Wireless World

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Television and V.H.F. Sound

THOUGH prophets are usually not lacking in courage, not many of them have been bold enough to speculate on the future of sound broadcasting *vis-à-vis* television. But, without entering into competition with those few who have chanced an opinion, we may suggest that the B.B.C.'s newly launched scheme for v.h.f. broadcasting may well point the way towards a closely integrated sound/vision system of the future.

The new B.B.C. scheme, conceived several years ago, represents an idea in large-scale broadcasting that is without parallel in the world. Essentially it is based on combining Band I television stations with Band II three-channel v.h.f. sound transmitters. Propagation characteristics of these two sets of signals are not wildly different, and the scheme represents good engineering, being economical in both equipment and manpower.

Just as the addition of sound broadcasting transmitters to the television stations is a relatively inexpensive matter, the provision of v.h.f. sound facilities in television receivers is even more economical. A number of these combined sets have already made an appearance, and more are to be expected. Such combined broadcast receivers may, in the future, well satisfy the needs of the majority, and their widespread use may well lead to a closer integration between sound and vision broadcasting.

Apart from these possibilities, there is the question of quality of the new service. Interference is now almost intolerable on the medium frequencies; it goes without saying that listeners within the v.h.f. service areas will get a much quieter background. But what of improved frequency range and dynamic range? Here there are obvious limitations, including the landlines, but the B.B.C. has given assurances that the new transmissions will permit a substantial improvement in receiver performance.

Electrostatic Loudspeakers

DEVELOPMENTS in electrostatic speakers, now being described in articles appearing in our pages, may conceivably have an important effect on the combined vision/sound receiver discussed in the preceding paragraphs. High-quality sound is not usually considered necessary in a television set, but improvement in this direction may be demanded when the set includes provision for v.h.f. sound reception. An obvious advantage of using the electrostatic speaker for such a set is that the necessary high polarizing voltage is already there without extra cost. It is too early to make guesses about the shape an ideal speaker would take; perhaps some change in the now-almost-traditional proportions of the television receiver cabinet would be needed.

Whether these speculations be justified or not, the resurgence of the electrostatic speaker is certainly a matter of the greatest interest. Every conceivable method of artificially reproducing sound has been explored, but for over a quarter of a century the moving-coil principle has met no serious challenger; now, good as it can be, further development seems unlikely. The moving-coil speaker has always had to carry two onerous limitations: the mass of its moving parts and the necessity for providing a diaphragm that is at one and the same time rigid and flexible. True, the mass has been utilized in designing for level output at low and medium frequencies, but the price of linearity in this range is a steady deterioration in output at high frequencies. This disability can be lessened only by allowing the diaphragm to "break up."

The electrostatic speaker, on the other hand, would appear to be the answer to the designer's dream. As was pointed out last month, its performance is always predictable, no matter what the size and shape of the diaphragm.

Since it has been shown that the electrostatic principle is not inherently non-linear, the field is open to almost limitless development. We have already heard working a prototype speaker which covers a frequency range from 40 c/s to the upper limits of audibility. There can be no denying that the quality of reproduction has a freshness not usually associated with the heavier diaphragms of moving-coil speakers. No doubt practical problems remain to be solved, but it seems likely that the electrostatic speaker, after a long period of hibernation, is coming back to vigorous life.

V.H.F. Broadcasting Starts

ON May 2nd, the v.h.f. station at Wrotham ceased to operate experimentally and started to work a regular service as the first station of the B.B.C.'s new f.m. broadcasting system. By the end of 1956, it is expected that eleven stations will be in operation and will cover 83% of the country with the Light, Home and Third programmes in a way which will be but little affected by interference. After Wrotham, a further ten stations are scheduled:—at Pontop Pike, Divis, Meldrum, Norwich, South Devon, Sutton Coldfield, Wenvoe, Holme Moss, Blaen Plwy, and Penmon.

At each station the three programmes will be radiated on frequencies 2.2 Mc/s apart in Band II. For Wrotham, the frequencies are 89.1 Mc/s (Light), 91.3 Mc/s (Third) and 93.5 Mc/s (Home). They will all be radiated from a common aerial array of the slot type. This has already been provided on many television stations (e.g., Sutton Coldfield and Holme Moss) and is evidence of the long-term planning of which this Band II service is the result.

The general plan is to have six 10-kW transmitters at each station. In effect, they will operate in parallel pairs to provide three transmitters of 20 kW each and, with the aerial gain, an effective radiated power of 120 kW each. The interconnection of the transmitters is not straightforward paralleling, however.

If we call one pair A_1 and A_2, another B_1 and B_2 and the third C_1 and C_2, then the outputs of A_1 and B_1 are combined and then mixed with the output of C_1 and fed to one-half of the aerial array. The outputs of A_2 and B_2 are similarly combined and mixed with the output of C_2 and fed to the other half of the aerial array.

The object of this somewhat curious arrangement is to minimize the effects of any fault. If any one transmitter develops a fault, the other one of the pair continues in operation and the result is merely a 3-db drop in signal strength. If a fault occurs in one-half of the aerial, the same thing happens. Indeed, there can be simultaneous faults in one-half of the aerial and in three of the transmitters on the same side of the chain with only a 6-db reduction in the signal. Arrangements are made to reverse the connections of the transmitters to the aerials so that, in the event of such a double fault, the good half of the aerial can be connected to the good transmitters.

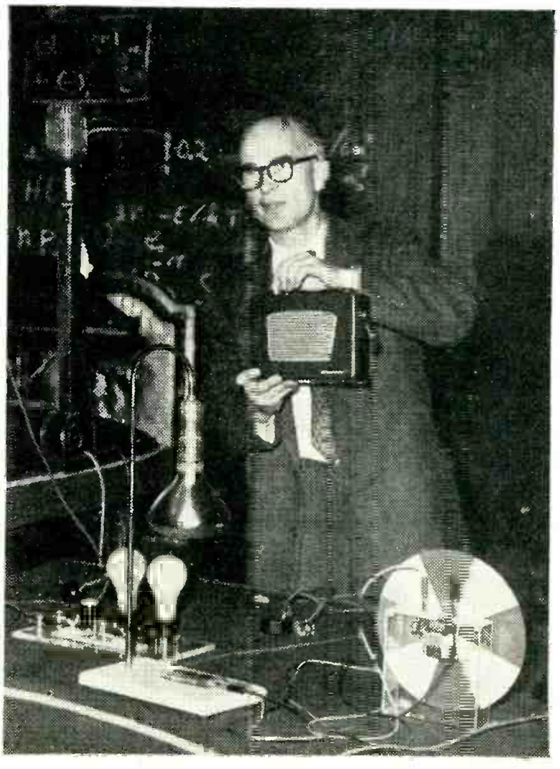
It might be thought that the parallel operation of transmitters around 100 Mc/s would be a difficult matter. Actually, however, they have a common drive. Each basic transmitter has its own drive unit but only one is used at a time to drive both transmitters of a pair, the other acting as a spare.

The system of modulation used is F.M.Q.[1], developed by Marconi's, who built the Wrotham station and from whom 46 other transmitters for the scheme have been ordered. The mean frequency is determined by a high-stability crystal oscillator and modulation is effected by a reactance-valve circuit which "pulls" the crystal frequency.

The general arrangement has been dictated by the requirement of extreme reliability, so that operating personnel are virtually unnecessary. Automatic monitoring devices are installed to call attention to any defect and, except for the repair of a fault, the stations should need no attention beyond routine maintenance.

The station at Wrotham differs quite a bit from this general description, for the apparatus is, in the main, that used for the experimental transmissions over the last few years. There are two 25-kW transmitters with two 4½-kW stand-by types and two 10-kW transmitters. The outputs of the two 25-kW ones are combined and then the signal is split into two. With each half is mixed the output of one of the 10-kW transmitters and each is fed, as before, to one-half of the aerial array. The final result is much the same, but the way in which it is achieved is different. It would clearly have been uneconomical to scrap two 25-kW transmitters, which is what would have been necessary if Wrotham were to keep to the general plan for the other stations.

[1] "F.M.Q.," by W. S. Mortley, A.M.I.E.E., *Wireless World*, October 1951, p. 399.



FATHER OF THE TRANSISTOR. This year's I.E.E. Kelvin Lecture was delivered by Dr. W. Shockley, leader of a team at Bell Telephone Laboratories which extended the foundations of semi-conductor physics and ultimately evolved the transistor. Dr. Shockley gave an account of the basis of transistor physics and described some of the many applications of this device, such as in hearing aids and portable radio receivers. He also dealt with the prospects of using semi-conductor junctions for converting light into electrical energy and disclosed that trials are to be carried out on rural telephone lines powered by sunlight.

Tropospheric Scatter Propagation

200-mile Transmission on Frequencies in the U.H.F. Band

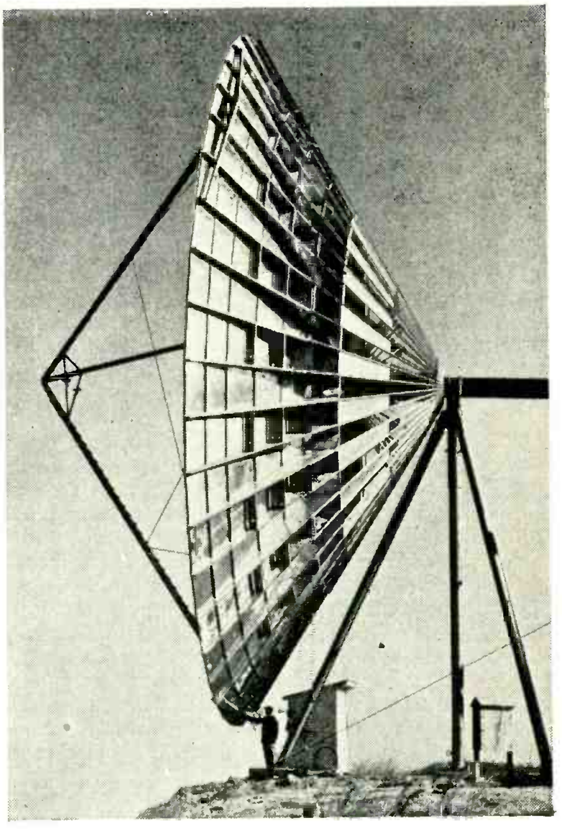
IN *Wireless World* for July, 1952[1], a type of relatively long-distance transmission for frequencies in the lower part of the v.h.f. range was described, in which propagation is by a forward scattering process from irregularities in the lower part of the ionosphere, so that a portion of the radiated energy is returned to the ground and is receivable at distances up to about 1,250 miles.

According to the theory of Booker and Gordon[2] a similar, but distinct, type of scattering should take place in the troposphere, even though the air there is not ionized. In this region the air is in a state of irregular motion, this turbulence being due to local irregularities in the speed and direction of the air flow, thermal instabilities, etc. Such a turbulent medium may be visualized as one containing a large number of spherical blobs, and the dielectric constant of the individual blobs may differ widely from the mean dielectric constant of the medium as a whole. Therefore their refractive indices differ from that of the medium, in a degree depending on the scale of the turbulence, and they thus constitute a system of scattering centres for radio energy, the amount of energy scattered depending on the relation between the size of the blobs and the wavelength. The energy is scattered mainly in a forward direction, so as to be receivable at points far beyond the radio horizon of the transmitting aerial. Of course the amount of energy scattered by unit volume of the atmosphere is extremely small, but by the use of highly directive beam aerials for both transmitting and receiving, both being directed on to a given area in the troposphere, a large number of scattering centres can be brought into use, and a usable amount of energy made available at the receiver. There is increased forward beaming of the scattering with increased frequency, so that on frequencies in the u.h.f. band the scattered energy per unit volume of atmosphere is much greater than on lower frequencies.

Practical Applications

Some experiments designed to put the above facts to a practical use have recently been carried out in America. They have been conducted jointly by Bell Telephone Laboratories and Massachusetts Institute of Technology on the lower frequencies in the u.h.f. band, and also by Syracuse University on a frequency of 915 Mc/s, the latter experiment being still in progress.

The result of the first of these experiments has been to develop a system of "over the horizon" transmission, capable of being used for television picture transmission, as well as for multi-channel telephone service. The propagation medium will thus support the wide-band transmission necessary for the above services, and signals would appear to be usable over a range of about 200 miles. It is visualized, therefore, that the present requirement for u.h.f. radio links to be within "line of sight," i.e., about 30 miles apart, will no longer apply, and that the new system may, in time, supersede the present microwave radio relay network across the United States, in which the stations are spaced by about that distance. If that is so, and the system is economical in use, one can see immediate useful applications for it in Europe; for example, in the international exchange of television programmes.



The 60-ft. experimental aerial reflector used to receive u.h.f. television pictures at a distance of 200 miles by means of tropospheric scatter propagation.

Courtesy Bell Telephone Laboratories

The experiment was based on the fact that signals were consistently obtained beyond the radio horizon with the present radio link system: signals which were most probably propagated according to the Booker and Gordon theory. The next step was to use higher power and erect larger aerials than are used in the conventional system. Ten-kilowatt transmitters were employed using aerial reflectors of 60 feet in diameter, that is 20,000 times the power and 30 times the aerial reflector area as compared with that used in the ordinary links. One of these aerial systems is shown in the accompanying illustration. By this means it was found possible to "beam" enough power on to the appropriate area of the lower atmosphere that sufficient energy was scattered in a forward direction so as to reach the receiving aerial far over the horizon, and there provide a workable signal. Towards the end of 1953 it was found possible to transmit 12 speech-frequency channels over the system, and in 1954 television was first successfully transmitted between Holmdel, N.J., and New Bedford, Mass., a distance of 188 miles.

The system may be likened to that of a powerful searchlight, which casts a beam in a straight line. Such a searchlight aimed at the sky can be seen from the ground miles away, even when the searchlight is behind a hill. This is possible only because some of the light is scattered by the atmosphere and reaches the observer on the ground.

It is emphasized that, in the United States, the new system will, at first, probably act as a supplement to, rather than as a replacement of, the present radio relay link system.

The system should not be confused with the ionospheric scatter system mentioned at the beginning of this article. The maximum distances possible are much less in the present case, but, on the other hand, the ionospheric system will not support the wide-band transmission necessary for television.

The experiment being conducted by Syracuse University appears to be on much the same lines as that just mentioned, the transmitter being at Lexington, Mass., and the receiver at Syracuse, N.Y., a distance of 254 miles, the intervening mountains ranging up to 3,000ft. The transmitter power is 12 kW and the aerial reflectors 28ft in diameter, these being identical at transmitter and receiver. A.M., f.m. and pulse signals are being used. The transmitting and receiving aerials are manually adjustable in azimuth and elevation in order to determine the most suitable angles for optimum results. These tests are designed to determine which type of modulation is best suited to this type of radio link, and to determine the variations in reception with time of day, weather and seasons of the year.

REFERENCES

[1] "New Kind of V.H.F. Propagation," *Wireless World*, p. 273, July, 1952.

[2] Booker, H. G., and Gordon, W. E., "A Theory of Radio Scattering in the Troposphere," *P.I.R.E.*, Vol. 38, No. 4, p. 401, April, 1950.

"Adjacent-Channel" Colour Television

INVESTIGATIONS by the radio industry into the merits of various colour television systems for this country were discussed at a recent lecture by L. C. Jesty to the Television Society. One system under consideration, which has often been mentioned in *Wireless World*, is the modified version of the American N.T.S.C. system in which the colour signal is transmitted outside of the normal monochrome band, but overlapping the monochrome band of the station in the adjacent channel. For example, the colour signal of Kirk O'Shotts (Channel 3) would be transmitted within the monochrome band of Sutton Coldfield (Channel 4), and although this would undoubtedly cause some interference it would probably not be so bad for the Midland viewers as having their own colour signal continuously present and interfering in Channel 4.

Of course, the amount of interference in this system would depend on the geographical proximity of the stations in the adjacent channels, and it appears that the radio industry's investigation so far has been largely concerned with this matter. Mr. Jesty showed a map which indicated the areas most likely to suffer from the colour-signal interference, the worst-affected ones appearing to be largely in the North and the West. This, however, was only based on calculation and it would be necessary to carry out actual field tests if the system proved worthy of further investigation. Expressed in actual figures, the calculated results suggested that only about 1.5-2% of the viewing public would suffer from the interference for 1% of the time, and this, said Mr. Jesty, did not look too impossible.

F.M. Tuner Kit

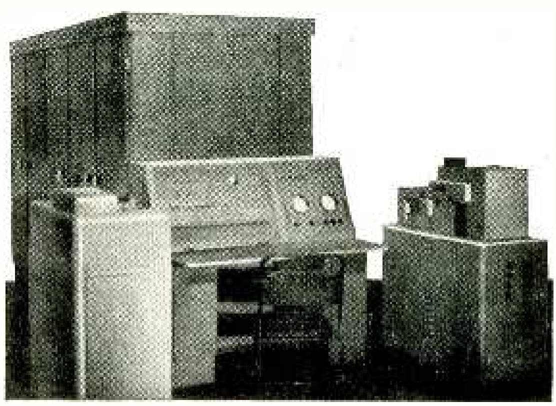
CAPACITOR and resistor kits for the F.M. Tuner described in our May 1955 issue have been put up by Erie Resistor, Ltd., and should now be obtainable from retailers. To assist constructors the 270-Ω, ±10% and the 180-Ω, ±10% resistors for R_2, R_8 and R_{10} are included so that either EF80 or EF91 valves may be employed. The alternative resistors are included free of charge. Resistors R_{20} and R_{29} are, however, not included as the former is not made by Erie and the value of the latter has to be found experimentally.

The capacitor kit costs £2 5s 6d and the resistor kit £1 7s 2d. It should be noted that type NPOL is included for C_6 and type NPOM for C_{11} as these are more suitable than type NPOK which was originally specified.

Election Result Computor

BELOW is the electronic digital computor which the B.B.C. are using on election night to calculate the totals of seats won, lost and retained by the parties and also to forecast the final result. Built by English Electric, it is an engineered version of the N.P.L. ACE (Automatic Computing Engine) and is therefore appropriately named DEUCE (Digital Electronic Universal Calculating Engine). A feature of the machine is a magnetic drum storage system in which the two sets of recording and pick-up heads (16 heads on each) can be shifted automatically to any one of 16 positions across the 256 tracks on the drum in 25 milliseconds. This facility permits a great saving in electronic equipment and in fact about 1,300 miniature valves are used.

Numbers are represented in binary form by trains of pulses at a p.r.f. of 1 Mc/s, each train (or "word") containing 32 binary digits or the equivalent of 9 decimal places plus a sign. The magnetic storage drum will hold 8,192 of these "words." High speed of operation, however, is achieved partly by the use of acoustic delay lines of limited capacity for the main store, giving quick access to the stored information. Another saving of time is achieved by the precise timing of the coded instructions which initiate the various arithmetical operations. Most operations are, in fact, accomplished in 64 microseconds.



WORLD OF WIRELESS

Organizational, Personal and Industrial Notes and News

B.B.C. Band III Television

WHEN announcing the plan for the clearance of mobile radio from Band III (see our May issue) the retiring P.M.G.—Earl De La Warr—stated that four of the eight channels ultimately to be made available for television would be allocated to the I.T.A. and the remainder for an alternative service in that band. In anticipation, therefore, of the P.M.G.—whoever he may be in the next Government—granting these channels to the B.B.C. for a second television service, the Corporation has ordered sound and television transmitters for two stations.

The 10-kW vision transmitters with the associated 2.5-kW sound transmitters are scheduled to be delivered by Marconi's towards the end of next year.

Competitive Television

LONDON'S first competitive television programme is to be broadcast on September 22nd from the I.T.A.'s transmitter being built at Beaulieu Heights, Croydon. The I.T.A. announces that for a few weeks prior to the opening, high-power test transmissions will be radiated.

The transmitter, which will have an e.r.p. of 60 kW, will radiate in Channel 9 with offset carriers (vision 194.75675 Mc/s, sound 191.27 Mc/s). The approximate service area was given on page 12[illegible] of our [illegible] issue.

Import-Export Ratio

THE provisional figure of £7,625,000 for British radio equipment exported during the first quarter of this year is an increase of more than £650,000 on the figure for the same period in 1954—a record-breaking year. The Radio Industry Council in announcing this figure draws attention to the continued marked rise in the overseas sales of sound recording and reproducing equipment. The value for the first three months of the year was £1.3M, an increase of more than £430,000 over the same period last year when exports for the whole year were valued at the record figure of £3.7M.

Although exports of valves and c.r. tubes increased during the period under review by some £175,000, and, moreover, imports of these accessories fell by nearly £130,000, there was still an adverse balance of trade of over £50,000 in this section of the industry.

Taking radio equipment as a whole, imports (according to figures issued by the Board of Trade) increased by £650,000—the increase recorded for exports.

PERSONALITIES

Sir Edward Appleton, F.R.S., the new president of the Radio Industry Council in succession to Lord Burghley (who has held the office since 1952), has been principal and vice-chancellor of Edinburgh University since 1949. For ten years prior to going to Edinburgh Sir Edward was secretary (administrative head) of the Department of Scientific and Industrial Research. It will be recalled that in 1947 he was awarded the Nobel Physics Prize for his work on atmospherical physics and his discovery of the Appleton layer.

R. H. Hammans, recently appointed chief television engineer of Granada Theatres—one of the four programme contractors to I.T.A.—was with the B.B.C. from 1935 until taking up his new appointment. Originally on sound outside broadcasts he transferred to television O.B.s in 1937. Before going to the B.B.C. he was with the International Marine Radio Company for four years. Mr. Hammans, who operates an amateur station with the call G2IG, is executive vice-president of the **R.S.G.B.**

Alfred H. Whiteley, O.B.E., Comp. Brit.I.R.E., the new president of the Association of Public Address Engineers, founded in 1926 at the age of 33 the Whiteley Electrical Radio Company, manufacturers of components, accessories and electronic equipment. He was elected a Companion of the Brit.I.R.E. in 1949 and became the first Companion to serve on the Council of the Institution.

T. D. Humphreys, M.Brit.I.R.E., who joined Reproducers and Ampliers, Ltd., as general manager in 1953, has been elected to the board. Before going to R. & A., he was general manager of Radar Components, Ltd., and was previously with A. C. Cossor, Ltd.

L. Kearton Parker has joined Winston Electronics, Ltd., of Hampton Hill, Middlesex, as chief sales engineer. He was for ten years with the Telephone Manufacturing Company, Ltd., which he joined in 1945 at the age of 29, and was for some time head of the audio and acoustics section of the Development Department. From 1952 to February this year he was telecommunications consultant to the company.

In addition to those mentioned in our last issue who had received the Insignia Award in Technology (C.G.I.A.) **Charles H. Rumble** received the award for his thesis on the manufacture of matrices for the production of long-playing records. Mr. Rumble is a director of the Transcription Manufacturing and Recording Company, Ltd., of Mitcham, Surrey.

Sir George Nelson, who is chairman and managing director of the English Electric group of companies, which includes Marconi's, has been appointed a governor of the Imperial College of Science and Technology.

OUR AUTHORS

W. C. Pafford, contributor of the article on some problems of lighting in television studios, is both a television engineer and lighting engineer. In 1932 he joined the B.B.C. Midland Regional transmitter which was then transmitting sound for the 30-line television experiments. He became a maintenance engineer on 405-line television in 1936 and was later in charge of maintenance and wartime operations at Alexandra Palace. Mr. Pafford, who is now a lighting supervisor on television O.B.s, is also an artist and a number of his cartoons, signed "Paff," have appeared in *Wireless World.*

G. H. Leonard, who describes a wobbulator adaptor for Band III in this issue, has for six years been with Ultra Electric, Ltd., where he is senior engineer in charge of radio and television test equipment. He was educated at University College, London, graduating with honours in physics in 1947.

OBITUARY

Charles J. Pannill, who was the first chairman of the Board of editors of our American contemporary, *RCA Review*, until publication was temporarily suspended in 1942, died in New York in February. He was associated with Professor R. A. Fessenden in his early wireless experiments and in 1912 received the first American radio operator's licence. He became general manager of Radiomarine Corporation of America in 1928 and was president when he retired in 1947.

Arthur H. Morse, who was with the Marconi Company as an engineer specializing in direction finding before going to N. America in the early 1920s to become managing director of the Canadian Marconi Company, died in New York on April 6th, aged 74. He joined Marconi's on their acquisition of United Wireless Telegraph Co., of which he was superintendent. In his book "Radio: Beam and Broadcast," published in 1925, he reviewed the history of radio patents, on which he was an acknowledged authority.

IN BRIEF

Television Licences in force in the United Kingdom increased during March by 96,373, bringing the total to over 4.5 million. The number of domestic sound-only licences totalled 9,208,936 (including 62,506 issued free to blind persons). Television licences totalled 4,503,766 and car radio 267,794, giving an overall total of 13,980,496.

Competitive Television.—The licence granted by the P.M.G. to the I.T.A. on April 6th for the operation of its stations will continue in force until July, 1964. It names only the Croydon station but permits the establishment of stations "at such other places in the United Kingdom, the Isle of Man or the Channel Islands, as shall be approved." The annual fee payable is £500.

B.R.E.M.A. Council.—The following member firms of the British Radio Equipment Manufacturers' Association have been re-elected to the executive council for the ensuing year. The names of the companies' representatives are in parentheses: Balcombe (E. K. Balcombe); Bush (G. Darnley Smith); Cole (G. W. Godfrey); Cossor (J. S. Clark); English Electric (D. C. Spink); Ferguson (L. Bentley-Jones); G.E.C. (M. M. Macqueen, chairman); Gramophone Co. (F. W. Perks); Kolster-Brandes (P. H. Spagnoletti); Philips (A. L. Sutherland); Pilot (H. L. Levy) and Ultra (E. E. Rosen).

At the annual general meeting of the **British Sound Recording Association** on May 13th Norman Leevers, director of Leevers Rich and Company, was re-elected president for a second year of office. R. W. Lowden continues as honorary secretary, H. J. Houlgate, membership secretary and D. W. Aldous, technical secretary.

It was announced at the annual dinner of the **British Wireless Dinner Club** that Harold Bishop (B.B.C. Director of Technical Services) and Earl Mountbatten had accepted the invitations to become president and vice-president respectively. The membership now totals 368.

Independent Commercial TV? A special licence was granted by the Post Office to the J. Arthur Rank Organization for relaying television programmes, including specimen "commercials," by a 6,800-Mc/s transmitter from the State Theatre, Kilburn, to the British Industries Fair at Olympia, where demonstrations of Cintel large-screen television were given.

The present extended schedule of B.B.C. **Television Trade Tests** (weekdays 11.0-1.0) which was introduced last September will continue until August 31st.

Since we published particulars of the international contest for **Radio-Controlled Models** in our May issue the dates have been changed. The boat competition will be on July 30th and the aircraft contest on the following day. Further details are obtainable from D. W. Aldridge, 1, Fowberry Crescent, Fenham, Newcastle-upon-Tyne, 4.

I.T.A. Headquarters.—Towards the end of June the I.T.A. plans to move from the temporary premises at Woods Mews, Park Lane, occupied since last October, to its permanent administrative headquarters at 13-14, Princes Gate, London, S.W.7.

Transistor-Grade Germanium—single crystal or polycrystalline—is available to specified characteristics from G. A. Stanley Palmer, Maxwell House, Arundel Street, Strand, London, W.C.2, who will supply small quantities if required.

Band III Tests.—There has been some confusion regarding the times of the transmissions (vision 194.75 Mc/s, sound 191.27 Mc/s) from the Belling-Lee station, G9AED, at Croydon. A test pattern is now radiated from 10.30-12.30 and 2.0-4.0 (Monday to Friday) and 10.0-1.0 (Saturday).

What is V.H.F.? What is f.m.? Shall I need a new set to receive v.h.f.? These questions and many more are answered for the non-technical listener in a booklet prepared by the Engineering Information Department of the B.B.C. Sketch maps giving the approximate coverage of the first ten v.h.f. stations planned are included in the 12-page booklet obtainable free from the B.B.C. Publicity Department, 12, Cavendish Place, London, W.1.

Maximum Allowances for second-hand sound and television receivers purchased by dealers are given in the booklet "Used Radio and Television Set Values (1955)" prepared by the Radio and Television Retailers' Association and published by the Trader Publishing Company. It costs 2s 9d, including postage. The oldest sound and television receivers listed are of 1949 vintage. A nominal allowance of £2 is quoted for older television sets.

EXHIBITIONS

Twenty papers on the production and properties of plastics will be presented at the Convention which is being held during the **British Plastics Exhibition** at Olympia from June 1st to 11th. Admission to the exhibition, which is organized by *British Plastics* and will be open daily from 10.0-6.0, is 2s 6d.

"Silicones for Industry" is the title of an exhibition covering the production and application of silicones, which is being held at the Midland Hotel, Manchester, from June 13th to 18th. Invitation tickets can be obtained from the organizers, Midland Silicones, Ltd., 19, Upper Brook Street, London, W.1.

Instruments on Show.—The third British Instrument Industries Exhibition opens at Earls Court on June 28th. It will be open from 10.0-6.30 daily (except Sunday) until July 9th. Admission is 2s 6d.

Amateur Radio Show.—The R.S.G.B. has tentatively booked accommodation in the Royal Hotel, Woburn Place, London, W.C.1, for the week November 21st-26th for this year's amateur radio show.

A Scottish Exhibition of electronic equipment in which 26 firms are participating has been arranged at the School of Engineering, Burnbank, Lanarkshire. It will be open daily (10.0 to 9.0) from June 6th to 11th.

BUSINESS NOTES

An order for six more v.h.f. transmitters, making 46 in all, has been placed by the B.B.C. with **Marconi's.** They will provide a three-programme service from Holme Moss; two transmitters being operated in parallel for each programme. The Corporation also has on order 38 transmitters from Standard Telephones & Cables.

Aveley Electric, Ltd., representatives for Rohde and Schwarz, Munich (communication and laboratory equipment), are closing their office in Tottenham Court Road, London, W.1, on June 12th and moving into a new factory at Ayron Road, Aveley Industrial Estate, South Ockendon, Essex (Tel.: South Ockendon 3292).

Closed-circuit television equipment has been installed in a ship of the Royal Canadian Navy by **Pye Canada, Ltd.**, to permit visual communication from the operations room to various key points in the vessel. A camera in the operations room will be focused on the plotting chart upon which the movements of other vessels are recorded. Receivers will be installed at five or six key points in the ship so that officers will have an immediate picture of the tactical situation rather than mere information about it.

Radio communication equipment, radar and other electronic aids to navigation and fishing have been installed by the **Marconi International Marine Communication Company** in the new fishery research vessel *Sir William Hardy*. Other recent Marconi Marine installations include communication equipment and d.f. gear in the new 32,000-ton-capacity steam turbine tanker *British Victory*, telegraphy-telephony transmitter, receivers, echometers and direction finders in the motor trawler *Princess Anne*, and an R/T transmitter-receiver and echometers in the motor trawler *Bermuda*.

McMurdo Instrument Company, of Ashtead, Surrey, announce that sales of their Unitags, both unassembled and assembled, are now conducted by Harwin (Engineers), Ltd., 101, Nibthwaite Road, Harrow, Middx. (Tel.: Harrow 0381), to whom all enquiries and orders for this component should be sent direct.

Airtech, Ltd., of Aylesbury and Thame Airport, Haddenham, Bucks, have been awarded, by the Canadian Department of Defence Production, the contract for the maintenance and repair of all radio and electronic equipment used by the Canadian air force in the United Kingdom.

Gresham Transformers, Ltd., have transferred the production of small transformers for the Electronics Division to their Lion Works on Hanworth Trading Estate, Feltham, Middlesex. K. G. Lockyer, B.Sc., A.M.I.E.E., A.M.Brit.I.R.E., who has been appointed manager of Lion Works, was formerly production manager with Solartron Laboratory Instruments, having previously been with Philips (Mitcham Works), Plessey and London Electrical Company.

A transposition of figures in **Goodmans'** advertisement in this issue has been noticed since the page went to press. The fundamental resonance of Type 1205 is 75 c/s and that of Type 1210 is 35 c/s.

Among the contracts recently placed with **Pye Marine** for v.h.f. radio-telephone equipment are installations for 10 tankers operating on the Manchester Ship Canal; for Aberdeen fishing vessels—providing short-range intercommunication whilst fishing in pairs; and for the new Trinity House pilot vessel *Pathfinder*. Pye Marine have also provided a fixed station at the boat yard of Saunders-Roe (Anglesey), Ltd., and a mobile set is taken on board new craft undergoing sea trials so that results of the tests can continually be communicated to the yard at Beaumaris.

A new factory at West End, Congleton, Cheshire, has been bought by **Aerialite, Ltd.,** for the manufacture of television aerial equipment, convertors and components.

The radio components (Clix) and wiring accessories departments of the **Edison Swan Electric Company, Ltd.**, have moved from 21, Bruton Street, London, W.1, to the company's head office at 155, Charing Cross Road, London, W.C.2 (Tel.: Gerrard 8660).

EXPORT NEWS

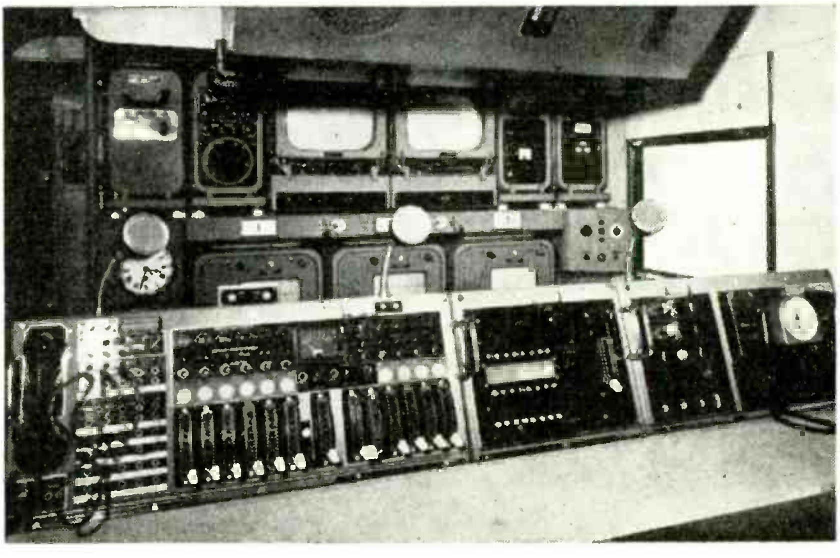
The equipment for another radio link for the Swiss television network has been supplied by the **General Electric Company**, who equipped the trans-Alpine link in time for the European programme exchange last year. The new link connects Uetliberg (Zurich) with La Dole (Geneva)—a distance of about 150 miles—and also ties in with the earlier installation linking Chasseral and Monte Generoso.

An order worth over £20,000 to supply the Eire Department of Posts and Telegraphs with three 12-channel open-wire telephone carrier systems has been secured by the **Automatic Telephone and Electric Company** in face of keen Continental and American competition. The equipment will link Limerick and Tralee, Limerick and Ennis, and Mulingar and Cavan.

A technical assistance mission from the International Civil Aviation Organization is advising the Afghanistan government on bringing the country's two main airfields up to international standards. As part of the development scheme the Department of Civil Aviation has ordered from **Redifon, Ltd.**, twelve 5-W radio-telephones, three 50-W radio-telephones, two 500-W h.f. transmitters for ground-to-air telephony, two non-directional beacons and four communication receivers. Twelve of these communication receivers, which cover the range 13.5 kc/s to 32 Mc/s, have also been ordered by the New Zealand Posts and Telegraphs Department.

Six studio tape recorders (Type BTR/2A) have been ordered from **E.M.I. International, Ltd.**, by All India Radio, which has previously ordered 17 transportable tape recorders (Type TR/50A). Thirty-two of these transportable instruments have also been supplied to the Indian Ministry of Information and Broadcasting.

Redifon radio equipment has been installed in the fleet of 75-ft motor trawlers built in Hong Kong for the South Korean government under a United National Korean Reconstruction Agency procurement plan.



THE LATEST B.B.C. mobile control room for television O.B.s which is fitted with three Marconi cameras and associated control and monitoring equipment. In the foreground are the 10-channel sound-mixing panel and the vision-mixer which will accept eight inputs. Behind are the picture monitors.

Components Exhibition

TRENDS EVIDENT AT THIS YEAR'S R.E.C.M.F. SHOW

The "private" exhibition held in London by the Radio and Electronic Component Manufacturers' Federation from 19th to 21st April is reviewed in these pages. In addition to describing in detail some of the new components and accessories shown, we give in each category a list of exhibitors and their main products. Test and measuring equipment, and also valves, are dealt with on pp. 274 and 277. New sound-reproducing equipment will be discussed in a later issue.

RESISTORS

ONE of the most interesting and useful resistance devices seen for some time was shown this year by Erie. It consists of a low-value resistor with a tensioned coil spring soft-soldered to one end, the whole being enclosed in a ceramic capsule. It is intended to combine the functions of a surge limiting resistor and fuse in the anode circuit of mains rectifiers and is appropriately called a fuse resistor. In the event of a heavy current flowing for an appreciable time the heat generated in the resistor melts the solder and releases the spring and so opens the circuit. The fuse "blows" about 15 sec after the breakdown, or short circuit developing.

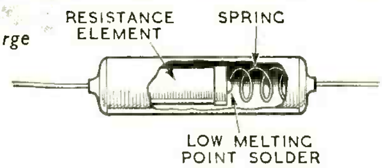
Metallized film resistors are being more widely adopted where high stability is required and although the technique is not new it laid dormant for many years before revival in admittedly a modernized form a few years ago. The latest addition to this type is the new "Q" model developed by Erg. It measures 2in long by $\frac{11}{32}$in in diameter and is rated at 2 W. The metal film is deposited on a glass rod and then spirally cut to give the required resistance values.

Two main lines of development can be seen in connection with the ubiquitous carbon volume control. One is the introduction of still smaller models with, of course, lower wattage ratings. For transistor equipments only low-wattage types are required at present. Egen have a sub-miniature pre-set open type rated at $\frac{1}{10}$ W and measuring approximately $\frac{3}{4}$in × $\frac{1}{2}$in; Plessey have one, described as the Type G, on a circular base of just over $\frac{1}{2}$in in diameter while Morganite have some models designed originally for hearing aids and later developed for other uses.

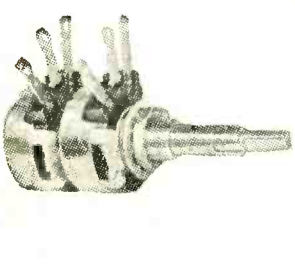
Reduction in size of the domestic-type volume control proceeds apace and several firms, Dubilier being one, have extended the idea by ganging their miniature "Q" type in order to save panel space. Concentric spindles are employed. Ganged type are popular in mobile equipments and especially in car radio sets where the frontal aspect has to be kept down.

The final main development is complete sealing of the element, the object being to give better stability under widely varying conditions of temperature and humidity. Many ingenious ways are employed to seal the spindle without introducing too much friction.

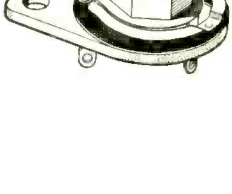
Manufacturers: A.B. Metal Prodts.; British Elect. Res.; Bulgin; Colvern; Dubilier; Egen; Electronic Comp.; Electrothermal; Erg; Erie; Labgear; Morganite; N.S.F.; Painton; Plessey; Salford; Welwyn; W.B.; Zenith.



Right: Erie anti-surge fuse resistor



Left: Double "Q" volume control made by Dubilier



Right: Miniature $\frac{1}{10}$W pre-set volume control (Egen)

CAPACITORS

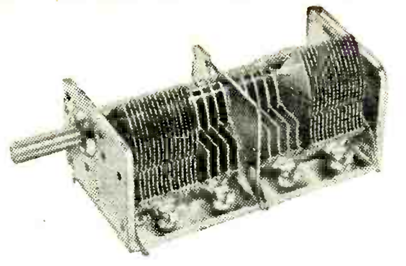
TWO fairly recent developments in electronics are largely responsible for a new trend in capacitor design. One is the transistor, which has called for some quite high-value capacitors for low-voltage operation (1.5 volts upwards). The other is the more recent jump to popularity of the printed circuit. This, and the transistor assault, has required capacitor makers to think in terms of sub-miniature parts, so we now have quite a large number of what can only be described as lilliputian capacitors, fixed and variable.

T.C.C. have introduced a range of low-voltage electrolytics designed especially for transistor circuits. Known as the CE58 series, they have capacitances ranging from 0.25 μF to 6 μF and in working voltages of from 25 for the small capacitance to 1.5 for the larger. Those in this series measure $\frac{5}{8}$in long and only $\frac{1}{8}$in in diameter. Some slightly larger models with higher working voltages are also available.

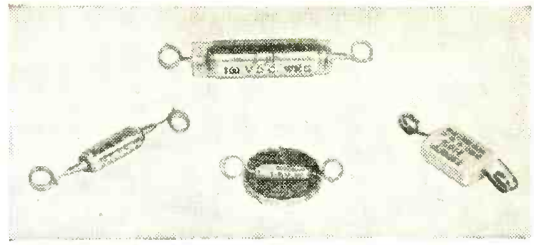
Sub-miniaturization of ceramic and other types is being applied for use in printed circuits, also the position and kind of connecting wires may be almost, if not quite, as important as the size of the component itself. Erie has introduced a range of components, including capacitors, described as "stripped." The omission of moulded cases and other "protection" has resulted in quite a big reduction in size. While the lead-out wires are arranged to suit their own particular versions of the printed circuit there are many Erie capacitors that meet without modification the requirements of other styles of printed circuitry.

Hunt's have modified several of their existing capacitors for printed circuit use. The main changes consist of fitting thin easily solderable wires to electrolytics and other capacitors which previously had unsuitable connections and bringing out the leads along the side of a tubular rather than at the extreme ends. The "Thermetic" Type W97 is a new Hunt's product and is one of the smallest metal-clad metallized-paper capacitors seen so far. A 400-V, 0.001-μF capacitor in this range measures only 0.135in in diameter and 0.61in long. The range includes 200-, 400- and 600-V type from 50 pF to 0.04 μF.

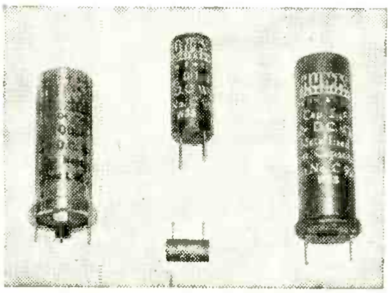
A smaller version of the Polystyrene series of capacitor made by Suflex is now available; it measures only $\frac{1}{2}$in



Wingrove and Rogers a.m./f.m. two-gang capacitor.



Selection of latest T.C.C. capacitors including transistor sub-miniature types.



Hunt's capacitors modified for printed circuits.

long and $\frac{3}{16}$in in diameter and is made in capacitance ranging from 5 to 250 pF. Some Suflex models now have the connecting wires brought at one end instead of at both ends; these are intended primarily for printed circuit use, but have other applications as well.

Although Dubilier did not show capacitors made especially for printed circuits it was pointed out that so many of their capacitors are in the lilliputian class that they fit the requirements without modification. They have introduced a new range of lead-through capacitors for use with screened rooms and screened equipment of various kinds. They are metal clad and some models are actually two capacitors back-to-back with a common "earthing" plate between them. Some of the larger (physically speaking) models will carry as much as 5A; a 0.1-μF type in this category measures only $\frac{3}{4}$in in diameter and extends $1\frac{1}{8}$in either side of the earthing flange. This model is for 250 V a.c. or d.c. working.

An interesting development is a vitreous capacitor using glaze for both the coating and the dielectric. Known as the Vitricon range they are made by Welwyn Laboratories, and are said to be quite satisfactory for use up to 150° C. At this temperature the insulation resistance is better than $10^{10}\,\Omega$. They are quite small and available in a wide range of values.

The demand for a tuning capacitor suitable for an a.m./f.m. receiver has been met by Wingrove and Rogers with a model having a normal capacitor section associated with a special wide-spaced anti-microphonic v.h.f. section. The v.h.f. sections are set in the middle of a 2-gang assembly each side of the dividing screen with the a.m. sections before and behind them respectively. A capacitance swing of 17.4 pF is provided for f.m. tuning. These are available to manufacturers only.

Jackson Bros. have a range of gang capacitors embodying what is described as a band-spread section in each unit. These sections can be of various values and the smallest, giving about a 12-pF swing, would serve a.m./f.m. requirements. The main capacitor unit is of the usual size for medium- and long-wave use.

Special two-gang variable capacitors for f.m. units and convertors giving under 20 pF coverage were shown by Plessey, Jackson and Wingrove and Rogers, while a long range of lilliputian variables in single, butterfly and split-stator patterns were seen on the Stratton stand. These have small-diameter spindles and provision is made for ganging any number by means of appropriately small flexible couplers.

Manufacturers: B.I. Callenders Cyldon; Daly; Dubilier; Erie; Hunt; Jackson Bros.; London Elect. Manf.; Mullard; Plessey; Stability Radio; Stratton; Suflex; T.C.C.; T.M.C.; Walter Inst.; Wego; Wingrove and Rogers.

COILS AND TRANSFORMERS

BY combining a 10.7-Mc/s i.f. transformer with one of 465 kc/s or so in a single screening can a considerable saving can be effected in the space taken up by i.f. transformers in an a.m./f.m. receiver. Dual i.f. transformers of this kind were shown by the Wireless Telephone Company (one of the Plessey group) and by Weymouth.

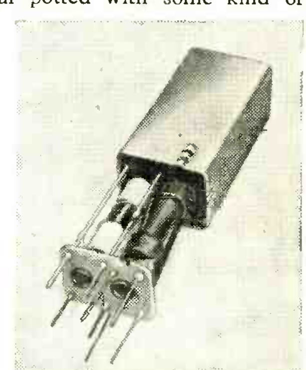
The W.T.C. model is housed in an aluminium can measuring $1\frac{1}{4}$in × 1in × $2\frac{1}{2}$in high and the two transformers are mounted side-by-side lengthwise in the can with the dust cores accessible from top and bottom. Each is independently trimmed. The "Q" of the a.m. transformer is given as 110 and that of the f.m. one somewhat less. The f.m. bandwidth is said to be about 330 kc/s. In addition to the dual i.f.s. there is a dual a.m./f.m. ratio detector unit and a separate 10.7-Mc/s i.f. transformer.

In the Weymouth models the two transformers are assembled crosswise in the can with the dust cores accessible from two opposite sides. The f.m. transformer is designed for 10.7-Mc/s working, has a bandwidth of 330 kc/s measured between 6-db points and a nominal "Q" of 80. The companion a.m. transformer is designed for an 11-kc/s bandwidth (6-db points), has a "Q" of 55 and is centred on 470 kc/s. The ratio detector model has a peak-to-peak bandwidth of 400 kc/s and the a.m.-rejection is said to be −45 db.

Stratton also were showing some 10.7-Mc/s and some 5.2-Mc/s transformers, and these included both ratio detector and Foster-Seeley types.

Except for improvements to detail nothing outstanding was seen in the design of iron-cored components. Further developments and expansion in the application of the resin potting technique was evident, and in the principal makes there are now some four different styles available; resin cast, metal potted with some kind of filling, hermetically sealed and open windings, now almost always vacuum impregnated.

Manufacturers: Advance; Associated Electronic; Elac; English Electric; Ferranti; Goodmans; Gresham; Igranic; Parmeko; Partridge; Plessey; R. & A.; Rola; Stratton; T.M.C.; Weymouth; Wireless Telephone; W.B.; Woden; Wearite; Zenith.



Wireless Telephone (Plessey) a.m./f.m. dual i.f. transformer.

TELEVISION COMPONENTS

THE double-triode cascode r.f. amplifier and the triode-pentode frequency-changer form the basis of nearly all television receiver "front-ends." Tuners embodying them fall into two groups of similar external appearance and controls. Most have switch station selectors with 12 positions giving a choice among five Band I and seven Band III stations. The other control is an oscillator trimmer.

In one group, the turret tuners, there are individual coils for each station, fixed to strips carrying the connecting contacts which are mounted on a rotating framework. The individual coils are thus brought round to the circuit for connection. The other group is of the incremental inductance type. Wafer switches are used and between each pair of contacts is connected the small inductance needed to change the tuning from one channel to the next. With this type, alignment must be done first on the highest frequency channel, then on the next channel lower and so on. With the turret tuner, however, the coils for each channel can be aligned independently.

The Cyldon Teletuner Mark 1 is of the turret type and is claimed to have noise factors of 5 db and 9 db on channels 1 and 8 with gains of 43 db and 36 db. The oscillator drift is stated to be under 100 kc/s for a temperature rise to 60°C.

The N.S.F. tuners are examples of the incremental-inductance type. One model covers not only the 13 Bands I and III stations but has an extra switch position to enable reception to be obtained in the u.h.f. band if it becomes necessary in the future.

The Weymouth television i.f. strips are virtually complete receivers except for the scanning circuits and power supplies. They comprise sound and vision i.f. amplifiers with the detectors, noise limiters, video stage and sync separator. The r.f. side is made as a separate unit which can be dropped into a cut-out in the main chassis.

This firm also showed a two-valve convertor for Band III which is designed to provide an output in Band I at the frequency of the local station. Aerialite also showed Band III convertors intended for use with any Band I receiver.

Little change was evident this year in scanning components save in details of design. The use of Ferroxcube, dust-iron and similar materials has obviously come to stay, as has the castellated yoke. Mullard now have such a yoke with 16 slots, enabling a better field distribution to be secured. Deflection assemblies for 90° tubes were shown by several firms, including Igranic and Plessey, and can be picked out at once from the 70° types by the enormous turned-up front ends of the line coils. It is interesting to see that in these assemblies the frame coils are not the conventional saddle type but are the so-called toroidal type. That is, there are four frame coils wound around the core material.

Line-scan transformers are of the type that has now become conventional, but it is obvious that increasing attention is being paid to insulation. In some Igranic models, for instance, the e.h.t. rectifier is mounted inside what can only be termed a plastic "bath-tub"!

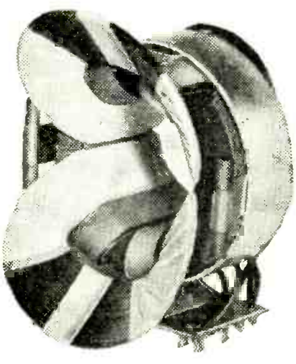
The permanent magnet for focusing and for ion traps was well in evidence. Goodmans showed a new focusing unit in which the magnets are held by a die-casting, while Elac showed several types. Among these is the Duomagnette with two opposing ring magnets. The Marrison & Catherall unit is designed to minimize astigmatism and both the focus and the shift controls can be adjusted from outside the receiver.

***Makers:** Aerialite (C); Cyldon (T); Elac (F); Goodmans (F); Igranic (D, Tr.); Long & Hambly (M); Marrison & Catherall (F); James Neill (F); N.S.F. (T); Plessey (D, F, T, Tr); Weymouth (C); W.B. (D, F, Tr).

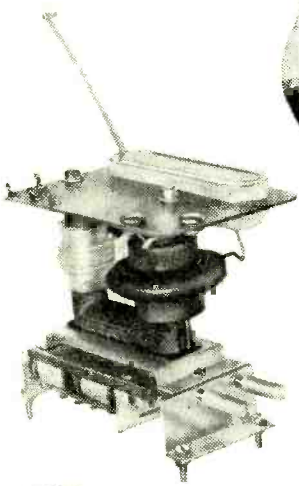
***Abbreviations:** C, convertors; D, deflector coils; F, focus units and ion-trap magnets; M, masks; T, tuners; Tr, transformers.

SUB-ASSEMBLIES

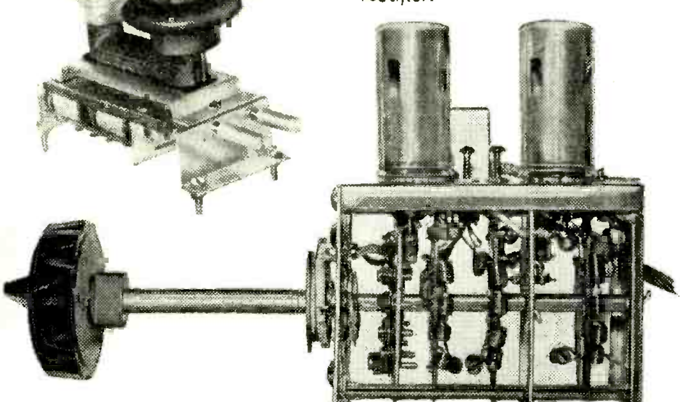
AMONG the larger items in this category was a new a.m./f.m. tuner shown by Weymouth. It covers the medium- and long-wave bands and the full f.m. allocation from 84 to 96 Mc/s, and the wavechange switch also has a position for "Gram." The r.f. amplifier is a 6AM6 and is operative only on the f.m. band, while the frequency changer is a 6BE6. Maximum power consumption is 0.6 A at 6.3 V for l.t. and 12-22 mA at 200 V for h.t. Another new tuning unit, for the medium-wave band, was shown by Cyldon, but this contained no valves and was simply a



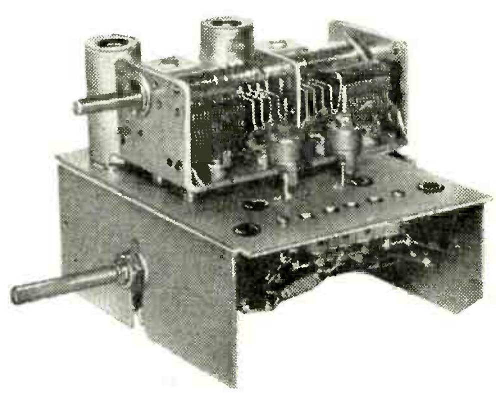
Right: Plessey deflector coil for 90 degree tube.



Left: Igranic line-scan transformer; note the "bath-tub" for the rectifier.



N.S.F. television tuner of the incremental-inductance type.



Weymouth a.m./f.m. tuner.

system of pre-set permeability-tuned coils operated by push-buttons, with facilities also for manual tuning.

Printed circuits were very much in evidence and a wide range of circuit configurations, including Band I/Band III television tuners and aerial cross-over networks, 35-Mc/s i.f. transformers, computor panels, transistor circuits and r.f. filters, were displayed by T.C.C. These were made by the conventional etching process, but examples of a new method of manufacture were to be seen on the Erie stand. In this the insulating base material is embossed with the required circuit and the copper foil is pressed into the declivities, the excess copper on the raised parts being milled off afterwards. The method is claimed to avoid any troubles which may be caused by acid remaining from the etching process and also to give thicker conductors capable of carrying more current.

The valve-circuit support shown by McMurdo last year, with the valveholder mounted on top of a plug-in pedestal, is now supplied by the makers with the customer's circuit components already assembled and potted in a solid cylinder of resin around the pedestal.

Makers*: Advance (D); B.I.C. (D); Cyldon (T); Erie (P); Ferranti (D); Hunt (P); McMurdo (VC); Plessey (P, LA); T.C.C. (P); Wego (D); Weymouth (T, LA); Wright and Weaire (LA).

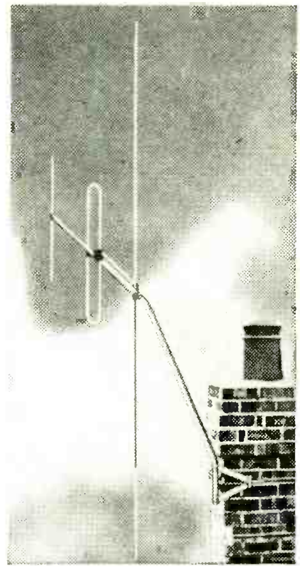
***Abbreviations:** D, delay networks; LA, coil assemblies; P, printed circuits; T, tuning units; VC, valve circuit assemblies.

AERIAL EQUIPMENT

ALTHOUGH the new f.m. broadcast service is due to commence long before Band III television will materialize the whole emphasis in the aerial display at the show this year was Band III aerials and adaptors.

It is now apparent that anywhere outside the immediate vicinity, or swamp area, of a Band III station something more elaborate than a simple dipole, or dipole adaptor, will have to be used. This may not always be necessary in order to get a strong enough signal, but very often to differentiate between the direct signal and a signal arriving by an alternative path or paths and produced by reflections from buildings of one kind or another. These invariably give rise to ghost images.

Simple adaptors for existing types of Band I aerials will find many applications and some quite ingenious and inexpensive arrangements were seen this year. For example, Belling-Lee have a kit comprising a number of rods and two plastic insulators for holding them in position on a single dipole. The rods extend each side of the centre insulator and lie parallel with the dipole and partially enclose it. They behave on Band III as two transmission lines end-feeding the exposed end parts of the Band I aerial. These end parts behave as three-quarter wavelength aerials fed in phase. The result is that on Band III there is a gain of about 3 db over a plain dipole.



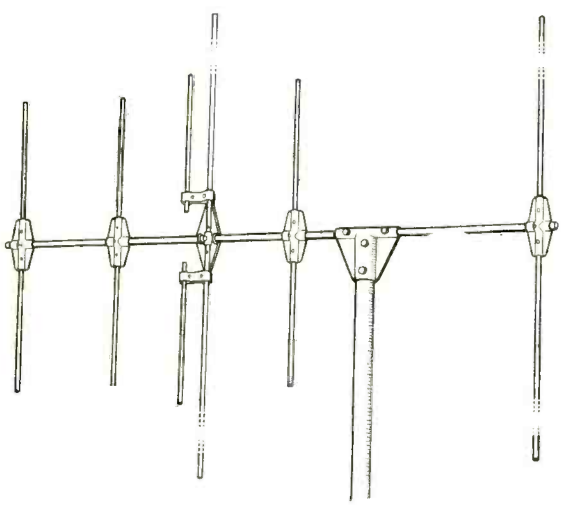
Belling-Lee combined Band-I dipole and director and folded dipole for Band III.

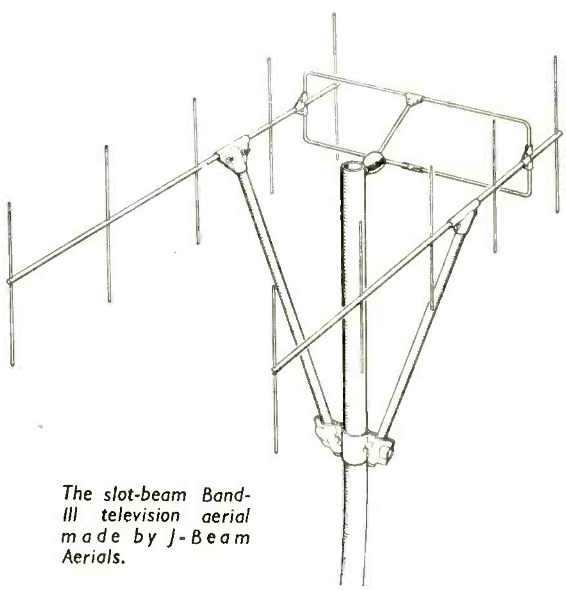
Other firms have applied various schemes which enable the Band I aerial to be made to operate as an harmonic-type aerial giving a gain over the existing aerial. Adaptors of one kind or another for "H" and "X" aerials were shown by Aerialite and Antiference.

The more elaborate kind of adaptor takes the form of two or more elements of Band III length fitted to an existing "H" or multi-element aerial and utilizing in some cases one of the existing larger elements to reinforce the pick-up on Band III. Sometimes the mast is employed as an untuned reflector element. These adaptors are arranged to be fixed either in line with the existing Band I elements or at any desired angle, the latter to cope with conditions arising from the Band I and Band III stations being differently sited. Aerialite, Antiference and Belling-Lee showed these additional aerial parts mounted on outriggers for attachment to the cross arm of an existing "H" type and capable of swinging to any direction required irrespective of the alignment of the "H." In all cases the aim is to provide more gain from the Band III system than given by the accompanying Band I aerial, as this will generally be found necessary.

Whereas a four-element aerial is about the largest it is practical to use for Band I, it will be quite practical to go to a 10- or 12-element Yagi on Band III, given a suitable kind of mast. The smallest independent Band III aerial was a 3-element one, the largest had 10 to 12

Antiference combined Band-I "H" and Band-III 4-element Yagi television aerial.





The slot-beam Band-III television aerial made by J-Beam Aerials.

elements, giving a gain over a plain dipole of 14 db or more. Like the Band I 4-element Yagi these multi-element types can be mounted either as a stack, i.e., one above the other with appropriate spacing, or as a broadside array; the two system being a half wavelength apart and side-by-side. Being generally smaller stacking or broadside mounting is more practical on Band III than on Band I. All the firms making aerials had several designs of this kind.

When separate Band I and III aerials feed into a single input on the receiver, or a combined aerial such as a Band I with adaptor elements feeds into separate inputs on the set, a filter is required between the aerial system and the receiver to prevent inter-action between the aerials. These filters take various forms, but basically they separate out the signals on the two bands and direct them along their correct courses. Belling-Lee call their unit a "Diplexer Tuned Filter." Antiference call theirs a "Y Box" and it provides rejection of the unwanted band of something over 20 db; its insertion loss is said to be no greater than 0.75 db on any channel and it is intended for 70- to 80-Ω cables.

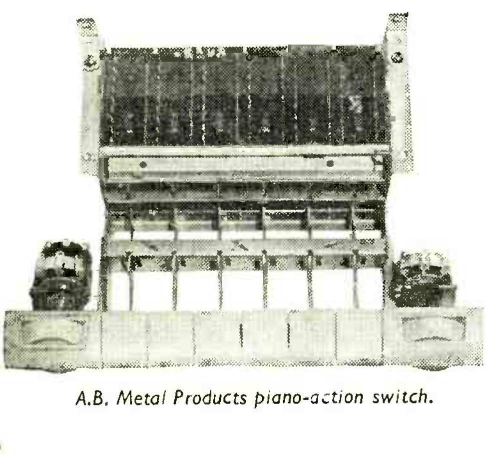
A Band III aerial of very unusual design is made by J-Beam Aerials. It consists of a horizontal skeleton slot flanked on each side by a 4-element vertical Yagi. The combination is matched to an 80-Ω cable and it is said to give a gain over a plain dipole of 14 db. The ends of the slot form bent-over aerial elements for the Yagis and the long sides the matching section for end-feeding the two Yagis. Although J-Beam Aerials specialize in end-fed television aerials this must surely be a unique application of the principle.

Manufacturers: A.B. Metal Products; Aerialite; Antiference; Belling-Lee; B.I. Callenders Cables; Henley's; J. Beam; Permanoid; Sutlex; Telcon; Transradio.

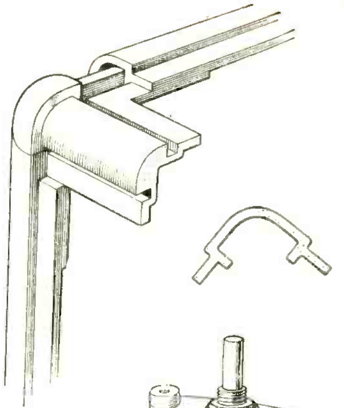
SWITCHES

THE advent of a.m./f.m. reception has obviously brought with it some complications in receiver switching. The new switches designed for this type of circuit by A.B. Metal Products bring to mind the days of press-button tuning, for they use a piano-key type of action. A maximum of eight keys can be provided in one unit and there are six sets of changeover contacts on each key. Mountings for coils are also incorporated. Slider switches intended for a.m./f.m. receivers were shown by Plessey, and these had a two-way action with as many as 10 poles available.

Amongst the rotary switches a new precision type on the Electronic Components stand was notable for the even pressure of the wiper contacts on the fixed contacts, obtained by a helical spring inside the wiper (see sketch). The switch has 32 positions and can be supplied with one, two or three poles and up to six banks. Another rotary switch using helical springs in a similar way was shown by N.S.F. and was capable of carrying up to 10 amps. A version of the well-known German Winkler rotary switch is now being made by Painton, and a notable improve-



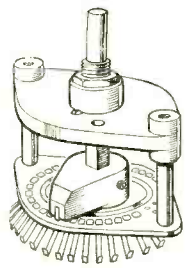
A.B. Metal Products piano-action switch.

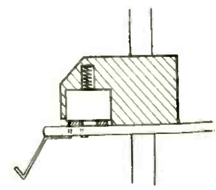


Carr Fastener plastic locking nut.

Left: Imhof-Elliott interlocking system for cabinets.

Electronic Components precision rotary switch.





ment is the use of a moulded panel to carry the fixed contact studs. The contacts can be silver-, gold- or rhodium-plated.

A new range of micro-switches was shown this year by Pye, with operating pressures ranging from 3 oz to 18 oz. Some of these are worked directly by the plunger while others have a lever acting on it. The contact ratings are all 5 A, 250 V for a.c. and 5 A, 12-29 V for d.c. Bulgin have extended their range of micro-switches and were again showing the more recent sub-miniature types which are not in the usual Bakelite cases.

Makers*: A.B. Metal Products (L, P, R, S); B.E.R.C.O. (R); Bulgin (L, M, P, R); Diamond, H. (L, R); Electronic Components (P, R); Erie (R); N.S.F. (L, P, R, S); Painton (L, P, R); Plessey (L, P, R, S); Pullin (R); Pye (M); T.M.C. (L, P); Walter (L, P, R, S); Whiteley (P, R, S); Wright and Weaire (R).

***Abbreviations:** L, lever or toggle; M, micro-switch; P, push-button; R, rotary; S, slide.

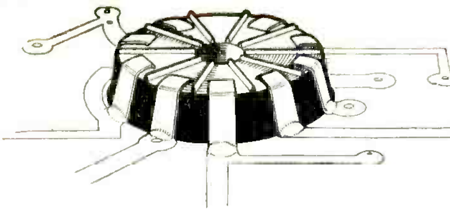
CHASSIS FITTINGS

THE rapid development of printed circuits is having a noticeable effect on the type of chassis fittings now coming on to the market. Flat, strip-type connectors were shown by Bulgin, McMurdo and Belling-Lee (see picture) and specially designed valveholders by Carr Fastener, McMurdo and British Mechanical Productions. Some of the valveholders have tags which project downwards through holes in the printed circuit plate, but the one shown by British Mechanical Productions has long spring fingers bent upwards which press on the edges of the circuit when the holder is let into a hole in the plate.

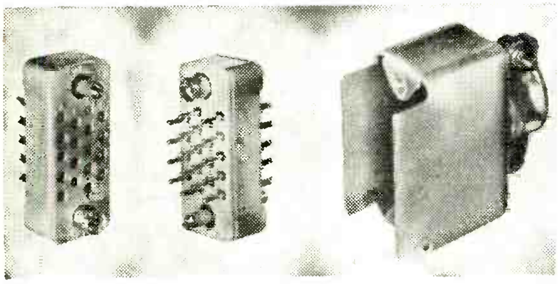
A wide range of spring clips for various applications was displayed by Simmonds Aerocessories, the two latest additions being clips for holding screening cans and a small coil-former support (see sketch). Another new fixing device was a self-locking plastic nut shown by Carr Fastener. It snaps into a hole in the metal and when a self-tapping screw is driven into it the plastic expands and grips tightly.

Tag-strip in a very simple and cheap form was a popular exhibit on the Creators stand. Known as "Plantag" it consists of a rigid P.V.C. moulding of L-shape cross-section with tags in one plane and fixing holes in the other, and it can be supplied in any length. By warming the P.V.C. the strip can be bent round in a circle if required.

Prefabricated cabinets were again the main feature of



Printed-circuit valveholder by British Mechanical Productions



McMurdo miniature connectors

the Widney Dorlec stand, and this year die-cast corner units were on view. Imhof have now entered this field in conjunction with Elliott Brothers, the instrument manufacturers, and they were showing an interlocking system for fixing the struts of the cabinet frame into the corner pieces (see sketch).

Makers: Aerialite; Antiference; Associated Electronic Engineers; Belling-Lee; British Mechanical Productions; Bulgin; Carr Fastener; Creators; Colvern; Egen; Electrothermal; Electronic Components; Hassett & Harper; Hellerman; Igranic; Imhof; Long & Hambly; McMurdo; Micanite; Painton; Plessey; Ross Courtney; Simmonds; Spear; Standard Insulator; Stocko; Stratton; Telcon; Thermoplastics; T.M.C.; Transradio; Tucker-Eyelet; Tufnol; Weymouth; Whiteley; Widney-Dorlec; Wimbledon; Wingrove & Rogers.

RELAYS

THE switching of r.f. circuits on coaxial cable presents a difficult problem in relay design because of the impedance mismatching which can occur. Besson & Robinson have tackled it successfully, however, and were showing three coaxial changeover relays with very low standing-wave ratios. The latest one, type A07, is characterized by having permanently fixed cable tails instead of sockets. The v.s.w.r. is 1:1.1 while the impedance is 45/60 ohms or 70/80 ohms and the operating voltage 17/28 volts d.c.

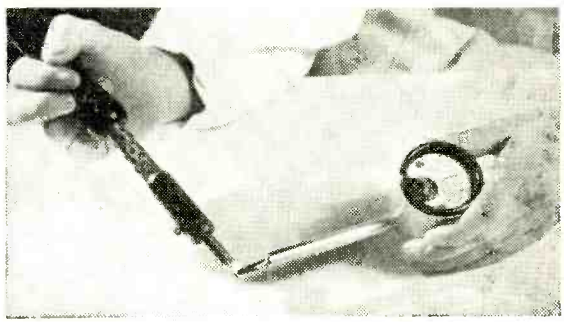
A new relay notable for its sensitivity was shown by Magnetic Devices. It operates on a current of 1 mA at under 0.5 V and will switch two circuits of either 5 A at 250 V a.c. or 5 A at 30 V d.c. The mechanism is hermetically sealed and mounted on an octal plug-in base. Like many other of the relays on show it has a balanced-type armature to prevent false operation by external shock or vibration. The Besson & Robinson K01, for example, an alternative to the Post Office type 3,000 relay, will withstand accelerations of up to 25*g*.

Makers: Besson & Robinson; Magnetic Devices; N.S.F.; Oliver Pell Control; Plessey; Pullin; T.M.C.; Walter Instruments; Woden; Zenith.

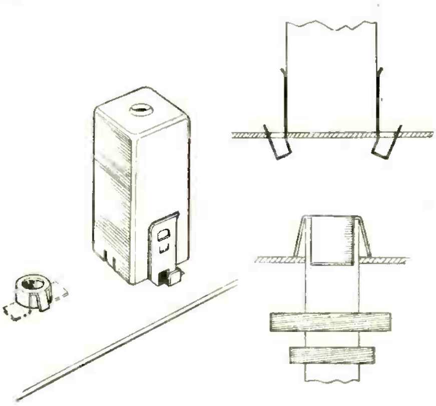
MATERIALS

IN the production of high-permeability nickel-iron alloys by conventional melting processes, the properties of the material are often adversely affected by the inclusion of impurities originating in the crucible lining or de-oxidizing fluxes. It is also difficult to control the composition due to the different rates of loss of the constituent elements. A powder-metallurgy process developed by Henry Wiggin and Company uses carbonyl nickel, iron and other metallic powders as raw materials, and retains the original measured proportions and produces an alloy which is less susceptible to the presence of water vapour in the hydrogen atmosphere used for final heat treatment. There is also less susceptibility to surface effects which reduce permeability when the strip is rolled, and an initial permeability of 25,000 is maintained down to a thickness of 0.0005in in Ni77, Fe14, Mo4, Cu5 alloy.

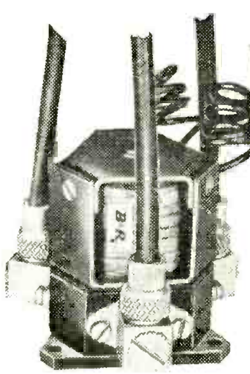
Most manufacturers of core laminations are concentrating on the production of oriented-grain silicon steels, primarily for "C" and "E" cores fabricated from bent strip. Strip thickness down to 0.002in are available from



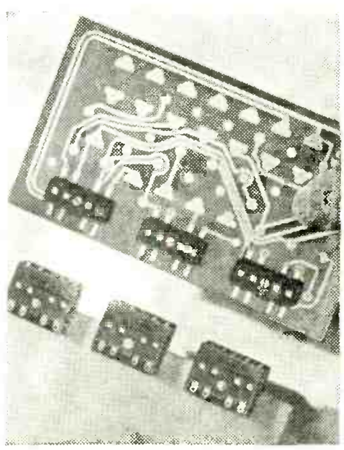
Multicore solder thermometer.



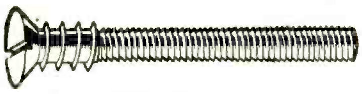
Clips for screening cans and coil former support by Simmonds Aerocessories.



Besson & Robinson coaxial relay with fixed cable tails.



Belling-Lee connectors for printed circuits.



G.K.N. loudspeaker fixing screw

Telcon-Magnetic Cores. Geo. L. Scott also supply flat laminations of this material 0.012in thick for cores assembled in the conventional manner. Joseph Sankey and Sons have introduced a new interlaminar coating which will withstand re-annealing temperatures of 800°C and is also waterproof.

Ferrite moulded cores for television line timebase transformers and deflection yokes, and extruded rod for r.f. inductors and aerials have been added to the range of moulded magnetic materials made by Salford Electrical Instruments.

Among "hard" magnetic materials the new Mullard "Ticonal L" anisotropic alloy, designed for loudspeaker magnets, is of special interest to manufacturers of loudspeakers using a centre-slug type of magnet assembly. It has a remanence of 14,000 gauss, and increases of up to 10 per cent on the previous upper limit of flux density of gauss/cm^2 are possible.

Most manufacturers of winding wires are now in production with polyurethane coatings which need not be previously removed before soldering. A new coating with exceptional resistance to the action of solvents has been developed by Connollys. It is known as "Conyclad" and consists of a basic layer of vinyl acetal enamel, coated with nylon. The outer layer protects the base enamel from "crazing" under the action of varnish solvents, and eliminates the annealing process which is normally adopted to reduce crazing.

The successful production of wave-wound coils depends upon the mechanical as well as the electrical properties of the wire, and Fine Wires, Ltd., have produced a range of single and multiple conductors with a variety of textile coverings specially for use on wave-winding machines.

Manufacturers of r.f. cables have anticipated the demand for Band III television aerial downleads with coaxial cables in which the dielectric is cellular polythene. Compared with a sold polythene dielectric cable the attenuation may be reduced by as much as 40 per cent, and typical figures for a 0.290in outside diameter cable are 3.3 db/100 ft at 200 Mc/s with a capacitance of 17 pF/ft. Another advantage of the cellular type of filling is that no elaborate precautions are necessary to seal the ends, as there are no connecting passages between the air cells, and moisture cannot penetrate the dielectric.

Polythene-insulated cables can give rise to microphonic noise which may be troublesome at very low signal levels. This has been overcome in Telcon "G" coaxial cables by coating the outer surface of the polythene with graphitic conducting film to disperse charges which might otherwise fluctuate with intermittent movement of the outer braiding. This year a further improvement has been effected in a "GG" cable in which similar treatment is applied to the inner surface of the insulant.

Silicone elastomer materials are finding increasing applications in the preparation of insulating cloths, tapes and sleeving. In the "Symel" grade of sleeving made by H. D. Symons the mechanical strength is improved by glass braiding applied on the inside and/or the outside of the silicone. A similar combination of special interest for high-temperature applications was shown by Suflex, Ltd.

Electrical insulating tapes coated with a thermosetting adhesive have been added to the already wide range of "Scotch Boy" tapes made by the Minnesota Mining and Manufacturing Company. Curing is effected during the normal drying-out process in coil manufacture, to give a permanent bond which will withstand subsequent varnishing or impregnation. The composition of the adhesive is controlled to obviate any possibility of initiating corrosion in the wires.

Impregnating resins of the ethoxyline type with low viscosities at room temperature are among the new plastics introduced by Aero Research, Ltd. No solvent is necessary and polymerization on heating is effected without the evolution of any vapours which might cause voids. Another recent "Araldite" product is a cold-setting adhesive for fixing electrical strain gauges.

Formers for the resistance elements of wire-wound potentiometers are usually of phenolic plastic strip, and difficulty is often experienced in finding material of suitable thickness which will not crack when bent. A suitable grade has been developed by H. Clarke & Co. (Manchester) which can be bent into circles of less than 1in diameter without cracking.

Printed circuits and dip soldering techniques have made new demands on the services of solder manufacturers, who have responded with a full range of special alloys, fluxes, and chemicals for preparing and preserving metal surfaces. Other new products in this field include a neat and robust junction pyrometer by Multicore for measuring rapidly the temperature of soldering baths or soldering iron bits. The scale is calibrated in Centigrade and Fahrenheit with a maximum of 400°C (752°F). Enthoven have demonstrated a new cored aluminium solder which functions at ordinary soldering iron temperatures without any auxiliary aids such as ultrasonic vibration. Copper wires can be soldered to aluminium of light-gauge and commercial purity and also to a number of aluminium alloys.

Finally, since screws can be regarded as a raw material as far as radio engineers are concerned, we mention two interesting developments by Guest, Keen and Nettlefold. One is the introduction of B.A. and wood screws in solid nylon, which, apart from their obvious non-conducting and good dielectric properties, are free from corrosion. The tensile strength is 5 tons/in^2 at room temperature and 7 ton/in^2 at -40°C. The other Nettlefold screw is a combination of a left-hand wood screw and a B.A. screw on the same shank for fixing loudspeakers to baffle boards. The left-hand wood thread ensures that any movement when finally tightening the fixing nuts will tend to draw the screw further into the woodwork.

Makers*: Aerialite (C, IS, W); Aero Research (IM); Associated Technical Manufacturers (B, C, IM, IS, W); Bakelite (IM); Geo. Bray (CF, CE); B. I. Callenders (C, CO, IS, W); British Moulded Plastics (IM); Bullers (CF, CE); Clarke (CF, IM, IS); Connollys (C, IM, W); Cosmocord (CF); Creators (IS); De La Rue (IM, IS); Duratube and Wire (B, C, CO, IS, W); Ediswan (W); English Electric (L); Enthoven (S); Fine Wires (W); Guest, Keen and Nettlefolds (BO); Hellerman (CF, IM, IS); Henley's (C, CO, IM, W); Insulating Components and Materials, Ltd. (IM); Langley, London (IM); Long and Hambley (IM, IS, RP); Magnetic and Electrical Alloys (L, M); Marrison and Catherall (M, L); Micanite and Insulators (CF, IM, IS); Minnesota Mining (IM); Mullard (DC, M); Multicore (S); Murex (RM, M); Mycalex (CF, IM); James Neill (M); Permanoid (C, IM, IS, W); Plessey (CE, DC, M); Reliance Wire (C, CO, IS, W); Rola Celestion (D, L, M); Salford (DC, M); Sankey (L); Geo. L. Scott (L); F. D. Sims (C, CO, W); S.T.C. (M); Steatite (CF, CE); Stratton (CF); Suflex (B, CO, IM, IS, W); Swift Levick (M); H. D. Symons (IM, IS); Taylor Tunnicliff (CE); Telcon (C, DC, IM, L, M, RN, W); Telcon Magnetic (L); Telephone Manufacturing Co. (DC); Thermo Plastics (CF, IM); Transradio (B, C, IS, W); Tufnol (IM); United Insulator (CF, CE, IM); Vactite Wire (RM, W); Whiteley Electrical (CF, M).

***Abbreviations:** B, braiding; BO, bolts; C, cables; CE, ceramics, CF, coil formers, bobbins; CO, cords; DC, dust cores, ferrites; IM, insulating materials; IS, insulating sleeving; L, core laminations and strip; M, magnets and magnetic alloys; RM, refractory metals; RP, rubber products; S, solder; W, bare or covered wires.

Directory of Metals

A COMPREHENSIVE guide to the physical properties of the non-ferrous metal elements and their alloys is contained in the "Metal Industry Handbook and Directory 1955." Not the least useful section of this work is the list of proprietary alloys, their makers, properties and uses.

A separate set of tables gives the specific resistances of alloys which are not normally found in electrical reference books, and there is a large section on the technique of electroplating, anodizing and other electrolytic processes which should be of value to workers in the radio industry.

Published by the Louis Cassier Company, Ltd., Dorset House, Stamford Street, London, S.E.1, this directory costs 15s.

Wide Range Electrostatic Loudspeakers

By P. J. WALKER*

2—Problems of Air Loading : Different Requirements of Moving-coil and Electrostatic Drive Units

IN the first part of this article we showed that it was possible to design and construct electrostatic driving units which were capable of applying a force which virtually acted directly on to the air, and we showed that this force was linear. This state of affairs applied over a bandwidth of several octaves for any single unit, depending upon the efficiency required from that unit, and it was further shown that that bandwidth could be placed anywhere in the audio range.

The only mechanical impedance likely to affect performance is the suspension compliance of the diaphragm, necessary to offset the negative compliance due to electrical attraction. We can therefore begin to draw an electrical analogue circuit of the mechanical elements of the loudspeaker as in Fig. 1, showing the force fed in series with a capacitance. In practice the compliance will considerably exceed the electrical negative compliance, so that this capacitance C_d is almost solely due to the diaphragm compliance.

For simplicity we will restrict consideration to units driven from constant-voltage sources, so that no elements need be included to indicate amplifier source impedance.

Since the loudspeaker will be coupled to the air, we can now add the front air load radiation resistance R_f and the front air load mass, M_f and we can include the impedance Z which represents the impedance presented to the back of the diaphragm.

The impedance Z may include dissipative terms in the form of absorption and/or acoustic radiation resistance. With most acoustic devices the analogy elements change with frequency and the problem, as with all loudspeaker design, is to arrange matters so that the power developed in the radiation resistance(s) is independent of frequency.

The electrostatic unit differs from the moving coil in that there is no large mass component (cone and speech coil) which normally appears as a large inductance in series with C_d. The absence of this inductance profoundly alters the requirements for Z, and since Z is the cabinet or back enclosure it is to be expected that the form of cabinet for electrostatic units will follow trends entirely different from those that have been evolved for moving-coil units. A further difference is that the shape of the diaphragm area is more versatile, so that R_f and M_f may be independently varied over reasonable limits.

Due to the absence of large mass we can, if we wish, arrange the constants so that R_f is large compared with the other elements, and therefore becomes the controlling factor for the equivalent current in the circuit, i.e., the velocity of motion of the diaphragm. This means that the impedance looking back into the loudspeaker can be very low. When this is so, any increase in the acoustic resistance on the front of the diaphragm will result in *reduced* power output. If, on the other hand, the impedance of the loudspeaker is made to appear high by arranging that the total impedance is

* Acoustical Manufacturing Co. Ltd.

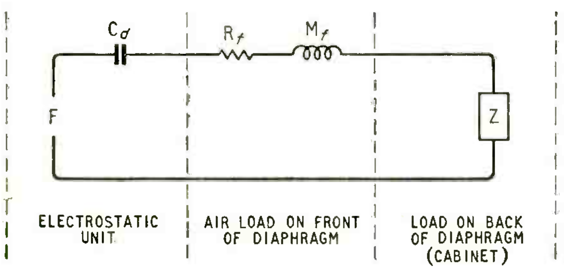


Fig. 1. Elementary equivalent circuit of mechanical and acoustical parameters of an electrostatic loudspeaker.

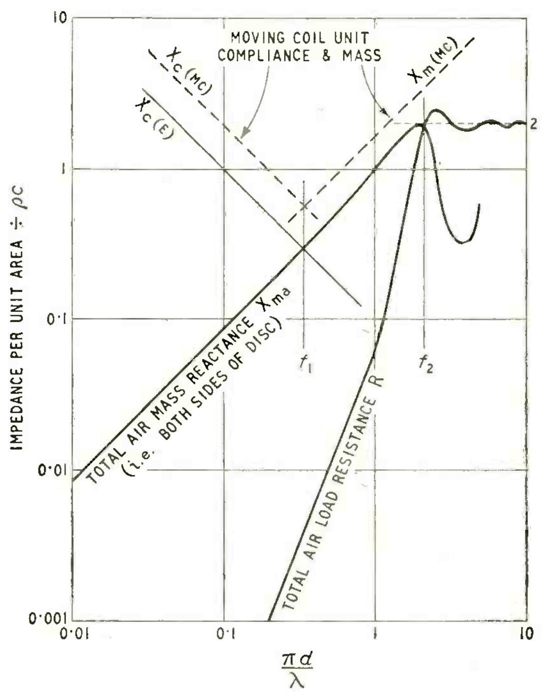


Fig. 2. Mass and radiation resistance loads on circular diaphragm in free air. The normalized frequency scale is in terms of the relationship of diaphragm size to wavelength.

large compared with R_f then an increase in acoustic resistance on the front of the diaphragm will result in *increased* power output. This ability to control the impedance looking back into the diaphragm is a useful feature in designs where R_f is subject to fluctuations due to surroundings, horn reflections, etc., and, in particular, where one loudspeaker unit is influenced by another unit at cross-over frequencies.

In order to show the action of an electrostatic unit which is small compared to the wavelength of the radiated sound it is convenient to commence with a circular shape, because impedance information is readily available for such a shape. Load impedance for other shapes is best obtained by considering the diaphragm as a number of unit areas of equal size and calculating the impedance of each unit area, taking into account the mutual radiation due to the presence of all other unit areas.

Fig. 2 shows the load on a piston operated in an unlimited atmosphere without a baffle. The diaphragm compliance reactance $X_c(E)$ is also drawn. Between f_1 and f_2 the controlling factor is the air mass, and the velocity of motion will vary directly with frequency until resonance between $X_c(E)$ and X_{ma} is approached. R, however, falls rapidly with frequency, and the power output will fall at approximately 6db per octave with declining frequency. (Exactly the same would occur with a moving coil unit, control this time being the mass of cone and speech coil designated $X_m(MC)$. $X_c(MC)$ is the moving-coil suspension compliance.)

Multiple diaphragms without baffles, having the above characteristics, form the basis of design for loudspeakers to provide the directivity of a doublet. Such a system has useful attributes in relation to the listening rooms, a subject to be dealt with in a later article.

Above f_2 the velocity of the moving-coil unit would still be controlled by $X_m(MC)$ (except for cone "break-up") and, since the resistance becomes constant, the response will fall with increasing frequency. In the electrostatic case above f_2 the velocity will be controlled by the air load resistance, and the response will be independent of frequency.

Extending this comparison to units in very large baffles we have the curves of Fig. 3. Here the radiation resistance varies with the square of the frequency below f_2. With a moving coil the response will be level below f_2 and will fall with frequency above f_2. With the electrostatic the response will be level below f_2 and also level above f_2, but there will be a step in response so that the output level above f_2 will be 3db higher than that below f_2.

A simple arithmetical example will make clear the reason for this step. With constant force F applied to the diaphragm, the velocity of movement will be

$$\frac{F}{\sqrt{R^2 + X^2}}$$

and the power expended usefully in the radiation resistance will be $P = \left(\frac{F}{\sqrt{R^2 + X^2}}\right)^2 \times R$

At f_B in Fig. 3, neglecting Z due to the declining air mass reactance, we have for a constant force F = 1, $P = \frac{R}{R^2} = \frac{2}{4} = \frac{1}{2}$. At f_A, on the other hand, the air mass predominates and, if R can be neglected in calculating the velocity of motion, $P = \frac{R}{X^2} = \frac{0.01}{(0.2)^2}$

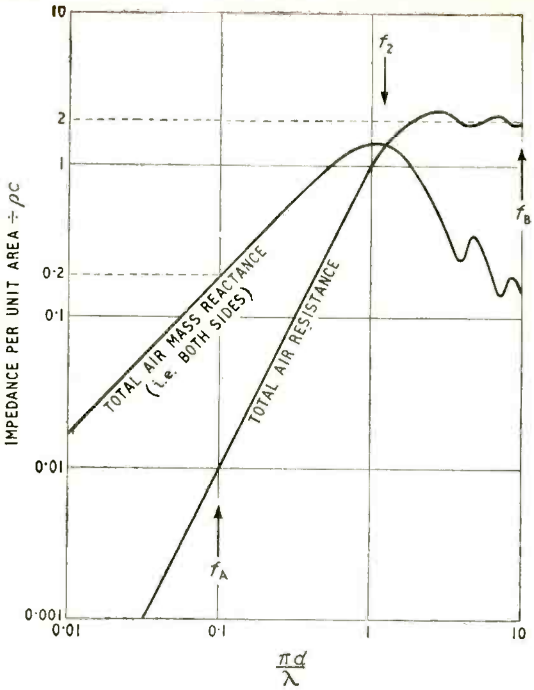


Fig. 3. Mass and radiation resistance curves for a circular diaphragm in a large baffle. The power radiated at any frequency f_A well below f_2 is half that radiated at frequencies f_B well above f_2 (see text).

$= \frac{0.01}{0.04} = \frac{1}{4}$, or half the power at f_B. A similar relationship will be found for any other pair of values of R and X at points below f_2.

This change in level can be overcome by deviating from the circular piston shape. For wavelengths large compared to the diaphragm size the resistance per unit area is dependent upon the new area and not upon the shape, whereas the mass is mainly dependent upon the smaller dimension. By elongating the diaphragm shape the output level below f_2 can be made equal to that above f_2.

We have so far been considering a comparatively small diaphragm in a flat baffle, the latter being very much larger than the piston, and the size of the complete system is obviously that of the baffle. The reason that the piston has been kept small is purely for the convenience of the moving-coil unit, because its diaphragm is driven at only one point. In the electrostatic case we no longer have this restriction, and it will always be preferable to increase the size of the piston (without increasing the total size of the complete system). This will usually be necessary because there is a limit to the available amplitude of movement, and thus, for a given power output per unit area, we have a minimum limit to the radiation resistance in order that the diaphragm excursions may be attainable. Increasing the size of the piston for a given power output has the double advantage of reducing power requirements per unit area, and, where the loading is below $2\rho c$, of increasing the radiation resistance per unit area, and therefore reducing the amplitude required to provide that power output. For reasons of efficiency we shall in any case limit the high-frequency response of the unit so that optimum design is obtained by increasing the area of the diaphragm to the point where the piston just begins to become directional at the frequency which we have chosen for cross-over (set by the efficiency laid down in the design requirements).

Continuing the consideration of the air load on diaphragms, reference should be made to horn loading. Here we have large resistive and mass components due to the horn. Fig. 4 shows the load of an idealized horn to which has been added X_m(MC), the cone mass of a typical moving-coil loudspeaker which might be used with such a horn. It will be seen that at low frequencies the cone mass is largely swamped by the horn impedance, so that the design of horns for electrostatic units differs very little from the design for moving-coil units. Although we can now have the advantages of a virtually distortionless driving unit, we are still left with the disadvantages of practical horns, which are present independently of the drive units. Horns are normally used to match the high impedance of moving-coil diaphragms to the low impedance of the air. Since we have no such fundamental mismatch with the electrostatic loudspeaker, and since diaphragm shape and size are not fundamentally restricted, we shall not normally have to resort to the use of horns to the same degree. It should be remembered, however, that any back enclosed volume is a direct function of throat area, so that in some applications it is possible to use space for providing a length of horn in exchange for saving in size of capacitive enclosure. Again, we may wish to restrict the front-wave expansion in order to maintain a reasonable resistance per unit area at low frequencies (utilizing the corner of a room, for example).

One of the most desirable diaphragm shapes for electrostatic designs is that of a strip having a length (together with floor or wall image) large compared to $\lambda/3$ at the lowest frequency of interest, and a width small compared to wavelength at the highest frequency of interest. The strip may be curved along its length if desired, provided the radius of curvature is not less than $\lambda/3$ at the lowest frequency.

To consider the load on such a strip it is convenient to assume the strip as being infinite in length (legitimate provided it is at least $\lambda/3$ in length). With such a diaphragm there will be no expansion of sound in the direction of the length since all pressures along the length of the strip will be equal. Expansion from any given element of the diaphragm takes place in one plane only and will therefore take the form $S = S_0x$. This is the expansion of a parabolic horn. At low

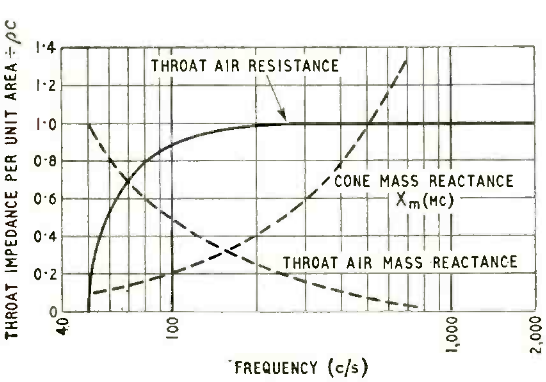


Fig. 4. Throat air resistance and reactance curves of idealized horn with moving-coil mass reactance superimposed.

frequencies the front air load resistance is falling directly with frequency (instead of f_2 as with the circular piston shape). The advantages of the strip shape may now be enumerated:—

(a) The air resistance even at low frequencies (since $R \propto f$) is sufficient to develop adequate power with reasonable diaphragm amplitude.

(b) The narrow diaphragm gives good dispersion for several octaves (up to the frequency at which width $\approx\lambda/3$).

(c) The narrow diaphragm enables other units to be placed close to it, thus being less than ¼ wavelength apart at cross-over frequency.

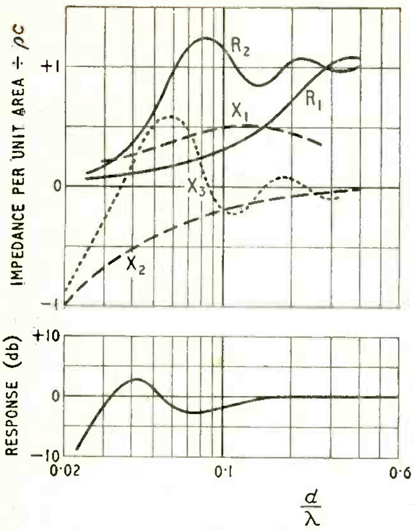
(d) The frequency limitations, amplitude at the low end, and directional problems at the high end, fit in nicely with the 4-5 octave range which we established in Part I of this article for satisfactory efficiency. Thus a strip shape can form one basis of design for our ideal—the perfect loudspeaker.

It will be obvious that a curved front source similar to that illustrated in the photograph of Fig. 5 in Part I of this article will give similar distribution to a strip, and, due to the larger surface, smaller spacing may be used and higher efficiency may thus be achieved. In such a case however, the diaphragm must be large compared to wavelength in both dimensions, because it is the nature of curved surfaces to become directional when the radius of curvature is comparable with the wavelength. When the diaphragm is large compared to λ it is impossible to design an intimate acoustic cross-over. This small inherent imperfection would appear to preclude its use in a "perfect" loudspeaker design, although its "efficiency" advantages will have obvious applications in some practical compromise designs.

Although designs free to the air on both sides have useful attributes, it is obviously desirable also to produce loudspeakers in cabinet form, enclosing the rear. This rear enclosure, if it is to be of reasonable size, will be the controlling factor for the diaphragm velocity, at least at low frequencies.

With any unit, the high-frequency limit will be set by efficiency requirements, and the low-frequency limit by amplitude limitation or by the compliance of the enclosure in series with the diaphragm compliance. This compliance will resonate with the air mass on the front and back of the diaphragm (unless the diaphragm is so large that the loading is ρc—for example, as in the curved diaphragms previously mentioned). Since the total mass is small, this resonance will usually occur above the lowest frequency of interest. It may be dealt with in two ways, (1) by adding acoustic mass within the cabinet to reduce the resonant frequency to the lowest required frequency, or (2) critically damping the resonant frequency and maintaining response below this frequency either by re-matching or by a secondary acoustic resonant circuit, or both.

There are innumerable ways in which either of these alternatives may be achieved. Consider the first alternative. Suppose that the enclosure is made deep and narrow (or fitted with partitions so that it appears deep and narrow to the loudspeaker): then, at wavelengths just under four times the depth, the reaction on the diaphragm will be positive. This will effectively force the resonance to the ¼ wavelength reasonance of the depth of the enclosure. Absorbent wedges may now be fitted to control the resonance and to present



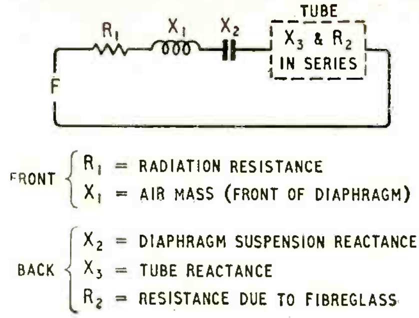


Fig. 5. Strip loudspeaker, long compared with wavelength, and of width d, mounted in a wall, with the back of the diaphragm loaded by a tube with cross-sectional area equal to that of the diaphragm and of a length 5d, blocked at the far end. Resistance (fibre-glass wedge) included in tube to control impedance.

a purely resistive load at all higher frequencies. Sound compression within the wedges becomes isothermal, decreasing the speed of sound, so that the depth of the enclosure can be reduced accordingly.

Fig. 5 shows the impedances of a strip unit loaded on this principle together with a curve showing the power output radiated as sound for constant applied voltage. The output is extended by more than an octave over that which would be obtained if the same volume of enclosure were allowed to act as a lumped capacitance.

Turning now to the second method of extending the low frequency range, Fig. 6 shows a diaphragm loaded by a capacitance leading through resistance and inductance into a larger capacitance. Both volumes have dimensions many times less than the wavelength in the ranges where they are operative.

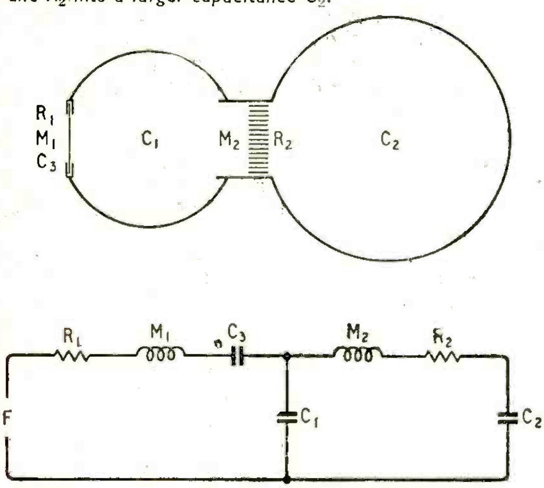
If the constants are adjusted to give a step in response as the frequency is lowered, then the total volume of the enclosure is reduced accordingly and the response restored to level by re-matching at the step frequency.

Fig. 7 shows a strip diaphragm loaded by a capacitance with series resistance, all elements continuing along the whole length of the structure. With this assumption there will be no waves in the enclosure along its length so that the constants can be calculated on a sectional element of thickness *t*. If the cross section of C_2 has dimensions which are many times smaller than the wavelength, then C_2 will behave as a capacitance (independent of length). If this proviso is not met then R_2 must be distributed to avoid C_2 appearing as a multi-resonant circuit.

Where the unit crosses over to another unit for low frequencies then R_2 may be adjusted to give a Q of 0.7 so that the cross-over components are already present in the acoustic circuit.

When the lower-frequency unit is arranged so that the two diaphragms are close and intimately coupled, then R_1 will be increased in value by the mutual radiation of the low-frequency unit. R_2 is then reduced to restore Q and we find that if R_1 is larger

Fig. 6. Diaphragm loaded by an equivalent capacitance C_1 leading through an acoustic mass and resistance M_2 and R_2 into a larger capacitance C_2.



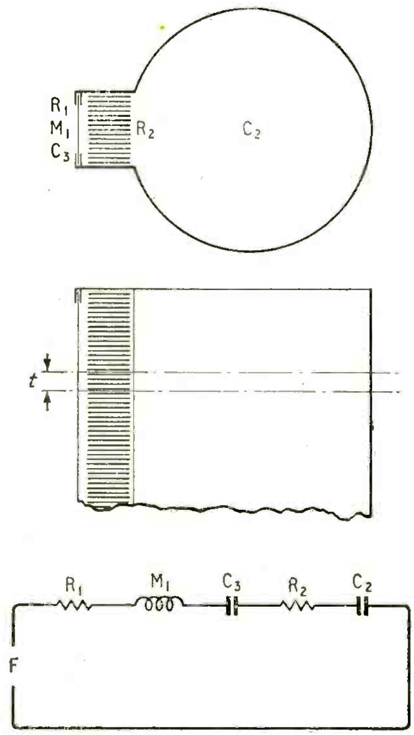


Fig. 7. In a long cylindrical structure the air column will be driven equally at all points along its length and no appreciable longitudinal standing waves can be established, at frequencies other than that corresponding to λ/4.

than R_2 a useful self-compensating effect takes place.

If the voltage applied to the low-frequency unit is reduced at cross-over due to tolerance in its cross-over components then R_1 is automatically reduced and the output of the higher-frequency unit increases at cross-over. At cross-over $P_{out} \propto \frac{R_1}{(R_1+R_2)^2}$

Where the enclosure of Fig. 7 is used for the unit covering the lowest part of the audio range, bass response may be extended by rematching or by introducing a secondary resonant circuit and utilizing back radiation from the diaphragm. If an aperture is provided at one end of the enclosure, opening to the air, then, when the enclosure length is ¼ wavelength, resonance will occur along its length, and there will be radiation from the aperture. 3/4, 5/4 resonances, etc., will not arise, because the enclosure is excited by a force distributed along its length. At frequencies above the ¼ wavelength, the enclosure will behave approximately as a capacitance, as if the aperture were not present.

The next part of this article will deal with electrostatic units as part of delay lines, and the application of various complete designs, "built in," "boxed in" and "doublet" in relation to the listening-room. Complete electrostatic loudspeakers can take several different forms, each of which in terms of frequency response, distortion and sound dispersion can meet a specification virtually to perfection. When the listening-room and subjective factors are considered it becomes impossible to lay down a rigid specification. To adopt a quotation "Each design is perfect, but some designs are more perfect than others"!

Acknowledgement. Fig. 2 is based on Fig. 5. 9, p. 127 of "Acoustics" by Leo. L. Beranek (McGraw Hill).

(To be continued)

LETTERS TO THE EDITOR

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

Situations Vacant

WITH the present state of full employment in the electronic profession, the competition amongst employers to find suitable men is fierce. This is shown by the numerous posts advertised in technical journals. The time has come, however, for employers to pay a little more attention to the "Sits. Vac." replies.

Three members of my laboratory have, over a period of the last six months, written to a dozen advertisers. The results have been very disheartening; only 40 per cent of the applications were acknowledged. The applicants were qualified men: A.M.I.E.E., A.M.Brit.I.R.E., Higher National, National and City and Guilds certificates. In good faith they have taken some trouble to apply for positions, expecting that they would be treated with good manners by the advertiser, and have been embittered by the callous manner in which their applications were treated.

I would ask "Sits. Vac." advertisers to read page 498 of *Electronics* for March, 1955, and then to make moves at least to treat engineers with the courtesy their professional status deserves. J. GILBERT.

Biophysics Dept.,
Postgraduate Medical School of London.

Transistor Symbols

IT would seem that an over-riding factor when assessing the desirability of a logical system of transistor symbols is whether the advantages of the system are more important than international standardization. It is impossible to ignore the fact that there is a well-established convention at present widely used in both Europe and the U.S.A., and it is, to say the least of it, unlikely that any alternative suggestions at this late stage will replace the accepted practice. I would suggest that it is better to follow the generally accepted convention and concentrate on clearing up minor differences about points such as the thickness of base line and the presence of a circle to isolate the transistor from the rest of the circuit.

Leaving on one side the question of standardization, there is still a doubt whether your suggested symbols (April and May, Editorial Comment) do in fact add to an understanding of the devices. The symbol you suggest is particularly undesirable since it is very misleading to regard a transistor as a back-to-back arrangement of two diodes.

Finally, the point raised about the abbreviation to use in circuit diagrams can be met without causing confusion by using the same "V" for the crystal valve as for the thermionic version. B. R. BETTRIDGE.

General Electric Company,
London, W.C.2.

BOTH D. Nappin and W. E. Thompson (your May issue) regard the transistor as a new device needing a new symbol, but surely this problem arose as the normal valve developed.

It was no doubt thought that gas triodes and neon stabilizers were separate devices, that each needed a new letter symbol, but in fact they are both given the letter V, and no confusion is caused by this. The type of device is made clear by the circuit symbol.

I suggest, therefore, that the letter V be kept to include the transistor.

London, N.1. M. LEVY.

WHILST in full agreement with the general scheme of transistor symbols proposed in your April and May Editorials, I should like to plead for the symbol originally shown for the *n-p-n* junction transistor in *Wireless World*, July, 1954, p. 325, Fig. 2(c), rather than the new version in Fig. (f) of the May Editorial. This later version is likely to cause error, particularly when pencil sketches are copied in the drawing office or print room. Furthermore, the original version appears more logical and distinct, being characterized by a black and white triangle like the symbol for the *p-n-p* transistors.

London, N.W.3. FRANCIS OAKES.

Electronics on the Farm

R. S. DRAKE'S letter (your May issue) is very interesting and certainly very pertinent. Within limits one must admit that a manufacturer should know! However, I beg leave to suggest that there is justification for some comment, if not criticism.

Popularity obviously justifies manufacture and sale, but it does not follow that it confirms excellence of design and practical value. Established habits die hard.

It may be true that there is no serviceable electronic "switch" or "trigger," but I feel that there is no valid objection to a glass-enveloped tube in a fencer unit. These units must in practice be effectively boxed and weather-proofed, and in any case we have electric lights all over the place on farms these days.

I still hope to find an electronic dry battery unit on sale in the not-too-distant future; a unit which is neatly boxed and requires no servicing beyond the occasional plugging in of a relatively inexpensive replacement. Furthermore, I consider that this unit should carry its own test equipment. I see no reason why this should be very expensive, even if it does have to involve more than a neon tube or a blade of grass, and I think loose test equipment is an anachronism. In theory it enables one to test the fence at any point, but in practice this is an advantage of negligible value. Nine times out of ten one naturally puts the unit at the gate or most convenient point of approach, and again nine times out of ten if the fence is "down" the only effective way of locating the fault is to walk the fence. Finally, more often than not it is easier and more convenient to switch off before one walks so that one can repair in comfort. Of course, one *can* wear gloves, one *can* withstand the shock, one *can* use a handkerchief, kick down a weed or pull off a branch. But how often does one in practice? In practice it is far more desirable to be able to check when there, without having to remember to take the tester, than to be able to test at all sorts of odd points.

No doubt my desired unit would not be cheap, but I fail to see why it should be any more expensive than the average unit now on the market.

Hempstead, Essex. H. G. TAYLOR.

"As She Is Spoke"

I HAVE just been reading M. G. Scroggie's letter in your May issue, and I notice that the linoleum in my immediate vicinity is very clean. This must be due to the fact that Mr. Scroggie has been wiping the floor with me.

I apologise to him for having wrongly deduced from his previous letter that he objected to the use of the word "recording" as a noun; I now realize that he only objected to its use in reference to a recording.

As Mr. Scroggie now concedes that we can have a recording on a record, I readily agree that there should be no logical objection to using the words "tape record" to refer to a recording on tape. In fact, I notice that this nomenclature has already been adopted by your journal, so that just about clinches the argument.

Wharfedale Wireless Works, Ltd., Bradford. G. A. BRIGGS.

Earthing Metal Braiding

IN the illustration of the component layout for P. J. Baxandall's pre-amplifier in your February issue, the method shown of making a connection to a metal braid screening is by wrapping a connecting wire round it. This, I know, is a common method, but it involves soldering which may injure the sleeve or insulated wire directly beneath. It also does nothing to remove the jagged ends of the braiding, and I have known them penetrate the insulation beneath and cause a short when the conductor is sharply bent.

Another method, suggested to me long ago, is better on both counts, but does not appear to be widely known. About one inch from the end of the braiding the wires of the "warp" are separated and so are the wires of the "weft." This leaves a diamond shaped hole and the sleeve or insulated conductor within the inch of braiding is pulled out through the hole. The braid thus left empty forms a convenient pigtail for connection to the remainder.

London, N.W.7. W. J. CLUFF.

Commercial Literature

Audio Amplifier, the Cape 25, by Cape Electrophonics, mentioned in the March issue. An error of 0.08% was made in the distortion figure, which should be 0.12% at 64 c/s with 26 watts output. At 1,000 c/s, 25 watts output, the distortion is claimed to be 0.03%.

Band-III Aerials, including composite Band-I/Band-III types, add-on units for existing aerials; indoor types and also converters, pre-amplifiers and downleads. Described in a leaflet from Aerialite, Castle Works, Stalybridge, Cheshire. Also a non-technical leaflet explaining aerials and converters for Band III.

Marine Communications Receiver covering long, medium and trawler wavebands with Consol navigational aid. Power supply from 12-V or 24-V ships' battery. General specification in a leaflet (also containing a list of available Consol charts) from Pye Marine, Oulton Works, Lowestoft.

Small Electrolytic Capacitors with paper dielectric construction and very low leakage currents. Capacitances of 0.5-50μF, working voltages of 250-25V d.c. and sizes up to 2in × 0.6in (diam) approx. Technical bulletin from the Telegraph Condenser Co., North Acton, London, W.3.

Magnetic Permeability Tester for measuring metallurgical uniformity of production samples from foundries, rolling-mills, etc. Brief outline in a leaflet from Excel Sound Services, Celsonic Works, Garfield Avenue, Bradford, 8, Yorks.

Impregnation Plants for impregnation of coils, transformers, etc., with varnish, resin or other materials under alternate vacuum and pressure. Also available for "potting" work. Features described in a leaflet from Blickvac Engineering, 96-100, Aldersgate Street, London, E.C.1.

Geared-down Motors, fractional horsepower, either series-wound, variable speed, for a.c./d.c. or capacitor-induction, constant speed, for a.c. only. Output speeds ranging from 0.2 r.p.m. to 840 r.p.m. with torques from 3 lb-in to 75 lb-in. Technical specification from M.R. Supplies, 68, New Oxford Street, London, W.C.1.

High Quality Sound Reproduction equipment including combined amplifier and record-playing units; separate record players and amplifiers; and loudspeaker units. Leaflets from Pye, P.O. Box 49, Cambridge.

Inexpensive Oscilloscope with circuit for measuring voltage of waveform, or a selected portion of it, on a voltmeter within the range 0.2-500V. Deflection sensitivity, 1cm/V; bandwidth, 3Mc/s; and time base frequencies, 3c/s to 120kc/s. Leaflet from E.M.I. Electronics, Hayes, Middlesex.

Power Oscillator, giving 120 watts into 10Ω with frequency range of 10c/s-10kc/s, for driving vibration generator. Leaflets on this, and also on moving-coil electro-dynamic exciters with peak thrusts from 2 to 300lb, from Goodmans Industries, Axiom Works, Wembley.

Timer, for hand-setting, driven by synchronous motor. Can be provided with dial for any time range between 0-30 seconds and 0-7 days. Normal switching capacity 5A at 230V. Descriptive leaflet from the Electrical Remote Control Co., East Industrial Estate, Harlow New Town, Essex.

Aluminium Soldering Tool. A steel wire brush in the soldering bit vibrates and cleans the work surface while a pool of molten solder around the bit protects the cleaned area from the air. Illustrated leaflet from Belark Tool & Stamping Co., 33, Sussex Place, London, W.2.

Nickel Alloys in Valves; applications of the metal in cathodes, grids, anodes, supports, springs, non-magnetic components and glass-to-metal seals described in an illustrated booklet from Henry Wiggin & Co., Thames House, Millbank, London, S.W.1.

"The Cosmocord Story" is the title of an illustrated booklet describing the development of the firm's work in piezo-electric crystal devices and also some of the present manufacturing techniques. From Cosmocord, 700, Great Cambridge Road, Enfield, Middlesex.

V.H.F. Equipment from Germany. F.M. transmitters; receivers for radio relay systems; dual-receiver equipments; f.m. transmitter aerials; broadband receiving aerials; and test equipment; made by Rohde & Schwarz. Leaflets from the British agents, Aveley Electric, 44, Tottenham Court Road, London, W.1.

Physical Society's Exhibition

NEW ELECTRONIC DEVICES AND TECHNIQUES

This report is followed by surveys of recently introduced valves and allied devices; also of test and measuring gear. These surveys cover exhibits at both the Physical Society's and R.E.C.M.F. shows. Some products appeared at both, so no distinction is made here between the two exhibitions.

RESEARCH

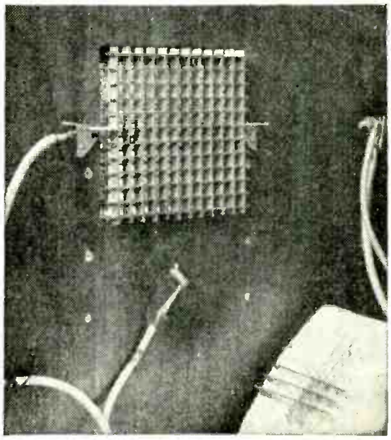
MANY physical effects have been exploited in the search for the ideal electro-acoustic transducer (loudspeaker) and a new one, demonstrated by D. M. Tombs, of Imperial College, makes use of the fact that a corona discharge between points is accompanied by a wind, generated by the migration of ionized air particles. Under normal conditions the wind is unidirectional, because of the difference in mobility between the negative and positive ions, but by interposing a grid, suitably biased, between the point electrodes the opposing streams can be balanced. If, now, an alternating signal voltage is superimposed on the grid, acoustic radiation is possible and was in fact demonstrated. From the initial asymmetry of air movement one deduces that, in its present state of development, the transfer characteristic would be non-linear—a sort of "ionic Stentorphone"; but at least it opens a new line for investigation in improving what most people agree is the weakest link in the sound reproducing chain. A similar electrical principle is involved in the "corona triode" also shown by Mr. Tombs. Like the transistor it requires no heater current, and it gives a gain of 5 with an a.c. resistance of 500 MΩ and a mutual conductance of 25 μA/kV.

A photocell amplifier with a simple wide-range a.g.c. system was shown by the Armament Research Establishment. It makes use of the fact that the input resistance of a valve is inversely proportional to the grid current; thus an input potential divider is established with the photocell impedance which automatically reduces the grid voltage due to steady illumination. The a.c. gain is not affected and light modulation does not vary more than ±3 db over a frequency range of 10 c/s to 10 kc/s even when the steady background illumination is varied over a range of 1,000:1 from, say, 0.0002 lumen to 0.2 lumen.

The basic causes of the residual interference from the gas discharge in fluorescent lamps, and similar phenomena in vacuum filament lamps, are being investigated by Siemens and a demonstration was given showing how the radiation is related to the electrode emission and the filament current. Normal gas-filled filament lamps do not radiate.

Research into the properties of new and existing materials was prominently represented at this exhibition. Wayne Kerr were showing examples of potting resins specially compounded to minimize mechanical and thermal shocks, and the reduction of valve microphony obtained by the use of semi-flexible resins was demonstrated. Butyl rubber as a moulded insulator for high-voltage transformers was shown by B.T.H.

Much interest is being shown in silicon as a semiconductor for diodes on account of its low reverse voltage, which is held to much higher temperatures than in germanium. B.T.H. demonstrated the method of growing crystals and also a method of radioactive analysis to show



Corona wind loudspeaker (D. M. Tombs).

the distribution of residual impurity in the growing crystal.

Development continues in the production and utilization of new ferrites. Plessey were demonstrating a ferrite switch depending on the large change of incremental permeability when the operating point is changed from remanence to saturation, and have also produced a range of nickel ferrites with magnetostrictive properties.

The Faraday magneto-optic effect in which the plane of polarization of electromagnetic waves in a medium is rotated under the influence of a magnetic field is exploited in special ferrites to attenuate or modulate microwaves (Radar Research Establishment), (Plessey). It is also used for current measurement in high-tension power distribution systems, where the use of a current transformer would present difficulties (British Electrical and Allied Industries Research Association).

Ferroelectric behaviour in ceramics formed the subject of a comprehensive exhibit by G. E. C. Research Laboratories, and it was shown that the large change in permittivity at the Curie point could be exploited to generate a fire alarm signal. Dielectric amplifiers based on the hysteresis characteristics of these materials were also demonstrated.

NON-INDUSTRIAL ELECTRONICS

IMAGE converter tubes are well known for their use as "electronic shutters" in high-speed photography, but hitherto the shortness of exposure has been limited to about 30×10^{-9} second by the inability of the electrical circuit to convey pulses of such short duration. Mullard were showing how this exposure can be reduced some ten times to 3×10^{-9} second by using r.f. techniques—the pulse being conveyed by a coaxial line to a modified image converter tube with coaxial connections and a ring of resistors providing correct termination of the line. The switching pulse was actually generated by a spark, and it was the light from this spark that was being shuttered, a visual image appearing on the screen of the image converter. By using mirrors to vary the length of the light path from the spark point to the tube photo-cathode (and so altering the arrival time of the spark image relative to the shuttering pulse), it is possible to examine individual stages of the spark formation—reducing the effective exposure time to as small as 3×10^{-10} second.

The scanning and display principle used in the flying-spot microscope (represented at the show by the well-known Cintel model) is now extending into other fields. One particularly interesting example was a scanning X-ray system shown by the Royal Cancer Hospital. Here, the place of the flying-spot c.r. tube is taken by a special X-ray tube in which an electron beam scans a platinum-foil target about the size of a post-card. The raster of X-rays so produced passes through the thin target and the tube face and after being modulated by the object under examination is picked up by a scintillation detector. The signal pulses from this are then integrated and amplified and used to intensity modulate a display c.r. tube which is being scanned in synchronism with the X-ray tube. Because of the great sensitivity of the scintillation detector the system is claimed to be about 20 times more sensitive than conventional X-ray apparatus.

Another exhibit using the flying-spot principle was an equipment for counting and sizing small particles, demonstrated by Mullard. This works on the same general principle as the Mullard apparatus shown last year, but for sizing purposes the scanning spot is given a secondary deflection, downwards across the particle and back again, at the end of the first line scan. The length of the excursion is then used as a measure of the particle size.

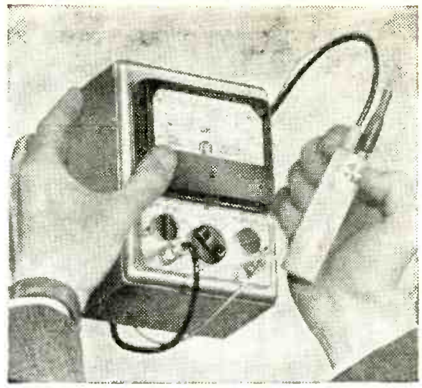
For the actual process of counting and registering pulses the well-known Dekatron was very much in evidence in a large number of instruments. There is now, however, a new type of decade counting tube which is a good deal faster in operation than the glow-discharge transfer method. This is the Mullard E1T, a miniature c.r. tube using electrostatic deflection of the beam into ten different positions, and in a demonstration it was shown counting at a p.r.f. of 100 kc/s. Counting is also the basic operation in digital computors, and in this field the same firm were demonstrating how transistors can be used in place of valves for various functions—with considerable advantage in reliability and heat dissipation.

There were actually no complete digital computors to be seen at the exhibition, but several of the analogue kind. A particularly interesting one, shown by Elliott and using d.c. amplifiers as functional units, is designed so that problems can be set up on a series of detachable panels, each of which plugs into a d.c. amplifier. It is thus possible to remove a problem *en bloc* and keep it set up whilst leaving the main instrument free for other work. A miniature analogue computor was demonstrated by Saunders-Roe, while Southern Instruments had a correlogram computor with photo-electric line followers to work from continuous line records on film or paper.

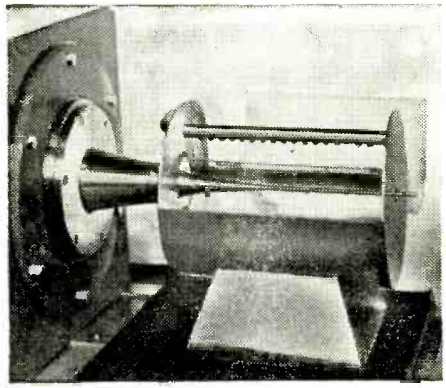
INDUSTRIAL ELECTRONICS

THE measurement and recording of fundamental physical quantities such as displacement, velocity, acceleration, temperature and pressure forms the basis of the application of electronics to industrial processes. Initially, a transducer is required to convert the physical quantity into a voltage or current which can be amplified by valves or magnetic amplifiers. The output from this transducer is generally applied to a self-balancing potentiometer, operated by a servo motor, and the setting of the potentiometer is recorded on a moving chart or may be used to control industrial processes through relays or larger servo motors. Typical of this widely represented branch of the electronic art are the Foster continuous-balance electronic potentiometers, the Cambridge Instrument multi-point electronic recorder and the Boulton and Paul automatic manometer for use in wind tunnels or in any fluid pressure system.

Variation of capacitance forms a sensitive method of measuring distance or displacement and is applied in the prototype of a probe for the exploration of the internal diameter of small bores. It is used in conjunction with the three-terminal bridge shown last year by Wayne Kerr and can be calibrated to give direct readings of distance at balance.



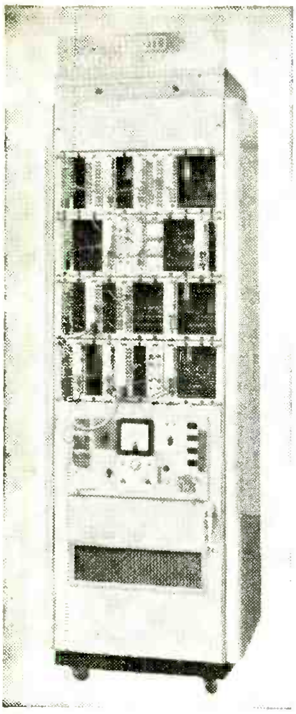
Pye miniature pH meter.



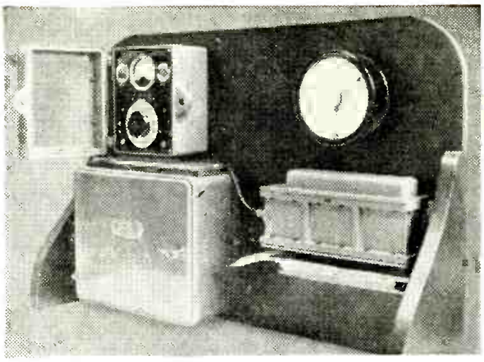
Fatigue testing of rod specimens by ultrasonic vibration (Mullard).

The thickness of electroplated films can be measured magnetically as in the B.S.A.-Tinsley gauge in which the adhesion of a small magnet is balanced against the tension of a light spring balance; or thermo-electrically as in a method developed by the British Non-ferrous Metals Research Association and shown by Elliott Brothers. A hot probe and a cold probe are applied to the surface of the plating and the thermal e.m.f. generated between the plating and the base material appears between the two probes. A magnetic amplifier is used between the probe output and any suitable indicator, recorder or relay.

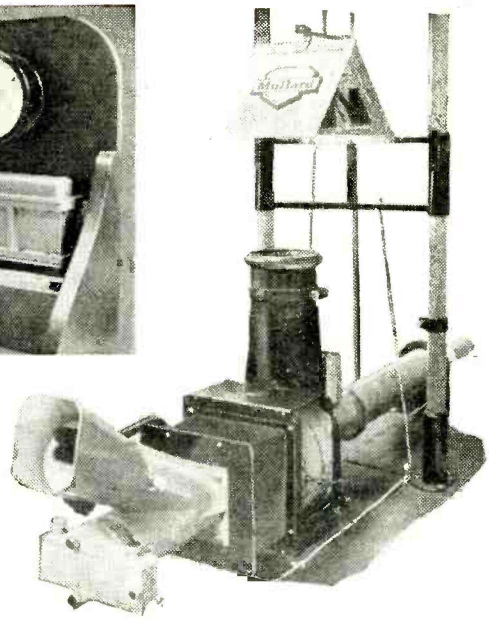
Measurement of thickness by ultrasonic methods where only one side of the material is accessible, as in the case of pressure vessels, may be effected in several ways. In the Dawe Instruments "Visigauge" standing-wave resonance in the thickness of the plate increases the power absorbed from the driving oscillator and this change is displayed as a "pip" on the vertical scale of a cathode-ray tube. The horizontal scale is a function of frequency, which is swept cyclically through an appropriate range, and can be calibrated to read thickness directly. In the Kelvin-Hughes depth and thickness accessory for their standard ultrasonic flaw detector, a short pulse is applied simultaneously to the plating under test and to a liquid delay line of adjustable length. Both return pulses are displayed on a c.r. tube, and, when adjusted to coincidence, the depth can be read off directly. The instrument is calibrated for mild steel and has a range of ¼in to 4in. By a technique, in which an electrical step function is applied to a thick barium titanate disc with heavy mechanical damping to give a stress with a sharply defined leading edge, the Ultrasonoscope Company (London) have succeeded in resolving echoes in steel and aluminium for thicknesses down to 0.02in.



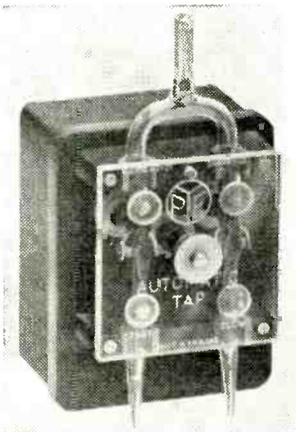
Elliott analogue computor.



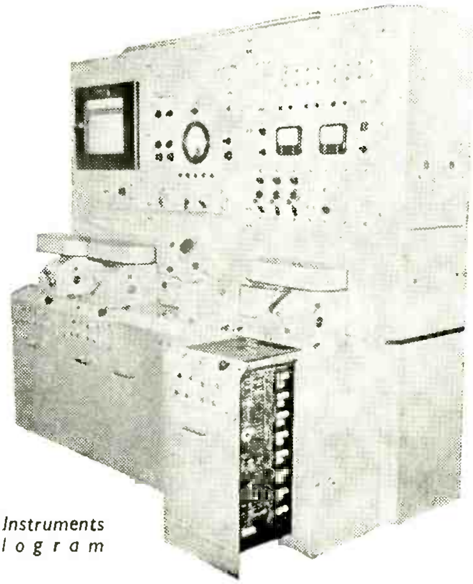
Isotope Developments Type 150 beta ray thickness gauge.



Mullard high-speed photography apparatus.



Magnetically-controlled tap for automatic titration (Pye).



Southern Instruments correlogram computor.

Applications of ultrasonics for the non-destructive testing of materials were shown by the National Coal Board (elastic properties of coal) and by A. E. Cawkell (for checking the compressive strength of concrete in fabricated building units). A spectacular demonstration of the time that can be saved in fatigue testing of metals was given by Mullard. Short rod specimens, welded to a tapered mechanical transformer element were excited with ultrasonic power of the order of kilowatts at a frequency equivalent to the half-wave longitudinal resonance of the bar. Under these conditions velocities are a maximum at each end, and compressional and tensile stresses at the middle. Strain is measured by capacitance probe near the free end. To show the magnitude of the forces which could be applied, specimen bars were raised to incandescence in the centre in a matter of seconds. Normally, of course, the specimen would be water-cooled.

Continuous monitoring of thickness of sheet materials during manufacture by the absorption of beta rays (electrons) from a radioactive source has long passed the development stage, and ruggedly housed units suitable for use under factory and mill conditions are made by a number of firms. Typical of this trend is the Type 150 beta gauge made by Isotope Developments. In the Ekco thickness gauge, provision is made for automatic overall standardization every 30 minutes with servo correction for amplifier sensitivity and source decay or contamination. The thickness at predetermined points across the width can be sampled at intervals, the duration of which can be pre-set by the operator. To meet the needs of the paper industry Baldwin Instruments have produced an accessory to their "Automat" beta ray thickness gauge designed to measure the weight per unit area, and thus the "height" or "profile" of the paper surface, across its whole width. A continuous record is obtained on a pen recorder.

As an alternative to electron penetration, the back-scatter due to gamma radiation is now coming into use for the measurement of thickness. In a prototype instrument shown by Ekco Electronics, cobalt 60 is used as the radiation source and a differential circuit is used to separate the reflected photons from the primary radiation. The detecting photomultiplier tube is associated with a circuit time constant long enough to remove random fluctuations from the indicator. Baldwin Instruments also showed a prototype back-scatter thickness gauge designed to measure metal sheet thickness where only one side is presented, and a transmission gamma-ray thickness gauge for revealing non-uniformity due to variations of ingot temperature in hot steel rolling mills.

In chemical analysis increasing use is being made of electronic methods. The measurement of hydrogen ion concentration (pH) is already well established and the trend is towards miniaturization, as exemplified in the Pye Type 11084 instrument.

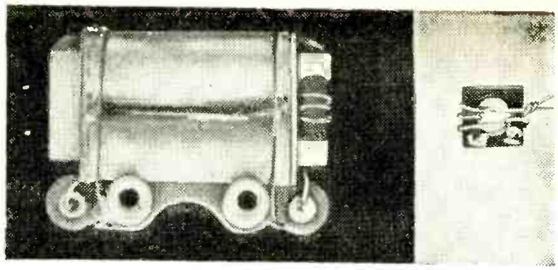
In the estimation of acids and alkalies by titration, the end point is usually indicated by a pH meter and in the Pye Type 11600 instrument the out-of-balance signal from the pH meter is used to control a magnetic stop valve with fast and slow rates of dispensation of the neutralizing reagent. The end point may be pre-set to any value within ± 0.1 pH and the changeover from fast to slow dispensation can be set to come into operation up to 5 pH units before the end point.

A different method of titration with many interesting features is employed in the automatic titrimeter shown by Electronic Instruments. Instead of using calibrated acid or alkaline solutions of known concentration, the starting point is a neutral salt of indeterminate strength. A current is passed through the salt solution in a cell with semi-permeable ends and acid or alkali is liberated at the electrodes, depending on the direction of the current. The current is integrated by a low inertia motor and counter unit of the type designed by Electro Methods and gives a direct measure of the amount of reagent generated and used for the titration (1 gram equivalent ion is equivalent to 96,494 coulombs). The process is stopped automatically when the predetermined end point is reached on the pH meter.

Rapid analysis of the constituent elements of solutions is possible by a method known as polarography, in which a progressively rising e.m.f is applied to a mercury dropping electrode. Current flows in well defined steps in which the starting e.m.f. is related to the identity of the conducting ion and the height of the step to its concentration. In the Tinsley recording polarograph the first derivative di/dv of the current-voltage relationship is displayed, which gives better resolution, and a square-wave method developed by Barker and Jenkins, of A.E.R.E., and utilized in the Mervyn Instruments polarograph gives greater latitude in dealing with constituents of widely different concentration.

MISCELLANEOUS EXHIBITS

A MAGNETIC reactor, having various applications involving frequency shift of an oscillator by means of an externally applied audio or d.c. voltage has been developed by Plessey. A fruitful field of usefulness is for frequency modulating v.h.f. oscillators and transmitters and for automatic frequency control of a v.h.f. oscillator.



Plessey magnetic ferrite reactor.

The reactor consists of a small ferrite former with a few turns of wire wound toroidally on it and forming part of the tuned circuit of the oscillator it is required to control, or frequency-modulate as the case may be. The toroidal coil is mounted in an electromagnet system in such a way that by applying either a d.c. or an a.c. voltage to the electromagnet winding the incremental permeability of the ferrite core, and hence the inductance of the toroidal winding, can be varied. An inductance change of the order of 10 per cent is attainable. The unit shown by Plessey is designed for use at frequencies of from 50 to 100 Mc/s.

Some really lilliputian input and output audio transformers were exhibited by Fortiphone. The company has, of course, had a wide experience in the manufacture of very small parts for hearing aids. The transformers shown were mainly for transistor circuits and were in ratios of between 2 and 10 to 1 and either encapsulated in potting resin or open. The smallest measures $\frac{1}{4}$in × $\frac{3}{8}$in × $\frac{3}{8}$in, while the largest of the miniatures is only $\frac{3}{4}$in × $\frac{3}{4}$in × $\frac{5}{8}$in. Primary inductances (with no d.c. flowing) of 30H or so are achievable with some of these tiny transformers.

Recent improvements in the precision-type silvered-mica capacitors made by Johnson, Matthey consist of using thinner mica and a larger silvered area than hitherto and thus providing more pFs per unit area.

TEST AND MEASURING GEAR

Apparatus Shown at the R.E.C.M.F. and Physical Society's Exhibitions

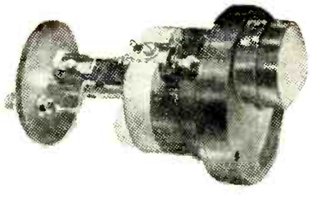
MANY of the instruments to be mentioned were shown in prototype or pre-production form, and are therefore subject to modification before they become available, if they do. Likewise many of those which were available for the first time had been previously reported in *Wireless World* so are not mentioned again unless the modifications were substantial.

After a period during which the design of unamplified meters had seemed almost to have reached finality, signs of renewed activity were to be seen in a considerable number of new models. The demand by the Services for hermetical sealing has been met by several makers. The well-known Avometers 7 and 8 now have counterparts in Araldite "D" tropical dress as 7X and 8X. The trend towards wide-angle deflection continues. British Physical Laboratories showed sub-panel-mounted meters to accord with contemporary styling, and Everett Edgcumbe a new system of scale lighting distributed by a Perspex surround. Pullin now have two multi-range d.c./a.c. test meters of the Amp-Volt-Ohm type, one with a 1 mA movement and the other 50 μA, for which a special 20-way multi-bank switch was developed; there is also a miniature d.c./a.c. 19-range set. The same firm showed a moving-coil voltmeter mounted in a probe for measuring television e.h.t. up to 25 kV; full-scale current, 40 μA. An ingenious device enables the whole of the scale to be used for either positive or negative voltages without reversing connections. To the Pye series of "Scalamp" high-sensitivity instruments has been added a voltmeter taking a full-scale current of 1 μA (i.e., 1 MΩ per volt, for those who prefer to put it in that roundabout way). The lowest range is 10 mV f.s.

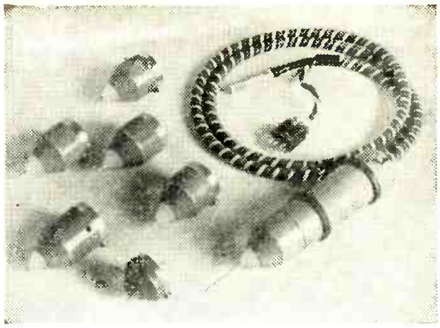
Another conception of rugged sensitivity is the Doran portable combined pointer and reflecting galvanometer, obtainable with various full-scale readings; examples are ± 0.12 mV (10-Ω coil) and ± 1.5 μA. Among new frequency meters are those by Pullin and Electrical Instrument Co.; the latter also showed differential a.c. meters in which two opposing rectifiers are connected to a centre-zero movement, obtainable with f.s.r. from ± 50 μA upwards.

The valves in valve voltmeters have hitherto been of the vacuum type, but this year a sign of the times is the British Physical Laboratories' "Transranger" multi-range voltmeter and megohmmeter in which an instrument outwardly uniform with their test meters having a movement requiring 25 μA for f.s.d. nevertheless is fully deflected by 1 μA, the gain being provided by an internal

Pullin e.h.t. probe voltmeter.



Combined pointer and reflecting galvo made by Doran Instruments.



E.M.I. cathode follower probe with some of the interchangeable heads available.

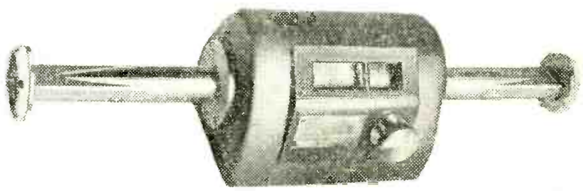
transistor amplifier. Changes due to temperature coefficient are neutralized by initial setting-up procedure. Voltage is measurable from 0.001 to 500, and resistance from 0.001 to 100 MΩ. A new Avo multi-range d.c. voltmeter also takes 1 μA f.s., but uses conventional valves. So does the Marconi Instruments TF1041 on its d.c. ranges, which extend up to 1,000 V; but for a.c. measurements use is made of a probe containing a rectifier valve of the coaxial type, by means of which the frequency range is maintained level within 1 db up to 700 Mc/s. Resistance is measurable from 0.2 Ω to 500 MΩ. This instrument is in production. So is the latest version of the Pye d.c. microvoltmeter, in which a galvanometer moving coil is made to set up an a.c. signal which is amplified and rectified. A somewhat similar means of stepping-up sensitivity is used in a new Pye instrument, called a "Nanoammeter" because on its most sensitive range the f.s. reading is 10×10^{-9} A.

A considerable number of new or improved oscilloscopes were shown, including several each by Cossor, Nagard and Solartron. Most if not all of these use post-deflection accelerator tubes to give adequate traces at the very high speeds which now are expected of even general-purpose instruments. Along with this goes wide bandwidth in the deflection amplifier; for example, 5 c/s to 10 Mc/s in the "Solascope" CD514, notwithstanding that this is a relatively inexpensive model. A new Cossor model (1056) covers from 5 kc/s up to no less than 80 Mc/s. The E.M.I. Type WM5 includes the valuable feature of meter-read voltage and time along the X and Y axes of the trace, together with the ability to put a television picture on the screen and select any part of any line of it by means of a marker and then switch over to normal waveform examination of the selected part. A cathode-follower probe unit with interchangeable attenuator heads enables the wide frequency band to be maintained up to the point of application. E.M.I. distributed amplifiers, suitable for oscilloscopes, handle a bandwidth of over 100 Mc/s; to the earlier high-level Type 2C has now been added a low-level type that can be cascaded with it to give an overall gain of × 300.

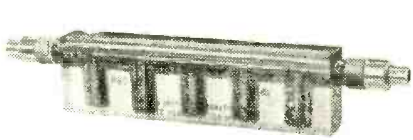
It is interesting to compare methods of providing more than one trace. Cossor continue to use their single-gun split beam, with improved non-interaction, in their new Model 1059. Nagard and Southern Instruments use the 20th Century Electronics multi-gun tubes, of which advantage is taken in Southern's M972 of the ability to make one of the traces a horizontally expanded version of the other. In the Mullard L101 the two traces result from electronic to-and-fro switching of a single beam during each flyback. Lastly, Cintel provide any number of traces by means of separate c.r. tube units, which can be assembled like bricks. Incidentally, the Nagard "Unitel" system imparts similar flexibility to the oscilloscope as a whole.

A number of new attenuators were to be seen. The Advance A63 turret model for frequencies from zero to 1,000 Mc/s provides 10 db steps from 0-50 db using resistance arms. It is of 75-ohm coaxial construction, and the operations of withdrawing both end connections axially, bringing a new attenuator pad into line, and closing up the contacts, are all performed by a continuous rotational movement of the control knob. Separate 75-ohm encapsulated attenuator pads for use up to 300 Mc/s were shown by British Physical Laboratories. Coming to microwaves, an assembly was shown by Wayne Kerr for calibrating S-band attenuators from a piston attenuator at 80 Mc/s to within 0.015-0.02 db. Elliott demonstrated absolute calibration of X-band attenuators by a process of adding together two signal outputs previously adjusted to equality, thereby giving a 6.02 db step, from which further steps can be determined. The B443 continuously-variable X-band attenuator shown by the same firm is a beautiful piece of instrument making. It is calibrated direct in db, standing-wave ratio and voltage reflection coefficient, and of the total range up to 100 db that up to 40 db is of high precision.

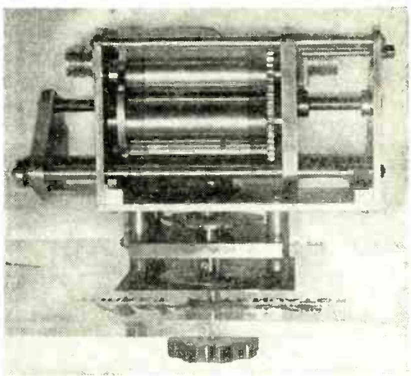
In the field of bridge work a most imposing exhibit



Elliott precision "X"-band attenuator.



Encapsulated attenuator unit, FA200, made by British Physical Laboratories.



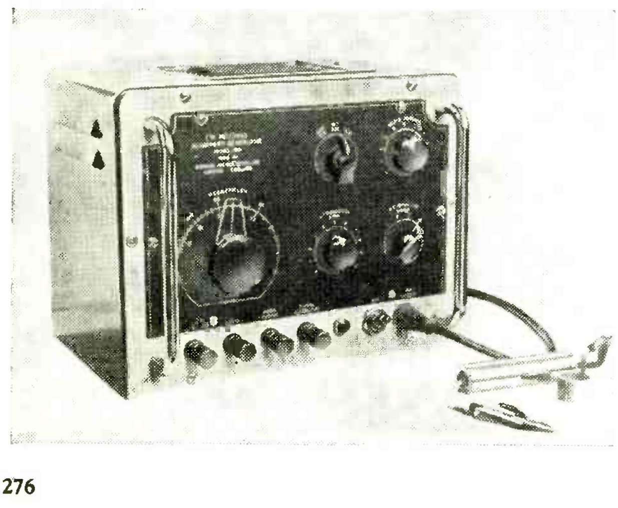
Top view of turret attenuator made by Advance Components.

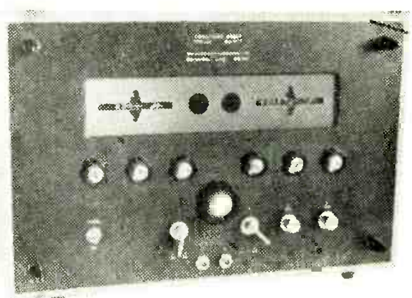
was the Smith bridge on the Tinsley stand, for the measurement of thermometer resistors to within 4 in 10^6. Notable features are the massive switchgear and the elaborate precautions to ensure constancy of the manganin resistance standards, such as the method of spirally winding a helix of the annealed wire between Perspex discs, and the devices for maintaining constant and uniform temperature. A modern version of the Kelvin double bridge for low resistances was shown by the Cambridge Instrument Co. For use with the r.f. capacitance bridge by Electronic Tubes for the measurement of interelectrode capacitances can now be obtained a series of jigs to Anglo-American Service standards, each for a particular type of valve holder. Doran showed a new universal a.c./d.c. bridge and a bridge amplifier-indicator; Griffin and George a "Nivoc" unit system from which bridges can be assembled; and Salford Instruments an incremental-inductance bridge of the Owen type, with c.r.t. balance indicator. In the Muirhead D728 equipment the impedance and phase angle of two-terminal networks between 0.3 and 100 kΩ are measured at 50 and $10^4/2\pi$ c/s by comparison with resistance in a balanced amplifier circuit. The same firm showed an instrument for comparing the voltage and phase of two sinusoidal signals. Comparison is also the basis of an instrument by the Electrical Instrument Co. for measuring and grading components. Its standard is normally their push-button decade capacitor (also shown), and a useful feature of the comparator is a sensitivity switch by which the meter can be made direct-reading in percentage deviation of the component under test. The display mechanism in the Wayne Kerr CR and LR bridges, by which mistakes in reading are rendered almost impossible, appears in improved form in the production versions of those instruments.

The same admirable attention to operational convenience is found in the new decade oscillator of the same make, in which the frequency from 10 c/s to 110 kc/s is directly shown. The decade principle for oscillators has been used by Muirhead for some years, and the latest example is their D695, considerably smaller than previous models but with a high performance. Where spot frequencies (5 c/s to 50 kc/s) and output voltages (5 mV to 20 V) will do, the Cawkell OSP31 oscillator gives 0.1 per cent frequency calibration at a low price—and there is a 1-per cent model at a lower price. The beat-frequency principle is used in the Furzehill 50 c/s to 20 kc/s oscillator, a feature of which is a ±50 c/s incremental control. For the exceptionally low frequency range 0.03-30 c/s Airmec use a rotating capacitor to modulate a h.f. signal which is rectified and amplified to yield the output.

Most of the new oscillators and signal generators for the higher frequencies have been inspired by developments in television and f.m. broadcasting. The Advance range has been supplemented by Type R1, covering the whole v.f. 30 c/s to 3 Mc/s in one range, and 3-10 Mc/s in another, using a RC type of oscillator. Bands I, II and III and the relevant i.f.s are included in a low-priced sweep oscillator by Taylor, in which 5-250 Mc/s is covered in one beat-frequency range; wobbulation is by reactance valve. The Cossor "Telecheck" Model 1323 also covers all three bands and their i.f.s in a more elaborate specification that includes a crystal oscillator to provide accurate frequency marker pips on the trace. Owners of the earlier Model 1322, which is similar except for the absence of Band II, may be interested in Model 1324, which is an alignment generator specifically for testing f.m. receivers, and includes a display of the discriminator characteristic. The Avo Type TFM a.m. and f.m. signal generator, shown in prototype last year, has not yet reached finality, but is expected to cover 5-255 Mc/s with an a.m. signal and 80-100 Mc/s with f.m. The frequency scale is direct reading and fitted with a device for correcting it by known frequencies. At the laboratory level, Marconi Instruments have recently introduced the TF1077 f.m. signal generator covering 19.7-102.5 Mc/s. A piston attenuator is used, and frequency modulation is by varying the permeability of a ferrite core on which the r.f. inductor is wound. A new M.I. a.m. signal generator is the TF801B, covering the unusually wide frequency range of 10-500 Mc/s. Range changing is by contactless switch, and the r.f. valves are of the disc-seal type. For still higher frequencies (L band, 960-1,250 Mc/s) there is now the TF1078, with a piston attenuator having a range up to 110 dbm. Yet another new generator of the same make is the OA1000, for the increasingly important Q band (33,300-37,500 Mc/s). The oscillator is, of course, a klystron, its frequency being stabilized by a variety of the Pound system. A feature of the latest version of the Airmec general-purpose 30 kc/s to 30 Mc/s signal generator is a horizontal direct-reading illuminated frequency scale 4ft long on every range.

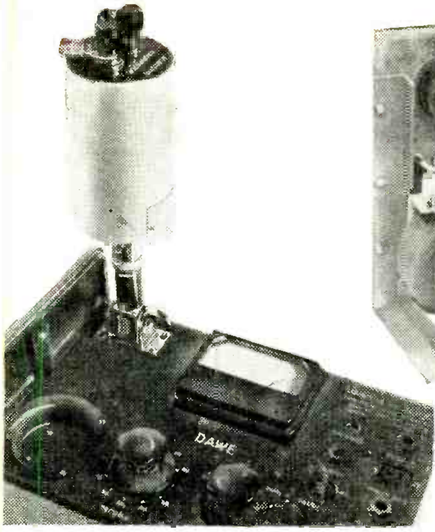
With applications in such fields as television, radar, communications and nucleonics, the need for pulse generators is growing, and new types were shown by Solartron, British Physical Laboratories and E.M.I., with pulse width adjustable down to a few millimicro-seconds. The Mullard L141 generator produces pulses in pairs separated by an interval variable from 1 μsec to 0.1 sec, B.P.L. also exhibited a pulse-height voltmeter, independent of pulse width and repetition rate above 700 p.p.s. For amplified testing Solartron have a square-wave generator (GO511) with rise and fall times as low as 40 and 25 μsec respectively on the highest frequency range. An entirely different kind of special waveform is produced by the Dawe "white noise" generator Type 419, in which a thyratron in a magnetic field generates a noise output uniform from 20 c/s to 5 Mc/s, reducible to 500 kc/s or 20 kc/s for testing apparatus over narrower frequency bands. For taking frequency characteristics, etc., such a generator simulates transient signals such as speech more closely than does c.w., and acoustic standing waves are avoided.

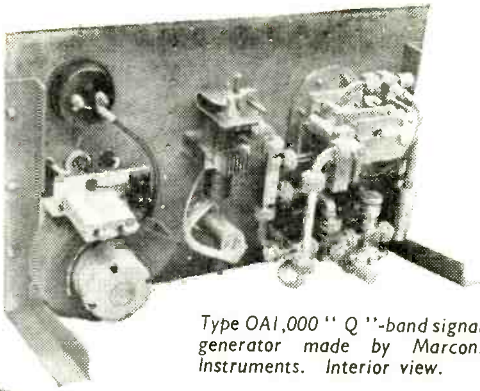




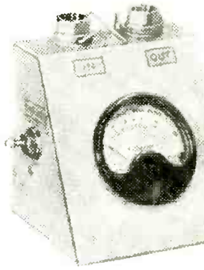
Capacitance Bridge Type B221 made by Wayne Kerr.

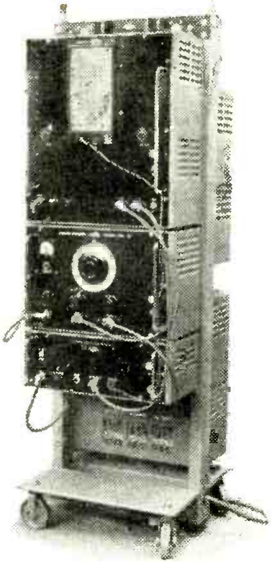
Left: Cossor Model 1324 F.M. alignment signal generator with probe and capacitance coupling.





Type OA1,000 " Q "-band signal generator made by Marconi Instruments. Interior view.





Acoustic calibrator shown in position on microphone of Dawe sound meter.

Right : Labgear standing-wave-ratio direct-reading meter.

Airmec rack-mounted frequency measuring equipment with electronic counter.

Useful in conjunction with it, or with other apparatus such as a sound level meter, is the Dawe Type 1410 octave-band analyser, consisting of switched filters selecting six octaves in the range 75-4,800 c/s (also 20-75 c/s and 4.8-10 kc/s), a calibrated attenuator, amplifier and output meter. Another new Dawe instrument is an acoustic calibrator, consisting of a stable $2\frac{1}{2}$in loudspeaker mounted at one end of a cylinder designed to fit over the microphone of a sound level meter. By feeding the loudspeaker with a known signal voltage, the calibration of the meter can be checked.

Both the Avo and Taylor valve testers have been improved into new models, especially as regards ability to cater for new valve types. The Taylor (45C) has additional switch positions and an adaptor for c.r. tubes. Two new laboratory equipments for c.r. presentation of families of valve characteristic curves were shown: one by Cossor, which is capable of displaying two sets of curves simultaneously, and is particularly suitable for revealing the characteristics in the positive-grid region, inaccessible by static tests; and the other an extremely elaborate three-rack set-up by Electronic Tubes, in which not only the valve curves but the graticule is produced via the same amplifier and beam, making the calibration independent of amplifier linearity and stability. Bridge measurements of the valve parameters can also be made at any desired point.

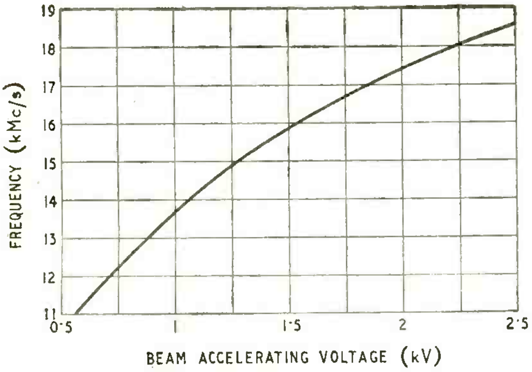
A neat standing-wave-ratio meter by Labgear enables v.h.f. loads to be matched to 75-ohm coaxial lines. The instrument is direct-reading in s.w.r. The Solartron s.w.r. and reflection coefficient indicator is an amplifying detector with an input impedance of 20 kΩ, for use with a slotted-line in microwave circuits. The Advance range of instruments now includes a moderate-priced and versatile Q-meter, Type T1. The basic principle is the conventional one, and a wide frequency range (100 kc/s to 100 Mc/s) is practicable owing to the use of an inductive coupling of very low impedance. The oscillator is modulated at 50 c/s, enabling a sensitive valve voltmeter to be used without the need for zero setting. A still more versatile instrument is the Airmec "TeleVet," which, as its name implies, is for television servicing. It contains in one portable case all that is normally required, including wobbulator, pattern generator, a.m. signal generator, a.f. oscillator, oscilloscope, e.h.t. voltmeter, a.c. and d.c. valve voltmeter, and crystal calibrator. The instrument covers 8-70 and 168-230 Mc/s, is safe when used with a.c./d.c. sets, and for such a comprehensive equipment is inexpensive. The same maker exhibited an electronic counter rack with very clear direct-reading illuminated display of the number of cycles, suitable for quick and accurate frequency measurement.

VALVES AND SEMI-CONDUCTORS

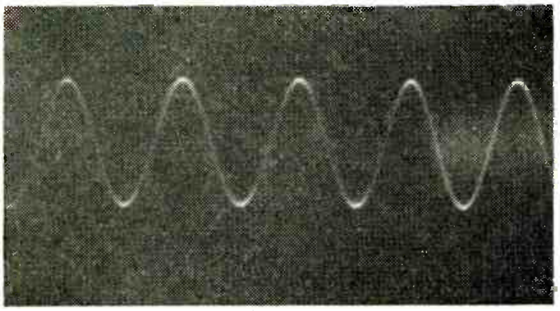
THE most unusual valve be seen this year was undoubtedly the backward-wave oscillator or "carcinotron" shown by Mullard. It is similar in form to the ordinary travelling-wave tube but the r.f. field energy travels in the opposite direction to the electron beam flow. A characteristic feature is the very wide tuning range, which is obtained simply by varying the electron beam accelerating potential (see graph). The collector potential is 200 V and the beam current 25 mA, while the power output is 50 mW at 11,000 Mc/s or 120 mW at 18,000 Mc/s.

In conventional travelling-wave tubes there were two new types shown by English Electric, the N1001 and N1002. Operating as amplifiers, they both have a gain of 25 db over the frequency range 1750-2300 Mc/s, the N1001 giving an output of 20 W and the N1002 an output of 1 mW. Another microwave valve using velocity modulation of the electron beam is the klystron, and on view was a new Ferranti type with the high output power of 500 watts at 9,400-9,700 Mc/s. The cathode of this valve is designed to give a very heavy beam current and the power dissipation of the collector, which has to be water-cooled, is 4 kW.

Of particular interest amongst the receiving-type valves on show was the Osram KT55 beam tetrode. This is intended for use as an audio amplifier in a.c./d.c. circuits (the heater rating is 0.3 A, 52 V) and two of the valves connected as pentodes in push-pull will give an output of 25 watts from a mains supply of 220 volts. In this pentode condition the KT55 has the high mutual conductance of 16 mA/V. Another new audio valve for large output powers was the Mullard EL34. It is notable for its



Tuning range of Mullard carcinotron.



500-Mc/s sine wave recorded on 20th Century oscilloscope tube S6A20-3.

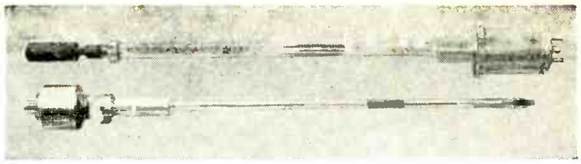
high maximum anode voltage of 800 V, which permits operation in push-pull circuits with output powers up to 100 watts (at 5 per cent distortion). Both the KT55 and the EL34 are on the octal base.

High power and high mutual conductance were also the outstanding features of the new Ediswan beam tetrode 13E1, a d.c. control valve intended for use in stabilized power supplies or servo control systems. The slope is actually 40 mA/V, while the maximum anode dissipation is 90 watts.

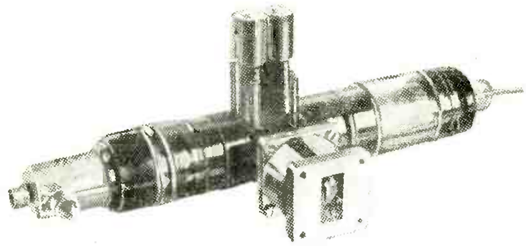
Cold cathode triodes, or trigger tubes, for use in electronic switching circuits are still very popular because they are reliable, long-lived and need no heater supplies. Osram were showing one, the CCT6, which can be used in circuits having wide component tolerances, while the Mullard Z803U is notable for the stability of its trigger characteristics.

New entrants into the transistor field are Pye Industrial Electronics, who have come out with a complete range of germanium junction *p-n-p* types, hermetically sealed, for audio and i.f. applications. Under the series type number of V10, they have collector voltages of 10 V and various input and output resistances. A similar range of junction *p-n-p* types have been produced by G.E.C. It comprises the EW53 and EW59, which are intended for power applications and will operate at frequencies up to a few hundred kilocycles, and the EW58, designed for low-power, low-frequency amplifiers such as in hearing-aids. Yet another series of junction transistors which may be already well known are the TJ1, TJ2 and TJ3, shown by Brimar and S.T.C.

A junction transistor using silicon is the next thing to be expected, but in the meantime we have a range of silicon junction diodes, types ZS10A, B and C, produced by Ferranti. These are characterized by their extremely low reverse current of less than 10 μA for a reverse voltage of -50 V and by their ability to operate at temperatures as high as 100° C. Forward currents are 0.1 A continuous and 1 A peak. A developmental silicon junction diode was also shown by S.T.C.



English Electric travelling-wave tubes N1001 and N1002

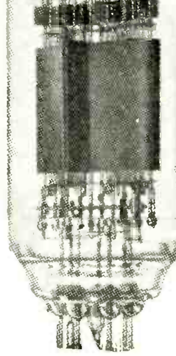


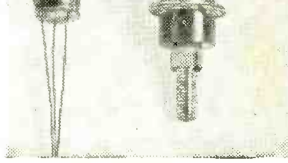
Ferranti 500-watt klystron.

Germanium junction diodes are still being developed, however, and one interesting example was the G.E.C. type EW54, intended for power rectification. Fitted with cooling fins it will give a rectified output of 50 V, 24 A, and good regulation is obtained because of its low forward resistance of 0.05 ohm. For h.t. power supplies based on relaxation-oscillator generators, Mullard were demonstrating a power transistor used with germanium junction rectifiers to produce a d.c. output of 150 V at 5 watts from a 12-volt supply. The photo-electric properties of the germanium junction were also represented, by the S.T.C. miniature germanium photocell type P40A, which is so small that six of them can be arranged in a row across standard teleprinter tape for "reading" the punched holes.

Amongst conventional plate rectifiers the most interesting development was a range of new Westinghouse types with aluminium cases which are bolted flat to the chassis to conduct the heat away. This enables the size of the rectifier to be reduced for a given power rating. A similar reduction in size is given by elements each capable of handling 27 volts in the tubular selenium rectifiers shown by Salford.

Oscilloscope c.r. tubes were well represented, and an outstanding one for high "writing" speeds was the 20th Century S6A20-3, which has three post-deflection accelerator electrodes and is capable of recording a 500-Mc/s sine wave with a time-base speed of 650 cm per microsecond. Mullard were showing two new 3-inch tubes, DG7-32 and -36, the first-mentioned being notable for its low final anode voltage of 500 V.





G.E.C. germanium junction diode EW54 (right) and EW51 point contact transistor (left).

Left: Ediswan beam tetrode 13E1.

DESIGN FOR A

20-Watt High-Quality Amplifier

2.—*Constructional Details and Performance*

By W. A. FERGUSON,*
B.Sc.(Eng.), A.C.G.I., Grad. I.E.E.

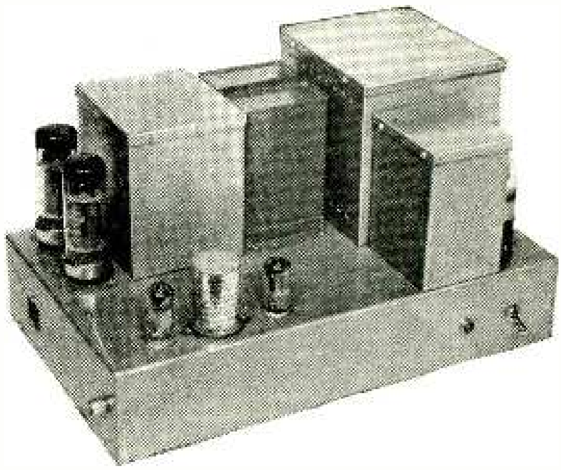
IN the first part of this article some considerations were discussed which affect the choice of valves and circuit arrangements in the output stages of amplifiers designed for use in high-quality sound reproduction.

In amplifiers designed to handle power outputs greater than 12 to 15 watts and in which low-distortion operation towards peak power output is still required, the use of distributed load operation with valves of the 25-watt anode dissipation class is of particular interest. By using this method of valve loading the effective power output of a low-distortion triode push-pull stage (approximately 12 watts) can be raised to 30 to 35 watts whilst the benefits of low inherent distortion and relatively low output impedance are well maintained. Performance typical of the Mullard EL34 output pentode with partial screen-grid loading was illustrated in Fig. 3 of the previous article.

The present article describes a design for a high-quality amplifier of 20 watts rated output in which similar load conditions are used for the EL34 valves in the output stage. The amplifier is intended to allow of the highest standard of sound reproduction when used in association with suitable pre-amplifier circuits, high-grade pickups and loudspeaker systems.

TABLE I
Summary of Performance of Prototype Amplifier

Power output:
20 watts minimum from 30 c/s-20 kc/s.
Power response:
within 0.5 db of 1 kc/s level at 20 watts over range 30 c/s-20 kc/s.
Frequency response (1 watt level):
within 1 db of 1 kc/s level 2 c/s-100 kc/s.
Harmonic distortion (400 c/s):
$<$0.05% at 20 watts.
Intermodulation distortion (40 c/s, 10 kc/s; ratio 4:1):
0.7%, with peak corresponding to 20 W sine-wave power.
1.0%, with peak corresponding to 29 W sine-wave power.
Hum and noise:
−89 db relative to 20 W with 10-kΩ source resistance.
Sensitivity:
220 mv for 20 W output.
Phase shift:
10° maximum at 10 c/s.
20° maximum at 20 kc/s.
Output impedance:
approximately 0.3 Ω at 40 c/s, 1 kc/s and 20 kc/s at 20 watts output.



General view of top of prototype 20-watt amplifier, which uses EL34 output valves.

A summary of the overall performance of the amplifier is given in Table 1.

A circuit diagram and list of component values is given in Fig. 1. The circuit arrangement is basically similar, except for the output stage, to that used in the Mullard 5-valve 10-watt high-quality amplifier design in that the output stage is driven from a cathode-coupled twin-triode phase-splitting amplifier which is in turn preceded by a high-gain voltage amplifier stage. The first stage in the amplifier is d.c. coupled to the phase splitter in order to minimize low-frequency phase shifts. The main feedback loop includes the whole circuit, the feedback voltage being derived from the secondary of the output transformer and injected in the cathode circuit of the first stage.

Output Stage.—The main feature of interest in the output stage is the use of the Mullard EL34 high-slope output pentode with partial screen-grid loading, the screen grids being fed from taps on the primary of the output transformer. Measurements during the course of design showed that optimum conditions are obtained in this form of output stage when about 40% of the primary winding of the output transformer is common to anode and screen grid circuits. In the present design a C-core transformer is used which has tappings at 43% of primary turns.†

The anode-to-anode loading of the output stage is 6.6 kΩ and, with a feed voltage of 440 at the centre-tap of the output transformer primary the combined anode and screen-grid dissipation of the output valves is 28 watts per valve. With the particular screen-grid to anode load ratio used, it has been found that improved linearity is obtained at power levels above 15 watts when resistors of the order of 1,000Ω are inserted in the screen-grid feeds. The slight reduction

* Mullard Valve Measurement and Application Laboratory.
† Partridge Transformers, Ltd.—Type P3878.

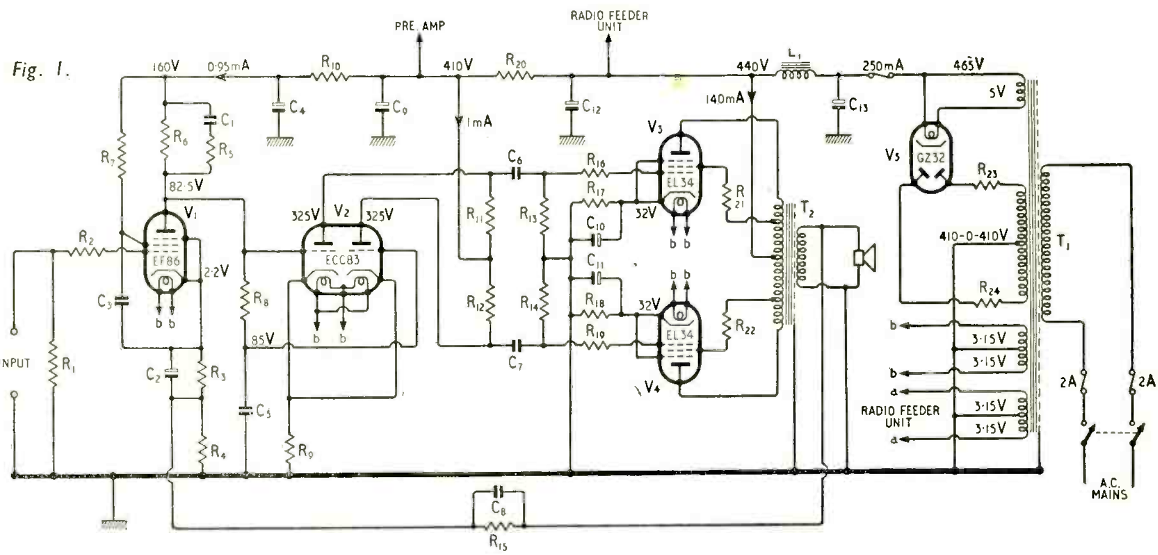
in peak power-handling capacity which results is not significant in practice. Separate cathode-bias resistors are used to limit the out-of-balance d.c. current in the output transformer primary; the use of further d.c. balancing arrangements in the output stage has not been considered necessary. It is likely, however, that some improvement in performance, particularly at low frequencies, would result from the use of d.c. balancing. It is necessary in this type of output stage that the cathodes are by-passed to earth even when a common cathode resistor is used. Thus a low-frequency time-constant in the cathode circuit cannot be eliminated when automatic bias is used.

Power Supply.—The power supply is conventional and uses a Mullard GZ32 indirectly heated full-wave rectifier in conjunction with a capacitor input filter. Paper smoothing capacitors have been used in the prototype amplifier, though the alternative use of electrolytic capacitors is possible. The value of the limiting resistors R_{23} and R_{24} will depend on the winding resistances of the mains transformers used. Their purpose, when required, is normally one of voltage control only. Where a transformer having very low winding resistance is used, a secondary voltage rated at 400-0-400 may be found adequate.

The rating of the mains transformer is such that an additional 30 mA may be drawn from the h.t. supply to feed pre-amplifier circuits and radio feeder. Additional decoupling will be required for these supplies.

Driver Stage.—This stage uses a Mullard ECC83 twin-triode and fulfils the combined function of phase splitter and driver amplifier. It is of the cathode-coupled form and enables a high degree of push-pull balance to be obtained. With the high line voltage available the required drive voltage for the output stage is obtained at a low distortion level, which is approximately 0.4% for 20 watts power output. The anode load resistors R_{11} and R_{12} must be matched within 5%, R_{12} having the higher value for optimum operation. Optimum balance is obtained when the effective anode loads differ by 3%. It is necessary also that the grid resistors R_{13} and R_{14} in the output stage are of small tolerance since they form part of the anode loads of the driver stage. High-frequency balance will be largely determined by wiring layout since equality of shunt capacitances is required. Low-frequency balance is controlled by the value of the time constant R_8 C_5 in the grid circuits

Fig. 1.



LIST OF COMPONENT VALUES

R_1 1 MΩ ¼ watt ±20%
R_2 4.7 kΩ ¼ watt ±20%
R_3 2.2 kΩ* ±10%
R_4 100Ω* ±5%
R_5 4.7 kΩ ¼ watt ±10%
R_6 100 kΩ* ±10%
R_7 390 kΩ* ±10%
R_8 1.0 MΩ ¼ watt ±20%
R_9 82 kΩ ½ watt ±10%
R_{10} 270 kΩ ½ watt ±10%
R_{11} 180 kΩ† ½ watt ±10%
R_{12} 180 kΩ† ½ watt ±10%
R_{13} 470 kΩ‡ ¼ watt ±10%
R_{14} 470 kΩ‡ ¼ watt ±10%
R_{15} 8.2 kΩ* (15-Ω load) ±5%
R_{16} 2.2 kΩ ¼ watt ±20%
R_{17} 470Ω 3 W min ±5%
R_{18} 470Ω 3 W min ±5%
R_{19} 2.2 kΩ ¼ watt ±20%
R_{20} 15 kΩ ½ watt ±20%
R_{21} 1 kΩ ½ watt ±10%
R_{22} 1 kΩ ½ watt ±10%
R_{23}, R_{24} May be required for voltage control depending on mains transformer.
C_1 47 pF ±10%
C_2 50 μF 12 V wkg.
C_3 0.05 μF 350 V wkg.
C_4 8 μF 450 V wkg.
C_5 0.25 μF 350 V wkg.
C_6 0.5 μF 350 V wkg.
C_7 0.5 μF 350 V wkg.
C_8 220 pF (15-Ω load) ($C_8 R_{15} = 1.8\ \mu$ sec)
C_9 8 μF 450 V wkg.
C_{10} 50 μF 50 V wkg.
C_{11} 50 μF 50 V wkg.
C_{12} 8μF 500 V wkg.
C_{13} 8μF 500 V wkg.
L_1 10 H, 180 mA, 200 Ω
T_1 Power transformer Secondary 410-0-410V, 180 mA; 5 V, 3A; 6.3 V, 4 A centre-tapped; 6.3 V 2.5 A centre-tapped.
T_2 Partridge Type P3878
V_1 Mullard EF86
V_2 Mullard ECC83
V_3, V_4 Mullard EL34
V_5 Mullard GZ32

* High-stability carbon. † Matched within 5%. $R_{12} > R_{11}$. ‡ Preferably matched within 5%.

and this value has been chosen to ensure adequate balance down to very low frequencies. A disadvantage of the cathode-coupled form of phase splitter is that the effective voltage gain is about one-half of that obtained from one section used as a normal voltage amplifier. Due to the high μ of the ECC83 (100) the effective stage gain in the circuit is still about 25 times.

First Stage.—This stage is a high-gain pentode voltage amplifier using the Mullard EF86 low-hum pentode. The stage gain is approximately 120. High-stability cracked-carbon resistors are used in anode, screen-grid and cathode circuits and give appreciable improvement in measured background noise level as compared with ordinary carbon resistors. This stage is d.c. coupled to the input grid of the phase splitter in order to minimize low-frequency phase shift in the amplifier and improve low-frequency stability when feedback is applied.

Negative Feedback.—The sensitivity of the amplifier without feedback is 6.5 mV for 20 watts output. With feedback approximately 220 mV is required for the same output level, the designed overall loop gain being 30 db. The loop gain, overall frequency response and phase shift characteristics of the complete amplifier are shown in Fig. 2.

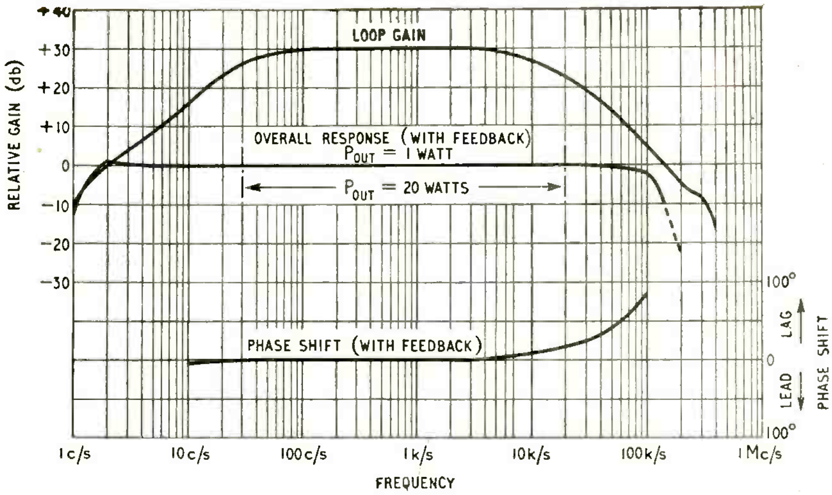


Fig. 2. Loop gain and frequency response and phase shift characteristics with feedback.

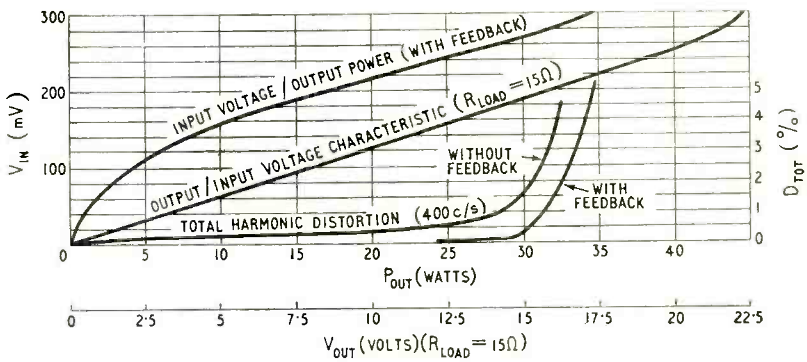


Fig. 3. Harmonic distortion and input/output characteristics of prototype amplifier.

In spite of the high degree of negative feedback used in the present design an adequate margin of stability has been achieved. Complete stability is maintained under open-circuit conditions in the prototype amplifier. An increase in feedback of at least 10 db, obtained by reducing the value of R_{15} should be possible before signs of high-frequency instability occur. In the form of design used oscillation with capacitive loads is the form of instability most likely to occur, but even with very long loudspeaker leads, instability is unlikely to arise.

Distortion.—The harmonic distortion of the prototype amplifier at 400 c/s, measured without feedback under resistive load conditions, is shown in Fig. 3. The distortion curve towards the overload point is also shown for feedback conditions. At the 20 watt level the distortion level without feedback is well below 1% and with feedback applied falls to below 0.05%. Harmonic distortion at 400 c/s reaches 0.1% at approximately 27 watts output. The loop gain characteristics are such that at least 20 db feedback is maintained from 15 c/s to 25 kc/s and 26 db down to 30 c/s.

Measurement of intermodulation products has been made, using a carrier frequency of 10 kc/s, and a modulating frequency of 40 c/s, with a ratio of 40-c/s to 10-kc/s amplitudes of 4:1. With the combined peak amplitude of the mixed output at a level corresponding to the peak sine wave amplitude at 20 watts r.m.s. power, intermodulation products expressed in r.m.s. terms totalled 0.7% of the 10 kc/s carrier amplitude, and at 29 watts approximately 1%.

The output/input characteristic shown in Fig 3 shows that excellent linearity is obtained up to 20 volts across 15 Ω, corresponding to 27 watts output.

Sensitivity.—The sensitivity of the amplifier is approximately 220 mV for 20 watts output and 300 mV at the overload point at mid frequencies. The background level in the prototype amplifier was 89 db below 20 watts, measured with a source resistance of 10 kΩ. This is equivalent to about 5.5 μV at the input terminals. It is possible to increase the overall sensitivity of the amplifier by 6 db whilst still maintaining a low background level, high loop gain and a high margin of stability. However, considerations involved in the design of suitable pre-amplifier circuits, in particular the need for adequate signal-to-noise ratio, render a higher sensitivity of doubtful advantage.

Power Response.—It is important that adequate power-handling capacity is available at the low-frequency end of the audible range. This is determined chiefly by the characteristics of the output

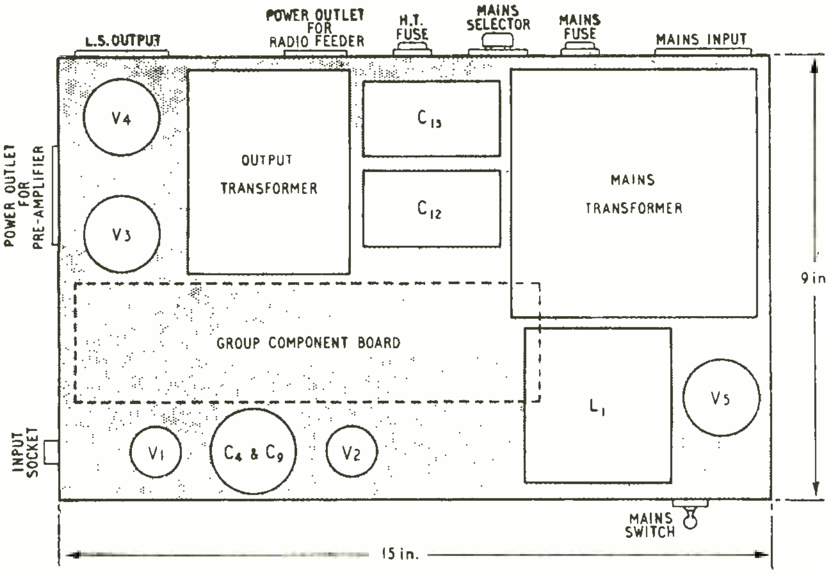


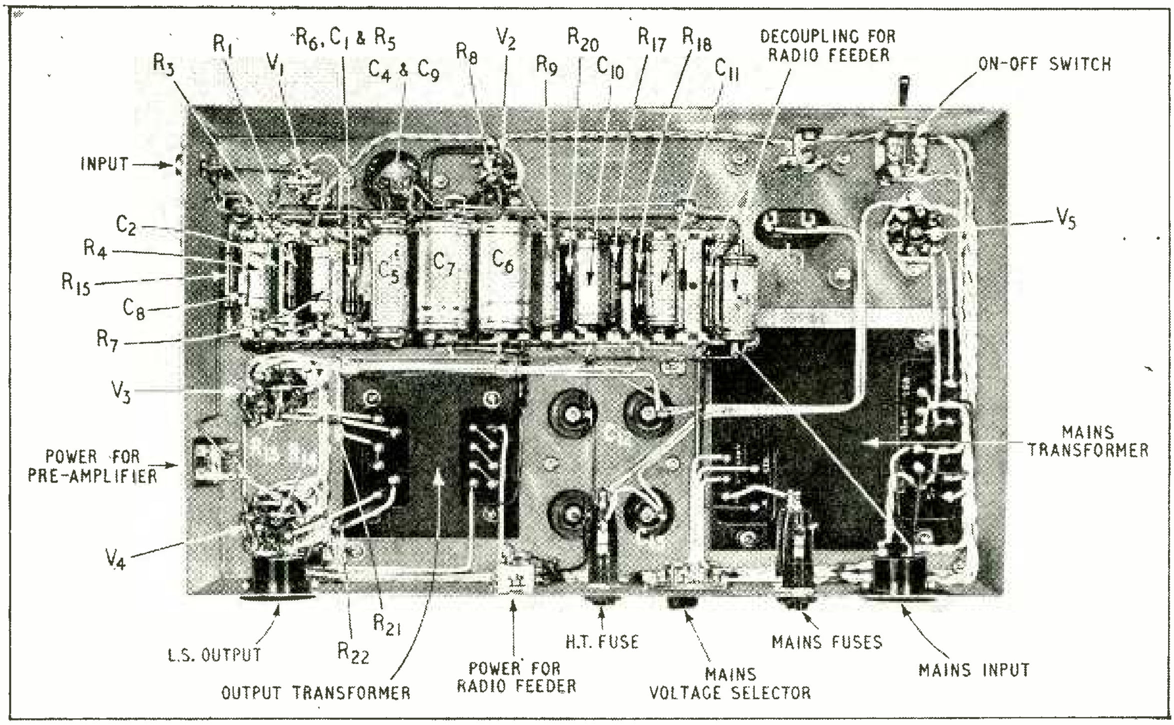
Fig. 4. Layout of principal components in prototype amplifier.

transformer employed, and it is desirable that associated pre-amplifier circuits should attenuate the very low frequencies which the amplifier is incapable of handling at rated power output without excessive distortion. With the output transformer at present employed at least 20-watts capacity is available down to 30 c/s, and the frequency response at the 20-watt level is linear from 30 c/s to 20 kc/s.

Output Impedance.—Due to the low inherent output impedance of the output stage, combined with a high degree of negative feedback, the output impedance is very low, measuring approx. 0.3 Ω on a 15-Ω termination for 20 watts output at 40 c/s, 1 kc/s and 20 kc/s. This corresponds to a damping factor of approximately 50.

Phase Shift and Transient Response.—In practice a compromise must be effected between the phase shift of the amplifier, particularly at high frequencies, and the margin of stability required with a given loop gain. In the present design emphasis has been laid on ensuring as high a margin of stability as possible. The phase shift is held to a comparatively low level in the audible frequency range and, as seen from Fig. 2, reaches about 20° at 20 kc/s. Excellent response to signals of a transient nature is obtained, and the rise time of the amplifier is of the order of 5 μsec.

Mechanical Construction.—A diagram of the layout of the chief components as used in the prototype amplifier is shown in Fig. 4. Although this differs extensively from the layout used in the original experimental circuit no difficulty due to instability has been encountered in either arrangement. A bus-bar earth return has been used with chassis connection at the input socket. With minor exceptions all resistors and capacitors are mounted on group terminal boards, shown dotted on the diagram.



Underside of chassis showing one possible grouping of the smaller components.

Wobbulator Adaptor for Band III

Attachment to Existing Band-I Swept Frequency Oscillators

By G. H. LEONARD, B.Sc. (Hons.) Lond.*

THE introduction of new television channels in Band III has posed many problems for development and manufacturing organizations, not the least of which has been the problem of production test equipment. At the time that the production of Band I/Band III receivers was first contemplated by the author's firm, the few types of test gear for Band III which were then available were not considered suitable for mass production work. The most pressing need was for a swept frequency generator or wobbulator for the alignment of tuner units, and the equipment about to be described was built to fulfil this requirement.

The design of equipment for internal use by a manufacturing organization is inevitably governed to some extent by "domestic" considerations. In this case, the fact that substantial numbers of commercial Band-I wobbulators (Samwell & Hutton Type 41) were already in use for Band I alignment led to consideration being given to the provision of an adaptor to provide r.f. in Band III, the rate of frequency sweep being so arranged that the existing display facilities could be utilized. A further consideration was the company's policy of manufacturing tuners initially for Channels 8 and 9 only, provision being made for interchangeable coils to adapt the tuner for any channel when required. This gave some latitude in the initial specification of the equipment, in that, although the basic system needed to be suitable for any channel, equipment could initially be made with some limitation in performance other than on the two specified channels.

With these requirements in mind, consideration was given to the possibility of a heterodyne adaptor being designed to provide a Band-III output, using the Band -I output of the existing wobbulators in conjunction with a local oscillator. Examination of this proposal showed that each 10-Mc/s sweep available on Band I had at least one, and in many cases, two, harmonic sweeps covering such a large proportion of Band III that the output from such a heterodyne device would be likely to contain unwanted frequencies over at least a portion of the sweep. In practice this could lead to errors in alignment which would not necessarily be predictable, a drawback sufficiently serious to rule out further consideration of heterodyne methods. Examination of the harmonic problem, however, drew attention to a further method which was eventually adopted.

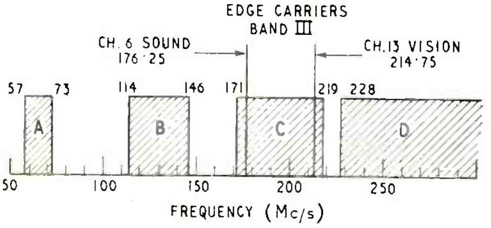


Fig. 1. Frequency sweep of the Band-I wobbulator is shown at A, while its 2nd, 3rd and 4th harmonics are at B, C, and D respectively.

One of the sweep ranges on the Band-I wobbulators was 60-70 Mc/s and it was noticed that the third harmonic of this sweep, 180-210 Mc/s, covered Channels 8 to 11 with a sufficiently large margin to allow for the skirt bandwidth of Band-III tuners. Tripling this output of the wobbulator would therefore cover four channels in one sweep, and the desired channel could be selected by adjustment of the sweep and shift controls of the wobbulator display. A simple prototype showed that the system was workable. Consideration was then given, in consultation with the makers of the wobbulators, to the final design of an instrument capable of covering the whole of Band III.

The frequency sweep obtained from the instrument must ideally cover the whole of Band III plus a considerable margin to allow for the examination of the skirts of a response curve. This calls for a very wide sweep and a compromise has been necessary so that the sweep covered is sufficient to allow some examination of the skirts of Channels 6 and 13 while at the same time excluding unwanted harmonics. The frequency relationships are shown in Fig. 1, the wobbulator coverage being suitably modified.

Using a sweep of 171 to 219 Mc/s, there is a margin of 5.25 Mc/s below Channel 6 sound and 3.25 Mc/s above Channel 13 vision; adjacent harmonics do not fall within the band but are, however, still too close for comfort and special measures are needed to eliminate them.

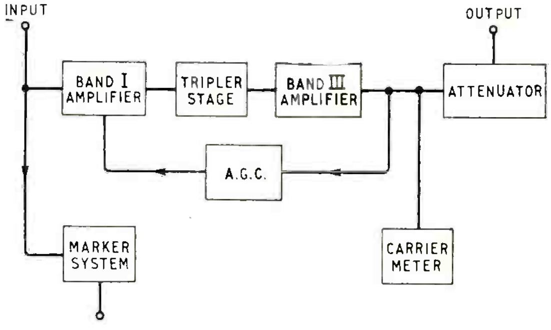


Fig. 2. Block diagram of the adaptor.

Within the desired band the output of the instrument is held flat within close limits. At first sight this does not appear necessary; from the alignment point of view a slope of up to 1db over any one channel might well be tolerable but this would mean that a consider-

* Ultra Electric.

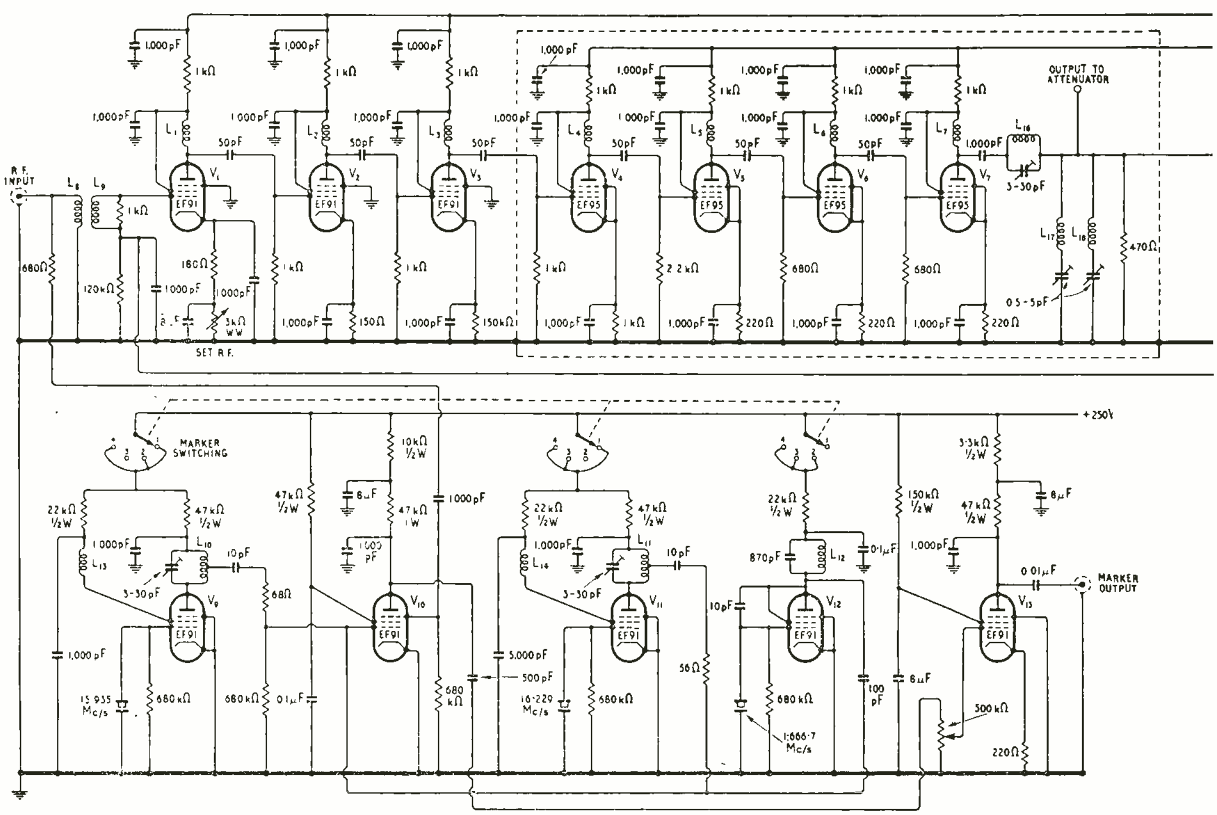
able difference in basic level could exist between, for example, the two end channels, which would then place any comparison of sensitivities in doubt. The flat response, which is achieved by means of an a.g.c. system, enables sensitivity measurements to be made anywhere in the band with some confidence.

Frequency markers are obtained by beating the Band-I input with crystal-controlled oscillators. The use of the input for this purpose enables a conventional form of oscillator to be used, and it is only necessary to select a crystal frequency sufficiently high to ensure that only one harmonic occurs in or near the Band-I sweep.

A block schematic of the adaptor is given in Fig. 2 and the complete theoretical circuit in Fig. 3. V1, V2 and V3 form a stagger-tuned amplifier for the band 57-73 Mc/s, gain control being obtained by cathode biasing of V1 by the "SET R.F." control. The output from V3 is sufficient to severely overdrive the grid of the tripler valve V4. The strong third harmonic component present at the anode is selected by a tuned circuit consisting of the variable inductance L_1 and the stray circuit capacitance, the frequency setting being in the region of 195 Mc/s. The Band-III r.f. so developed is amplified by V5, V6 and V7, all of which are EF95 pentodes, having characteristics which render them particularly suitable for use at this frequency. L_7, the anode coil of V7, is tapped down to give a low impedance feed at approximately 75 ohms to the attenuator and also to the 2nd and 4th harmonic rejection filters containing L_{16}, L_{17} and L_{18}. The Band-III amplifier is only partially stagger-tuned, the response being arranged to peak somewhat below the centre of the passband in order to increase the discrimination against 4th harmonic. This unwanted component is most likely to be developed during the "low" end of the Band-I sweep (input frequencies about 57-58 Mc/s) when the 4th harmonic falls very close to the desired band. Tuning is so arranged that at this end of the band the Band-III amplifier has a response between 171-174 Mc/s which is considerably above the response between 228-232 Mc/s. Since the highest second harmonic is 25 Mc/s below the desired band, this slight bias to the low frequencies has little or no effect upon the second harmonic content and the peak in the amplifier gain is well within the range of the a.g.c. system.

The Band-I wobbulator frequency sweep is generated by an oscillator whose output frequency is continually swept by a motor-operated variable capacitor revolving at 1,500 r.p.m. In consequence, any variation of gain with frequency in the system has the effect of modulating the r.f. output voltage with a waveform whose repetition rate is 25 c/s. This modulation is detected by the upper crystal diode CG12E, so connected that an increase in output gives a positive signal. The resulting 25-c/s waveform is fed to the grid of the high-gain audio stage V8 where it is amplified by over 100 times and reversed in phase. The output from the anode of V8 is fed in the form of an a.c. bias to the "earthy" end of L_9, the grid coil of V1; thus any increase in output appearing at the

Fig. 3. Complete circuit diagram of the adaptor. Lead-through 1,000-pF capacitors are used for decoupling the valve heaters. All resistors not marked with wattages are small $\frac{1}{8}$-watt types. Coil-winding data is given in the separate table.



CG12E will cause a large increase in bias at the grid of V1, with a consequent reduction in gain to cancel the rise in output. The system is very effective and allows considerable latitude in the tuning of the Band-III amplifier; it is therefore possible to arrange the response so that unwanted harmonics are minimized.

The time constants of the a.g.c. system are chosen as a result of practical experience. When the attenuator is switched from one position to another a momentary change in impedance occurs when the wiper is between contacts, giving rise to a large momentary change in output. If the time constants in the circuits of V8 and V1 are too long this causes a damped, very low frequency oscillation of output level which may be observed as a variation in response curve amplitude or as a fluctuation of the carrier meter reading. It has been found possible to make the system "dead beat" by a suitable choice of time constants.

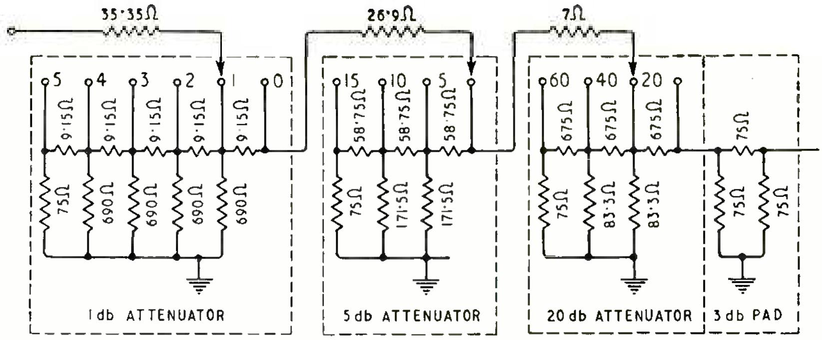
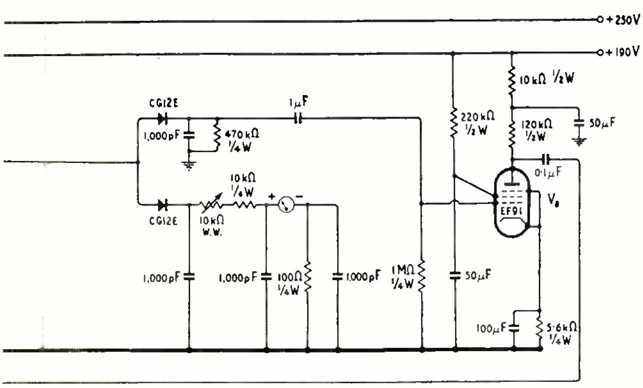


Fig. 4. Circuit of the attenuator used in the output of the adaptor.

The marker system, which was developed in close co-operation with the wobbulator manufacturers, operates in the following manner. V9 and V11 are crystal-controlled oscillators, the screen grid circuit in both cases being tuned to the fundamental and the anode circuit to the 4th harmonic of the crystal frequency. The two frequencies so developed are ⅓ of the sound and vision carrier frequencies of Channel 9. V12 is a crystal-controlled oscillator operating on 1.666 Mc/s (which is ⅓ of the spacing between two sound or vision carriers) and produces a substantial harmonic content. The outputs of the three oscillators are mixed at the grid of V10, producing frequencies at ⅓ of each of the following:—

(1) Channel 9 vision frequency.
(2) Channel 9 sound frequency.
(3) Other vision carrier frequencies (by mixing ⅓ Channel 9 vision frequency with 1.666 Mc/s and its harmonics).
(4) Other sound carrier frequencies (by a similar process).



The 57-73 Mc/s sweep is injected at the suppressor of V10 and a heterodyne beat is produced as the wobbulator sweep passes through each of the above frequencies, the higher frequency components of these beats being by-passed and the lower frequency components being amplified by V13 and fed to one Y plate of the wobbulator display tube. The beats appear on the trace as quite narrow markers, the amplitude of which may be controlled by the potentiometer in the grid circuit of V13.

The four-position switch is arranged to break the h.t. supply to any one oscillator, permitting four marker arrangements to be made available. These are:—

(1) Channel 9 sound and vision only (V12 not oscillating).
(2) All sound markers (V11 not oscillating).
(3) All vision markers (V9 not oscillating).
(4) All sound and vision markers (all oscillators functioning).

This marker system does not lend itself to the im-

COIL DATA

L1:, **L2:**, **L3:** 5 turns 28 s.w.g. enamel covered wire on 9/32-in former, permeability tuned.

L4: 2½ turns, **L5:** 1½ turns, **L6:** 2½ turns, **L7:** 6½ turns — 22 s.w.g. tinned copper wire on 9/32-in former, brass-slug tuned.

L8: 2 turns, **L9:** 6 turns — 28 s.w.g. enamel covered wire on 9/32-in former, permeability tuned.

L10:, **L11:** 7 turns 16 s.w.g. enamel covered wire on ½-in "air" former, tapped 2 turns from h.t. end.

L12:, **L13:**, **L14:** 33 turns 28 s.w.g. enamel covered wire on 9/32-in former, permeability tuned.

L16: 3½ turns 22 s.w.g. tinned copper wire on "air" former ¼-in long and 5/32-in internal diameter.

L17: 5½ turns 18 s.w.g. tinned copper wire on "air" former ¾-in long and ⅜-in internal diameter.

L18: 4½ turns 18 s.w.g. tinned copper wire on "air" former 9/32-in long and ½-in internal diameter.

mediate identification of channels other than Channel 9, but this has been simplified by bringing the wobbulator X shift and sweep control circuits out to a number of preset potentiometers. These are selected by a channel selector switch so that any desired portion of the sweep is presented at the centre of the display, over-riding vernier controls being provided for fine adjustment. The circuit of this section is not shown since it is associated with the wobbulator rather than with the adaptor.

An alternative marker system has been investigated with which no such ambiguity arises. This employs two oscillators, one operating on the desired channel sound frequency and the other on 1.166 Mc/s, i.e., $\frac{1}{3}$ of the sound-to-vision separation. This system gives the sound marker, vision marker, a spurious marker corresponding to sound frequency minus 3.5 Mc/s or, by switching off the 1.166-Mc/s oscillator, the sound marker only. This system possesses the disadvantages that separate crystals are required for each channel and that each must be switched on channel selection. As the preset shift and sweep settings are desirable for mass-production use, the advantages of the second system were not considered to be worth while in view of the extra complication involved.

During development certain facts relating to the attenuator system came to light. It became evident that a constant-input-impedance network was desirable in order to avoid changes in the tuning of L_7 which might affect performance, while other design

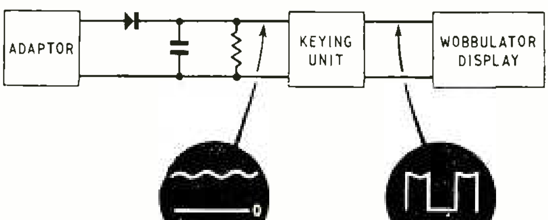


Fig. 5. Keying system used in examining response of the adaptor.

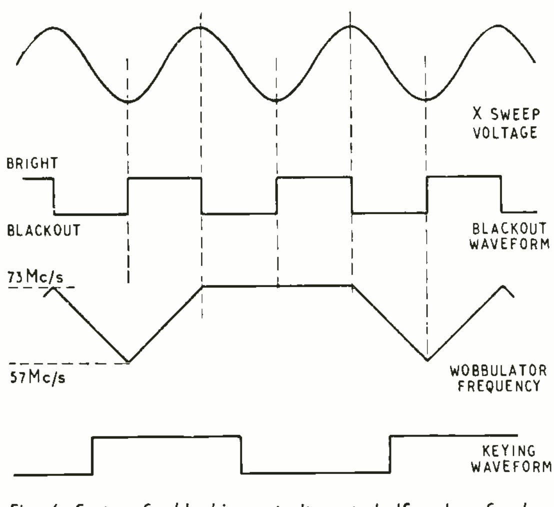


Fig. 6. System for blacking out alternate half-cycles of wobbulator display time-base, showing relationships of waveforms to frequency sweep.

considerations demanded a minimum possible insertion loss and ease of mechanical construction. The final attenuator design chosen was built in three Advance Components A37 attenuator cases, the circuit shown in Fig. 4 being employed.

Considering the 20-db section, it will be observed that, provided the output is terminated in 75 ohms, the input impedance is constant at 68 ohms for any switch position and the resistor values are such as to produce the desired attenuation. A resistor is in series with the input so that the impedance into which the 5-db step attenuator works is also 75 ohms. This, and the 1-db section, have circuits of a similar type. The output impedance of the attenuator is not 75 ohms but this is not important theoretically, since if the output cable is properly terminated no reflections should occur. In practice no undesirable effects have been noticed but a 3-db pad has, however, been incorporated in order to reduce the effects of variations of termination on the attenuation. When measurements are made working into a 75-ohm input circuit, and damping of the circuit by 75 ohms is desired, the use of an external 6-db pad is recommended.

Because of the small values used in the 1-db section and the physical limitations imposed by the Advance Components casting, high-stability resistors cannot be used and, in any case, theoretical considerations suggest that a simple resistive rod should possess better r.f. characteristics than the spiral of high-stability types. The resistors employed were made from ordinary $\frac{1}{4}$-watt resistors by removing the ceramic cases, scraping the rods to the required value and enclosing them in protective plastic sleeves. The lower values of $\frac{1}{4}$-watt resistor frequently have a metal band sprayed on to the rod to obtain the desired value. The presence of this band increases the capacitance between the end caps of the resistor, so for the range where these bands were known to exist a lower value was chosen and the band scraped off. The use of this type of resistor is, of course, theoretically questionable in the matter of stability, but in practice no important errors have yet been observed.

The initial alignment of the Band-I and Band-III amplifiers is carried out using a signal generator. For final adjustments, and in order to establish that the a.g.c. circuit is operating satisfactorily, it is necessary to check the instrument under normal operating conditions with the swept frequency input from the wobbulator. This can, of course, be effected by connecting a detector to the output socket and displaying any variations in the detector voltage on the wobbulator cathode-ray tube. However, this method has the disadvantage that since the wobbulator Y amplifier is a.c. coupled no indication of amplitude is obtained. Although the latter parameter is indicated by the carrier meter, it has been found inconvenient to observe both meter and tube while adjustments are taking place; furthermore, it is desirable that variations in amplitude through the band should be easily observed in relation to the r.f. output level. Since a detector connected to the output produces a d.c. voltage proportional to the mean output level, with superimposed a.c. corresponding to any variations, the desired display is achieved by the use of a piece of ancillary equipment to "chop up" or "key" the detector output as shown in Fig. 5, so that an alternating voltage whose amplitude varies with the total output is produced. The

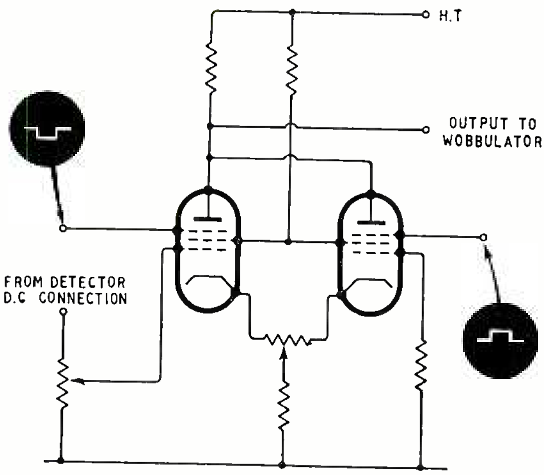


Fig. 7. Circuit diagram of keying unit used in Fig. 5.

wobbulator display employs a 50-c/s sinusoidal time base, with alternate half-cycles blacked out, which is related to the frequency sweep as shown in Fig. 6. The keying device is operated at 25 c/s so that the display shows a zero-volts base line in addition to the response of the adaptor.

The keying unit employs a beam-switch type of circuit (Fig. 7) using two pentode valves with a common anode load. The keying waveform shown in Fig. 6 (derived from a mains-synchronized 25-c/s multivibrator) is applied to the two suppressors in antiphase so that when one valve conducts the other is cut off. One valve has its grid returned to earth and the other is d.c. connected to the detector, a variable biasing arrangement allowing the currents through the valves to be made identical under no-signal conditions. When r.f. is applied to the detector the resulting d.c. alters the bias of one valve so that the currents are no longer equal and a 25-c/s waveform appears at the anodes. This is fed to the wobbulator Y amplifier and, since the time base operates at 50 c/s, produces two traces on the screen, a zero-volts base line and the response of the adaptor. The separation of the two traces indicates the amplitude of the adaptor's output.

The keying unit is used not only to examine the response of the adaptor but also to check the output level against a standard signal generator. For this test the adaptor output is set to give a definite separation between the traces; it is then disconnected and replaced by the signal generator, whose output is adjusted to give the same separation. This method is used to calibrate the carrier meter on the adaptor.

The adaptor is built so that it may be conveniently linked with the wobbulator to provide a compact Band I/Band III unit, the adaptor forming a pedestal on which the wobbulator stands with its display tube at eye level. The unit has a light alloy angle frame, the circuits being built up on flat plates which are screwed in. This arrangement facilitates assembly and provides a rigid pedestal for the wobbulator. The Band-III amplifier is completely screened and this screening is bonded to the rear of the attenuator in order to avoid earth currents. Lead-through capacitors, used for decoupling h.t. and heater lines, form convenient anchoring points and all "hot" leads are kept as short as possible. The channel selector switch and preset controls are mounted along one side, the edge of the switch knob being engraved so that the switch position is easily seen.

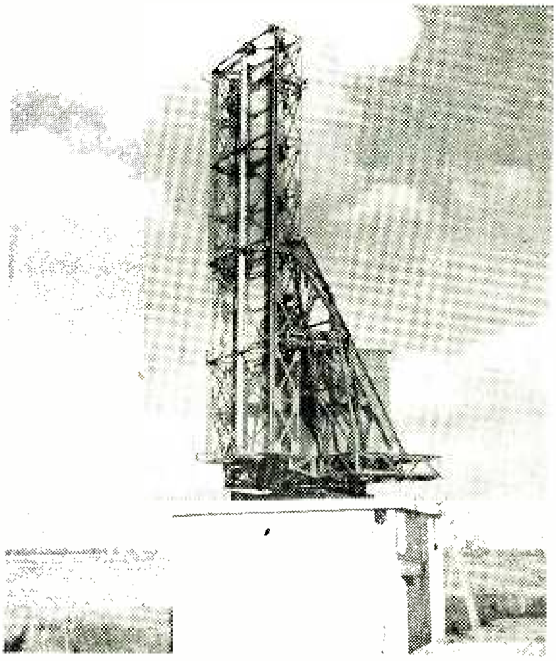
Finally, the author would like to acknowledge the parts played by M. Phillips, who was responsible for the original conception and basic design of the instrument, and A. H. Jacob, who carried out the practical work.

Radar Height Finder

SHOWN in the illustration is the latest Marconi Type S13 long-range radar height finder which, it is understood, will be installed at London Airport by the Ministry of Transport and Civil Aviation. It operates in the 10-cm waveband and provides a peak pulse power output of about 500 kW and has a working range of about 150 nautical miles. An accuracy of ±500ft at 50 nautical miles is claimed.

The aerial system, which is designed to transmit a very narrow beam of radar pulses only 1 degree in the vertical and 4.5 degrees in the horizontal planes respectively, consists of a slotted waveguide positioned along the focal line of a vertical paraboloid reflector. It is made to oscillate in the vertical plane at about 10 times a minute and scans an angle of between −1° and +25° to the horizontal. Horizontal rotation of the aerial is effected as required by remote control when an aircraft has been located on the plan position display of any available search radar. It can also be rotated continuously at about 10 r.p.m. if required.

In the form shown the transmitter and receiver are housed in the concrete building with the aerial mounted on its roof, but a separate gantry can be used for the aerial where existing buildings for the equipment are available.



The photograph shows the Marconi radar height finder, Type S13, with the aerial system mounted on the building housing the transmitter and receiver.

Some Problems in Television Lighting

By W. C. PAFFORD, A.C.G.I., D.I.C.

VIEWERS sometimes complain that the lighting in television appears to vary from one camera to another. This apparently elementary matter is difficult to explain without first briefly outlining the principles involved in lighting for this new medium.

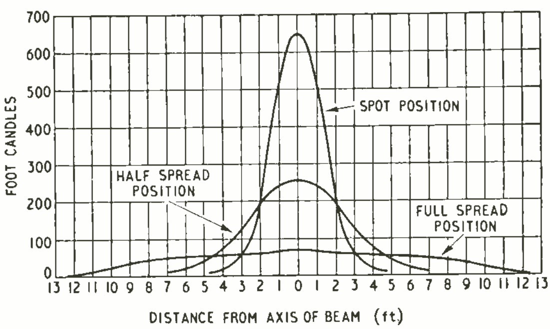
The subject itself is complex, involving not only physical optics and illumination, but also photographic principles and artistic appreciation. Not least among these is the study of the human eye and reaction to tonal quality and balance. Broadly, there are two distinct basic functions of lighting for television.

First, it must create the right artistic effect for any given production so that the mood of drama or comedy is effectively conveyed to the viewer; for example, "drama" is usually portrayed in "low-key" lighting with heavy shadows and contrast, whereas "comedy" is assisted by "high-key" lighting which creates a lighter mood with less contrast and brighter atmosphere. But this aspect of lighting obviously requires special study and may be regarded as beyond the scope of this particular article.

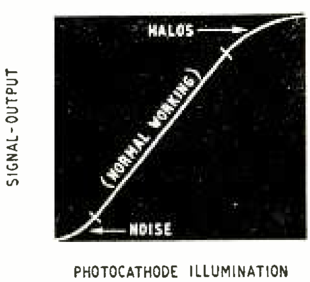
Secondly, television cameras need a certain basic light level and a suitable disposition of lamps in order to obtain pictures which are technically acceptable. In theory it is possible to estimate the total lighting required by any given scene by referring to the illumination-efficiency curves (Fig. 1) of the lamps to be used. In practice, however, the assessment of the kilowatts of lighting required to give a predetermined level of incident light is largely a matter of experience. The pre-war Standard Emitron camera for instance was comparatively insensitive and required a scene brightness of 200-300 foot-candles. The more recent C.P.S. Emitron tube now used in the studios needs less than half this amount of incident light. The latest image-orthicon cameras, used on outside broadcasts, are so sensitive that intelligible pictures can be obtained with as little as 1 foot-candle of incident light.

Although acceptable pictures are obtained with a basic light of about 10 foot-candles, in practice it is found that an incident light value of 25–30 foot-candles allows an image-orthicon camera to use a lens stop of $f/8$, which gives maximum optical efficiency and also a good depth of focus. It also helps in the operation of the tube, which for best results should be made to work on the linear part of the signal-light curve (see Fig. 2).

Type of Camera	Incident foot-candles	Permissible Contrast	Average Lens Stop $f/$ number
Standard Emitron	200–300	50/1	3.0
C.P.S. Emitron	100–130	30/1	6.3
Image-Orthicon	25–30	20/1	8



Above: Fig. 1. Typical curves showing the spread of light for a 2-kW lens spot.



Left: Fig. 2. Signal-light curve of image-orthicon camera tube.

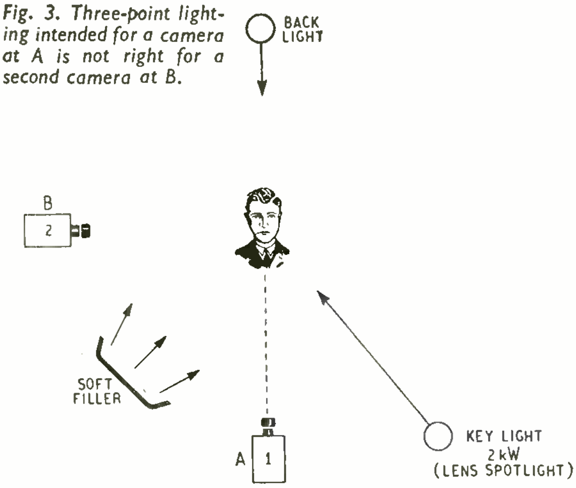
If the illumination on the photocathode is too low we not only run into low signal-noise ratios, but also the detail in the darker parts of the picture is crushed into the blacks. On the other hand, if the level is too high there is a tendency to flatten out the highlights and run into instability. Having established the correct basic illumination, it is now necessary to consider the disposition of the various sources of light.

"Hard light," derived from a lens spotlight or other focus source is suitable for use as a key light, and "soft light" which consists of floods is used for filler and general softening of hard shadows. Additional "sparkle" can be added to the picture by using the film-studio technique of introducing "back light." The diagram in Fig. 3 shows an elementary lighting plot using a single camera at A. In this case the lighting engineer has a fairly straightforward job to do, and by adjusting these three lamps a well-balanced portrait can be obtained.

But if we now introduce a second camera at B, then clearly it will not be looking at a very well-balanced portrait, as the key light is now acting as a three-quarter back light. To put this right it is necessary to re-balance the light sources while with three cameras a further compromise is necessary until the light balance has been restored as seen from each camera position.

It will be appreciated, therefore, that when in addition to this, the subject is, say, a crowded stage in a

Fig. 3. Three-point lighting intended for a camera at A is not right for a second camera at B.



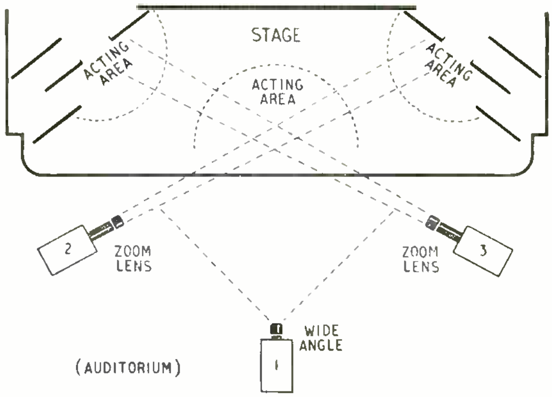


Fig. 4. General arrangement of cameras for, say, a theatre.

theatre, and possibly the available lighting positions in the auditorium or circle are restricted, then it becomes difficult to get a good balance on all three cameras. A good deal of ingenuity is called for and the lighting engineer may have to decide which camera is likely to take most of the important close-ups on principal actors, for instance. The more general shots may have to take second place. Another problem, of course, is that the best camera positions, particularly in a theatre, are not always the easiest from a lighting angle.

Fig. 4 shows a typical camera set up for an outside broadcast from a West End theatre, where two cameras (non-tracking) use zoom lenses for close-up work and usually cut across the stage into the opposite corner of the stage set. A third camera is sometimes used in the auditorium or circle to give wide-angle shots. The main problem is to get sufficient light for the close-up work and at the same time to keep a balance so that rapid switching from one camera to another is not accompanied by an apparent change in light level. In this respect the colour and design of the background become very important.

For example, the background in a stage setting may well depend for its harmony on a delicate choice of colour or, say, a well-balanced composition made up of areas of blue-green and orange-red, which to the eye would be completely satisfying. But when translated into a monochrome picture by a panchromatic camera, the tonal composition will probably be something very different. Generally, the background needs a good a.c. light component or, in other words, a well broken-up design. Supposing, for the sake of argument, we use a chess-board type of background then, in long shot, we shall get good results. But, unfortunately, as soon as we move into a close-up, there is the danger of one camera seeing a portrait against a dark background, and the other camera getting the same portrait lit against a light background, which is usually disastrous.

A good practical example of this sometimes occurs in ice shows where the lens catches a large proportion of reflected light off the ice, leaving the figures sadly silhouetted against an unbroken white background.

A further contributory cause of unbalance, especially on faces, could be due to a mismatch in a colour response of the tubes in question, particularly if fluorescent lighting is present.

Another reason why pictures from different cameras do not always appear to match up can be demonstrated by the case of televising a boxing match with

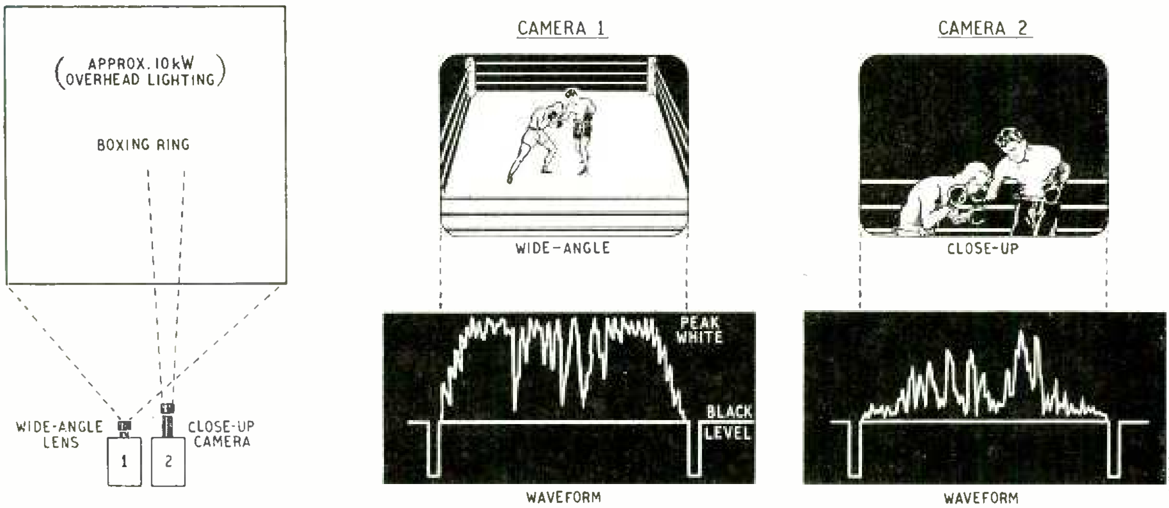


Fig. 5. In a boxing match the lighting is constant, but a wide-angle view gives a higher average brightness than a narrow angle, with the result that the waveforms differ as shown.

two cameras in the same position. In these circumstances there can be no question of different camera angles or of unbalanced lighting because boxing matches are always lit with a perfectly symmetrical overhead rig which remains static. The problem of lighting has now become one of "picture content." This is shown in Fig. 5 where camera 1 may be using a wide-angle lens giving a picture which is largely composed of white. If the adjacent camera is using a close-up lens then the picture content is predominantly black and contrasty. Clearly, a rapid series of cuts from camera 1 to camera 2 will subject the eye of the viewer to sudden changes of brightness as seen on the cathode-ray tube in the receiver. Hence the unfortunate illusion that the lighting is varying. It is, however, possible to introduce an artificial correction in the camera channel circuit by altering the electrical signal.

Probably the most difficult feature of the image-orthicon camera tube is that it has a very limited contrast range, consequently the lighting contrast has also to be kept down to the order of 20 to 1. If this is exceeded we get the familiar "throw-off" (black halo around bright objects), and also "ghosting effect" due to excessive secondary electrons emitted from the target where image highlights occur. It is usual, therefore, to employ much softer lighting for television than that used in film studio work.

Most of the above problems have been taken as typical examples occurring on outside broadcasts where physical limitations are the main obstacles. But lighting difficulties are just as prevalent inside the studios although, in this case, it is more a question of complexity of production, involving camera angles, microphone-boom positions and the use of multiple stage-sets. A fast-moving production, for instance, may use nine or ten different set designs, each requiring its own lighting plot, and each balanced so that there are no irritating changes in light level. In a studio play, for example, it is essential to maintain continuity of mood from camera to camera, whether in close-up or long-shot. This applies even more so with a ballet presentation which relies largely on its pictorial appeal. It is desirable, therefore, that not only should the studio-lighting installation be capable of a high degree of artistic control, but equally important that the receiver should be able to reproduce subtle lighting effects.

A reference has already been made in this article to the importance of having a good a.c. background so that the picture at all times contains well-proportioned areas of black, white and mid-tones. In addition, it is also very important that the overall light level (i.e., the d.c. component*) should be faithfully reproduced on the screen of the receiver. Otherwise, the viewer will probably be looking at pictures which are either suffering from excessive d.c. level with consequent loss of detail in the high lights or, alternatively, a lack of overall brightness resulting in degradation in the dark areas. In either case, the receiver is not conveying the correct photographic qualities intended by the lighting engineer.

* "The Importance of the D.C. Component," by D. C. Birkinshaw, *J. Tel. Soc.*, June 1953.

Terminology of Acoustics

A REVISED edition (1955) of British Standard 661—**Glossary of Acoustical Terms**—has been issued to take into account the change of emphasis and advances in technique since the original issue in 1936. New sections on ultrasonics and underwater sound have been added, and the section on recording and reproduction has been enlarged and now includes terms used in magnetic recording. Copies, price 6s, are obtainable from the British Standards Institution, 2, Park Street, London, W.1.

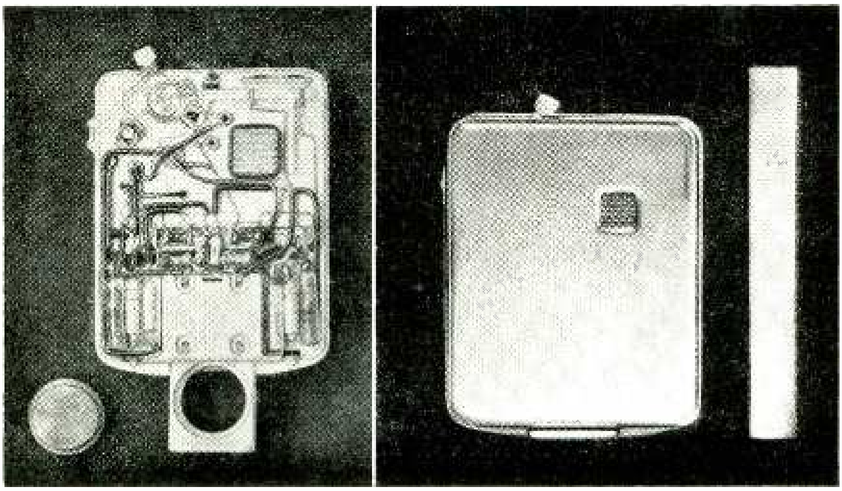
MINIATURE TRANSISTOR HEARING AID

ALTHOUGH weighing only $1\frac{1}{2}$oz and measuring less than $2\frac{3}{8}$in × $1\frac{7}{8}$in × $\frac{1}{2}$in, the "Minuet" hearing aid employs a 4-stage resistance-coupled transistor circuit designed to give high-quality reproduction with sufficient gain and output for the majority of cases of deafness. At 30°C the gain is 20db and the maximum acoustic output 125db referred to 0.0002 dyne/cm^2.

A single 1.3-V Mallory cell (type RM625) gives approximately 175 hours' working on the total current demand of 2mA. This cell, which is of the disc type, fits in a miniature drawer in the base of the instrument and can be replaced without opening the case. An intricate plastic moulding forms the chassis and provides a rigid housing for the various components. The microphone is resiliently mounted to eliminate case noises.

In addition to the usual volume control there is a combined on-off switch and two-position tone control with normal and top-cut responses. Alternative earpieces are available with normal rising response or a flat response curve and there is a choice of mounting clips.

The price is £56 13s and the makers are the Multitone Electric Co., Ltd., 223/7, St. John Street, London, E.C.1.



Multitone "Minuet" transistor hearing aid.

B.B.C. Television Frequencies

Medium- and Low-power Stations on Offset Carriers

ONE of the provisions of the Stockholm Plan for v.h.f. broadcasting in Europe is that sound and vision carriers of some television stations should be offset by a maximum of 20 kc/s to avoid mutual interference between transmitters sharing a channel. The B.B.C. is, therefore, operating some of its recently introduced medium- and low-power stations on offset carriers and the deviation adopted is plus or minus 6.75 kc/s for the vision frequency and 20 kc/s for sound. In the appropriate columns in the following table the nominal channel frequencies are accordingly marked + or − where they are offset. With the exception of the frequencies given for Londonderry (which have yet to be approved by the P.M.G.) all the information has been confirmed with the Engineering Information Department of the B.B.C.

In conformity with the general practice on the Continent the B.B.C. has adopted the principle of indicating that the carrier frequencies are offset by suffixing the channel number with + or − (i.e., Channel 2− for North Hessary Tor).

In the fifth column is given the e.r.p. of the permanent vision transmitter, but where there is at present a temporary transmitter in use this figure is followed by the e.r.p. of the low-power installation in brackets. Stations not yet in operation are marked with an asterisk in this column.

Another provision of the Stockholm Plan to minimize interference, and adopted by the B.B.C., is the use of directional aerials. For stations with directional aerials we give in the appropriate column the minimum and maximum e.r.p. for both the permanent and temporary transmitters. No figure is available for the e.r.p. of the temporary North East Scotland transmitter at Redmoss which will be replaced by the permanent station at Meldrum (marked †) at the end of the year. Incidentally, the temporary Belfast station at present operating at Glencairn will be replaced next month by the permanent station at Divis.

The e.r.p. of the new B.B.C. London transmitter which is being built at Crystal Palace and is scheduled to be brought into service next year will be 200 kW.

We are unable to include details of the proposed I.T.A. stations as they have not yet been agreed. It was, of course, stated by the P.M.G. some months ago that the London and Lancashire transmitters would share Channel 9 (194.75 Mc/s vision and 191.25 Mc/s sound) and that the carriers of the London transmitter would be offset by +6.75 kc/s and + 20 kc/s, respectively.

Channel	Station	Carrier Frequencies (Mc/s)		Vision E.R.P. (kW)	Polarization
		Vision	Sound		
1	Alexandra Palace (London)	45.0	41.5	34	V
	Divis (Belfast)	45.0 −	41.5 −	20 (0.4)	H
2	Holme Moss, Yorks. ...	51.75	48.25	100	V
	N. Hessary Tor, Devon ...	51.75−	48.25−	1-16 (0.5)	V
	Rosemarkie, Inverness ...	51.75−	48.25−	1*	H
	Dover area, Kent	51.75+	48.25+	0.1-1*	H
	Londonderry, N. Ireland ...	51.75−	48.25+	0.5*	H
	Truleigh Hill (Brighton) ...	51.75+	48.25+	(0.3)	V
3	Kirk o'Shotts, Lanarks. ...	56.75	53.25	100	V
	Tacolneston (Norwich) ...	56.75	53.25	1-10 (0.14-1.3)	H
	Rowridge, I.O.W.	56.75−	53.25−	1-32 (0.3-9)	V
	Blaen Plwy, Cardigan. ...	56.75+	53.25+	1*	H
4	Sutton Coldfield, Warwicks.	61.75	58.25	100	V
	Meldrum, Aberdeenshire ...	61.75−	58.25−	20(†)	H
	Carlisle area, Northumb'd...	61.75+	58.25+	1*	H
	Jersey, C.I.	61.75+	58.25+	1*	H
5	Wenvoe, Glam.	66.75	63.25	100	V
	Pontop Pike (Newcastle) ...	66.75−	63.25−	10 (1)	H
	Douglas, I.O.M.	66.75+	63.25+	1 (0.25)	V

TV PROGRESS REPORT

WORK began in April on the Channel Islands station at Les Platons, Jersey, which the B.B.C. hopes to bring into service in September. Transmissions from the South Devon station at North Hessary Tor will be received on the S.W. coast of Guernsey and relayed by radio to the Les Platons station—some 20 miles away—for retransmission. Until the permanent transmitter is in use in South Devon—probably early next year—the Channel Islands television service may not be consistent.

The contract has been placed for the erection of the permanent 560-ft stayed mast for the East Anglian station at Tacolneston, near Norwich. This mast will carry the aerials for both television and the v.h.f. sound transmissions. It is hoped that the permanent television transmitters will be installed and the aerials ready for the station to replace the temporary equipment about the middle of next year.

Some difficulty has been experienced in securing a suitable site on the Isle of Man for the permanent station. The ideal position is said to be at the summit of Snaefell, but objections have been raised by the Ministry of Civil Aviation as it is feared the television station might cause interference with the Ministry's transmitting and receiving station already operating on Snaefell. Further tests are, however, to be carried out next year. In the meantime the opening of the permanent station at Divis, Northern Ireland, in July should give a service to the population in the north of the island. The temporary transmitter at Carnane, near Douglas, serves about 60% of the population.

Cathode Followers—

With Particular Reference to Grid Bias Arrangements

By "CATHODE RAY"

LOOKING at the basic circuit diagram (Fig. 1) we might think there wasn't much that could be said about the cathode follower. As for its grid bias, with beautiful simplicity the one and only resistor in the circuit sees to that as well as doing its main job. So it appears.

But when one thinks one knows all about cathode followers, some unsuspected complication comes to light. I hope, however, that you will not take that remark as the prelude to an astonishing new revelation. I doubt whether I am about to disclose anything new, but it may be new to some who have not made a special study of cathode followers or who have not yet had to adapt the theoretical circuits to practical work. There are one or two things about arranging their grid bias, for instance, that are not always made clear in the books.

First we had better have a quick review of cathode followers in general. Their chief use is to enable a waveform derived from a high-impedance source to be reproduced accurately across a comparatively low or variable impedance. They can do this because (1) their input impedance is exceptionally high; (2) their output impedance is exceptionally low; and (3) they cause exceptionally little distortion. These features are due largely to the 100% voltage negative feedback resulting from the position of R, on the cathode side of the valve. From the point of view of the output terminals, the impedance appears to be R in parallel with approximately $1/\mu$ times the valve's actual anode resistance, r_a. This r_a/μ is the same thing as $1/g_m$. For instance, if g_m (the mutual conductance of the valve) is 5 mA/V, that is 0.005 *amps* per volt, and 1/0.005 is 200, which is the apparent number of ohms resistance in parallel with R*. This is far lower than a valve having its output taken from the anode side, and load impedances down to a few thousand ohms can be connected across it without making much difference to the output voltage.

I need hardly repeat the various ways (explained in all the books) by which negative feedback reduces distortion. In the cathode follower *all* the output is fed back, so (as regards a single valve at least) reduction of distortion is a maximum.

The high input impedance comes in two ways. The fact that the anode is held at a constant potential cuts out the "Miller effect," which in an anode-loaded valve greatly magnifies the effective grid-to-anode capacitance. On the other side, the effective grid-to-cathode capacitance is only a small fraction of its book value, because the potential of the cathode *follows* that of the grid†, the grid-to-cathode signal voltage being only the difference between the input and output voltages. Thus the cathode follower has all the benefit of high-resistance input possessed by any valve operated with its grid negative, but without most of the spoiling effect of capacitance to anode and cathode.

Unless we are careful with our grid bias arrangements, however, we may throw away something of these advantages.

As I said at the beginning, R in Fig. 1 provides grid bias at the same time as coupling impedance. But doing two things at once often means that neither is done properly—or at best only one of them. I wouldn't say that the simple Fig. 1 circuit *never* gives satisfaction. Like some of the films reviewed in the cinema trade press ("Might get by with unsophisticated audiences") it is all right if you are easily satisfied. If the resistance of R is too small for grid bias purposes, then grid current flows at the positive peaks of input, and bang go the high input impedance and freedom from distortion. If too large, negative peaks reach the "bottom bend" and the valve ceases to cathode-follow. But if R is chosen midway between these two calamities it will be much smaller than optimum as a coupling resistance.

Adapting the Diagram

To see this in all its naked clarity we should draw a characteristic-curve diagram. Fig. 2 is a sample‡. It starts with an ordinary set of anode-current/anode-voltage curves, as found in valve catalogues. Those in Fig. 2 refer to a rather mediocre triode, having $r_a = 10\text{k}\Omega$, $\mu = 17$, so $g_m = 1.7$ mA/V. Let me emphasize that these figures, like all such published for valves, refer to only one set of working conditions (represented by one point on the diagram) and vary a good deal over the area of the diagram. If it were not so, the curves would be evenly-spaced straight lines. Because they never are, there is always distortion. Each curve, of course, represents the way the anode current (I_a) varies with anode voltage (V_a) at the fixed value of grid voltage (V_g) marked beside the curve. Take special note of the fact that V_g is the voltage *relative to the cathode* (as, indeed, is also V_a). In the ordinary use of a valve that is the same thing as the voltage relative to earth or −h.t. or the lower input terminal, for all these things are tied to cathode either directly or through a by-pass capacitor.

It is because one gets so used to assuming this that the cathode follower is apt to muddle one. When the input voltage varies the grid potential, it varies the cathode potential too; so one can't use the cathode as a fixed-potential point from which to reckon all voltages. The obvious zero-potential reference point is E. And the valve electrode held at constant potential by it is not the cathode but the anode (separated only by the

* To be precise, one should multiply $1/g_m$ by $\mu/(\mu+1)$, but that makes little difference unless μ is exceptionally small.

† That is why the term "anode follower" for the see-saw circuit is so silly; in it the anode does just the opposite of following the grid.

‡ If the principles of this kind of diagram are not understood, see next month's article.

fixed voltage V_{HT}, as shown in the inset to Fig. 2). So our reckoning of the valve electrode voltages has to be upside down as compared with ordinary usage. V_a on the curve sheet therefore really means minus the cathode voltage (relative to fixed anode). And V_g can't be used directly at all, because it is between two varying-potential points. What mathematicians call the independent variable is not V_g but V_{IN}. But this amounts to the same thing as V_{ag}, the voltage of the grid relative to anode. Can we somehow get V_{ag} or V_{IN} curves on to the diagram?

Well, if we look at the inset we see that V_{ag} is the difference between V_a and V_g, which are both on the diagram. So all we have to do to plot a curve of "$V_{ag} = x$ volts" is to join together all points at which $V_a - V_g = x$; that is, $V_a = x + V_g$. So where $V_g = 0$, V_a must be 250 to locate a point on this curve. That is point *a*. Next, at $V_g = -2$, V_a must be $250 - 2 = 248$; so we find the point on the $V_g = -2$ curve at which $V_a = 248$, namely *b*. And so we go down the V_g curves, moving a corresponding number of V_a volts to the left every time, to give the "$V_{ag} = 250$" curve when all the points are joined up. In the same way curves for V_{ag} = anything else can be drawn; I have done the 237.5 and 262.5 volt curves. The reason I chose 250 for a start is that we are going to assume for example that V_{HT} is 250. That being so, V_{IN}, which is $V_{HT} - V_{ag} = 0$ anywhere on the $V_{ag} = 250$ curve, as marked in brackets (to show that it applies only on the assumption that $V_{HT} = 250$). So our starting point, representing zero input voltage, must be somewhere on this curve. But where?

If it were down near the foot, where I_a is small or even zero, there would be plenty of room for increase of current during the positive half-cycles of V_{IN}, but the negative halves would be cut off. And if the starting point were placed at the top, the negative halves would be all right but the positive halves would be in the positive grid region and grid current would flow. So we follow the usual procedure for valve diagrams and put the starting point about half way between zero grid bias and cut-off bias. We see that cut-off bias at $V_a = 250$ is about -16 volts. But half that, -8 volts, looks rather alarmingly low down, so I have put it at -7. Then the "load line" is the one drawn through "$V_a = 250$, $I_a = 0$" (point *c*) and the newly located starting point (*o*). It is shown dotted.

What this dotted load line does is to show the drop in V_a below 250 volts when current passes through the resistance (R) represented by it. At $I_a = 0$, no volts are dropped in R, so V_a is the full 250V h.t. (point *c*). At the starting point *o*, $I_a = 10$mA, and we see that $V_a = 243$; a drop of 7V. The resistance that requires 7V to pass 0.01A through it is $7/0.01 = 700$ ohms. So the dotted line represents a load resistance R of 700 Ω.

Results

Next, let us see what happens when an input signal swings the grid alternately positive and negative. This is where the other two V_{IN} curves are needed. If the peak voltage of the input is 12½ volts, the working point moves along the dotted line as far as the curve "($V_{IN} = +12.5$)"—and where, incidentally, $V_g = -2$, which is about as far as we can go in that direction and still be quite sure of grid current not starting—and in the other direction to "($V_{IN} = -12.5$)" which is about as near cut-off as it is wise to go.

If you like you can try alternative load resistances and working points to see if you can get less distortion at this input, or more output for equal distortion, but I shall be surprised if you do much better working from "$V_{IN} = 0$." How do we know how much output is obtained? Well, the inset shows that any change in V_{OUT} must be at the expense of V_a, so is equal and opposite to it. The movement of the working point along the dotted line takes us from 243V at the start to 235V at the positive peak and 249V at the negative, which is -8V and $+6$V respectively; so the peak values of V_{OUT} are $+8$V and -6V. Another and more accurate way of obtaining these values is to read the rise and fall in I_a and multiply by R; this gives them as $+7.7$V and -6.2V.

We note from this that (1) unlike the anode-loaded amplifier, V_{OUT} has the same polarity (or is in the same phase) as V_{IN}; (2) the device is by no means distortionless, for equal + and − V_{IN} give considerably unequal + and − V_{OUT} (as a matter of interest, the 2nd harmonic distortion calculated in the usual way from the above data is 5.4%); and (3) the voltage

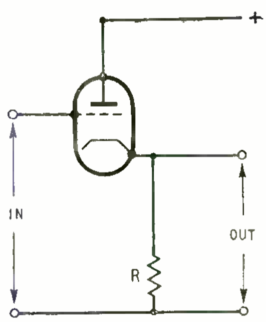


Fig. 1. Basic circuit diagram of cathode follower.

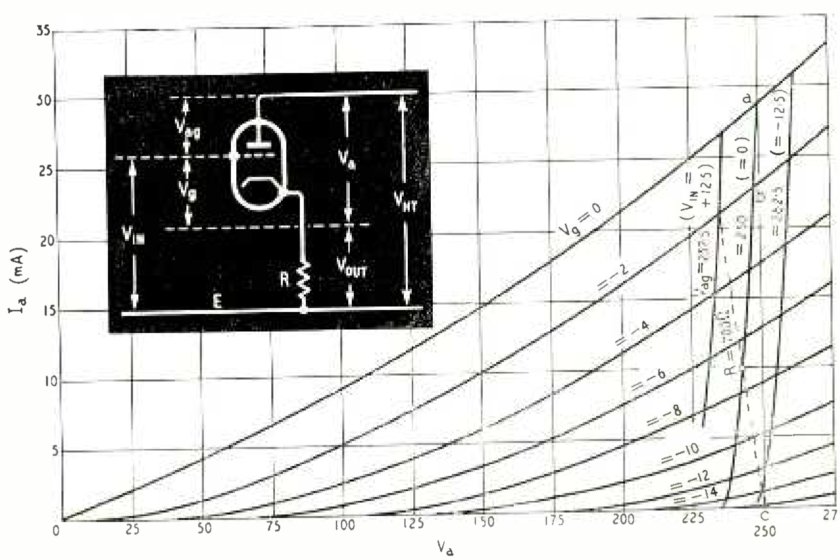


Fig. 2. Showing how to use the ordinary I_a/V_a valve curves to construct cathode-follower characteristic curves.

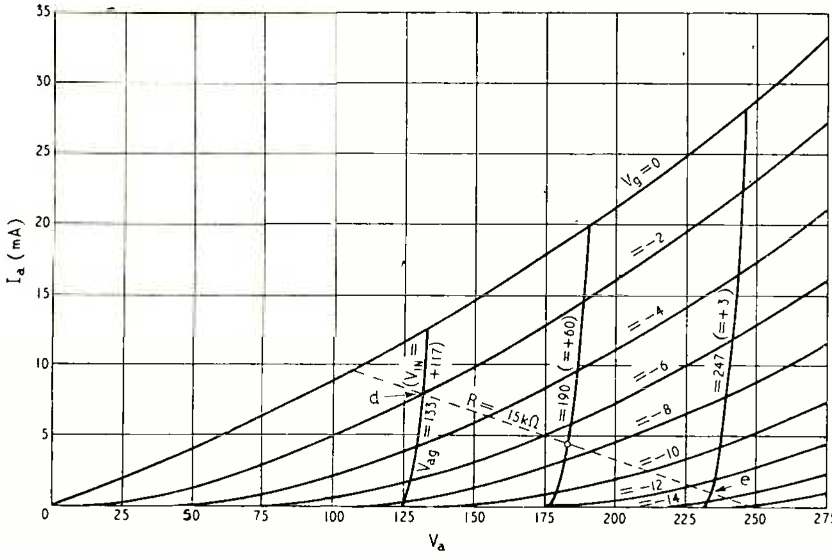


Fig. 3. By using a much higher value for R in Fig. 1 than the 700Ω in Fig. 2, maximum output is greatly increased and distortion reduced.

" amplification," V_{OUT}/V_{IN}, is 13.9/25 (peak to peak), which is 0.56, or a loss of nearly half. We also note that the grid voltage V_g swings between −2 and about −14, or 12V peak to peak, so the voltage amplification of the valve itself is 13.9/12 = 1.16. If the valve were used in the ordinary way, with R on the anode side, V_g would be the same as V_{IN} (as regards signals at least), and its negative peak would be the same as the positive (5V), so the negative V_{OUT} would be only 5.1V and the distortion would be greater (10.2%). As compared with this, the cathode-follower arrangement gives about half the amplification, but about half the distortion and a shade more output.

But it is a pretty miserable output—less than 7V peak using 250V h.t. As anyone who is accustomed to valve load diagrams will see at once, the reason is that the slope of the dotted load line is too steep, signifying that the resistance is too low. The less the slope, the greater the range of voltage represented by it between the grid-current and cut-off boundaries. To get the utmost voltage output, the resistance should be so large as to be represented by a nearly horizontal line right down near the V_a scale. But then the current range would be almost nil, and the valve would be incapable of supplying appreciable signal *power*. For maximum power, a designer would choose a medium slope, such as that of the dotted line in Fig. 3, which represents a resistance of 15kΩ. V_g = −7 again puts the starting point (*o*) about half way along the useful part of the line, and if we draw a V_{ag} line through it we find V_{ag} here is 190V. So V_{IN}, being $V_{HT} - V_{ag}$, is +60V. If again we are cautious about grid current and allow a full −2V as the minimum grid bias, the positive limit is at point *d*, where V_{ag} turns out to be 133V. This makes V_{IN} 57V more positive than at the start, so the negative limit is found by making V_{IN} 57V less than at the start, namely +3V, and drawing the V_{ag} = 250−3 = 247V curve.

The output is now probably easier to read direct as change in V_a than indirectly as I_a; it is +52V and −51V. Not only is that more than seven times what it was with R = 700, but the distortion is far less—below a half of one per cent. Actually we could probably go up to at least ±60V peak output without much increase in distortion or risk of grid current. The voltage ratio V_{OUT}/V_{IN} is also better—103/114 = 0.9, or only 10% loss instead of 44%.

By using a higher resistance, the maximum voltage output could be pushed considerably higher and the distortion still lower; but if only a *voltage* output were needed there would be no point in using a cathode follower at all—the input signal would do. Presumably there is some additional load in parallel with R. If it is a d.c. path, then its effect is of course exactly the same as reducing R. If it is an a.c. path (such as a resistance load fed through a blocking capacitor) the real load line pivots on *o* instead of on the 250-volt point on the V_a scale, and if *o* has been placed low by making R very high it is so near cut-off that distortion sets in sharply at quite a small output.

The fact to which everything so far has been leading up, however, is that when the resistance of R has been chosen to give reasonable operating conditions it is far too much for grid bias. In Fig. 3 the preferred starting point is "V_{IN} = +60," and if that positive bias were not supplied it would mean that the grid was 60V too negative. So now we come at last to our main object—to discover how best to provide this +60V or whatever it may be. There are a lot of different ways. Also there are some snags.

The simplest and best, if circumstances make it possible, is to connect the grid straight to a source of signal that also provides the necessary positive bias. If the source is the anode of another valve, that is probably the answer: Fig. 4(a). If 60V is altogether too low for the anode of that stage, it may be practicable to design the cathode follower to work well with a more positive grid.

But perhaps there is some good reason against this—the cathode-follower load is low or widely variable, the previous anode voltage is unavoidably high, or maybe the signal source is not an anode at all, or the cathode-follower may be needed to work from different sources so must be self-contained as regards bias. In such cases it is usually necessary to admit the signal through a blocking capacitor to make sure that the bias it not short-circuited by the signal source. The grid must then be connected to a source of bias through a high resistance " grid leak," so as not to short-circuit the signal source. An obvious method of getting the bias is from a potential divider across V_{HT} (Fig. 4(b)). Perhaps there already is such a potential divider, whether called by that name or the more unpleasant one of " bleeder," needed for some other purpose, and it is only a matter of tapping it at a suitable point. But if not, it is easy enough to find suitable values for R_2 and R_3, because the grid takes no current, so V_{bias} is to V_{HT} as R_3 is to $R_2 + R_3$. For the same reason, R_2 and R_3 can be quite high resistances, of the megohm order, provided they are reliable. If there is any question of an undesirable amount of hum getting at the grid from + h.t., a largish capacitance C_2 can be added.

But if R_2 and R_3 are high, as suggested, why have R_1 at all? True enough; if the resistance of R_2 and R_3 in parallel is made equal to whatever would be considered a suitable grid-leak resistance, then R_1 is unnecessary and the circuit simplifies to Fig. 4(c). A suitable grid-leak resistance is the same as in a conventional amplifier; that is to say, the resistance should not be higher than the valve maker recommends as a top limit, nor low enough to load the signal source seriously. Something of the order of one megohm is usual.

One Resistor; Two Valves

Since one of the main objects of a cathode follower is to load the signal source as little as possible, it may happen that even the valve maker's top limit for grid resistance is lower than one wants to have across the signal source. My impression is that the valve makers cover themselves pretty well by fixing a low limit, and one can usually get away with a considerably higher value. But however that may be, one of the special features of a cathode follower is that the grid leak resistance seen by the signal source can be far higher than it is from the valve maker's point of view. This remarkable ability to have the best of things both ways is not achieved in the circuits seen so far, but it is in Fig. 4(d). This, I think, is the commonest bias arrangement for cathode followers, but I doubt whether everybody who uses it does so with the conscious intention of obtaining the advantage just mentioned. Nor, perhaps, is everybody who uses it aware of a possible snag that we shall come to in a moment.

The principle of Fig. 4(d), of course, is that R in Fig. 1 provides slightly more than the positive bias needed to neutralize the negative excess provided by it, so a point can be found on it which gives the right amount and to which R_1 can be connected. In our Fig. 3 example the total drop in R was 67V, of which 7 was needed for negative bias and therefore 60 had to be neutralized. A simpler way of looking at it, perhaps, is to regard the upper portion of R, R_4 in Fig. 4(d), as the conventional bias resistor to provide the required voltage, 7 in this example. Either way, if $R_4 + R_5$ were 15kΩ as before, R_4 would have to be 7/67 of this, or 1,565Ω, and R_5 15kΩ less this.

Suppose the valve maker's rating for maximum grid-to-cathode resistance is 1 MΩ. Then we would probably make that the value of R_1 (R_4 being by comparison negligible). It looks at first sight as if the impedance across the input terminals is practically the same (C_1 having been made large enough for its impedance to be negligible at the signal frequency). But imagine for the moment that the lower end of R_1 were taken away from R_4 and R_5 and connected to the grid, so that both ends of R_1 were at the same potential. Then obviously no current would flow through R_1. The same would be true if it were connected to a second signal source the same as the first, for both ends would still be at the same signal potential at every instant. If it were connected to the cathode, that end would receive (in our calculated example) nine tenths of the input signal, in phase. So only one tenth of the input signal voltage would

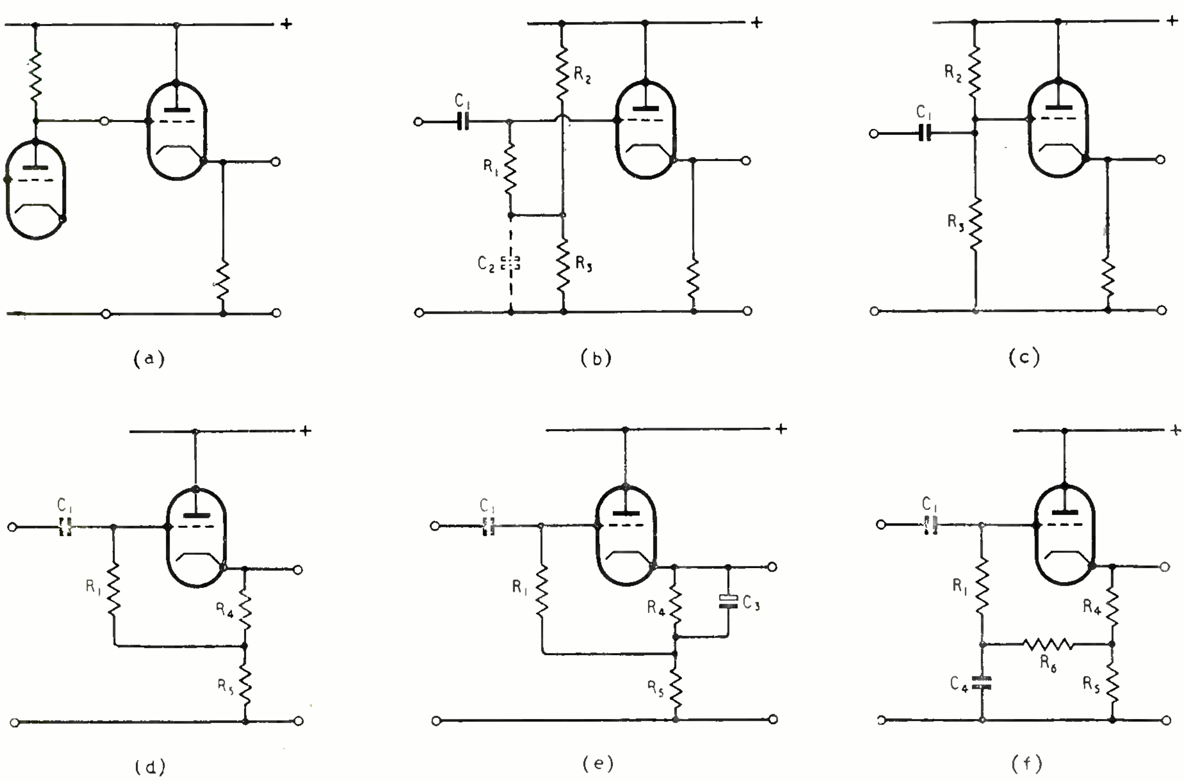


Fig. 4. Various methods for enabling the higher resistance indicated in Fig. 3 to be used in practice, by providing appropriate grid bias.

actually come across R_1, and therefore *it would take no more current than* 10MΩ *connected across the whole input voltage.* Connected as in Fig. 4(d) it receives about eight tenths of the input voltage, and so acts as a load of 5MΩ.

There is more juice still left in the orange, for C_1 does not have to be large enough to be negligible in comparison with 1MΩ but with 5MΩ. Now the voltage loss in C_1 is only 1% if the reactance of C_1 is one seventh of the effective load resistance. If that resistance were literally R_1, the reactance would have to be one seventh of a megohm; and if the lowest frequency to be handled were 20 c/s that would mean C_1 = a little over 0.05μF. But with R_1 as in Fig. 4(d) it need be only 0.01μF for the same results.

Now for the snag. The negative feedback in a cathode follower consists of the whole output voltage (signal voltage across $R_4 + R_5$) fed back to the grid, and in this version of the circuit it can only reach the grid via the signal source. To simplify things let us for the moment imagine that the lower end of R_1 is moved up to the cathode. Then the impedance of the signal source and R_1 act as a potential divider across $R_4 + R_5$, and only that part of the fed-back voltage which is developed across R_1 actually reaches the grid. If the signal source impedance at any signal frequency were 1MΩ, then, with our 1MΩ R_1, only half the voltage would be fed back, and we would have only half a real cathode follower Things are not quite so bad with R_1 where it actually is, but in our example it would be nine tenths as bad. Remembering again that the main point of using a cathode follower is usually to work from a high-impedance source, this rather subtle propensity must not be overlooked. The impedance of the signal source at any signal frequency should not be more than, say, one tenth of the actual value of R_1. Even this precaution may not be strict enough if the source impedance is largely reactance and we want to keep phase shift in the cathode follower very small.

The signal source impedance normally consists of the anode resistance of the valve (after allowing for the effect of negative feedback, if any) in parallel with the load impedance.

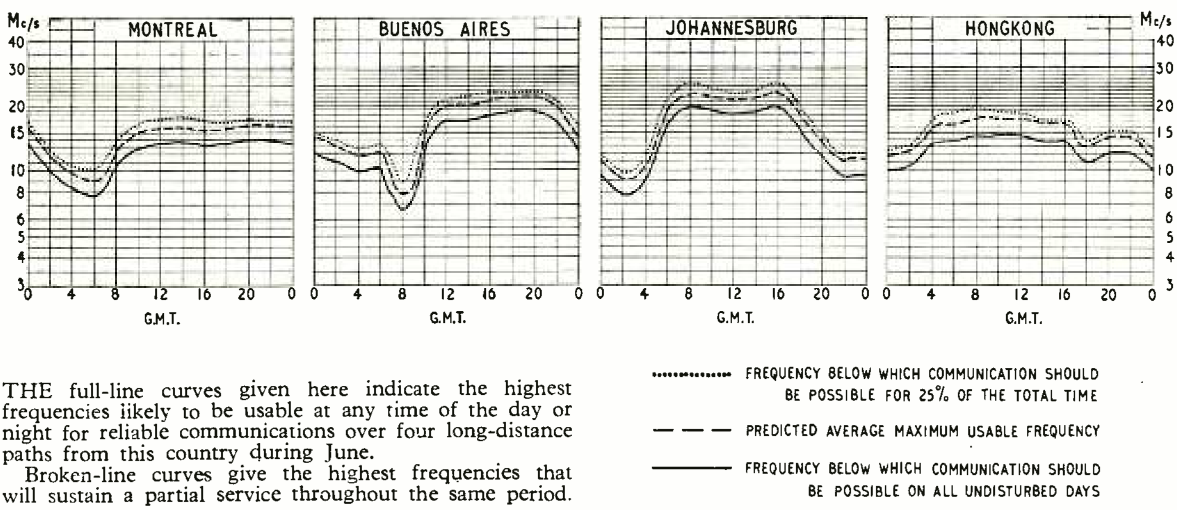
A variation of Fig. 4(d) that one sometimes sees is Fig. 4(e). The only difference is the by-pass capacitor C_3, sufficiently large to have negligible impedance (compared with R_4) at any signal frequency. So far as signals are concerned, R_1 is connected straight to the cathode (which is, if anything, a slight disadvantage), and the cathode-to-earth resistance is R_5. But so far as d.c. is concerned it is $R_5 + R_4$. So if we were doing a Fig. 3 diagram for this circuit we would have to draw the dotted line at a slope to represent $R_5 + R_4$, and then draw through *o* a steeper line representing R_5 alone, this being the line along which signal voltages would operate. Personally I consider C_3 a waste of money.

Lastly, to overcome the loss of feedback in circuits (d) and (e), type (f) has been suggested, in which R_1 is " decoupled to earth " for signal voltages, but receives its bias voltage from the junction of R_4 and R_5 as before. The impedance of C_4 at the lowest signal frequency should be very much less than R_6. For this to be so, $R_1 + R_6$ is almost sure to be appreciably higher than R_1, which means that the input signal load, which is R_1, is appreciably lower than the valve maker's limit which (if we follow his advice) is $R_1 + R_6$. This arrangement seems to me to have no great advantage over (c), and is less simple. On the other hand, (c) — and (b) — have the advantage that the cathode potential is stabilized (given constant V_{HT}) at a few volts above a level fixed by the ratio of R_2 to R_3.

Summing up: (a) is much the best if it can be arranged; if not, (c) is most likely to perform as expected, whereas (d) enables one to achieve a much higher signal input resistance but has to be carefully considered for possible loss of feedback. The others also ran.

SHORT-WAVE CONDITIONS

Predictions for June



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 June.

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

F.M. TUNING INDICATOR

Obtaining Zero Voltage Readings with Conventional "Magic Eye" Indicators

By J. R. DAVIES

THE writer, when engaged in the design and development of an f.m. tuner, was confronted with the necessity of providing a tuning indicator which could be made to give readings that were true and reliable. Also, the indicator had to be reasonably inexpensive and capable of use by non-technical persons.

At present, it seems to be fairly general practice to employ conventional tuning indicators in the f.m. receivers which are manufactured in this country, these indicators being operated from the rectified voltage appearing across the stabilizing capacitor (assuming a ratio discriminator), or from the grid resistor of an i.f. limiter valve. This system is not without its disadvantages; partly because it is necessary to ensure that the i.f. stages are accurately "peaked" (and remain so "peaked" for considerable periods of time) at the centre frequency, and partly because the initial deflection of the indicator on tuning in a strong signal is liable to be much greater than the small additional increment given at what is assumed to be the point of correct tuning.

An alternative method of obtaining tuning indications is available when a balanced ratio discriminator is employed. With such a circuit the audio take-off point provides a d.c. potential with respect to chassis which varies as the receiver is tuned through the signal being received. The d.c. potential decreases as the signal frequency deviation decreases, and it reverses polarity as the signal passes through the centre frequency. Assuming that the diode load resistors are accurately balanced about chassis, this d.c. potential may be employed to operate a tuning indicator; the position of correct tuning being represented by zero voltage.

The circuit described in this article takes advantage of this fact, and employs a conventional 6U5 "Magic Eye" tuning indicator in conjunction with a 12AU7 double triode. Interpretation of the pattern display given by the indicator is obvious since zero voltage is represented as maximum shadow angle, and excursions into either positive or negative voltage cause the shadow to "close." The sensitivity is high, zero shadow angle being given by a voltage around 2 volts on either side of zero. Due to the inherent nature of the circuit, maximum indication may not necessarily be given at zero volts, but at a potential which is very close to zero volts. Empiric tests with sample valves gave errors of less than 0.1 volt on either side of zero for the point of maximum indication. This error is quite small when it is considered that the d.c.-potential swing of the audio take-off point in most conventional f.m. receivers is usually well above 2 volts positive and negative.

The Circuit.—The circuit employed is shown in Fig. 1. In this diagram the audio take-off point from the balanced ratio discriminator is connected, *via* R_1 and R_2, to the grids of a double triode, V1. The cathode of V1(a) is taken direct to chassis, whilst the cathode of V1(b) is taken to a potential which is positive with respect to chassis.

Let us assume that the potential at the audio take-off point is sufficiently negative to allow V1(a) to pass only a small anode current. V1(b), due to the positive potential on its cathode, is cut off. In consequence of this, the potential at the grid of V2 is that given by the potentiometer R_4, R_5 and R_6. Due to the low anode current passed by V1(a), the cathode of V2 has a potential which is considerably higher than that at its grid. In consequence, the triode section of V2 is cut off, and the display indicator presents zero shadow angle.

If the negative potential with respect to the chassis at the audio take-off point is advanced towards zero (ultimately to reach a positive value), V1(a) passes a continually increasing current. This causes the cathode potential of V2 to drop until a stage is reached when the indicator shadow commences to "open." As the audio take-off potential continues to approach zero, the shadow opens further. At a potential close to zero, positive grid current commences to flow through R_1 and the increase of anode current in V1(a) ceases.

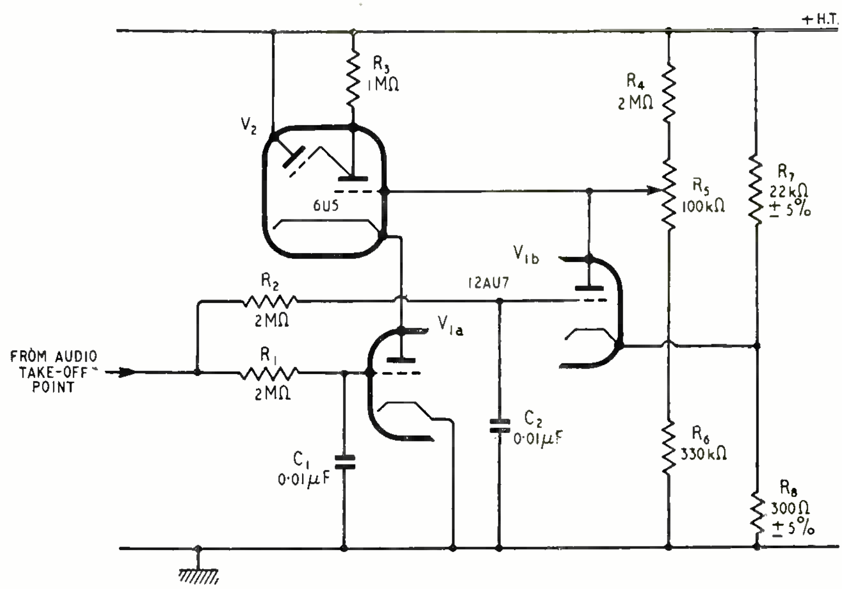


Fig. 1. The circuit of the indicator device described in this article.

The potential at the cathode of V2, in consequence, becomes comparatively steady.

Very shortly before the commencement of grid current in V1(a), V1(b) commences to conduct. However, its rate of change of anode voltage is lower than that of V1(a), and so the latter valve gives the greater control over shadow angle. After the condition of positive grid current has been reached the potential at the anode of V1(a) remains comparatively steady. As the audio take-off potential continues to rise, that at the anode of V1(b) now commences to drop further. In consequence, the grid of V2 goes further negative with respect to its cathode, and the indicator shadow commences to close again. Zero shadow angle is achieved when the audio take-off potential has gone sufficiently positive.

(It may be worth mentioning that, during the positive excursion of the audio take-off voltage, the grid potential of V2 does not affect its cathode current to any large extent, since the latter flows mainly between cathode and target.)

Operation.—It will be remarked that the circuit of Fig. 1 cannot give an accurate indication of zero voltage as the only "reference point" is that at which positive grid current commences to flow in V1(a); and this will vary from valve to valve. Also, the positive potential at the cathode of V1(b) may affect the operation near zero voltage.

However, empiric tests with a working circuit show that the device provides a maximum indication at points which are very close to zero voltage. Four different 12AU7s of varying ages give maximum indications which are all within 0.1 volt on either side of zero. Also, four-hour tests for drift do not show any measurable shift of the potential required for maximum shadow angle. Again, changes in h.t. line voltage between 200 and 250, and in heater voltage between 6 and 6.6, produce no noticeable shift. This is not sufficient evidence, of course, to assume that the circuit will function as well for all 12AU7s; and it is possible that the worst instances of drift, or of inaccurate voltage indication, will occur in the early life of a brand new valve.

The values of R_7 and R_8 are fairly critical. The writer was tempted to make R_8 a variable component, but the values shown in Fig. 1 coped satisfactorily for the valves tested in his particular case. Decreasing the value of R_8 decreases the sensitivity of the circuit, and the indicator ceases to function altogether before the potential which gives maximum indication is shifted at all seriously. Increasing the value of R_8 results in an indication of maximum shadow over a period between the potential which initiates positive grid current and a further positive potential. The consequent lack of sensitivity is immediately apparent.

Due to the fact that the potential at the cathode of V2 rises as the audio take-off potential goes negative, a dimming of the indicator pattern takes place for high negative control voltages. This dimming becomes just noticeable at approximately 4 volts negative, and the indicator is almost completely extinguished around 10 volts negative.

The potentiometer R_5 is employed to set the grid of the 6U5 to the potential which gives optimum sensitivity. Before adjustment, the slider should be set to the high-potential end of the track and the audio take-off point short-circuited to chassis. The slider is then brought down until the 90-degree shadow angle given by the short-circuit is reduced to approximately 85 degrees. The setting of R_5 is not very critical, and it might be possible to use fixed components in this part of the circuit.

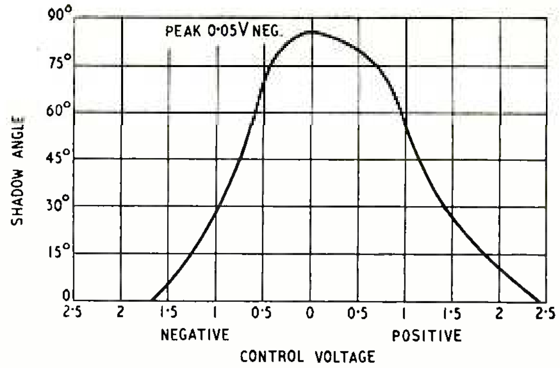


Fig. 2. Relationship between shadow angle and control voltage for typical 6U5 and 12AU7 valves.

The capacitors C_1 and C_2 are included to prevent modulation voltages from blurring the indicator pattern. A graph showing shadow angle against audio take-off potential for a typical 12AU7 and a 6U5 is given in Fig. 2.

Performance.—After the circuit had been put into working order (with the aid of a potentiometer and centre-tapped dry battery to stimulate the voltages appearing at the audio take-off point) it was tested with a working f.m. receiver. To ensure that the different source impedance did not affect accuracy of indication, a valve-voltmeter was also connected between the receiver's audio take-off point and chassis. However, the different source impedance did not introduce any measurable shift in the potential needed to give maximum indication.

In use, it was found that the readings given by the indicator were very satisfactory indeed. Normally, the shadow remained open until a station was tuned in; whereupon the shadow closed abruptly. At the centre frequency of the station, however, the shadow opened once more, and it was consequently possible to obtain a beautifully precise indication of correct tuning. Subjective tests carried out by having non-technical persons tune in the receiver resulted in an accurate position of optimum tuning being achieved in every case.

Acknowledgments.—Acknowledgments are due to Allen Components, Ltd., for facilities made available to the writer for the development of this circuit.

RECEIVER SALES

A SURVEY of the retail sales of domestic receivers during the first quarter of this year, prepared by B.R.E.M.A., shows that by comparison with the same period last year the demand for television receivers increased by 70% and sound receivers and radiogramophones by 51%. The table gives the 1955 monthly retail sales. The totals for the first quarter of 1954 are in parentheses.

	Sound	Radiograms	Television
January	98,000	35,000	103,000
February	99,000	33,000	98,000
March	95,000	24,000	85,000
Quarter's total ...	292,000	92,000	286,000
	(254,500)		(168,500)

NEW DECCA RADAR

JUST over five years ago Decca produced their first radar set (Type 159) which was marketed at about half the price of existing equipment. Two other models (Types 12 and 45) were subsequently produced and together these three models have been fitted in over 3,700 ships—about two-fifths of the world's radar-equipped vessels.

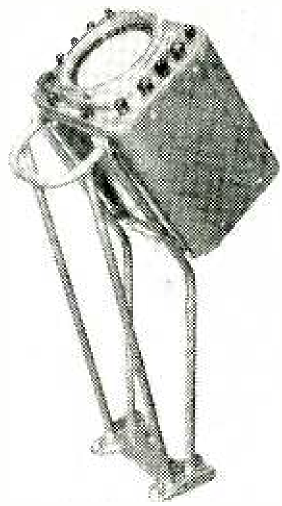
The majority of the world's medium- and large-tonnage vessels are now equipped with radar and it was to meet the demand for a set for small ships—coasters, trawlers, etc.—that Decca recently produced the Type 212. Although considerably smaller, lighter and cheaper than its predecessors it is claimed to meet the stringent M.o.T. specification for marine radar and has been submitted for type approval.

A feature of the earlier Decca sets was the fitting of the r.f. head as part of the scanner unit, thereby eliminating a long waveguide run. As it is essential in smaller vessels to reduce top weight, and, also, it is possible to have a short waveguide run, the r.f. unit in the new model is separate.

The set, which has a 9-in p.p.i., has six ranges—0.5, 1, 3, 8, 15 and 30 miles—with calibration rings varying from 0.2 to 5 miles according to the range scale in use. It has a minimum range of 30 yards and a discrimination of 25 yards on the shorter ranges.

The r.f. unit, giving a peak output power of 10 kW, has a pulse duration of either 0.1 μsec or 0.2 μsec according to the range in use. The unit can be mounted either below deck or (in a special waterproof case) at the base of the mast. The familiar Decca separate half-cheeses for transmission and reception, have given place to a single parabolic cylinder scanner of approximately 4 ft across.

Decca have equipped two vehicles with this radar unit which are now touring the ports in the U.K. and on the Continent.



The 212 display unit may be mounted on the bulkhead, deckhead or, as shown, on a pedestal.

CLUB NEWS

Barnsley.—The subject for the meeting of the Barnsley and District Amateur Radio Club on June 24th is "Fifty Years of Ham Radio" and the speaker is P. Denison (G8OK). Meetings are held at 7.0 at the King George Hotel, Peel Street, Barnsley. Sec.: P. Carbutt (G2AFV), 33, Woodstock Road, Barnsley, Yorks.

Birmingham.—"The Application of Valves for Communication Purposes" is the subject of the talk to be given by G. Nicholson (G3HKC) to members of the Slade Radio Society on June 10th. On 24th L. Glew, of Marconi Instruments, will speak about instruments at v.h.f. The club room at Church House, High Street, Erdington, is open every evening and lecture meetings are held on alternate Fridays at 7.45. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Chelmsford.—At the next meeting of the Chelmsford Group of the British Amateur Television Club—on June 9th—members are to hear a description of a portable monoscope unit. The group meets at the home of the secretary, M. Barlow (G3CVO), 10, Baddow Place Avenue, Gt. Baddow, Essex. Test transmissions are radiated each Saturday evening on 436 Mc/s by R. L. Royle (G2WJ/T), one of the members.

Cleckheaton.—T. C. Isaac (G4RQ), of Ambassador Radio, will speak on "High Quality Sound" at the meeting of the Spen Valley and District Radio and Television Society on June 1st. The club meets on alternate Wednesdays at 7.30 at the Temperance Hall, Cleckheaton. The final meeting of the session will be on July 13th. Sec.: N. Pride, 100, Raikes Lane, Birstall, Nr. Leeds, Yorks.

Coventry.—At the meeting of the Coventry Amateur Radio Society on June 20th, at 7.30 at 9, Queens Road, Coventry, D. Clift (G3BAK) will speak about v.h.f. transmission and reception. Sec.: J. H. Whitby (G3HDB), 24, Thornby Avenue, Kenilworth, Warwicks.

RANDOM RADIATIONS

By "DIALLIST"

F.M. and Hi-Fi

THE B.B.C.'s decision not to strive after really high fidelity in its Band II service is due mainly to the fact that the cables provided for its use by the G.P.O. have a bandwidth limit of somewhere about 8 kc/s. Nor will the G.P.O. allow radio links. A pity, of course; still, I don't think that those in the Home Counties who buy or build first-rate v.h.f. sets will be very disappointed by the quality of those Wrotham transmissions which emanate from studios or concert halls in London—Broadcasting House and Wrotham are linked by good lines. I have listened to Wrotham for a couple of years and found the programmes a revelation in the quality that can be obtained from a good receiver. There was a high-grade m.w. set in the same room as the v.h.f. receiver. As both were fitted with a muting arrangement it was possible to change instantly from the one to the other. Even to one who can lay no better claim than I to being musical, the difference was amazing. On the v.h.f. transmission, for example, you could pick out particular instruments in a big orchestra and follow them easily. I can't do that on any m.w. orchestral programme.

Blessed Relief

MY new abode is well over 100 yards from the nearest main road. Thanks to the distance and to the fact that the aerial is some 50-60 ft above the level of the road surface, I get no interference with television reception worth talking about; in fact, the limiter isn't in use at all and I can allow my whites to be really white. Much as I rejoice in this happy state of affairs my heart bleeds for those unfortunate enough to live on or near the road in question. It is one of the links between London and the south coast and, at this time of year anyhow, there is a constant stream of motor traffic along it all day and most of the night as well. Perhaps people grow so used to ignition interference that they cease to notice it particularly. I can't think how they can, for I'm sure I couldn't watch pictures that were continually marred by those awful lines of white spots. Nevertheless, one finds that a good many of the houses standing right alongside the road are surmounted by "Hs," "Xs" or "Ks" and that many of these "look" right over it towards Alexandra Palace.

Sets of Yesteryear

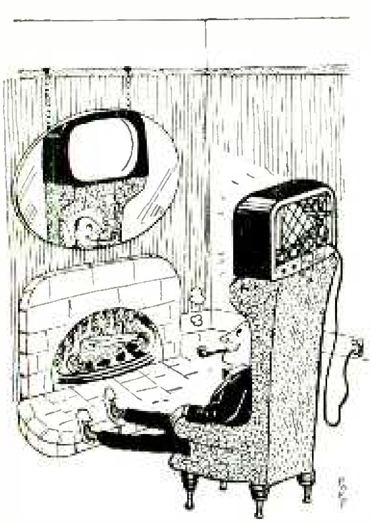
AMONG the long-forgotten papers that came to light when I was sorting things out on the eve of moving house was a 24-page receiver supplement of the then weekly *W.W.* of December 9th, 1932. One of the first things that caught my eye was the advertisement of the Decee-Acee receiver: "Will work off a.c. or d.c. mains without alteration. The *only* set of its kind." With built-in loudspeaker (which many sets of those days had not) this s.g.-det-pentode 3-valve receiver cost 18 guineas. There was also a 4-valve model with two h.f. stages, at 23 guineas. The fashionable set then was clearly the 3-valve "straight" costing £10-£12 for battery models and £16 upwards for mains models. More engaging is a page containing front and back view drawings of a typical 3-valve chassis "which will enable the features of modern sets to be readily identified." The said features include: vari-mu h.f. valve, power-grid detector and pentode output (coupled by l.f. transformer, parallel-fed), screened bandpass coils, single-dial tuning, metal chassis (with decoupling circuits mounted below), full-wave valve rectifier and electrolytic smoothing condenser. There were some bargains in wireless sets in those days. For £3 you could buy a 2-valve "Brownie," complete with moving-iron loudspeaker, but without batteries. Batteries and all, the K-B "Pup" cost £4 10s and there were a.c. and d.c. models of the same set for £7 10s. There were quite a few superhets. The all-wave "Faraday," containing 4 s.g. valves and a power pentode and offered in a.c. or d.c. models went for 27 guineas and the G.E.C. had an a.c. mains model (with heterodyne whistle filter and automatic station index) for 26gns. The same firm offered a 6-valve all-wave, battery-operated superhet, constructed to tropical specification, for 24 guineas.

Wireless: Unlawful Use of

IN these queer days when we are so hedged about by a multiplicity of little-known laws, orders and regulations, many of us must do what we "didn't orter" at one time or another without being aware of the fact. The charge of making unlawful use of wireless telegraphic apparatus, in that he received a police message when not authorized by the Postmaster General to do so, brought recently against an army officer is a case in point. The Andover magistrates very sensibly granted the accused an unconditional discharge, the chairman remarking that not one member of the bench had previously realized that it was an offence. If you own a receiver covering Band II, you can hardly fail to pick up such messages at times. I've often done so when tuning in Wrotham; in fact, I recall puzzling our local police superintendent one day by saying: "I hope you got that report off all right." "What report do you mean?" "Why, the one that headquarters was gingering you up about by wireless this morning." I wasn't run in.

Offenders in Spite of Ourselves

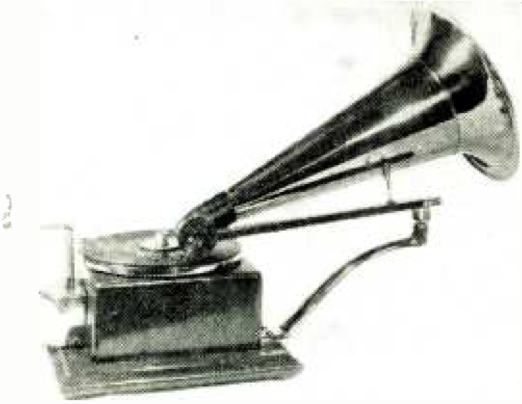
If the authorities are going to make a practice of bringing such charges, one foresees that they'll have their hands pretty full when the B.B.C.'s Band II system gets into its stride and v.h.f. sets are in use in homes everywhere. And what of those who have telephony from near-by police stations forced upon their unwilling ears by way of the loud-speakers of their television sets? Having filled up the appropriate forms, they beg the P.M.G.'s engineers to rid them of the nuisance, only to learn that occasional (or it may be frequent) breakthrough is inevitable at such short range. Will some legal reader of *W.W.* tell us whether such folk could charge the police with aiding and abetting them to break the law?



Back projection ?

UNBIASED

By FREE GRID



1897 needle-using disc gramophone

be warmed from the mains via a step-down transformer and a buried cable.

I am going to suggest that a compact oscillator unit working on TV frequencies is marketed enabling us to feed oscillations into a special transmission line and radiator buried among our plant roots or maybe suspended just above them. Frankly I don't know what will be the results as I'm no biologist but I remind myself that the scientists who detonated the first atom bomb in New Mexico in July, 1945, weren't any too sure about results.

Talking Machines

I RATHER pride myself on historical accuracy and feel compelled to draw attention to a chronological inexactitude in an otherwise excellent article by S. Kelly on "Needles for Talking Machines" in the May issue.

Speaking of the needle or stylus the author says "Sapphire or diamond in 1900, steel needles from about 1910 to 1935 . . ." which surely implies that steel-needle machines were rare, or at any rate in the minority, before 1910. I have no statistics before me but relying on my memory of those years (which has often made the B.B.C. scrapbooks bite the dust) I venture to say that the author's statement is at least misleading.

Now let us get this matter straight. At the time of Queen Victoria's death (Jan. 22nd, 1901) there was certainly a large number of sapphire-using cylinder machines in use and I have one on the table before me as I write. But even then the needle-using disc machines were —if I may coin a word—"populescent" and by the time of King Edward's Coronation (Aug. 9th, 1902) had virtually stolen the market. Side by side with my Victorian cylinder machine I have the H.M.V. disc-and-needle-using "dog" model.

Sapphires were available with some disc machines, but, in the early years of the present century, which is the period in question, by far the greater number used needles only; in fact, it is not too much to say that discs necessarily meant needles. If I can be proved wrong I am willing to spend a night of penance on a bed of upturned steel gramophone needles like an Indian fakir.

The author is also rather misleading when, a little later in his article, he says "about 1910 the disc finally ousted the cylinder for domestic reproducers. . . ." Surely this implies that the cylinder died with King Edward (May, 1910). Actually the cylinder, like Charles II was "an unconscionably long time a dying" and although the process started long before 1910, it lingered on until after the beginning of the Kaiser's war.

Several cylinder machines are listed in Gamage's catalogue of 1913 and I recollect buying one for 3s 6d —yes three shillings and sixpence— and it certainly wasn't a toy one. It's only disadvantage over the more costly ones was that it would not take the famous Edison "Amberol" cylinders which were the L.P. "microgroove" records of the period. For these cylinders the screwed rod which moved the stylus across the record had a much finer pitch than the one normally used.

Electronics in the Garden

IN THE SUMMER of 1940 I attended a lecture given by Dr. P. Dalton before the Brit. I.R.E. on the interesting subject of radio therapy. I remember how this new therapy affected the processes of the body and how it had been discovered. Apparently it had been found that wireless operators sitting near the works of powerful s.w. transmitters had suffered ill effects.

I have often wondered whether this therapy with its strong effect on normal biological processes could not be applied to our gardens to speed up the growth of plants and an item I spotted recently in an American newspaper has convinced me that it can. It has been observed that in the vicinity of certain high-powered television transmitters weeds grow wilder and tulips taller and I am getting to work immediately on the problem.

If the editor keeps his promise to let us have *W.W.* on the fourth Tuesday of each month, this issue will appear on May 24th which is not only Queen Victoria's birthday but the day on which the present Queen will open the famous Chelsea Flower Show of the Royal Horticultural Society. I intend to be right there in the electrical section where they always demonstrate how our seedlings can

"Pidgin" Radio

IT IS an old saying that the lazy man works the hardest and I have been rather forcibly reminded of it by a few remarks that appeared in the correspondence columns of *W.W.* a month or two ago about wireless and mathematics. To my way of thinking the man who tries to take the "easy" way of trying to understand the intricacies of radio without a preliminary grounding in mathematics will find the going very heavy.

He generally proceeds by way of mechanical analogies which, seemingly apt and excellent at first, break down and leave the non-mathematical student stuck firmly in a mental morass. The mathematical man, on the other hand, sails along without the necessity of conjuring up mental pictures of the phenomena which his equations represent.

An analogous state of affairs was often to be observed over a quarter of a century ago, when the home-construction phase of wireless was at its height. I frequently came across men who were very ardent and, indeed, very skilful home constructors who were unable to understand a "theoretical" circuit diagram, a form of shorthand which enabled the essentials of the receiver of that period to be seen literally at a glance. These earnest constructors, however, could and did follow the intricacies of the practical wiring plan with a skill and celerity which left me breathless and which must have needed a lot of hard work to acquire.

If I may be permitted to use an analogy after condemning them earlier in these remarks, the non-mathematical radio aspirant may be likened unto the speakers of "pidgin" English in New Guinea and elsewhere. To learn standard, or at any rate basic, English would take only half the time, pain, power and sheer hard work which they put into acquiring a knowledge of this truly astonishing lingo.