Wireless World

ELECTRONICS, RADIO, TELEVISION

MAY 1959

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Transistor Transmitter for 500kc/s

The recently introduced Mullard OC24 power transistor is suitable for high-frequency applications and it can dissipate several watts at the collector. The combination of these qualities has made possible the design of a 500kc/s push-pull amplifier capable of delivering an output of 4 watts into a resistive load. This amplifier can be used as the output stage of a transmitter such as that shown in the accompanying circuit.

The transmitter was designed for operation in the International Marine Frequency Band. It is particularly useful for lifeboats and life rafts, but it can be adapted, using an automatic-keying system, for life-jackets, air-sea rescue equipment, helicopters and radio beacons for coastal stations. The long life and reliability of the transistors make them particularly suitable for the type of apparatus suggested above, in which standby conditions of long duration are experienced. The low-consumption, light weight and compactness add to these advantages. A 4 ampere-hour accumulator will power the transmitter for some 60 hours. For emergency applications a self priming battery, which requires no attention (other than charging and sealing) until it is needed for use, is suitable.

The transmitter comprises an oscillator, a modulator, a driver and a power amplifier stage. The oscillator is crystal controlled and uses an OC45 transistor. The resonant circuit in the collector line is tuned to the series-resonant frequency of the crystal. The crystal is connected in series with the feedback winding to control the frequency of oscillation.

The modulator is a silicon transistor (OC201) also recently announced. The output from the modulator is applied to a driver amplifier and then to a push-pull power amplifier which feeds an aerial. The modulator, driver and power-amplifier stages are all operated under Class B conditions.

The design of the Class B push-pull amplifier follows the same basic technique as that for an audio amplifier except that, as the collector circuit is tuned, no bias is required to eliminate cross-over distortion. The use of a shared emitter resistor reduces the effect of variations in base-emitter voltage V_{be}, and reduces the lengthening, caused by hole storage, of the collector-current pulse. This reduction of the hole-storage current gives a marked improvement in the efficiency of the amplifier. The winding details for the output transformer are shown on the circuit.

The design procedure for the driver and modulator stages is similar to that for the output stage. A 6V supply is used for the modulator because of the voltage limitations of the oscillator transistor. This supply is also used because it is convenient for the modulator, and because of the keying system adopted.

A crystal-controlled oscillator with a tuned collector is used. Feedback is obtained by a transformer coupling from the parallel-tuned circuit in the collector circuit, to the base. The crystal is connected in series with this feedback winding. The collector circuit is tuned to the series-resonant frequency of the crystal. The series resistance of the crystal is low enough for the feedback current to start oscillation. The oscillator operates under Class A conditions, the base bias is provided by a potentiometer (R1R2). The emitter resistor is bypassed to r.f. signals.

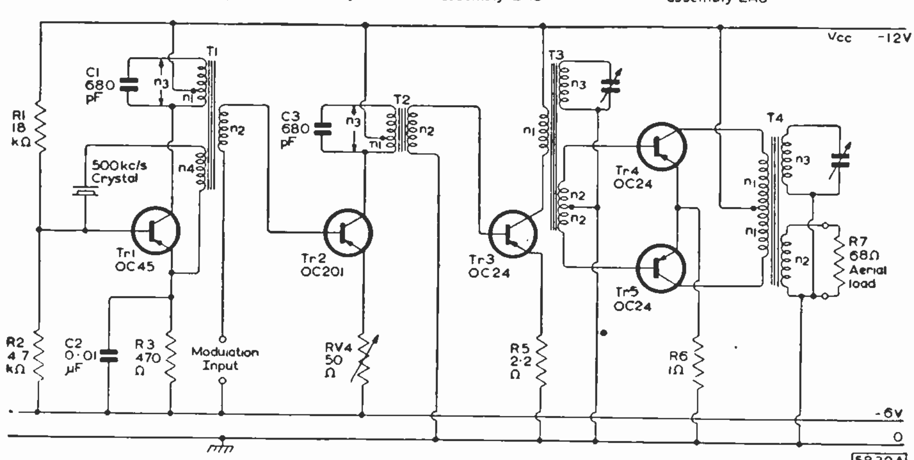
It is hoped to publish details of the modulation arrangements and the automatic keying system (transmitting SOS signals) at a later date.

The tuning procedure adopted is the usual one of rough tuning at reduced power, followed by adjustment at full power. A resistor of 27Ω is connected in the emitter lead of the modulator amplifier Tr2, the 12V supply is then connected to the transmitter, and the oscillator tuned-circuit is adjusted to the series-resonant frequency of the crystal. The modulator amplifier is tuned next. The driver and power-amplifier stages should then be tuned for a maximum power output (about 2 watts) across the 68Ω load.

The emitter resistor of Tr2 should then be short-circuited. The complete transmitter, from the oscillator to the power amplifier, should be progressively readjusted. Careful tuning of the power amplifier is necessary, because excessive collector current flows if the stage is off tune. The full output of 4 watts should now be obtained.

An experimental transmitter was built and the performance tested over a temperature range from 0 to 60°C. The output falls gradually at temperatures above 25°C, although quite reasonable output is still available at 60°C. Field tests were carried out under licence using a 520kc/s crystal, the transmitter being retuned to this frequency. A transmitting aerial 30ft high and a receiving aerial of about 30ft of wire were used. Strong signals were received within 12 miles across land. This is not the maximum range over land, and a range of at least 50 miles can be expected at sea.

Oscillator Transformer T1	Modulator Transformer T2	Driver Transformer T3	Output Transformer T4
n_1 18turns, n_2 7turns, n_3 52 turns, n_4 6 turns — 9/0024 bunched conductors	n_1 6turns, n_2 4turns, n_3 52turns — 9/0024 bunched conductors	n_1 4turns, n_2 3+3turns, n_3 30turns — 19/0028 bunched conductors (n_1,n_2) 3 strands	n_1 2+2turns, n_2 4turns — 21 s.w.g enamelled copper; n_3 33 turns 19/0028 bunched conductors
Ferroxcube adjustable pot-core assembly LA35	Ferroxcube adjustable pot-core assembly LA35	Ferroxcube pot-core assembly LA3	Ferroxcube pot-core assembly LA6



Complete Circuit of the Transmitter

MAY 1959
Vol. 65 No. 5

Wireless World

Making and Selling Valves

IT has been rightly said that valves and cathode ray tubes are at the heart of our affairs, and although in this journal we are concerned primarily with the technical aspects of their use, we cannot always stand aloof from the manner of their supply and marketing. Commercial considerations will always be an important factor in setting the pace of development in an industry where capital costs are high.

British valve manufacturers and their Association, the BVA, have never lacked critics of their marketing methods, and these critics have not concealed their satisfaction in the abandonment by the BVA of price-fixing agreements in 1956 just prior to the publication of the "Report on the Supply of Electronic Valves and Cathode Ray Tubes of the Monopolies and Restrictive Practices Commission,"* and again last month in the decision of the BVA not to offer evidence at the Restrictive Practices Court hearing in support of a continuation of agreements on "exclusivity" and maximum discounts or of the practice of limiting the number of wholesalers handling BVA valves.

The Restrictive Trade Practices Act, 1956, which requires registration of certain types of agreements and restrictions, is in many ways a new form of legislation—at least in this country. It has established a Court and a Registrar who may bring before the Court any association whose agreements are deemed to be contrary to public interest. The onus then rests on that association of proving to the satisfaction of the Court that the practices in question are, in fact, in the public interest.

What is "the public interest"? In wartime it was the restriction of the supply of valves to the public to a mere trickle. To the man in the street today it could mean the reduction of prices to the absolute minimum—if necessary by cut-throat competition, which would divert the whole of the manufacturer's resources to the cheaper production of existing types. To others it might mean an increase in prices so that more money could be applied to the discovery of entirely new valve techniques to keep this country in the lead and to improve the balance of trade. The Act enunciates no fewer than seven criteria by which the public interest is to be assessed. These are of a highly complex nature and must involve lengthy stage-by-stage legal argument before it can be decided whether an agreement may stand—or must be abandoned.

* Her Majesty's Stationery Office, price 7s.

In the case of the BVA many of its trading agreements have their origin in the early days of broadcasting when the dumping of foreign valves was a serious menace to an industry which had not yet built up adequate capital resources. Today they are in a much stronger position. Set manufacturers and servicemen in general prefer to use BVA valves; in 1955, according to the Report mentioned earlier, imported valves not sold through BVA channels were estimated to amount to 5% of the total supply. Faced with the alternatives of fighting for the maintenance of the old-established collective agreements or standing on their own feet, the member firms of the BVA have, we think wisely, decided to take the latter course. The decision is unlikely to influence the prices of valves and tubes which have for a long time been determined by far more fundamental factors than trade agreements. The industry has already declared its profits and opened its books for analysis by the Monopolies and Restrictive Practices Commission and the results are set out in great detail in their 1956 Report. It should be compulsory reading for all would-be critics—in particular those who complain that set makers get valves for 2s 6d each which cost the best part of £1 to buy in the shops. This comparison overlooks the fact that the cheaper valves will be subject, as part of a set, to distributive costs which are of the same order as those which apply to a maintenance valve. It is true that valve manufacturers charge *on an average* 10% more to a wholesaler than they do to a set maker, but this is accounted for by the smaller bulk of supplies, the cost of special packaging and by the fact that short production runs of replacement valves for maintenance are often very expensive. Again on average, the valve manufacturer's profit on cost to the set maker in 1954 was about 18% and to the wholesaler 28%. If this difference were levelled, television sets might cost anything up to £10 more to the customer. It is clearly in the consumer's interest that the sixteen odd valves he *must* buy in the set cost him less per valve than the two maintenance valves that, on a statistical, basis, he *may* have to buy during the life of the set. (The ratio of "first-equipment" to maintenance valves sold is about 8:1.)

In spite of the fact that the valve makers have had difficulty in finding proof of specific and substantial public benefit from some of their past trading restrictions, we think that valve users, both professional and domestic, are well served by what is undoubtedly an efficient and well-managed industry.

Fifth International Instrument Show

EXHIBITS BY FIFTY-SIX FIRMS OF TEN NATIONALITIES

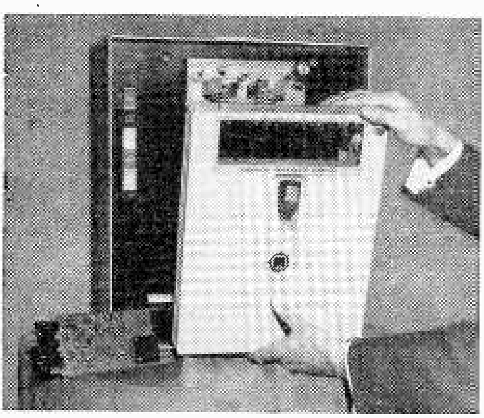
HELD for the first time at the International Instrumentation Centre, London, this year's international instrument exhibition was a little smaller than last year's, and many of the exhibits had been seen before, in at least prototype form. Nevertheless, since most of the larger instrument shows are restricted to British exhibitors, this one offers a welcome opportunity for comparing foreign developments, and there are always some interesting novelties.

Data Recorders

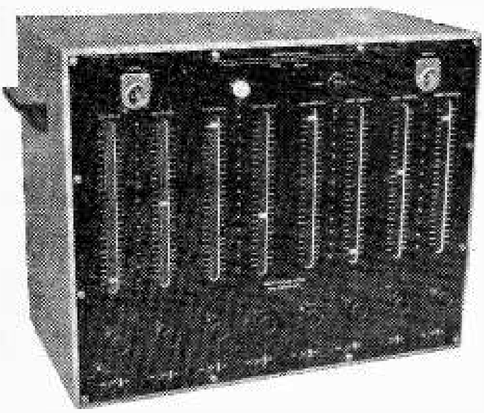
One of these is the PS.200 tape data recorder by Precision Instrument Co. (U.S.A.). This uses 1-in magnetic tape, carrying 14 tracks. Two pairs of 2:1 tape speeds, selected from the range of $1\frac{7}{8}$, $3\frac{3}{4}$, $7\frac{1}{2}$, 15, 30, and 60 in/sec, are available by motor-pole switching and drive-belt change. Four varieties of recording are available: direct; f.m. (using a kc/s carrier-frequency equal to nine-tenths tape speed in in/sec); pulse-width modulation; digital. One of the most interesting features is that tapes are mounted in rectangular magazines which can be changed in a few seconds by a plug-in arrangement whereby the tape is self-threading. The whole of the gate is visible all the time through a window. Another feature is that the weight of the equipment has been reduced from nearly half a ton to 65 lbs by the use of transistors and printed circuits, making the equipment fully portable for field use. It will, incidentally, run off 24-volt d.c. as well as the usual a.c. Control is by push tabs, which are back-lighted to show clearly the state of operation.

An altogether different type of data recorder is one that was shown by Elema-Schonander (Sweden), in which a jet of ink is squirted at a moving paper strip from the centre of a galvanometer movement which deflects the jet. Instead of the mess which this procedure might be expected to create, beautifully fine traces are produced, thanks to the extreme fineness of the jet; and when several channels are in use the traces can cross and recross without mutual interference. It is remarkable, too, for an ink-and-paper instrument, that frequencies can be recorded up to 1,000 c/s, with sensitivity as high as 0.2 mm/mV.

Yet another interesting recording technique appears in the Hughes Aircraft (U.S.A.) "Memotron" c.r. tube —a 5-in tube in which traces applied in the conventional manner are not only displayed but retained on the screen until erased. This result is achieved by means of a

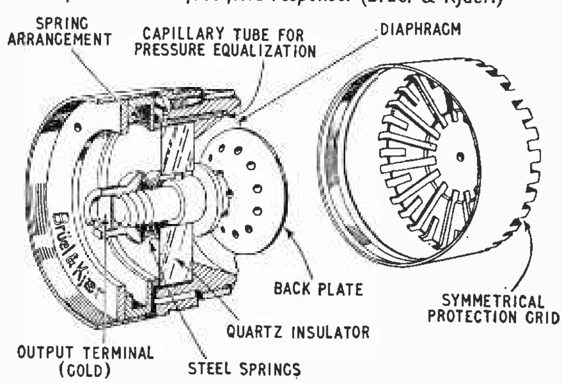


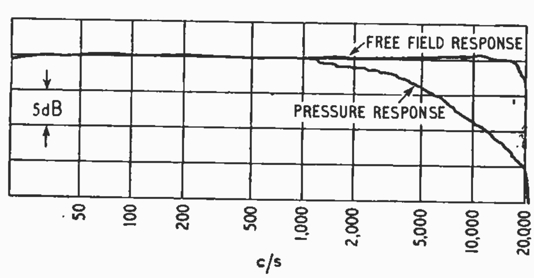
Type PS200 tape data recorder, showing tape magazine being changed and (left) one of the printed circuit panels. (Precision Instrument Co.)



Type TF823 variable multi-octave-band filter (Peekel)

Construction of the Type 4131 capacitive microphone and its pressure and free-field response. (Brüel & Kjaer.)





dielectric storage mesh and two electron guns: a writing gun and a flood gun. This type of tube is incorporated in a complete c.r.o.—the " Memoscope."

For audio workers, the Peekel (Holland) TF.823 variable multi-octave band filter is a particularly interesting and useful instrument. It consists of a low-pass filter, a high pass filter, and six intervening octave filters, covering between them roughly 30 c/s to 16 kc/s. Each filter can be individually adjusted by a vertical sliding linear attenuator with a dB scale, so that an infinite variety of frequency characteristics can be set up, for such purposes as equalization, intelligibility and distortion studies, and bridge measurements. The attenuator scales being arranged across the front panel, their settings trace a visual frequency curve. With all the attenuators at zero, the insertion loss is nil. Input and output impedances, 200 Ω.

The portable sound spectrum meter by the same firm, mentioned last year, now appears in improved form.

Much of the very extensive Brüel & Kjaer (Denmark) range of instruments is for a.f. work, and a notable newcomer is their Type 4131 capacitive microphone. It is a precision instrument for sound measurements as well as for high-quality studio use. The free-field response is practically flat from 20 c/s to 18 kc/s, and the sensitivity is 5 mV/microbar. Combined with it is a cathode follower, and a full range of accessory equipment is available.

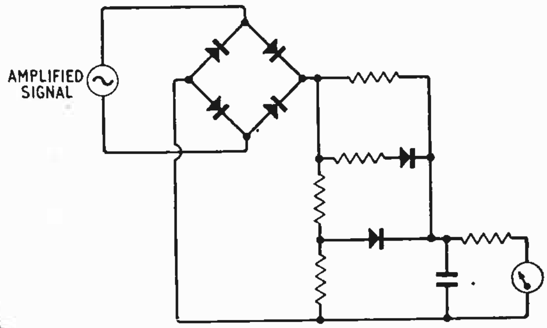
The most interesting feature of the new B & K valve voltmeter—which is of the high-sensitivity amplifier type, covering 2 c/s to 200 kc/s and 1 mV to 1,000 V—is the arrangement for enabling peak, average, and true r.m.s. values to be measured. The r.m.s. facility is provided by a network as shown in the circuit diagram, approximating closely to a parabolic character*.

The same firm showed a series of deviation bridges for production-line use in component manufacture. A special knee-operated test connector release speeds operation, and the scales are marked in percentage deviation from standard in impedance and phase-angle. Bridges are available for test frequencies of 100 c/s, 1 kc/s, 10 kc/s, and 1,000 kc/s.

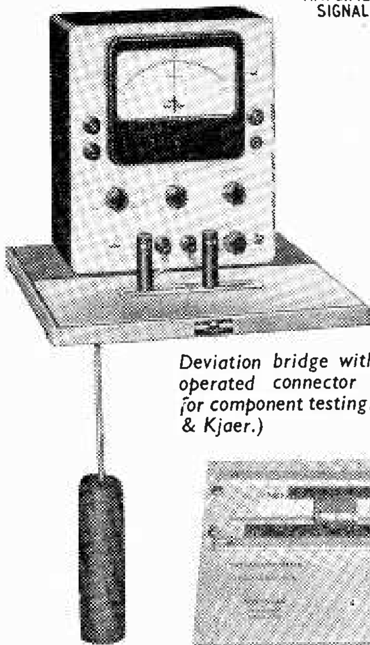
pH Meters

Except in so far as they exemplify extra-high-input-impedance voltmeter techniques, pH meters hardly come within the scope of *Wireless World*, but the Seibold (Austria) Model GV-52 is a striking illustration of how what used to be a delicate and non-portable assemblage of laboratory apparatus requiring skilled handling can now be obtained as a single smooth functional unit which is operated simply by dipping one end in the liquid to be tested, pressing a button and reading the meter at the other end.

A notable feature of the exhibition as a whole was the increasing use of transistors and other semiconductor devices. Its advantage in the " Precision " tape recorder has already been noted. H. Struers (Denmark), whose unusual types of regulated power supply units were mentioned two years ago, have taken advantage of the high current ratings of transistors to design a unit (" Transistavolt ") supplying 0-6 A at a voltage adjustable from 5·6 to 6·3 V. The internal resistance is less than 5 mΩ, the ripply voltage 1 mV, and mains fluctuations from −15% to +10% affect the output voltage less than 0·02%.

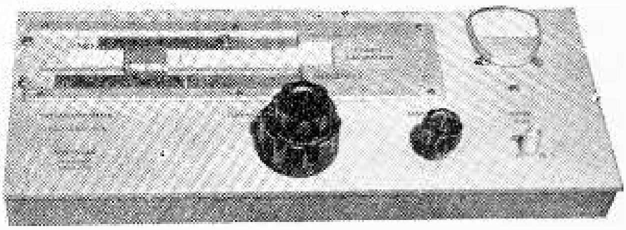


Square-law (parabolic) network for r.m.s. measurements used in the new B & K valve voltmeter Type 2409.



Deviation bridge with knee-operated connector release for component testing. (Brüel & Kjaer.)

Type SL7626 microwave search frequency meter (Sivers).



Several transistorized power units are supplied by Valor Instruments (U.S.A.), who have also a transistor checker which must be invaluable wherever many transistors are used. It locates burnt-out transistors, identifies type (p-n-p or n-p-n), measures leakage current, checks voltage breakdown, identifies terminals, and checks characteristics and electrodes shorts and open-circuits.

Microwave equipment figured largely, and Polarad Electronics (U.S.A.) have again upheld their reputation for spectrum analysis equipment. Model SA.84 covers the remarkable frequency range 10 to 44,000 Mc/s in eight bands. There is only a single tuning control, with direct-reading linear dial. The frequency deviation is adjustable from 0·5 to 5 Mc/s.

Sivers (Sweden) again showed a very wide range of microwave cavity wavemeters, waveguide joints and switches, etc., to which they have now added Type SL.7626 search frequency meter—a compact and handy instrument for measuring oscillator frequencies over the wide band 1 to 10 kMc/s. Two signals can be separately measured on linear vernier scales, and inaccuracy as low as 0·2 to 0·5% is claimed.

* " A True r.m.s. Instrument," by C. G. Wahrman. *B. & K. Technical Review*, No. 3, 1958, pp. 9-21.

WORLD OF WIRELESS

Budget Changes

THE exemption of cathode-ray tubes (both new and rebuilt) from purchase tax, previously standing at 60%, is welcomed as it removes an anomaly and is a first step in bringing the radio industry into line with others where there is no P.T. on spares. In announcing this concession the Chancellor of the Exchequer stated "this tax has been represented to me as being unduly burdensome, and technical developments in the reconditioning of tubes have made it difficult to administer the tax with equity".

To ensure that this concession "does not give an opportunity for tax avoidance on sets themselves", the Treasury has made an order stating that "television receiving sets of the domestic, portable, or road vehicle types and apparatus of the domestic type designed for receiving television programmes re-transmitted by wire, except kits of parts . . . (whether or not in a cabinet) which are complete or substantially complete *except that they lack a cathode-ray tube* . . . are to be treated for tax purposes as if a cathode-ray tube formed part of the receiver, and the value of a new tube of appropriate size and character is to be included in the full value of the receiver, upon which tax is charged."

With the general reduction of purchase tax by a sixth (except in the 5% rate), the tax on television sets, sound receivers, radio-gramophones, record players and reproducers, record changers, turntables, pickups, valves, r.f. tuners, gramophone records, etc., is reduced to 50%.

Radio in Space Research

AT the first meeting of the newly-formed National Committee on Space Research a report on the U.K. observations of artificial earth satellites by radio and optical methods was presented by the I.G.Y. Artificial Satellite Sub-committee. The report was an outline of work in progress, covering the types of observations and giving details of the twelve U.K. radio observing stations (and other organizations) and their facilities. Several prominent people well known in the radio world are members of the National Committee on Space Research, including Dr. R. C. Cockburn, Professor A. C. B. Lovell, Dr. J. S. McPetrie, J. A. Ratcliffe and Dr. R. L. Smith-Rose.

Mobile Radio

THE Third Report of the Mobile Radio Committee* to the Postmaster General proposes the introduction of 25-kc/s carrier separation, instead of 50-kc/s, in the land-mobile "low" band (71.5 to 88Mc/s). It will be recalled that its Second Report covered the reduction of channel spacing in the "high" band (165 to 173Mc/s) from 100 to 50-kc/s. This recommendation is in the process of being implemented.

The present report has been adopted by the P.M.G. and the new channel spacing comes into force on June 1st. Five years is being allowed for the change-over to 25-kc/s equipment by present users. After June 1st all new land-mobile schemes in the low band will have to use equipment meeting the 25-kc/s specification. The report includes a revised allocation of channels amongst the various categories of users.

R.E.C.M.F.—At the annual general meeting of the Radio and Electronic Component Manufacturers' Federation in March, Major L. H. Peter (Westinghouse) handed over the presidency to E. M. Lee (Belling & Lee). The new vice-presidents are K. G. Smith (N.S.F.) and A. F. Bulgin (Bulgin & Co.). The new council consists of the representatives of the following member firms: Bakelite (G. J. Taylor); Belling & Lee (N. Dundas Bryce); Garrard (H. V. Slade); A. H. Hunt (S. H. Brewell); Multicore (Richard Arbib); Painton (C. M. Benham); Plessey (P. D. Canning); Reliance Cords and Cables (C. H. Davis); Salter & Co. (C. Ottewell); S.T.C. (L. T. Hinton); T.C.M. Co. (Dr. G. A. V. Sowter) and Texas Instruments (Dudley Hayward). This year's chairman and vice-chairman are Hector V. Slade and Dr. G. A. V. Sowter, respectively.

B.R.E.M.A. Audio Group.—At the first general meeting of the recently formed Audio Manufacturers' Group of the British Radio Equipment Manufacturers' Association, Major J. F. E. Clarke, chairman and managing director of Clarke & Smith Manufacturing Co., was elected chairman of the Group. The companies elected to the management body were: B.T.H. Sound Equipment; Clarke & Smith Manufacturing Co.; E. K. Cole; Dynatron Radio; Electric Audio Reproducers; E.M.I. Sales & Service; Grampian Reproducers; Jason Motor & Electronic Co.; Lowther Manufacturing Co.; and Trix Electrical Co.

VHF/UHF Convention.—The fifth international amateur v.h.f./u.h.f. convention organized by the R.S.G.B. and the London U.H.F. Group will be held at the Prince of Wales Hotel, De Vere Gardens, London, W.8, on May 30th. The morning session will be devoted to informal discussions and the afternoon to lectures. Tickets for the convention and dinner, costing 22s 6d, are obtainable from F. G. Lambeth, 21 Bridge Way, Whitton, Twickenham, Middx.

Ghana is to have a television station operating in time for the visit of H.M. The Queen in November. The station, which will be in Accra, the capital, and will operate on the 625-line 7-Mc/s standard, is being provided jointly by Marconi's and Pye. A large number of television receivers is to be installed in community centres, hospitals and public places.

* H.M.S.O. 1s 3d.

Careers.—A number of organizations in the field of radio and electronics are participating in the careers section of the forthcoming National Education and Careers Exhibition. Organized by the National Union of Teachers, it will be held at Olympia from May 26th to June 5th.

Hospital Equipment.—Radio and electronics manufacturers are among the 150 exhibitors at the International Hospital Equipment and Medical Services Exhibition, which is being held at Olympia from May 25th to 30th. The exhibition, which is sponsored by the Institute of Hospital Administrators, is open to the public from 1.0 to 6.30. Admission costs 2s 6d.

A.P.A.E. News.—Although the Association of Public Address Engineers has not held an exhibition for several years, the committee has met regularly to further the interests of its manufacturer and user members. This year's annual meeting and luncheon at the King's Head Hotel, Harrow, was well attended and a small private exhibition was arranged for members. The president for 1958/59 is S. V. Williams, of Pamphonic Reproducers, who was invested with the badge of office, a recent gift to the Association by A. E. Buchan, of Aberdeen, who was president in 1953/54. The honorary secretary is Alex. J. Walker, 394 Northolt Road, South Harrow, Middx.

Full House.—As far back as March 16th all tickets for G. A. Briggs' concert-demonstration at the Royal Festival Hall, London, on May 9th had been sold.

University of London.—Two lectures are being given in London at the end of April by Professor B. D. H. Tellegen, of Philips Research Laboratories, Eindhoven, and the University of Delft, under the scheme for the interchange of British and Dutch lecturers. The first lecture, entitled "The Gyrator as a Network Element," will be given at King's College on the 29th, and the second, entitled "The Search for a Complete Set of Ideal Non-linear Network Elements," at Imperial College on the 30th. Admission to both lectures, which start at 5.30, is free; tickets are not required.

Sound Reproduction.—A series of six lectures on high-fidelity and stereophonic sound reproduction is being given by J. Moir at Norwood Technical College on successive Tuesday evenings, from May 19th. Full details of the course, for which the fee is 10s, are obtainable from the College, Knight's Hill, London, S.E.27.

Broadcast Receiving Licences.—Combined TV/Sound licences in the U.K. increased during February by 108,549, bringing the total to 9,152,927. Domestic sound-only licences decreased during the month by 109,440, reducing the total to 5,189,399. Car radio licences rose by 3,603 to 372,297. The overall total of receiving licences was 14,714,623.

Radio Control.—The Post Office issued the three thousandth licence for the radio control of models, such as aircraft, boats and cars, etc., in March. These licences, which cost £1 and remain in force for five years, were introduced on June 1st, 1954.

Personalities

A. G. Touch, M.A., D.Phil., since 1954 Director of Electronics Research and Development (Ground) in the Ministry of Supply, has been appointed senior superintendent of the Radio Department at R.A.E., Farnborough, in succession to **Dr. J. S. McPetrie** (see *W.W.*, November 1958, p. 526). After graduating at Oxford, Dr. Touch joined Watson-Watt's radar team at Bawdsey research station in 1936. For his contributions to the development of meter-wave AI and ASV he received a substantial award on the recommendation of the Royal Commission on Awards to Inventors. From 1941 to 1947 he was liaison officer with the British Joint Services Mission in Washington. On his return to this country he became superintendent of the Blind Landing Experimental Unit at Martlesham Heath, Suffolk, and from 1952 to 1954 was Deputy Director of Electronics Research and Development (Air) in the M.o.S.

D. W. Fry, M.Sc., M.I.E.E., having been appointed director of the Atomic Energy Establishment, Winfrith, his place as deputy director of the Atomic Energy Research Establishment, Harwell, is to be taken by **F. A. Vick,** O.B.E., Ph.D., since 1950 Professor of Physics in the University College of North Staffordshire. Mr. Fry was at T.R.E. throughout the war working on problems of centimetre-wave techniques. Dr. Vick was assistant director of scientific research in the Ministry of Supply from 1939 to 1944.

E. M. Lee, B.Sc., M.I.E.E., M.Brit.I.R.E., successor to **Major L. H. Peter** as president of the Radio and Electronic Component Manufacturers' Federation, has been managing director of Belling & Lee since its formation in 1922. He is also a director of Insulators Limited (Plastics). During the war he was chairman of the Joint Industries and Services Technical Components Committee. Mr. Lee is keenly interested in the educational side of the industry and is chairman of the Radio Trades Examinations Board.


E. M. LEE


E. W. HAYES

E. W. Hayes, M.I.E.E., becomes head of the B.B.C.'s Planning and Installation Department on the retirement of **A. N. Thomas.** Mr. Hayes joined the Corporation in 1933 and was appointed assistant to the Superintendent Engineer Transmitters in 1946. For three years from 1948 he was resident engineer in the British Far Eastern Broadcasting Service, Singapore, and since 1951 has been head of the Transmitter Equipment Section of the Planning and Installation Department. Mr. Thomas, who joined the B.B.C. in 1926, served at a number of transmitting stations before transferring in 1929 to the Research Department where he assisted in the establishment of synchronized transmitter networks.

D. B. Weigall, B.A., A.M.I.E.E., who succeeds Mr. Hayes as head of the Transmitter Equipment Section of the Planning and Installation Dept., has been with the Corporation since 1933. He was seconded for two years in 1940 as chief engineer to the Malayan Broadcasting Corporation and in 1943 was seconded to the Ministry of Information as technical adviser on broadcasting.

L. Essen, O.B.E., D.Sc., Ph.D., A.M.I.E.E., has received the Wolfe Award of £500, which is the first of ten annual awards to be made under the terms of a will to the research worker who is considered by the Department of Scientific and Industrial Research to have made an outstanding contribution to the research work of the Department during the previous 12 months. Dr. Essen, a senior principal scientific officer at the National Physical Laboratory, receives the award for his work on the establishment of the cæsium atomic frequency standard as a basis for the future standard of time. Dr. Essen joined the N.P.L. in 1929.

J. W. Godfrey is retiring from the position of Editor, Technical Instructions, in the B.B.C.'s Engineering Training Department. He joined the B.B.C. maintenance staff in the London control room in 1929 and in 1935 transferred to the Technical Recording Section. He became an instruction writer in 1942 and four years later was appointed to his present position in which he has been largely responsible for building up this section of the Corporation's Engineering Training Dept. Mr. Godfrey, who is editor of the B.S.R.A. journal *Sound Recording and Reproduction*, is joint author with G. Parr of "The Technical Writer." He is being retained by the B.B.C. in a part-time consultant capacity.

S. W. Amos, B.Sc.(Hons.), A.M.I.E.E., a frequent contributor to *Wireless World,* succeeds Mr. Godfrey as editor in the Technical Instruction Section of the B.B.C. on May 1st. He has been with the B.B.C. since 1941. He spent three years as an instructor in the B.B.C. Engineering Training School before joining the Section in 1946. He has been assistant editor in the section since 1957. He is joint author with D. C. Birkinshaw of the four-volume B.B.C. engineering text book "Television Engineering," issued by our publishers, and author of "Principles of Transistor Circuits."

S. W. AMOS.

HECTOR V. SLADE.

Hector V. Slade, M.B.E., this year's chairman of the Radio and Electronic Component Manufacturers' Federation, became managing director of the Garrard Engineering and Manufacturing Co. in 1957 on the retirement of his father. He joined the company as an apprentice in 1935. On returning from military service in 1947 he became assistant managing director and in 1952 joint managing director.

J. W. Soulsby, chief radio officer in the British India Steam Navigation Company's *Uganda*, has been elected chairman of the Radio Officers' Union, for the fifth successive year. He has been on the staff of the Marconi Marine Company since 1918. The vice-chairman of the Union is **W. S. Armstrong,** elected for the third year in succession. He was for some years on Marconi's sea-going staff but since 1947 has been a member of the company's technical shore staff and is now an inspector.

A. R. Williams has retired from the managing directorship of Grampian Reproducers, which he founded in 1932. At the recent annual meeting of the Association of Public Address Engineers he was made an honorary life member in recognition of his services to the public address industry. For 21 years prior to forming Grampian he had been with Marconi's, where he was for some time commercial manager.

E. D. Hart, M.A., A.Inst.P., A.M.I.E.E., for the past five years general secretary of the Scientific Instrument Manufacturers' Association, has joined the board of Industrial Exhibitions Limited. He was with Marconi Instruments for twelve years before joining, in 1952, the Equipment Division of Mullards as head of the technical department.

T. C. Owen, advertisement manager of *Wireless World*, has retired after 47 years' association with the journal. In 1912 he joined Marconi's, who issued *The Marconigraph*, which in 1913 became *Wireless World.* In December, 1917, after being invalided out of the Army, Tom Owen transferred to Wireless Press Ltd., and he was appointed advertisement manager when *Wireless World* was acquired by Iliffe & Sons Ltd. in 1925. He is succeeded as *W.W.* advertisement manager by **G. Benton Rowell,** who had been assisting him since 1950.

C. C. Whitehead, author of the article on variable-gain magnetic amplifiers, was for 12 years in the Royal Corps of Signals and six years with the B.B.C. before starting his industrial career in 1938 when he joined the Telephone Manufacturing Co. He was with them for a two-year contract in charge of the radio section to fulfil a foreign order for v.h.f. communications equipment. He then joined Marconi's, where for ten years he was on development and research work. From 1950 to 1953 he was chief development engineer with Bailey Meters & Controls, and since 1954 has been senior engineer (research and development) with the Sperry Gyroscope Co.

OBITUARY

Professor J. T. MacGregor-Morris, D.Sc.(Eng.), M.I.E.E., Emeritus Professor of Electrical Engineering, University of London, died on March 18th, aged 87. He received his scientific education at University College (London), where he was a student under Professor (later Sir) Ambrose Fleming, and afterwards spent some years as his assistant. He was, therefore, well qualified to write in 1954 a biography of Sir Ambrose Fleming entitled "The Inventor of the Valve." In 1898, at the age of 26, MacGregor-Morris started organizing classes in electrical engineering at what subsequently became Queen Mary College, London. When the college was affiliated to London University he was appointed Professor of Electrical Engineering and occupied the chair until his retirement in 1938.

Alexander James Muir, M.B.E., who died as a result of a road accident at Malvern on February 28th, was well known in the field of radar. He joined D.S.I.R. in January, 1927, and worked as an assistant at Ditton Park. In 1935 he was one of Watson-Watt's original team of six to build the first radar station at Orfordness. He moved to the research establishment at Bawdsey with the inception of the programme for CH stations, and later to R.R.E., Malvern, where he was still actively engaged on radar development at the time of his death. Sir Robert Watson-Watt pays tribute to Muir's work in his book "Three Steps to Victory."

H. Howitt, secretary and later director of the British Radio Valve Manufacturers' Association from its formation in 1926 until his retirement in 1936, died on April 5th at the age of 85.

Radio Components Show

NEW DEVELOPMENTS SEEN AT THE R.E.C.M.F. EXHIBITION

ONCE again the annual show of the Radio and Electronic Component Manufacturers' Federation was held in Grosvenor House and Park Lane House, London, W.1 (6th-9th April). The number of firms exhibiting was the largest ever and the stands were crowded with visitors from abroad and with British engineers and technicians from industrial firms and Government establishments.

Our technical staff found a great many new techniques in component design as well as the less spectacular, but none the less important, steady improvements in established products. The following review is a selection of those exhibits which seemed to us to hold the greatest originality and technical interest.

Resistors:—The main trend indicated by development over the last year is not a new one—both fixed and variable resistors are getting smaller; but at this year's exhibition the effects of miniaturization were very marked indeed. Possibly the most far-reaching example of this was the introduction by S.T.C., Painton and Dubilier of ranges of miniature high-stability carbon resistors. The Dubilier Type S27 resistor, rated at $\frac{1}{10}$W, is the smallest of a new range in sizes rated up to 2W and 800V, using turned-brass silver-dipped end-caps. The finish applied is three coats of a silicone varnish and the new series identified by the serial letter "S," corresponds (with the exception of the $\frac{1}{10}$-W size) to the existing "R" series. The new S.T.C. resistor is also rated at $\frac{1}{10}$W; but Painton's Type 70, though of roughly the same physical size (about 0.35in long and 0.1in in diameter) is rated at $\frac{1}{5}$ watt—this increase is due to the use of their Sintox base material, which has a heat conductivity similar to that of steel. An improved ceramic with low-alkali content is used by Welwyn as the base in ranges of oxide-film resistors both for high-power-dissipation and high-stability applications. This, and improved overall-coating and film-depositing processes, allow the use of these resistors at temperatures of at least 150°C.

A new power resistor from Dubilier—the PW series—is of all-insulated construction. The wire element is wound on a glass-fibre core, silicone impregnated and placed in a ceramic "coffin" which is sealed with a ceramic cement. Ratings are 5, 7 and 10 watts in ±10% and ±5% tolerances.

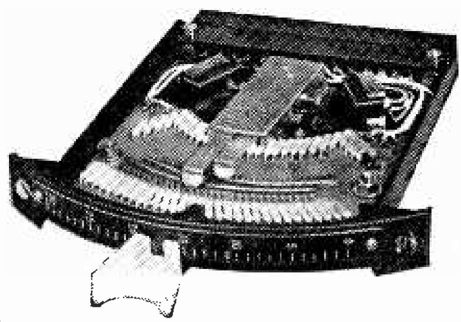
The difficulty of removing heat from high-temperature components such as power resistors is not a new one; but as units become more compact the difficulty increases. One solution to this problem for mains droppers is the provision of a "chimney" in the form of an aluminium tube through the resistor itself. This technique was employed by Pye in their 110° television receiver* and the logical development is to dispense with a separate former and use the metal tube itself. This has been done by several manufacturers—Labgear were showing examples of both types, called "Convectalite" The insulation employed is a silicone-impregnated asbestos paper and a 5:2 reduction in weight is achieved by the elimination of the ceramic former. Also using silicone-impregnated asbestos paper were Welwyn; but Erie favoured a mica compound.

"Convectalite" mains-dropper resistors by Labgear. Resistor on right is wound on insulated aluminium tube.

Another approach to resistor cooling problems was shown on the Ministry of Supply stand. This took the form of a finned light-alloy shield enclosing the resistor, which was packed in silicone rubber; but the main cooling effect was achieved by conduction into the chassis. A resistor, which, to outward appearances, was a 5-W type, was stated to be capable of dissipating 20 to 50W: this method would seem to be ideally suited to a cooled-chassis technique.†

For more normal applications Morganite have introduced a new range of non-insulating $\frac{1}{10}$-W carbon resistors in standard values between 10Ω and 10MΩ. These are available in 5, 10 and 20% tolerances and are known as "Type X."

Painton's new $\frac{1}{5}$-W high-stability resistor is no doubt partly responsible for the small size of a new professional vision or sound attenuator of the quadrant type. This, too new to have a type number yet, is only half the thickness of the normal type, yet



"Half-thickness" fader by Painton.

it is provided with plug-in connections and microswitches for operating internal scale and warning lamps. Electronic Components, too, have introduced a new small fader unit; but this consists of two "half-thickness" attenuators mounted together so that the double unit plugs into the same space as the existing single type. Again, internal switches for scale and warning lamps are incorporated, and there is also a companion unit of reduced height (4½in) with a smaller number of studs. Another new Painton product is the Bournes Trimpot. This is superficially not unlike the "Flatpot" shown last year—it is a small rectangular pre-set; but it is available in a wide diversity of mounting styles and values and can be operated at up to 175°C. It is

* *Wireless World*, January, 1959, p. 23.

† "Cooling Airborne Electronic Equipment," by L. A. Williamson, *Wireless World*, February, 1959, p. 87.

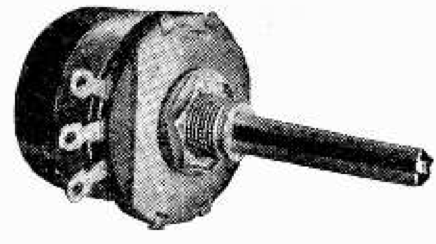
fully sealed and the element can be either of wirewound or carbon construction.

Among the many printed-wiring adaptations of ordinary potentiometers were noted several of the mount-through type in which the ordinary spindle-bush nut clamps the unit to the board, the tags being extended forward to locate on the printed wiring (Egen 315 series, Reliance 2W wire-wound, etc.). One pre-set unit designed expressly for printed-wiring use was shown on the Colvern stand. Rated at $\frac{1}{2}$W this is available in values up to 50kΩ.

Perhaps the most interesting trend in controls for domestic equipment is that manufacturers are tending, more and more, to buy complete control sub-assemblies rather than separate units. Some of these are mounted on the cabinet; but some pre-set groups are designed for printed-wiring mounting with very little mechanical support other than tags. Several manufacturers expressed the hope that there would be an increase in the use of flexible links between the knobs exposed to the rigours of everyday domestic life and the delicate printed-wiring board.

Single controls are, of course, still being produced in vast numbers and several new developments feature increased safety or a better product at a lowest cost. As an example of the first trend, Morganite were showing volume controls with a hard p.v.c. spindle. This is splined on to a short steel stub which takes the place of the spindle on an otherwise normal unit. Originally produced for the Scandinavian market, this control obviously presents no danger of electric shock should the control knob be broken or pulled off.

A large number of potentiometer failures in domestic equipment are due to the sprayed track being damaged by the wiper. Several years ago Plessey produced their moulded-track units to overcome this; but as they are rather more expensive than the sprayed-track type their use has been confined to better-class apparatus. However, they have now produced a moulded-track potentiometer to sell at a price only slightly higher than a sprayed-track type by using a far less costly assembly than is usual. The main feature of the Type Y is a triangular-section spindle formed from sheet brass: at the inside end this is splayed to make the switch operating cam, brush carrier and stop, whilst the slight springiness enables a simple, moulded push-on knob without a retaining spring to be used. Another new



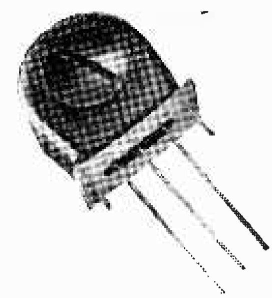
Triangular-spindle potentiometer with moulded track (Plessey).

Plessey product is a range of moulded-track sub-miniature preset potentiometers rated at $\frac{1}{4}$W and designed for panel grouping for television receivers.

A cam-corrected precision potentiometer usually requires a higher driving torque than the uncorrected type. In an effort to reduce the additional drag Colvern have developed a cam-corrected potentiometer with a very light action. In this the cam acts as the "slip-ring" contact and a very light cranked wire bears on it. This twists against light spring pressure, rotating a fork carrying the brush, so moving the brush and achieving correction. The Reliance SPP25 is a precision potentiometer with an accuracy of 0.1% which is achieved, not by a correcting mechanism, but by careful manufacture. The other new products from the Reliance Manufacturing Company are a sine/cosine resolver potentiometer (Model CO3) with 2% accuracy and a miniature (Type J12) helical potentiometer 1-in long and of $\frac{1}{2}$-in diameter. Siemens Edison Swan offer a 10-turn helical type only 0.3in by 0.6in and Ferranti have produced a 3-gang precision potentiometer only $\frac{3}{4}$-in in diameter which weighs only $\frac{1}{2}$oz and has a linearity tolerance of 0.1%. Ferranti state that its production has been made possible only by the design of a new winding machine capable of handling wires of diameter down to 5×10^{-4}in.

Manufacturers*: A.B. Metal (W, V); Ardente (V); Armand-Taylor (W); British Electric Resistance (W, V); Bulgin (W); Colvern (V); Dubilier (C, HS, W, V); Egen (V); Electronic Components (W, V); Electrothermal (HS, W); Erie (C, HS, W); Fortiphone (V); Jobling (HS); Labgear (W); McMurdo (W); Morganite (C, V); N.S.F. (V); Painton (HS, W, V); Plessey (W, V); Reliance Mfg. (V); S.T.C. (HS); T.M.C. (W), Welwyn (HS, W); Zenith (W).
***Abbreviations:** C, composition; HS, high stability; W, wirewound; V, variable (wirewound or composition).

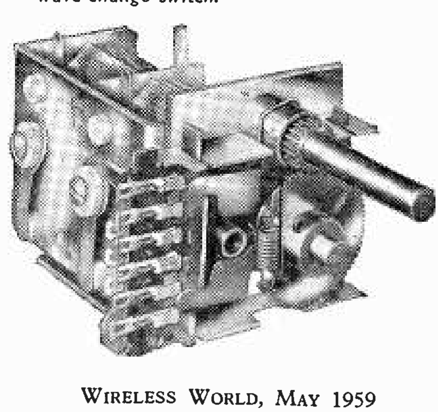
Variable Capacitors:—A major trend at once evident in tuning capacitors for radio receivers was that the double, spring-loaded anti-backlash gear is becoming popular for at least one stage of the reduction drive.



Co'vern wire-wound pre-set potentiometer printed-wiring boards.

Among the numerous samples seen a 50:50 distribution between cut gears and the stamped-from-sheet type was noted. Cost, of course, is the deciding factor; but the superiority of the cut gear is evident at once from handling the drive. A cut gear is used on the Wingrove and Rodgers two-gang C86/302, which is a double type of maximum capacitance 500pF and 10pF. Designed for a.m./f.m. receiver manufacturers, this capacitor has an exceptionally rigid frame and the reduction-drive provided is 3:1. Another product shown by this company was a miniature 3-gang capacitor (Type C78/23), only $2\frac{1}{4} \times 1\frac{1}{2} \times 1\frac{1}{2}$in approximately, with a maximum capacitance of 196pF per section. The small size is realized by the use of a gap of only 12 "thou" between fixed and moving vanes. Jackson, too, were showing a two-gang a.m./f.m. capacitor—in this case pressed gears are used and the vane shape is modified slightly to give a good frequency distribution over the scale (Type LFM2). Very rigid f.m. sections are a feature of this model, and a new version of Jackson's "OO" two-gang capacitor for transistor applications is fitted with a concentric slow-motion drive and "spikes" for printed-wiring-board mounting.

Plessey tuning capacitor with anti-backlash reduction gear and integral wave-change switch.



Plessey have extended the scope of wavechange switches ganged to the tuning capacitor with several new models: the Type S has a fork mechanism which actuates at each end of travel of the capacitor a double-pole changeover switch. This is not unlike one "wafer" of a push-button switch and is completely insulated from the frame of the capacitor. The Type V capacitor is a two-gang a.m./f.m. type fitted with a cut-gear reduction drive which is notable for a very smooth action.

Fixed Capacitors: — Electrolytic capacitor developments during the last year have been confined mainly to reductions in overall size. One point made by Daly was that the use of etched foil for the cathode, as well as for its more customary use as the anode, can allow a reduction in size to be effected. An improvement in technique is responsible for the increase in maximum operating temperatures announced by T.C.C. for their tantalum-anode capacitors. The range covers capacities and working voltages from 200μF (6V) to 16μF (150V) in polarized types (non-polarized versions exhibit half the capacity of the polarized types) and the operating temperature range is now -55°C to $+125$°C.

Possibly the most interesting development in ceramic capacitors was a 0.1μF type, shown by Hunt, which measured about ½-in square by 1mm thick. Some of the gilt is taken off the gingerbread by the maximum voltage rating (30), but this capacitor should be ideal for transistor applications where space is very limited. Made by a new process of rolling-out the dielectric material, a permittivity of 6,000 is realized.

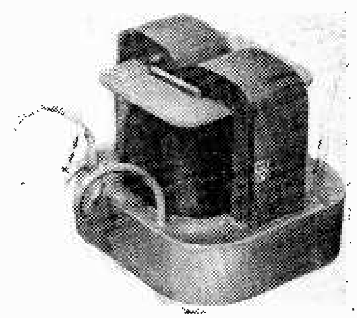
B.S.415 seems to have been responsible for a considerable divergence of opinion over the amount of external insulation needed on isolating capacitors for use in live-chassis apparatus; several manufacturers produce isolating units with only a light, external insulating coating, whilst others produce capacitors in a moulding of a material capable of withstanding the test potentials. Erie produce both types in tubular and disc shapes, and they were showing also two new high-voltage ceramic-capacitor series, designed specifically for line timebase applications. The type numbers are 2163B (15 to 25pF, 2kV) and 2163C (18 to 56pF, 3 to 4 kV). A modification of Erie's PAC component assembly (the Mk. III) features individually replaceable components from their "Pluggable" ranges with tags at 0.25-in centres.

Polycarbonates are thermoplastic compounds containing aromatic rings linked by the carbonate group electrically not unlike polystyrene; but with a higher softening point. Suflex capacitors utilizing polycarbonate dielectrics exhibit much the same characteristics as polystyrene types; but they can be used at temperatures up to 140°C. Stantelac capacitors (S.T.C.) also use a synthetic film dielectric; but the films are so thin that they cannot be handled; they are coated onto aluminium foil which is itself only 8μ thick! Working voltages are 50 and 100, and the capacity range is 0.01μF to 2.2μF.

The Dubilier Type 560 is a high-grade paper dielectric capacitor encapsulated in mineral-loaded resin. It is claimed to be resistant to mechanical shock and moisture: it exhibits an insulation resistance better than 2×10^{4}MΩ at 30°C and life expectancy for a 1 in 10 failure rate is better than 10,000 hours at 70°C and 50% d.v. overload. Hunt's popular "Moldseal" range is now produced with a new coating material which is more resistant to mechanical shock than the original substance and the end-mounting printed-wiring adaptations of this range feature a new moulded end cap. This holds the lead-out wires rigidly in position and provides a three-point support for the capacitor.

Manufacturers*: Ardente (V); B.I.C.C. (P); Bird (T); Bulgin (M); C.C.L. (E); Daly (E); Dubilier (C, E, F, M. P); Erie (C. M, T, V); Hunt (C, E, F, M, P); Jackson (T, V) L.E.M. (C, F, M. T); Mullard (T, V); Mycalex and T.I.M. (M); Plessey (C, E, F, P, T, V); Salford (F); Stability (C, F); Stratton (V); S.T.C. (C, E, F, M, P); Suflex (F); T.C.C. (C, E, F, M, P, T); T.M.C. (F, M, P); Walter (T); Wego (F, M, P); Wingrove and Rodgers (T, V).
***Abbreviations:** C, ceramic or glass; E, electrolytic; F, plastics film; M, mica; P, paper; T, trimmer; V, variable (tuning, etc.).

Transformers and Inductors: Wound-strip transformer cores are usually regarded as too expensive for use in domestic-equipment because of high costs, due mainly to the "banding" process of holding the C-shaped sections of the core together. However it has been shown, by "re-thinking" the C-core process, that it is a realistic form of core for low-cost transformers. An example of a new low-cost assembly process was shown on the Telcon-Magnetic Cores stand. The wound core is cut, not across the middle of the long sides; but as near to one end as is practicable. The bobbin carrying the windings is then placed on the smaller sections; the larger sections are placed in position and a d.c. of sufficient magnitude to attract firmly together the core sections is then



C-core transformer assembled by new method (Telcon-Magnetic Cores).

passed through a winding. A resin potting compound is poured round the assembly to a sufficient depth to cover the join between the core sections. In this way the cores automatically align themselves and the whole transformer is held rigidly.

Also on show on the Telcon-Magnetic stand were some examples of their Y-cores. These are wound-strip cores for 3-phase transformers; but instead of being formed in the usual E-shape they resemble a "star" (as opposed to "delta"). This is claimed to give a superior phase balance and to ease winding problems.

Partridge Transformers have pro-

Partridge Type MC7 microphone transformer.

duced a new range of microphone transformers—the MC5, MC6 and MC7. All three use Mumetal cores and are fitted into $\frac{1}{16}$-in thick Mumetal round cans with a single-hole mounting so that they can be rotated for minimum hum pick-up. The MC6 is provided with two 150-Ω primaries for use with a 600-Ω balanced line and the MC7 matches a 30-Ω line into the grid circuit, both have a response within 1dB from 30c/s to 20kc/s. The MC5 is a smaller and cheaper unit with a more limited response providing a 50:1 ratio from 20-Ω line.

To provide a "tropicalized" transformer of high reliability at low cost Hinchley Transformers have "potted" vacuum impregnated units into drawn aluminium cans, using pitch as the sealing material. This is claimed to be more satisfactory in reducing electrolysis of the insulants than the usual pitch-dipped type of construction. Also featured were mains-isolating transformers for service-bench and domestic use.

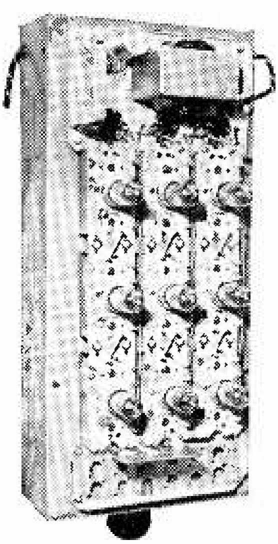
Weymouth were showing samples of their popular Type "H" coils wound on a new former moulded from high-impact polystyrene. This reduces losses and improves performance. Also shown by Weymouth was a high-precision delay line. It is possible to "repeat" inductors to fairly close limits on production (Weymouth quoted 1%) but the lumped effect of small errors could cause a precision delay line to be useless. In view of this the inductors are wound with adjustable iron-dust cores and each line is set up for optimum performance.

Both Plessey and Weymouth are now producing double-tuned i.f. transformers for transistor receivers: whilst slightly more costly than the single-tuned versions they do offer improved performance, particularly on selectivity. One very neat solution to "Q-boosting" problems was noted on the Plessey stand in their range of miniature i.f. transformers for transistor circuits. This range is identical in performance with the established sub-miniature range employing pot-cores; but by the use of bigger ($\frac{13}{16}$-in square) cans losses can be cut down to the point where the pot core is no longer necessary except for the final transformer. The use of a pot core here is avoided by fitting a U-shaped ferrite section round part of the coil only. The increase in permeability enables a small enough quantity of wire to be used to realize a Q of 160. In the double-tuned range of transformers the detector diode and filter have been fitted inside the screening can to reduce 2nd harmonic radiation.

Another example of the accuracy possible with modern coil-winding techniques was shown by Plessey. This was a permeability-tuned coil for the 20 to 40Mc/s range for use in their 1750-channel communications equipment. A 0.4% tolerance on inductance between a set of six inductors at any insertion of the cores is allowed, and to realize this an accuracy of turn spacing of 2×10^{-3}in is required.

Manufacturers*: Ardente (LA, LR, TA); Belling and Lee (LR, TR), Bulgin (LR); Dubilier (LA); Electro Acoustic (TA, TR); English Electric (LA, TA TR); Erie (LR); Fortiphone (LA, LR, TA, TR); Goodmans (LA, TA); Gresham (LA, TA, TR); Haddon (LA, TA, TR); Hinchley (LA, TR); Henry and Thomas (LR); Lion (LA, LR, TR); Mullard (LA. LR); Painton (LR); Parmeko (LA, TA, TR); Partridge (LA, TA, TR); Plessey (LA, LR, TA, TR); Reproducers and Amplifiers (LA, TA); Richard Allan (TA); Rola Celestion (TA); S.T.C. (LA, LR, TA); Stratton (LR, TR); Teledictor (LA, TA); T.M.C. (LA, TA); Wayne Kerr (TA); Welwyn (LR); Weymouth (LA, LR, TA, TR); Whiteley (LA, LR, TA, TR); Wireless Telephone (LA, LR, TR); Woden (LA, TA); Wright and Weaire (TA); Zenith (LA, TA).
***Abbreviations:** LA, a.f inductors; LR, r.f. inductors; TA, a.f. transformers; TR, r.f. and pulse transformers.

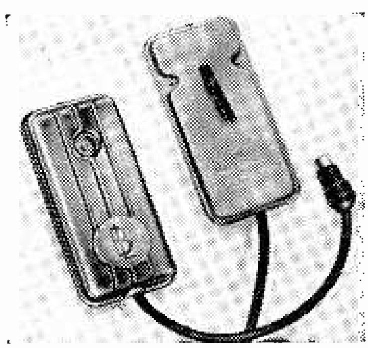
Aerials and Accessories:—A new loft aerial provided an interesting example of economy in design. Produced by Kimber-Allen, it consists of a ground-plane Band-I aerial with a telescopic vertical element which gives a variation in gain of about 20dB as well as enabling resonance to be achieved on any channel in Band I. The horizontal ground-plane element is shortened and carries the Band-III directors and reflector; proximity coupling is used so that a common feeder can be used and a Band-II "twig" is available (only one is used). The feeder connection is simplicity itself—a saddle connector for the coaxial-cable outer conductor is effective and quick and the inner conductor is clamped under the head of the bolt retaining the Band-I vertical element. A universal clamp and a key-hole mounting complete what should be a popular and effective design. Labgear were showing a new dual-band aerial—Band-I dipole and director with five directors for Band III The Band I dipole carries two "twigs" which are claimed to cause the whole dipole to behave as a co-linear array, so boosting signal pick-up.



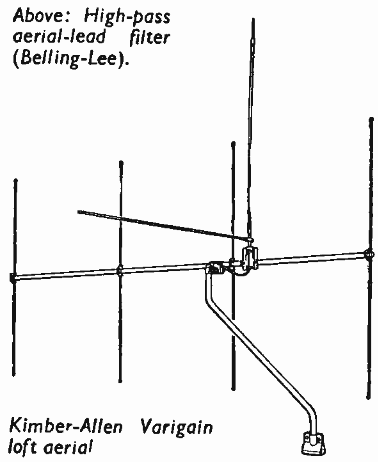
Wolsey A3/3/3 high-gain distribution amplifier for Bands I, II and III.

Wolsey Electronics were showing a new range of equipment for communal-aerial installations including padded and terminated outlet boxes with attenuations between 38 and 20dB, and splitter networks. Designed to fit conduit or for surface mounting the outlet boxes are fitted with isolating capacitors to BS415 (so protecting other users of the installation should one receiver become faulty) and they provide two outlets, if desired, one for f.m., one for TV. The A3/3/3 amplifier consists of three of Wolsey's high-gain amplifier strips and a power supply and it can be provided with a conduit type outlet. Providing a 50dB gain on one channel each in Band I and Band III and over the v.h.f./f.m. band, it is designed for feeding large blocks of flats, small estates, etc.

A new triplexer by Antiference (Type Y4) is designed for mast-head or gutter mounting. It uses a plastics moulding to carry conventional



Above: High-pass aerial-lead filter (Belling-Lee).



Kimber-Allen Varigain loft aerial

components and it is claimed that it can be used as a diplexer between f.m. and television aerials also. The out-of-band losses are 20dB and pass-band attenuation is 2dB.

Two new products from Belling and Lee should prove popular—one mainly for export, the other for the home market. The L1418 is a 300Ω twin-feeder outlet box moulded in high-density polythene. Solderless connections are made by crimping, in both the box and its associated plug. The L1425 is a high-pass multi-section filter with a characteristic impedance of 80Ω. It has an insertion loss in the region of 2dB at frequencies down to 40Mc/s, 55dB at about 38.5Mc/s and 90dB at about 33Mc/s. The trim flat case carries a plastics clip to hold the unit on the receiver back and it is supplied complete with a standard coaxial plug. Belling and Lee were also showing some examples of multi-section telescopic rods for on-the-receiver aerials.

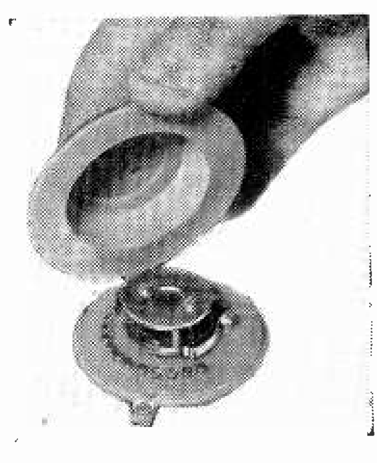
Manufacturers*: Antiference (AS, DA); Belling and Lee (AS, DA, D); J-Beam (AS, CA, DA); Kimber-Allen (DA); K.L.G. (DA); Labgear (AS, DA, D); Wolsey (AS, DA, D).

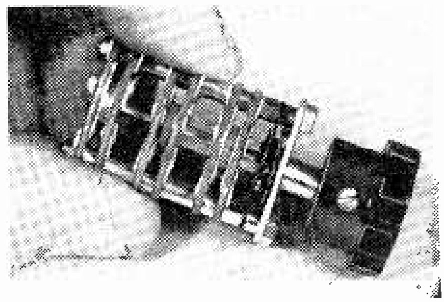
***Abbreviations:** AS, accessories; CA, communications aerials; DA, domestic aerials; D, distribution amplifiers and equipment.

Switches:—Miniaturization is still the main trend in switch development. One of the smallest rotary switches on show was a wafer type by Ardente, measuring about ½ inch in diameter. An interesting feature of the design is that each switch bank consists of a pair of wafers with fixed contacts, between which a shorting contact is moved round by the drive shaft. An example with three banks was shown, but more can be used. The switch has 6 ways and up to 3 poles and is continuously rotating.

Miniature OAK type rotary wafer

Electronic Components front-of-panel stud switch.





Ardente miniature rotary wafer switch.

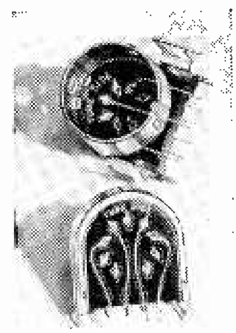
switches (about 1 inch in diameter) were shown by N.S.F., who also had a miniature version of their Ledex rotary solenoid, which drives 4-6 wafers in 12 steps with an input power of about 7 watts. The OAK switches, in common with several other rotary switches seen on other stands, had wafers made of a glass fibre material instead of the usual resin bonded paper. This is a new trend, giving better insulation resistance and greater mechanical strength.

Probably the ultimate in miniaturization has been accomplished by Electronic Components in a new rotary stud switch, which is made to disappear altogether—at least from its usual place behind the control panel. In fact, the mechanism is designed to fit on the *front* side of the panel, underneath its control knob. A particular advantage of this scheme, apart from space saving, is that the studs are freely accessible for cleaning or lubricating when the control knob is removed.

Manufacturers*: A. B. Metal Products (K, T, P, R, SL); Ardente (P, R, SL); B.E.R.C.O. (R, ST). Bulgin (K, T, M, P, R, SL, ST, TH); Diamond H (T, R); Egen (P, R); Fortiphone (T, R); Henry and Thomas (K, T); Kimber-Allen (T), Magnetic Devices (P), N.S.F (K, T, P, R, SL); Painton (T, P, R, ST); Plessey (K, T, P, R, SL); S.T.C (TH); T.M.C. (K, T); Walter (T, P, R, SL, ST); Welwyn (T, P); Whiteley (K, P, R, SL, ST).

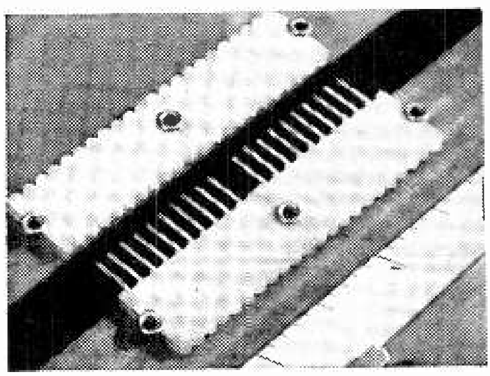
***Abbreviations:** K, key, T, lever or toggle; M, micro, P, push-button, R, rotary; SL, slide, ST, stud; TH, thermal delay.

Chassis Fittings: — Right-angle valveholders have been introduced by Painton to permit horizontal mounting of valves on printed circuits, thereby making possible more compact circuit assemblies and simplifying heat sink arrangements. A new nylon printed-circuit valveholder shown by Cinch is available with a detachable half-circle clip



Painton right-angle valve holders.

which provides a simple means of anchoring valve retainers. The clip can be rotated to the desired position and is located by small slots in the nylon holder. This firm also had metal clip transistor holders. Other types on show were cylinders of p.v.c. to give a push fit (Hellermann) and T-shaped flat pieces of



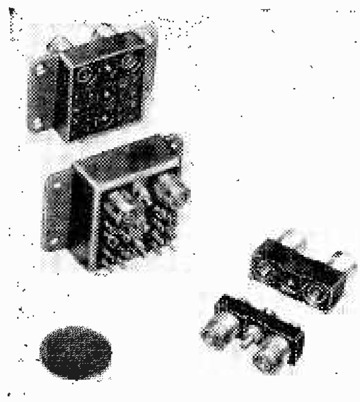
Siemens Edison Swan printed-circuit connectors.

Neoprene designed to fold over and enclose the transistor (Electrothermal).

Different types of multi-way connectors for printed circuits are still being developed. The latest, from Siemens Edison Swan, is a simple and compact system of round pins and sockets inserted into flat pieces of nylon, each unit being 1-inch long and containing ten pins or sockets. An inexpensive connector for multi-way cables shown by Plessey has the pins and sockets shrouded in single-piece polythene mouldings, which eliminate the need for gaskets and provide the necessary anchorage. The pins or sockets are crimped or soldered to the cable away from the mouldings then inserted into keyed holes in the polythene.

New terminal arrangements included a terminal block with spring-

Electronic Components coaxial connector system.



Belling-Lee coaxial Unitors.

loaded wire grips instead of screw clamps (Hellermann). Spring loading is also used for quick release in some large insulated pillar terminals (Mycalex) for providing mains supplies on benches or counters. The insulated pillar is deflected by the fingers, allowing the ends of the flex wire to be inserted in a serrated brass grip.

A new design of coaxial cable connector by Electronic Components simplifies considerably the task of preparing the cable ends and assembling the connector parts. It is unnecessary to bare the braid sleeve. A knife-edged metal collar is inserted between the inner insulator and the braid, which is clamped on to the collar by means of a threaded bush which grips on to the outer covering of the cable. Belling-Lee have extended their "Domino" miniature Unitors to include coaxial connectors. The plugs and sockets are mounted in pairs with earth pins on small insulating blocks, and these blocks are assembled in groups in metal shrouds to form the Unitors. Ordinary single-pole connector blocks can be assembled with the coaxial ones if necessary. For jointing coaxial cables Hellermann were showing cable crimps consisting of copper cylinders with nylon bushes inside and small concentric metal bushes to take the cable inners. Crimping is done by a special tool.

Widney Dorlec have increased the versatility of their "prefabricated" cabinet system by providing for movable tapped holes in the main frame members to take the fixing screws of equipment panels. This avoids the need for having the main members already drilled and tapped at regular intervals. A pre-drilled metal strip is bolted behind the main frame members and the holes in this are used as a location for drilling into the main frame. Small tapped blocks are then inserted behind the clearance holes in the main frame to take the panel fixing screws.

Manufacturers*: Antiference (CPS); Bakelite (P); Belling and Lee (CPS, T, F, J, V); B.E.R.C.O. (DL, K); Brayhead (EFC); Bulgin (V, EFC, CPS, DL, ES, T, F, J, K); Carr Fastener (EFC, CPS, T, F, V); H. Clarke (T); Colvern (RPS); Cosmocord (K); Creators (EFC, G, T); Egen (CPS); Electro Methods (CPS, T); Electronic Components (CPS, DL); Electrothermal (CPS, EFC); Fortiphone (CPS); Goodmans (CR); Hallam, Sleigh and Cheston (CR): Harwin (EFC, CPS, T); Hasset and Harper (CR, EFC, ES); Hellermann (EFC, G. T, K); Imhof (CR); Insulating Components (DL, P, T, V); Jackson (DL, DR); K.L.G. (T); Long and Hambly (G); Lustraphone (EFC); McMurdo (V, CPS); Mica and Micanite (EFC, T, V); Morganite (CPS); Mullard (CR): N.S.F. (CPS); Painton (CPS, DL, T, K); Permanoid (CPS); Plessey (CR, CPS, DR, T, P, F, K, V); Salter (EFC); Siemens Edison Swan (CPS, T, V); Simmonds (EFC); Spear (EFC, CPS); Standard Insulator (EFC, G); Stocko (EFC, T); Stratton (CR, CPS, DL, DR, K); Suflex (ES); T.C.C. (P); Telcon (CPS); Thermo-Plastics (CR, DL, ES, T); Thorn (P); T.M.C. (J); Tucker ((EFC, G); Tufnol (T); Walter (P); Weymouth (DL, T, K); Whiteley (CR, CPS, T, K, V); Wimbledon (CR, EFC, DL, ES); Wingrove and Rogers (DR, T); Wolsey (CPS).

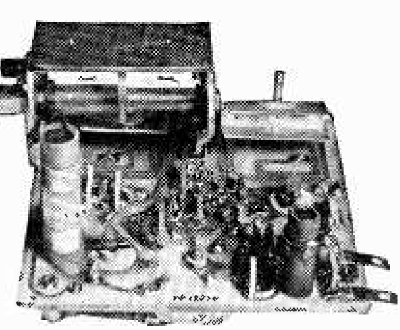
***Abbreviations:** CPS, connectors, plugs and sockets; CR, cabinets, racks and chassis; DL, dials; DR, drives; EFC, eyelets, fasteners and clips; ES, escutcheons; F, fuseholders; G, grommets; J, jacks; K, knobs, P, printed circuits; T, terminals and tagboards; V, valveholders.

Sub-Assemblies: — Manufacturers of television tuners are now producing them in alternative versions to cope with varying requirements. The Plessey-Brayhead tuner, for example, which has so far been in production with a 10-position turret, is now available with 14-position and 18-position turrets. The 14-position tuner provides for all 13 television channels and the 18-position one for 13 television channels and four f.m. sound channels—both models looking far enough ahead to include the extra position for possible u.h.f. broadcasting in Band V. Provision is made also for dual-frequency i.f. strips—34/38Mc/s for television and 10.7Mc/s for f.m. sound. Other versions of the tuner are available for 625-line television sets and f.m. sound-only receivers.

An interesting f.m. tuner introduced by Cyldon is based on a printed circuit which includes the coils, and these are tuned by an eddy-current system. Rotation of the control shaft operates a cam which causes small metal plates to approach, or move away from, the printed coils —the cam being designed to give a linear tuning scale. A single ECC85 double triode is used, one half acting as an r.f. amplifier and the other as an oscillator/mixer. The gain is 60dB at 87Mc/s or 57dB at 101Mc/s. The printed circuit is made from glass fibre and the oscillator drift is 35kc/s for a 15°C temperature rise.

Band-pass crystal filters of small size and high selectivity for the i.f. sections of communications receivers were shown by Cathodeon Crystals. Three types, intended for channel spacings of 50kc/s, 25kc/s and possibly 12.5kc/s, have centre frequencies of 10.7Mc/s and bandwidths (at −6dB) of 25, 12.5 and 6kc/s respectively. The crystals and other components are mounted on printed circuits and hermetically sealed in compact metal cans (2in × 2in × 1¼in) with two terminals.

Encapsulated circuits for many different functions were noted. As an example, Wayne Kerr had a resin-



Eddy-current tuning system of Cyldon printed circuit f.m. tuner.

Cathodeon crystal filter.

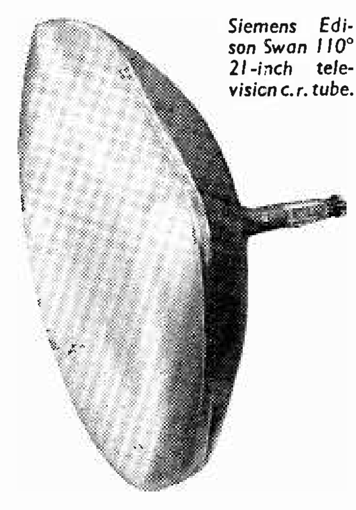
cast voltage stabilizer consisting of a chain of small neon tubes with a series/parallel striking network. Versions with stabilizing voltages from 370V to 5kV are available. The structure can be made slighrly radio-active to ensure an adequate level of residual ionization after periods of storage.

Manufacturers*: A.B. Metal Products (T); Belling-Lee (F, IS); B.I.C.C. (DN); Brayhead (T, AD); Bulgin (IS); Cathodeon (F); Cyldon (T); Dubilier (DN, IS); Erie (PC); Goodmans (F); Hunt (IS); Labgear (F. IS); Lion (DN); Morganite (IS); Mullard (DN, F); Plessey (AD, F, IS, T); Salford (F); S.T.C. (IS, F); Stratton (IS); T.C.C. (DN, IS); T.M.C. (F, IS); Wayne Kerr (F, IS); Wego (DN); Weymouth (DN, F); Whiteley (AD, IS).

***Abbreviations:** AD, r.f. adaptors; DN delay networks; F, filters; IS, interference suppressors; PC, pre-assembled components; T, tuners.

Valves and Tubes:—For use in the cascode r.f. amplifier stages of television tuners, Mullard have introduced a new variable-mu double-triode, the PCC89, of considerably improved performance. It has a frame grid, by means of which the grid-cathode spacing is reduced, and as a result the slope is as high as 12.5mA/V—which is twice that of the conventional PCC84 now commonly used. The noise factor is 5.5dB at 200Mc/s.

Another new double triode for this application is the Ediswan Mazda 30L15 (with conventional grid) which has a slope of 9mA/V, while its companion triode-pentode frequency changer is the 30C15. Brimar also have a new triode pentode, the 6BR8. The two sections have separate cathodes and the valve is mainly intended for a.f applications in which the two stages are connected in cascade. An r.f. beam tetrode from the same firm, the 6688, is intended for wide-band amplifiers and has the high slope of 16.5mA/V.



Siemens Edison Swan 110° 21-inch television c.r. tube.

The Nodistron numerical indicator tube of S.T.C. has been improved in a new model, G10/201E. This glow-discharge device has larger numerals, is now capable of working from both d.c. and a.c. and has no wire mesh anode in a visible position to obscure the view of the numerals.

Television cathode-ray tubes with 110° deflection angles are now well-established on the market. A new addition to the types already available (from Mullard and Siemens Edison Swan) is the 17 inch C17AA from Brimar. It has electrostatic focusing and operates with a final anode voltage of 16kV.

As ion trap magnets are not used in these tubes other means have to be provided to adjust the alignment of the beam emerging from the electron gun. This is provided for by wire-ring magnets produced by Eclipse (James Neill), which are magnetized across a diameter and fitted round the tube neck. Known as "steering magnets," strengths of the order of 10 to 30 oersteds are used.

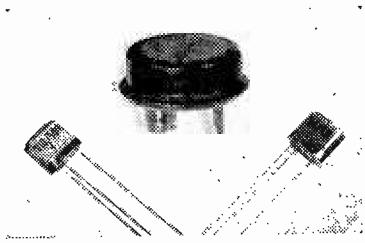
Manufacturers*: Ferranti (CC, IT, M, R, T); M-O (CC, IT, M, PC, R, T); Mullard (CC, IT, M, PC, R, T); Siemens Edison Swan (CC, IT, PC, R, T); S.T.C. (CC, IT, M, R, T).

***Abbreviations:** CC, cold-cathode; IT, industrial and transmitting; M, microwave; PC, photocells; R, receiving; T, cathode-ray tubes.

Semiconductors:—The v.h.f. transistor is now very much a reality. As an example, some of the micro alloy diffused types available from Semiconductors will give useful gains at frequencies up to 200Mc/s. Mullard have introduced a new series of r.f. transistors made by the alloy diffusion technique, and the first of these, the OC170, has an average cut-off frequency of 70Mc/s and a current gain of 80. The maximum collector dissipation is 60mW. Newmarket Transistors have developed an alloy-junction drift transistor, the V15/20R, with a maximum cut-off frequency of 75Mc/s.

The above are all germanium transistors. Silicon types, with their ability to work at temperatures up to about 150°C, are now being produced in appreciable quantities, mainly for switching applications. Texas Instruments showed an extensive range of grown-junction n-p-n types, including an h.f. tetrode, 3S004, capable of giving a power gain of 20dB at 70Mc/s. Silicon alloy-junction transistors for switching applications have been introduced by both Semiconductors and S.T.C. As an example of performance, the rise time obtainable with the SA496 made by Semiconductors is 80 milli-microseconds. A range of p-n-p junction silicon transistors was shown by the Brush Crystal Company. These types, OC430 to OC470, have total power dissipations of 330mW and are intended for use in d.c. amplifiers, class-B output stages and switching circuits.

An interesting experiment in tackling the problem of variations in characteristics between transistors of the same type number has been started by Mullard. They are introducing packages of specially selected and tested transistors which give guaranteed minimum overall gain figures when used in suitable circuits.



Newmarket power transistor and r.f. transistors.

An a.f. package contains a matched pair of OC78 output transistors and an OC78D driver. This is to give an audio output of 500-600mW with a maximum input requirement of 30μA. An r.f. package contains three OC44/OC45 transistors (for oscillator/mixer, 1st and 2nd i.fs), guaranteeing a minimum overall gain of 74dB. In general, better gain figures are said to be achieved than the averages obtained with randomly chosen transistors.

Power handling capacities of transistors continue to be developed. A notable example on show was the Texas Instruments power transistor 2N458, which has maximum collector ratings of 80 volts and 5 amps. Newmarket have introduced a range of power types (in experimental production) with a junction geometry of a special kind which gives higher emitter efficiency and current gain than is normally obtainable at high currents (here up to 6 amps). A new Mullard type, OC27, intended for the output stages of car radios, will give an output of 4W in class-A output stages operating from 7- or 14-volt supplies.

In the rectifier field, S.T.C. were showing a new range of selenium h.t. rectifiers which correspond with their well-known RM series but have somewhat smaller radial dimensions. Texas Instruments have extended the range of their Zener voltage reference diodes to cover Zener voltages up to 91 volts. The maximum power dissipation of these types is 8 watts.

Manufacturers*: Brush (D, TR): Ferranti (D, TR); M-O (D, TR); Mullard (D, TR, TH); Newmarket (TR); Salford (D, MR); Semiconductors (TR); Siemens Edison Swan (D, TR); S.T.C. (D, MR, TR, TH); Texas (D, TR); Westinghouse (D, MR).
***Abbreviations:** D, diodes; MR, metal rectifiers; TH, thermistors; TR, transistors.

Materials:—A modification of the transfer moulding process is used by Insulating Components and Materials and Anglo-American Vulcanized Fibre to produce transformer bobbins for high-temperature operation. The material used is an epoxy-resin and glass-fibre mixture and bobbin walls as thin as 0.015in can be achieved.

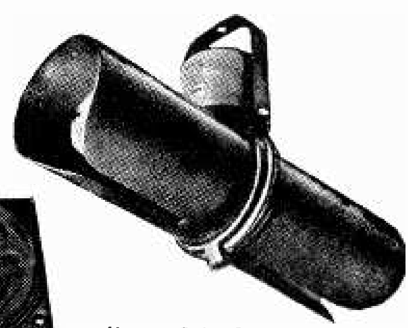
Swift Levick had on show a high-saturation magnetically soft material for use as pole-pieces where very concentrated fields are required. Called Vaco-Iron, it is a mixture of cobalt, iron and a small quantity of vanadium; but, in spite of the vanadium content, it can be machined easily and with high accuracy. The saturation flux is about 25% higher than ordinary mild magnet steel.

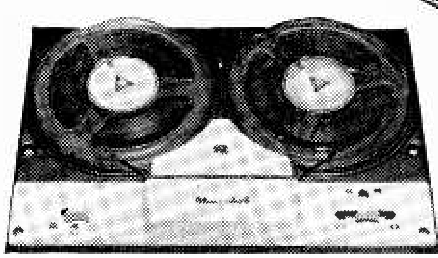
Strictly speaking, Magloy (Plessey) is not a new magnetic material, but the result of a process. Normally when a magnet of, say, Alnico, is required it is cut into sections such that they conform to the shape of a leakage field about the poles of another magnet. The sections are then allowed to cool through the Curie point in the leakage field; then they are joined to make a magnet of complex shape. In the Magloy process a shaped field, produced by an arrangement of conductors, is used instead of a leakage field, so far more complex shapes can be produced in one piece. Also, Magloy magnets can be covered with aluminium jackets which serve two purposes—they prevent the approach of other magnetic assemblies to the point where the Magloy magnets sustain damage, and they provide a convenient mounting arrangement.

Manufacturers: — *Insulating Materials:* Anglo-American Vulcanized Fibre, Bakelite, Geo. Bray, CIBA, H. Clarke, Creators, Enanlon, Formica, Hellerman, Henry and Thomas, I.C.I., Insulating Components and Materials, Jobling, K.L.G., Langley London, Long and Hambly, Mansol, Mica and Micanite, Micanite and Insulators, Minnesota, Mycalex T.I.M., Plessey, Siemens Edison Swan, Standard Insulator, Steatite, Symons, Telegraph Construction, T.C.C., Thermoplastics, Tufnol, Wandleside, Wayne Kerr.

Magnetic Material: Darwins, Marrison, Mullard, Murex, James Neill, Plessey, Salford, Swift Levick, Whiteley.

Audio Equipment:—The automatic trip mechanism in a record player can often be damaged if the pickup arm is moved too far away from the record. The possibility of such damage is, however, prevented by using a cam action for this trip in a new range of E.M.I. 4-speed record players. A finger-tip speed-change control is provided by using a larger knob than usual and placing its edge vertical and partially protruding through the base plate, instead of, as is more usual, horizontally above the base plate.





Above: Rola Celestion twin re-entrant loudspeaker.

Left: B.S.R. T.D.1 tape deck.

New tape decks were shown by Collaro and B.S.R., this being the first tape deck, as distinct from other audio equipment, that B.S.R. have made. The B.S.R. Monardeck T.D 1. is a single-speed ($3\frac{3}{4}$in/sec) device powered by a single motor. The record/replay head gap length is 2×10^{-4}in. The new Collaro deck uses a single pair of heads (unlike their other model). Three speeds are provided ($1\frac{7}{8}$, $3\frac{3}{4}$ and $7\frac{1}{2}$in/sec) and three motors are used.

In a new twin loudspeaker for relatively low-level public address purposes introduced by Rola Celestion two re-entrant horns placed back-to-back each load a corresponding loudspeaker cone. The two voice coils are placed at opposite sides of the same magnetic gap so that only a single magnet is needed. A slot along the bottom of each horn gives some downward sound radiation in addition to that to two sides from the horn mouths. The frequency response is from 375 to 8000c/s and the power-handling capacity 3 watts.

The problems of inhibiting cone break up and relieving stresses at the corners in rectangular "slot" speakers have been tackled by Rola Celestion in their 8 by $2\frac{3}{4}$in C28 model by means of two long strengthening protruberances in the cone covering most of the cone length on either side of the voice coil, and by making the rolls in the surround larger at the corners and across the breadth than along the length.

Several items shown also at the London Audio Fair are discussed in our review of that exhibition.

Manufacturers: — *Loudspeakers:* — Richard Allan; Electro-Acoustic Industries; E.M.I.; Goodmans; Plessey, Reproducers and Amplifiers; Rola Celestion; Truvox; Whiteley Electrical
Magnetic Tape:—E.M.I.; Minnesota Mining and Manufacturing.

Pickups and Microphones:—Ardente; B.S.R.; Collaro; Cosmocord; Electronic Reproducers (Components); Fortiphone; Garrard; Goldring; Lustraphone, S.T.C.; Technical Ceramics; Vitavox; Walter; Whiteley Electrical
Tape Recorders:—B.S.R.; Collaro; E.M.I.; Multimusic; Truvox; Walter; Wright and Weaire.
Turntables:—B.S.R.; Collaro; E.M.I.; Garrard; Goldring; Staar.

Test and Measuring Equipment:—In the Wayne-Kerr LT100 the resistance of a thermistor in a glass probe is measured using a Wheatstone bridge powered by a U2 battery. The thermistor resistance varies non-linearly with temperature. This normally results in a non-linear scale, but this is avoided in the Wayne-Kerr LT100 with the aid of compensating non-linear resistances in the form of Zener diodes. Temperatures from 0 to 100°C can be measured and leads to the probe up to 1000 ft long are available.

Two new multi-range meters were shown by Taylor. In the pocket-size 127A the maximum sensitivity is 20,000Ω/V on the d.c. ranges, and resistances up to 20MΩ can be measured (up to 200kΩ centre scale). A centre-pole meter with a f.s.d. of 40μA is used. In the Taylor 100A an 8μA f.s.d. centre-pole movement gives a maximum sensitivity on the d.c. ranges of 100,000Ω/V. All the d.c. and a.c. range scales are coincident except for the most sensitive a.c. range (10V f.s.d.). Another useful facility on this meter is a push-button for reversing the polarity.

A new a.m. signal generator covering frequencies from 2Mc/s to 225 Mc/s was shown by Avo (Type 378). The spurious f.m. is claimed to be particularly low on this instrument. This is achieved by means of a circuit in which non-linear crystal diodes are used to ensure that the a.m. occurs at a constant impedance.

Manufacturers:—Avo; British Physical Laboratories; Dawe; Labgear; Lion Electronic Developments; Measuring Instruments (Pullin); Siemens Edison Swan; Taylor; Wayne Kerr.

"Variable-μ" Magnetic Amplifier

System of Controlling Gain Giving a Versatile Circuit

By C. C. WHITEHEAD

MAGNETIC amplifiers at the present time are undergoing developments comparable with those of semiconductor amplifiers and the valve amplifiers of two or three decades ago. Each type of amplifier (valve, semiconductor or magnetic) has its advocates, who press for its application over as wide a field as possible. In truth these alternative forms of amplifier are, in various fields of application, both competitive and complementary.

Broadly speaking the magnetic amplifier scores over its rivals when the following conditions have to be met:—

1. Mechanical robustness. It is relatively free from maintenance troubles.
2. The ability to deal with large power in relatively small space.
3. The ability (given suitable design) to work under very unfavourable environmental conditions, e.g., wide variations of ambient temperature and pressure, dust, dirt, moisture, etc.
4. High overload capacity. In comparison with valve or semiconductor amplifiers of similar rating it has relatively enormous overload capacity.
5. It is capable of developing full gain with very low input impedance—especially useful in d.c. amplifier applications.

The magnetic amplifier is not, however, the most desirable choice when: (a) an extremely high input impedance is needed; (b) an extremely fast response (rise-time on a step-function input) is required.

The simplest form of magnetic amplifier is shown in Fig. 1, where L_S is an iron-cored choke in which air-gaps have been reduced to the absolute minimum and the core material has a closed circuit, of, as far as possible, uniform cross-section throughout normal to the magnetic flux. These features ensure that the core is relatively easily and fully saturated. The special oblique line symbol indicates this type of core. An additional winding is for convenience provided to carry the control current (d.c.) to saturate the core. Specially developed magnetic alloys (such as HCR, Deltamax, Orthonol, in which the optimum combination of permeability and saturation flux density have been achieved) enhance the performance.

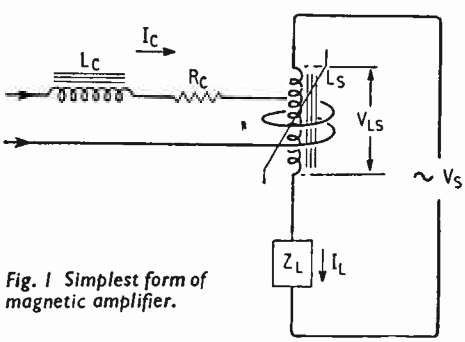


Fig. 1 Simplest form of magnetic amplifier.

The degree of saturation of the choke is dependent upon both the a.c. supply voltage and the d.c. control current. If the supply voltage (V_S) is constant, and the impedance of L_S is decreased due to saturation by the control current (I_C) ampere-turns, the voltage across the choke (V_{LS}) decreases owing to the voltage drop in the load impedance (Z_L). So consequently does the degree of saturation of the core, necessitating a larger value of control current to obtain a given degree of saturation.

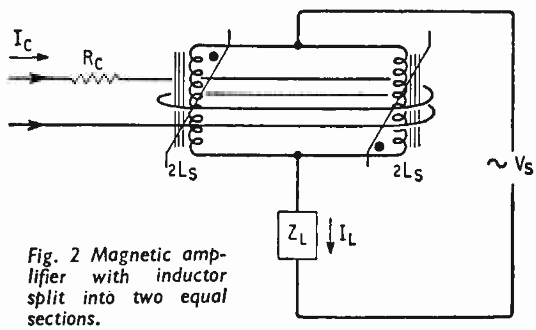


Fig. 2 Magnetic amplifier with inductor split into two equal sections.

The current-gain of this amplifier (see Appendix) is defined as

$$\frac{\text{Change of load current}}{\text{Change of control current}} = \frac{dI_L}{dI_C}$$

The self-limiting action just described is quite analogous to that of the valve cathode follower. There is a high degree of inherent negative current feedback, with the result that control ampere-turns (N_CI_C, see Appendix) and load ampere-turns (N_LI_L, see Appendix) are always equal, a univeral characteristic of basic non-feedback magnetic amplifiers. The power-gain of the amplifier (see Appendix) is easily seen to be $\frac{dI_L{}^2R_L}{dI_C{}^2R_C}$ where R_L and R_C are the load and control circuit resistances respectively. Modest power gains of the order of 10 to 20 (20 to 26 dB) are commonly attained. That is to say, the current gain is usually in the region of $\sqrt{10}$ to $\sqrt{20}$.

This simple amplifier has other disadvantages besides that of relatively low gain. A considerable voltage at the supply frequency is induced in the control winding. If we make $N_C > N_L$ in order to enhance the current gain (which, as in the case of a transformer, is simply N_C/N_L) the induced voltage into the control winding may be very high indeed, and especially so since, owing to saturation, the load-current waveform is non-sinusoidal. The power fed back into the control circuit is abstracted from that delivered to the load, and if the source of control

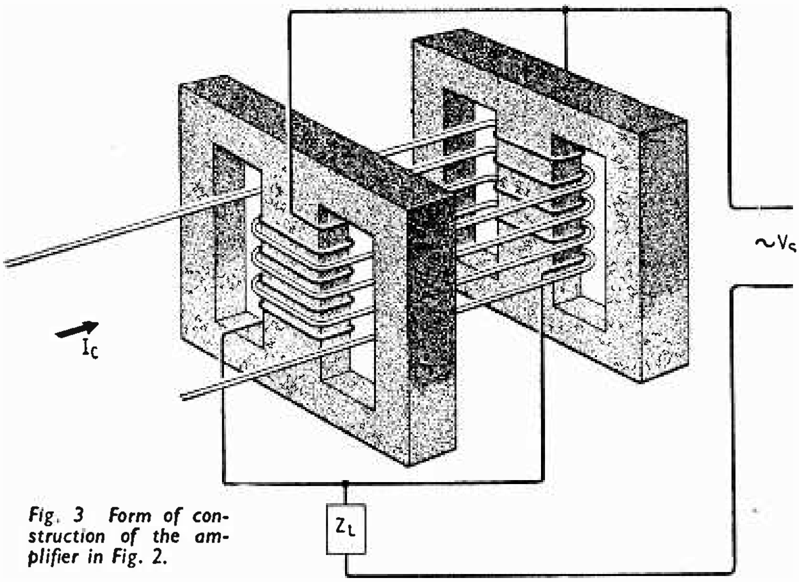


Fig. 3 Form of construction of the amplifier in Fig. 2.

current has a low impedance, the control winding acts as a short circuited turn, rendering the device inoperative. Consequently in cases where this form of amplifier is used, a choke (L_C) is included in the control circuit to block the induced current. This makes the device practicable, but the resistance of L_C in the control circuit further reduces the available power gain.

Consequently the next step in development was to split the choke into two equal sections, each carrying also half of the control winding. The sense of the windings (conventionally indicated by a dot showing the start of a winding, all windings being assumed to be wound in the same direction) is so arranged that the induced voltages in each half of the control winding are in opposition. Our amplifier can then take the form of Fig. 2. This is usually constructed as shown in Fig. 3, with a single control winding embracing both cores, the direction of the fundamental supply frequency flux in the two cores being in opposition in relation to the control winding. The Output (I_L)/Control (I_C) characteristic of this device (usually termed a transductor, see Appendix) takes the form of Fig. 4.

This arrangement allows us to do a trick in the way of providing *positive* feedback to offset the inherent negative feedback discussed above. If we instal a pair of rectifiers, as shown in Fig. 5(a), we get the characteristic as shown in Fig. 5(b). A transformer or transductor requires a certain value of current drawn from the supply to maintain the flux, and this results in a minimum value of load current, shown in Figs. 4 and 5(b) as I_0. This is usually (in a good design) less than 5% of the average load current.

In the amplifier without feedback this value of load current (I_0) flows when the control current (I_0) is zero, and the two branches of the characteristic are symmetrical about $I_C=0$.

Fig. 5(b) presents a very different picture. Here I_L at $I_C=0$ has risen to a high value, and I_0 has been displaced to the region of negative (reversed) I_C. What has happened is that I_0 (a.c.), flowing through each rectifier on alternate half-cycles of the supply, has produced a pulsating d.c. current (I_{fb}, see Appendix) flowing in the closed loop around the load windings as shown, tending to saturate the cores, and so producing a high value of I_L at $I_C=0$. This feedback current is seen to be strictly proportional to the load current, so that over the region of the right-hand branch of the characteristic, where the control and feedback currents are acting in the same sense in the individual cores in the appropriate half-cycles, the slope of the I_L/I_C characteristic (and therefore the current gain) is greatly increased. Over the region of the left-hand branch, where I_C and I_{fb} are acting in opposition, the slope of the characteristic is correspondingly reduced.

In order to make use of this increased gain, another winding (the so-called bias winding) is for convenience provided, in order to set the working point, where $I_C=0$, at a convenient part of the characteristic.

In passing, the curious resemblance between the characteristic of Fig. 5(b) and that of the I_a/V curve of a triode valve will be noted, and, in fact, with a high degree of feedback such as is usually attained in an amplifier of this type, it is possible to operate the amplifier in modes analogous with the Class A, Class B or Class C of the valve amplifier. In Fig. 5(a) the analogue of Class A operation is shown, where $I_{L mean}=\frac{1}{2}I_{L max}$.

Consider now Fig. 6. If $N_L=N_C$ we have at all times that $I_L=I_C$, $dI_L/dI_C=1$ and the slope of the characteristic is $45°=\theta_0$ *when there is no feedback* (i.e. when the rectifiers are omitted or are inoperative). *With feedback* (i.e. the rectifiers are operative) the right-hand branch of the characteristic subtends an angle θ_1 and the left-hand branch subtends an

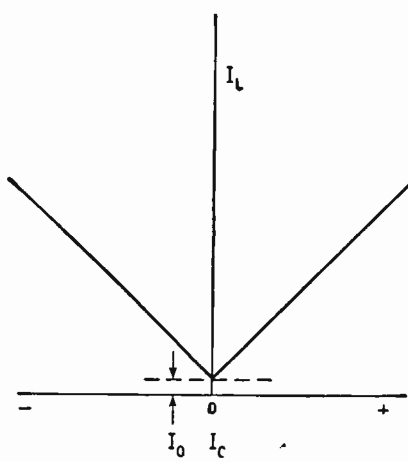


Fig. 4 The output-current/control-current characteristics of the amplifier in Figs. 2 and 3.

angle θ_2 with the abscissa. If we assume a "feedback factor" due to the rectifiers, which factor we will call β, we find that

$$\theta_1 = \tan^{-1} \frac{1}{1-\beta}$$

$$\text{and } \theta_2 = \tan^{-1} \frac{1}{1+\beta}$$

which define the increase and reduction of slope respectively. Bearing in mind that normally we use only the right-hand branch of the characteristic, the relationship between the current gain of the amplifier without feedback (A_0) and with feedback (A') is simply

$$A' \frac{A_0}{1-\beta}$$

and the change in current gain due to the action of the rectifiers is $1/(1-\beta)$. In accordance with convention this change in gain may be expressed in "decibel" terms as $10 \log_{10} A'/A_0$ or $10 \log_{10} 1/(1-\beta)$.

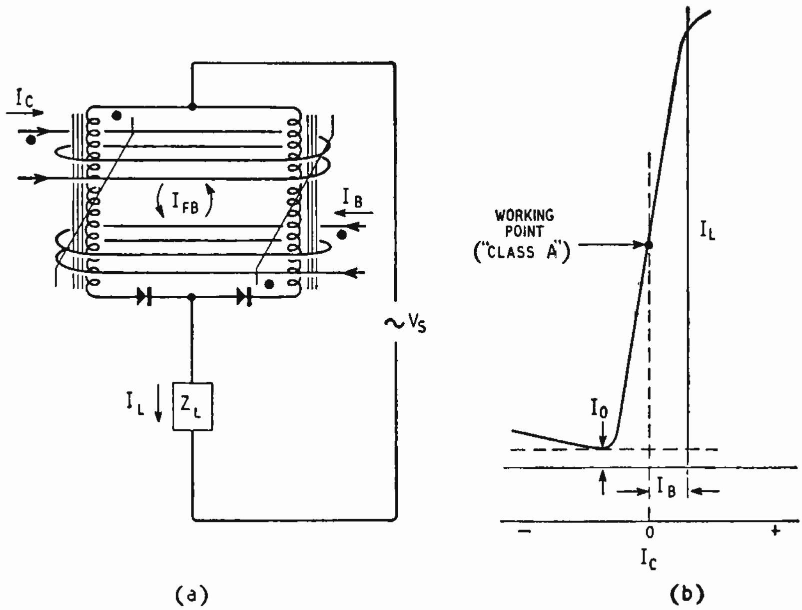


Fig. 5 (a) Magnetic amplifier with rectifiers to give positive feedback, and (b) the characteristic obtained.

It generally happens that in usual designs β seldom lies outside the limits 0.94 and 0.99. Therefore we can tabulate the change in gain due to the use of the rectifiers as follows:—

β	A'/A_0	dB
0.94	16.7	12.25
0.95	20.0	13.0
0.96	25.0	14.0
0.97	33.3	15.25
0.98	50.0	17.0
0.99	100.0	20.0

As a simple numerical example, let us assume a transductor assembly with a normal power gain (without rectifiers) of 20. This means a current gain of $\sqrt{20}$ or 4.45. If we now install rectifiers giving a feedback factor of say 95% (0.95), we cause two things to happen:—

1. We cause I_0 (which we have neglected in the immediate discussion above) at $I_C = 0$ to increase to 20 I_0.

2. We cause the current gain to change from 4.45 (6.5 dB) to 89 (19.5 dB), a change of 13 dB.

If we can arrange to control, continuously, the effectiveness of the rectifiers, we have a means of controlling the inherent gain of the amplifier from A_0 to A', which range of control is dependent basically upon the value of β, as tabulated above. This can conveniently be done as indicated in Fig. 7, where Z'_C is a variable impedance (or resistance) shunting the rectifiers. Owing to the fact that it is not usually convenient to make Z_C' large in comparison with the reverse resistance of the rectifiers, the full range of control of gain indicated in the table is not attained, but something pretty close to it (generally within 1 dB) can be realized.

The writer has succumbed to the temptation to call this device a "variable-μ" amplifier for the following reasons. The "variable-μ" valve is made by using a grid structure of variable pitch. As the static bias on this grid is increased in the negative sense, the fine-pitch (high-μ) portion of the grid, by shutting off the anode current *from the underlying portion of the cathode*, becomes ineffective, whilst the coarse-pitch (low-μ) portion of the grid remains effective. Notice that two things are happening here:—

1. There is a change in μ, defined as dV_a/dV_g (I_a constant), due to the change from a grid of high μ to one of low μ.

2. There is a change in the mutual conductance (g_m), defined as dI_a/dV_g (V_a constant), due to the reduction in effective cathode area.

Which of these two effects is the more important

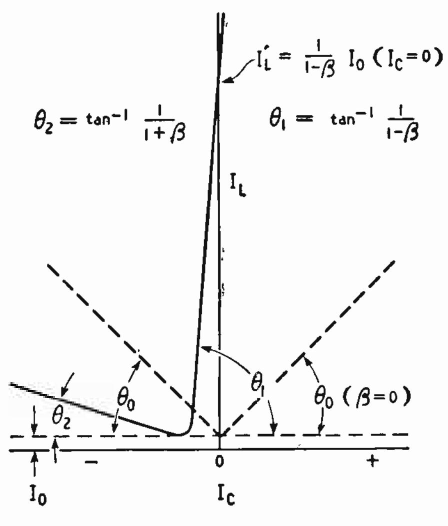


Fig. 6 Comparison of amplifier characteristics with feedback (full line) and without feedback (broken line).

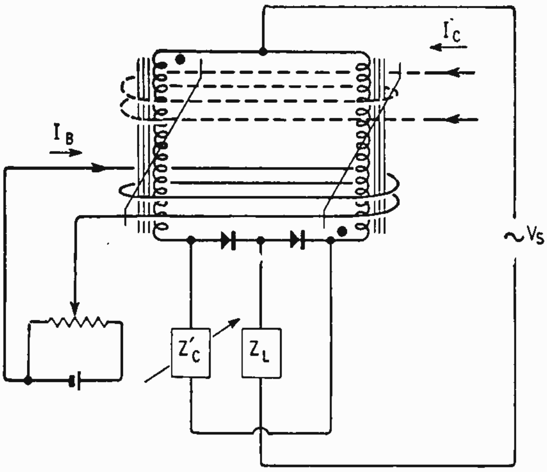


Fig. 7 Method of controlling the effectiveness of the rectifiers to get variable gain.

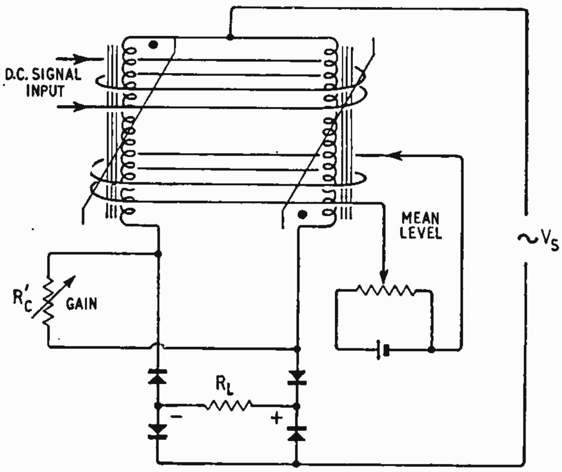


Fig. 8 A d.c. amplifier, with control of gain and mean level of output.

depends upon whether, corresponding with 1 and 2 above,

1. Z_L (the load impedance) is much higher in value than the valve internal resistance (R_a) and the valve is operating as a constant-voltage generator.
2. Z_L is much lower in value than R_a, and the valve is operating as a constant-current generator.

Since practically all variable-μ valves are tetrodes or pentodes, operating under condition 2, the change in mutual conductance is the more important effect by far. The term "variable μ" is therefore (as other writers have pointed out) a misnomer, but sticks by reason of custom and convenience. "Variable-mutual-conductance," "variable-g_m" or "variable-perveance" (American) do not trip off the tongue so easily. "Variable μ" valves have the following characteristics—

$$dI_a/dV = k.V_g \text{ if } Z_L << R_a$$

In the magnetic amplifier under discussion,

$$dI_L/dZ_C = k.Z_C \text{ if } Z_L << Z_i$$

where Z_i is the internal impedance of the amplifier. This establishes an analogy. The validity of the term "variable μ" *as generally understood* falls

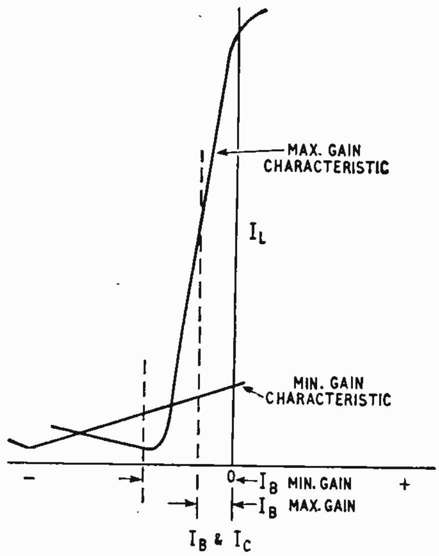


Fig. 9 Biasing point can be fixed for both high- and low-gain characteristics or varied to obtain greater signal handling capacity at low gain.

down in both cases if $Z_L >> R_a$ or Z_i, and is only truly applicable *in the classical sense* in the case of the valve amplifier if $Z_L >> R_a$, a condition which rarely obtains in practice.

The amplifier of Fig. 7 has another interesting attribute. It may be controlled by means of Z'_C alone. As Fig. 6 shows, if bias and control windings are omitted, variation of Z'_C causes I_L to vary between the limits I_0 and $(1/1\text{-}\beta)I_0$. No source of control current is needed. The amplifier in effect provides its own control current. This is sometimes very convenient. In the conditions of either maximum or minimum output (or gain, when Z'_C is used as a gain control) the amount of power dissipated in Z'_C is negligible, and is never greater than the amount of power dissipated in a control winding having the same resistance and number of turns as the control windings in series, for any given level of output power. The writer, for want of a better name, has dubbed this an "impedance-controlled amplifier." He will be grateful if any reader can think of a better term.

Fig. 7 also indicates an amplifier with a normal control winding and a bias winding, Z'_C then being used to control the gain, in "variable-μ" fashion. This can be done over a number of stages by the use of ganged variable resistances for the Z'_C's.

Fig. 8 shows an amplifier—a "d.c." amplifier in which the mean output level is set by means of the current in a bias winding, whilst the gain is controlled in the way already described. "Complementary" rectifiers are used to obtain a d.c. output.

There is one interesting difference between the magnetic amplifier and its valve counterpart, a difference in favour of the former. In the variable-μ valve amplifier the "undistorted" signal-handling capacity of the amplifier is reduced at low values of controlled gain. This is often inconvenient, since low values of gain are often required with large signals, and vice versa. In the case of the "variable μ" magnetic amplifier the signal-handling capacity is restricted with increase of gain and vice versa. In the case of the valve amplifier, nothing can be done about this restriction in signal-handling capacity, since both the signal and the bias are operating upon the same electrode. In the magnetic amplifier separate "electrodes" (windings) are used, and it is possible, as Fig. 9 shows, either to work with a constant bias current, giving the same signal-handling capacity at both high and low gain, or to vary the bias in accordance with the input signal, by means of a circuit such as that shown in Fig. 10, in order to obtain greater signal-handling capacity at low gain setting. In this figure, an auxiliary bias winding is supplied with current derived from the load voltage, and acting in opposition to the normal bias current, reducing the effective bias as the gain is increased. This could of course also be done by means of the manually-controlled scheme of Fig. 11, which will usually be preferred.

One very useful feature of the d.c.-controlled magnetic amplifier is that any number of control windings of similar or differing current-gain values may be used, up to the limit that it is physically possible to install, and that there is no interaction between them. They may of course be connected to signal sources at widely different mean potentials, floating or earthed. Consequently such an amplifier is a useful computer component for algebraic addition, since

$$I_L = I_0 + (k_1 I_1 + k_2 I_2 + k_3 I_3 \dots \text{etc.})$$

where k_1, k_2 etc. are the current-gain factors of the control windings, and I_1 I_2 etc. the corresponding control currents. If in addition we have the "variable-μ" feature we have

$$I_L = K (I_0 + k_1 I_1 + k_2 I_2 + k_3 I_3 \dots \text{etc.})$$

where K is the controlled "variable-μ" gain, multiplying a number of algebraically added quantities by a common factor. "Circuitwise," as the Americans say, I_0 can be eliminated in the output, one obvious method being by using a push-pull stage. This use of the amplifier is indicated in Fig. 12.

Finally, in Fig. 13, the results of an experiment upon a stage in which no attempt had been made to optimise the performance in any way, are shown. The various quantities are in linear units. Several interesting things appear. The current gain and power gain are roughly linear over the full range of R'_C. The voltage-gain behaves in a peculiar manner, being linear over the first 5% of R'_C and constant over the upper 50%. The load resistance was of the optimum value, which for optimum efficiency is, as in the case of a triode valve, equal to V_S/I_{Lmax}. There is, it will be noted in this case, a *classical* "variable-μ" action over a small portion of the characteristic, but this is not of much practical importance since it amounts only to some 6 dB in range, whilst the whole of the variable-gain region amounts to roughly 14 dB.

The range of variable current gain obtainable with this type of amplifier per stage (about 20 dB as a maximum) does not seem impressive when compared with the 25-30 dB change obtainable with the variable-μ valve amplifier, but it is fully adequate for the great majority of applications. Most amplifiers

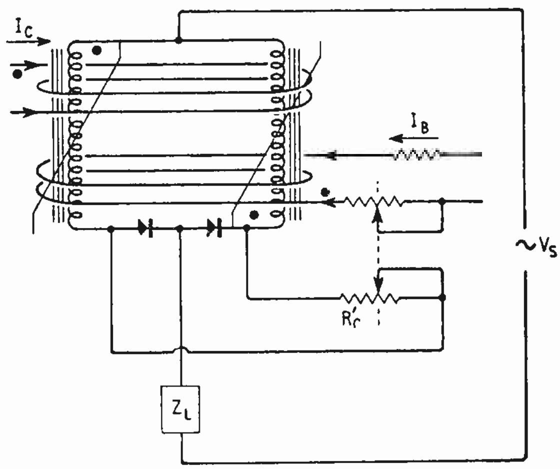


Fig. 11 Ganged manual control of bias and gain.

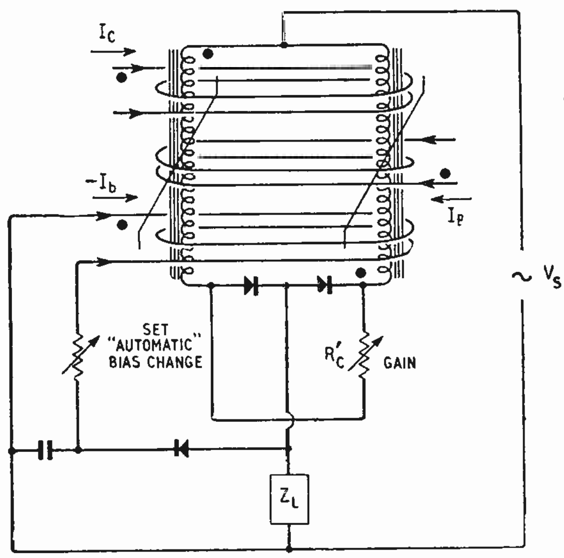


Fig. 10 Amplifier with auxiliary bias winding to give automatic bias setting with varying gain.

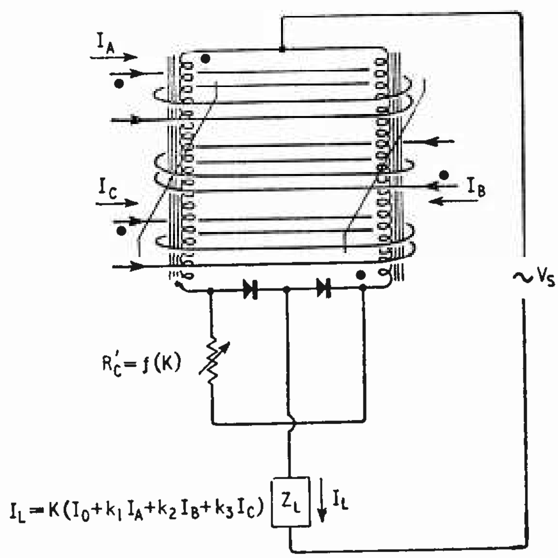


Fig. 12 Magnetic amplifier used as a multiplier or an adder.

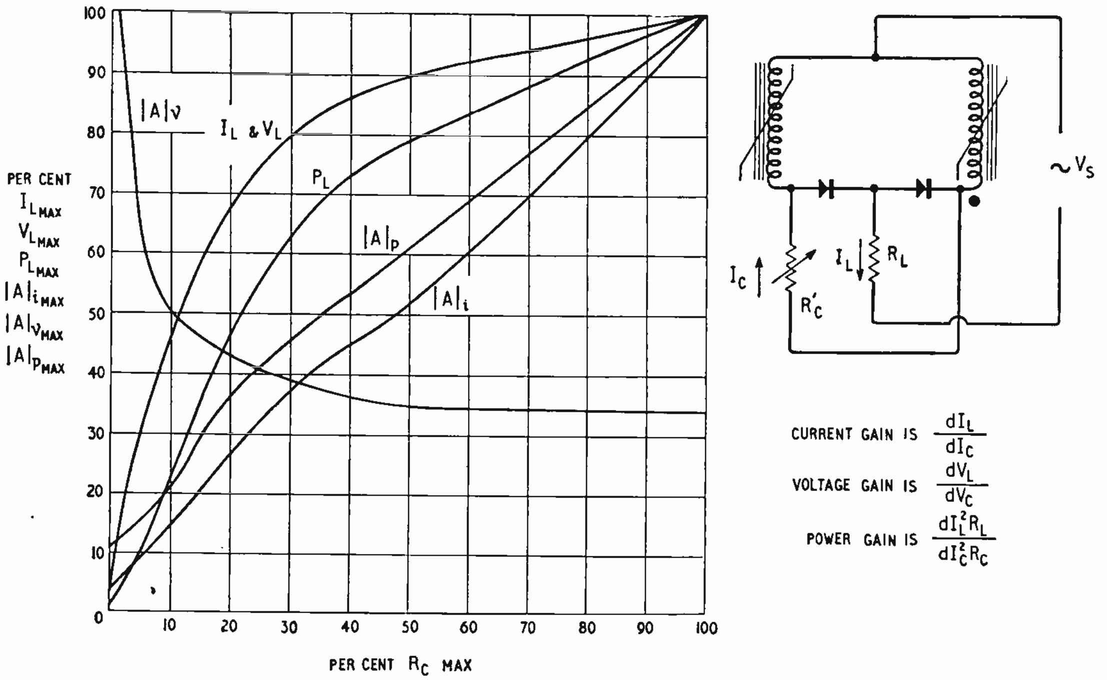


Fig. 13 Characteristics of the amplifier on the right with different settings of the gain control R'_C. I_L = load current, V_L = load voltage, P_L = load power, $|A|_i$ = current gain, $|A|_v$ = voltage gain, $|A|_p$ = power gain.

of this type, if properly designed, will be working with a β of about 96%, which after allowing for the limitation in range of Z'_C, will give a variable-gain (current) range of about 13-14 dB per stage. The numerical example given earlier corresponds closely with the results obtained with an experimental amplifier built by the writer.

To conclude, the writer would like to acknowledge his indebtedness to his colleagues for technical assistance and constructive criticism.

APPENDIX

Nomenclature, explanations and definitions

N_L: number of turns in series in the load circuit winding(s).

N_C: number of turns in series in the control circuit winding(s).

I_L: current (average a.c., or if rectified, d.c.) flowing in the load circuit.

I_C: current (d.c.) flowing in the control circuit.

I_b: current (d.c.) flowing in the bias winding. (N_b, the number of turns in series in the bias winding, is not mentioned in the text, as it is not necessary for purposes of explanation.)

R_L, Z_L: resistance, impedance in the load circuit, exclusive of the resistance or impedance of the load windings of the transductor.

R_C: resistance in the control circuit, exclusive of the resistance of the control windings of the transductor.

R'_C, Z'_C: value of the gain-control resistance or impedance.

L_S: effective series inductance of the transductor in the load circuit.

L_C: choke inductance used in control circuit of single-core magnetic amplifier stage.

β: the "feedback factor" due to the use of rectifiers. (In practice, generally lies within the limits 94-99%.)

I_{fb}: mean value of (pulsating d.c.) current flowing in series with the load windings and "feedback" rectifiers.

Current-gain: by definition, dI_L/dI_C, and by analogy with customary (though incorrect) practice in the case of the valve amplifier, where the voltage gain is defined as (in dB terms) $10 \log_{10} V_{out}/V_{in}$, we define the current-gain as $10 \log_{10} I_L/I_C$. This also gives ½ the power gain, if R_C and R_L are equal.

Power-gain: by definition $\dfrac{\text{change of power in load}}{\text{change of power in control current source resistance.}}$

$=dI_L^2R_L/dI_C^2R_C$.

Voltage-gain: by definition $dV_L/dV_C=dI_LR_L/dI_CR_C$ and is not used in the text, because the magnetic amplifier is normally used as a current amplifier.

A_0: the basic current-gain of the amplifier, as above defined, when $\beta=0$.

A': the enhanced current-gain of the amplifier, when rectifiers are used, $A' = A_0/(1 - \beta)$

V_S: the supply voltage (a.c.).

V_{LS}: the voltage drop in the load circuit across the choke or transductor due to the load current.

V_L: voltage across the load, average a.c. or (rectified) d.c.

I_0: the magnetizing current (a.c.) of the transductor or choke. Defines the minimum load current, unless special arrangements are made.

Transductor: term used to connote the core-and-windings assembly used in magnetic amplifiers. If of single-core type (as Fig. 1 in the text) it would be referred to as a "saturable reactor."

All gains are given in terms of current gain. Rough indications of power gains are obtained by squaring the linear values, or doubling the dB values. The purist will object (and rightly) that this is only correct if we assume that input and output impedances are equal, but for changes in gain the objection does not apply.

London Audio Fair

NEW EQUIPMENT FOR SOUND REPRODUCTION

UNFORTUNATELY space does not permit a description of all the new products shown at this year's Fair but a selection of those thought to be of more than usual interest is given in this review. While the main emphasis was on stereo, considering audio equipment generally, the most obvious changes were in a field partly outside stereo, that of tape recording.

Tape Recording and Reproduction.—The many new tape recorders shown included two by Trix, a company whose products have previously been in other fields of audio. The "Everest" is a two-speed ($3\frac{3}{4}$ and $7\frac{1}{2}$ in/sec) model with a specified frequency range of 30-12,000c/s $\pm$3dB at $7\frac{1}{2}$ in/sec and a signal/noise ratio of 60dB. The "Companion" is a single speed ($3\frac{3}{4}$ in/sec) portable, weighing only 21lb which incorporates the recently introduced B.S.R. "Monardeck" tape mechanism.

In the Tandberg Model 5 shown by the Harting-Tandberg group the track width has been reduced sufficiently to accommodate four instead of the usual two tracks on normal width tape. This model can reproduce tapes in which the four tracks are divided into two staggered stereophonic pairs; alternatively, erasure, recording and replay of the tracks one at a time is possible.

A considerably lower crosstalk figure is required for satisfactory recording and reproduction of independent rather than stereo signals, since the difference between the levels of the wanted and unwanted signals is likely to be greater with independent signals, and the unwanted signal tends to be more noticeable when it is quite different from the wanted signal. A sufficiently low crosstalk figure in the region of -50dB or better is claimed for the Tandberg stereo Model 5 for four tracks, and for two-track stereo models shown by Reflectograph (Model 570) and Grundig (TK55).

The reproducing head magnetic gap length is now very frequently made as short as about 10^{-4}in so as to reduce the speed required to give a high-frequency response up to the region of the highest audible frequencies from $7\frac{1}{2}$ to $3\frac{3}{4}$ in/sec. Unless care is taken in the design of the tape transport mechanism, wow and flutter are now likely to be the factors limiting quality when halving the speed from $7\frac{1}{2}$ to $3\frac{3}{4}$in/sec. However, several of the new recorders claim acceptable total wow and flutter figures of about 0.25% at $3\frac{3}{4}$in/sec.

A speed as slow at $1\frac{5}{8}$in/sec is provided on the new Stuzzi "Tricorder". At $1\frac{7}{8}$in/sec, the next higher of the three speeds available, the response is stated to be 3dB down only at 8kc/s and the wow and flutter only 0.3% r.m.s. Up to $5\frac{3}{4}$-in diameter reels can be handled and space for an extra head and amplifier is provided. For office use, stethoscope type headphones for taking dictation from the recorder and an adaptor for recording telephone conversations are available. Remote control facilities are also provided.

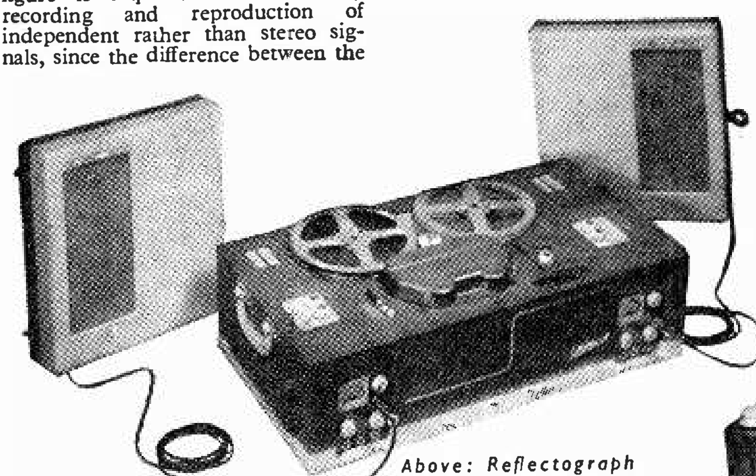
Independent level adjustment and mixing facilities for two or more channels are now fairly often incorporated into tape recorders. The use of d.c. to heat the filaments of valves amplifying low-level signals, so as to reduce the hum level, was also noted in several cases. No pressure pads are used in a number of the newer models (notably throughout the Telefunken range) and one possible source of head wear is thus avoided.

Tape tension is made more constant in the Telefunken M85 series by using a spring-loaded finger on which the tape bears. As the angle formed by the tape at the finger alters with the amount of tape on the reel, the component along the tape of the force due to the spring alters so as to reduce changes in the tape tension.

American Ampex professional tape recorders, including their tape duplicator series S-3200C for copying $3\frac{3}{4}$in/sec or $7\frac{1}{2}$in/sec master tapes at a speed of 30 or 60in/sec, are now available in this country from Rank Cintel.

Special features of a small studio recorder shown by Telefunken (M23) include 4-channel mixing facilities, a recording level meter calibrated in dB, and alternative type of plug-in head assembly which can be located accurately enough to avoid the need for additional azimuth adjustment. A smooth fade-in on pre-existing recordings is automatically obtained by bringing the tape gradually into contact with the erase and recording heads.

Reflectograph were brave enough to demonstrate stereo recording as well as subsequent reproduction. Two ribbon microphones, spaced about three feet apart and angled slightly outwards and downwards, were placed about a foot above an accordionist who moved about in



Above: Reflectograph stereo recorder with the two halves of the lid containing the monitor loudspeakers detached.

Right: Tandberg Model 5 four-track reproducer with add-on unit for stereo recording on the left.

front of the microphones while playing. The size of the room was only about 10ft by 12ft, but the experiment was completely successful.

Two transistorized recorders were seen. One of these, the Stuzzi Magnette, has already been described in *Wireless World* (June 1958, p. 276). The other is the Fi-Cord whose size is only 9⅝in × 5in × 2⅝in and which weighs only 4¼lb This recorder is unusual in that the ratio of the two available speeds of 7½ and 1⅞in/sec is four rather than the almost universal two to one. Four special miniature 2-V accumulators are used, and a charger is supplied. A high-frequency transistor oscillator supplies the erase and bias voltages and also the h.t. for the valve level indicator.

Tape of half the standard thickness giving double the playing time of standard tape for the same reel size or 33⅓% more playing time than long-playing tape of two thirds of the standard thickness, was introduced by E.M.I., B.A.S.F., M.S.S. and M.M.M. (Scotch Boy). A p.v.c. base chemically similar to that generally used for standard thickness tape was used by B.A.S.F., whereas M.S.S. and M.M.M. (Scotch Boy) used a polyester base.

Pickups.—An unusual mechanical arrangement seen in the Goldring 700 variable-reluctance stereo pickup uses a cantilever pivoted about its middle rather than one end. This enables the two sets of magnetic gaps to be placed one at each end of the cantilever rather than both at one end. By thus separating the gaps crosstalk problems are reduced. The lateral and vertical compliances are both 4×10^{-6}cm/dyne and the effective mass at the stylus tip is 8mgm.

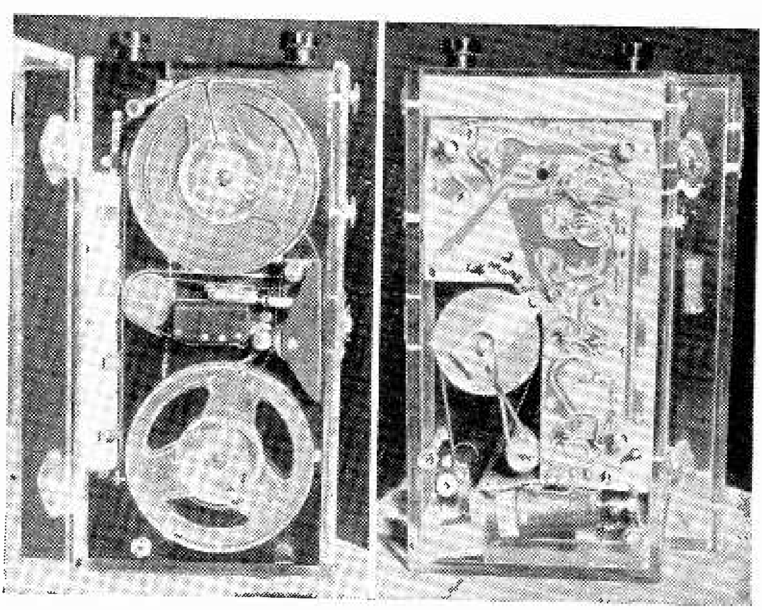
In the Connoisseur crystal stereo pickup, by using two very small (0.25in × 0.06in × 0.025in) ceramic crystals and partially de-coupling the crystal assembly from the stylus in the usual way by means of a rigid cantilever, the effective stylus tip mass has been reduced sufficiently to raise the resonance between this mass and the record groove wall compliance up to about 18kc/s.

An effective stylus tip mass of only 0.6mgm has been achieved in a new Cosmocord mono crystal cartridge. An unusual feature of this cartridge is that the compliance of 12×10^{-6} cm/dyne is provided in the cantilever itself which is not rigid This cartridge was mounted in a specially balanced arm whose static side thrust and vertical frictional forces are equivalent to only 0.02 and 0.05gm respectively The arm is little affected by external vibrations. The design of the pickup has already been described in *Wireless World* (April issue, p. 182) and the design of the arm will be described in a forthcoming issue.

A modification of Cecil Watts' "Dust Bug" which can be clipped on to most pickup arms and which is recommended for use with record changers was shown by Cosmocord. A downward-bearing spring counteracts the weight of the "Dust Bug", whose tracking angle can be adjusted. The decrease in stylus and record wear resulting from the removal of dirt in the grooves more than compensates for any harmful effects due to an increase in the side thrust caused by friction between the "Dust Bug" and the record.

Radio Tuners.—An impressive specification is quoted for the Avantic combined v.h.f./f.m. and medium wave a.m. tuner type BM612. For f.m. reception two i.f. stages and two limiters precede the Foster-Seeley discriminator to give a sensitivity of 2μV for an a.m./f.m. rejection ratio of 50dB. A.f.c. is provided, and the extent of this can be varied to avoid the "capture" by strong stations of neighbouring weak stations whose reception may be desired. Inter-station noise suppression to a variable extent is available with both a.m. and f.m. reception. The a.m. selectivity is ±4.5kc/s for a 6dB loss in output.

Top (left) and bottom (right) views of the Fi-Cord transistorized tape recorder in a special transparent cover.



Pre-amplifiers and Amplifiers.—A stereo balance control range of up to about ±4dB is now frequently provided. Such a control can be simply obtained by connecting the fixed ends of a single potentiometer at similar points in each of the two amplifiers. The connections must be made where the movable contact on the potentiometer will be earthed (so that crosstalk is eliminated) and also, of course, where the resistances in the potentiometer can influence the gain. As the balance control potentiometer is altered, the gain of one channel is increased while that of the other is reduced. If the average gain is arranged to remain the same, readjustment of the level control will probably be unnecessary.

Ganged pairs of switched precision resistors were used instead of ganged potentiometers for the level control in the Rogers HG88 and Jason J4-4 amplifiers so as to reduce variations in the balance as the level is altered.

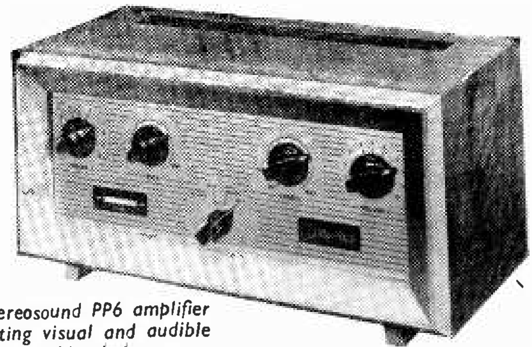
Very comprehensive facilities for checking balance are provided in the Stereosound PP6 amplifier. The balance between the two amplifiers and pre-amplifiers can be checked by feeding 100c/s ripple from the h.t. before smoothing to both inputs in parallel. The outputs from the two amplifiers are sampled at special tertiary windings on the output transformer, backed off against each other, and fed to a valve tuning indicator. Maximum separation of the illuminated portions of the indicator shows zero input, and thus correct balance of the amplifier. The balance of the whole system, including loudspeakers, can be aurally checked using an internally generated approximately sawtooth oscillation. This oscillation also is fed equally to both inputs in parallel, and the balance control adjusted until the metronome-like sound appears to come from mid-way between the two loudspeakers.

Two types of channel switching are frequently offered: the two signals can be interchanged between the two reproducing systems and the phase of one of the two signals can be reversed.

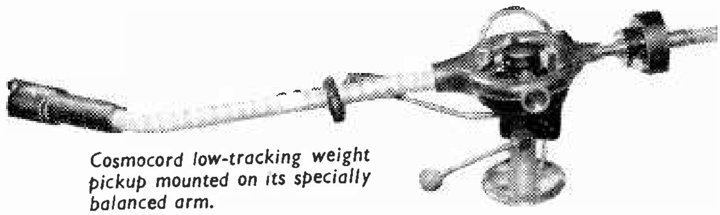
Although Lowther have shown low-level transistor amplifying stages for some time as separate units, such

Right: Goodmans Triaxiom 12/20 loudspeaker with crossover unit mounted on the magnet.

Wharfedale Coaxial 12 loudspeaker with tweeter level control.



Right: Stereosound PP6 amplifier incorporating visual and audible methods of checking balance.



Cosmocord low-tracking weight pickup mounted on its specially balanced arm.

stages are only now being incorporated into complete pre-amplifiers. Examples were shown by Lowther and Sound Sales (A-Z). Steep-cut low-pass filters in which the cut-off point can be continuously varied were noticed in the Lowther control units and Rogers HG88 amplifier.

Mixing units using valves are already available from several manufacturers, and a simple high-impedance resistive unit can now be supplied by T.S.L.

Those who like to "roll their own" will be pleased by the appearance of several stereo amplifier kits such as those shown in the Audio Fair by Altobass and Jason, for example. For amplifying the signals from pickups on musical instruments such as the guitar, the 10-watt Valencia made by Grampian combines amplifier and loudspeaker in a single baffle/cabinet with readily accessible tone controls.

Loudspeakers and Cabinets.—An interesting system of mounting was shown by Rogers in their 1284 3-speaker system. The 8-in and 12-in low-frequency speakers are connected in parallel and mounted at the top and bottom respectively of a column shaped cabinet 37in × 15in × 14in. The 12-in speaker faces a normal circular opening (equal to the effective cone size) in the bottom of the cabinet. The 12-in speaker is, however, spaced 1½in from its opening so that this space forms a reflex port for the radiation from the rear of the speakers. The opening in the bottom of the cabinet is filled with a layer of foam plastic ¾in thick so as to add resistive loadings to both the front of the 12-in speaker and the port. The foam plastic also prevents all frequencies above about 200c/s from being radiated from the bottom of the cabinet, thus producing a crossover effect between the two bass speakers. The foam plastic layer furthermore tends to act as a secondary diaphragm. This arrangement is claimed to result in damping of both the normal resonances of a reflex cabinet, and also lowering of their frequency by a factor of about 1.4 down to about 75c/s and 35c/s.

The analogue computer for investigating the effect of various parameters (including resistive loading in various places) on both the steady and transient response from reflex loudspeaker cabinets which was described in our April issue (p. 162) was shown by Ekco.

Two methods of avoiding cabinet wall resonances used by Wharfedale in their new speaker systems are the inclusion of ¾in polystyrene panels mechanically strengthened on both sides by a thin skin of plywood in their PST/8, and the gluing and battening of ceramic tiles in critical positions in their W3 and W4 cabinets.

In small cabinets, for an inward cone excursion the temporary increase in the air pressure inside the cabinet may be considerable over an appreciable range of frequencies. If this causes the surround to balloon outwards, not only is the tension exerted by the surround on the cone increased and more non-linear distortion thereby produced, but furthermore, the sound from the surround will be out of phase with that from the rest of the cone and some cancellation will occur. For this reason a more rigid than normal surround must be used for speakers in small cabinets. A single half-wave corrugation of rubber-treated resin-impregnated fabric forms the surround for the Wharfedale WLS/12 which has been specially developed for sole use in their relatively small W2, W3 and W4 reflex systems.

New coaxial speakers were shown by Goodmans and Wharfedale. Two concentric magnetic gaps with completely separate cones are used in the Wharfedale Coaxial 12. The angle of the 2-in diameter inner tweeter is only about 80 degrees. This tweeter is fitted with an inner aluminium dome and the total weight of its moving parts is only 1gm. The Goodmans Triaxiom 12/20 actually has three cones. The outer two are mechanically connected in the usual way so that at higher frequencies where the radiation from the large outer cone falls off because of its weight the lighter inner cone takes over and tends to move by itself to prevent any overall loss in output. The innermost tweeter magnet and cone are completely separate. The cone is loaded by a horn of elliptical cross-section so that dispersion is wider in a plane parallel to the breadth of this ellipse than in a plane parallel to the length.

A number of modifications have been made to the well-known Tannoy dual concentric coaxial loudspeaker. The useful flux in the gap for the low-frequency outer cone has been increased by about 20% by reducing the overall magnetic reluctance by partially shunting the gap for the high-frequency inner diaphragm at the rear of the magnet. This shunt is made so thin that it becomes magnetically saturated. The field in the high-frequency gap, which is limited by magnetic saturation at the pole pieces, thus remains unchanged. The rear of the high-frequency diaphragm is now damped by a small cavity with a hole in it which is filled with acoustically resistive material.

LETTERS TO THE EDITOR

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

Evaluating Aerial Performance

MR. C. F. WHITBREAD'S letter in the April issue raises two points which could usefully be further discussed. These are (a) the extent of the validity of my approximations, and (b) the practice of feeding a receiving aerial into a matched load although considerations of noise-factor dictate a mismatch. Matching is, I believe, standard commercial practice and mainly justified by the fact that the bandwidth of many commercial aerials would not be adequate without it.

Bandwidth as defined in my article is a property of the aerial only and takes no account of what is done between the aerial terminals and the grid of the first valve in the receiver. Use of a matched load should tend to double the bandwidths given by my formula.

Generally speaking I would say that if the bandwidth given by the formula is less than the required system-bandwidth one or other of a number of undesirable consequences tend to follow, such as the necessity of a matched load, or the various effects listed in my discussion of standing wave ratio in the second part of the article. I have not yet had a chance to check up on the references, but referring to p. 864 of Terman ("Radio Engineers' Handbook") Fig. 101 (which is after Schelkunoff) confirms my formula over a bandwidth of at least 25% to within the accuracy to which the curves can be read. The resistance variation, to which your correspondent refers, introduces some asymmetry in the impedance characteristic but is not significant in relation to the context.

The average characteristic impedance of an aerial (Terman, *loc. cit.*) is given by $276 \log_{10} \frac{\text{length}}{\text{radius}} - 120$ and comes to about 550 ohms for a Channel 1 dipole made from 1-in tubing, so that from my formula, $B = \frac{4}{\pi} \times \frac{73}{550} \times 44 = 7{\cdot}4$ Mc/s. Doubling this on the assumption of a matched load gives 14·8 Mc/s which is not far short of your correspondent's figure of 17·25 Mc/s. The impedance plot shows a change of only ±15% in the resistive term over the bandwidth used in my example.

L. A. MOXON.

Long Distance V.H.F. Reception

I WAS extremely interested in Mr. H. V. Griffith's article in your April issue, as I have myself been making fairly regular observations on sporadic-E propagated signals in Band I since 1955.

In general my observations have only served to corroborate previous evidence concerning the prevalence and behaviour of sporadic-E propagation, but in view of Mr. Griffith's article I would like to make the following comments, which may be of interest.

Over the path from Europe to Tangier, at distances of 1,000 to 1,500 miles, sporadic-E propagation is considerably more prevalent than over the paths observed at Tatsfield. Observations made during 1955/1958 gave the following results, in terms of days on which signals were observed:—

1955—July 1st to August 31st	32
1956—June 10th to September 14th	50
1957—May 8th to August 14th	64
September 8th to October 8th	5
1958—April 22nd to June 30th	41
July 22nd to October 8th	24

Over the months May/August signals were observable on more than 50% of the days. By far the most prevalent, and the strongest, signals came from the various B.B.C. television transmitters. On some occasions these signals provided pictures of entertainment quality for a whole evening. Signals were also observed from Belgium, Czechoslovakia, France, Germany, Holland, Italy, and Switzerland. I believe that it has been stated, I think by Mr. Bennington, that paths of the order of 1,000 to 1,200 miles are the best from the point of view of sporadic-E propagation. This may account for the prevalence of such signals in Tangier, which lies at an ideal distance from the source of many television transmissions in Band I.

During 1956 and 1957 I was also in a position to observe some channels in Band II. These observations showed that during some periods of sporadic-E activity, signals of up to nearly 100 Mc/s were being propagated. Between June 30th and July 14th, 1956, a B.B.C. transmission on 89.1 Mc/s was heard on three occasions, and an Italian transmission on 89.9 Mc/s once. During 1957, between May 18th and August 11th, the B.B.C. on 89.1 Mc/s was heard on 19 occasions, a German station on the same frequency on four occasions, and an Italian station on 89.9 Mc/s also on four occasions. In addition, at a station some 100 miles south of Tangier, a German f.m. broadcast station caused severe interference on 93 Mc/s, on July 31st and August 1st.

J. E. le B. TERRY,
Tangier, Morocco. RCA Communications, Inc.

Alternatives to the Wien Bridge

WITH regard to Mr. J. F. Young's comments in your April issue, I should like to point out that the reference in *General Radio Experimenter*, Vol. 6, November, 1931, describes the use of a Wien Bridge for the measurement of audio frequency by balancing the bridge network and not for a resistance-capacitance tuned oscillator.

Resistance-capacitance oscillators appear to date from 1921 when a U.S. Patent 1,442,781 was filed by Nichols describing a single-stage amplifier giving 180° phase shift together with a 4-section resistance-capacitance ladder network. However, the earliest references to the Wien Bridge and similar circuits as the tuning element of an oscillator which I was able to locate after an extensive search made some years ago are those given in my letter published in your April issue.

W. V. RICHINGS,
London, W.5. Dawe Instruments, Ltd.

Printed Circuits

IT is interesting to follow the correspondence with regard to the disadvantages of printed circuits to the servicing engineer.

As specialists in the development and manufacture of printed circuits, we appreciate the need, not only for the development of new types of processes and applications for printed circuits but to ensure their advantages and popularity with manufacturers, users, and that most important last link in the chain, the man who has to maintain the apparatus in efficient working order.

For this reason we have introduced as a new development (patent pending) the printing on the top (component) side of printed panels a mirror image of the circuit in colour. This means that when the components are mounted the panel, the main cause of criticism that, to quote Mr. Kisch in the March issue, "a disjointed array of resistors and capacitors fixed apparently at random and one is unable to see the interconnections," no longer applies and the engineer sees a complete traceable circuit. Of course, as most components, valve holders, etc., normally have bare metal or wire ends on the top side of the panel, it is possible to fault-find with the normal test equipment on the component side of the panel.

D. L. PHILLIPS,

Coventry. Mills & Rockleys (Production), Limited.

I HAVE followed the letters re printed circuits with great interest. I would like to add my views on this important subject. I agree with Mr. Flack only on the point that printed circuits should not really be so difficult to service as claimed. We have surmounted many obstacles in the past, we remember amongst others the chassis without an inspection flap at the bottom of the cabinet which was separate to the tube, and could not be tested outside its cabinet without either extending the leads or having a special lead adaptor from the makers, and the multi-chassis monstrosity which defied any attempt to service it until it was completely dismantled from its cabinet and precariously assembled all in separate pieces on the bench.

Let us cut out the humbug and realize that printed circuits are here to stay on one count only, cheapness. We are all well aware that wiring failures have never been even a factor in television or radio breakdowns compared to other causes. The odd dry joint has arisen, but the printed circuit is equally prone to this. Without insulting anyone's intelligence, it is obvious that the conventional chassis with its greater flexibility of wiring can withstand vibrations better.

Regarding the points raised about tracing faults in printed circuits, I regard these as red herrings, correct interpretation of meter readings must invariably reveal the fault and in the old-type chassis makers often bound their wires in tight bundles in any case, making tracing just as hard. Mr. Flack appears to have taken a peculiar stand in a technical journal, for if he wants greater reliability why not start much higher up the scale with say, valves, controls, line output transformer, etc.? What about designing sets well within the valve maker's ratings? Will he now tell us that the present-day sets using only 14 valves are more reliable because they have fewer valves to give trouble?

Let me hasten to say, however, that I believe we are forced to accept printed circuits, etc., because the trade must keep competitive to maintain a high level of employment. I only want to be completely honest (at least in this journal) and face up to the undeniable fact that the printed circuit, those banks of shoddy, preset controls, the 14-valve chassis are retrograde steps in quality, but forced upon us by the iniquitous purchase tax.

I cannot but admire the ingenuity displayed by the manufacturers in producing cheaper, bigger screens, glossier cabinets, brighter pictures, in spite of rising costs, and how they manage to prune substantial amounts of solidity with every succeeding model and still get the performance they do. Happily, the customer rarely looks inside, and we, the servicing fraternity, have never counted anyway Even though the compromise between design and production has invariably worked out to the detriment of the service engineer the public are getting cheaper and cheaper sets, and even they can't have it both ways.

London, S.W.18. J. L. WILDGOOSE.

MAY I, on behalf of all service engineers, thank Mr. Flack for descending from the Olympus of the golfing weekend, to discuss the problems of the poor souls, towards whom the passing buck inexorably gravitates.

In the matter of printed circuits, his company is not among the most hated. There are, however, among the silent observers, those to whom the criticisms justly apply, including one ingenious designer, save the mark, who, having backed his printed panel by a stout metal plate and anchored it firmly in position by short connecting leads, proceeds to fit valves through the plate!

There has also been introduced a new, diabolical method of securing control knobs which has I am sure, caused consternation in the courts of heaven.

In conclusion I firmly believe, in company with all other service engineers, that the incredible mistakes that are made, including the urgent circular commanding modifications to be carried out to protect customers from electrocution, are not the work of idiots but are part of an international plot, designed to ensure that most technicians will be in mental homes in the event of their services being needed in a national emergency!

Leigh-on-Sea. L. W. TURNER.

Rigidity of L.S. Diaphragms

FURTHER to Mr. H. A. Hartley's letter in your March issue, on the effect of damp on foam plastic, I have soaked a piece of expanded polystyrene in water for five weeks, and its modulus in bending, measured while still wet and before drying out is almost unchanged, i.e., the material has *not* become limp. In practice, when foil or other materials are used to form sandwiches, not only will the foil reduce water absorption, as Mr. Hartley suggests, but even if water absorption does occur, the bending stiffness will be unaltered, as it depends almost entirely on the skins (see article p. 564, Dec. 1958 issue), the core being merely a lightweight device to keep the skins apart and to prevent them from buckling. If Mr. Hartley's material gives trouble, I can only conclude that it is not the same type as mine and that with correct choice of plastic water absorption is not a problem.

Banbury. D. A. BARLOW.

Plymouth Effect

I WAS very surprised to read in your December 1958 issue that the flutter effect which Mr. Grant has labelled "The Plymouth Effect" is still being puzzled over, so I would like to put forward my observations, the conclusions I came to and "the way around the problem" I found quite satisfactory before I left Plymouth in early 1957

The sharpish ridge known as Maker Heights over which the signals have to pass is around 450ft in height and causes considerable upcurrents of air or turbulence, similar to convectional currents, and somehow the warm rising air meeting the colder upper air presents alternative paths to the signals, reflecting and refracting them. I reached this conclusion after 'scoping and noticing the amplitude variations in Cawsand and making use of a highly directional radar device from approximately the same route as the signals would meet the ridge, which gave not only the expected solid response signals from the ridge but gave, when moved up approximately 150ft above the ridge, a group of continually varying signals at the same range above the ridge in space. Thus, the transmission having to pass varying paths, the signals received in Cawsand arrived in and out of phase with each other, varying in amplitude considerably. Lines were pulled when overall delays occurred, and there were overall brilliance variations also.

I found the best way round the problem was to screen "H" aerial from direct transmissions and to swing it 70° out to sea, and thus receive the re-radiated transmissions from Staddon Height aerials lattice masts (¼in horizontally to the right on your December maps) and use the 40% of the "direct" signal—thus making use of the main ghost noticed on direct reception without any ghosting whatsoever.

Just before I left I did contact Mr. Cooms of the B.B.C. to suggest the possibility of improving the reflecting surface of the Staddon Height masts to give us a better "ping off".

Hoping the above may help to lay the TV ghost of our village before my return in May 1960.

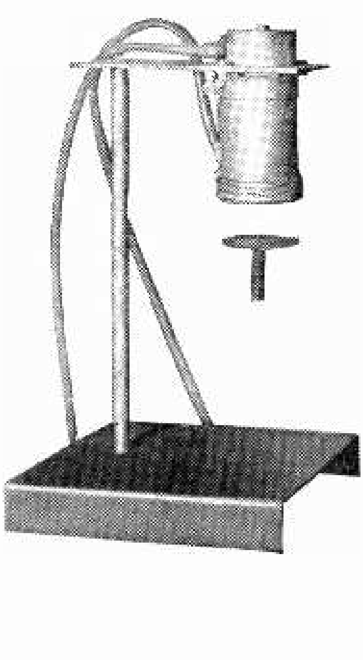
Singapore. A. MAYHEW.

Technical Notebook

Self-Monitoring Colour Tube to give automatically the correct chrominance balance in a colour television receiver is suggested as a possibility by J. J. Belasco and J. J. Chantrill in B.B.C. Engineering Monograph No. 23 (February, 1959). The proposed tube is a single-beam type working on the beam-indexing principle—the red, green and blue colour signals being gated to modulate the beam according to its position as it scans red, green and blue vertical phosphor strips. In this respect the tube is similar to the well-known Philco "Apple" c.r.t. (January, 1957, issue, p. 2) but instead of the beam-position information being obtained by a secondary emission process a photoelectric system is used. This involves vertical strips of photoconductive or photoemissive material laid on the viewing side of the fluorescent screen to correspond with the colour phosphor strips. All the red photo-sensitive strips are connected together and similarly with the green and blue strips, and the resultant three connections provide signals for gating purposes. The chrominance balancing system makes use of a small group of photosensitive strips at the edge of the picture, masked from view and not connected to the others. These are activated by a white bar produced by injecting a pulse into the video amplifier during the line suppression period. They consequently monitor the red, green and blue components which are combining to form the white bar. The voltage outputs from the monitoring strips are compared with reference voltages which have the correct relative proportions to form white when combined. The colour error signals so produced are then used to adjust the gain of each colour channel for the following line period.

Compatible Stereo "left" and "right" signals from widely-spaced (about 6ft or more) microphones are possible according to Bell Telephone Laboratories. The Bell modification to the ordinary left and right signals to make them compatible depends on the psycho-acoustic phenomenon known as the "precedence" or Haas effect. This effect arises if two identical or similar sound waveforms are reproduced at different places at nearly equal intensity levels with a delay of between 5 and 35 msec between them, when the apparent loudness of the delayed or echo sound is reduced by about 10dB below its actual intensity. The Bell modification combines each stereo signal with the other signal delayed by about 10msec and with its level reduced by about 1dB When both the left and right modified channels are reproduced then, because of the Haas effect, the delayed signals are each masked by the corresponding undelayed signals on the other channel, so that apparently only the left and right signals are reproduced, as required. When only one channel is reproduced the combination of one signal with the other one delayed and at a slightly reduced level is said to provide a compatible signal This modification has been developed primarily for use with stereo broadcasts in which a separate transmission is used for each channel, but in which an unmodified receiver tuned to only one of the two transmissions is required to give a compatible signal.

Levitation, though normally associated with the occult, can be achieved on strictly physical principles with an apparatus recently demonstrated by G.E.C. Research Laboratories. In this a small bar permanent magnet is made to hang in mid-air a



few inches below an energized electromagnet. Normally, of course, the bar magnet would either drop to the ground or fly up to the electromagnet. The secret of the trick is therefore to adjust continuously the field of the electromagnet so that its pull just balances the pull of gravity on the bar magnet. This is done by a servo system. The energizing current in the electromagnet is made to depend on phase variations in a tuned circuit which are produced by a disc of metal on top of the bar magnet altering the inductance of a coil mounted on the electromagnet. A 2.6-Mc/s oscillator supplies two signals to a phase detector, one direct and one through the sensing tuned circuit containing the coil. Phase changes in the tuned circuit due to movements of the bar magnet are thereby detected, and they produce a signal which is used to control the electromagnet current in a corrective sense. Positive feedback has to be applied in the control system to achieve stability.

Solid Circuits is the name given to small blocks of semiconductor material in which transistor, diode, resistance and capacitance elements are formed into complete circuits by special manufacturing techniques of diffusion, etching, masking, deposition, etc. (see Nov. 1957 issue, p. 516). They have now reached the stage of commercial development and are expected to be available for certain applications in the U.S.A. some time during the year. Texas Instruments recently exhibited two examples, each measuring less than $\frac{1}{4}$in × $\frac{1}{8}$in × $\frac{1}{32}$in. One was a multivibrator circuit, containing as integral parts of the semiconductor material the equivalent of twelve normal electronic components—two diffused-base transistors, two capacitors and eight resistors. The other was an oscillator containing the equivalent of nine components—one transistor, five resistors and three capacitors. The whole object of solid circuits is, of course, to reduce drastically the size and weight of electronic apparatus in such things as satellites, airborne equipment and computers. The criterion here is "component density" (though "volumetric efficiency" is sometimes quoted), and with solid circuits it is possible to achieve densities of up to 34 million components per cubic foot. This compares with several thousand per cubic foot for conventional circuitry.

High-Temperature Diode, made of the semiconductor material gallium arsenide, is another recent introduction by Texas Instruments in America It is said to be capable of operating in the extremely wide temperature range of −65°C to +325°C.

Elements of Electronic Circuits

2.—CLAMPING OR D.C. RESTORATION

By J. M. PETERS, B.Sc. (Eng.), A.M.I.E.E., A.M. Brit. I.R.E.

IT is sometimes necessary for the potential at a point in a circuit to be restricted to variations within fixed limits. The use of a clamping diode makes this possible. The name is chosen because the valve

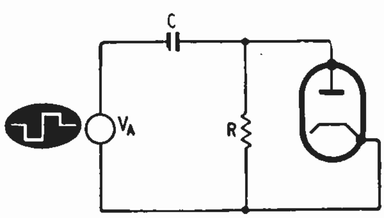


Fig. 1.

appears to fix or " clamp " the point to the desired potential.

A common arrangement using a diode and CR circuit is shown in Fig. 1. For the purpose of explaining the action of this circuit we will assume that the peak voltage of the applied square wave V_A in Fig. 2 is 20 volts.

(i) The application of 20 volts to R (AB in Fig. 2) causes the diode to conduct.

(ii) When the diode conducts R is short circuited, hence the time constant is very small. C quickly charges to 20 volts, causing V_R to decay to zero (BC).

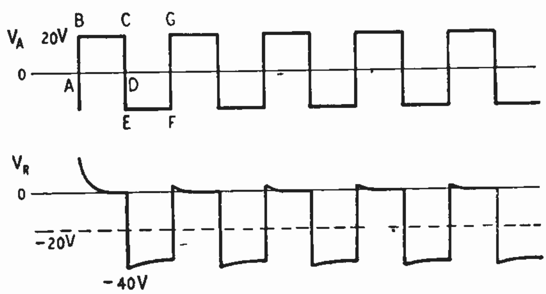


Fig. 2.

(iii) V_A now falls from C to E, i.e., from +20 volts to −20 volts. So −20 volts is applied to the circuit. V_C is, however, also at −20 volts, thus making the voltage across the resistance $V_R = -40$ volts.

(iv) Since the anode of the diode is now negative with respect to the cathode the valve does not conduct. Consequently as the time constant CR is now long, C only discharges very slightly (EF).

(v) When V_A goes from F to G the applied voltage again becomes +20 volts. V_C is, however still only about −19 volts, making $V_R = +1$ volt.

(vi) C quickly charges, V_R quickly falls to zero again and the cycle is repeated. Except, therefore, for a very small positive excursion at the commencement of the positive-going applied pulse, the maximum positive value of V_A is " clamped " to zero volts.

It can also be shown that if the diode connections are reversed as in Fig. 3, V_R is made all positive and

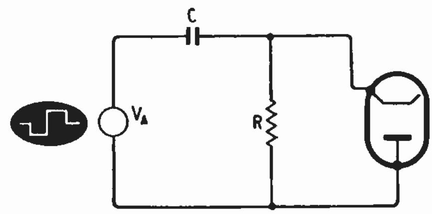


Fig. 3.

the maximum negative value of V_A is " clamped " to zero. In each case a direct voltage component is introduced into the original applied waveform, −20 volts in the circuit of Fig. 1 and +20 volts in the circuit of Fig. 3. It is often said that d.c. (voltage) restoration takes place under these conditions.

We will now consider what happens when a biasing voltage is applied to the diode. With the diode biased, the " clamping " voltage may be made as required. In the example in Fig. 4 an input square wave of 30 volts peak (Fig. 5) is applied to a

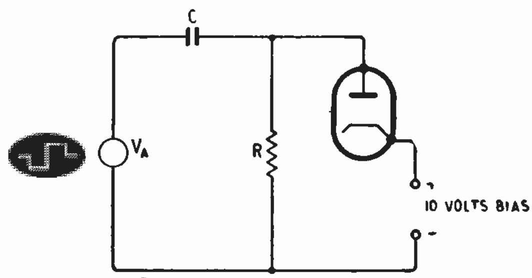


Fig. 4.

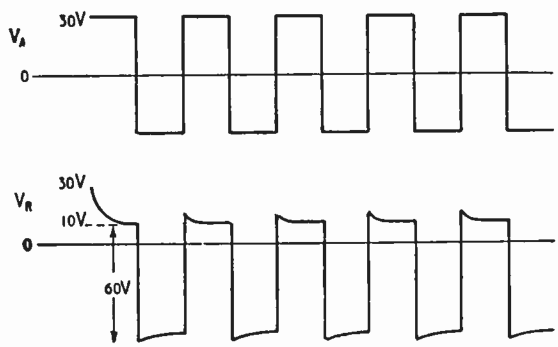


Fig. 5.

diode whose cathode is biased at +10V. The result is as shown in the lower part of Fig. 5, where the maximum positive excursion of V_A is clamped to +10 volts. Similarly, if the bias is reversed the maximum negative excursion of V_A is clamped to −10 volts.

Now let us consider the use of a triode valve for clamping. Here, as shown in Fig. 6, the grid and

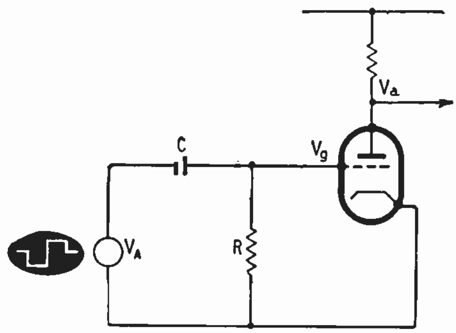


Fig. 6.

cathode act as a diode to the applied square wave V_A, which, for the purposes of the description, is assumed to be 10 volts peak (Fig. 7). V_g, the grid voltage, is therefore clamped to zero. The negative excursion of the input wave will now exceed the cut-off bias of the triode, with the result that the anode voltage waveform V_a is clamped to h.t.

It is important to note that, as illustrated in Fig. 7, a peak input voltage of 10V can cut off a valve which has a cut-off bias of 15V. This is due to the intro-

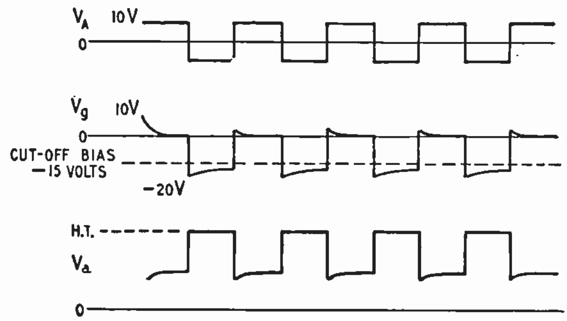


Fig. 7.

duction of a −10V d.c. component which makes the maximum negative excursion of the applied voltage (V_g) = −20V.

Before leaving this section it may be of interest to note that applying a similar treatment to the diode detector in conventional radio circuitry may offer a more satisfactory explanation of its operation than that sometimes given in textbooks.

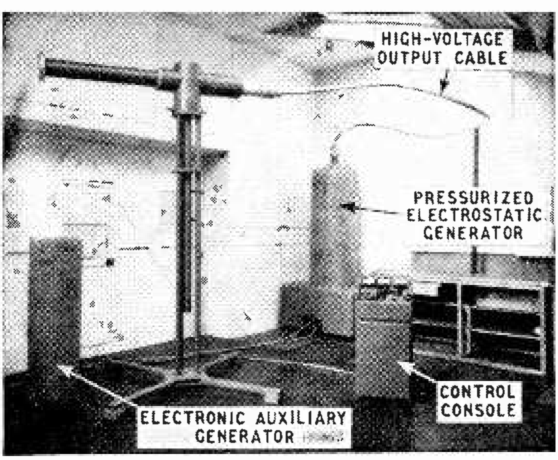
CORRECTION

In the first paragraph of last month's article (p. 156) the sentence beginning "If the input voltage is maintained at steady value . . ." should continue to read as follows: ". . . the voltage across the resistor will drop as the capacitor C charges through R. This rate of charge through the resistor depends on the values of C and R; the greater the values of C and R the longer will this time be." Also, the next paragraph should begin: "On discharge, it can be shown from theory . . ."

High-Voltage Generator

EQUIPMENT for generating voltages up to about one megavolt is finding increasing application in industry for such purposes as testing high-voltage cables, insulators and switchgear, as well as for use in electron microscopes, X-ray apparatus and various kinds of particle accelerators.

Miles Hivolt, Ltd., who in this country market the high-voltage generators made by the Société Anonyme de Machines Electrostatiques of Grenobles, recently demonstrated one of the S.A.M.Es. 600-kV generators at their works at Shoreham Airport.



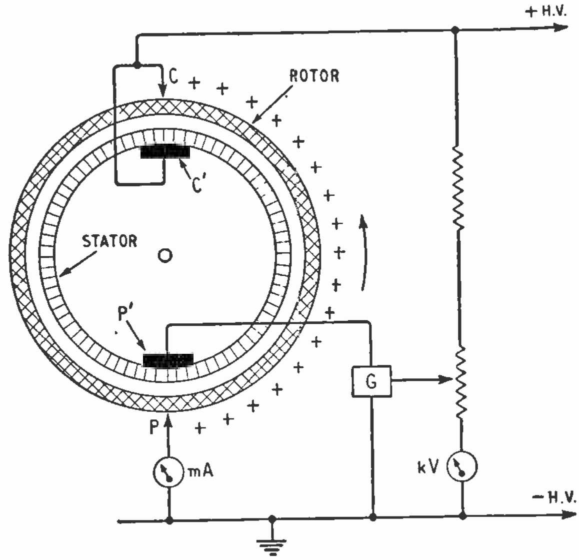
The three units of the Model CD600/4 high-voltage generator with oil-filled output cable on supporting stand.

The Model CD600/4, as this 600-kV generator is known, will give 4mA output, which, while not impressive by this figure alone, actually represents 2.4kW at 600kV. This equipment is relatively small in size, being easily assembled in a single vehicle if necessary and, complete, weighs a little over 2,000lb.

These are electrostatic generators (once called "influence machines") and closely resemble the Van de Graaff generator in principle, though not in form.

Basically the S.A.M.Es. generator consists of a stationary glass cylinder (the stator in the diagram) with another cylinder of insulating material (the rotor) revolving around it at relatively high speed. A positive charge is "sprayed" on to the revolving cylinder from electrodes P and P', the priming charge being provided by an auxiliary generator G. The charge is carried round to the collector electrodes C and C' where the voltage builds up to the working value. Prototype generators of this kind were shown at the Physical Society's exhibition in 1951 and 1954.

The CD600/4 generator consists of three main units, a pressurized electrostatic convertor unit, auxiliary electronic generator and remote-control console; these three are shown in the photograph. The pressurized unit contains the glass stator, rotor and its driving motor and the high-voltage resistance network and stands 8ft 10in high. It is filled with hydrogen at a pressure of about 25 atmospheres, and is water cooled. The rotor



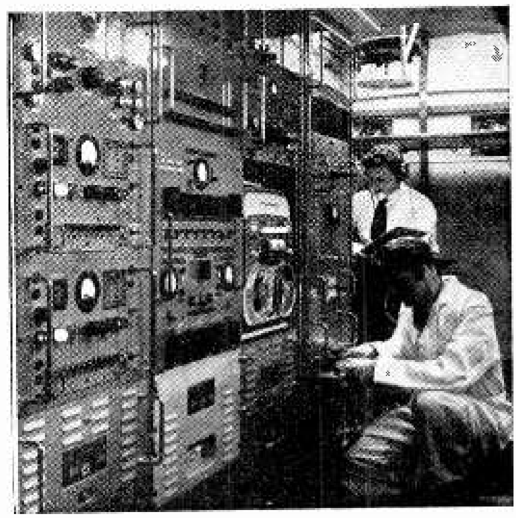
Schematic arrangement of the S.A.M.E. electrostatic high-voltage generator.

driving motor is a three-phase machine running at about 2,800 r.p.m. Cooling water circulates in the pressurized unit at between 1 and 2 gallons a minute.

The auxiliary, or priming generator, consists of a r.f. oscillator, high-voltage unit and a small electrostatic generator and provides priming voltages of from 10 to 50kV according to the output required. It is built into a floor-standing cabinet 4ft 4in high and includes voltage-regulating and stabilizing circuits and the various safety devices essential in high-voltage generators. Voltage stabilization is ±1% of the selected output in the Model CD600/4 and it can be as close as 1 part in 10^5 in some of the high-stability versions of these generators, such as, for example, the 50-kV model "Samtron 50."

The remote control console is a cabinet 3ft 3in high and houses equipment for selecting and measuring the priming and output voltages and current.

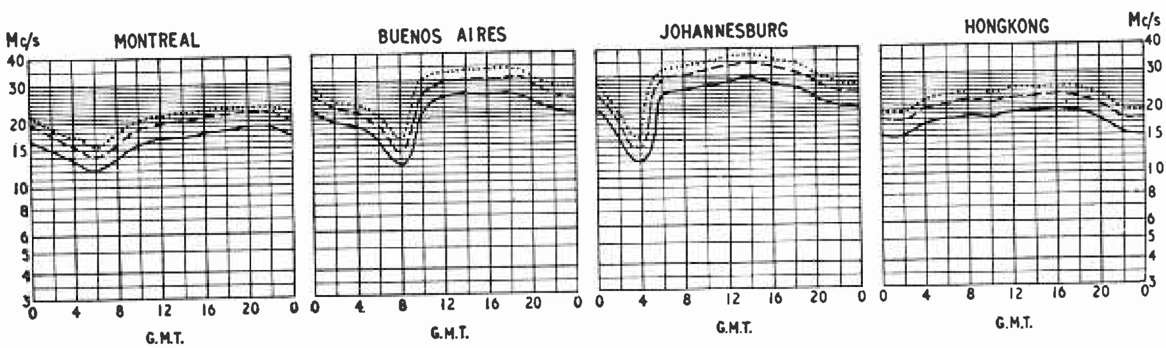
Comprehensive safety and protecting devices are incorporated in the equipment and it would seem impossible to damage any apparatus used with the generators by accidental flash-over, internally or externally. If sparking occurs the electromagnetic waves radiated are picked up by a telescopic aerial on the auxiliary generator unit and this "signal" is used to suppress the priming voltage and the output falls to zero. After a brief interval of time it slowly builds up again to the exact pre-selected value. Voltage or current overloads also "trip" the generator. The total consumption of the CD600/4 is about 3.5kW.



RADIO CONTROL FOR THE CANBERRA U Mk. 10:—Short Brothers and Harland Limited have produced a remote control system for this aircraft which is used as an unpiloted "target" for guided missile tests. The Canberra is controlled from the ground via a v.h.f.-radio link, the commands being in the form of pairs of tones. Twenty-four of these pairs are available and a transponder is installed in the aircraft to improve its radar "visibility" The photograph shows part of the interior of the control station.

SHORT-WAVE CONDITIONS

Prediction for May



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

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

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

THE full-line curves 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 May.

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

Long-Distance Propagation

DETAILS OF FORTHCOMING TESTS BETWEEN ASCENSION ISLAND AND SLOUGH

THE Department of Scientific and Industrial Research with the co-operation of Cable and Wireless, Ltd., will in June set up an experimental radio station at Ascension Island, from which two of their staff will conduct test transmissions to their Radio Research Station at Slough, Bucks, for a year. The object of the tests will be to investigate propagation over long distances.

The D.S.I.R. officer in charge of the project at Slough is A. F. Wilkins, who was closely associated with Sir Robert Watson Watt in the early development of radar. The two officers going to Ascension are L. A. Brackstone and R. Aria. On the Cable and Wireless side, arrangements have been made by R. J. Hitchcock, head of the section dealing with radio propagation, who is also a member of the Ionospheric Communications Committee of the Radio Research Board.

Explaining the objects of the tests, Mr. Hitchcock writes:

"Over certain parts of the earth's surface we now know a great deal about the characteristics of the ionized layers of the upper atmosphere by means of which high-frequency radio communication is established. But we do not know much about the exact path followed by radio waves in the course of their journey from transmitter to receiver, and this, in spite of the fact that commercial high-frequency circuits have been in operation for the past 30 years or more. The actual paths taken by radio waves are called the 'modes of propagation,' and it is to investigate the nature of these modes that the tests at Ascension Island have been planned.

"It may well be asked why such investigations are necessary, for if we point a directional transmitting aerial in Nairobi towards, say, London, and use the right order of frequency for the route, the signal will in all probability be receivable in London. The answer lies in the fact that, in common with all forms of engineering, it is becoming increasingly important to do the job efficiently. In Cable and Wireless, Ltd.'s particular case, the necessity providing the spur is an ever-increasing congestion of the radio spectrum, an increasing demand for reliability and, possibly the most important factor of all, an ever-increasing demand for additional channels on existing and planned circuits.

"Considered academically, high-frequency systems are exceedingly wasteful, for although signals are required only at the few acres where the receiving aerials are located, they fall over great areas of the earth's surface to no useful purpose. Furthermore, we have no assurance at present that we are in fact putting down the maximum possible energy at the point where it is required. These are the sort of problems we must tackle if we are to improve the efficiency of our radio systems and remain competitive in the rapidly progressing communications world.

"Preliminary investigations into modes of propagation have been going on for some years, and many will recall the transmissions already made from the Ascension Island relay station for the D.S.I.R. Useful though these transmissions have proved, they were only a start, and we now go deeper into the matter with more complex and specialized apparatus.

"A receiver and transmitter have been developed at Slough which, even if separated by great distances, may yet remain accurately in tune with one another while the radio frequency is automatically changed.

"This particular equipment is capable of sending and receiving signals on nearly 2,000 different frequencies between 5.5 Mc/s and 50 Mc/s in the space of about 15 minutes.* Only the transmitter will go to Ascension. The receiver will remain at Slough, where the signals will be observed and analysed.

"Possibly, from the Cable and Wireless point of view, the most important group of experiments will be those associated with aerial effects. Aerial design is largely dictated by propagation considerations, and an interesting series of tests is planned to see the effects of shooting into the ionosphere at different angles. We have always wanted to know the best angle to the horizon at which we should transmit radio energy on long radio routes, and all the indications at present are that this angle should be very low. In this experiment three dipoles at different heights above ground are to be erected on a 150ft mast. By placing this mast as near as possible to the water's edge and transmitting from each dipole in turn, it is possible to alter the shape of the vertical polar diagram of transmitted energy and to see what effect this has on the received signal at Slough. It is believed that this is the first time a controlled experiment of this nature has been made. In addition, our own rhombic aerials at Ascension Island will be used to test the effects of good and poor sites as represented by having sea in front of one aerial and rock in front of the other.

"Although we shall not be making any direct observations in connection with the new 'forward scatter' techniques now being used for communications, we shall be using a very important new technique based on the radar principle, and developed by A. F. Wilkins and his colleagues, to measure 'back scatter.' This is the small fraction of energy scattered back to the transmitter from the ground reflection areas along the radio path. The technique shows not only the location of these areas, but also indicates the relative strengths of the signals in these areas. A change of frequency and/or aerial can substantially change the 'back scatter' pattern, and its value to the transmitting engineer, in ensuring that he is covering the reception point with the strongest possible signal, can be appreciated.

"We should not overlook the effect this project is having in expanding our good relations with the D.S.I.R. In recent months A. R. Harrison, Manager at Ascension Island, S. G. Crow, the previous engineer at Ascension, and J. Berry, his relief, have all visited Slough to inspect the equipment and discuss details of the project.

"We know the D.S.I.R. would very much like to carry out the next series of large-scale experiments from Singapore, to which place one piece of research equipment is already on its way. With our extensive traffic commitments between there and the U.K., we must look forward with particular interest to the results of investigations into the complexities of this route."

* Dr. Smith-Rose in his presidential address to the R.S.G.B. disclosed that in similar tests to Malta the frequency was changed every 0.4 sec by steps of 20 kc/s, the two sets of equipment being kept in synchronism by very stable crystal clocks.—Ed.

A Second Band-III Programme?
—The Aerial Problem

Requirements for Wide-Band Coverage With Useful Gain

By F. R. W. STRAFFORD,* M.I.E.E.

(Concluded from page 174 of the April issue)

THE previous article dealt with the conventional Yagi array and showed that such aerials were less efficient than simple dipoles when operated three channels from the optimum design frequency. Since Yagi aerials represent by far the largest proportion of Band-III installations. and are particularly concentrated in the fringe areas, it will be seen that quite a serious problem must be overcome before the fateful day.

The lazy way of approach is the add-on technique which, in this instance, would mean duplication of the existing aerial optimized for the additional channel and somehow erected over the already overcrowded chimney and connected through yet another diplexing filter to the input feeder. Remembering that the greatest problem will exist in the genuine fringe area where double-stacked six-element Yagis mounted on 12ft poles are commonplace, the prospects are quite alarming.

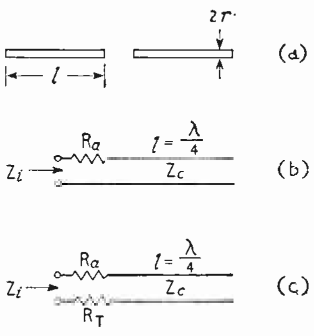


Fig. 1. Basic half-wave dipole (a). the equivalent series circuit for deriving intrinsic bandwidth (b) and equivalent series circuit for deriving loaded bandwidth (c).

Obviously, the sensible long-term approach is to replace the existing Band-III aerial with one which will receive both stations with equal efficiency. In order to rationalize production the aerial should cover the whole frequency band, namely, 174-216Mc/s. The two extremities of this band are already occupied by other services but the P.M.G. has pledged to release them for the television service in due course.

It is the object of this article to study the requirements for the design of a wide-band aerial capable of providing a directive gain of the order of 9dB, and to suggest the lines upon which development might proceed.

Bandwidth of a Half-wave Dipole.—Whether a single dipole with reflector, or a combination of suitably connected dipoles are used, the bandwidth must be 42Mc/s when operated into a 75-ohm feeder and load resistance. In this instance the loss should not exceed 1.0dB at the extremities.

The 3-dB bandwidth has been studied, empirically, by various workers including the author[1] and it would appear that a bandwidth of about 84Mc/s, that is, twice the desired coverage, based upon 3-dB points will result in a 42-Mc/s bandwidth for the 1-dB loss which is the target in this instance.

The intrinsic 3-dB bandwidth of a half-wave dipole, fed at the centre, may be derived empirically by replacing the dipole by a loss-less quarter-wave transmission line in series with a resistance equal to the radiation resistance of the dipole referred to the centre, Figs. 1(a) and (b). For a cylindrical dipole Schelkunoff[2] calculates an *average* characteristic impedance Z_c given by the formula:—

$$Z_c = 120(\log_e 2l/r - 1) \quad .. \quad .. \quad 1.0$$

The input impedance of the equivalent dipole circuit of Fig. 1(b) is:—

$$Z_i = R_a + Z_c \coth \frac{j\pi l}{\lambda}$$

$$= R_a + Z_c \coth \frac{j\pi}{2}\left(1 \pm \frac{\delta\lambda}{\lambda_o}\right)$$

$$= R_a + iZ_c \tan \frac{\pi\delta f}{2f_o}$$

where f_o is the resonant frequency. The 3-dB half-power points occur when the resistive and reactive components are of equal magnitude, i.e. when

$$R_a = Z_c \tan \frac{\pi\delta f}{2f_o}$$

Equating and solving for δf we obtain:—

$$\delta f = \frac{2f_o}{\pi} \tan^{-1} \frac{R_a}{Z_c}$$

The total bandwidth is given by:—

$$\Delta f = 2\delta f$$

So that:—

$$\Delta f = \frac{4f_o}{\pi} \tan^{-1} \frac{R_a}{Z_c} \quad .. \quad .. \quad .. \quad 1.1$$

Since the ratio R_a/Z_c is always much less than unity, equation 1.1 may be further simplified as tan x equals x for small values. Hence we may now write the general empirical formula for the total 3-dB bandwidth of a centre-fed halfwave dipole as:—

$$\Delta f \doteqdot \frac{4f_o R_a}{\pi Z_c} \quad .. \quad .. \quad .. \quad .. \quad 1.2$$

This result was also derived by Smith[3] by an alternative approach.

Equation 1.2 is very useful for preliminary design

* Radio and Electronics Consultant.

work and has been experimentally confirmed[1]. These results for the calculated and measured bandwidth for a very thin dipole checked remarkably well, but there was some discrepancy for the thicker dipole. This was due to overlooking the fact that the radiation resistance for the thick dipole was lower than that for the thin one so that equal values for R_a were used in both calculations. Had a lower value of R_a been inserted in the thick dipole calculation much closer overall agreement would have been reached.

The interesting point about equation 1.2 is that it gives the intrinsic bandwidth for the 3-dB points. In the presence of a load resistance equal to the radiation resistance, and this is the practical arrangement, Fig. 1(c), the bandwidth now becomes:—

$$\Delta f = \frac{4f_o(R_a + R_T)}{\pi Z_c}$$

$$= \frac{8f_oR_a}{\pi Z_c} \quad .. \quad (R_a = R_T) \quad .. \quad 1.3$$

Hence, the working bandwidth is twice the intrinsic bandwidth, so that by working on the basis of 3-dB intrinsic bandwidth one automatically obtains the 1-db working bandwidth as previously explained.

As a starting point for preliminary calculations, let the dipole radius be 0.25in. The mid-band frequency is 195 Mc/s and l, which is about 90% of a physical quarter-wavelength, works out to 13.75in. The radiation resistance of such a dipole, erected at least one wavelength from the ground and clear of surrounding conductors, is of the order of 50 ohms. Combining this data in equations 1.0 and 1.2 the required 1-dB loaded bandwidth works out to 34.5 Mc/s, so that the 0.5-in diameter dipole does not make the grade since the bandwidth is less than the required 42 Mc/s. In order to meet the requirement it will be found that the elements must be increased to 2in in diameter, but this is accompanied by a drop in radiation resistance to about 40 ohms. The mis-match loss to a 75-ohm load through a 75-ohm feeder will be slightly less than 0.4 dB, but this must be added to the 1dB loss at the margins of the band, and one must not forget the inherent feeder losses—they all add up!

The dipole need not have cylindrical elements. It is an advantage to employ a shape which provides a low value of average characteristic impedance but maintains the radiation resistance nearer to the 70 ohms of the thin dipole. The bi-conical dipole of Schelkunoff[2] achieves this objective. The basic arrangement is shown in Fig. 2(a) but the cones may be skeletonized by the use of a bundle of flared rods, Fig. 2 (b), with little effect on its properties.

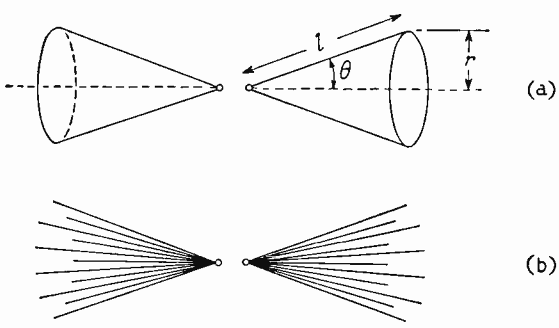


Fig. 2. Basic bi-conical dipole (Schelkunoff) shown at (a) with a skeletonized equivalent using thin flared rods.

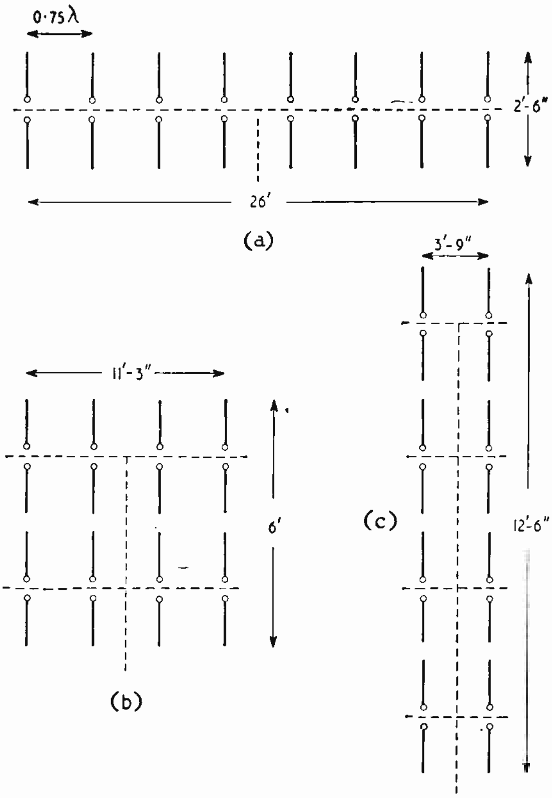


Fig. 3. Three methods of arranging eight half-wave dipoles to produce a gain of 9dB. (a) has an area of 65 sq ft, (b) an area of 67.5 sq ft and (c) an area of 47 sq ft. Dotted lines represent booms and masts.

The bi-conical dipole possesses the rather amazing properties of having *constant* values of distributed inductance and capacitance per unit length so that the *exact* characteristic impedance may be calculated. This is given as:—

$$Z_o = 120 \log_e (\cot \theta/2) \quad .. \quad .. \quad 1.4$$

Note that when θ is very small:—

$$Z_o \doteqdot 120 \log_e 2l/r \quad .. \quad .. \quad .. \quad 1.5$$

This latter expression is used to derive the average characteristic impedance of a thin cylinder by integrating equation 1.5 between the limits $l = 0$ and $l = l$ from which equation 1.0 is obtained.

A bi-conical dipole constructed of six 14-in. rods 0.25in in diameter and flared so that $\theta = 20°$ has a characteristic impedance of 260 ohms and a radiation resistance of 70 ohms. Substituting these values in equation 1.2 the loaded 1-dB bandwidth is 66 Mc/s and is more than adequate for full Band-III coverage. By reducing θ to 5° the 1-dB bandwidth is just 42 Mc/s. In these circumstances, however, it is a more practical proposition to use simple cylindrical rods or tubes of about 1.0in diameter to obtain the same result at the expense of somewhat lower radiation resistance.

Gain and Directivity.—Having shown that a fat dipole, suitably shortened to maintain mid-band resonance, will provide adequate wide-band response it remains to consider how one or more of these may be arranged to provide a power gain of, say, 9dB as a fairly modest target.

The power gain of N dipoles, spaced at east 0.75 wavelength to reduce mutual interaction, and connected so that all values of instantaneous induced currents are in phase at the feeder input, is given by:—

$$G = 10 \log_{10} N \text{ (dB)} \quad .. \quad .. \quad .. \quad 1.5$$

To obtain 9dB gain N must equal 8 and this number of dipoles must be stacked in some convenient manner of which Figs. 3(a), (b) and (c) are examples. All these arrangements present quite formidable mechanical problems in terms of mounting them on chimney stacks and providing adequate strength for 80 m.p.h. wind gusts. A further problem is that of connecting all dipoles in the appropriate phase. Series connection of dipoles does not work when unbalanced coaxial feeder is used—in fact, it does not seem to work at all well when balanced open-wire feeders are used. Parallel connections must therefore be made to the main feeder and the net impedance must be suitably transformed to match its characteristic impedance, which is usually of the order of 75 ohms. If N elements are connected in parallel, each having a radiation resistance of 50 ohms, the resultant resistance presented to the main feeder will be 50/N ohms so that eight elements will amount to 6.25 ohms. If no transformation is introduced the mis-match loss into a 75-ohm feeder will exceed 5.0dB, which would be intolerable. The mis-match may be removed by the use of the transforming properties of feeders whose electrical length is made any odd integral multiple of one quarter-wavelength. Such a feeder terminated by a resistance R_a has an input resistance given by $R_i = Z_0^2/R_a$ so that $Z_0 = \sqrt{R_i R_a}$. It is desired to connect eight 50-ohm dipoles to a main feeder of 75 ohms characteristic impedance so that each interconnecting feeder must present an impedance of 600 ohms. Hence, the characteristic impedance of each inter-connecting feeder will be given by $Z_0 = \sqrt{50 \times 600} = 175$ ohms. Lines having this characteristic impedance are readily constructed from 0.25-in diameter rods spaced about 2.25in between centres. According to the mode of connection the array may be given omni-directional, bi-directional, or uni-directional characteristics. To maintain a high signal-to-noise ratio and minimise the effects of multi-path reflections a uni-directional array must be chosen, in which case the arrangement of Fig. 3(b) would have to be used and fed in such a manner that the currents in the left (or right) set of dipoles were lagging in phase by 90° with respect to the other set. Unfortunately the quarter-wave transformer is frequency selective—it must obviously be so—and the use of inductive and/or capacitative parallel stubs must be included and laborious adjustments made to give the desired overall bandwidth. These adjustments are invariably made by using apparatus for the measurement of the standing-wave ratio of the reflections set up in the main feeder and an overall figure of less than two-to-one must be achieved before the performance can be regarded as satisfactory for the stringent requirements that have been set.

From the viewpoint of stacked dipoles the arrangement of Fig. 3(c) is desirable since the major support comprises the mast which need not be more than, say, 15ft in length. By introducing the 90° phase shift in one set of elements the uni-directional characteristics will be obtained and the gain will rise by a further 2.5dB, the theoretical limit being 3dB

Corner-reflector Aerial.—An alternative, and very simple, aerial giving a forward gain of the order of 9dB with good directivity, and which uses only one dipole, is the corner reflector which has been very thoroughly investigated by Moullin[4]. The reflector need not be constructed from sheet material, an open-mesh netting, or a row of rods, may be substituted provided that their spacing does not exceed 0.1 wavelength A manageable, although not altogether attractive sample, was made by the author for operation on Channel 9 prior to making a further mode on a reduced scale for operation at the B.B.C. experimental frequency of 654.25Mc/s. This latter aerial was described by the author in a previous article[5] The original model was designed for Channel 9 because measurements were more readily available in terms of existing measuring apparatus.

Fig. 4 shows a plan of the corner-reflector aerial in which the fat dipole is placed at a distance *d* from the apex. When the included angle is 90° Moullin obtains the two curves relating power gain and radiation resistance to *d* in terms of wavelength These curves are based upon the assumption that the reflector is of infinite length and breadth. Moullin goes on to show that the reflectors may not only be made finite in size, but may be reduced to practical proportions without serious change in

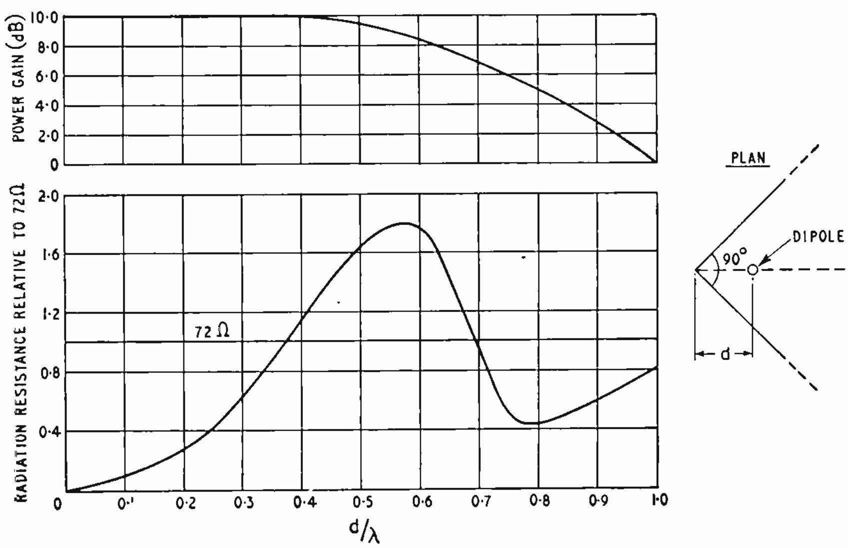


Fig. 4. Variation with spacing (d) of radiation resistance and gain for a corner-reflector aerial.

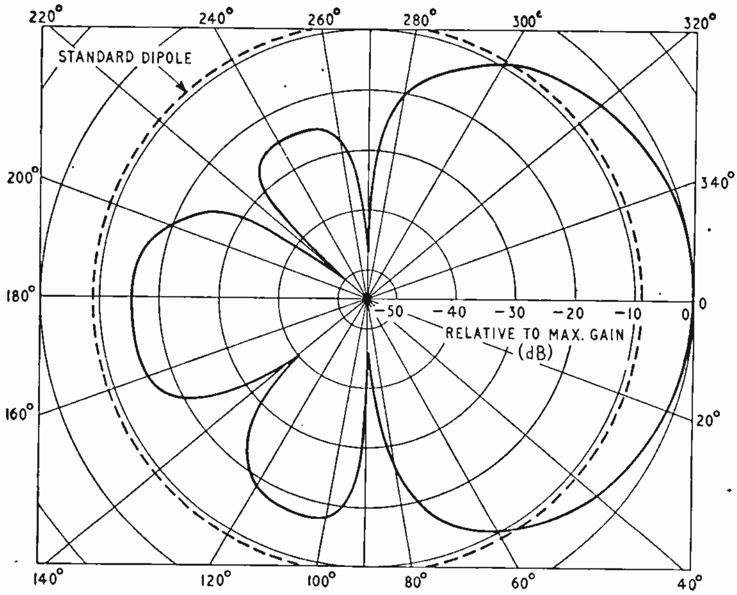


Fig. 5. Polar diagram of the corner-reflector aerial.

characteristics. It will be observed that, up to $d = \lambda/2$ the radiation resistance rises from zero, through 72 ohms up to 120 ohms while the power gain remains flat at 10dB. From $d = \lambda/4$ to $\lambda/2$ the mis-match loss to a 75-ohm feeder will not exceed 1.6/1.0 so that less than 0.3dB will be lost. If, therefore, the dipole is located at a distance $d = 3\lambda/8$ from the apex a deviation of $\pm 33\%$ about the design frequency can be allowed. Since only $\pm 10\%$ is required for complete coverage of Band III the attractiveness of this simple aerial will be obvious. The author constructed an experimental corner reflector for Channel 9 (194.75Mc/s). The overall dimensions of each leg were 5ft long and 3ft wide and consisted of 0.25-in diameter rods spaced 6.0in apart. The dipole consisted of two 1.75-in diameter tubes 12in long and tapered to 0.25in diameter over the last two inches from the centre to which the coaxial feeder connections were made. A forward gain of a little over 9dB was obtained with a front-to-back ratio of 14dB and a beam width between half-power (3-dB) points of 65 degrees.

Four sharp minima, very useful for de-ghosting, in excess of 40dB were observed towards the rear. The directional response is shown in Fig. 5. This is plotted in dB which does not make it appear in such a flattering light as the conventional voltage-ratio scale, which the author does not support since it does not link up with all the other parameters of a complete TV system from transmitter to receiver, where everything else is expressed in dB.

The projected area of this aerial on the axis of the beam is about 21 sq ft which is considerably less than anything obtained by stacking sufficient dipoles to give the same gain. There is no reason why the rods comprising the reflector should not be replaced by wire netting of 6-in mesh suitably reinforced at the corners to give self-support. Such an aerial should give comparable results and a fairly low windage might be achieved by the use of the latter form of construction.

Summarising, there does not appear to be any simple way of providing the unique properties of the Yagi array over a wide frequency range without recourse to a much larger structure with its attendant mechanical problems. This contention would appear to be supported by a study of the theoretical and experimental work carried out to date, and particularly, by examination of specifications for wide-band aerials designed for television transmitters and general v.h.f. and u.h.f. telecommunications equipment.

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Principles of Transistor Circuits

ANYONE who is about to embark on the design of transistorized equipment, and has had no previous experience of transistors, is faced with a wealth (or shall we say a welter?) of literature on the subject, ranging from advanced physical treatises through complex network analyses to the most superficial of popular treatments. There is a great need for a concise introduction to the design of transistor amplifiers, receivers and other circuits, which will give the student, engineer or amateur constructor only the sort of information that is really essential to his purpose.

Such a book has just been issued by our publishers—"Principles of Transistor Circuits" by S. W. Amos, B.Sc. (Hons), A.M.I.E.E. Assuming no previous knowledge of the subject, it starts off with two chapters on the physical principles and electrical characteristics of transistors. But the main emphasis is on the application of these principles to the practical problems of design, and the bulk of the book is concerned with the determination of such quantities as input resistance, stage gain, optimum load, power output, values of coupling capacitors and transformer winding inductances.

The mathematics is confined to simple algebraic manipulation and is illustrated by a large number of numerical examples, which show the order of practical magnitude of the various quantities. Some details are included of photo-sensitive devices, transistor relaxation oscillators, and the newer types of high frequency transistors.

The book, which contains 167 pages and 105 diagrams, is available from booksellers, price 21s, or direct from our publishers at 21s 11d including postage.

Convention on Stereophony

INTERESTING PAPERS AND LIVELY DISCUSSION AT THE I.E.E.

ALMOST every conceivable aspect of stereophony was discussed at the excellent two-day convention held recently at the Institution of Electrical Engineers in London, but only the more recent developments or lesser-known aspects of the subject which were discussed are reported here. The full papers and discussion will be published in the Proceedings of the Institution.

Theory of Hearing.—F. H. Brittain described some of the results on stereophonic listening which have been obtained by Dr. B. Sayers and Dr. D. M. Leakey working under Professor C. Cherry at the Imperial College of Science and Technology. These results indicate that in hearing the position of a sound source is obtained from the difference between the times of arrival at the two ears of the sound, as distinct from the intensity difference at the two ears of the sound as has sometimes been thought. The variations of this time difference produced by head movements as small as one tenth of an inch are used to remove the ambiguity as to whether the sound source is in front or behind (both positions would produce the same sounds at the ears).

When listening to two loudspeakers in a stereophonic system each ear hears both loudspeakers, but the sounds at each ear from the two loudspeakers apparently combine to form a single sound provided that the time difference between the sounds from the two loudspeakers is less than about 0.5msec. For longer time differences up to about 3msec, such as might be produced by off-centre listening or a spaced-microphone recording technique, partial apparent combination at each ear of the sounds from the two loudspeakers can still occur.

The apparent arrival time of each combined sound relative to the arrival times of each of its two constituent sounds from the two loudspeakers depends on the relative intensities of these two constituent sounds, and also, for delays between the two constituent sounds of more than about 0.5msec, increasingly on the arrival time of the earlier of the two sounds. This latter phenomenon is known as the Haas or precedence effect.

The difference between the apparent arrival times of the combined sounds formed at each ear gives the apparent single source position. Thus intensity differences between the two loudspeakers are converted in hearing into apparent time differences between the two ears. This somewhat surprising asymmetry between sounds from the loudspeakers and the corresponding sounds at the ears can (in case any readers are sceptical about it) be derived trigonometrically (see for example the paper by H. A. M. Clark, Dr. G. F. Dutton and P. B. Vanderlyn in *Proc.I.E.E. Part B*, Vol. 104, Sept. 1957, p. 422). This asymmetry arises because each ear hears both loudspeakers—an elementary fact of loudspeaker as distinct from headphone stereophonic reproduction that is sometimes forgotten.

Reproducing Conditions—Rooms.—In stereophonic reproduction interfering reflections from the walls of the listening room should be avoided by absorbing material in suitable positions according to T. Somerville of the B.B.C. In the excellent B.B.C. demonstrations, given at the I.E.E. during the convention, reflections were avoided by hanging curtains so as to form a sort of room within a room.

The deliberate use of reflections from the room walls using directional loudspeakers has been suggested as a means of producing apparent loudspeaker sources farther apart than the actual loudspeakers and thus as a means of increasing the apparent size of the overall sound field beyond the region between the two loudspeakers. However, this increase will not occur for the reverberant sound which consists mainly of low frequencies at which loudspeakers are not directional.

Reproducing Conditions—Loudspeakers.—A discrepancy between the apparent size of the reverberant and direct sound fields also arises in the sometimes used system in which signals at frequencies below about 300c/s in the two channels are added together and reproduced by a single loudspeaker. This economical system is generally advocated on the grounds that stereo information is mainly confined to the upper frequencies and that sound source positions can be located less and less accurately as the frequency decreases. This latter point was challenged by H. A. M. Clark and by F. H. Brittain who stated that he had been able to locate mortars fired on Salisbury Plain at great distances to an accuracy of one degree although their sound on arrival did not contain any energy above 50c/s and had a maximum energy at 20c/s.

Compatibility.—A combination of the two stereophonic signals to form a single signal which can be reproduced by ordinary unmodified single-channel equipment so as to sound as good as or only slightly inferior to the corresponding non-stereophonic signal is said to be compatible.

The sum of the left and right stereophonic signals is often stated to be compatible, but a number of criticisms of this view were put forward in two papers by T. Somerville and D. E. L. Shorter of the B.B.C. This sum signal is least compatible when a multi-microphone recording technique has been used. Such a technique may be necessary to correct for poor acoustics and is often used in "pop" music or drama to correct the relative intensities of the various parts of the sound source. When the alternative of a single pair of coincident (or nearly so) microphones is used its optimum position may not be the same as that for a single microphone for a single-channel recording. Also when a coincident microphone recording technique is used, this sum signal may be equivalent to that from a microphone of unsuitable polar response, though according to Dr. W. S. Percival this response can be improved by altering the phase of one of the stereophonic signals by ninety degrees before addition. Incidentally, use is often made of the fact that signals obtained with microphones with one kind of characteristic can be combined to produce signals which would have been produced by microphones with different polar responses. When a pair of spaced microphones is used the difference between the times of arrival of the same sound at the two microphones may produce some cancellation at

various frequencies in the sum signal. A revealing ear-opener was provided in the B.B.C. demonstration when, with a soprano, choir and orchestra, the emphasis on the soloist was very much greater when the sum of the left and right signals rather than the stereophonic recording was played.

Broadcasting.—Two new systems were mentioned by T. Somerville and D. E. L. Shorter. These use primarily amplitude modulation, and this can be at frequencies in the ordinary medium waveband as distinct from the more usual frequency-modulation multiplex systems at v.h.f. In the R.C.A. system the left- and right-hand signals are carried one on the upper and the other on the lower sideband, so that this might be described as a double single-sideband system. An ordinary detector will give an output proportional to the sum of the left- and right-hand channels. In the Philco system the sum of the left- and right-hand signals is used to amplitude-modulate the carrier in the usual way and provide a compatible output from an ordinary unmodified receiver, while the difference between the left- and right-hand signals is used to phase-modulate the carrier. The difference modulation is confined to frequencies above 300c/s to avoid certain complications in the receiver circuit. In both these systems distortion is possible in the detector when one modulation is much deeper than the other.

In an interesting paper by J. J. Geluk of the Netherlands Broadcasting Union (some of the results from which have also been given by the same author jointly with H. J. van der Heide in *E.B.U. Review, Part A* (*Technical*) for Feb. 1959, p. 15) a comparison was made between a number of versions of the v.h.f./f.m. multiplex system in which the sum of the left- and right-hand signals is used to frequency-modulate the main carrier and provide a compatible signal for an unmodified receiver, while the difference between the left- and right-hand channels is used to frequency-modulate a sub-carrier of the main frequency. In all the cases considered the total maximum deviation was kept at 75kc/s while being sub-divided in various ratios between the two modulations. Three factors of importance in comparing various systems are the loss in the power transmitted from the main compatible carrier caused by the power which must be diverted to maintaining and modulating the sub-carrier; the differing amounts of filtering between the carrier and sub-carrier necessary to secure a sufficiently low cross-talk and finally, the various amounts of spurious radiation which could cause adjacent-channel interference. A possible detector for the difference signal was described using four double-triodes in which the difference signal is used to synchronize a multivibrator. By limiting the output from the multivibrator rather than limiting the difference signal itself very efficient limiting is obtained. With efficient receiver limiting, the sub-carrier deviation can be decreased so that the power loss on the main channel is only 2.7dB and also cross-talk between the two signals and spurious radiation are reduced.

Systems in which the sub-carrier is amplitude rather than frequency modulated were also considered by Geluk. The detector can be simpler than with an f.m. sub-carrier, but the r.f. stages are more difficult to design, since a flat amplitude response over the channel bandwidth is required to avoid distortion rather than the more easily obtained flat phase response required for an f.m. sub-carrier. The cross-talk tends to be higher using an a.m. sub-carrier so that, unlike the case with an f.m. sub-carrier, it is unlikely that two **independent signals could be satisfactorily transmitted.** As was pointed out by D. E. L. Shorter, a time-division multiplex system would be equivalent to using a sub-carrier spaced by the switching frequency and a.m. by the difference signal.

In considering the optimum division of available power between the sum and difference signals, it is often assumed that the peak level in the sum is considerably greater than that in the difference. In fact, the usual difference between these levels is only about 4dB, according to Shorter, and can be less even than this value.

Considerable interest was aroused by the discussion of the Percival system, of which some details have already been given in *Wireless World* (Vol. 64, Nov. 1958, p. 521) and in which the directional information is separated from the signals themselves and processed so as to occupy a bandwidth of only about 100c/s. The processing is primarily based on the Haas or precedence effect which can be stated in the form that in hearing the apparent direction of a sound is determined primarily from the first few milliseconds of it. Thus the directions of a number of nearly simultaneous sounds can be apparently given by stereophonically reproducing only their beginnings provided that these beginnings are not simultaneous to within a few milliseconds. Even when the whole orchestra is supposed to start together the attacks of the individual instruments seldom coincide exactly and the system usually remains unbeaten. The processing of the directional information thus mainly consists in heavily weighting the initial transients of signals.

One advantage of separating the directional from the main signal is that the latter signal can be obtained from one or more microphones independently of the directional signal, and so can be made more compatible.

Some attention was given to the possibilities of stereophonic sound in television. This is surprising since in this case the widest possible sound source corresponds to the widest possible picture so that little benefit would seem to be obtainable from stereo in home viewing even considering large projection models. The difficulty of changing the apparent sound field to correspond with every change in the field of view is also obvious.

Pickup Design.—Two lesser-known but still very important sources of distortion which apply equally well to monophonic or stereophonic pickups were discussed in a paper by D. G. Jaquess relating to the Decca stereo pickup. These sources of distortion are, first, impacts between the stylus and groove when vertical groove motions are not satisfactorily traced (which cause most of the wear on the record), and secondly, longitudinal stylus movement in the direction of the unmodulated groove.

The reasons for using two balanced pairs of magnetic gaps in the design of variable-reluctance stereophonic pickups were discussed in a paper by S. Kelly. If each magnetic gap between the moving armature and a fixed pole piece is not balanced by a corresponding gap on the other side of the armature, then, as the side thrust varies across the record due to changing tracking error and frictional force in the modulated groove, the lengths of the unpaired gaps will alter so as to alter the relative sensitivities of the two channels. The sensitivity of at least one of the channels will for a similar reason vary with the playing weight, though for gap lengths parallel to the two modulation directions this will not affect the relative sensitivities of the two channels. Another

(*Continued on page* 241)

disadvantage of an unbalanced gap system is that induced hum cannot be cancelled by suitably winding two separate coils for each channel.

An interesting sidelight on the hazards of pickup manufacture mentioned by P. Wilson in the discussion is that the rejection rate is about 75% for the coils of two American pickups using 54 and 56 gauge wire.

Four-track Tapes and Cartridges.—Two important disadvantages of tape relative to disc—its higher price per reproducing time (particularly for stereophonic tapes) and the inconvenience of threading it on to the tape deck—have both been tackled recently in America. Some of the results were described in papers by A. D. Burt and D. R. Andrews and also by Dr. G. F. Dutton. The price per time of tape has been reduced both by using four instead of two tracks across the ¼in width and also by halving the speed to 3¾in/sec. To secure the same response at high frequencies at 3¾in/sec as at 7½in/sec the effective gap length of the reproducing head must be halved down to about 10^{-4}in, but this can be achieved.

To keep losses caused by spacing of the tape from the replay head due to the tape roughness to an acceptable value the tape must be made smoother. Smoother tape (and also greater freedom from dropouts) are also necessary to allow the halved wavelengths at the slower speed to be recorded satisfactorily. The allowable angular azimuth error of the gap length direction is proportional to the recorded wavelength divided by the linear error along the tape between the two sides of the gap, i.e., this error is proportional to the tape speed divided by the track width, and thus remains unchanged. In stereophonic reproduction crosstalk problems are reduced by staggering the four tracks so that no two stereo tracks are adjacent to each other. The signal-to-noise ratio tends to deteriorate when four rather than two tracks are used since the signal is proportional to the number of magnetic particles, i.e., the tape width, and the noise is more nearly proportional to the square root of the number of magnetic particles. An increased recording emphasis at frequencies near the region of maximum hearing sensitivity has been suggested as a method of reducing the apparent signal-to-noise ratio. According to Dr. G. F. Dutton however, results on orchestral output spectra show that peak signal levels in this region can only be increased by about 4dB or less before overloading occurs.

The slower speed also increases the difficulty of making the transport mechanism sufficiently free of wow and also (particularly) of flutter. For example, a slipping clutch providing take-up tension tends to be jerky and produce longitudinal oscillations of the tape. The flutter produced by such oscillations will be more serious at the shorter wavelengths recorded at the slower speed. The inertia of a given capstan which tends to smooth out irregularities in the tape motion will be quartered at the slower speed. The wow and flutter for the R.C.A. 3¾in/sec tape cartridge on its deck was quoted as about 0.3%.

Easier handling of the tape has been achieved in a number of ways. For example, half loops at the ends of the tape are automatically caught and pulled through the transport mechanism in a development of the Armour Research Foundation of America. The paper by A. D. Burt and D. R. Andrews described the R.C.A. cartridge. In this the tape is enclosed in a plastic container which can be readily slotted into its correct playing position on the tape deck. Thus the cartridge can be removed even when the tape is only partially played through, and a particular tape cannot be "lost" by being transferred on to another reel by mistake. The two hubs carrying the tape before and after playing do not have any flanges on them at the side of the tape so that the whole space between the hubs can be filled with tape throughout the playing time. Windows in the cartridge allow the amount of tape which has been played to be seen. The tape is secured by a loop at each end which slips over a peg on each hub. At the end of each reel the change in the position of the end of the tape as the peg completes its last revolution can be used to actuate a trip mechanism to stop the tape or reverse it and replay on another track. Interlocks (which can be removed) between the transport mechanism and cartridges carrying pre-recorded tapes prevent such tapes from being accidentally erased.

Is Stereo Worth While—Dr. W. S. Percival was brave enough to give an opinion on this question. With both stereo and mono reproducers their value increases proportionately to their price at low price levels but tends to flatten out to a constant value at high price levels. At first the value for money increases more rapidly with single-channel than with stereo reproducers. The maximum attainable value is, however, greater with stereo so that at some point the value-for-money curves cross for the two types of reproducer. Dr. Percival would not, however, commit himself as to what price this occurred at!

New Range of Kits

ITEMS from the American Heathkit range are becoming available in this country from Daystrom, Ltd., of Gloucester. Kits already obtainable from the audio range include two stereo combined amplifiers and pre-amplifiers, a loudspeaker system and two transistor receivers, and from the test and measuring gear range an oscilloscope and valve voltmeter. A kit for an amateur 40-W transmitter covering the 80, 40, 20, 15 and 10 metre bands is also available. Forthcoming kits will include an R-C bridge, audio oscillator, wattmeter, sensitive a.c. valve voltmeter and low-level stereo pickup and tape head amplifier.

The S-88 stereo combined amplifier and pre-amplifier incorporates two 8-watt ultra-linear push-pull output stages using ECL82 triode pentodes. A low-pass filter cutting off at a rate of about 18dB per octave above 4, 8 or 12kc/s can be switched in. A balance control with a range of ± 4dB is incorporated, and the two stereo signals can be interchanged. Similar facilities are provided in the S-33 amplifier kit, except that there is no low-pass filter, and the output uses two EL84s in single-ended ultra-linear stages to give 3 watts per channel.

The UXR-1 transistor receiver kit covers the medium and long-wave bands and uses six transistors. A push-pull output stage feeds a 7-in × 4-in loudspeaker. The UJR-1 kit is intended for beginners and also covers the medium and long-wave bands. It uses a single transistor (with reaction) to feed headphones with an impedance between 2 000 and 4,000 ohms.

The 0-12U 5-in oscilloscope kit has a maximum Y-amplifier sensitivity of 14mV/cm and a frequency response flat within 1dB from 8c/s to 2.5Mc/s. An X-amplifier with a maximum sensitivity of 170mV/cm and a response flat within 1dB from 1c/s to 200kc/s is provided, or, alternatively, a time base with a repetition frequency variable from 10c/s to 500kc/s is available.

The V-7A valve voltmeter can measure alternating or direct voltages (1.5V to 1,500V f.s.d.), resistances (0.1Ω to 1,000MΩ) and power ratios. The input impedance is 11MΩ on the d.c. ranges, and the frequency response on the a.c. ranges within 1dB from 40c/s to 7Mc/s.

MAVARS

By "CATHODE RAY"

ANOTHER KIND OF QUIET MICROWAVE AMPLIFIER

YES, I know they are usually called parametric amplifiers, but that is an octosyllabic mouthful, liable moreover to be confused by the quick reader with paramagnetic amplifiers, which could be parametric or on the other hand could be the crystal maser described last month or in fact something altogether else. So I prefer the title given in America* MAVAR, meaning "Mixer Amplification by Variable Reactance." Except that as I abhor the term "mixer" for a modulator or frequency changer I make the "m" stand for "microwave," as in "maser," even though in theory the mavar could be used for other waves.

If you are thinking that "maser" and "mavar" sound like twins, that is all to the good, because it quite rightly suggests some likeness between the devices so named. They both amplify, and both yield a much better signal/noise ratio than conventional amplifiers, enabling weaker signals to be effectively received. This is most valuable at the very high frequencies called microwaves—wavelengths of a few centimetres or millimetres. Both kinds of amplifier tend to be sharply tuned, unlike travelling-wave tubes, which cover a wide frequency band.

Amplification in Masers

In the maser, the amplification comes from the release of energy when atoms or molecules drop back from an "excited" or energized state to their normal state, in response to stimulation by the weak signal. The frequency at which it amplifies is determined by the energy difference utilized; in the ammonia maser this is fixed by Nature, making it a very precise and reliable frequency standard; but in the more practical cold-crystal or solid-state maser it can be varied by a magnetic field. The basic principle of the mavar is completely different. and while its chief application is in the microwave band and one variety makes use (like one variety of maser) of electronic spin in paramagnetic atoms, these resemblances are coincidental rather than essential.

The solid-state maser, as we saw, is almost unbelievably simple for the highly sophisticated apparatus it is—just a special kind of crystal stuck in a metal box at the end of a waveguide, tuned by a magnet and cooled by liquid helium or oxygen. The difficulty lies in understanding exactly what goes on in the crystal, because it involves rather advanced knowledge of atomic structure and behaviour. The general idea of energy lifts and drops in an atom is not too hard to grasp, however.

The general idea of the mavar is also simple, but its working is not at all easy to visualize clearly. I have been finding it a severe test of my doctrine that anything which can be dealt with mathematically can be explained to the non-mathematical by analogy, diagram or model. And yet it involves no recondite concept such as ψ waves; only straightforward basic circuit theory.

Briefly, a mavar is like the frequency changer in a superhet, except that (a) the local oscillator varies a reactance instead of a resistance, and (b) amplification takes place without change of frequency.

Fig. 1 is a circuit diagram of a simple frequency-changer stage as used in many receivers, especially for radar. Currents of two different frequencies, due to incoming signal and local oscillation, are mixed by coupling them into the same circuit. If everything in that circuit were linear, no signal at any other frequency would appear. Merely mixing is not enough. Hence my dislike of the name "mixer" for an arrangement in which the key component is the crystal, Cr, which is essentially a non-linear resistor—i.e., one whose current/voltage graph is not a straight line, so that its resistance varies with the current through it or voltage across it, contrary to Ohm's law.

Ohm's law or not, the current through a resistor is equal to the applied voltage divided by the resistance (at that voltage). Alternatively—and in what follows we shall find it simpler—the current is equal to the voltage multiplied by the conductance. Either way, if the resistor is linear the resistance and conductance are constants, so the current has exactly the same waveform and mathematical form as the voltage. If the voltage has two frequencies, the current has two and only two.

Let us call the voltage at any instant v, and suppose it consists of two frequencies (oscillator and signal) f_o and f_s, with peak amplitudes V_o and V_s. For brevity we use the usual symbol ω for $2\pi f$, and have

$$v = V_o \sin \omega_o t + V_s \sin \omega_s t \quad \ldots \quad \ldots \quad (1)$$

If we multiply this by a constant conductance G,

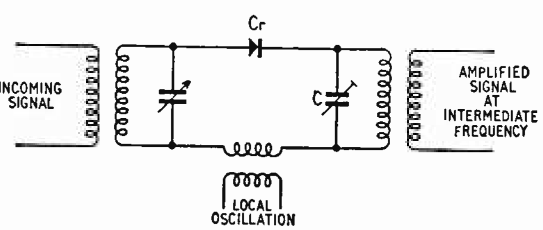


Fig. 1. Simple frequency changer circuit, in which the crystal diode, Cr, is essentially a non-linear resistor. If a non-linear reactor is used instead, the system is nearly a mavar.

then the result (the current, i) obviously has the same form.

But now let us suppose that the conductance depends on the voltage. In a diode, for example, the conductance is less than the average during the negative half-cycles and more during the positive half-cycles. A simple case would be one in which the conductance was equivalent to a fixed amount, G_o, plus

* "The Mavar: A Low-Noise Microwave Amplifier," by Samuel Weber, *Electronics*, 26th Sept. 1958, pp. 65-71.

an amount varying in proportion to the voltage, vG. The whole conductance is usually denoted by a small letter to show it is variable:

$$g = G_o + vG$$

And, since $i = vg$,

$$i = v(G_o + vG) \quad .. \quad .. \quad (2)$$

We have already written out v in full (1), so we can fill it into (2) to obtain

$$i = (V_o \sin \omega_o t + V_s \sin \omega_s t) [G_o + (V_o \sin \omega_o t + V \sin \omega_s t)G] \quad .. \quad .. \quad .. \quad .. \quad (3)$$

If you are one of those who can only tolerate trigonometry in very small doses there is no cause for alarm, for all you are being asked to do is take note of the fact that this expression inevitably involves $\sin \omega_o t \times \sin \omega_s t$. And if you look up any list of trigonometrical formulæ you will find that this (usually in the form sin A sin B) is equal to a half of $[\cos (\omega_o - \omega_s) t - \cos (\omega_o + \omega_s) t]$. (The appearance of cos instead of sin, and a minus sign between them instead of a plus, signifies no more than the phase relationship; they are still, with reference to a suitable starting point, sine waves.) So we have two new frequencies, equal to the difference and sum of those put in, and can take our pick of them for the i.f. signal, by tuning to it by means of C in Fig. 1.

Incidentally, anyone who might feel like working out (3) in detail but who doesn't want unnecessary work can take advantage of the fact that V_s is usually so small compared with V_o that its effect on g is negligible, and so the second occurrence of $V_s \sin \omega_s t$ in (3) can be omitted without much error. The sum and difference frequencies still come.

Those who are completely allergic to any sin-and-cos at all can convince themselves of at least the production of the difference frequency by a diagram such as Fig. 2, which is a typical current/voltage characteristic of a diode. The input voltage waveform is drawn on end, below, with the signal frequency exaggerated in amplitude to show it up clearly. Being different in frequency from the oscillation, it alternately strengthens and weakens it, giving the phenomenon known as beating. The beat frequency is equal to the difference between the two input frequencies, but there is no voltage at the beat frequency. All the positive half-cycles in one whole beat are nullified by negative half-cycles. Nor, if this voltage were applied to an ordinary resistor, represented by a straight-line graph, would there be any beat-frequency current to use as an i.f. signal. But when applied to a diode the negative half-cycles are suppressed as shown, and the current averages to give a beat-frequency component, shown dotted. There is also a sum-frequency current, but it is masked from sight by the currents at the original frequencies.

Let me emphasize again that the reason for the production of sum and difference frequencies is that the conductance of the diode depends on the applied voltage, as shown one way in Fig. 2 and another way by $g = G_o + vG$. Actually the conductance in Fig. 2 would not follow such a simple formula, but the principle is the same.

I have recapitulated the elementary principles of frequency changers at length, well known though they must be to all radio students, because the likenesses and differences of the mavar will be clearer if this basis for comparison is fresh in the mind. The mathematical treatment is bulkier but no more difficult in principle than what we have just gone through.

The difficulties begin when we try to visualize what is happening. Directly we substitute a reactance for the diode we rule out the Fig. 2 kind of diagram, which only works when current and voltage are in phase. If it were an ordinary constant reactance, then vector diagrams would come to our aid. But if you

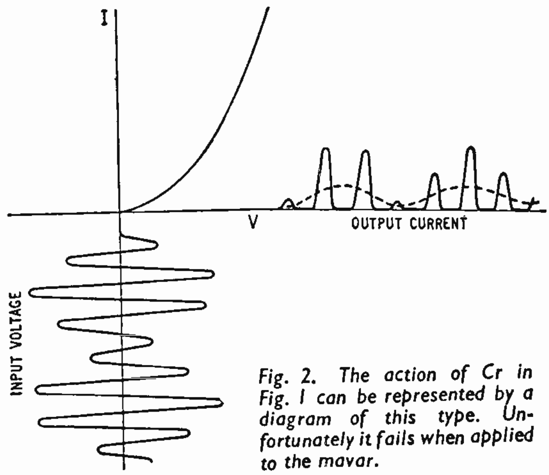


Fig. 2. The action of Cr in Fig. 1 can be represented by a diagram of this type. Unfortunately it fails when applied to the mavar.

can make a vector diagram work satisfactorily for a circuit in which the reactance is a function of the voltage you are a better man than I.

The reason for wanting some sort of visual aid perhaps more than usual is that the story told by the mathematics is something we should probably never have expected. And if you are one of the types who regard all mathematical results with suspicion until supported by clearer evidence you may even have some difficulty in believing it.

Negative Resistance

The mathematical result in this case is that if the usual non-linear resistance of the simple additive frequency changer is replaced by a reactance, it looks to the signal like a negative resistance. In other words, power finds its way from the local oscillator into the signal, *at the frequency of the signal*, and in proportion to the *signal* voltage. In still other words, the signal is amplified, without change of frequency, and the power for doing this comes from the local oscillator, working at a different frequency. As we shall see, this result is not absolutely inevitable—certain conditions have to be fulfilled—but that it should happen at all is surely interesting enough to stimulate investigation.

Either inductive or capacitive reactance can be used, but I think capacitive is better for a first study, because the simplifying assumption that it is free from resistance is very nearly true of familiar capacitors. It also offers better possibilities for mechanical models, real or imaginary. What may take a little more getting used to is capacitance that varies according to the voltage across it. (Inductance that varies with the current through it is only too familiar.)

The basic fact about capacitance is that it is a measure of the amount of electric charge a given voltage can store. Just like, in fact, the size of a tyre

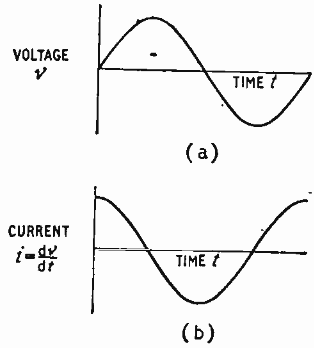


Fig. 3. Showing how the current through a capacitive reactance can be derived graphically from the voltage.

or balloon, where the charge is air and the voltage is pressure. In symbols:

$$Q = CV \quad .. \quad .. \quad (4)$$

This says that the charge is directly proportional to both voltage and capacitance. We are quite used to applying varying voltages to capacitors, but usually their capacitances are constant. So the effects of variable capacitance are less familiar, except perhaps to specialists such as engineers of the Compton Organ Co., who do exactly the reverse of most of us—vary C sinusoidally while keeping V constant. The result is the same, however.

It is unfamiliarity with this, presumably, that gives rise to the question with which successive generations of students try to baffle their teachers: If a capacitor is charged and then dismantled, what happens to the charge (and its energy)? It is assumed that the insulation of the plates is maintained. The charge, Q, therefore remains; and, in so far as C is reduced by the dismantling, V rises. For proof, see (4). This is the basis for the "Cathode Ray" voltage raiser, proposed in the May 1950 issue. (No doubt lots of other people proposed it centuries ago, so don't write in to tell me.)

Current Flow

Now of course a charge in motion is a current, so if one varies either V or C (but not both at once in opposite directions so that V × C is constant) a current must flow in and out. Expressed more precisely, and using small letters to indicate variables:

$$i = \frac{dq}{dt}^{\star}$$

If C is constant, then q (= Cv) varies at C times the rate that v is varied. So we have

$$i = C\frac{dv}{dt}$$

Supposing v is our usual sine wave, V sin ωt:

$$i = C\frac{d\,(V \sin \omega t)}{dt}$$

Fig. 3(a) shows a single cycle of v, and underneath at (b) is drawn a curve showing the rate at which v is varying. It is easily derived from (a); for example, v increases fastest at the start, making dv/dt a positive maximum; it isn't varying at all at the peaks, so then dv/dt is zero; and so on. It is, in fact, a cosine wave. The well-known calculus result is $d(V \sin \omega t)/dt = \omega V \cos \omega t$. And the capacitive current is proportional to this, as we have just seen, so

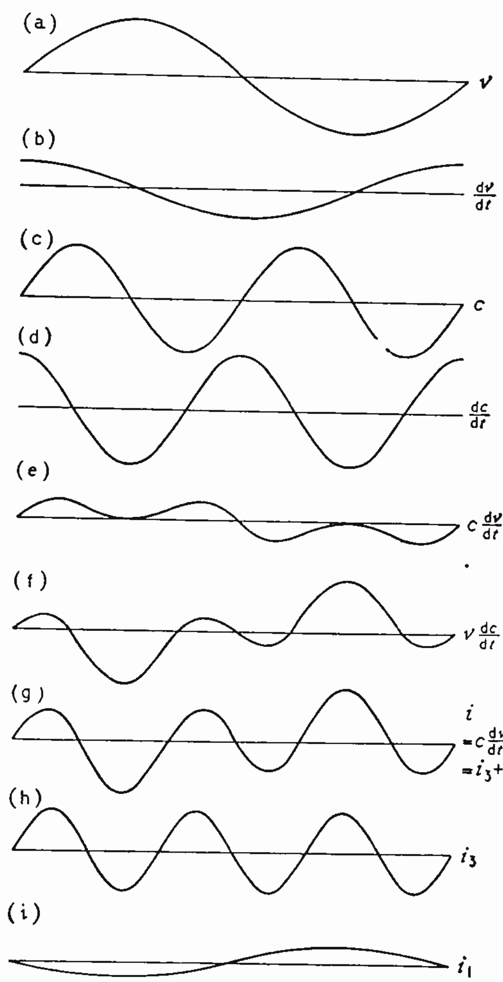
$$i = \omega CV \cos \omega t \quad .. \quad .. \quad (5)$$

which is the same waveform as v but advanced quarter of a cycle in phase. That is the familiar fact of a.c. theory, commonly expressed by showing a current vector leading a voltage vector by 90°. We are familiar, too, with the fact that when you multiply i by v to find the power you get a positive product during the first and third quarters of the cycle, when v is charging C, and an exactly equal negative product during the second and fourth quarters, when C is discharging back into the source. The net power either way is therefore nil.

Again, we have gone through all this old stuff

*If, most regrettably, you are unfamiliar with the differential calculus, there is no need to be dismayed by the appearance of $\frac{dq}{dt}$, which is simply a short way of saying "the rate of change of charge with respect to time" or "the slope of a charge/time graph."

Fig. 4. These waveforms represent: (a) the applied signal voltage v; (b) the slope of (a), which could represent the current driven v through a constant capacitance; (c) the variation of the capacitance due to the pump oscillator, working at twice the frequency of v; (d) the slope of (c); (e) current due to v applied to the variable capacitance (c), found by multiplying (b) by (c); (f) current due to variation of (c) with v applied, found by multiplying (a) by (d); (g) total current, equal to (e) plus (f); (h) triple frequency part of (g); (i) the part of (g) at same frequency as (a), and in opposite phase, signifying negative resistance.



for the sake of comparison with the less familiar case of capacitance varying and voltage constant. If we make c vary in the same way as v did ($c = C \sin \omega t$) then obviously the result is the same except for interchange of V and C, which as (5) shows makes no difference at all.

It is quite interesting to realize that precisely the same current-making result can be obtained by varying capacitance exposed to a constant voltage as by varying voltage across a constant capacitance. Note in particular that there is no net transfer of power.

But in a mavar both vary at once, just as both voltage and conductance vary at once in a frequency changer. What makes the mavar a little more complicated is that what we are interested in is not just the product of two varying quantities (as in $i = vg$ for the frequency changer, or $q = cv$) but their slope or rate of change. We have found that, when v alone is varying the current is $c\,dv/dt$, and when c alone is varying it is $v\,dc/dt$, so when both are varying:

$$i = c\frac{dv}{dt} + v\frac{dc}{dt} \quad \ldots \quad \ldots \quad (6)$$

As before, let us make our signal voltage

$$v = V \sin \omega_s t$$

We know that

$$\frac{dv}{dt} = \omega_s V \sin \omega_s t$$

And, as we did with g, we can make c consist of a constant part, C_0, and a part varying at the frequency of the local oscillation:

$$c = C_0 + C \sin(\omega_0 t + \theta)$$

The θ denotes the phase difference, if any, between the two voltage waves. The rate at which C_0 varies being obviously nil,

$$\frac{dc}{dt} = \omega_0 C \cos(\omega_0 t + \theta)$$

Filling these into (6) and working out how much current there is at each frequency we have

$$\begin{aligned} i &= \omega_s C_0 V \cos \omega_s t + \omega\, CV \sin(\omega_0 t + \theta) \cos \omega_s t \\ &\quad + \omega_0 CV \sin \omega_s t \cos(\omega_0 t + \theta) \\ &= \omega_s C_0 V \cos \omega_s t + \frac{\omega_s CV}{2} [\sin(\omega_0 t + \theta + \omega_s t) \\ &\quad + \sin(\omega_0 t + \theta - \omega_s t)] \\ &\quad + \frac{\omega_0 CV}{2} [\sin(\omega_s t + \omega_0 t + \theta) \\ &\quad + \sin(\omega_s t - \omega_0 t - \theta)] \\ &= \omega_s C_0 V \cos \omega_s t + \frac{CV}{2} [(\omega_s + \omega_0) \sin(\omega_0 t + \theta \\ &\quad + \omega_s t) + (\omega_s - \omega_0) \sin \\ &\quad (\omega_0 t + \theta - \omega_s t)] \quad \ldots \quad (7) \end{aligned}$$

The first term of the final result is of course the current that v would cause if the capacitance consisted only of C_0. The "cos" indicates that it is 90° out of phase, dissipating no power.

The first of the two terms in the square bracket represents the "sum" frequency current, and the second the "difference" frequency. If we assume $\theta = 0$, then (remembering that $\sin - x = -\sin x$) whatever frequencies are chosen the first term must be positive and the second negative. This means

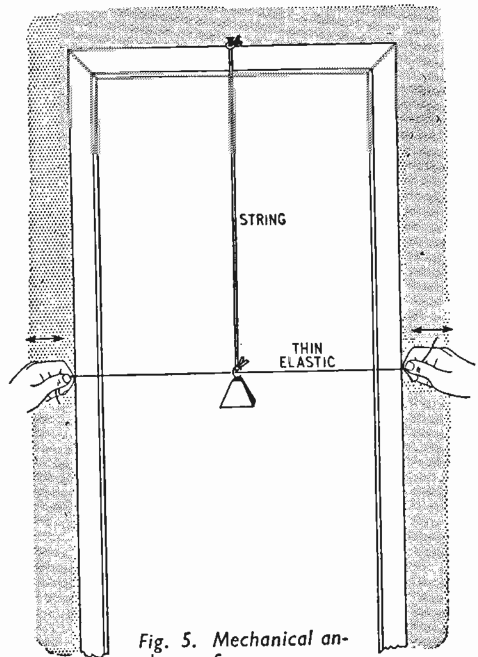


Fig. 5. Mechanical analogue of mavar.

that the sum-frequency current is a positive sine wave and would draw power from a sine voltage at that frequency, but the difference frequency is a negative sine wave so would deliver power to a sine voltage at that frequency. If we choose our frequencies so that $\omega_0 - \omega_s = \omega_s$ (i.e., $\omega_0 = 2\omega_s$) then the second term simplifies to $-\omega \sin \omega_s t$, indicating power flowing into the signal. Which, as Euclid said, *erat faciendum*, meaning it's just the job.

That is why in mavars the local oscillator, colloquially termed the pump, usually works at twice the signal frequency. The closer scrutiny we shall later give (7) will show that this is not the only possible useful frequency, but it will do to be going on with.

Graphical Illustration

Meanwhile we must do our best for those who find purely mathematical treatment obscure or unconvincing. We can, with a bit of an effort, accomplish the same thing less precisely but more graphically by drawing waveforms. In Fig. 4 (a) is one cycle of the applied voltage v—a sine wave. Next, at (b), is a graph of the slope of (a), dv/dt—a cosine wave. (c) represents the variable part of c—a double sine wave, because the pump frequency is twice the signal frequency. Next, at (d), comes dc/dt—a double cosine wave. The part of the current due to variation of v—$c\,dv/dt$—is got by multiplying (b) by (c), and is shown at (e). And the part due to variation of c, which is (a) multiplied by (d), appears at (f). Finally, the complete current is obtained by adding (e) to (f), as at (g).

This appears pretty clearly as a mixture of a sine wave of three times the frequency of (a), starting in phase with it, and a sine wave of the same frequency as (a), but opposite in phase. They are shown separately at (h) and (i). Because (h) is different in frequency from the voltage (a), it conveys no net power—its single half-cycle of current in opposition to the voltage half-cycle exactly balances its two half-cycles in the other direction because it comes near the voltage peak. But (i) is always *into* the voltage source, feeding it with power.

Any to whom even this procedure smacks too much of maths and who are more mechanically minded may like to try the following. Take a weight, say 1 lb, and suspend it by about 4 ft of string from the centre of the lintel of an open doorway, preferably one not in frequent use (Fig. 5). Attach the middle of a piece of thin elastic (or the ends of two pieces) to the weight. Standing on the side away from the door, hold one of the free ends in each hand. Now set the weight swinging towards and away from you and then rest your hands on the door posts. The swinging will gradually die out like the pendulum of an unwound clock. But if you alternately increase and decrease the stretch of the elastic by moving your hands away from and towards the weight, at twice the frequency of the weight's swing and in phase with it, you should with a little practice be able to keep the weight swinging indefinitely (which means until you get tired). You must not cheat by moving your hands other than strictly at right angles to the direction of swing. If the elastic is kept in contact with the

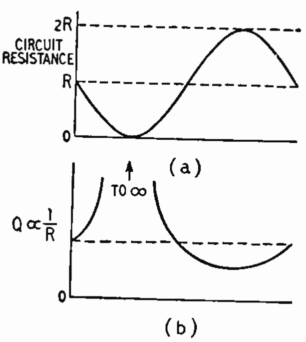


Fig. 6. If the r.f. resistance of a circuit, R by itself, is periodically varied by a mavar from 0 to 2R as shown at (a), the Q of the circuit is affected as shown at (b), which results in net amplification.

door posts, even the most sceptical should be convinced that power is being fed in by periodical variation of mechanical capacitance (which is the compliance of the elastic). The constant and greater part of this capacitance is due to gravitational pull on the weight. The velocity of the weight represents i, and the pull on the weight due to gravity and elastic represents v.

This helps to explain how in both electrical and mechanical systems having reactance which depends on voltage or stress there sometimes occur subharmonic oscillations (frequencies *lower* than one would expect). Loudspeakers, for example. This is quite a big subject in itself, so the brief hint must suffice, while the attention of the trigonometrists is directed back to equation (7).

If $\theta = \frac{\pi}{2}$ (which is 90°) then, since $\sin\left(x + \frac{\pi}{2}\right) = \cos x$, the whole current becomes "wattless." When θ is increased to π, the difference-frequency term represents power taken instead of given. If the pump is not synchronized with the signal, so that θ continuously drifts on, the signal circuit gets on the average as much positive resistance as negative, which (it might seem) would do the signal no good. Fortunately this is not so, for the signal amplitude is proportional to Q or 1/R; consequently a given amount of negative resistance builds up the signal more than the same amount of positive resistance damps it down. Suppose the resistance of the signal circuit without benefit of mavar was R ohms, and that owing to lack of synchronism the resistance contributed by the mavar alternated slowly between +R and −R. The +R could do no worse than halve the signal amplitude, but the −R would eliminate all circuit resistance and start the signal building up towards infinity, as shown in Fig. 6. The signal would of course be amplitude-modulated at the frequency by which the pump oscillator was straying from exact synchronism with twice the signal frequency.

Other Pump Frequencies

For microwaves, this need for the local oscillator to be twice the signal frequency is likely to be a nuisance. Although the simplified way in which we have looked into the mavar principle doesn't directly show it, the fact remains that other frequencies—including lower ones than the signal—are possible. Equation (7) does show that there is an opposite-phase current at the difference frequency, no matter what ω_0 may be in relation to ω_s. So far, we have considered only the special case in which $\omega_0 = 2\omega_s$, so that $\omega_0 - \omega_s = \omega_s$. When $\omega_0 - \omega_s$ is something different, say ω_i, a resistive so-called idling circuit must be provided for this current to flow in. Its flow there sets up a voltage at the same frequency across the reactance, and that, in combination with the pump voltage, results in a current into the signal circuit.

In some experiments by Chang and Bloom, their choice of frequencies (in Mc/s) was $f_s = 380$, $f_0 = 300$, and $f_i = 220$. Twice f_0 (produced as a harmonic by the non-linearity of the reactance) minus 220 yields f_s. In their work they used a germanium diode as the varying capacitance. (Its use for a.f.c. has already been described in *Wireless World*—by G. G. Johnstone, August 1956, p. 354.)

The original mavar made use of electronic spin in paramagnetic crystals to vary inductance, in a rather similar way to the 3-level maser described last month. But it needs such an enormous amount of pump power (20 kW has been mentioned!) that the whole thing is in danger of going up in smoke. The diode scheme, which needs only milliwatts, looks much more practical, though there may well be doubts about the higher frequencies. Still another, and again remarkably different, method of putting the mavar principle into action is by means of varying space charges in a tube. This arrangement, the precise functioning of which does not exactly leap to the mind's eye, has been developed by the Zenith Radio Corporation of America and was described on the Technical Notebook page in the November 1958 issue.

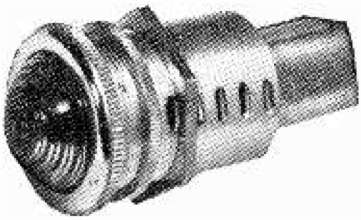
Although a noise figure of 1 dB is claimed for this tube, the tendency is for mavars to be nearer the 3-4 dB mark—not so quiet as masers with their liquid helium, but markedly better than conventional amplifiers. Besides avoiding extreme refrigeration, mavars also handle much more power than masers. So we are likely to hear quite a lot more about them. Why (you are asking) are they so quiet, in spite of working at room temperature? Because the business part of the device is a reactance, which being non-resistive doesn't generate thermal noise.

Manufacture 's' Products

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

Versatile Signal Lamp Fitting

A NEW signal lamp fitting possessing a number of novel features is the new Bulgin model D788. It fits panels up to 0.5in thick, can be supplied to take a wide variety of British or American indicator and signal lamps, filament or neon in bayonet or screw types; the lamp socket is adjustable for depth within the body and the lamp can be renewed from either the front or the rear. The front bezel can be either plastic or metal. It fits into a $1\frac{1}{32}$-in diameter panel hole.



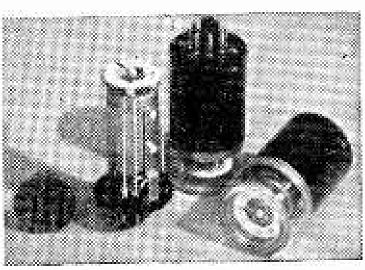
Versatile Signal and Indicator Lamp (Bulgin).

The front lens, which is nearly 1in in diameter, can be either plastic or glass, in the former material it can be either transparent or translucent but in glass only transparent lenses are available. In either material there is the choice of five colours.

The makers are A. F. Bulgin and Co., Ltd., Bye Pass Road, Barking, Essex.

Measuring Relays

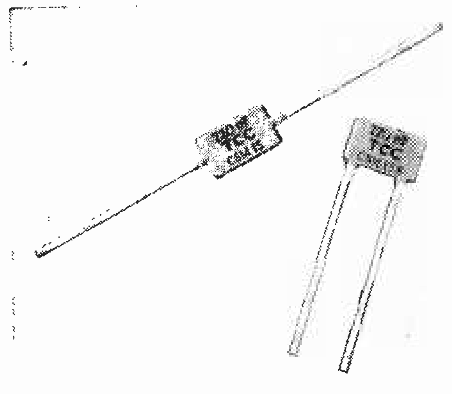
FRENCH Leland Leroux "Sensitact" relays are now available in England. Each relay consists of a screened moving-coil galvanometer with pointer and contact attached, and two separate contacts adjustable over the full range of the scale provided. Sixteen models are available with full-scale deflections ranging from 10mA down to 0.02mA. For the most sensitive model the minimum change of control power necessary to make or break contact is about 0.05μW; the maximum power which can be handled by the contacts in all models is 200mW. The response time is from 0.1 to 0.2 seconds, depending on the positions of the adjustable contacts. The cost of these relays ranges from £13 10s to £15, and they are available in this country from Leland Instruments, Ltd.. 22-23, Millbank, London, S.W.1.



Leland Leroux "Sensitact" measuring relays.

Miniature Silvered Mica Capacitors

THE new range of protected miniature silvered mica capacitors recently introduced by the Telegraph Condenser Co. Ltd., North Acton, London, W.3, measure only $\frac{7}{16} \times \frac{1}{4} \times \frac{3}{32}$in, yet the rated working voltage is 350 d.c. and the test voltage 1,000 d.c. The range covers capacitances of 10pF to 220pF with tolerances of from 1% to 20% as required. These capacitors have a power factor of less than 20×10^{-4} at 1Mc/s and a temperature coefficient of +5 to +50 parts per 10^6 per degree C over the temperature range -70°C to $+100$°C and the insulation resistance is better than 10^5MΩ.



New miniature T.C.C. silvered mica capacitors Types CSM15 (end connections) and CSM15s (side connections).

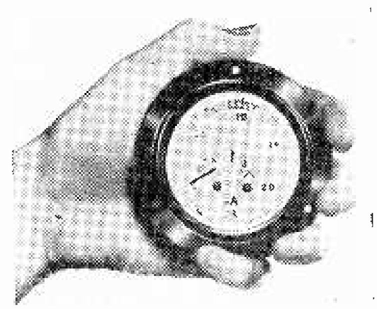
The new capacitor is available in two styles, one, the CSM15, with flat end-connecting strips and the other, CSM15s, with side-entry connections.

Miniature Long-scale Meters

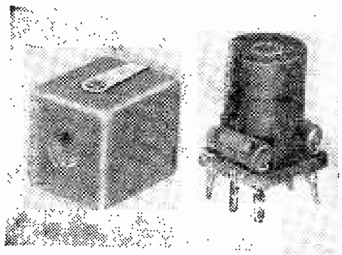
A RANGE of small, flush-mounting, moving-coil measuring instruments, based on the design of the well-tried Crompton Parkinson industrial switchboard meters, has been introduced for use in electronics, telecommunications equipment and test gear. These have pointer rotations of 240° and are available with 2-in or $2\frac{1}{2}$-in diameter dials and assembled in either moulded-plastic or die-cast metal cases, the latter being a sealed type conforming with the requirements of British Draft Defence Specification 62.

The $2\frac{1}{2}$-in models provide a scale $4\frac{1}{4}$in long, while that of the smaller meter is $3\frac{1}{8}$in. The range includes d.c. microammeters, milliammeters, ammeters and voltmeters, also a.c. milliammeters and voltmeters, the resistance of voltmeters being 1000Ω/V.

In a flush-mounting moulded case a 0-200 d.c. micro-



Crompton Parkinson 240°-scale moving-coil milliammeter in moulded case.



Left: Neosid miniature pot-type coil, shown with screening can removed.

Hermetically sealed "Transipack" d.c. convertor using semiconductors.

Above: Fane Acoustics bass loudspeaker.

ammeter costs £4 5s for 2in or $2\frac{1}{2}$in size, and in sealed metal case £5 18s and £6 3s respectively. A 0-400 volt d.c. meter (moulded case) costs £5 3s 6d in $2\frac{1}{2}$in size. In 2-in size the highest range is 0-200V. A.C. meters cost about 12s more.

The makers are Crompton Parkinson Ltd., Crompton House, Aldwych, London, W.C.2.

Miniature Toroidal and Pot-Type Coils

COILS wound on miniature dust-iron toroids down to 2mm in outside diameter can now be supplied by Neosid to special order. They are primarily intended for computor equipment and these tiny coils can be machine-wound with up to 150 turns of No 47 s.w.g wire and even more by hand winding. A screwed slug in the toroidal core provides about 10% variation in inductance.

Some very small pot-type coils in $\frac{1}{2}$-in square screening cans for transistor and printed circuit applications are also new.

As shown in the illustration two tiny fixed capacitors can also be included in the assembly. Qs of 200 are readily obtained with coils or transformers for use up to 4Mc/s and with inductance values of up to 11mH, while a Q of 100 is realizable at 20Mc/s. A limited variation in inductances is provided by a slug in the centre of the pot core.

Further details can be obtained from Neosid Ltd., Stonehills House, Howardsgate. Welwyn Garden City,

"Transipack" Convertors

THESE are semiconductor h.t. supply units intended primarily for operating portable and mobile electronic and communications equipment from low-voltage batteries, such as 6 to 28 volts. They are available as hermetically sealed units, as illustrated, or housed in orthodox screening cases, and the range includes a miniature model of about 2 watts rating as well as one of the order of one kilowatt.

A typical sealed unit for 12-volt operation giving 300 volts d.c. output at 30 watts costs about £20. It measures approximately $2\frac{1}{4}$in x $2\frac{3}{8}$in x 3in and weighs about $11\frac{1}{4}$lb.

An unsealed unit, the Model 707, provides a d.c. output variable in 50-volt steps from 50 to 550 volts and with a rating of 30 watts. This model has a tapped toroidal transformer and is claimed to have an efficiency of 85%. It measures $4\frac{7}{16}$in x $2\frac{7}{16}$in x 1in, weighs 11lb 15oz and costs £12 3s.

The makers are Transipack, 29 Burnt Ash Hill, London, S.E.12.

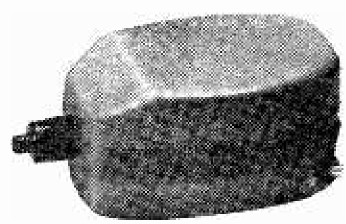
Bass Loudspeaker

ALTHOUGH developed primarily as a replacement for the bass loudspeaker originally used in their "Quartet" 4-speaker system (see Dec. 1958 issue, p. 607), the Fane Acoustics 12-in H.D. unit is also available separately.

It has a smooth response from 30 to 4,500c/s with a gradual roll-off beyond, and a maximum input power rating of 20W (continuous). The total flux is 160,000 lines; the flux density being 12,000 gauss and the voice-coil diameter 2in. The cone is curved-sided and is reinforced by a double roll at its junction with the foam plastic surround to inhibit bell-like vibrations. The cost of this speaker is £9 (not liable to purchase tax), and it is manufactured by Fane Acoustics, Ltd., Batley, Yorkshire.

Tape Bulk Eraser

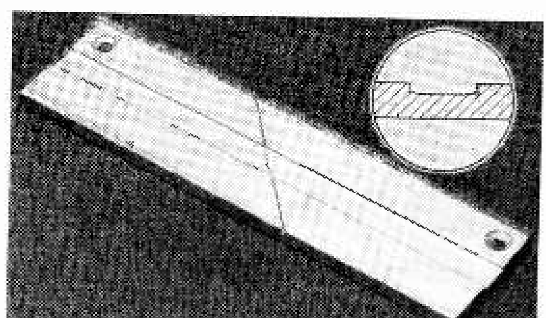
AN a.c. mains energized coil is wound on the centre limb of an E-shaped core to provide the magnetic field for the "Instant" eraser. The push-button switch is depressed and the dimpled side of the eraser passed over the entire area of both sides of the tape reel. The eraser is then removed some way from the reel (to allow the erasing field to decrease gradually) and the push-button allowed to spring back. Erasure of the tape is then complete. Reels should not be erased *in situ* on recorders with magnetic chassis as so much flux may be diverted through the chassis as to give incomplete erasure. This eraser costs 27s 6d and is available from Osmabet, Ltd., 14, Hillside Road, London, N.15.



"Instant" tape bulk eraser.

Magnetic Tape Splicer

IN the "Editape" splicing block, the tape holds itself in position in the shallow slot because of the special cross-sectional shape of this slot (see inset on photograph). The narrow slit crossing at 45° is for guiding the tape cutting blade—which should preferably be non-magnetic The splicing block costs 7s 6d (including postage) and is available from Sound Developments, 9, Osborne Road, Kingston-upon-Thames.



"Editape" splicing block with inset showing special cross-sectional shape of shallow slot for retaining the tape

News from the Industry

Philips-Cossor Link.—Philips Electrical Ltd. have acquired control of Cossor Radio and Television Ltd., a subsidiary of A. C. Cossor Ltd., together with the right to use the Cossor trade mark in the fields of domestic sound radio, television and sound reproduction in all countries except Canada and Pakistan. The new directors of Cossor Radio and Television Ltd. are A. L. Sutherland, director of Philips since 1956, E. W. Brades, director and sales manager of Philips' associate company Stella Radio and Television, and J. S. Clark, joint managing director of A. C. Cossor Ltd. and a director of a number of companies within the Cossor group. D. I. Turner, former sales promotion manager of Cossor, is appointed sales manager. For the time being correspondence should continue to be addressed to Highbury Grove, London, N.5.

Pilot Radio has become a wholly owned subsidiary of Ultra Electric Ltd., who have also acquired from the Pilot Radio Corporation, of America, "Pilot" trade marks in 17 European countries. Pilot Radio, whose works are at Park Royal, Middlesex, was formed in 1935.

E.M.I.-S.T.D. Link.—An agreement has been entered into between E.M.I. Sales & Service Ltd. and Scientific & Technical Developments Ltd. (S.T.D.), of Wallington, Surrey, whereby E.M.I. will undertake world distribution outside the U.K. of the "Orthotone" range of high-fidelity units. Equipment will carry both "Emisonic" and "Orthotone" trade marks. Distribution to the Trade in the U.K. will continue to be the direct concern of S.T.D. The identity and management of S.T.D. remains unchanged and the manufacture of all "Orthotone" products will continue at the Wallington factories.

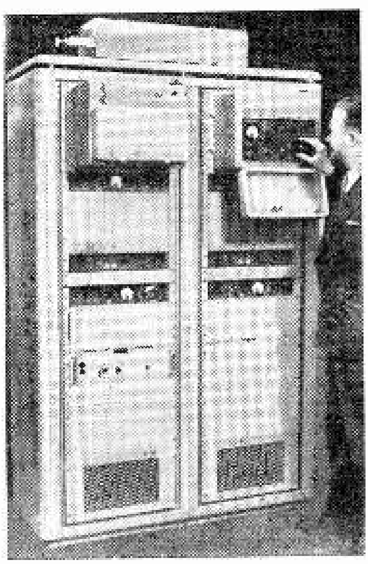
Miniature Relays.—One of the subsidiaries of the Elliott-Automation Group, C. P. Clare, Ltd., which was formed towards the end of last year to manufacture and sell under licence the products of C. P. Clare & Co., of Chicago, received £12,000 worth of orders for its miniature relays in its first full month of operation.

The "Gramdeck" turntable-driven tape transport and transistor record/replay mechanism mentioned in "Technical Notebook" in our July 1958 issue (p. 330) is now marketed by Andrew Merryfield Ltd., 29-31, Wright's Lane, London, W.8. It costs £13 12s.

Marconi's and A. T. & E. have been jointly awarded a contract by the United States government for the supply of a mobile microwave telephone and telegraph communication system linking many of the U.S. Air Force bases in this country. The radio equipment, which is capable of carrying 240 telephone channels and operates in the 4000-Mc/s band, will be supplied by Marconi's and the telephone carrier equipment, which operates in the 60-552kc/s band, by A. T. & E., who, in association with Telephone Manufacturing Co., will also supply the telegraph channelling equipment. The overall value of the order is about $3.5M.

Educational Technical Developments Ltd., of Market Place, Reading, Berks., has been formed by R. Clyne, well known in the industry as a supplier of kits and parts, etc. (who is chairman), and P. T. V. Page, until recently manager and director of instruction at E.M.I. Institutes (who is principal). The company is providing "Radiostructor" postal tuition courses with which the student is given components for constructional work.

Datum Metal Products Ltd. is the new title adopted by Davis & Thompson Ltd., of Watford, Herts., manufacturers of Datum instrument racks, cases, chassis and consoles. The company is a member of the Camp Bird Group.



E.M.I. ELECTRONICS are supplying this microwave link equipment to convey the B.B.C. television service from the mainland to the Orkneys' transmitter.

Telemechanics Ltd., of Hythe, Southampton, which was formed by F. M. Hills in 1946 and became part of the Pena Group, has been reacquired from the liquidator of Pena by Mr. Hills, who is managing director. The company, which is engaged in the manufacture of "Telemax" test equipment, marine broadcast receivers and power units, can offer production facilities to the industry.

Cossor airborne radar transponders for traffic identification have been ordered by B.O.A.C. for its fleet of Boeing 707 jet aircraft. The transponder, which replies to ground interrogation with a coded train of pulses, is compulsorily fitted in high-flying civil airliners in the U.S.A., and arrangements are being made for its use in Europe.

Truvox.—Because of the report which appeared in some journals regarding the liquidation of Truvox Holdings Ltd., we have been asked to state that the liquidation of this non-operative company in the Truvox Group in no way affects the activities of Truvox Ltd., manufacturers of tape recorders. The company was liquidated "for purely administrative reasons."

Pye.—The Norwich studios of Anglia Television Ltd., the programme contractors for the I.T.A.'s Mendlesham, Suffolk, station is being equipped with cameras and control gear by Pye, who are also supplying an O.B. unit. The transmitting equipment at Mendlesham is also being provided by Pye, whose transmitters are in use at the I.T.A.'s Lichfield and St. Hilary stations.

Decca harbour surveillance radar, Type 32, has been installed in the re-furbished radar station at Gladstone Dock, Liverpool. The 3-cm radar equipment, which has seven displays all fed from a common scanner, provides a composite picture of the harbour and its approaches. In bad visibility when pilots ask to be kept under observation minute-by-minute information of the exact position of the ship is passed by radio to assist the pilot in navigating the river and approach channels.

EXPORT NEWS

Microwave transmitters and associated equipment for a radio network providing a television and telephone link between Sundsvall and Boden (a distance of 300 miles) have been ordered by the Royal Board of Swedish Telecommunications from Standard Telephones and Cables. The installation, which will work in the 4000-Mc/s band, will provide six parallel two-way channels each capable of carrying 960 telephone circuits or one television transmission complete with sound.

Television cameras, specially designed by Pye for use in reactors, are being demonstrated during a tour of American and Canadian atomic energy plants by Victor Hessen, manager of Pye's Atomics Division, and Donald Jackson, chief mechanical engineer of the company's Transmission Division. The equipment was shown at the Atomic Fair which was held recently in Ohio.

Ultrasonic inspection equipment to the value of £10,000 has been ordered from Kelvin Hughes for installation in a Czechoslovakian steel works. The equipment will facilitate the rapid scanning of rolled mild steel bars for internal defects and consists of a remote control console containing the c.r.t. presentation and recording equipment and the remote operating controls for a scanning unit situated above the main feed conveyor.

Telecommunication Equipment.—As part of the programme for the expansion of the telecommunications service between East and West Pakistan and overseas, the Posts and Telegraphs Department has ordered from Marconi's three high-power h.f. transmitters for telegraph and teleprinter circuits.

Television transmitters, cameras and ancillary equipment are being supplied by Pye for two new commercial stations being built in Australia. One is in Adelaide and the other in Perth.

Lisbon Trade Fair.—Among the 350 or so manufacturers participating in he British Trade Fair, which is being held in Lisbon from May 29th to June 14th, are a number in the radio and electronics industry. Some are participating in group exhibits, but many have taken individual stands including a number of domestic sound and television equipment manufacturers. Among the 300 or more exhibits in the display staged by the Council of Industrial Design are a number of sound and television receivers.

Italy.—Industrial Products Agencies S.r.l., of Via Carlo Fea 11, Rome, are seeking agencies of United Kingdom manufacturers of electronic and nuclear instruments; microwave equipment; impulse generators; magnetic sound and vision recording equipment and servo mechanisms.

TRANSISTOR EXHIBITION

THE manufacturers and organizations listed below have taken stands at the International Transistor Exhibition being organized in conjunction with the Transistor Convention sponsored by the I.E.E. The exhibition, being held at Olympia, London, concurrently with the convention (May 21-27), opens each day at 9.0 and closes on the 21st and 25th at 6.0, the 22nd, 23rd and 26th at 8.0, and 27th at 4.0. It will not be open on Sunday. Tickets for the exhibition are obtainable free from the organizers, Industrial and Trade Fairs, Ltd., Drury House, Russell St., London, W.C.2.

Those wishing to attend the convention, which is being organized by the Electronics and Communications Section of the I.E.E., must apply to the Institution (Savoy Place, London, W.C.2) for registration forms.

Alma Components
Ashburton Resistances
Associated Electrical Industries

B.B.C.
B.T.H.
Belling & Lee
Birlec
Brush Crystal Company

Compagnie Francaise Thomson-Houston
Compagnie Generale de T.S.F.

Dawe Instruments
Dependable Relay Co.

Edwards High Vacuum
Electrovac Hacht & Huber
Elga Products
Elliott Brothers (London)
English Electric Valve Co.
Ever Ready Co.

Ferguson Radio Corp.
Ferranti

G.E.C.
G.E. Industrial Supplies
G.P.O.
Hatfield Instruments
Heraeus Quarzschmelze

I.C.I.
I.E.E.

Johnson, Matthey & Co.

Kynmore Engineering Co.

Livingston Laboratories

Mallory Batteries
Mansol (G.B.)
Mining & Chemical Products
Ministry of Supply
Mullard

Newmarket Transistors

Plessey Company
Pye

RCA Great Britain
Racal Engineering
Radio Heaters
Rank Cintel
Raytheon Manufacturing Co.
Rivlin Instruments
Roband Electronics
Roe, A. V., & Co.

Sanyo Electric Company
Semiconductor Information Service
Semiconductors
Shockley Transistor Corp.
Siemens & Halske A.G.
Siemens Edison Swan
Sintering & Brazing Furnaces
Societa Generale Semiconduttori
Solartron Electronic Group
South London Electrical Equipment Co.
Standard Telephones and Cables
Sylvania Electric Products

Tekade
Telefunken
Texas Instruments
Tokyo Shibaura Electric Co.

U.K. Atomic Energy Authority
Ultra Electric
Union Miniere Du Haut-Katanga
University of Birmingham

Venner Electronics
Vidor and Burndept

Wayne Kerr Laboratories
Welwyn Electrical Laboratories
Westinghouse Brake & Signal Co.
Whiteley Electrical Radio Co.
Wire Products & Machine Design
Wirepots

MAY MEETINGS

LONDON

5th. Brit.I.R.E.—"An experimental diode parametric amplifier and its properties" by I. M. Ross, C. P. Lea-Wilson, A. J. Monk and A. F. H. Thomson at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

8th. I.E.E. Medical Electronics Discussion Group.—"Microwave radiation hazards" by Dr. D. H. Shinn (Marconi's) and Dr. N. L. Lloyd (Ministry of Supply) at 6.0 at Savoy Place, W.C.2.

13th. I.E.E.—"The application of statistical techniques to the electronic valve industry" by E. G. Rowe at 5.30 at Savoy Place, W.C.2.

13th. Brit.I.R.E.—"Improving communication techniques—what have engineers to learn from information theory?" by Professor D. Gabor at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

14th. I.E.E.—"On the conceivable future of telecommunications" by Professor E. C. Cherry at 6.30 at Savoy Place, W.C.2.

14th. Physical Society Acoustics Group.—"High energy ultrasonics" by E. Neppiras at 5.30 at Imperial College, Prince Consort Road, S.W.7.

15th. Institute of Navigation.—"Electronic surveys in the Caribbean" by Capt. E. G. Irving, R.N., at 5.15 at the Royal Geographical Society, 1 Kensington Gore, S.W.7.

21st. Physical Society.—Presidential address by J. A. Ratcliffe at 5.45 at the Royal Institution, 21 Albemarle Street, W.1.

BIRMINGHAM

8th. Institution of Electronics.—"The design of transistor h.f. amplifiers" by L. E. Jansson (Mullard) at 7.0 in the Byng Kenrick Suite Lecture Hall, New College of Technology, Gosta Green.

BRISTOL

5th. Television Society.—Mullard Film Meeting at 7.30 at the Grand Hotel (Joint meeting with R.S.G.B. and R.T.R.A.).

CHELTENHAM

1st. Brit.I.R.E.—"Transistor amplifiers" by F. Butler at 7.0 at North Gloucestershire Technical College.

PRESTON

6th. I.E.E.—Annual general meeting at 7.15 followed by "Domestic high-fidelity reproduction" by J. Moir at the North-Western Electricity Board Demonstration Theatre, Friargate.

CONFERENCES AND EXHIBITIONS

Latest information on forthcoming events both in the U.K. and abroad is given below. Further details are obtainable from the addresses in parenthesis.

UNITED KINGDOM

Symposium on Instrumentation and Computation in Process Development and Plant Design, Central Hall, Westminster, London, S.W.1 .... May 11-13
(Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.)

International Convention and Exhibition on Transistors, Earls Court, London, S.W.5 .... May 21-27
(I.E.E., Savoy Place, London, W.C.2.)

International Plastics Exhibition and Convention, Olympia, London, W.14 .... June 17-27
("British Plastics," Dorset House, Stamford Street, London, S.E.1.)

British Computer Society's Conference, Cambridge .... June 22-25
(British Computer Society, Finsbury Court, Finsbury Pavement, London, E.C.2.)

International Convention on Television Engineering, Cavendish Laboratory, Cambridge .... July 1-5
(Brit. I.R.E., 9 Bedford Square, London, W.C.1.)

National Radio and Television Show, Earls Court, London, W.5 .. Aug. 26-Sept. 5
(British Radio Exhibitions Ltd., 49 Russell Square, London, W.C.1.)

Scottish Industries Exhibition, Kelvin Hall, Glasgow .... Sept. 3-9
(Matthew H. Donaldson, 2 Woodside Terrace, Glasgow, C.3.)

Farnborough Air Show .... Sept. 8-14
(Society of British Aircraft Constructors, 29 King Street, London, S.W.1.)

Conference on Dielectric Devices, University of Birmingham .... Sept. 14-17
(Electrical Engineering Department, The University, Birmingham, 15.)

Conference on Modern Network Theory, University of Birmingham, Sept. 21-24
(Electrical Engineering Department, The University, Birmingham, 15.)

Conference on Some Aspects of Magnetism, Sheffield University .. Sept. 22-24
(Institute of Physics, 47 Belgrave Square, London, S.W.1.)

International Scientific Research Exhibition, Olympia, London .. Oct. 3-10
(I.S.R.E. Ltd., Oswaldestre House, Norfolk Street, London, W.C.2.)

Radio Hobbies Exhibition, Royal Horticultural Hall, London, S.W.1, Nov. 25-28
(P. A. Thorogood, Museum House, Museum Street, London, W.C.1.)

OVERSEAS

Interdisciplinary Conference on Self-Organizing Systems, Chicago, May 5-6
(Scott H. Cameron, Armour Research Foundation, Chicago 16, U.S.A.)

Electronic Components Conference, Philadelphia .... May 6-8
(Brig. Gen. Edwin R. Petzing, A.G.E.P. Secretariat, University of Pennsylvania, Philadelphia, Pa., U.S.A.)

Radio Engineering Convention, Melbourne .... May 25-30
(Australian I.R.E., 157 Gloucester Street, Sydney, New South Wales.)

British Trade Fair, Lisbon, Portugal .... May 29-June 14
(British Overseas Fairs Ltd., 21 Tothill Street, London, S.W.1.)

International Air Show, Le Bourget, France .... June 12-21
(Union Syndicale des Industries Aeronautiques, 4 rue Galilée, Paris XVIe.)

International Conference on Information Processing, Paris .... June 15-20
(B.C.A.C. Group B, c/o I.E.E., Savoy Place, London, W.C.2.)

I.R.E. International Symposium on Circuit and Information Theory, Los Angeles .... June 16-18
(Richard A. Epstein, Jet Propulsion Laboratory, Pasadena, California, U.S.A.)

International Chemistry Conference and Exhibition, Paris .... June 16-30
(Conférence Internationale des Arts Chimiques, 28 rue Saint-Dominique, Paris 7.)

International Electronic, Nuclear and Cinematographic Exhibition, Rome .... June 16-30
(Rassegna Internazionale Electronica Nucleare, Via dell a Scrofa 14, Rome.)

Second International Conference on Medical Electronics, Paris .. June 24-27
(Secretariat, 131, Boulevard Malesherbes, Paris XVIIe.)

National Convention on Military Electronics, Washington .... June 29-July 1
(L. R. Evringham, Radiation Inc., Orlando, Fla., U.S.A.)

German Radio, Television and Audio Show, Frankfurt .... Aug. 14-23
(Messe- und Ausstellungs-GmbH., Frankfurt a.M.)

Western Electronic Show and Convention, San Francisco .... Aug. 18-21
(Wescon, 1435 South La Cienega Boulevard, Los Angeles 35, Calif., U.S.A.)

International Congress on Acoustics, Stuttgart .... Sept. 1-8
(Dr. Ing. E. Zwicker, Breitscheidstr. 3, Stuttgart.)

Salon Belge de l'Electronique, Brussels .... Sept. 19-24
(Comité des Expositions de la Radio-Electricité, de la Télévision et des Industries Connexes, 7 rue de Florence, Brussels, Belgium.)

National Symposium on Telemetring, San Francisco .... Sept. 28-30
(Robert A. Grimm, Dymec Inc., 395 Page Mill Road, Palo Alto, Calif., U.S.A.)

Irish Radio and Television Show, Mansion House, Dublin Sept.28-Oct. 3
(Castle Publications, 38 Merrion Square, Dublin, Eire.)

I.R.E. Canadian Convention, Toronto .... Oct. 7-9
(Convention Office, 1819 Yonge Street, Toronto, 7.)

National Electronics Conference, Chicago .... Oct. 12-14
(N.E.C., 84 E. Randolph St., Chicago, Ill., U.S.A.)

Conference on Electrical Techniques in Medecine and Biology, Philadelphia .... Nov. 10-12
(Dr. L. E. Flory, RCA Laboratories, Princeton, N.J., U.S.A.)

RANDOM RADIATIONS

By "DIALLIST"

Man-made Blackouts

ONE gathers that there has been considerable uneasiness in the U.S.A. owing to the discovery that wireless and radar signals can be blocked by bursting a nuclear bomb at a great height above the earth's surface. Before any announcement on the subject was made officially in America, Russian scientists had attributed the unexpected density of the inner radiation zone (which at the magnetic equator is 1,500-4,000 miles above the earth) to the effects of nuclear explosions. Later, an official statement was made in the U.S.A. that, as part of the I.G.Y. programme, three such bursts had taken place last year at heights of about 300 miles. In each case the flash of the explosion was followed at once by a faint luminosity extending along the magnetic line of force through the burst point. This line of force returns to our atmosphere in the northern hemisphere near the Azores. Aircraft stationed in the region for observation purposes noted a short auroral glow. The work was then taken up by the satellite Explorer IV which, travelling day after day "through the man-made 'shell' of trapped radiation," sent back to earth measurements which enabled its intensity and shape to be worked out. It has been suggested that anyone mad enough or wicked enough to start a nuclear war could put the other side's distant early warning radar system almost, if not entirely, out of action by leading off with a number of bursts in the right places.

Towards Better TV

THOUGH at the time of writing the Television Advisory Committee's report has not been completed, it seems almost a certainty that the definition recommended for Bands IV and V will be 625 lines. If 8-Mc/s channels are adopted by international agreement (6-Mc/s for vision and 2-Mc/s for sound), this should certainly mean an overall improvement in picture quality. The change would, presumably, also mean adopting negative vision modulation and f.m. sound modulation. Improvements are always to the good and one must welcome them; but I've always felt that when we do make use of Bands IV and V we should change things in a big way to, say, 1,000 lines or more and not be content with a mere fifty-per-cent rise in the number of lines. If, as the years go by, scanning remains the only practicable method of transmitting and reproducing television images, systems with a far greater number of lines than 625 are bound to come.

Stereo Sound

AT the I.E.E.'s Stereophonic Sound Recording, Reproduction and Broadcasting Convention* it was clear that nobody yet really knows all the hows and whys of the process. I think that, like other animals, we were provided with two ears to enable us to turn our eyes towards the place from which the sound comes in case it is a warning of lurking danger. If the sound lasts an appreciable time, we seem to do this by turning our heads so as to phase up the waves reaching our eardrums. But what of short sharp sounds such as the snapping of a twig? They don't last long enough for this to be done, yet we do instinctively look towards their source. Dr. Percival maintained that the directional signals are mainly in the transients and this may possibly explain our quick reactions to snappings, pops, bangs and so on. Then, as T. Somerville, of the B.B.C., pointed out, the use of two loudspeakers reproducing the right-hand and left-hand sounds would give directions in the horizontal plane only. For there to be an impression of vertical directivity three or more would be needed. Curious that; for our two ears certainly make us look up or down as the case may be for the source of any sound. No doubt it'll all be worked out in time and one of the most valuable things about a convention of that kind is that it helps people to realize just how much they don't know and stimulates them to try to find all the answers. Meantime, stereo-sound as it comes from our loudspeakers seems pretty good to me and recording it or listening to it has become one of the most popular of hobbies.

* See also p. 239 of this issue—ED.

TV on the Railways

CLOSED-CIRCUIT television is, I see, to be installed at some of the level crossings in France which can't be seen from the nearest signal box. At many of those on busy roads it has been necessary to have an employee permanently on duty; in future the man in the signal box will be able to see for himself just what's going on and to open or close the gates as required. Something of this kind would be a vast improvement in the flatter parts of this country such as Cambridgeshire, where there are many level crossings. Quite a few of these are unattended and one can't always get a view of the rails for any great distance in either direction. Fixed high up, so as to be out of harm's way, the camera could be moved by the signalman by remote control so as to let him see vehicles approaching the crossing from either direction and enable him to open or close the gates at the right moment. Actually, television is already in use on our railways for other purposes. There's a camera, for instance, at the approaches to King's Cross Station in London which enables train arrival times to be checked and in marshalling yards.

Mendlesham's TV Station

IF all goes well, the I.T.A. should be able to open its East Anglian TV station earlier than many people expected. Test signals are to start in July or August with an e.r.p. of 10kW from a temporary aerial mounted at a height of about 500ft on the unfinished mast. Full-power trade tests should start in October, provided that the 1,000-ft mast is finished by then. That must depend a good deal on the weather and I take it that what is most wanted is that there should be no high winds. I haven't been Mendlesham way lately, so I don't know yet how that gigantic mast is getting on. When finished it should indeed be worth seeing, for I believe it will be the tallest TV mast in the country. It should be visible over a largish part of the Suffolk landscape.

Guarantee Periods

SOME of the firms which rebuild cathode-ray tubes guarantee their products for seven months, others again for nine and a few for a full year. Rather a queer state of affairs, that! I expect that as time goes on they'll all adopt an agreed guarantee period. I've long felt that our valve and tube manufacturers should fall into line with those of other countries by giving a year's guarantee on all their wares. I don't think I'm wrong in believing that the bulk of British-made valves and c.r. tubes exported *do* carry such a guarantee. They certainly have to in territories where they have to compete with those manufactured in countries where this is the normal period of guarantee.

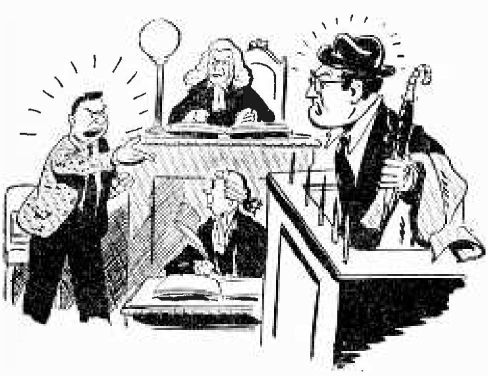
UNBIASED

By FREE GRID

What is Truth?

AS I grow older, I come more and more to share the opinion of the late Henry Ford that "history is bunk," as I am constantly reading and hearing contradictory versions of historical events. I have always supposed that the first *public* demonstration of television was given by Baird at 22 Frith Street, Soho, in January 1926, but now I see that the famous Oxford Street store, which used to house the 2LO transmitter, is claiming that TV was demonstrated on its premises in 1925.* What am I to believe?

Then again, the Editorial Comment in the April issue tells me by its title that the Editor is in a similar difficulty about the late King Canute,



" Contradictory versions of events "

or Knud as his Danish compatriots call him. The Editor obviously favours the outmoded story that Canute sat on the beach near Southampton in the year A.D. 1028, and commanded the incoming tide to recede, fondly imagining that it would do so.

Nowadays most historians are agreed that Canute was no fool, and only staged this act to prove to his sycophantic followers that he had no magic powers. I am not, of course, suggesting that the Editor is wrong; after all, he had to choose between two versions just as I shall have to do in the case of the date and venue of the first public TV demonstration.

The classic instance of this difficulty of deciding between two versions of the same thing is not concerned with history but with natural history. We often read that the foolish ostrich sticks his head in the sand, thinking that because he cannot see his approaching enemies, they cannot see him. The other version is that the ostrich is a highly intelligent bird which camouflages himself by crouching down amid the local desert scrub, and at the same time puts his head *on* the ground so that he can hear more clearly his enemy's footsteps and so decide whether he is coming or going.

You pays your money and you takes your choice.

* Both "Free Grid" and (don't let's be coy) Selfridge's are right according to whether silhouettes (such as the test bars and crosses sometimes transmitted by the B.B.C. and I.T.A.) are or are not regarded as "television."—ED.

Lawless Listening

I WAS surprised when recently reading my wireless licence, to learn that I am not allowed to use a portable set with an external l.t. battery unless I am using it on my own premises or in some vehicle, marine or territorial, occupied by me. Thus, if my l.t. battery runs out when I am having a picnic on the beach, I must not plug the set into my car's electrical circuit, nor may I stagger down with the car battery so that I can connect it up to my portable set with a suitable series resistance.

Reading the regulations has made me very nervous, and as a result I nearly caused a nasty accident to a child the other day. I was taking advantage of one of those few lovely days we had recently, and was sitting on the beach with my portable. The l.t. ran out and I stepped across the road to a local electrical shop for a replacement. All they had in stock was a large $1\frac{1}{2}$-volt dry cell which would not go into the battery compartment, but I bought this and soon had it connected up.

Unfortunately, a passing policeman saw me and as he walked in my direction I hastily disconnected the "evidence" and hurled it in the sea, narrowly missing the head of a child who was paddling. Baulked of his lawful prey, the policeman proved himself a man of resource and booked me under the Anti-litter Act. Can any of you legal pundits tell me if it would be a good defence to plead that the cell, when hurled away, fell on the seaward side of low tide mark.

Correcting the O.E.D.

I SUPPOSE every reader has heard of the Oxford English Dictionary. It is to be found even in Cambridge, and by no means always in the inner recesses of booksellers' shops, hiding its head shamefacedly among those volumes which the police periodically seize, and the magistrates order to be destroyed.

I refer to the O.E.D. here because it is proposed to issue a new supplement to it, and I have been looking at a list of suggested new words and expressions running from AL-AZ. Even in this small part of the alphabet there are more than 800 new words or phrases. In the list each word has printed alongside it the year in which it is thought it was first used.

There seems to be a large number of words and expressions wrongly dated; not only ordinary non-technical ones but also the specialized ones which concern various technologies. I give herewith over a dozen words from the list, together with the years of first usage assigned to them, which will be of particular interest to readers of *Wireless World.*

	No Date
Alive (Electricity)	1934
All-electric	1948
All-mains	1940
Ampere-hour	1902
Ampere-turn	1948
Appleton layer	1932
Appleton region	1939
Asdic	1945
A.S.V. (Radar)	1943
Attenuation (Electricity)	1940
Audio	1923
Audio-frequency	1940
Automatic gain control	1940
A.V.C.	

The Editor of the O.E.D. Supplement, 40, Walton Crescent, Oxford, seeks to know if any earlier use of these words is known. Before any of you get killed in the rush to enlighten him, I would point out that he does not want just vague memories. He wants to know exactly where the earlier usage occurs, and he wants each word dealt with on a separate sheet of paper of 6-in × 4-in dimensions, which he will supply if necessary.

Psychotrons

IN THE March issue, I was discussing the extra-spatial electrons of which I supposed ghosts and their world to be constructed. It has occurred to me that the expression "extra-spatial electrons" would be far too clumsy to come into general use as it will tend to do in years to come when some experimental research worker eventually plays Hertz to my theoretical Clerk-Maxwell. I would, therefore, suggest the word psychotrons to describe these extra-spatial electrons.

I think that in 20 years time we shall be as familiar with the science of psychotronics as we are now of electronics. At least, some of us will be; by then others will be on the far side of the psychotronic curtain.