World*†. Work done on these mechanical improvements has also shown some very gratifying results with respect to the electrical characteristics. Not only has it been possible to produce redesigns which are electrically interchangeable with the existing types, but added advantages have been obtained in that there is a significant reduction in characteristic spread, a lower drift of characteristics in early life, reduced electrical noise and improved microphony performance. Fig. 2 shows a typical improvement in mutual conductance spread and Fig. 3 relates to the low frequency noise distribution.

In addition, it has been established that many of the theories held regarding valve instability are second-order effects compared with the advantages resulting from mechanically strengthening the valve structure. As an example, it has been possible to produce double triodes for d.c. amplifier work and Fig. 4 shows the improvement achieved on the type 6158.

The successful elimination of early life catastrophic

* Brimar Engineering Division, Standard Telephones & Cables. This article makes use of some of the information and diagrams in a paper "Thermionic Valves of Improved Quality for Government and Industrial Purposes," to be published in *Proc. I.E.E.*

† "Trustworthy Valves," by E. G. Rowe. *Wireless World*, March, 1952.

Progress Report

failures under vibration is shown in Fig. 5, which compares the 8D3 with the 6064 and also demonstrates the improvement which can be achieved by selective testing of ordinary commercial valves.

With normal static life testing we have used a method popular in the U.S.A. and based on a 500-hour life test. At the end of the run the average life of the group of valves is assessed by using the formula:

$$\text{Average life percentage at } x \text{ hours} = \frac{\text{Sum of life hours for all valves under test}}{x \text{ hours and number of valves started}} \times 100$$

American specifications for the minimum acceptable life performance give a figure of 80 per cent for normal commercial valves and 95 per cent for the reliable types, while R.C.A. quote 97 per cent for their Red Series. Our figures on three of our "Trustworthy" types are 99.82 per cent, 99 per cent and 100 per cent respectively.

Having said something about the design of reliable valves, let us now look at the manufacturing problems.

An average valve has seven glass-to-metal seals and 35 welds, with over 800 separate and distinct manufacturing steps to convert the raw material into the finished product. The production engineer has the task of manufacturing mass-production quantities of such complex articles with the minimum variation of mechanical, chemical and human tolerances. The problems of reliability resolve themselves into greater efforts to control the materials, the processes and the operators' variability.

There are two schools of thought regarding the place in which special quality valves should be made. One advises an entirely separate location from the ordinary types, but much can be said in favour of their manufacture in the centre of the main assembly groups, so that with strong supervisory control the effect of the lessons learned will have a large psychological effect on the whole factory. This point is doubly important when it is realized that in the event of another war very large numbers of special quality valves will be demanded.

To obtain the high quality demanded it is necessary to have continuity of production over long periods and the corollary to this is that the diversity of valve types shall be limited as much as possible.

Mass-Production Outlook

Initially the assembly of "Trustworthy" valves was done on a time-work basis with no incentive towards speed. However, it was found that this was so alien to the mass-production outlook in valve manufacturing that a change was made to operate teams controlled by a quality control system working on each assembly position. It has now been possible to introduce an incentive scheme based on quality and quantity, and a study of the results has demonstrated that when an operator is given a simple sequence of jig-aided operations the work begins to flow at her natural rate with maximum efficiency.

The achievement of failure rates as low as 2 per cent per 1,000 hours is not dependent solely upon structural design and the control of the manufacturing unit. Good design and manufacturing controls combine to ensure that the manufacturing variations will be small and that there will be a few random faults or errors, but they cannot guarantee their complete elimination. It is imperative, therefore, that a form of valve testing shall be adopted which takes into account both "manufacturing variations" and "manufacturing errors." The development of suitable testing procedures is very important, as it is easy to evolve a series of unwieldy tests which can make large-scale production impracticable.

So much for the problems involved in making reliable valves—but the matter does not end there. The contribution required from those who use valves is a very large and vital one. It is the very versatility of the valve which gives so much scope to the circuit designer's ingenuity.

It may not be appreciated that the rate of failures of specific valves in different equipments can vary by a factor of 10. This can best be minimized by co-operative effort between the designers and the valve

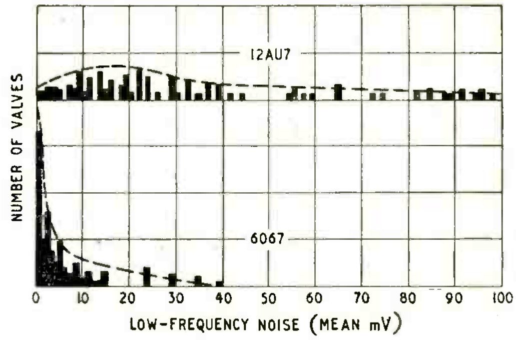


Fig. 3. Comparison of low-frequency noise output distributions for type 12AU7 and its special-quality equivalent, 6067.

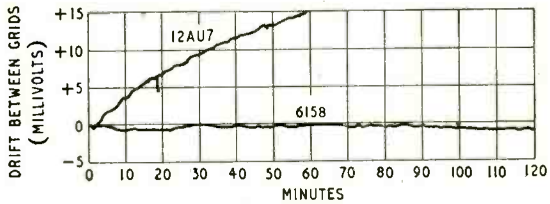


Fig. 4. Comparison of drift performance between type 12AU7 and special-quality type 6158 (equivalent to 13D3).

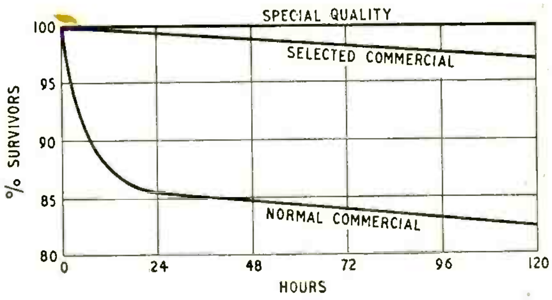


Fig. 5. Comparison between special quality, selected commercial and normal commercial valves for survival under vibration (470 c/s at 3.5g for a period of 120 hours).

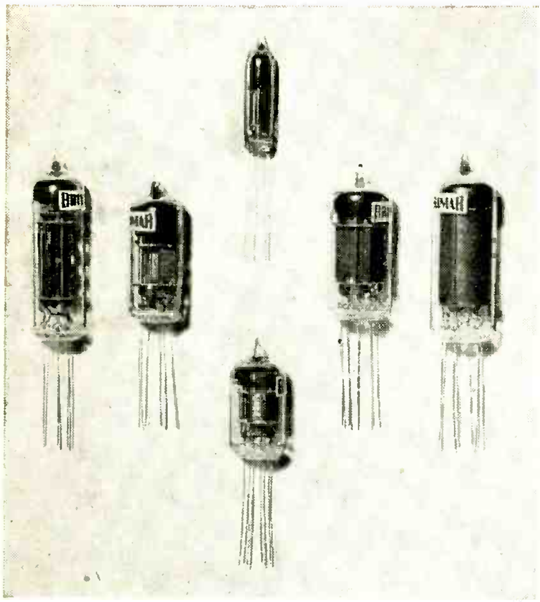


Fig. 6. Typical examples of flying-lead valves.

makers. The valve manufacturer makes the request to all designers that they should take full advantage of his intimate knowledge of the idiosyncrasies of valves. Valves are defined by specifications, but these can only cover the applications known and visualized at the time the valve was introduced. Close collaboration can ensure that all valves which meet the test specification will perform satisfactorily in service and will enable the valve maker to carry out adequate checks to cover any use of special characteristics. By this means a compromise is reached whereby the most suitable valve for the job is used, from the point of view characteristics and continued availability, and the best-known circuitry is utilized to accomplish its purpose.

Avoiding Glass Fractures

Now for the equipment manufacturer. Reliability can depend on more mundane matters than circuitry and valve characteristics. The valve is a glass article and should be treated as such. Glass is severely weakened by the minutest of scratches, and jumbling valves together in a box, for example, will produce scratching by the nickel pins. Modern valves such as miniatures have a complex multiple glass-to-metal seal, and leaks result from strains caused by mechanical incompatibility with the valve-holders. It is therefore important that wiring jigs shall be inserted into all holders before chassis wiring takes place, and as the valve pins are easily distorted on handling, all valves should be pin-straightened in a proper jig, and not with pliers, immediately before insertion into holders.

In circuit testing the valve should not be tapped harder than is necessary to check for noise. The tendency to use a screwdriver for this purpose is unfortunate.

It may be thought that some of these comments are irrelevant, but experience has shown that such practices are common and contribute materially to setting up conditions which cause delayed fractures some time after the installation of the equipment. The recent publication of a Code of Practice, CP.1005, on the correct usage of valves, should be learnt by heart by all designers, and is every bit as important in our sphere as the new Highway Code is intended to be to the road user.

It is obvious that electronic equipment in the future is likely to become more and more complex, and it is important that steps are taken to see that circuit complexity and unreliability do not become synonymous. The equipment designer must create and engineer his apparatus so that it becomes just a "black box" as far as the user is concerned. As an example, the telephone is a simple device to the user, yet we are all aware of the complexity of automatic telephone equipment. It is therefore increasingly important that equipment is designed conjointly with *all* component manufacturers and with adequate thought given to problems that will confront the user.

Now, what about the valve outlook—present, past and future?

Valves for the immediate future are taken care of by an adequate number of reliable miniature types. The past can best be dealt with by applying the testing techniques established for reliable valves to the domestic manufacture of the older types of valves, thereby eliminating the early life catastrophic failures due to unsatisfactory workmanship.

Further improvements in valve reliability must be at the expense of the present type of valveholder. Incompatibility between this and the valve pin positioning can cause failures in excess of the target achieved by the valves alone, and it is logical to adopt wired-in techniques which, in addition to reducing failures, can permit greater exploitation of the valve characteristics. There is a great need for bright circuit engineers to cast aside the chains of present circuit-technique thinking. They should regard these wired-in valves as new tools to be used on their own merits and in circuitry designed to use them to their full capabilities, so that the whole ratio of ironmongery to electronic circuitry is drastically changed. Some typical wired-in types are illustrated in Fig. 6.

As valve makers we dislike intensely the suggestion of unreliability which is cast at the electronics industry. One rarely hears such comments in the civil and mechanical engineering fields, but we are confident that we are on the brink of an era when electronics will have grown up and will have no more of this slur.

NEWS FROM THE CLUBS

Kingston-on-Thames.—The Osram 912 amplifier and G.E.C. metal-cone loudspeaker will be demonstrated at the meeting of the Kingston and District Amateur Radio Society at 7.45 on January 13th at Penryn House, Penryn Road, Kingston-on-Thames. Sec.: R. S. Babbs, 28, Grove Lane, Kingston-on-Thames, Surrey.

Cleckheaton.—The meeting of the Spen Valley and District Radio and Television Society on January 12th at 7.30 in the Temperance Hall, Cleckheaton, will be devoted to films. On the 25th members will meet the Bradford Radio Society in a quiz at Cambridge House, Bradford, Yorks. Sec.: N. Pride, 100, Raikes Lane, Birstall, Nr. Leeds, Yorks.

Coventry.—At the meeting of the Coventry Amateur Radio Society at 7.30 on January 3rd at 9, Queens Road, Coventry, T. R. Theakston will speak on "Mathematics." Sec.: K. G. Lines, G3FOH, 142, Shorncliffe Road, Coventry, Warwicks.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by correspondents

"*Inexpensive 10-Watt Amplifier*"

IN his criticism in your November issue of the Baxandall type of amplifier your correspondent John Brighton underrates the benefits of negative feedback when applied to tetrodes and pentodes working into loud-speaker loads.

An increase in load impedance, such as occurs at high and low frequencies, will cause the "violent increase in third-harmonic distortion" mentioned only if the signal voltage is maintained constant, and occurs on account of the increased anode-voltage swing. When negative feed-back is applied, even in small amount, the grid-voltage swing is automatically adjusted to maintain the output voltage reasonably constant against load variations, and the condition which would cause the sudden increase in third harmonic distortion is prevented from arising. It is a fallacy to say that negative feedback can only reduce distortion to the same extent as the gain; where the feed-back prevents an overload, as in this case, the reduction can be much greater for the cause of the distortion is, in fact, removed.

Apart from this consideration, of course, the quoted typical figure of 40 db for feedback would apply only for the correct load condition. An increase in load also causes a corresponding increase in loop gain, and on this account alone the picture would be brighter than that painted by Mr. Brighton.

Chislehurst, Kent. D. J. R. MARTIN.

YOUR correspondent, John Brighton, in your November issue, raises again the hypothetical objection to the use of tetrodes in the output stage of a "quality" amplifier, but what, might we ask, does this alleged "violent" increase in third harmonic distortion really amount to in practice? Precious little!

The real reason why the Baxandall amplifier has not become popular is more likely to be owing to the fact that it requires 4 volts r.m.s. to give full output, which in many cases is inconveniently insensitive. A big point in its favour, however, is that it is a very "sanitary" design, meaning that its author's specification of performance can be achieved with ease. Despite protestations to the contrary, I do not think that this is quite so true of the Williamson. Constructors would be very well advised always to check performances with square waves as Baxandall suggests, and prepare themselves for some shocks!

Enfield, Middx. J. K. WEBB.

JOHN BRIGHTON, in his letter published in the November issue, suggests that tetrodes are less desirable than triodes for use in the output stage of a high-quality loudspeaker amplifier employing negative feedback, because of increased third-harmonic distortion when the load impedance becomes reactive and/or higher in value than the nominally correct value.

The following experimental results have been obtained recently, on an amplifier which is the same as that described in my article in *Wireless World*, January, 1948, except for the use of a smaller and cheaper output transformer with a silicon-steel core.

TABLE

Load Resistance (ohms)	11	13	15	17	20	25	30	∞
Third Harmonic Distortion (per cent)	0.172	0.089	0.070	0.061	0.056	0.053	0.052	0.042

With a 15-ohm load resistor connected to the output, a 500-c/s sine-wave input, of negligible third-harmonic content, was adjusted to give a mean power output of 10 watts; i.e., an output voltage of 12.2 volts r.m.s. With the input voltage kept constant, the value of the load resistor was then varied, and the effect on the third-harmonic distortion was as shown in the table.

An air-cored inductor, having a reactance of approximately 15 ohms at 500 c/s, was then connected across the amplifier output, and it was found that the third-harmonic distortion, at a level of 12.2 volts, was considerably less than with a 15-ohm resistive load. Reduced distortion was also obtained with a 16-μF capacitance load.

The above results thus show that, with this amplifier, the distortion is not critically dependent on either the value or the phase angle of the load, and that an increase in load impedance actually causes a reduction in distortion. What, then, is wrong with Mr. Brighton's argument?

In the absence of feedback, it is perfectly true that an increase in the load impedance of a tetrode amplifier, with constant signal input, causes an increase in third-harmonic distortion.* It should be noted, however, that there is also an increase in output voltage and an increase in gain.

When a large amount of voltage negative feedback is applied to a tetrode amplifier, on the other hand, an increase in load impedance causes almost no increase in output voltage, the feedback automatically reducing the signal applied to the grids of the output valves by the appropriate amount. Since this reduction in grid swing is accompanied by an increase in the forward gain of the feedback loop (i.e., more decibels of feedback are brought into play), it is hardly surprising that the third-harmonic distortion falls off as the load impedance is increased.

It would thus appear that Mr. Brighton has overlooked the beneficial effects of reduced grid swing and increased loop gain which automatically occur when there is a rise in the load impedance of a feedback amplifier using tetrodes.

Malvern. P. J. BAXANDALL.

* See, for example, Fig. 13.30, p 570, "Radio Designer's Handbook," Fourth Edition.

"*Quality on V.H.F.*"

I AM surprised and disappointed to learn from H. Bishop's rejoinder (December issue) to your editorial that it is not the B.B.C.'s intention at least to try to transmit as many programmes as possible that justify high quality, with a full 15-kc/s frequency response. The B.B.C. apparently intends to use ordinary Post Office music circuits for all its transmissions. These, I believe, are equalized only up to 8,500 c/s, and hence constitute a poor feeder for quality transmitters.

Mr. Bishop states that the better quality is brought about by the improved signal/noise ratio. I take it that the P.O. music circuits are better than the f.m. transmitters in this respect. However, surely the main advantage to be gained from a better signal/noise ratio is the wider dynamic range attainable. Even this, I suppose, will not be realized, as the programmes will be common to both f.m. and medium-wave transmitters, and the manual compression necessary for the latter is done at the studios. It is also unfortunate that this compression is more noticeable on f.m. as the now discernible concert hall atmosphere and microphone hiss rise and fall. The outlook certainly looks black for music lovers and quality enthusiasts, of which there must now be a great and quickly increasing number in the country—witness the expanding sales of "hi-fi" equipment and L.P.s; also the popularity of Mr. Briggs' lectures.

Surely a circuit equalized up to 15 kc/s could be provided from the local studios to the transmitters at a cost small compared to the cost of the transmitters themselves. A 15-kc/s line could also be provided to much-used concert halls—a small "hi-fi" network. After all, it is done for television, and up to 3 Mc/s, too, probably at a far greater cost than for 15 kc/s circuits.

Let us hope that, in years to come, a high-quality national network will enable, for example, Londoners to hear an Usher Hall concert with 15-kc/s bandwidth. However, why not start now with a few local circuits—why spoil the ship for a ha'p'orth of tar?

London, N.10. A. F. HARRISON.

Television Quality

I WOULD like to draw attention to the picture degradation that is evident in the regular B.B.C. television news and newsreel.

Bearing in mind the high standard of reproduction set by the previous newsreel, I feel that there can be little justification for the noticeably low picture quality, the snowstorm effect of innumerable scratches, spots and lines brought about by imperfect camera and development processes, and the unnecessarily large and often thrice-repeated cueing marks which could be easily replaced by other less obtrusive methods of cueing.

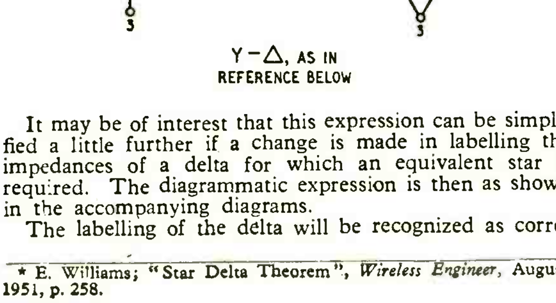
Perhaps quality is partly determined by the small gauge film techniques involved in producing a daily news film service and partly by the transcription equipment. It might be argued that no better equipment is available at present, but as far as the film is concerned there can be no excuse.

Instead of carrying on with the present feature, the B.B.C. might well consider reverting to the style and quality of the earlier newsreel until such time as they are in the position to operate with equipment and film processing techniques free from avoidable degradations.

London, S.W.4. G. T. CLACK.

"Some Electrical Theorems"

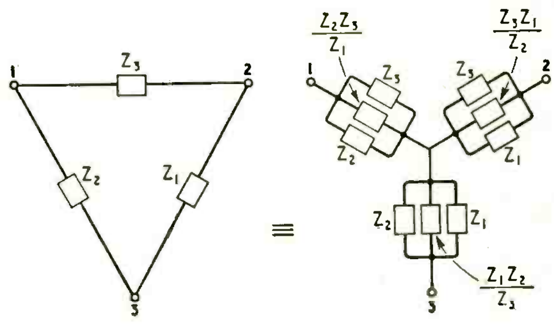
THE publication of this article by W. Tusting in the November issue of *Wireless World* recalls to mind a communication by Professor Williams* on a diagrammatic expression of the star-delta transformation.



Y − Δ, AS IN REFERENCE BELOW

It may be of interest that this expression can be simplified a little further if a change is made in labelling the impedances of a delta for which an equivalent star is required. The diagrammatic expression is then as shown in the accompanying diagrams.

The labelling of the delta will be recognized as corre-



Δ − Y, WITH CHANGE OF LABELLING

sponding to the commonly used method of identifying the sides and angles of a triangle.

Portland, Dorset. H. V. HARLEY.

* E. Williams; "Star Delta Theorem", *Wireless Engineer*, August, 1951, p. 258.

Mathematics

DO you not think, Sir, that the general tone of some of your articles tends to *increase* the non-mathematical reader's fear of mathematics? I have noticed repeatedly that "the mathematician" is regarded as some strange creature with a curious twist of mind quite beyond normal comprehension. For example, "Cathode Ray" spoke of the filter expert who disposed of the non-expert with a cosh, as though it were something dreadfully obtruse and difficult, whereas in fact the use of mathematics renders the subject easier, not harder, if one takes the trouble to learn it. And it is only a matter of taking trouble; one does not need to be in any way extraordinary.

I see that Thomas Roddam has heard mutterings in the undergrowth about his use of maths. (This is hardly surprising, since a non-mathematical reader doesn't know what a polynominal is anyway, and isn't encouraged when he notes that it is a Tchebycheff variety!) Surely this is all the more reason for trying to debunk the supposed difficulty of maths, not to encourage such an attitude. It is with great pleasure, therefore, that one notes W. Tusting's attempt (November issue) to popularize the use of the better-known circuit theorems. But *have* they got "high sounding" names? Or is it just imaginary difficulty with the theorems themselves which makes the titles seem a supercilious affectation on the part of "the mathematicians"? I fear it is the latter!

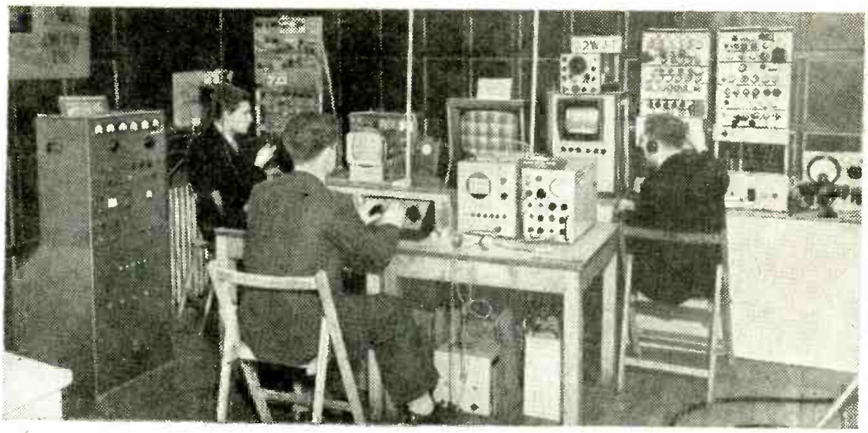
Harefield, Middx. F. V. BALE.

"Neon Timers"

IN your December issue B. T. Gilling advocates the use for photographic work of a timer which gives a constant interval irrespective of fluctuations in mains voltage. Surely this is not worth any bother and, in fact, the timer is better without it.

The visual light output of a normal filament mains lamp is proportional to approximately the fourth power of the mains voltage. The effect on normal blue-sensitive bromide paper presumably varies with an even higher power. An ideal photographic timer would, therefore, reduce the interval by, say, 6 per cent for each 1 per cent increase in mains voltage. To do this it would be necessary to have the capacitor charging voltage only a few per cent higher than the neon striking voltage. This is probably impracticable, as the interval would also vary rapidly with small changes in component values, etc., but at least it is clear that for photographic work a stabilized h.t. supply actually makes the overall performance worse as well as making the unit more expensive. For black-and-white work a normal timer is sufficient and for colour work the enlarger bulb must be run from a constant voltage source; the same can be used for the timer.

Bristol, 6. N. J. WADSWORTH.



Amateur television station G2WJ/T as installed at the exhibition. On the extreme left is the 436-Mc/s transmitter, while the rest of the equipment consists of video control gear. Two cameras (not shown) were used for televising personalities, talks and demonstrations.

R.S.G.B. Exhibition

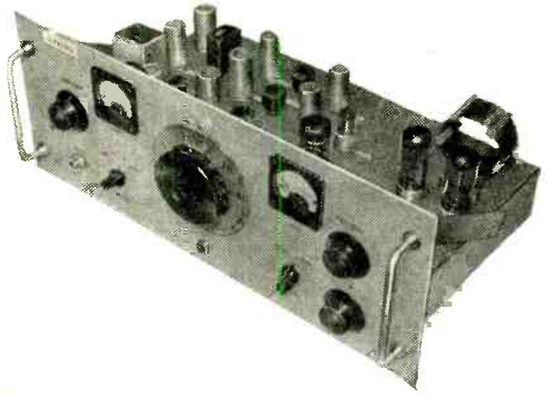
Amateur and Commercial Equipment at the Eighth Annual Show

SINGLE-SIDEBAND techniques were again very much in evidence at the recent show organized by the Radio Society of Great Britain, and their bandwidth-saving properties came in for special mention by Harry Faulkner, C.M.G., who opened the exhibition. Mr. Faulkner, as a former Deputy Engineer-in-Chief of the Post Office, once had a great deal to do with international frequency allocations and he said that anything concerned with saving space in the ether came very close to his heart.

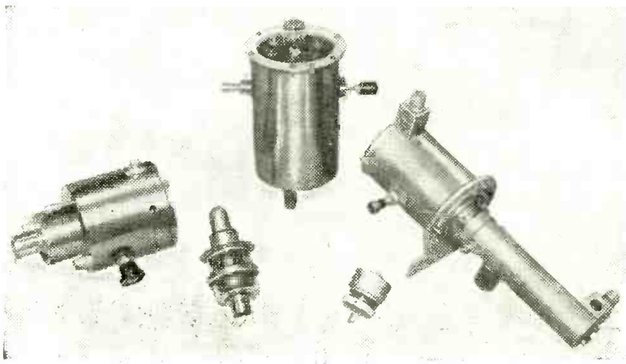
Two main methods of achieving single-sideband telephony transmission were actually represented. In one, known as the "filter" system, the audio signal is first modulated on to a low-frequency r.f. voltage and the unwanted sidebands resulting from the process are removed by a filter. (The "carrier" is suppressed by the use of a balanced modulator.) The remaining sidebands are then mixed with a high-frequency r.f. oscillation to produce the desired output frequency. In the other method, which seems to be more generally popular, the audio signal is first of all split into two components with a phase difference of 90° between them. An r.f. oscillation is similarly divided into two components and these are modulated respectively by the two a.f. signals and finally combined. The carrier again is suppressed by the use of balanced modulators, while the phases of the resulting sidebands are such that in the combined output one sideband is balanced out and the other is augmented. This method requires fewer stages but is perhaps more difficult to adjust.

One of the practical difficulties of the last-mentioned "phasing" method is in obtaining two a.f. outputs displaced 90° in phase, but one exhibitor was showing some small units designed for this purpose which are manufactured (on an amateur basis) and made available to other amateurs who feel unable to cope with the problem themselves.

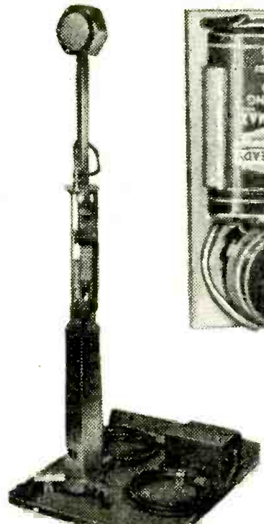
Another branch of amateur work praised by Mr. Faulkner was the active experimentation which has been going on for some time in the 70-cm band. He said that as the professional radio people seemed rather reluctant to move into Band IV the amateurs would now be able to lead the way once again, as they did in the old days. There was, in fact, a good



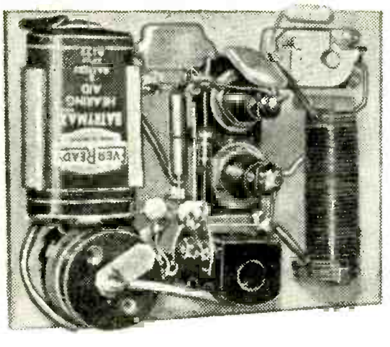
Representative single-sideband transmitter for operation on 3.8 Mc/s and 14 Mc/s.



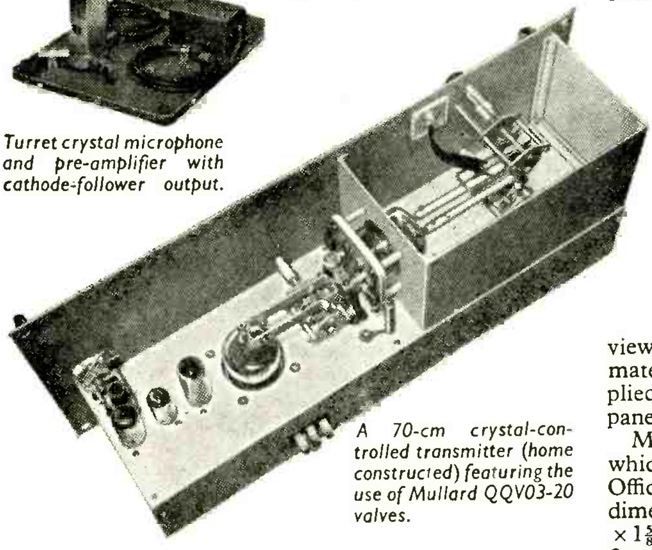
Right: Examples of workmanship in "plumbing" for operation on 70 centimetres.



Turret crystal microphone and pre-amplifier with cathode-follower output.



Midget transistor transmitter operating on 7 Mc/s and powered by a hearing-aid battery.



A 70-cm crystal-controlled transmitter (home constructed) featuring the use of Mullard QQV03-20 valves.

deal of 70-cm transmitting and receiving equipment on show with some very fine examples of workmanship in "plumbing" and tuned-line techniques.

Mr. Faulkner was, however, referring more particularly to the amateur television transmissions in the 70-cm band. These were represented at the exhibition by a complete amateur television station with two cameras and a transmitter working on 436 Mc/s. The r.f. output (20 watts peak white) was being absorbed in a dummy load, and from this a probe supplied an input to a 70-cm convertor, which represented the receiving side. The 45-Mc/s output from the convertor was then "piped" to various standard television receivers distributed about the hall. Apart from the cameras, the video side of the transmitting equipment included the usual sync-pulse and waveform generators, a 3-camera mixer unit, a monoscope unit and c.r.t. monitors for checking the video waveform and the outgoing picture. The transmission standards were 202½ lines non-interlaced.

Transistor transmitters are apparently becoming quite popular. The transistors at present available, however, are somewhat limited in their operating frequencies, and most of the transmitters on show were for working on either 1.8 Mc/s or 3.5 Mc/s. In one notable exception, however, the designer had succeeded in making the transistor oscillate at 7 Mc/s. The tiny transmitter (shown on the Brimar stand) was crystal controlled and it used a new point transistor made by Brimar, Type TP2, which officially has a maximum operating frequency of 2 Mc/s. Other new transistors shown by Brimar were the TP1 point type, for switching applications up to 100 kc/s, and the TJ1, TJ2 and TJ3 junction types for audio applications.

Brimar also had some interesting new miniature valves suitable for Band IV receiving circuits. The 6AM4 is an earthed-grid triode on the B9A base suitable for amplification or mixing, while the 6AF4 is a B7G triode intended for use as an oscillator. Both will operate at frequencies up to 1,000 Mc/s. Suitable circuits for these valves have already been described in *Wireless World*.*

Apart from the home-constructed transmitters there were two new commercial equipments on view, Both were fairly compact table models, with band switching from about 3 to 30 Mc/s. The Labgear model gave a nominal output of 150 watts while the Panda equipment was for the lower power of 35 watts. Amongst the new "prefabricated" transmitting units shown by the Minimitter Company was an aerial matching unit, which permits the separate tuning of open-wire feeders, and a 35 ft steel mast which is hinged in the middle to allow adjustments to be made to the aerial on top.

A comprehensive range of cabinets shown by Philpott's Metalworks included a portable instrument case for amateurs who like to give their home-constructed test gear a finished and professional appearance. The one on view, with a black crackle finish, measured approximately $8\frac{1}{2} \times 6\frac{1}{2} \times 4\frac{1}{2}$in, but other sizes can be supplied. Miniature racks, complete with chassis and panels, were also displayed.

Magnetic Devices were showing a useful new relay which is almost identical in operation with the Post Office Type 3,000 relay but is somewhat smaller. The dimensions (above chassis) are $2\frac{1}{2}$in high × 1in wide × $1\frac{5}{8}$in deep. A dust-proof can is provided. When fitted with a 10-kΩ coil the pull-in current is approximately 4 milliamps. An associated firm, Cathodeon Crystals, featured their quartz crystal units, which can now be supplied to order in as short a time as one week.

* "Valves for Bands III, IV and V," by D. N. Corfield. *Wireless World*, June, 1954, p. 272.

FIRMS SHOWING

Amos (Electronics), 45-49, High Street, Bletchley, Bucks.

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

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

English Electric Valve Co., Waterhouse Lane, Chelmsford, Essex.

Enthoven Solders, Enthoven House, 89, Upper Thames Street, London, E.C.4.

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

Grundig (Great Britain), Kidbrooke Park Road, London, S.E.3.

Labgear (Cambridge), Willow Place, Cambridge.

Magnetic Devices, Exning Road, Newmarket, Cambs.

Minimitter Company, 37, Dollis Hill Avenue, Cricklewood, London, N.W.2.

Panda Radio Company, 58, School Lane, Rochdale, Lancs.

Philpott's Metalworks, Chapman Street, Loughborough.

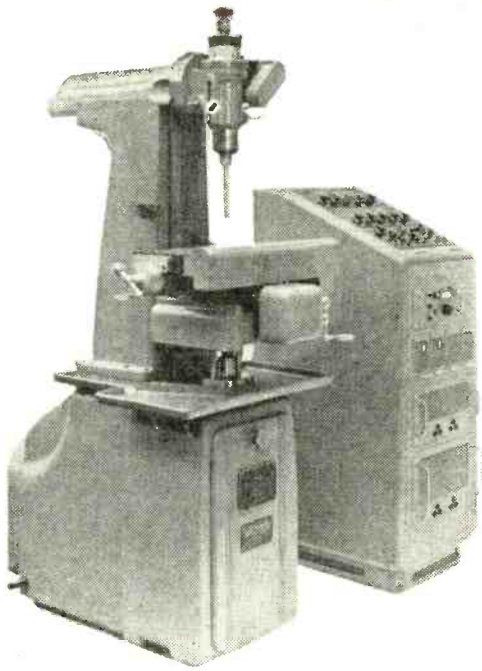
Pye Telecommunications, Ditton Works, Newmarket Road, Cambridge.

Standard Telephones & Cables (Brimar), Footscray, Sidcup, Kent.

Taylor Electrical Instruments, Montrose Avenue, Slough, Bucks.

ELEC ... ONIC ... NING

...ds for Automatic Machine Tools



Electronically controlled drilling machine. The required position of the work-table is set up initially on the control desk (right).

...idea of controlling machine tools by electronic ...chanisms may not seem very startling to the average radio or electronics man, but it is creating quite a stir in the engineering world. Various systems are being tried out, some more advanced than others, but they all have the same ultimate end in view: to replace the human operator, working his lathe or drill or milling machine, by an electronic apparatus controlled by a continuous input of information from some kind of storage medium, such as a punched card or magnetic tape.

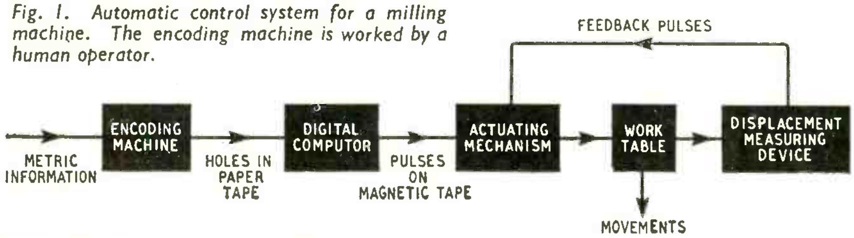
The scheme is really intended for manufacturing relatively small quantities of precision machined parts where the use of normal mass-production techniques would be somewhat inefficient. Exponents of the idea say that it will be more accurate than using human operators (because electronic mechanisms don't get tired) and that the machine tools will be used more efficiently: the machining operation is carried straight through at maximum speed and the control apparatus does not have to stop periodically to scratch its head, so to speak.

A fairly advanced system is shown schematically in Fig. 1. This has been devised by Ferranti's (at Edinburgh) for the automatic control of a milling machine, the work-table under the cutting tool being moved in accordance with information fed in from a magnetic tape. The whole system is based on the principle of specifying the contours of the part to be machined by a series of points, each having x and y co-ordinates from a given reference point. The x and y values are then used to move the work-table in two directions. This does not mean, however, that a human "programmer" has laboriously to put all this information on to the magnetic tape point by point. A digital computor is brought into play here, for most contours can be represented by mathematical expressions and it is only necessary to instruct the computor to calculate a straight line or a semi-circle or a parabola, as the case may be. Thus all that the human "programmer" has to do is to feed in information about the points of change on the contours (for example, where a straight line starts to bend round into a circle) and then the computor does the rest.

The real heart of the system, however (and the real subject of this article), is the mechanism by which the work-table is continuously positioned under the cutting tool. For precision machined parts this positioning has to be done to an accuracy of one ten-thousandth of an inch. The straightforward method of simply turning a calibrated lead-screw is therefore not good enough. With backlash in the work-table mechanism, one could never be sure that the work was actually being moved in accordance with the control information going into the lead-screw. The ideal method would be to measure the work itself as it was being cut and control the work-table movements accordingly. This, however, is somewhat difficult to do. In practice the best solution is to measure the movements of the work-table and use this information for controlling the positioning process.

The feedback type of mechanism by which this is achieved can be seen at the right-hand side of Fig. 1. The control system actually works on a digital, or step-by-step, principle because this enables it to be made as accurate as desired, according to the number of digits used. Thus a measurement or movement of 2.3075 inches can be represented more accurately in digits of one ten-thousandth of an inch than in digits of one thousandth of an inch, which would give either 2.307 or 2.308. Actually digits of one ten-thousandth of an inch are used. The actuating mechanism receives a train

Fig. 1. Automatic control system for a milling machine. The encoding machine is worked by a human operator.



of "command" pulses from the magnetic tape, each representing one digit. These cause the work-table to move and as a result the displacement measuring device produces a train of similar pulses representing ten-thousandths, which are fed back to the actuating mechanism. On the receipt of each "command" pulse the work-table moves in the required direction until a feedback pulse cancels the "command" pulse, when the movement stops. Thus the work-table can only move through the measured ten-thousandth of an inch and no further movement is possible until another "command" pulse arrives.

A similar digital servo system is used by Ferranti for positioning the work-table of a drilling machine (shown in the title picture). Here, however, there is no automatic control from magnetic tape. A human operator sets up the x and y co-ordinates of the hole to be drilled on a series of control knobs, then the machine proceeds to move the work-table until the required point is directly under the drilling bit. The work-table is driven by electric motors and, as before, its movement in each direction is measured by a device which produces a train of pulses, each pulse representing a displacement of one ten-thousandth of an inch. These pulses are counted by a decade counter until they have cancelled the number (in ten-thousandths) already set up on the control knobs by the operator. The "error signal" is then reduced to zero and the driving motors stop. There are five control knobs for setting up each dimension (x and y), the first for inches, the second for tenths, the third for hundredths and so on. Thus, if the operator sets the x dimension to, say, 5.7394 inches, this is the same as 57,394 ten-thousandths, and the decade counter has to count that number of digits before the cancellation occurs and the motor stops.

The electronic circuit which counts the pulses and finally cancels the original number makes use of the well-known Dekatron tube. For each dimension, x or y, there are five of these tubes in cascade, one for each decimal place of the number. The required number is set up on the five tubes by applying a negative voltage to a particular cathode on each one (this is done by the control knobs) so that the glow is initiated at this point. The arrival of pulses from the displacement measuring device then causes the glow to move, not in the normal clockwise forward direction, but backwards towards zero. In other words the incoming pulses are subtracted from the original number set up by the operator. This subtractive operation can be achieved quite simply because of the reversible properties of the Dekatron. It is only necessary to reverse the connections to the guide electrodes to cause the glow to be transferred in an anti-clockwise direction. Thus, when the incoming pulses have finally brought the original number down to zero the glow in the last tube transfers to the "zero" cathode and this produces an output signal which stops the work-table driving motor.

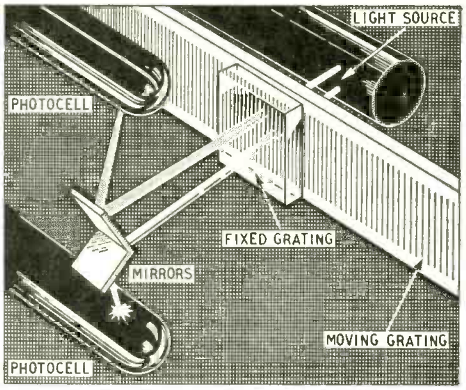


Fig. 2. Diffraction-grating system for measuring displacement and giving an output in digital pulse form.

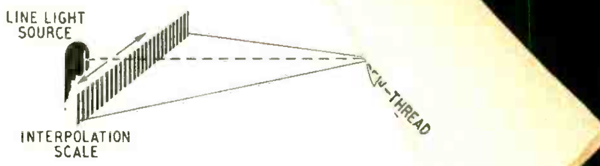


Fig. 3. Displacement measuring device using an machined coarse scale and optical interpolation syst

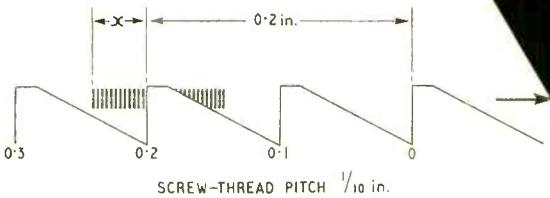


Fig. 4. Typical position of the interpolation-scale image of Fig. 3 in relation to the teeth of the coarse scale.

One of the most difficult problems from the practical engineering point of view is in producing a displacement measuring device capable of detecting a movement as small as a ten-thousandth of an inch. The two Ferranti machines use an optical system based on the interference pattern produced by two finely ruled gratings. Fig. 2 shows the general principle. A length of grating is fixed to the moving part of the work-table while another short length is fixed to the stationary part. The long grating therefore slides across the short one with the two surfaces almost in contact, and the pair are suitably aligned to produce an interference effect. A parallel beam of light is projected through the arrangement and when there is relative movement the interference effect modulates the intensity of the beam. One complete cycle of variation in intensity occurs for a movement equal to the pitch of the gratings, and from this it is possible to obtain two discrete electrical pulses per grating line. The gratings are ruled with 5,000 lines to the inch*, so that one pulse is produced for every ten-thousandth of an inch. By arranging two photocells as shown, so that the phase of the light variation is different in each, a two-phase electrical system is formed, and the phase rotation of this reveals in which direction the work-table is moving.

A rather different system of measuring displacement in digital form has been developed by Mullard. Measurements are made by referring to a standard marked off at intervals of a tenth of an inch with high accuracy. Such a standard can be produced in a tool-room by skilled craftsmen. An optical interpolation system is used for intermediate measurements, and the

* "The Production of Diffraction Gratings" by L. A. Sayce, *Endeavour*, October, 1953.

interpolating scale is easy to make photographically.

The standard takes the form of a long rod cut with a screw thread of sawtooth form, the pitch being one-tenth of an inch. Part of the rod is cut away to reveal a cross-section of the thread as shown in Fig. 3. The vertical edges are then individually ground and lapped to form scale graduations 0.1in apart with an absolute positional accuracy of 0.00005in. The rod is fixed to the moving part of the machine and is made of hardened steel with the same coefficient of expansion as that of the machine.

The principle of the optical interpolation is shown in Fig. 3. An interpolating scale four inches long has 1,000 equidistant vertical opaque bars 0.002in wide, alternating with transparent bars of equal width. A lens forms an image of this grid across the teeth of the screw-thread, and a reduction factor of 40 is used to make the image fit exactly between two teeth.

Fig. 4 shows a typical relative position of the two scales. The optical image is fixed in space while the screw-thread scale is moving past it to the right. Regarding the left-hand edge of the image as a fixed reference point, the total displacement of the first edge of the screw-thread scale (marked "0") is two tenths of an inch plus the fraction of a tenth x. The number of interpolation bars in x is the number of ten-thousandths of an inch in the fraction. To count these ten-thousandths electronically, the transparent bars in the scale are illuminated one by one by a line of light which moves behind it (Fig. 3). A photocell placed close behind the screw-thread scale then receives a succession of light pulses. As the sloping edge of the sawtooth is encountered by the moving light the pulses are reduced in amplitude until they finally disappear. Their sudden reappearance at the 0.2-in edge is the signal for them to be counted. This proceeds until the light reaches the left-hand end of the scale, when the total count is the fraction x of 1,000.

The scale is scanned repetitively by the line of light and the fraction x is determined afresh at each scan. In this way the system provides an output at regular intervals stating the position of the moving part of the machine. At the end of a scan the position is compared by means of a reversible counter with that set up initially by a human operator on six 10-position dials. The difference is then held and displayed on a meter until the end of the next scan, when a fresh value of the difference is available. The relative position is given within a definite limit, one ten-thousandth of an inch, since only whole numbers of interpolation scale bars are counted. However, the distance in which the count changes by one unit is less than 0.0001in, and the moving part of the machine can be set to these discrete positions with an even greater accuracy.

The reversible counter actually subtracts the measured dimension from the pre-determined dimension, and the difference displayed on the meter indicates whether the measured dimension is too long or too short and gives a rough indication of the magnitude of the error.

Both this Mullard machine and the Ferranti drill require a human operator to set up the controls in the first place—though, of course, no special skill is needed for such an operation. This could, however, be avoided by using a punched card system to supply the input information. The Ferranti drill would then be fully automatic and the Mullard machine could be made so by using the error signal (normally fed to the meter) to control motors which would drive the moving part of the machine until the error was reduced to zero.

THE DUST PROBLEM

A New Device for Cleaning Gramophone Records

By CECIL E. WATTS

GRAMOPHONE records when examined under a microscope all have one thing in common; dust can be observed in nearly every inch of groove. As the reproducing stylus must surmount most of those particles small enough to rest in the angle of the groove, it is certain the groove loses control of the stylus many times a second, with a corresponding loss in accurate tracing. It may be reasoned that microscopic dust is mainly airborne and is light enough to be pushed aside. This is no doubt true of the larger masses; the smaller particles, such as those shown in the groove in Fig. 1, must obviously be trapped by the contour of the stylus. This fact, plus the increased surface noise, extra wear and tear of stylus and groove wall, clogging of stylus tip, etc., provide sufficient reason for more than casual attention to the dust problem, which becomes increasingly important as the quality of the reproducing system is improved.

The use of a plush or other pad, with or without cleaning fluids, has been the recommended treatment to date. If this operation is performed in bright sunlight a close examination usually shows the groove to be anything but clean, and certainly by the time the record is played it is again well charged.

Elementary logic points to the "instant of playing"

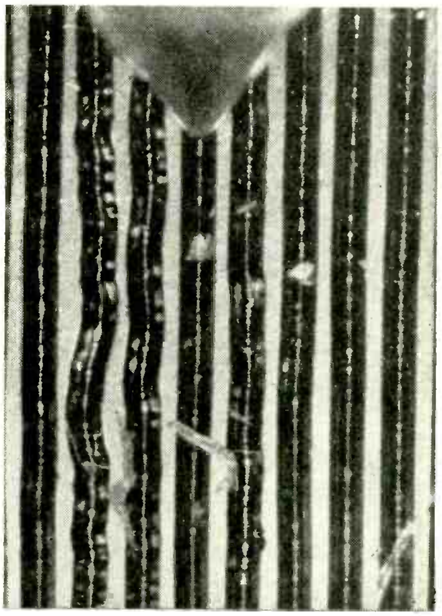
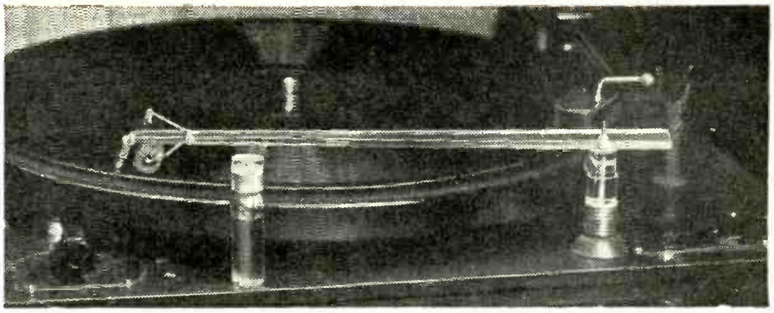


Fig. 1. Photomicrograph of record grooves before cleaning.

as being the ideal moment to clean the record; in practice with an interval of a fraction of one revolution of the turntable between cleaning and playing. No doubt the various types of brush attachable to the pickup arm which have been designed in the past have been produced with this object in mind. Any such fitment applied to the modern ultra-lightweight pickup is, unfortunately, more than likely to affect its performance.



Automatic record cleaning accessory ("Dust Bug") with suction mounting for fixing to the motor board.

A separate arm seems essential to carry such a cleaning device, and these thoughts have been embodied in the "Dust Bug," a device which has in fact a lightweight plastic arm terminating in a small brush of nylon bristles, each of which is pointed so that the bottom of the groove may be thoroughly explored. The bristles also serve to track the arm across the record. A cylindrical plush pad (the "bug") is situated immediately behind the brush and collects the loosened particles.

The device is placed at the commencement of a record just before the pickup is lowered and cleans the record as it is played. A wipe with the dispenser cork of the cleaning fluid bottle cleans and charges the pad with the minute amount of fluid required to dissipate any electrostatic charge induced by the friction of the reproducing stylus or by previous polishing.

Most record cleaning fluids seem to serve equally well, the one favoured being a moderate concentration of ethylene glycol in distilled water, this being a trusted favourite for use in direct disc recording. One advantage of this form of cleaning is that the quantity of any anti-static or cleaning fluid is so minute that it is extremely unlikely that any trace remains in the groove even after prolonged use. This is well illustrated in Fig. 2 which depicts the last few seconds of "Petrouchka" (Decca LXT 2502) where the final "high C" on the trumpet disappears into the tape and other background noise.

Fig. 3 has been included to emphasize the necessity for using the cleaner each time a record is played.

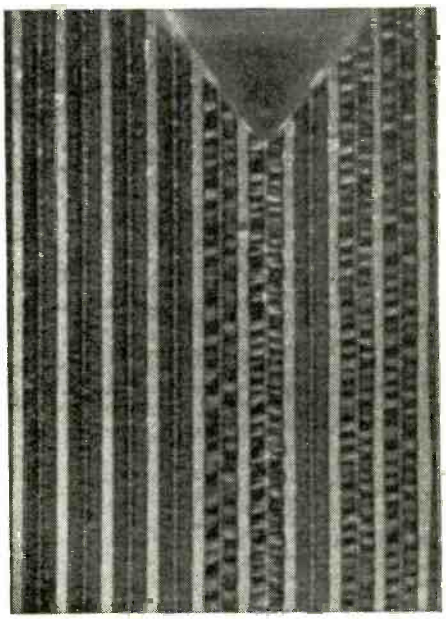
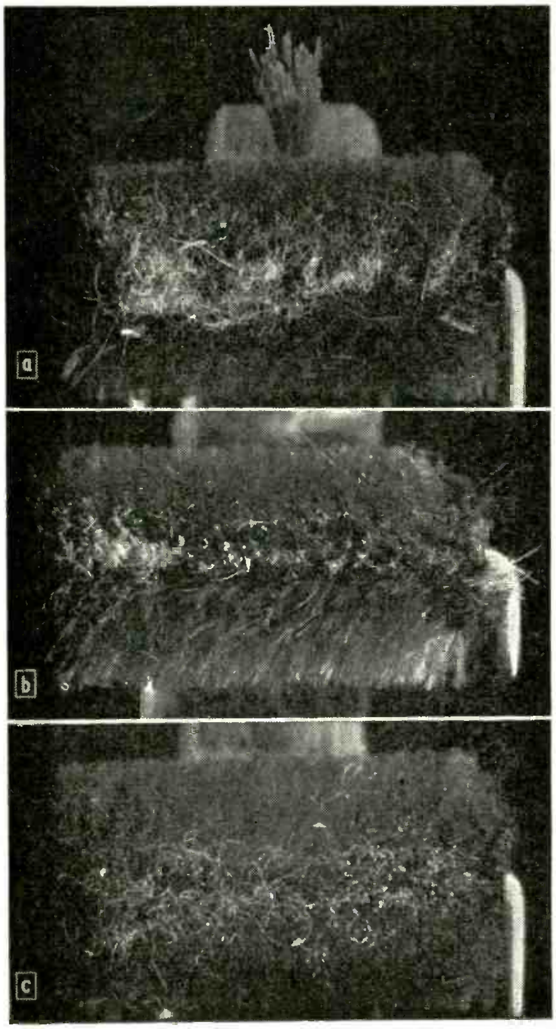


Fig. 2. Any residues remaining after cleaning are considerably less than the background noise modulation as seen in the four grooves on the left.



Left: Fig. 3. Dust particles, etc., collected by the plush pad (a) after the first use of the cleaner on a 12-inch l.p. record, (b) after a second playing immediately following the first, and (c) a third playing of the same record after being stored for a day in the maker's envelope.

ALL YOU NEED TO KNOW ABOUT RADIO

By "CATHODE RAY"

Technical Terms Used in the Underworld of Wireless

THIS particular season of the year is so full of things that there is grave danger of the necessities of life being crowded out by the luxuries. This page, for example, might receive less attention than usual, by reason of the prolonged concentration ordinarily demanded by it. As a concession to the flesh, therefore, I am this month bestowing a complete treatise on radio. It is so light that it can be assimilated even after the pudding, and yet so comprehensive that it is a good defence against the loss of dignity that is entailed by party games of the general knowledge sort. Originally presented free with the Christmas 1934 issue, it is now completely revised and enlarged.

Experience has shown that the whole of anything is equal to the sum of its parts. Know each part, and you know the whole. Samson himself might have struggled in vain to snap a bundle of firewood, but a child can take a stick at a time and break it. The reason why radio is found to be so difficult is that the student takes the whole bundle in his hand and expects to build Rome in a day. But when the loaf has been daintily sliced into separate grains of sand it soon (to put it metaphorically) makes a mighty ocean.

Each mysterious part of radio will now be clearly defined. This knowledge has hitherto been confined to a few experts; now, it is all revealed in language that everybody can understand. N.B.—*You are warned that it is not considered suitable for children.*

Band Pass. You don't suppose the musicians pay to get in, do you?

Band Spread. An effect closely associated with **Self Capacity** (q.v.).

Beat Frequency. Confidential information for avoiding a **Lightning Arrester.**

B.F. Source. According to Eton, Harrow. (And vice versa.)

Buffer Stage. Usually the last but one in the series. For a description, refer to W. Shakespeare (*As You Like It*, Act 2, Scene 7).

Cavity Resonance. A cause of unwanted whistles, often existing at the **Buffer Stage.**

Condenser. High official of the B.B.C., whose duty is to fit the programmes in at all costs. His work is often in vain, and may be either fixed or moving. See also **Padding Condenser.**

Detector. Post Office official equipped with clever apparatus that responds to absence of licence.

Dissipation. See **Featherweight Pick-up, Night Effect, Watt.**

Earth. All natural wireless sets must be planted with the roots firmly underground, and well watered. A flower-pot is not recommended; it might be neglected during holidays. Portable sets are grown under a frame and need no earth.

Eliminator. Chemical preparation for combating parasitic oscillation. See **Skin Effect.**

Featherweight Pick-up. A form of **Dissipation** (q.v.).

Feedback. A concomitant of **Instability** (q.v.); also noticed just after Christmas and at other irregular seasons. The **Pre-selector** is particularly subject to it.

Gain Control. See **OHMS Law.**

Hand Capacity. A high-frequency phenomenon especially noticeable on leaving a hotel, whether equipped with wireless or not. It is believed that some form of direction-finder is used in the acceptor circuit, for screening seldom avails to prevent one from being run to earth.

Harmonic Distortion. Well-known characteristic of music pupils and modern composers. In severe cases is known as **Random Noise.**

High Tension. A state which is liable to exist as a result of **Key Clicks** (q.v.).

Homing System. A device for cases of **Instability** (q.v.). In its more fully developed forms it can be used to suppress **Key Clicks** (q.v.).

Indoor Aerial. A device for foiling the **Detector.**

Insertion Loss. Money put in a fruit machine.

Instability. A variety of **Night Effect** (q.v.).

Key Clicks. Unwanted noises due to **Instability.**

Lightning Arrester. See **Beat Frequency.**

Microphonic Noises. Technical term for broadcast programmes.

Miller Effect. See **Dust Core** (if you can!).

Mutual Conductance, Tight Coupling, etc. These expressions are too romantic in character to be discussed in a prose publication. The subject is more suitable for an ode.

Night Effect. There are several varieties: one of them is usually most noticeable at the **Output Stage;** it is characterized by **Instability,** and, in severe cases, the seeing of two or more programmes at once. See also **Homing System, Key Clicks, Dissipation.** Another variety, which is common at a later stage, is also known as **Variable-Mu.** Still another (liable to be confused with the latter) is **Threshold Howl** (q.v.).

Noise Suppression. See **Output Stage, Threshold Howl.**

Non-linear Conductor. One that takes excessive stage gain.

OHMS Law. A law relating to Income Tax (or Remote **Gain Control**).

Output Stage. Generally coincides in time with severe outbreaks of **Night Effect;** usually about 10.30 p.m. **Noise Suppression** may have to be fitted at this stage.

Padding Condenser. A negative condenser employed when a programme runs short.

Phase-change. Often observed at the detector or lightning arrester stage, or when a communication is received relating to **OHMS** Law.

Pre-selector. Scientific term for acquisitive junior member of a family. The pre-selector stage is reached at the age of about two years.

Primary Cell. One designed for first offenders.

Random Noise. See **Harmonic Distortion.**

Reaction. A common result of **Dissipation.** A pick-up may be needed.

Self Capacity. Characteristic typical of the **Pre-selector.**

Shunted Meter. Device for avoiding electric charge.

Skin Effect. Also known as parasitic oscillation.

Speech Choke. Would be very valuable, but is not permitted in this country, since it conflicts with the tradition of "freedom of speech."

Superhet. A very powerful type of receiver that brings in every station, and most of them twice. From the American *super*=very, and *het*=hot (e.g., "all het up").

Tape Recorder. A tailor's assistant, who repeats everything back.

Thermal Agitation. Characteristic exhibited by a cat on hot bricks. See also **Variable-Mu.**

Threshold Howl. A form of interference peculiar to the weeks leading to Christmas. Is almost invariably followed by **Hand Capacity.**

Tracking. Operation of the **Detector.**

Trimmer. Another name for **Condenser** (q.v.).

Twin Feeder. The sort of thing one expects to see on "Inventors' Club."

Variable-Mu. A form of interference of feline origin. See **Night effect, Thermal Agitation.**

Watt. A character who, in his youth, performed useful services in the kitchen, such as preventing kettle lids from flying off, so that his name became symbolic of energy. In later life, however, he seems to have fallen into evil ways, to judge from frequent references to Watt's Dissipation.

Wavechange Switch. Despite the popularity of so-called continuous (or permanent) waves, this appliance meets with some application in the art of coiffure. Closely associated with step-up transformation.

Zero Beat. Absence of corporal punishment.

By now you will, I am sure, need no further evidence that radio is a sordid and degrading occupation. Perhaps you would care to make it the subject of a New Year Resolution?

MAKING A GOOD RECORDING

Importance of Microphone Technique

ENCOURAGED by the high standard of quality which is readily obtainable from commercial gramophone records these days, many people have bought disc or tape recorders to make their own musical recordings, either for self-criticism or for the delectation of friends. After spending not inconsiderable sums on the best available equipment it is a common experience to find the first results disappointing.

In nearly every case the trouble can be traced to unsuitable acoustical surroundings or to faulty microphone technique, and can be remedied only by practice and experience. This point was emphasized by G. Elliott in a recent lecture on "The Art of Balance and Control in Recording Studios" to the British Sound Recording Association in London. Mr. Elliott, who has many outstanding recordings to his credit, including the "tugboat" effects record (Mercury Sound Recordings) said that while there was as yet no perfect microphone there were many very good ones, each with characteristic merits and shortcomings which could be deployed to make the most of any given situation.

Microphones were the tools of the recording "engineer"—microphones and his own ears, which could best be trained by listening to all and sundry sounds, first directly and then through a simple reproducing channel consisting of microphone(s), amplifier and a monitoring loudspeaker. Where possible the same loudspeaker should always be used in the same acoustical environment, and it was significant that broadcasting and recording organizations concerned with the interchange of recorded material had recently initiated moves for the standardization of monitoring conditions.

Mr. Elliott described several typical recording problems and illustrated with tape recordings the synthesis of a good recording of an orchestra from the outputs of a number of microphones, distributed among the players and in the body of the hall. It was evident that a single microphone failed to give that elusive quality of "presence," so much esteemed by gramophiles.

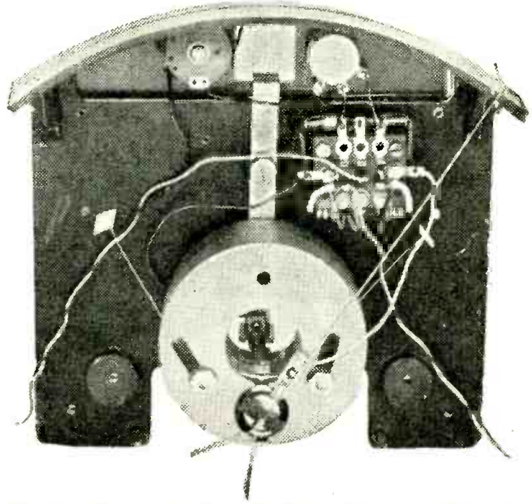
An interesting point which emerged from Mr. Elliott's talk was the increasing importance given by composers and arrangers of light music to "balance and control." It was now becoming the practice to include in the score specific instructions for emphasis, and even the introduction of artificial reverberation over part of an individual musical phrase. The results are undoubtedly stimulating and the means by which they are obtained were, in the examples played by Mr. Elliott, completely hidden by the "art which conceals art."

Extended-range L.F. Sine Wave Oscillator. The author asks us to correct a printer's error in the second line of this article (page 596, December, 1954, issue); the range of 20-20,000 c/s should be regarded now as *in*sufficient for exhaustive testing of high-fidelity amplifiers. He also points out that the 1-MΩ grid leak of the last valve should be returned to earth and not to cathode as shown.

TRANSISTOR D.C. AMPLIFIER

Stable Push-Pull Circuit for Low Level Operation

By G. JOHNSON*



The amplifier mounted on the base plate of a 7-in scale edgewise-reading meter. Batteries are on the back of the meter case. The control potentiometers can be seen immediately below the scale and their shafts protrude through the case on either side of the mechanical set zero.

AN instrument constructed in the laboratory using a barrier-layer photocell in a photometer arrangement proved to be too insensitive for certain uses and an attempt was made to improve it by adding a d.c. amplifier between the photocell and the meter. It was desirable to make the instrument portable and independent of the mains, and the transistor appeared to offer advantages in these directions. Since the completed amplifier measures 3in × 1½in × 2in, including the power pack of two 1.5-V cells, and could be made smaller if desired, it fulfils both these requirements.

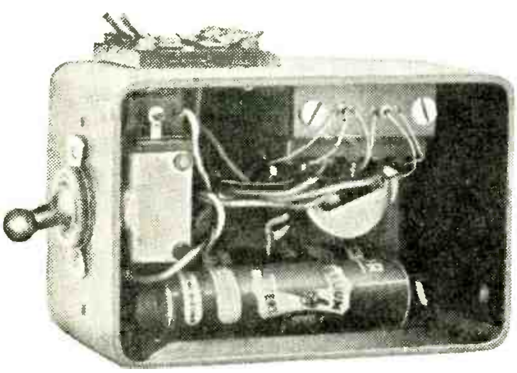
The main difficulty with d.c. transistor amplification is the extreme sensitivity to temperature variations. The collector current is approximately doubled for every 10°C rise in temperature. In this amplifier the problem was overcome by using a completely symmetrical push-pull circuit and arranging that any change in ambient temperature would equally affect both transistors.

Two Mullard OC71 *p-n-p* junction transistors are used in a simple earthed-emitter circuit with the 0-50μA meter connected between the collectors and the photocell with its attenuator connected between the bases. The voltage at the collectors is equalized by the load-balancing potentiometer, which acts as a set-zero control. The transistor temperatures are equalized by enclosing them in adjacent holes drilled in a small block of aluminium.

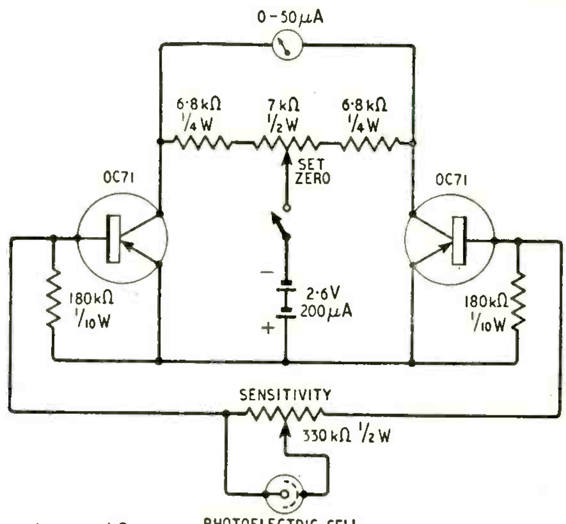
The power is derived from two Vidor V.0107 Kalium cells which are of the same dimensions as the U7 pencil battery but are capable of providing up to 3,000 hours use at the average current drain of 200μA required in this amplifier. With this length of life it was at first thought unnecessary to include a battery switch, but this is essential for the purpose of setting the mechanical zero of the microammeter, which has been found to vary quite as much as the zero variations due to the d.c. amplifier itself.

The measured overall gain is approximately 30, giving the 7-inch meter a sensitivity of better than 0-2μA full scale. The overall noise produces a fluctuation on the needle which does not exceed plus or minus half a scale division, i.e., better than ±0.01μA. This very low figure is due to the fact that most of

* Biophysics Department, Hurstwood Park Hospital.



Underside view of amplifier. The transistor leads can be seen emerging from holes in a Paxolin cover over the aluminium block. Controls are on the top of the case.



Right: Circuit of the transistor d.c. amplifier.

the transistor noise is of too high a frequency for the meter needle to respond.

Following the satisfactory results obtained with this amplifier a second one was constructed, the potentiometers, amplifier, chassis, and batteries being mounted inside the case of a similar 0-50μA meter with the controls accessible underneath the edgewise scale. This has proved to be a very useful general-purpose meter, taking the place of the cumbersome mirror galvanometer and having a very much shorter time-constant. The instrument works equally well as a centre-zero galvanometer since the set-zero control can be used to bring the needle to any point on the scale for zero input to the amplifier.

INTERNATIONAL STANDARDIZATION

Summary of I.E.C. Discussions on Components

By G. DAVID REYNOLDS,* Ph.D., M.Sc., M.I.E.E.

AS already recorded, the International Electrotechnical Commission held its Golden Jubilee meeting in Philadelphia in September. As in all international bodies the work of the I.E.C. is conducted by comparatively small committees representative of the countries participating. One of the sub-committees (12-3) deals exclusively with the standardization of radio and electronic components. This component committee has been working since 1950 on the international recommendations for standardizing methods of testing radio components and excellent progress has been made in spite of the fact that the full committee meets for only about eight days in each year. The radio industry and the Service establishments in this country had done a great deal of work, separately and jointly, on this subject before 1950 and this helped considerably in the rapid progress made internationally.

The meetings are not too formal and the committee works as a body of engineers with a common end in view and with a minimum of "politics." This year, at Philadelphia, thirteen nations took part and the co-operation and mutual understanding shown was even better than in past years. The British delegation to the components committee, of which I have been a member since 1950, is officially sponsored by the British Standards Institution and is paid for by the various associations in the radio industry.

In these notes a few items have been selected from the great mass of detailed discussion on every aspect of testing of capacitors and composition resistors at the Philadelphia meeting. They give some idea of the problems and difficulties met in reaching international agreement.

Capacitor and Resistor Standards

Draft standards for paper, ceramic, electrolytic and mica capacitors, for the colour coding of ceramic capacitors, and for carbon resistors, were discussed and brought near to completion. Work is now beginning on standards for high-stability composition resistors and carbon potentiometers and on the standardization of some of the principal dimensions of the components themselves.

The ceramic capacitor standard covers Type I capacitors, with moderate power factor and reasonably linear temperature coefficients. A standard series of values for the temperature coefficient has been agreed, and there are tolerances ranging from ±15 parts per million per degree centigrade for special purposes, to ±1,000 p.p.m./°C for general use. The capacitance values follow the E-series of preferred numbers (BS 2488), which is already used for carbon resistors.

The colour coding of ceramic capacitors has presented a very serious problem. There are at present several codes in existence with slight variations between them, and attempts to arrive at a standard code have proved very difficult. The code must cover temperature coefficient (one band or, sometimes, two), value (three bands using resistor code, with values in pF), and tolerance (one band). The principal difficulty is that there are only ten colours normally used while there are more than ten temperature coefficient groups, with their various tolerances, to put into the code. The latest I.E.C. proposal is for a five-band code except for the +100±30 p.p.m./°C, and the −3300±2500 p.p.m./°C coefficients which will need six bands. The code also covers two qualities of high-dielectric constant material (Type II).

The preparation of a series of standard values for electrolytic capacitors has also proved extremely difficult. In most European countries the "powers of two" series—2, 4, 8, 16, 32, 64—is used up to 64μF, but for higher values and for low voltages round values such as 10, 20, 25, 50, 60, 100, 150, 200, 250 are quite common.

For mechanical dimensions and tolerances in general, the R10 series of numbers adopted by the International Standardization Organization is widely used (BS 2045). Each term is obtained by multiplying the previous term by the tenth root of ten. The values are rounded to 1, 1.3, 1.6, 2.0, 2.5, 3.2, 4.0, 5.0, 6.3, 8.0, 10, etc. (Incidentally, the well-known resistor series is based on the twelfth root of ten.) At one stage it was suggested that the R10/3 series be used for electrolytic capacitors—i.e., every third item of the R10 series, making the values 1, 2, 4, 8, 16, 32, 130, 250, 500, 1,000—but this has not proved popular. The latest drastic proposal is 1, 2, 5, 10, 20, 50, etc., but this may not be the last word.

The agreement of standard voltages for electrolytic capacitors has proved equally difficult, and to meet the needs of all the representatives present a very long series has finally been adopted.

* Murphy Radio, Ltd.

Frame Flyback Suppression

Requirements and Circuitry

By W. T. COCKING, M.I.E.E.

IT is now a common practice to include frame flyback suppression circuits in television receivers. It has become common only in the last year or so, however, and many, if not most, existing sets do not contain them at all. The reason for this lies in the fact that the television signal itself is supposed to suppress any visible effect of the frame flyback. During the flyback period the signal is at or below black level and so the scanning spot is supposed to be extinguished and, therefore, invisible.

In practice, however, it is by no means rare for the flyback lines to show up on dark parts of the picture. It is often said that this occurs because the d.c. component of the signal is not fully retained in the receiver, but this is certainly not the only cause. If one starts initially with the receiver correctly adjusted on a picture of average mean brightness, the adjustment being such that good tone gradation is secured in the dark parts as well as the light parts, there should be no trace of the frame flyback even on quite black parts of the picture. If that condition is obtained and the mean brightness of the picture becomes less, the flyback lines will show if the d.c. component is not retained fully. A readjustment of the brightness control will then restore the proper conditions.

It does frequently happen, however, that with a picture of average mean brightness it is not possible to secure a complete absence of the frame flyback lines and at the same time to obtain good rendering of tonal values in dark parts of the picture. When brightness is adjusted so that the flyback lines just become invisible on a black part of the picture it is found that there is no tone gradation in dark regions. When brightness is adjusted for the best picture quality, the flyback lines show in the dark parts.

One possible, but not very likely, cause of this is the presence of an unwanted brightening pulse on the cathode-ray tube. In the frame timebase and deflection circuits pulses exist during the flyback period; in particular, there is a positive pulse of several hundred volts amplitude on the anode of the frame output valve. If, by stray coupling, this could reach the grid of the tube with an amplitude of only a volt or so it would have an appreciable effect. At the grid of the video stage it would have much more effect because of the gain of this stage.

Such effects are not very likely, however, because the grid of the c.r. tube is normally by-passed to chassis by a large capacitance and the video stage is usually well screened.

The unwanted appearance of the flyback lines is usually brought about by the curvature of the valve and tube characteristics. In an ideal system, the brightness of any point on the screen of the c.r. tube would be proportional to the brightness of the corresponding point in the scene being televised. The transmission system as a whole would be linear.

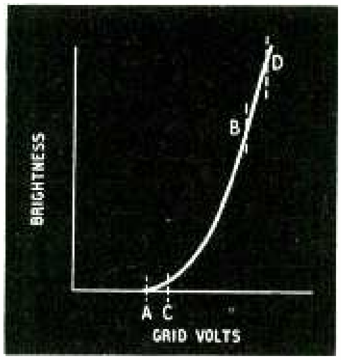


Fig. 1. Typical c.r. tube characteristic. With the bias set at A and the signal sweeping over AB there is little detail in dark regions. Better results are secured by biasing to C but only a relative black is then obtained.

The tube characteristic, however, is not linear. It is rather like that of a valve and there is a considerable amount of curvature towards cut-off. A typical characteristic has the form sketched in Fig. 1. If the tube is biased so that black level corresponds to point A changes of signal near black level cause only small changes of brightness, whereas the same changes of signal near white level (point B) cause much larger changes of brightness.

If the linearity of the system is perfect except for the tube characteristic, therefore, tone gradations in dark parts of the picture are less well reproduced than they are in the light parts. A considerable improvement can be secured by reducing the tube bias so that black level comes at the point C. Black and white now correspond to C and D and the difference between the slopes of the curve at these points is much less. As a result, a better tonal range in the black region is secured.

However, " black " is no longer a complete cessation of light output from the tube. It is really a dark grey, but it does appear black by contrast with the bright parts of the picture.

It might be thought that the flyback, being at black level, would not be visible even under these conditions. However, it is and the reason is because the flyback trace is superimposed on the picture. In a black region of the picture, and especially towards the bottom of the picture, the screen is still emitting some light when the spot retraces it for the flyback and re-excites the screen. In such a region of the picture the screen is excited twice per scanning cycle where the flyback crosses it but only once per cycle elsewhere. Only when black corresponds to zero light output from the tube does this effect cease to occur.

It is, therefore, inevitable that the flyback lines shall be visible as long as the flyback signal is at black level and black level is not a true black but only a relative back. In these days of bright pictures and the use of a good deal of ambient lighting, it is not often that a true black is permissible if a soot and whitewash effect is to be avoided. It becomes desirable, therefore, to suppress the signal on the tube during flyback by applying a pulse which drives the tube beyond cut-off.

Before going on to discuss the form of circuitry employed, it may be as well to deal with an objection that may be raised to the foregoing argument about the effect of the tube characteristic. Curvature of the tube characteristic means, in other terminology, that its "gamma" is not unity; it is actually about 2.2. In the transmitter, iconoscope-type tubes have a gamma of about 0.5 and so the camera tube and the receiving tube are complementary and produce an overall gamma of about unity. With other tubes gamma correction is employed.

It should happen, therefore, that the video signal is pre-distorted at the transmitter to correct for the curvature of the characteristic of the receiving tube. It thus appears that the argument based upon this curvature is a false one.

Video Stage

However, a similar curvature takes place in the video stage. Even if the transmitter pre-distortion corrects precisely for the tube curvature, therefore, the argument still holds for the curvature of the video stage. In practice, too, the pre-distortion cannot be precisely right for every receiving tube.

It is interesting to notice at this point that the effect of the video stage is quite different in modern receivers employing cathode feed to the tube than it was in early ones in which the video signal was fed to the grid. The video-stage characteristic is of the form sketched in Fig. 2 and when the signal is fed to the grid of the tube the valve is biased to point A, the video signal sweeping always negative with respect to A. The output then becomes more positive as the input becomes more negative for increasing brightness. The sync pulses and the dark regions of the video signal fall on the linear part of the valve curve and it is the white parts that come on to the curved portion. The result of video-stage curvature is thus to reduce the tonal range in the white parts of the picture.

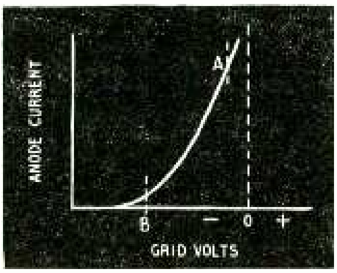


Fig. 2. Typical video stage characteristic. With grid feed to the c.r. tube the valve is biased at A; with cathode feed the bias is at B.

When the video signal is applied in the modern way to the cathode of the c.r. tube, however, the video signal must be of the opposite polarity. The video valve must be biased to point B in Fig. 2, so that as the input increases positively for increasing brightness, the output must change negatively to carry the tube cathode negatively. As a result, it is now the sync pulses and dark parts of the picture signal that fall upon the curved part of the characteristic and the white parts that come in the linear region.

Video-stage curvature is not, of course, a necessary thing. It can be avoided by using a big enough valve and supplying it with enough current. Also, various correction circuits are possible. All these things cost money, however, and apart from the flyback lines the curvature does not have a very large effect upon the picture quality.

Suppression Pulse

Because of these effects, therefore, it has become the practice to apply a suppression pulse to the c.r. tube, the pulse being derived from the frame timebase. The ideal pulse would be a rectangular one of the same duration as the actual flyback of the spot. The amplitude of pulse required is not critical; it must be sufficient to extinguish the spot during flyback but not so great that it can cause any damage to the tube.

Tube makers generally set a limit of about 200 V to the maximum negative grid-cathode voltage. At least one-half of this must be allowed for the brightness control and so it is probably undesirable that the pulse should exceed 50 V in amplitude. The minimum value for suppressing the spot is probably around 5 V. There is thus a good deal of latitude in the choice of amplitude. This is just as well because the ideal rectangular pulse is usually difficult to obtain.

The pulse can be applied to the control grid of the tube if it is negative-going, or to the cathode if it is positive-going. As the signal is applied to the cathode in most sets, applying a suppression pulse to the cathode as well involves mixing the two. It is simpler to apply the pulse to the grid if a negative pulse is as easily obtained as a positive.

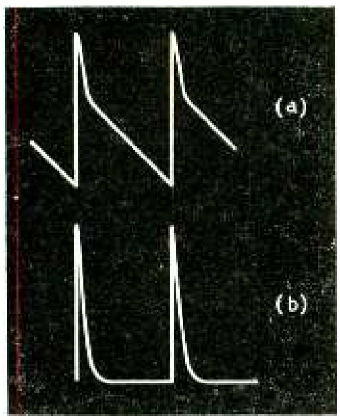
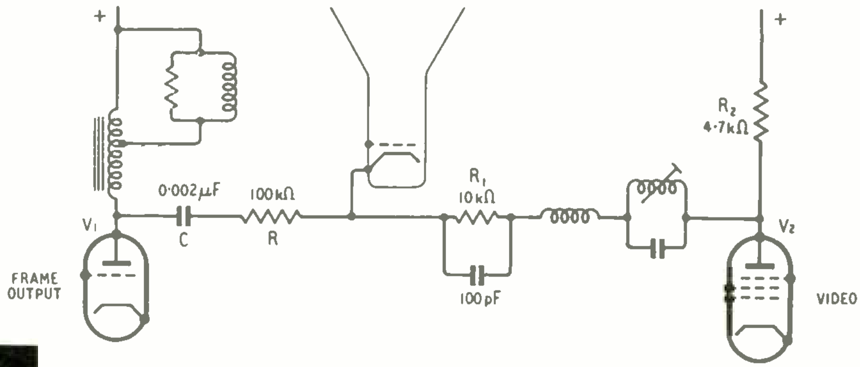


Fig. 3. The waveform on the anode of the frame output valve is sketched at (a) and the result of differentiating it at (b).

The usual commercial practice is to take a pulse which appears naturally in some part of the frame timebase and to apply it to the tube through a simple RC shaping circuit. The resulting waveform is very far from the ideal one but, as the requirements are not stringent, a satisfactory result is secured.

On the anode of the frame output valve there appears a waveform of the kind shown in Fig. 3(a). It comprises a negative-going saw-tooth during the scan period and a positive-going pulse during the flyback. The total amplitude is rarely less than 100 V and is usually several hundred volts. The rise of voltage at the end of the scan is very rapid indeed

Fig. 4. Circuit diagram of the video stage and frame output circuit of a typical receiver. The video signal from V_2 is fed to the cathode of the tube. The frame waveform on V_2 is fed to the tube through C and R which differentiate it; in addition R with the video components R_1 and R_2 form a potential divider to reduce the amplitude.



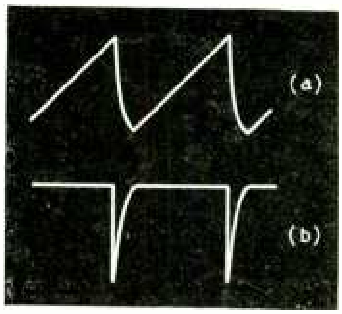


Fig. 5. The waveform across the charging capacitor of a timebase is shown at (a) and the result of differentiating it at (b).

and the subsequent fall during the flyback period is relatively slow and follows a more-or-less exponential law.

An RC coupling of differentiating type will remove the saw-tooth and leave a pulse wave as shown in Fig. 3(b). Such a wave can be applied to the cathode of the c.r. tube. The time constant of the coupling is commonly around 0.2 msec and the suppression circuit is no more than a 0.002-μF capacitor in series with a 100-kΩ resistor connected between the tube cathode and the anode of the frame output valve.

The video circuits connected to the cathode affect the performance, of course, and because of their moderate impedance the pulse is considerably attenuated. The impedance is commonly around 5 kΩ and the attenuation is therefore some 20:1. A typical circuit of this type is sketched in Fig. 4.

Another common method is to differentiate the waveform across the timebase charging capacitor and apply it to the grid of the tube. The waveform is roughly like the one of Fig. 5(a) and differentiating it changes it to the form (b) which is much the same as that of Fig. 3(b), but inverted. All that this involves in many cases is a resistor in series with the lead from the grid of the tube to the brightness control and a capacitor between the tube grid and the charging capacitor of the timebase.

Pulse Duration

In most sets, the flyback is governed mainly, if not entirely, by the output circuit of the frame timebase. The flyback of the saw-tooth generator itself can be quicker than the flyback in the output circuit. When this is the case it is unlikely to be satisfactory to take the suppression pulse from the saw-tooth generator. The pulse will be too short and will only suppress a part of the flyback.

Generally speaking, it is safer to take the pulse from the output circuit itself, for it is then necessarily related to the flyback on the tube. However, when the usual form of feedback circuit is used in the output stage the output flyback is fed back too and reacts on the input to modify the flyback there. As a result, there is a relation between the input and output flyback times and it can be quite satisfactory to take the pulse from the input; that is, from the charging capacitor.

The shape of the pulse obtained by simple means is far from ideal. The maximum amplitude is unnecessarily large and the quick initial return and slow end to the pulse mean that it is difficult to secure full flyback suppression at the top of the picture without darkening the picture itself at the top. In practice, it seems easier to get a satisfactory performance than one would expect on theoretical grounds.

In a test with the *Wireless World* Television Receiver, Model 2, a 100-kΩ resistor was inserted in series with the grid lead of the tube and the grid connected through a 0.001-μF capacitor to the "hot" end of the frame deflector coils. The output transformer is normally connected to be phase-reversing so a negative pulse is secured. The pulse amplitude is about 10 V only but is adequate for quite good suppression.

Transmitted Suppression Pulse

In recent months, the need for flyback suppression has been reduced by a change which has been introduced in the television waveform. This change amounts to the introduction of a small flyback suppression pulse in the video signal itself as transmitted. Before the alteration, the signal level immediately before and after the line sync pulses (the front and back porches) and on the tips of the inverse frame pulses was black, corresponding to 30 per cent of peak white signal. The present level is unchanged at 30 per cent but is now blacker than black, for the true black level of the picture itself has been altered to 35 per cent of peak white.

If the picture signal itself swings through 30 V between black and white the total video amplitude used to be 30/0.7=43 V, of which 13 V was sync-pulse amplitude. Now it must be 30/0.65=46 V of which 13.8 V is the sync-pulse amplitude and 2.2 V is the amplitude of the "suppression pulse."

The change is one which is helpful in preventing the flyback lines from showing whatever may be the actual cause of their tendency to appear. The pulse amplitude, however, is hardly sufficient to ensure the absence of the lines in all circumstances and it can hardly be increased in the transmission. Its presence does not remove the desirability of suppression circuits in the receiver, therefore, but it does make their design somewhat easier.

Transatlantic Telephone Cable

BOLD PROJECT CALLING FOR UNCONVENTIONAL AMPLIFIER DESIGN

IN one of the books on which our youthful enthusiasm for electrical communication was fed there appeared a confident statement that, despite the great progress made in ocean telegraph cables, a transatlantic *telephone* cable was (for reasons stated) forever beyond the bounds of possibility. So it was an interesting experience to be sitting in the I.E.E. lecture theatre listening to details of a transatlantic telephone cable, laying of which is to begin next summer*. And this cable is to provide not just one telephone circuit, but 36 simultaneously.

Admittedly it is not yet an accomplished fact. To the conservative engineer, brought up on generous factors of safety, it may appear bold to the point of foolhardiness to put some £12,500,000 into a scheme that includes a sub-ocean link more than 10 times longer and much deeper than any yet in use, and in which the failure of any one of 312 valves or of thousands of associated components at the bottom of the sea will cut off all 36 lines at once, with no spare in reserve.

To the ordinary radio man with emphatic views on accessibility for servicing, the idea of sinking all those amplifiers at 40-mile intervals across the bed of the Atlantic, under anything up to 2½ miles depth of water, must appear more like a nightmare than a serious engineering project. To say that it was asking for trouble would seem to be a sublime understatement. Other aspects of the matter spring to mind: how does one supply the valves with the necessary power? And how, when something goes wrong, does one locate the fault? Yet notwithstanding its rather unpractical appearance, the whole thing has been gone into and accepted by the best British and American brains, the contract between the American telephone companies and the British Post Office was signed more than a year ago, and preparations for carrying out the work are far advanced.

Why offer such hostages to fortune, instead of extending the radio telephone system that has served the transatlantic route for 27 years? The answer to that, at least, can readily be appreciated by the radio man. There are in fact two transatlantic radio telephone systems: the original long-wave circuit between transmitters at Rugby and Rocky Point, and the short-wave system providing at present 16 circuits. Not only are there no spare frequency channels left for extending the service, but interference is making things increasingly difficult on the existing channels. Unlike broadcasting, v.h.f. channels are not available to fall back on, because their range is too limited. Even the present short-wave frequencies are not entirely suitable, because they are at the mercy of ionospheric disturbances which suspend communication in an unpredictable manner, so that quite often the inadequate long-wave link is the only one effectively serviceable.

* Information from the lecture, "A Transatlantic Telephone Cable" by M. J. Kelly, Sir Gordon Radley, G. W. Gilman and R. J. Halsey, has provided the basis for this article.

Attenuation

The difficulty about a submarine cable is its attenuation, or loss of signal power with distance. Even with an open-air wire line there are limits to the distance before signals are reduced below noise level. A cable necessarily has solid dielectric, so the loss is greater. It increases with frequency, so the longer the cable the lower the maximum frequency that can be effectively transmitted. The first transatlantic cable was limited to something of the order of 1 c/s, so obviously only telegraphy was possible, and very slow telegraphy at that. New materials and techniques, especially Permalloy for continuous inductive loading, have enabled the bandwidth to be raised, in the very latest and best examples, to about 100 c/s. This is still far short of what is needed for a single speech channel, even if compressed by the device known as the Vocoder.

Ordinary underground telephone cables have an attenuation of the order of 1 db per mile at audio frequencies. At that figure, a 20-mile run reduces the power of the signal by 99

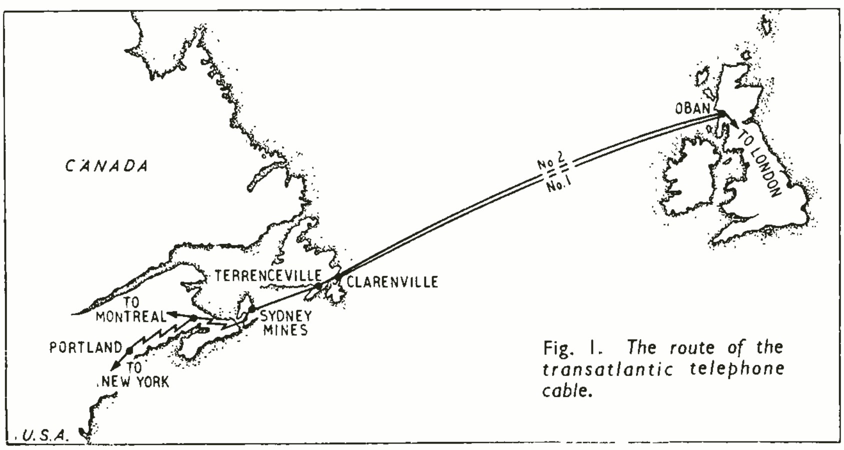


Fig. 1. *The route of the transatlantic telephone cable.*

per cent. This is not more than can easily be made up by a simple amplifier at the receiving end. But a 200-mile line having the same rate of attenuation would reduce the signal power to one hundred-trillionth; a loss that could *not* be made good, for although an amplifier with a power gain of 10^{20} could no doubt be made it would be futile, since it would be overloaded with its own noise, let alone any picked up by the line. Judge, then, of the impossibility of a transatlantic distance, which would reduce the signal power in the ratio 10^{-200}, to say nothing of the distortion caused by unequal velocity with frequency.

Long-distance telephony of any kind is only made possible by inserting amplifiers—called by telephone engineers *repeaters*—at intervals along the route. Thus although the loss caused by a 200-mile line is too much to make up in one go at the end, there is not the slightest difficulty in keeping it up to strength if amplification is applied every 20 miles, or even 40 miles. But where the telephone line is at the bottom of the sea for such (or greater) distances, the difficulties are only too obvious. The idea of having floating battery-driven repeater stations moored at intervals across the Atlantic was looked into and, not surprisingly, abandoned as impracticable.

Submerged Repeaters

The first submerged repeater put into telephone service anywhere in the world is one belonging to the British Post Office laid between Anglesey and the Isle of Man in 1943. There are now 31 G.P.O. repeaters underneath the seas around the British Isles, and more are being installed. But all this experience does not necessarily provide a basis for a transatlantic system, for not only are these European cables much shorter but they are laid in relatively shallow water. Nevertheless, a 300-mile cable between Scotland and Scandinavia was designed and constructed deliberately with Atlantic requirements in view, for experience, and 16 repeaters of the same type are to be used in the 340-mile section of the transatlantic system linking Newfoundland with Nova Scotia (Clarenville to Sydney Mines; see Fig. 1).

Meanwhile the Americans, who for geographical reasons are not much interested in shallow-water routes of moderate distance, had been studying the problem of a sub-Atlantic repeater *ab initio*, and have evolved a rather different type. In 1950, two cables (115 and 125 miles long) using five submerged repeaters of this type at depths from 120 feet to just over a mile were laid between Key West and Havana, and they have worked ever since without failure or deterioration. Fifty-two such repeaters are to be included in each of the two cables to be laid over the 2,000-mile route between Newfoundland (Clarenville) and Scotland (Oban).

A long-distance telephone cable providing only one communication circuit would not be an economic proposition. Multi-core cables, as used for local telephone circuits, are quite out of the question for submarine cables. Instead, a simple coaxial line is used, having sufficient frequency band width to take a number of separate speech channels. Single-sideband frequency changers are used to shift the 3,000-c/s wide speech band to higher frequency channels for transmission. So the transatlantic telephone cable problem is in fact much harder than it was when envisaged a generation or so ago and declared impossible, because it is required to transmit frequencies many times higher—and therefore many times more severely attenuated—than the highest speech frequencies. Hence the need for repeaters at fairly frequent intervals.

The net working bandwidth of the cable to be used for the main transatlantic link (Oban to Clarenville) extends from 20 to 164 kc/s, divided into 36 speech channels at 4 kc/s intervals (Fig. 2). Frequencies below 20 kc/s are to be used for one telephone channel and two telegraph channels for maintenance purposes, and 167-174 kc/s for certain test frequencies to be explained later. The second cable is not a spare; it is required for communication in the reverse direction. In the shorter Clarenville to Sydney Mines section the repeaters are much larger and enable that part of the cable (which is of the same type for both sections) to be used over a frequency band more than three times greater. This leaves room for no fewer than 60 speech channels in *both* directions, so only one cable is needed. Some of the extra channels

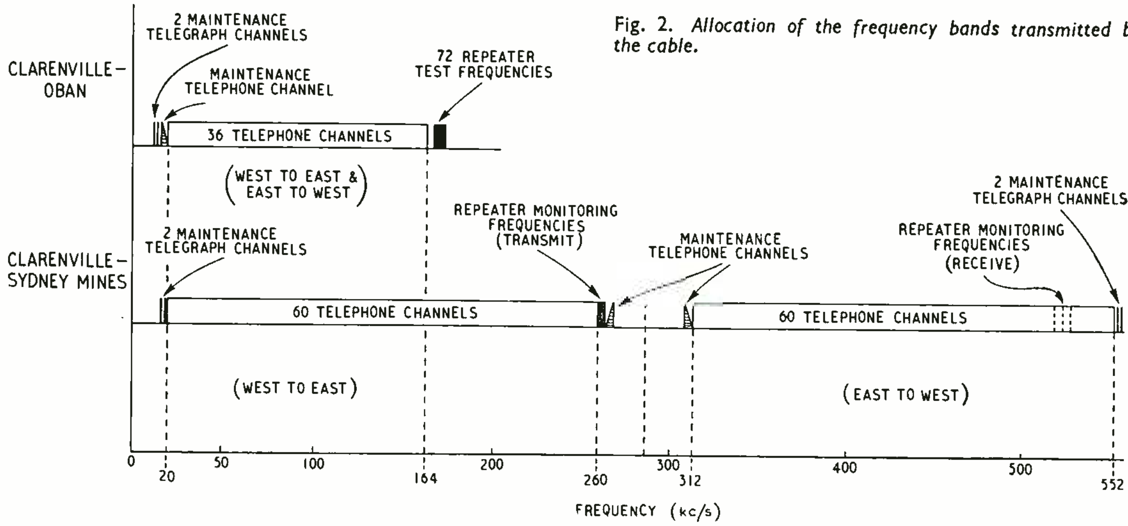


Fig. 2. *Allocation of the frequency bands transmitted by the cable.*

will be used for service between Newfoundland and the rest of Canada; the remainder will be spare.

The cable itself (Fig. 3) is built around a central copper conductor slightly thicker than 10 s.w.g., overwound with copper tape. The dielectric is Polythene—a valuable British contribution to cable technique—and the outer conductor is made up of six copper tapes, overwound with copper worm-resisting tape. Over this again is Telconax for screening, and steel armour wiring sandwiched between jute servings; overall diameter 1.21in. Near the shore ends, additional armour is used for extra protection.

Repeater Construction

Experience in laying cables had shown that unless great care was taken they were liable to be damaged, especially by kinking. Two things that conduced to kinking were irregularities in the cable itself and interruptions in the laying process. For both these reasons the Americans decided to design the repeaters to be used for the main crossing as nearly uniform with the rest of the cable as possible; in particular, that they should be sufficiently flexible to pass through the cable-laying gear without interruption. The repeater finally evolved takes the form of a flexible bulge in the cable, 8ft long and 2.8in diameter, tapering down to the normal cable diameter over a distance of 20ft at each end. To design and produce a repeater in such a narrow space, with protection against ingress of moisture or collapse under sea water pressure up to 3 tons per sq in, yet at the same time to be flexible; to fulfil a stringent specification of gain from 23 db at 12 kc/s to 65 db at 108 kc/s; to be fed and tested from the shore; and to maintain its performance within close limits, without access for not less than about 20 years—that was a problem indeed.

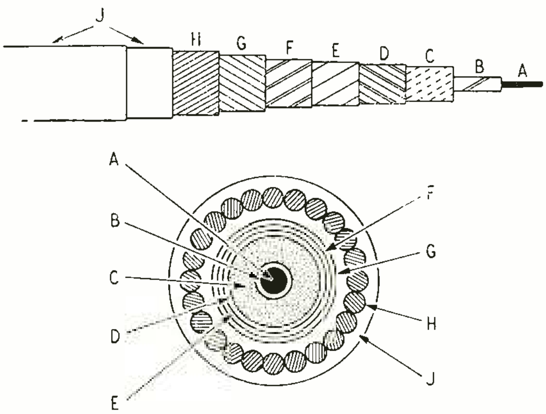


Fig. 3. Cross-sectional and constructional views of the deep-water type of coaxial cable. A. Centre conductor: 0.1318in dia copper. B. Three 0.0145in copper surround tapes. C. Polythene to 0.620in diameter. D. Six 0.016in copper return tapes. E. 0.003in overlapped copper anti-teredo-worm tape. F. Gapped Telconax tape. G. One serving of cutched jute. H. Twenty-four 0.086in diameter high-tensile steel armour wires. J. Two impregnated-jute servings.

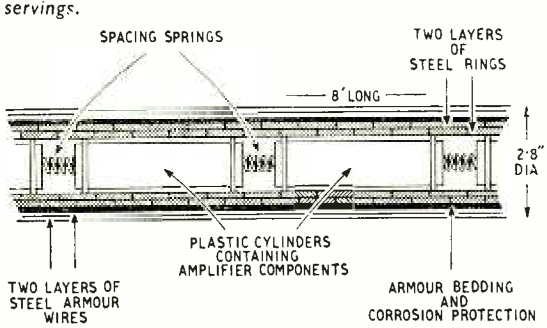


Fig. 4. Longitudinal section showing construction of American-type flexible repeater built into the main transatlantic run of the cable.

The construction is certainly unconventional (Fig. 4). The valves and components constituting the amplifier are divided into 15 separate parcels, each contained in a cylinder 5in long and about 1¼in internal diameter. These cylinders, made of a plastic material similar to Perspex, are coupled together with short springs to form a system resembling a string of sausages. They are protected against the external pressure by two layers of overlapping steel cylinders each ¾in long, over which is a layer of copper and then the usual armouring wires and jute. An elaborate system of seals is provided to prevent water penetrating the joints between this repeater housing and the cable proper. The tensile strength of the cable, which must be very considerable to stand the weight of several miles of itself from ship to sea bed, plus the laying stresses, has to be maintained throughout the repeater sections. Sufficient flexibility has been achieved to enable the repeaters to bend to a 3ft radius. To minimize risk of damage to the cables it is intended to lay the whole of the deep-water part of each (about 1,500 miles) in one operation. This length of cable weighs about 5,000 tons, and the only ship capable of doing the job is the British H.M.T.S. *Monarch*. It is hoped that the necessary twelve consecutive days of favourable North Atlantic weather will occur next summer, and again for laying the second cable the year after.

Amplifier Circuitry

Fig. 5 shows the circuit diagram of the American repeater. It is a 3-stage amplifier using pentodes of a type that is old enough to have been on continuous test for 13 years, and in which reliability, long life, and low anode voltage took precedence over high mutual conductance. The heaters are rated at 0.25 A 20 V d.c., so the three in series require 60 V, which is also the anode voltage. Initially, however, they are to be under-run as shown. The power is fed along the signal wire; consequently transformers are needed to keep it out of the amplifier circuits, and chokes to keep the signals out of the power circuits (which in Fig. 5 are drawn in heavy line). A necessity in an amplifier to cover a frequency band of more than 144 kc/s without intermodulation, and at the same time to maintain a stable gain for years without adjustment, is negative feedback. It is applied through a frequency-discriminating network to give the desired gain/frequency characteristic.

Two interesting details can be seen in the diagram. One is the quartz-crystal resonator shunted across the feedback circuit. Its effect virtually is to remove feedback at its resonant frequency. Each repeater has its crystal tuned to a different frequency, in the 167-174 test band already mentioned. At that frequency its gain is much greater than at other frequencies, and, moreover, is much more dependable on valve characteristics. By measuring the transmission

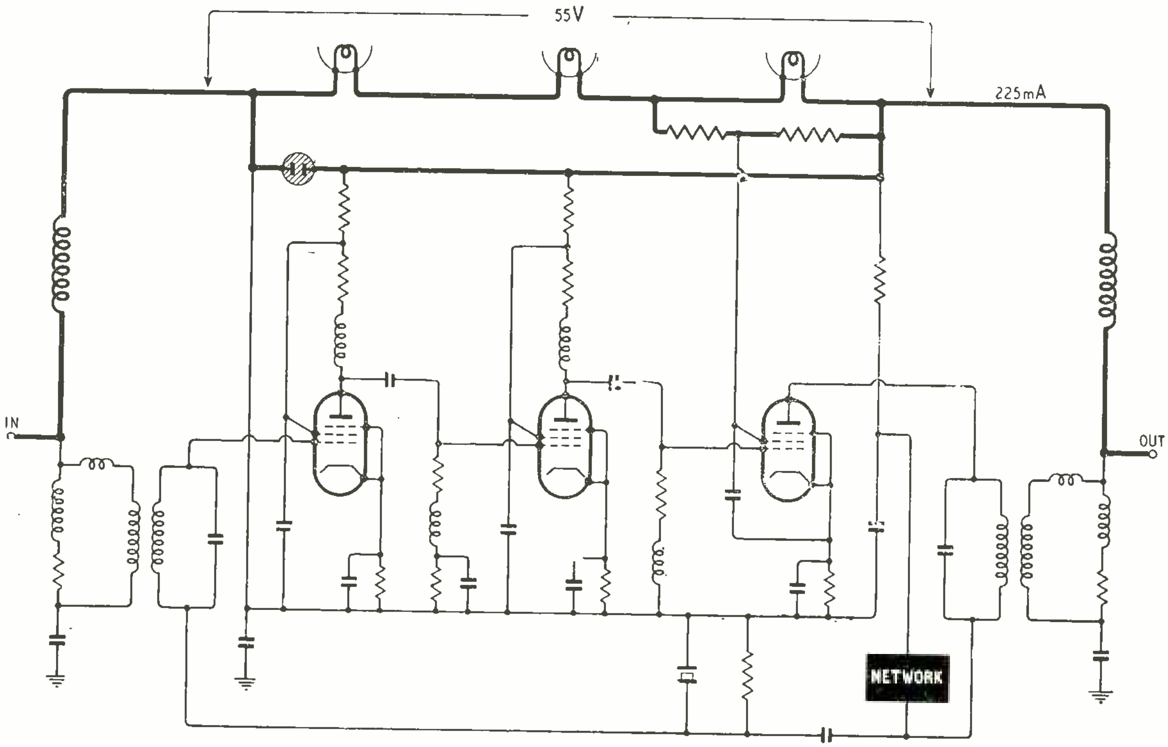
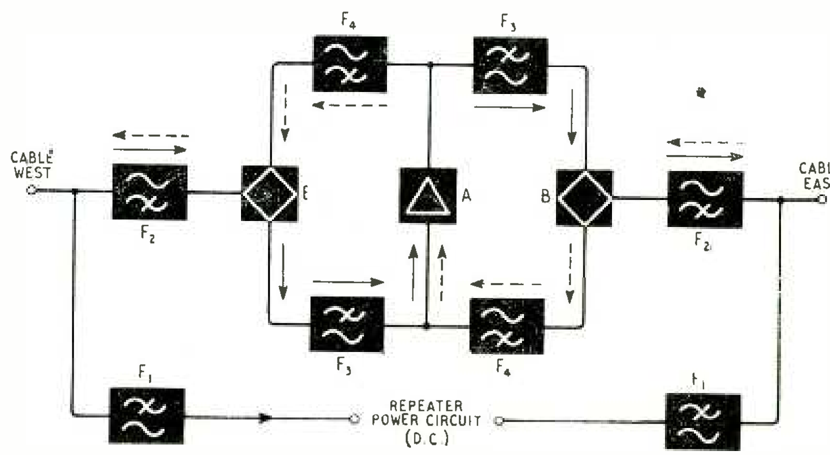


Fig. 5. Amplifier circuit diagram of the American-type repeater. The power circuit is distinguished by heavy line and for clarity the heaters are shown separately above the valves to which they belong.

of the cable at the 52 different frequencies in the test band to which the crystals resonate it is possible to locate any repeater that is falling below standard. Not only so but each high-gain peak at crystal resonance causes an increase in amplifier noise at that frequency, which can be detected by a sharply-tuned receiver on shore; it is, therefore, a quick and simple matter to locate any repeater that has failed. One has only to note the test frequency at which the noise peak is missing. It might be supposed that an open-circuited heater would interrupt the power feed for the whole cable, rendering this test impossible; but the second interesting detail is the gas-discharge tube shunted across the heater chain of each amplifier. The normal voltage across its electrodes is insufficient to strike it, but if any heater chain becomes open-circuited the voltage rises and the diode conducts, re-establishing continuity. Since the amplifier would then, of course, be out of action, the noise peak at its particular frequency would be missing and the fault would thereby be located.

Besides the 55-V drop across the three heaters, there is another 20-V drop in the 40 miles of cable between one repeater and the next, so the total drop for the whole cable with its 52 repeaters is nearly 4,000 V. Half of this voltage is provided by a constant-current generator between one end of the cable and sea, and the other half by another generator of oppo-

Fig. 6—Block diagram of British-type repeater for the Newfoundland to Nova Scotia section of the cable. Filters F_1 and F_2 separate the power and signal currents, and filters F_3 and F_4 separate the East to West (high frequency) signals from the West to East (low frequency). BB are balanced bridges, and A is a pair of parallel-connected amplifiers.



site polarity, at the other end. No part of the cable, therefore, is at more than 2,000 V to sea.

Because a single fault in any part of any of the repeaters would affect all the telephone circuits at once, perhaps fatally, and repair by cable ship is a lengthy, expensive and hazardous business, the most extraordinary care is taken in selection and assembly of all components. The repeaters are manufactured by specially selected workers in air-conditioned rooms and surgical type of clothing.

The circuit diagram of the amplifier in the British type of repeater used in the Nova Scotia to Newfoundland section of the system is very similar to Fig. 5, but in other respects the design of repeater is quite different. Following the techniques successfully used by the G.P.O. on a smaller scale in Europe, no attempt has been made to confine the outlines of the repeater to a slight and gradual bulge capable of passing through the normal cable-laying machinery. It takes the form of a rigid cylinder 9ft long and 10½in diameter. Since this provides about ten times the internal volume of the flexible repeater, there is room not only for both "ways" and more channels but also a duplicate amplifier to improve the reliability. Moreover the components are not subject to such cramping dimensional restrictions. Fig. 3 shows that all the East to West channels are higher in frequency than the West to East; it is, therefore, possible to separate the two lots of channels *en bloc* by means of high-pass and low-pass filters as in Fig. 6, so enabling one amplifier (actually two amplifiers in parallel) to be used for both lots, rather in the manner of a bridge-connected rectifier unit. Another contribution to achievement of the wide frequency band is the use of modern high-performance valves ($g_m = 6$ mA/V). A cure for the apparent gradual deterioration in mutual conductance, which is caused by the formation of a resistive barrier at the cathode,* has been found by the G.P.O. —the use of platinum cathode cores—and it is hoped that this will ensure that the valves will have stable characteristics over a very long life.

Testing of the British-type repeaters is by means of tones in the 260-264 kc/s band. Each repeater receives its own test tone and has a frequency-doubler that brings its frequency into the band that is amplified in the reverse direction. A signal at that frequency is consequently returned to the starting point, to provide a measure of the transmission level. Pulse-testing equipment is also provided for measuring the overload point in each repeater and thereby ascertaining whether both amplifiers are still working.

Mechanically, the cable is cut at the repeater points and the armouring firmly anchored at each end of the repeater housing. The apparatus compartment, which occupies about half the length, is firmly sealed at both ends, and filled with dry nitrogen to inhibit corrosion. An ingenious modification of the cable-laying machinery has been devised to pass the repeaters through without obstruction. Because of the wide frequency band covered, these repeaters are to be laid at shorter intervals of about 20 miles; 16 of them are, therefore, required along the single cable between Clarenville and Sydney Mines.

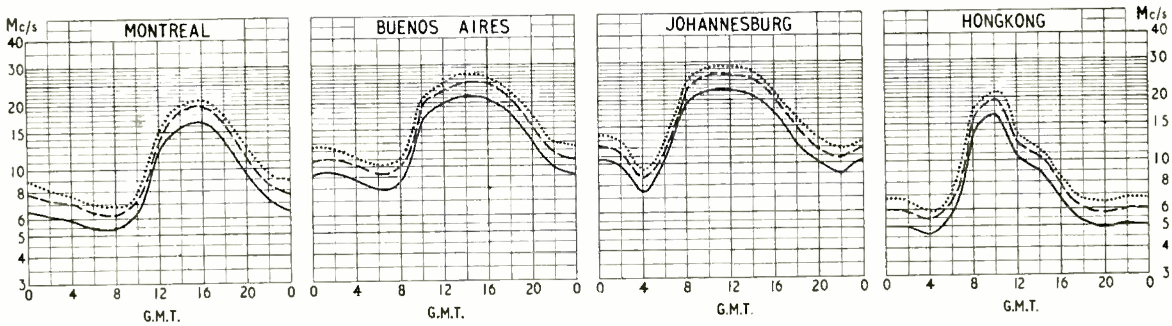
It will be interesting to see how the British and American ideas about submerged repeaters compare in practice over a period.

The authors of the I.E.E. lecture are already looking forward to a transistorized cable to supersede the present system. The number of repeaters, and consequently the frequency band that can be transmitted, is at present limited by the safe voltage that can be applied to the cable for supplying power to the valves. With its small size and modest power requirements the transistor has obvious attractions in this field. The authors look still farther forward to a transatlantic television cable as an eventual possibility. If sufficient financial provision could be seen, it is unlikely that technical difficulties would long remain unvanquished.

* "Valve Cathode Life," by C. C. Eaglesfield; *Wireless World*, Dec., 1951, p. 505.

SHORT-WAVE CONDITIONS

Predictions for January



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 January.

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

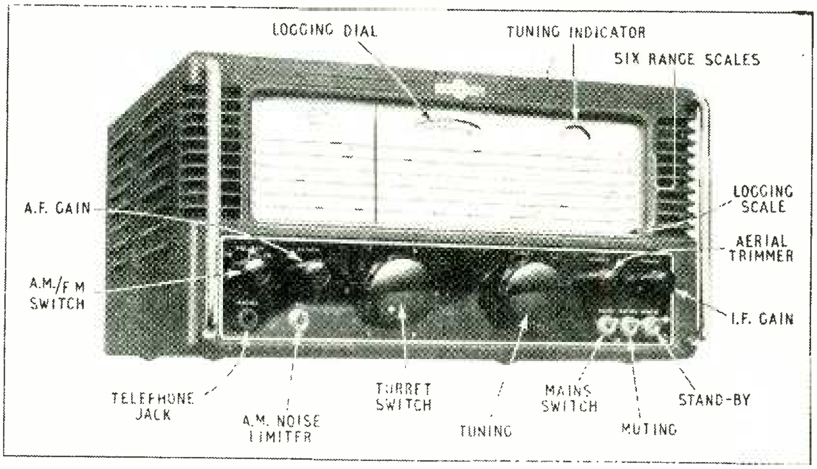
·············· FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

———— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

A.M./F.M. Communications Receiver

Review of Eddystone Model 770R, Covering 19 to 165 Mc/s



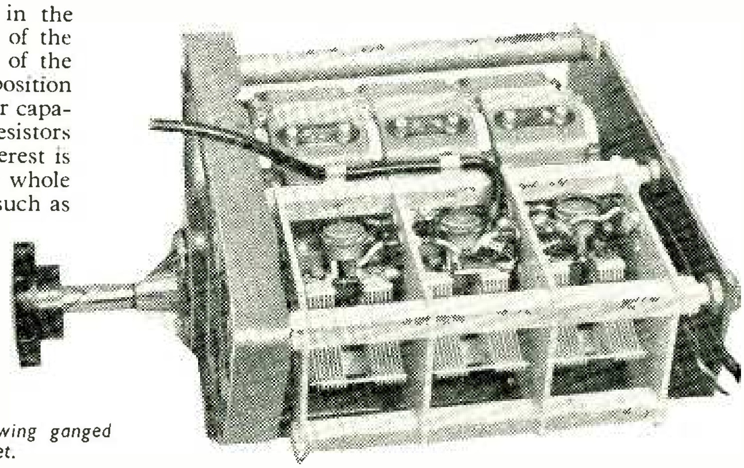
NINETEEN valves, of which all but two are miniature, and three germanium crystal diodes are used in the new Eddystone Model 770R wide range, v.h.f. communications receiver. The types of these valves, their circuit positions and functions will be found in the valve table. This set is believed to be the only British-made receiver now available giving continuous tuning over such a wide v.h.f. range as 19 to 165 Mc/s. There are six ranges and the extent of each, together with some of the services likely to be found in the various bands, are outlined in the frequency tables on the following page.

The 770R has an i.f. of 5.2 Mc/s and provides for the reception of a.m. and f.m. telephony and c.w. telegraphy. No marked departures from well-tried techniques are attempted, but considerable ingenuity is evident in the planning of the circuit and range-changing mechanism of the front-end, comprising the r.f., mixer and oscillator stages. This is, of course, the real heart of a receiver of this kind and its general performance depends almost entirely on the design of this part of the set. Its very satisfactory behaviour on all ranges, but especially on the 114-to-165-Mc/s one, is a tribute to the design of the front-end unit.

The r.f., mixer and oscillator stages in the 770R are a single unit, and a good idea of the general arrangement can be seen in one of the illustrations. The set employs a six-position rotary-coil turret, three ganged split-stator capacitors, valve-holders and sundry small resistors and capacitors. The main feature of interest is that virtually no r.f. wiring is used in the whole unit; the positioning of the main items, such as coil turret, tuning capacitors and valveholders, is such that their interconnecting points fall so close together that the soldering tags alone form the wiring. Moreover, little real wiring is employed inside the coil turret itself. As shown in the

VALVE TABLE

Circuit Position	Type	Function
V1	6AK5 EF95 (CV850)	Pentode r.f. amplifier.
V2	6AK5 EF95 (CV850)	Mixer.
V3	6AK5 EF95 (CV850)	Oscillator.
V4-V7	6BA6 (CV454)	I.F. Amplifier
V8	6AU6 (CV2524)	F.M. limiter.
V9	6AL5 (CV140)	F.M. discriminator.
V10	6AL5 (CV140)	Noise limiter and a.g.c.
V11	6AU6 (CV2524)	"S" meter valve on a.m. Tuning indicator on f.m.
V12	6BA6 (CV454)	Beat frequency oscillator (BFO)
V13	6AU6 (CV2524)	Noise amplifier (muting).
V14	12AU7 (CV491)	Muting stage.
V15	12AU7 (CV491)	A.F. amplifier and phase inverter.
V16-17	6AM5 (CV136)	Push-pull output stage.
V18	VR150 30 (CV216)	Voltage stabilizer.
V19	5Z4G (CV1851)	Full-wave h.t. rectifier.
CD1	Germanium	A.M. detector.
CD2-3	Germanium	Noise detectors (muting)



Right: Front-end unit of Eddystone 770R showing ganged capacitors, valveholders and (in rear) coil turret.

illustration of two of the turret coil assemblies, the higher-frequency coils are self-supporting and are soldered direct to the inside extensions of the external contact studs. Any trimmers included have the shortest possible leads to their respective points.

Turret Mechanism

The actuating mechanism of a coil turret for v.h.f. use is a vitally important feature of its design, as it is most essential that at all times the turret comes to rest in exactly the same position on any one range. A fractional displacement would either add to or subtract from the total inductance in the circuit and cause changes in tuning of sufficient magnitude to render the range scales, if calibrated directly in frequency as they are in the 770R, quite useless. Moreover, as facilities are provided for accurately logging the tuning positions of stations, any unreliability in the turret positioning would become immediately apparent when a previously logged station's position is sought after changing ranges. Apart from small initial variations in tuning caused by oscillator drift (which cannot be entirely avoided by voltage stabilization alone), no abrupt changes in the tuning position of a station was noticed by going from range to range and back to the original. We looked for these effects most searchingly on the highest frequency range and, finding none, conclude that the coil turret mechanism is above reproach in this respect.

The tuning system of the 770R is the same basic type as used in other Eddystone communications receivers. It provides an overall reduction of 140 to 1, embodies a flywheel to counteract frictional drag of the gears, and gives a smooth and free action. It is heavy enough to carry the pointer some distance along the scales by spinning the knob sharply. The weight is nicely chosen and does not give the impression of taking charge of the tuning, as sometimes seems to occur when the flywheel is too heavy. The pointer is a long pendant one and embraces seven 12-in long horizontal scales, six of which are calibrated linearly in frequency; the seventh is the logging scale marked 0-2,500 and having 25 divisions. Each division represents one complete revolution of a subsidiary logging dial which is visible through an aperture in the top centre of the main dial. This dial has a 360-degree scale and is engraved 0-100. In effect it expands every scale to the equivalent of 32 ft. Quite small changes in frequency can thus be observed on the logging dial.

FREQUENCY TABLE

Range	Frequency coverage (excluding overlaps)	Remarks
1	114 to 165 Mc/s	Aircraft, amateurs.
2	78 to 114 Mc/s	F.M. broadcast, land mobile, aero navaids.
3	54 to 78 Mc/s	Television, aero navaids.
4	39 to 54 Mc/s	Television, U.S. amateurs.
5	27 to 39 Mc/s	Amateurs, aero navaids, meteorological aids.
6	19 to 27 Mc/s	Broadcast, amateur, marine.

A.M./F.M. Arrangements

Owing to the rather high i.f. used (5.2 Mc/s) four i.f. stages have been included to satisfy the requirements of high sensitivity coupled with a wide band-

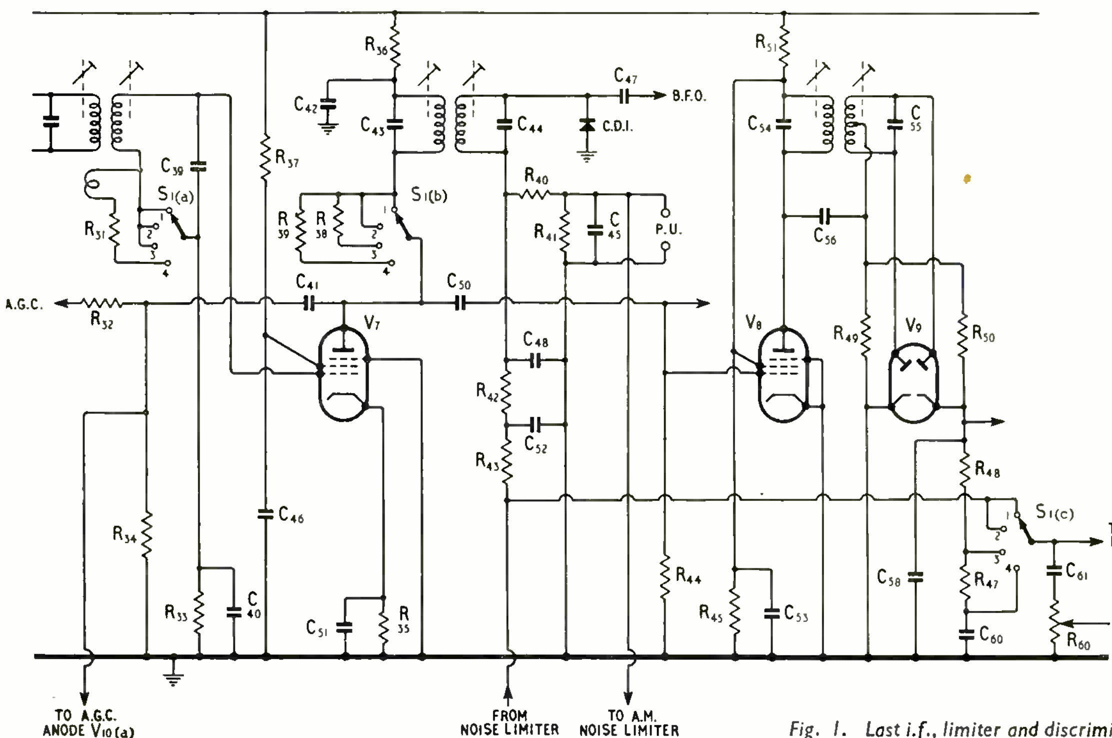


Fig. 1. Last i.f., limiter and discriminator stages of the Eddystone 770R receiver.

width for f.m. reception. For f.m. there is in addition a limiter and a Foster-Seeley discriminator. For a.m. reception there are no fewer than 10 tuned circuits and a crystal diode detector. Some interesting features (see Fig. 1) can be found in that part of the circuit, which includes the last i.f. stage V7 limiter V8 and discriminator V9. The switches S_{1a} to S_{1c} are part of a larger switching system, which might be called the "services switch," as it changes over from a.m. to f.m., adjusts bandwidth to suit each type of service and in the "CW" position switches on a BFO. S_{1a} and S_{1b} are for bandwidth adjustment of the i.f. amplifier at this point, the markings on S_{1a} indicating the four positions of the switching system; (1) CW, (2) AM, (3) NFM and (4) FM. NFM is narrow-band f.m. and is used for certain types of transmission for which the frequency deviation need not exceed ± 15 kc/s compared to the ± 75 kc/s of wide-band f.m.

In the top right-hand corner of the main dial is a small aperture disclosing a tuning indicator. It serves a twofold purpose; it functions as a single-strength meter for c.w. and a.m. transmissions, registering on the carrier level, and is used as a tuning indicator for f.m. It has a red-line centre zero on which the pointer is aligned for correct tuning on f.m. and a 0-9 "S"-scale for a.m. It is sometimes said that an f.m. signal can be tuned in correctly by adjusting for minimum background noise, but this region is generally far too broad for satisfactory tuning. The meter indicator of the 770R is very sensitive to small changes in tuning and enables the desired accuracy to be achieved in a simple manner.

Details of the circuit associated with this indicator are given in Fig. 2, which includes the switch S_{1d} for changing over the indicator's functions from tuning indicator to "S" meter as required. It forms part of the main S_1 switching system. The remainder of the circuit is reasonably straightforward.

A push-pull output stage is used, preceded by a phase-splitter and a.f. amplifier. Negative feedback is employed. An output transformer provides matching for an external loudspeaker of 2.5 to 3 ohms; a loudspeaker is not included in the set. Provision is made for headphones and—unusual in a set of this kind—for a gramophone pickup.

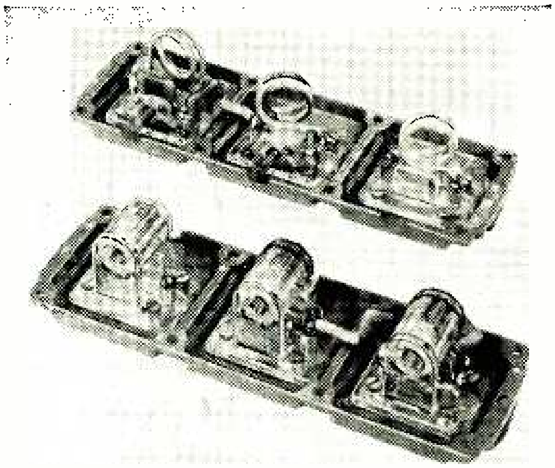
One other circuit detail, which, however, is common to most communications receivers, is a stand-by switch. It de-sensitizes the set in the stand-by position and also closes a pair of spare contacts to be used, if required, to control a nearby or remote transmitter via a relay.

Performance

The impression given by the set is that it has about as much sensitivity as can usefully be employed. The selectivity in the CW and AM positions is adequate for all v.h.f. requirements; and it must be judged on this basis. It leaves a little to be desired on the 19- to 27-Mc/s band, but these frequencies may be regarded as rather outside the normal scope of this receiver.

During our tests we dodged from range to range, noting station tuning positions and often coming back to them time and again; it was a form of monitoring and covered the whole v.h.f. range of the receiver. The set seems ideally suited for this type of work which could form one of its principal rôles.

The noise limiter suppresses ignition interference



Two of the coil units removed from the turret.

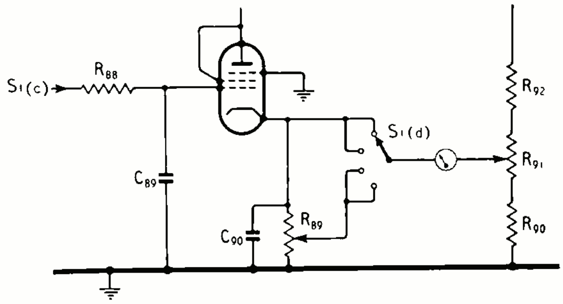


Fig. 2. The f.m. tuning indicator and a.m. "S" meter are combined in one stage.

on a.m. transmissions quite effectively, but seems to cut rather deeply into the upper frequency response. Indeed, it forms a useful way of suppressing most of the set noise when the full gain is employed and especially so when the BFO is used, which, as seems inevitable, adds considerably to the general background noise. However, this is not peculiar to the 770R.

The following extracts from the maker's specification serve to give some idea of the receiver's qualities.

Sensitivity.—Better than 5 μV on all ranges for a 15-db signal/noise ratio and 50 mW output.

Selectivity.—CW and AM; 40 db down, 50 kc/s off resonance. Narrow band FM; 40 db, 80 kc/s away from resonance. Wide-band FM; 40 db down, 175 kc/s off resonance.

Noise Factor.—Not greater than 14 on Range 1, decreasing to less than 5 on Ranges 5 and 6.

Image Ratio.—Better than 20 db at 165 Mc/s and correspondingly greater at the lower frequencies.

Frequency Stability.—Drift less than 0.001 of 1 per cent C, and less than 0.001 of 1 per cent for a 5-per cent change in mains voltage.

As the receiver covers the 21-, 28- and 145-Mc/s amateur bands it might have some appeal in this direction provided the price does not prove too great an obstacle.

The makers are Stratton and Co., Ltd., Eddystone Works, Alvechurch Road, West Heath, Birmingham, 31.

Circuit Symbols

Differences Between American and British Standards

By "SYMBOL SIMON"

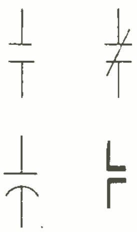
THE June, 1954, issue of *Proc.I.R.E.* contains a list of graphical symbols—covering *all* electrical needs—which have been agreed with the American Standards Association.

In this country, the "heavy" and "light" engineering fields are catered for by two British Standards: B.S.108 and B.S.530 respectively. Perhaps we shall one day see a similar amalgamation of these two Standards: this would prevent inconsistencies between the two Standards, which, although few, are puzzling to a draughtsman who has to choose symbols from both lists for use on one drawing.

The I.R.E. list generally gives two sorts of symbols, "single-line," i.e., simplified, somewhat similar to the British "block diagram," and "complete"—on the lines of our circuit symbols. The supplement to B.S.530 on waveguides uses a similar arrangement.

Mention should first be made of two symbols which may confuse the British reader:

(a) The American open contact, as used on "power" diagrams (left), is very like our capacitor.



(It must be remembered that Americans draw all lines of the same thickness.) Their closed contact (right) is rather like a British variable or pre-set capacitor which has lost the end of its shaft. They avoid confusion by giving their capacitors one curved plate (left). Possibly we could persuade them to change their open contact to our symbol used in Electric Traction diagrams by erasing half the horizontal lines (right). This change would remove any risk of confusion.

(b) Much less important. The American microphone (left) is similar to our buzzer (middle), whereas our microphone (right) has international agreement.

In passing, the British buzzer symbol is supposed to owe its origin to the practice (frowned on by the Post Office) of inverting the dome on a telephone bell to make it produce a quieter buzz. The American bell and buzzer are left and right respectively.

Apart from these contradictions, the symbols are generally self-evident, except, possibly, the plugs and sockets; for example, the socket (left) and plug (right),

which are "pictures" of the modern connectors with rectangular pins.

A choice is given for the inductance symbol: the (British) "loop" symbol (right) or a "semi-circle" symbol (left), which is easier to draw and quite unambiguous.

As an indication of the American preference between these two, it is interesting to note that the "semi-circle" symbol is used for an inductance in *every* case in the rest of the list. Perhaps we would do well to introduce this symbol in this country—it is already looked on with favour on the Continent.

The American "waveguide" symbols agree well with the "single-line" symbols in the supplement to B.S.530 mentioned above. This is not surprising, since an earlier draft of the American symbols was in the hands of the British "Services" committee which based its symbols on them and subsequently brought its decisions to the attention of the B.S.I.

To sum up, the list appears complete, and (with the few exceptions mentioned above) clearly intelligible to the British reader.

Millimetric Radar

WHAT is believed to be the first millimetric radar surface movement indicator is to be installed at London Airport by the Ministry of Transport and Civil Aviation. It will provide the control staff with an accurate picture of the positions of aircraft and vehicles on the airfield and enable them to supervise movements under conditions of poor visibility more expeditiously than is possible with position reporting by radio telephone. Owing to the expanse of London Airport it should ease the flow of air traffic in and out under all conditions of visibility.

The equipment to be used is the new Decca 8-mm airfield surface movement indicator which employs a beam width of 23 min only and a pulse length of 0.05μsec, giving a radar picture of exceptional clarity as may be seen from the accompanying p.p.i. display showing the runways at London Airport. The slight masking of the picture in the upper right-hand corner is caused by a temporary obstruction which will be removed before the equipment is installed in its permanent quarters.

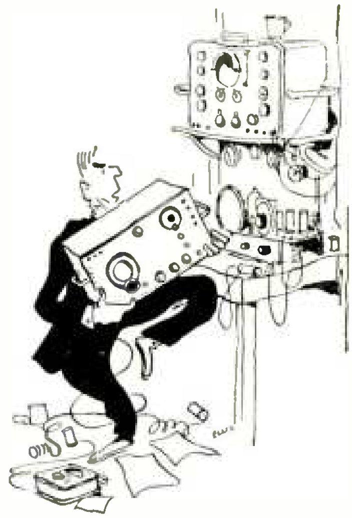
AIRCRAFT AWAITING TAKE-OFF CLEARANCE

AIRCRAFT TAKING-OFF

RADAR SITE ON TOP OF CONTROL TOWER

High definition p.p.i. display of London Airport's runways produced by the new Decca 8-mm surface movement indicator.

Talking of Test Gear...



A Cynic's View of Electronic Measuring Instruments

By A. J. REYNOLDS*

ONCE upon a time there was an engineer who, for want of a better name, shall be called Mr. P. H. Dee. Having made a great success of a research project at his university, working with apparatus made by himself and his assistants, he landed a highly paid job in industry (the sort in the small ads. section of *W.W.* at a salary at least twice what your firm pays), and looked forward to using some good professional apparatus. He was given an "X"-band development job and set about buying the necessary instruments. His first move was to study the advertisements in the technical press and the catalogues in the library. He picked out the eight most likely manufacturers and telephoned or wrote to them, and in due course finished up with four beautiful leaflets each describing an instrument allegedly suitable for his job. In this case, it was a fairly simple piece of waveguide apparatus, the main requirement being that it should achieve a reasonable degree of match. It was then that his bewilderment began, for he came up against the gentle art of "specification writing." It goes something like this, extracting the relevant passages from the manufacturers' leaflets:—

Instrument A: VSWR 1.2 at 10,000 Mc/s.
Instrument B: Standing wave ratio ≮ 0.8 at 10,000 Mc/s.
Instrument C: The degree of match achieved is better than 1 db.
Instrument D: The total reflected power is less than 1% over most of the band.

Now when converted to a common terminology all these mean almost the same thing, but it will be apparent to the keen student of Stephen Potter that the writer of leaflet D is a first-class lifeman. How much better his instrument sounds than if he had written:—

VSWR 0.8 over the middle 51% of the band, falling to 0.55 at the extremes.

Having sorted all this out Mr. P. H. Dee found all the literature extremely silent on one most important point—that of the "handleability" of the instrument concerned.

Handleability can perhaps be defined as "possessing the quality that a given movement of the controls produces the expected response in the expected degree." The possession of this quality largely determines whether or not an instrument will meet with wide approval and enormous sales. All of us at some time have had to use a magic box where a meter has to be set to a datum line by means of a knob on the front. How infuriating it is when the slightest touch of the knob causes the meter needle to dash madly to one stop or the other! One can never regard with any affection an instrument which has such tricks in its repertoire.

One or two examples of eminently handleable instruments come to mind. In the field of the humble multi-range meter one particular example has this quality to a high degree. Since it was designed, well before the war, it has successfully fought off challenges from a variety of competitors, some of which required a small chain wrench to turn the knobs and some whose plug and socket range selection could only be adequately operated by an international cribbage-marker—not to mention those with nice easy range factors like 2.5 and 6, and figures of merit like 310 ohm/V. When the equipment designer specifies that the anode voltage of V1 is 275V measured with a 1,000-ohm/V meter, one notes that it reads 34.5V × 6 on one's 310-ohm/V meter, so this stage is obviously in order—or is it?

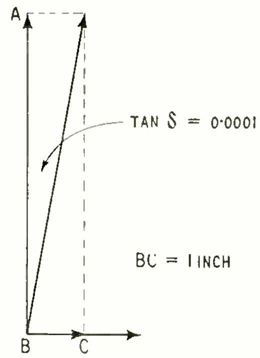
Attenuator Reaction

After the multi-range meter most people would agree that the signal generator is the next instrument to be purchased either for the average laboratory or service workshop. Here again the glossy leaflets are silent on the subject of handleability. It is easy to be misled by the paper specification into believing that generator A at half the price is just as good as generator B. Unfortunately, in instruments as in everything else, one gets just what one pays for (usually a little less). Most engineers have by now caught up with that old bogy of signal generators, spurious f.m., and in many cases the limits are included in the specification, but I have still to see attenuator reaction (that is, the effect of varying the attenuator on the emitted frequency) written into a specification. Yet this quality is by no means negligible in its effect on "handleability." The sequence goes something like

* Livingston Laboratories.

this. The indicating device at the end of the chain reads high, so the output from the generator is reduced by means of the attenuator until the pointer of the output meter is on the datum; this shifts the frequency so the generator is re-tuned to peak. The shift of frequency causes the output to drop, so the "Set Carrier" is advanced to its proper place. One then notices that the output meter is still a bit high and repeats the process.

Another quality of the signal generator rarely specified is the harmonic content of the r.f. signal. It may come as a surprise to hear that figures such as 25% second and third harmonic distortion are quite common even in high-grade instruments. The ever-widening bandwidths used to-day plus the use of feedback-type valve millivoltmeters as indicators make this point a matter of some importance. Before roundly condemning all signal generator manufacturers as scoundrels, remember that many of the best-known examples were designed in the days of bandwidths measured in small kc/s rather than large Mc/s, and that in these conditions the effect of r.f. harmonic distortion is small. 25% distortion only affects the level of the signal some 4%, and it is rarely that the level accuracy can be guaranteed to better than 10% for reasons quite unconnected with harmonic distortion.



In the last paragraph, passing mention was made of a now popular type of instrument, the valve millivoltmeter. Careful investigation is necessary before buying one of these. Apart from the usual points to watch such as zero stability and, in the case of the most sensitive types, noise on the lowest range, the form factor error is a variable and usually unspecified error that can affect the handling in many common applications. (Form factor being defined as the ratio of average voltage to peak voltage, that is, 1.11 for a sine wave.) One of these applications, the use of the instrument with a signal generator having a bad waveform, has been quoted above. These instruments are invariably calibrated in terms of r.m.s. volts and yet actually may be measuring peak voltage, half-wave average voltage, full-wave average, or a quantity that is not quite any of these. When fed from a distorting source, reading errors up to 50% are quite common between different instruments that agree extremely well on a pure sine wave.

Practically all the foregoing could be read as though my intention were to "debunk" the instrument industry, but this is not at all the case. The blame for many of the apparent shortcomings of instruments rests with the user who consistently demands an instrument having an enormously wide range of measurements.

We have grown so used to our micros and megas that we have lost a sense of wonder about such things. People look at a pulse displayed on an oscilloscope, for example, and say "the front edge is not too good —it is not much better than a twentieth, I suppose," meaning, of course, that the rise time of the pulse in question is some 0.05μsec. Recently a well-known and well-liked pulse generator was being roundly criticized for daring to have a time jitter in the "free run" position of 0.05μsec! It may come as a surprise to those who have never stopped to think about it that

0.05μsec is to 1 sec as 1 sec is to 7 months,

and yet people are now demanding presentation of an event lasting a fraction of a millimicrosecond!

A somewhat similar state of affairs exists in other fields. Insulating materials having a loss angle (tan δ) of 0.0001 are in common use. For those not familiar with the expression "loss angle," perhaps a word of explanation will not be amiss here. The perfect insulator when used as a dielectric material forms a capacitor that takes a current truly 90° ahead of the voltage in phase and hence has no loss. In practice, of course, this state never exists, and all practical capacitors have a small resistive component which modifies the resultant phase angle and represents the power dissipated in the dielectric. As, in the case of very small angles, the tangent is numerically equal to the angle, this figure is normally used to describe the merit of a particular dielectric material. Those readers whose arithmetic is better than mine can, for amusement, calculate the missing dimensions in the accompanying vector diagram (left). Yet this quantity is regularly measured at 10 Mc/s or even 100 Mc/s.

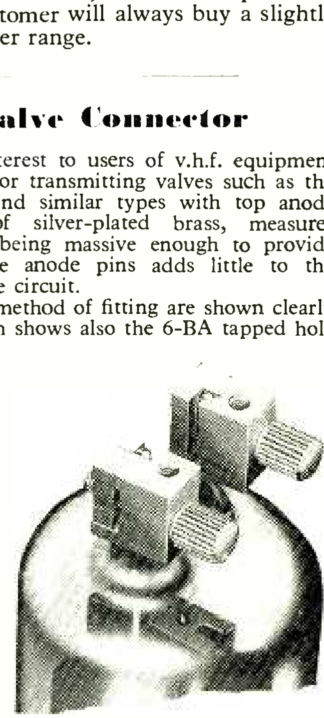
Perhaps these two example have been sufficiently striking to help you to appreciate the magnitude of the task that faces the instrument designer these days. This task is made even more difficult by the demand for instruments having a wider and wider range. The ideal signal generator covers from 0.1 c/s to 50,000 Mc/s in one range; has an output of several watts which can be attenuated (without leakage, of course) to 0.01μV; has internal f.m., a.m., p.c.m.; does not weigh more than 10lb or cost more than £100. It will then exhibit all the faults mentioned and have a few of its own. In general a narrow-range single-purpose instrument can be made to do its job supremely well, but, of course, the Sales Department can't sell it as the customer will always buy a slightly worse one with a wider range.

V.H.F. Valve Connector

A NEW product of interest to users of v.h.f. equipment is an anode connector for transmitting valves such as the QQV06-40, 829, 832 and similar types with top anode pins. It is made of silver-plated brass, measures $\frac{1}{2}\times\frac{1}{2}\times\frac{5}{16}$in and while being massive enough to provide effective cooling of the anode pins adds little to the capacitance of the anode circuit.

Its construction and method of fitting are shown clearly in the illustration, which shows also the 6-BA tapped hole providing the means of connecting to the external anode circuit.

Made by Power Controls, Ltd., Exning Road, Newmarket, Cambridge (one of the Pye group of companies) the price is provisionally 2s 3d each, but is subject to adjustment for quantities.



Top anode connectors for v.h.f. transmitting valves made by Power Controls.

JANUARY MEETINGS

Institution of Electrical Engineers

London.—January 12th. "Thermionic Valves of Improved Quality for Government and Industrial Purposes" by E. G. Rowe, P. Welch and W. W. Wright at 5.30 at Savoy Place, W.C.2.

January 24th. "Radio Aids to Marine Navigation" by Capt. F. J. Wylie, R.N. (Ret.), at 5.30 at Savoy Place, W.C.2.

January 27th. Faraday lecture on "Courier to Carrier in Communications" by T. B. D. Terroni at 6.0 at the Central Hall, Westminster, S.W.1. Admission by ticket obtainable from the Institution.

East Midland Centre.—January 25th. "Special Effects for Television Studio Productions" by A. M. Spooner and T. Worswick at 6.30 at the Gas Demonstration Theatre, Nottingham.

North-Western Centre.—January 5th. "The Experimental Synthesis of Speech" by W. Lawrence at 6.45 at the Engineers' Club, Albert Square, Manchester.

January 18th. Faraday lecture on "Courier to Carrier in Communications" T. B. D. Terroni at 7.30 at the Free Trade Hall, Manchester.

South Midland Centre.—January 24th. "Some Applications of Electronics to Telecommunications" by Col. C. E. Calverley at 6.0 at the James Watt Memorial Institute, Great Charles Street, Birmingham. (Joint meeting with Birmingham section of Institution of P.O. Electrical Engineers.)

Southern Centre.—January 28th. "Transistor Circuits" by G. B. B. Chaplin at 6.30 at the Technical College, Weymouth.

Oxford District.—January 12th. "The Future of Electronics in Industry" by E. R. Davies at 7.0 at the Demonstration Room, Southern Electricity Board, 37, George Street, Oxford.

British Sound Recording Association

London.—January 21st. Demonstration of a high-fidelity reproducing chain by T. S. Livingstone and N. C. Mordaunt at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.

Manchester Centre.—January 10th. "Design of a Recording System" by H. G. Bennetts at 7.30 at the Engineers' Club, Albert Square, Manchester.

Television Society

London.—January 19th. Fleming Memorial Lecture, "The Perception of Colour" by Prof. W. D. Wright (Imperial College) at 7.0 at the Royal Institution, Albemarle Street, W.1.

Radio Society of Great Britain

January 28th. Presidential address followed by "Antenna Matching with the Antennamatch" (with practical demonstrations) by Frank Hicks-Arnold, G6MB, at 6.30 at the I.E.E., Savoy Place, London, W.C.2.

Institution of Production Engineers

Luton.—January 25th. "Induction Heating" by Dr. R. H. Barfield at 7.15 in The Town Hall, Luton.

Electro-Physiological Technologists' Association

February 5th. Papers and demonstrations at 10.30 a.m. at the National Hospital, Queen Square, London, W.C.1.

British Institution of Radio Engineers

London Section.—January 26th. "A Survey of Tuner Designs for Multi-Channel Television Reception" by D. J. Fewings and S. L. Fife at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

West Midlands Section.—January 12th. "Electronics in Materials Handling" by L. Landon Goodman (British Electrical Development Association) at 7.15 at the Wolverhampton and Staffs Technical College, Wulfruna Street Wolverhampton.

North-Eastern Section.—January 12th. Address by the president, Rear-Admiral (L) Sir Philip Clarke, K.B.E., at 6.0 at Neville Hall, Westgate Road, Newcastle-upon-Tyne.

Merseyside Section.—January 6th. "Some Interesting Applications of Electronics to Photography" by D. M. Neale (Ilford, Ltd.) at 7.15 at the College of Technology, Byrom Street, Liverpool, 3.

North-Western Section.—January 6th. Discussion on the "Problems in the Design and Production of Car Radio," opened by C. L. Caiger (E. K. Cole) at 7.0 at the College of Technology, Sackville Street, Manchester.

South Wales Section.—January 12th. "Electronic Counting Devices" by Dr. F. H. Gage at 6.30 at the Glamorgan Technical College, Treforest.

Scottish Section.—January 13th. Discussion on "Band III Commercial Television" at 7.0 at the Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, C.2

January 20th. "Modern Ship-to-Shore Communication" by G. Macdonald (Marconi's) at 7.0 at the Department of Natural Philosophy, the University, Edinburgh.

Radar Association

London.—January 12th. "Invention and Development of SARAH" by D. Kerr (Ultra) at 7.30 in the Anatomy Theatre, University College, Gower Street, W.C.1.

Incorporated Practical Radio Engineers

South Coast Section.—January 13th. "Some Practical Applications of Transistors" by R. A. L. Cole (S.T.C.) at 7.30 at the Kings Arms Hotel, Castle Street, Christchurch.

North-West Section.—January 6th. "Cathode Ray Tubes" by a representative of the Edison Swan Electric Company at 7.30 at the Barley Mow Hotel. Turner Street, Manchester, 4.

East Midlands Section.—January 28th. "Electronics in the Radio and Electrical Industry" by C. Cowell (Fielden Electronics) at 7.15 at the Demonstration Theatre, Electricity Showrooms, Smithy Row, Nottingham.

Midlands Section.—January 5th. "K.B. Television Receivers and Modern Trends in Design" by a representative of Kolster-Brandes at 7.30 at the Crown Hotel, Broad Street, Birmingham.

North-East Section.—January 11th. "Rectifiers" by a representative of Standard Telephones and Cables at the Y.W.C.A., Saville Place, Newcastle-upon-Tyne.

Berks, Bucks & Oxon Section.—January 12th. "Visual Alignment" by J. Tomlin and G. Timberlake at 7.30 at the White Hart Hotel, St. Mary's Butts, Reading.

RANDOM RADIATIONS

By "DIALLIST"

TV Reception Freaks

INTERFERENCE with television reception by continental sound broadcasting stations has been widespread in recent months. I expect you've had some of it; I certainly have. It normally takes the form of faint, narrow, dark lines, sloping across the whole screen, now from left to right, now the other way. In severe cases these may give way to stationary vertical black bars, forming a sort of portcullis over the entire picture But the most curious television freak I've yet come across is reported by a friend who lives near Folkestone. The words "Télévision Française" appeared, faint, but perfectly legible, on his screen. Then a dim picture was seen accompanied by speech in French from the loudspeaker.

Shining 'Em Up

DURING a stay in Devonshire, in the late unlamented travesty of a summer, I was enormously impressed by the beautiful polish on the cabinet of my host's TV console. When I expressed my admiration he told me that it was due to a new kind of furniture polish which he'd been recommended to try a few months before. I brought some home and after giving it a thorough trial I feel that it is something of real value not only to owners of radio and television sets but to dealers and servicemen as well. "Topps," as it is called, is the easiest thing to use, as I found when I made my first experiment on a very old cabinet.

Live-chassis Sets

IT WAS stupid of me to suggest in these notes in the November issue that on d.c. all was well with a.c./d.c. receivers because they wouldn't work unless the mains connection was made the right way round. It must have been one of my absent-minded moments, for I know perfectly well that it's an even chance whether the live wire of most domestic d.c. systems is positive or negative to the earthed neutral. Apologies to readers and best thanks to A. B. Grief and others for pointing out the slip. A Dutch reader tells me that transformerless sets are used in Holland and asks whether the people of that country are thereby branded as uncivilized! I didn't know that the live chassis was permitted in the Netherlands, but I *do* know that the Dutch are amongst the most charming and cultured people in the world. A pity that they've followed our bad example with the live chassis. Most of those who have written to me share my dislike of a.c./d.c. television and radio receivers; but if the present trend continues I fear that this will soon be the only kind obtainable.

Reactivated C.R. Tubes

IT WOULD BE interesting to know, though no one is ever likely to do so, how many television c.r. tubes are needlessly scrapped in the course of a year. Leaving out of accounts the not inconsiderable number consigned to the rubbish dump by the kind of dealer who prescribes a new tube as the cure for ringing, or even for distorted sound, there are two common causes of failure which need *not* render a tube past redemption. The first of these is lost emission; and for this there are two possible remedies. One is to reactivate the cathode by raising it for a brief period to a temperature a good deal above that of normal working conditions. The other is to isolate the heater by fitting a special booster transformer and to apply permanently to it a voltage quite a bit above that reaching it when it was in the heater line. Neither kind of treatment can be guaranteed to be effective in every instance; but I know both reactivated and "boosted" tubes which are still going strong after months of use. The second kind of breakdown is the cathode-heater "short." Here again, the remedy is an isolating transformer, which, so far as my experience goes, is completely effective. Heater transformers of either kind can, naturally, be used only in sets worked off a.c. mains; but when he does fit one the knowledgeable dealer can kill two birds with one stone by improving the d.c. amplification on the lines suggested by W. T Cocking in the February, 1954, issue.

The Magic of Numbers

OLD HANDS will recall how in the early days of wireless we were wont to boast of the number of valves which our sets contained: the more of them there were, the greater our feeling of superiority and the better the sets sold. In one case the total was increased by the use of four little half-wave rectifiers instead of a single man-sized full-wave one! Screen size used to be the "criterion" of television sets, but that has now rather given way to the number of channels to which they can be tuned: the man in the street feels at least a head taller if he can boast of his 13-channel receiver. One's always meeting or hearing of people hailing from remote parts of the country who, when buying sets this year, have chosen to put down an extra £5 or more to pay for Band III tuners for which they're unlikely to have the slightest use before the said sets are worn out. As they say in the North, "There's nowt so queer as folk."

Maintenance Schemes

THE OWNER of such a complex assembly of expensive bits and pieces as a television receiver is probably wise to take out a maintenance contract or insurance policy with a reputable firm. This does not apply so much to readers of *Wireless World*, who can do their own repairs, as to those less gifted folk who don't know the first thing about the "works." Still, even boffins can find, if they are unlucky, valve after valve packing up after the guarantee on them has expired. Only the other day I met one who was bewailing the failure of a 17-inch c.r. tube after a life of seven months; and, as you know, there are other vulnerable parts which can provide unpleasantly expensive surprises. There are many soundly and honestly run maintenance schemes; but there are, one fears, certain others in different parts of the country which are far from being anything of the kind. The existence of these is a blot on the radio trade and I sincerely hope that steps will be taken to stamp them out.

"Well, actually Mrs. B, we've got a 27-inch screen."

UNBIASED

By FREE GRID

Render Unto Cæsar

FAR be it from me to join issue with the mighty who have been arguing about the origin of the valve. But the noise of conflict certainly set me thinking as to what exactly is meant by the word "valve." The Greeks had a word for it, but it isn't necessary to go farther back than the Latin word *volvere*, meaning "to turn." In the days of Cicero that part of an entrance which had to be turned or moved round in order to get through it was called a *valva*; in fact, Cicero himself used the word. The use of the word "valves" to describe the "leaves" of a folding door was not uncommon in Elizabethan days.

In 1615 the medical profession particularized the meaning of "valve" as a *one-way* door, using the word to describe those parts of the circulatory system which stop the blood regurgitating when the heart is not on its actual firing stroke. Forty-five years later it was used in engineering circles to describe an automatic one-way device inserted in a pipe through which water or air was flowing.

It seems obvious, therefore, that although literally there is no suggestion of unilateral conductivity in the word valve, its use as meaning a one-way device was well established three hundred years ago and so the expression "non-return valve" which we sometimes hear is tautological.

I have stated these facts at some length because attempts have been made in some quarters to say that de Forest and not Fleming patented the first *real* thermionic valve. Actually, of course, the addition of de Forest's grid to the existing thermionic valve turned Fleming's device into something else, namely, a thermionic relay.

A Vested Interest

MY ATTENTION has been drawn to a new question on the form which has to be filled in at the local post office if letters are to be redirected. This question demands to know the date of expiry of your sound or television licence.

Doubtless this question can be defended on the ground that it is merely a convenience to the P.M.G.'s clerical staff and also to the licence holder. But if this be so why does not the form ask about the date of expiry of the dog licence, another annually renewable affair handled by the P.O.? The reason is, I think, the entirely sordid one that the P.M.G. has a vested interest in one but not in the other. The £1 or £3 wireless licence yields quite a healthy rake-off to the P.M.G. but he would not get more than a few coppers out of the humble 7s 6d dog licence. Actually I believe I am right in saying he gets nothing at all but has to hand it all over to the local County Council, which is the authority responsible for licensing dogs. It is obvious, therefore, that the P.M.G. couldn't care less if we renew our dog licences or not.

How Many Microsqueers?

MORE than twenty years ago I published in these columns details of an appliance whereby a schoolmaster could put the administration of corporal punishment on a proper scientific basis so that there were "fair shares for all" in this matter.

Gauging the Vigour.

The haphazard methods employed at that time are unfortunately still in use with the result that those at the tail end of the queue in a mass caning receive less than their just due owing to pedagogic fatigue.

As you will see from the sketch reproduced from *W.W.* for April 7th, 1933, the apparatus was simple, consisting merely of two beams of light projected on to photocells so that the rate at which the cane moved, and, therefore, the force of the blow, was automatically calculated and shown on a large dial.

With the great advances in electronics which have been made in the past twenty years, the whole idea is now hopelessly out of date. Nowadays with modern technique it would be possible to dispense with the human element altogether and hand the delinquent schoolboy over to an electronic caner which would administer justice scientifically after the schoolmaster had decided on the correct number of microsqueers which the culprit deserved. The unit of flagellation is, of course, named after the famous Dickensian character.

Needless to say the electronic caner would incorporate some of the features of the Ace computer and also the encephalograph so that it could first measure the boy's nervous reactions and then adjust the strength of its blows accordingly, as some boys feel pain more acutely than others. The machine could thus, in some cases, modify the schoolmaster's sentence by applying electronically calculated mercy to human justice.

Telepathy by V.H.F.

THE name of Maskelyne usually conjures up—surely *le mot juste*—visions of a woman being sawn in half and it is a little odd to find that this well-known illusionist was one of the pioneers of radio. My attention has been drawn by the Rector of Ewhurst, Sussex, to an article in his parish magazine of over fifty years ago (July, 1901) in which are described experiments successfully undertaken by the Maskelyne concern and the Rev. J. M. Bacon, M.A., in wireless communication between the earth and a balloon in flight.

From this it is obvious that wireless signalling between aircraft and ground followed very hard on the heels of ship and shore communication. These aeronautical experiments were conducted in the summer of 1899 and in that same year the first wireless distress call was sent out by the East Goodwin lightship.

Four years later Nevil Maskelyne was still engaged in wireless experiments. There was some acrimonious correspondence in *The Times* following his attempt in 1903 to show certain weaknesses in wireless tuning by transmitting signals which broke in upon the receiver which Fleming was demonstrating at the Royal Institute. This incident is recorded in the recently published biography of the late Sir Ambrose Fleming.*

It is difficult to say from the meagre information available whether the famous conjurer had a genuine scientific interest in radio or was merely seeking to use it as a stage stunt as is done to-day with tiny v.h.f. transmitters in music-hall "telepathic" turns.

In the old days of stage "telepathy" a clever and elaborate code either of words, vocal intonation or even body posture was used by the stooge in the stalls to let the seer on the stage know what he was holding in his hand. According to Dr. D. J. West, M.B., the experimental research officer to the Society of Psychical Research, the successful use of the code required long practice, and I can well believe it. In his recently published book, "Psychical Research To-day," he remarks how much simpler is the modern technique of using a small radio transmitter. Unfortunately, Dr. West gives no technical details, but obviously the stooge must use a midriff mike and be a ventriloquist in the literal meaning of that term.

* "The Inventor of the Valve," by Dr. J. T. MacGregor-Morris. (Television Society.)