JUNE 1957

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Wireless World

Off the Record

LISTENING to music for recreation through the medium of gramophone records is as prevalent among professional radio and electronics engineers as it is in other sections of the community. Indeed, we are sometimes persuaded that the incidence is higher, and that the dissatisfactions which set in as the result of acquiring too great a knowledge of the processes of sound reproduction may ultimately exceed those of the layman who is assailed by doubts as to whether his present equipment is capable of the "high-fidelity" which he feels may be necessary to his full enjoyment.

We do not deny the value of this discontent which more than ten years ago gave rise to the *cri de cœur* in this journal that we "... get our music by scraping a steel point carrying tons of weight per square inch over what is virtually a refined macadamized roadway." It has since given us plastic records with lower surface noise and has forced pickup designers to abandon their early and too facile conception of what constitutes a "lightweight" pickup.

Yet even today, conditions in the microcosm bounded by the perimeter of the stylus-groove contact are such as might well have taxed the imaginative and descriptive powers of Dante, with accelerations more than a thousand times higher than that due to gravity, temperatures which *burn* off any asperities and pressures which produce plastic flow in the material under the record surface.

Reproduction of the sound image impressed on the record has long been known to be difficult; from what we now read of recent and even more searching investigations into the problem it would seem to be virtually impossible! Certainly one can never hope to reproduce with a spherical stylus tip all that can be recorded with a flat-faced cutter.

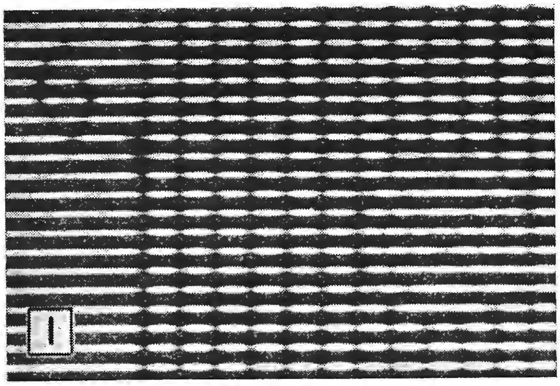
All this has generated in some quarters a pessimism which we believe to be unjustified. Just as the bumble-bee goes about its business in ignorance of the pronouncements of aerodynamicists that its flight is impossible, so we shall continue to be delighted by many if not all of the products of our recording studios and record factories.

The truth is that the content of the record is not always driving the reproducing equipment to the limits where distortion is produced. Even when distortion can be proved by measurement to be present, it does not necessarily follow that it will be noticed. A performance may have qualities of emotion or musicianship which hold the attention to the exclusion even of gross amounts of harmonic distortion.

The ultimate criterion of the success of a particular sound reproduction is not that the measured distortion is less than some arbitrary figure but that it is not high enough to introduce any incongruity which will distract the attention of the listener and so mar his enjoyment of the things that really matter. An objective assessment of overall performance cannot be made without including the temperament and experience of the listener and the nature of the programme material—which is tantamount to saying that an *objective* assessment cannot be made.

Information Engineering

IT will soon become possible to get an M.Sc. degree in Information Engineering (see page 257). This recognition by Birmingham University that information, in the non-semantic sense, is the basic commodity of several related branches of technology (communications, computers, control systems, etc.), and therefore represents a good approach for studying these subjects, is altogether praiseworthy. At the same time, it is hard to see how a mere 12 months' course of this nature can do much more than broaden the student's outlook—for a while. One cannot be just an Information Engineer for long, and each of the new M.Sc.s will be claimed by a particular specialization in the end—and then really begin to learn his subject. However, there is no doubt that the Birmingham University course will provide a much better background for specialists in these fields than has existed so far.



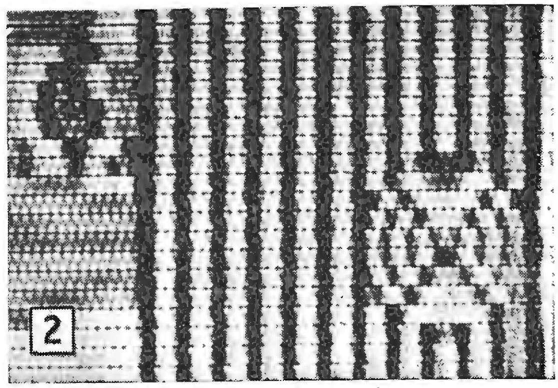


Fig. 1 shows a section of a test chart on one frame of a 405-line picture (202½ lines) without spot wobble. Fig. 2 is the same section with ordinary spot wobble applied to the c.r.t., while Fig.3 (on opposite page) shows the improvement effected by synchronous spot wobble on both c.r.t. and camera tube. A complete interlaced picture with s.s.w. is even better.

High Definition on 405 Lines

BETTER RESOLUTION GIVEN BY SYNCHRONOUS SPOT WOBBLE

IN discussions on British colour television standards it has often been suggested that a high-definition picture might be transmitted in Bands IV or V and that standards conversion might be used to obtain a 405-line version for transmission to the existing 7 million monochrome sets. Ruling out the "brute force" method of standards conversion (a camera "looking" at a monitor tube) on grounds of picture degradation, the direct electronic system proposed by H. A. Fairhurst* comes to mind. This, and most other proposals, tacitly assume that the high-definition picture will have a greater number of lines than the 405-line standard. There is, however, the interesting possibility that the high-definition picture might itself be 405 lines, but with increased resolution and bandwidth. The normal-definition 405-line picture could then readily be extracted from it by sampling at a rate appropriate to a 3-Mc/s bandwidth.

This suggestion emerged from a lecture on a new system of television recording given recently to the British Kinematograph Society by A. E. Sarson and P. B. Stock, with an historical introduction by L. C. Jesty. The new system is based on the well-known suppressed-frame method of recording on film, but it avoids the loss of picture information normally associated with using only alternate television frames by starting off with a 405-line picture of high definition. The 202½-line television frames recorded on successive film frames then contain much more information than they would with the normal definition, and when subsequently the film is scanned for transmission a much better picture is obtained. Of course, since the camera chain giving the high-definition picture for recording is also the means of producing the "live" programme, a 405-line picture of normal definition has to be extracted for transmission, and this is where the sampling process is used.

The increase of definition without extra lines is obtained by a technique known as synchronous spot wobble. With ordinary spot wobble the idea is simply to fill in the spaces between the lines, and this is particularly necessary on suppressed-frame recording where each film frame records only 202½ lines and there is no subsequent interlacing. As an example, Fig. 1 shows a section of a 202½-line frame and Fig. 2 how it is improved when ordinary spot wobble is applied to the c.r.t. The main drawback of ordinary spot wobble, however, is that it displaces picture information which should appear at only one point on the screen so that it also appears at other points. This produces among

* *Wireless World*, February 1955, p. 53.

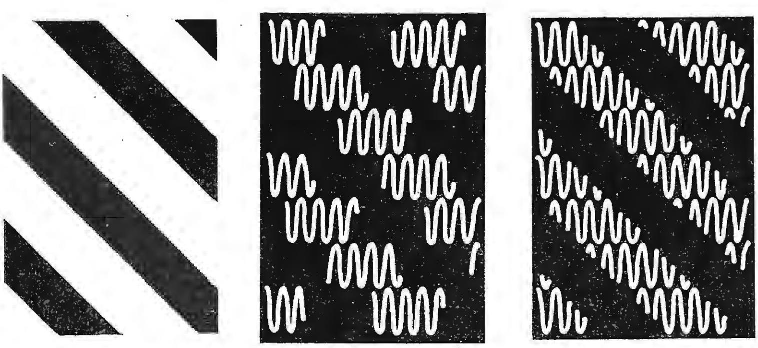
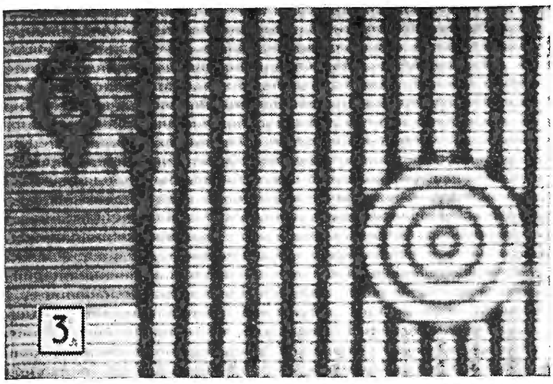


Fig. 4. When scanning diagonal bars (left) ordinary spot wobble gives a stepped effect (centre) but synchronous spot wobble fills in the spaces with genuine picture information (right).



other things a stepped effect when diagonal or curved lines are scanned, as shown in Figs. 2 and 4, with consequent deterioration of picture quality.

With synchronous spot wobble, however, these effects are avoided. The alternating wobble voltage is applied to the camera pick-up tube as well as to the monitor c.r. tube, and is synchronized in frequency and phase at both ends. The result is that the scanning spot has an increased path length and covers a greater area of picture detail than normal during the period of one line. Because of this higher scanning speed, information is transmitted through the closed-circuit system at a higher rate than normal, so that a larger bandwidth is required. In addition to filling in the spaces between the lines, the synchronous spot wobble gives a vertical "exploratory" component to the horizontal scan, with the result that the vertical resolution of the complete picture is increased. Actually the spot-wobble scanning is such that the improved definition is shared between the vertical and horizontal directions.

Fig. 4 (right) shows diagrammatically how the scanning of diagonal bars is improved by the use of synchronous spot wobble, while Fig. 3 demonstrates it on an actual screen picture of the section of chart in Figs. 1 and 2. Instead of just filling in the gaps between lines with spurious picture information, as with ordinary spot wobble, the new system adds genuine information which was previously missing. Of course, the price to be paid for the improvement is the increased bandwidth, but this does not matter in the closed-circuit system used for recording purposes. A spot-wobble frequency of 6 Mc/s has been found satisfactory, and this demands a video bandwidth of at least 6 Mc/s and preferably 9 Mc/s. In practice the spot-wobble scan produces the effect of a 6-Mc/s sub-carrier on the video signal, which is modulated by the line sync waveform and the picture information to form sidebands extending up to 3 Mc/s on either side.

To extract the "live" television picture from the high-definition closed circuit for transmission at normal 3-Mc/s definition, a sampling p.r.f. of 6 Mc/s is required (according to the well-known Hartley law). If the samples are of sufficiently short duration, and they are smoothed afterwards by passage through a 3-Mc/s low-pass filter, the "contaminating" effect of the vertical component in the synchronous spot wobble is removed and the resulting picture is practically indistinguishable from one generated in the normal way.

Of course, if the high definition 405-line picture were actually transmitted in a wideband public service, instead of just being confined to a recording closed circuit, some means would have to be adopted for synchronizing the spot wobble in the domestic receivers with that at the studio camera. Probably this could be achieved by transmitting a "burst" of several cycles of spot-wobble frequency as a phasing signal on the back porch of the existing line sync pulse— as is already done in the N.T.S.C. colour television system. (In fact the "burst" might easily serve a double purpose in a 405-line high-definition colour service.)

A picture composed of two interlaced frames with synchronous spot wobble is, of course, a good deal better than the single frame in Fig. 3, and *Wireless World* has seen several excellent examples.

CLYDE SHIP-TO-SHORE TELEPHONE

SHIPS in the Firth of Clyde can now be connected by radio to the public telephone system as a result of a new service opened by the Post Office last month. The radio system, which is on v.h.f. and uses frequency modulation, conforms to recent international agreements for this type of service, and corresponds to other systems already established in various parts of the world. The shore station is at Piper Hall on the Isle of Bute near Rothesay, from where a land line goes to Greenock telephone exchange—the official number being "Clyde Radio—Greenock 22255."

By the courtesy of Pye Marine, who built the shore station and have introduced shipborne transmitter/receivers for the service, *Wireless World* witnessed the opening ceremony from a launch in the Clyde estuary, when calls were put through to Liverpool, Cambridge and New York Harbour (via the transatlantic cable.) In all cases the clarity of speech and freedom from interference were quite outstanding. The shore station has an output power of 100 watts with a range of about 40 miles down the Firth, extending up river to around Gourock. This and the shipborne equipment is based on the f.m. version of the Pye "Ranger" series of mobile radiotelephones. Transmitters with powers of 3 watts, 10 watts and 20 watts (see illustration) are available for the mobile equipment.

Further v.h.f. services of this kind are being planned by the Post Office for operation from existing coastal radio stations at Land's End, Niton (Isle of Wight), North Foreland and Humber (Mablethorpe).

WORLD OF WIRELESS

Mobile Radio Channelling

AS was recommended in the Mobile Radio Committee's 2nd Report (see page 464 October issue) trials are to be undertaken by the Post Office of v.h.f. mobile radio equipment using 25-kc/s channelling instead of the present 50 kc/s. This is announced in a letter to the Radio Communication and Electronic Engineering Association which had asked the Post Office for clarification of the position. The trials are expected to begin in the early autumn.

The Committee's recommended reduction from 100 to 50-kc/s channelling in the 165 to 174-Mc/s band (as in the 71.5 to 88-Mc/s band) was introduced in January.

RCA and Colour TV

IN last month's *Wireless World* it was suggested that the Radio Corporation of America, which has hitherto been the main driving force behind colour television in the U.S.A., is losing its enthusiasm for colour. That view is not borne out by a joint statement from the chairman and president which has reached this country since the last issue went to press.

According to the statement, the number of regular colour programmes is, in fact, being increased in 1957, which should result in more colour receivers being sold. Colour television, the statement continues, is proving that it can supply a greater and more interesting service to the public and develop into a profitable business for all sections of the industry. Apart from its application to broadcasting, it is also expected to expand in the industrial, medical and educational fields.

Radio Exports

U.K. EXPORTS of radio and electronic equipment during the first quarter of this year were 17% higher than in the same period in 1956; £10.8M compared with £9.1M. As will be seen from the table the greatest increase was in sound reproducing equipment. Incidentally, the overseas sales of this type of equipment in the first quarter of this year were more than those for the whole of 1952.

	Jan.-Mar. 1957	Jan.-Mar. 1956
Capital goods (transmitters, navigation aids, etc.).	4.0	3.7
Components	2.5	2.0
Sound reproducing gear	2.4	1.7
Domestic receivers	0.9	1.0
Valves and c.r. tubes	1.0	0.7
	£10.8M	£9.1M

Scottish Show

A CONSIDERABLE number of new models of domestic sound and television receivers are being shown at the Scottish Radio Show at Kelvin Hall, Glasgow, which closes on June 1st. Most of the major domestic receiver makers are among the sixty exhibitors at the Show, which is the first to be organized in Scotland by manufacturers since 1935.

BREMA Report

THE ADOPTION of a standard television receiver i.f. by all its members and, as far as is known, by set manufacturers who are not members, is mentioned in the Annual Report of the British Radio Equipment Manufacturers' Association. It is, however, pointed out that in view of recent experiences of interference from ionospheric forward scatter transmissions around 35 Mc/s, "members may wish to reconsider the i.f. rejection characteristics of their receivers."

Plans are in hand for tests of colour systems other than the N.T.S.C. in Bands IV and V, but should these bands prove unsuitable then a compatible system in Bands I and III based on 405 lines would be the only practical one for the U.K.

The question of multi-path distortion in the v.h.f. sound service has been investigated on behalf of the members.

In an agreement reached between the Association and the G.P.O. regarding complaints of receiver interference, all cases where the receiver is found to be at fault will, in future, be reported to the maker of the set concerned.

Television licences in the United Kingdom must now exceed 7,000,000 for at the end of March they totalled 6,966,256 and the increase each month is approximately 100,000. Within the next few months the number of television licences will have exceeded that for sound only, which at the end of March was 7,558,843, including 306,053 for car radio.

Have you heard *Mayflower II?*—Although transmissions are restricted because of the need to conserve battery power *Mayflower II* is sending out a noon position each day and will transmit more frequently as she approaches the American coast. Her call is MXJW. Equipped with Marconi gear she operates on 'phone on 2009, 2198, 2301, 2381, 2406, 2527, 2534, 2738 and, of course, the international calling and distress frequency 2182 kc/s. She also operates on telegraphy in both the m.f. and h.f. bands.

Television Society Council.—Members elected to fill the vacancies on the Council of the Television Society are: J. E. Clark (Cathodeon), C. A. Marshall (*British Communications and Electronics*), A. A. Rowlands (Norwood Technical College), S. N. Watson (B.B.C.), and Dr. R. C. G. Williams (Philips).

TV Premiums.—At the Annual General Meeting of the Television Society the following premiums were awarded: E.M.I. Premium to A. H. Atherton (E.M.I.) for his paper "The secondary emission valve and its applications"; *Electronic Engineering* Premium to D. C. Birkinshaw (B.B.C.) for "Progress in American colour television"; Mervin Premium to H. A. Fairhurst (Murphy) for "The development of 21-inch colour television receivers"; Mullard Premium to Dr. R. L. Smith-Rose (D.S.I.R.) for "Properties and problems of Bands IV and V"; Pye Premium to R. A. Dilworth (G.P.O.) for "Interference with television reception: its causes and cures"; and *Wireless World* Premium to A. V. Lord (B.B.C.) for "Some problems in a band-sharing colour television system."

British Wireless Dinner Club.—The record number of 125 members attended the annual dinner, held on 26th April. Air Vice-Marshal E. B. Addison was elected president for the forthcoming year.

Thailand has ordered a complete television station, valued at £170,000, from Pye for erection in Bangkok. It will operate on the 525-line standard which is employed by the American-built transmitter already in operation at the capital.

A radio-telephone link between Ascension Island, in mid-South Atlantic, and its nearest neighbour, St. Helena, 800 miles away, has been introduced by Cable and Wireless. A radio-telephone service between Ascension Island and the U.K. has been in operation since November 1955.

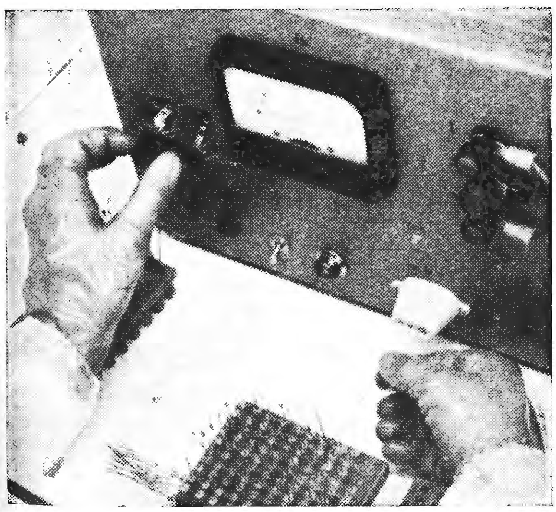
Science Museum (South Kensington, London, S.W.7) has arranged two special displays, one covering the International Geophysical Year, and the other electric power. An illustrated booklet (price 2s), being issued in conjunction with the I.G.Y. display, presents a general account of the phenomena to be studied and the observations to be made. The electric power display is introduced by a working reproduction of Faraday's apparatus of 1831 with which he demonstrated the continuous production of electric current.

R.T.R.A.—The new director of the Radio & Television Retailers' Association is M. Keegan, M.P., and the new secretary, J. E. Mountain. Both these positions were held by H. A. Curtis, who recently resigned. The Association has also appointed an assistant secretary, G. E. Ridgway. The president, F. C. Woodward, is continuing in office for a further year.

Technical Authors.—A committee is being set up by the City and Guilds to explore the problem of the training and qualification of technical authors, and if thought desirable and practicable to draft a scheme of syllabuses and examinations.

Ekco Research.—A four-storey extension to the Ekco works at Southend-on-Sea was recently opened as a research laboratory; most of the space is devoted to work in the nucleonic field. It will be remembered that Ekco Electronics recently shipped to Australia a set of instruments for the first atomic pile in that country.

"Design of the Year."—One of the certificates for 1957, awarded by the London Design Centre for 12 products chosen from some 3,500 shown at the Centre during the past year, was presented by Prince Philip to Pye for their CS17 television receiver.



TRANSISTOR MANUFACTURE.—This photograph, taken at the new Mullard Southampton works devoted entirely to semi-conductors, shows preliminary testing of a transistor before final enclosure. To prevent contamination, the test is made in a sealed "dry box."

R.R.E. now stands for Royal Radar Establishment. The Queen, during her recent visit to the Ministry of Supply's Radar Research Establishment, Malvern, granted the right to use the title, Royal. A large new laboratory for research in solid state physics is being built at Malvern.

Briggs' Demonstration.—Another concert of live and recorded music, this time in Liverpool, is being given by G. A. Briggs (Wharfedale) with the collaboration of P. J. Walker (Acoustical). It will be held in the Philharmonic Hall on July 2nd at 7.30. Tickets, price 3s 6d, will be obtainable from the Hall, dealers, or Wharfedale from June 1st.

CONFERENCES

A three-day conference on "The Avoidance of Collision by Airborne and Shipborne Means" opens at the Royal Geographical Society, Kensington Gore, London, S.W.7, on June 5th. It is a joint meeting of the Institute of Navigation, the Institut Français de Navigation, and the Ausschuss für Funkortung, and is open to non-members (fee £1). Among those making contributions to the conference are Captain F. J. Wylie and Captain R. G. Swallow, of the Radio Advisory Service, A. L. P. Milwright (Admiralty Signal and Radar Establishment), and Wing Commander E. W. Anderson (Elliott Brothers).

"Electronics in Automation."—At the time of going to press over 300 delegates, including many from overseas, had registered to attend the forthcoming Brit.I.R.E. Convention at Cambridge (June 26th to July 1st).

An invitation is extended by the Institution of Radio Engineers Australia to any *Wireless World* reader visiting Australia in October to attend the I.R.E. Convention at Sydney (October 21st to 26th).

Automation Conference.—The Institution of Production Engineers is holding a conference on "Automatic production—change and control" at Harrogate from June 30th to July 3rd.

Microwave Valves.—It is announced in the Annual Report of the I.E.E. that the Institution is arranging a convention on microwave valves for May next year.

U.H.F. Circuits and Aerials.—An international conference covering this subject is to be held in Paris from October 21st to 26th. It is being organized by the Société des Radio-électriciens, 10, Avenue Pierre-Larousse, Malakoff (Seine), France, from whom further particulars are obtainable.

COURSES

A Course in Information Engineering, lasting 12 months and leading by examination to the degree of M.Sc., is being offered to Honours graduates by Birmingham University.

"High Quality Reproduction."—A series of ten lectures on this subject began at the Northern Polytechnic, Holloway, London, N.7, on May 13th, and will be continued each Monday and Thursday (except during Whit-week) until June 20th. The lecturers in June include P. J. Walker (Acoustical), J. F. Doust (M.S.S.), F. H. Brittain (G.E.C.) and Percy Wilson (*The Gramophone*).

Colour TV Course.—Dr. G. N. Patchett began a course of six lectures on colour television at the Technical College, Bradford, on May 23rd. The lectures are being given each Thursday evening until June 27th (fee 10s).

Aerial Lectures.—A series of lectures on Band III aerials is being given by Antiference in Wales and the West Country in preparation for the opening of the I.T.A.'s transmitter at St. Hilary. They will be delivered in June in Exeter (18th), Bristol (19th) and Cardiff (20th).

Personalities

Sir Robert Watson-Watt, C.B., F.R.S., is on a two-months' visit to this country, and was among the guests at the 11th Annual Dinner of the Radar Association on May 10th. During a very amusing speech on the origins of radar, he greeted his "fellow radarians." He is here on behalf of his Canadian company of which there is a branch in this country (Adalia, Ltd., 12, Whitehall, London, S.W.1). Whilst here, he is reading the proofs of his autobiography to be published later in the year by Odhams.

Paul Eisler, Dr.Ing., M.Brit.I.R.E., has been made an officer of the French "Order of Merit for Research and Invention" for his pioneering work on printed circuitry. Dr. Eisler, who was born in Vienna in 1907, came to London in 1936, at the invitation of Marconi's, to conclude an arrangement on a television patent. He started work on printed circuitry at about this time, but it was not until towards the end of the war that his ideas were put to practical use in proximity fuses. Dr. Eisler received the 1954 Marconi Premium from the Brit.I.R.E. for his paper, "Printed Circuits—Some General Principles and Applications of the Foil Technique."

Dr. H. H. Beverage, whose name is given to a long-wire type of receiving aerial and who was also co-inventor of the diversity system of reception, has been awarded the Lamme Gold Medal by the American Institute of Electrical Engineers for his "conception and application of principles basic to progress in national and worldwide radio communications." Dr. Beverage is vice-president of RCA Communications and also director of radio research at RCA Laboratories.

A. D. Priestland, M.B.E., M.I.E.E., and **P. E. Trier,** M.A., A.M.I.E.E., have been appointed directors of the Mullard Radio Valve Company. Mr. Priestland, who joined the Company as a technical assistant in 1935 and during the war was responsible for valve manufacture at the Company's factory at Blackburn, has been a director of Mullard Blackburn Works, Ltd., since its formation in 1951. Mr. Trier, who is manager of Mullard Research Laboratories which he joined in 1950 as head of the communications and radar division, graduated as a wrangler in the Mathematical Tripos at Cambridge. He was at the Admiralty Signal and Radar Establishment from 1941 to 1950, where he was for some time head of the v.h.f. communications group.

C. L. Chapman, chief development engineer, and **R. P. Mason,** commercial manager, of Venner Accumulators, Ltd., sole manufacturers of silver-zinc accumulators in Great Britain, have recently returned from the annual conference of the Yardney International Organization in New York. The conference was called to discuss methods of manufacture and design of the lightweight silver-zinc accumulator based on the André-Yardney system.

J. W. Soulsby, elected for the third term of office as chairman of the Radio Officers' Union, is chief radio officer in the British India Steam Navigation Company's *Uganda.* He joined Marconi Marine in 1918, and during the war was in the armed merchant cruiser *Canton.* He is 57. The new vice-chairman is **W. S. Armstrong,** who was on Marconi's seagoing staff until 1947 when he was appointed permanently to the Inspectors' and Technical Employees' Section of the Union.

J. E. C. Bailey, C.B.E., the new chairman of the British Scientific Instrument Research Association, is chairman and managing director of Baird & Tatlock (London) Ltd. His term of office extends to July 1960. Mr. Bailey is also senior warden of the Guild of Scientific Instrument Makers formed last year.

Air Commodore Thomas U. C. Shirley, C.B.E., M.I.E.E., recently appointed air officer commanding and commandant of the R.A.F. Technical College at Henlow, Beds., was for a short while during the war director of radio engineering at the Air Ministry and subsequently deputy director of signals. A signals specialist, Air Comdre. Shirley, who is 48, joined the R.A.F. in 1925.

F. W. Perks is the new chairman of the British Radio Equipment Manufacturers' Association in succession to M. M. Macqueen, of G.E.C. Mr. Perks has been in the radio industry for over 40 years, having joined Marconi's in 1914. He subsequently transferred to the Marconiphone Company and is now sales director of H.M.V. and Marconiphone. He has been chairman of the exhibition organizing committee of the Radio Industry Council since 1947. The new vice-chairman of B.R.E.M.A. is A. L. Sutherland, director of Philips Electrical. The only change in the membership of the council is that Radio & Allied Industries takes the place of Ferranti, who have resigned from the Association.

T. S. Robson is to be engineer-in-charge of the I.T.A. Scottish transmitter at Black Hill, Lanarkshire, which will begin transmissions in August. Before joining the I.T.A. he was for ten years on the staff of E.M.I.

J. J. Bliss, B.Sc.(Eng.), Grad.I.E.E., is the first education officer to be appointed by Marconi Instruments, Ltd. A graduate of Nottingham University, he joined the technical literature section of Marconi Instruments in 1951 having served as a seagoing radio officer with Marconi Marine during the war. He has also had considerable experience in the educational field and was a member of the advisory committee in the Department of Physics at the Northern Polytechnic.

J. K. S. Jowett, B.Sc.(Eng.), M.I.E.E., who gives in this issue an explanation of the Band I interference experienced in Cornwall (see March issue), has been in the Post Office Engineering Department since 1936. For the past seven years he has been in charge of a group of the branch concerned with propagation studies relating to the operation of Post Office radio links, and with propagation matters in relation to the sound and television broadcasting services.

D. A. Barlow, M.Sc., whose article on record wear is concluded on page 290, is a metallurgist, his interest in sound reproduction being a spare-time activity. Since graduating at Birmingham University in 1943 he has worked in the research department of Aluminium Laboratories, Ltd., Banbury, Oxon, on the mechanical properties and plastic deformation of aluminium alloys.

OBITUARY

E. J. Emery, M.Brit.I.R.E., managing director of E.M.I. Sales & Service and a director of the parent company, died on May 10th at the age of 57. He joined the seagoing staff of Marconi's in 1916, and with the inception of sound broadcasting in 1922 transferred to the Marconiphone Company, now a member of the E.M.I. group. Mr. Emery played a leading part in fostering training schemes for technicians; he had been chairman of the City and Guilds Advisory Committee on Radio and Television since its formation before the war, and was also chairman of the Radio Trades Examination Board.

Audio Fair, 1957

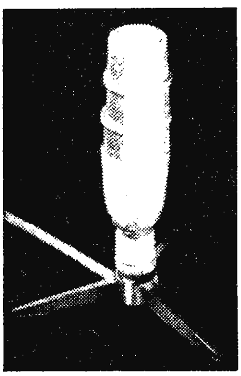
REVIEW OF RECENT TRENDS IN AUDIO EQUIPMENT DESIGN

THIS review considers the various types of apparatus in the order in which the audio signal passes through them. It includes "overflow" exhibits outside the Fair.

Records and Tape.—Connoisseur two-channel single-microgroove discs are approaching the production stage. The two channels are obtained by combined lateral and hill-and-dale recording in the same groove. In both the recording and reproducing pickups the two movements are mechanically coupled to a single stylus at a point where each has a null position. By this means a channel separation of the order of 25 dB has been obtained, and ordinary l.p.s. can be played without modification.

The new M.S.S. long-playing tape uses a thin PVC base, the coating being unchanged.

Microphones.—A new ribbon microphone (KTB1) introduced by Simon Sound has alternative output impedances of 25 Ω or 50 kΩ. True pressure gradient response is obtained up to at least 10 kc/s, the overall response extending somewhat further. The ribbon is extremely thin (about 1 micron) and its large area gives a higher sensitivity than usual. Lustraphone introduced a very small ($1 \text{ in} \times \frac{5}{8} \text{ in} \times \frac{1}{4} \text{ in}$) unit (DRA/62) using a differential-reed armature, and with an impedance of 1,000 ohms suitable for direct connection in transistor hearing aid circuits. It is also made up as a lapel microphone (LP/62), with an impedance of 30 ohms for normal requirements. The output peaks around 2,000 c/s, thereafter being substantially flat to 5,000 c/s. The sensitivity is 84 dB below 1 V/dyne/cm² for the 30-ohm model. A new pencil ribbon microphone (VR64) was also shown by Lustraphone. A crystal microphone (Type 39-1) introduced by Acos has a typical response (when fitted with the 8ft of cable provided) which has a 5 dB peak around 8 kc/s and is 3 dB down at 13 kc/s. The sensitivity is 62 dB below 1 V/dyne/cm².



Simon ribbon microphone.

Tape Pre-amplifiers. — Several manufacturers, including Sound Sales, Armstrong, Lowther and Rogers, have recently introduced units to enable tape decks to be used with their amplifiers and pre-amplifiers. These generally provide high-frequency bias and erase supplies which can be varied to suit particular heads; recording level indication is by meter or magic-eye, and compensation to enable an overall flat response to be obtained at various tape speeds and with various recording heads.

Tape Decks and Recorders.—A new deck used in their reproducer for tape records shown by Avantic uses two flywheels, the extra one being fitted to the take-up spool. These are roughly equivalent to the use of a single larger and more unwieldy flywheel on the capstan. By this means wow and flutter have been kept below 0.1%. The Brenell Mark IV deck incorporates a number of improvements, including the ability to change the tape speed by a simple change in capstan sleeving on top of the deck; the maximum usable reel size is increased to $8\frac{1}{4}$ in diameter. It can also, as is now the case with most tape decks, be fitted with a revolution counter. The new E.M.I. model (TR51) also allows the use of the larger $8\frac{1}{4}$ in reel. The Collaro Mark III deck now incorporates a pause control; and a safety device to prevent accidental erasure, which is actuated as soon as the recorder is stopped. A similar safety device is fitted to the Truvox Mark IV deck.

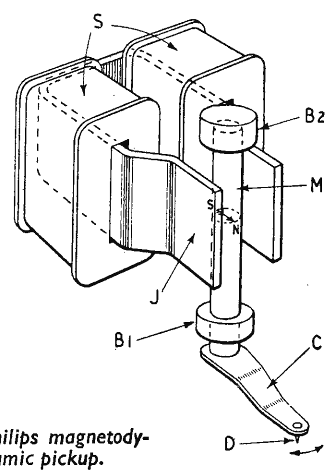
A Spectone recorder incorporating the Collaro tape deck was also introduced recently. Hum and noise is 45 dB (unweighted) below the 2% total harmonic distortion recording level. Low- and high-impedance microphone inputs and 15-ohm (4 watts) and cathode follower outputs are provided. A variable bass cut for close microphone recording is also available.

Stereophonic Decks and Recorders.—A new stereophonic head for fitting to their Mark IV deck was shown by Truvox. The two heads are vertically in line and have gap widths of 0.00025 in. Crosstalk is better than minus 45 dB.

Ferrograph have introduced two new stereophonic recorders using vertically in line heads. In one of these (88) both recording and reproduction can be stereophonic: in the other (77) stereophonic reproduction, but only monaural recording is possible. Of course, in all stereophonic reproducers it is generally very simple to obtain monaural reproduction if desired.

Pickups.—By taking advantage of the long-wearing property of a diamond stylus, which does not need provision for easy replacement, Goldring have been able to obtain the very low dynamic impedance of 2 mgm referred to the stylus tip in their new variable reluctance turnover cartridge (Type 600). The high-frequency resonance on vinyl records is thus at about 25 kc/s so the response is substantially linear to beyond 20 kc/s. The compliance is not less than 5×10^{-6}cm/dyne and the sensitivity 3.2 mV per cm/sec recorded velocity. A mu-metal shield is provided.

Philips were showing a new moving-magnet pickup (NG5400)



Philips magnetodynamic pickup.

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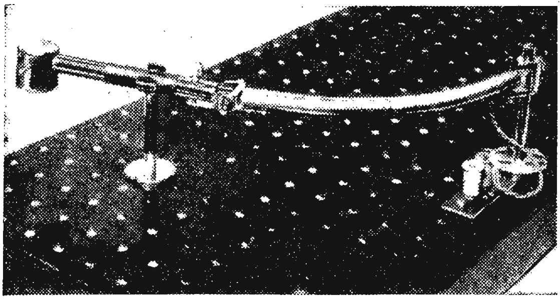
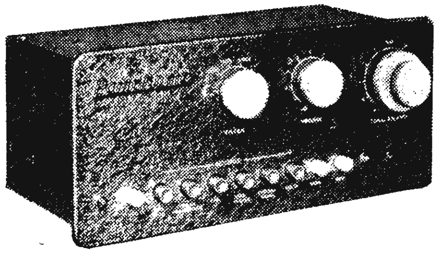
described in *Philips Technical Review* Volume 18, Nos. 4, 5, 6. The design of this has been made possible by the use of the lightweight, high-coercive, material Ferroxdure, which, when in cylindrical form as in this application, can be magnetized in a direction at right angles to the cylinder axis. In the schematic illustration of the pickup shown, lateral movement of the stylus D is converted by means of the cantilever C and the bearings B_1, B_2 into angular movement of the Ferroxdure magnet M. This induces an e.m.f. in the coils S wound on the magnetic material J in whose gap the magnet lies. In this design the effective mass compliance about 4×10^{-6}cm/dyne.

F.M. Tuners.—A prototype f.m. tuner (TP100) shown by Thermionic Products has a tuned cascode r.f. stage, 3 i.f. stages, a biased crystal diode limiter followed by a saturated pentode limiter, and a broadband (1500 kc/s) ratio detector. It is claimed that by this arrangement the need for a tuning indicator and a.f.c. is avoided. The sensitivity is better than 5 mV for 30 dB a.m. rejection. Decca were also showing a prototype f.m. tuner with a wide-band ratio detector and a sensitivity of 4 mV for 20 dB quietening. A new a.m./f.m. tuner shown by Avantic had a.f.c. on the f.m. side with a Foster-

pre-amplifier. This also has a very comprehensive pickup matching arrangement whereby the input impedance can be continuously varied from 500 Ω to ½ MΩ independently of the sensitivity, which can also be continuously varied. Steep-cut treble controls (generally with three alternative cutting positions) are also now nearly universal, and four alternative record compensation characteristics (3LP,178) are also usually provided, though there are six on the Pamphonic 1002B. Inputs for low-level pickups are also now nearly the rule, and the sensitivity of the Armstrong A10 and W.B. 12 pre-amplifiers have been increased in keeping with this



Expert pickup.



Pamphonic 1002B pre-amplifier.

at the stylus tip is 3 mgm, the lateral compliance at least 5×10^{-6}cm/dyne and the output 4 mV per cm/sec recorded velocity. The frequency response is flat from 30 c/s to 15 kc/s, the high-frequency resonance being at about 25 kc/s on vinyl discs.

The Expert pickup (and amplifiers and loudspeakers) are not new but have not apparently been shown at audio exhibitions before. The pickup is of the moving coil type and the h.f. resonance is above 20 kc/s on l.p.s. The arm is pivoted some way along its length where a spring arrangement allows adjustment of the stylus pressure. By this means the extra rigidity and low inertia of a short arm are combined with the better tracking properties of a long arm. Acos showed two new crystal pickups with outputs of 0.16 and 1 volt per cm/sec; the high-frequency response (with a 3 dB peak) being 3 dB down at 11 kc/s and 7 kc/s respectively. The German Elac Miratwin MST2 cartridge is now being distributed in England by Thermionic Products. This is of the turnover variable reluctance type, but with two completely separate assemblies. The high output of about 6 mV per cm/sec recorded velocity is due to an efficient magnetic circuit. The high-frequency resonance is at about 18 kc/s on vinyl, and the

Seeley detector and a sensitivity of 10 mV for 20 dB quietening. The Armstrong FM61 is now fitted with a.f.c. which can be switched off if desired.

Pre-amplifiers. — Three transistor pre-amplifiers were introduced by Lowther. The input is 4-15 mV at 5-60 Ω impedance for each, and alternative voltage gains of 30 (general purpose with no feedback) or 50 are available. One of the pre-amplifiers with a gain of 50 has 24 dB uncorrected feedback, the other can be corrected to the R.I.A.A. or 78 *ffrr* record reproducing characteristics, or to a flat, high gain characteristic for use with microphones.

A very comprehensive pre-amplifier was used by Acos for their demonstrations. On the bass and treble controls the turnover point and amount of alteration could be independently varied, and a continuously variable (3.5 kc/s-20 kc/s cut off) low pass filter was also provided.

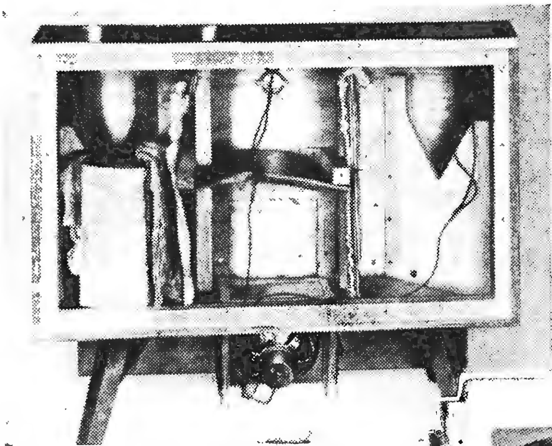
Several new valve pre-amplifiers were shown, "loudness" (tone-compensated volume) controls being increasingly fitted. These generally follow the Fletcher-Munson curves; but as Decca point out these curves apply only to sine waves, and so they have used somewhat different ones to provide the best compromise between speech and music in their prototype

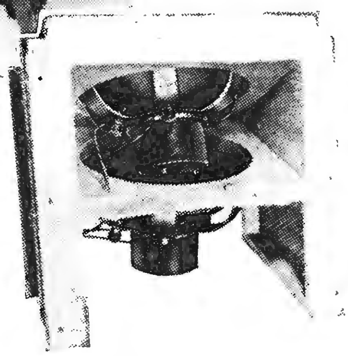
trend. Pilot (who are newcomers to this field) have a useful addition to their pre-amplifier HFC12 in the form of a muting switch to desensitize the pre-amplifier (time constant 1 second) while changing records or input sources. Vortexion showed a pre-amplifier (TRG10) which can be fully loaded from Wearite tape heads.

Amplifiers.—Philips were showing two transformerless amplifiers. These have been made possible by winding up to 800-ohm voice coils for their normal dual-cone loudspeakers. Two valves are used whose outputs add in the load but whose input is only single-ended. These amplifiers can deliver their full rated power at low frequencies and also have a wide, level frequency response. The separate amplifier and pre-amplifier gives 12 watts output for 0.1 per cent distortion at 100 c/s; a 4-watt transformerless amplifier is also used in their "Magic Box."

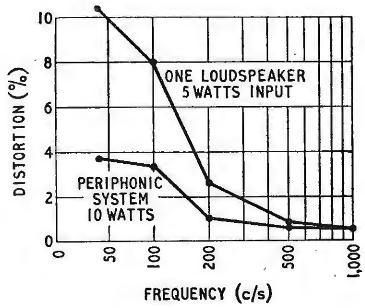
Lustraphone have introduced two portable P.A. transistor amplifiers giving 10 or 15 watts output for 5 mV low impedance microphone input, and with a substantially flat response from 100 to 10,000 c/s.

A considerable number of amplifiers are now stated to be stable for capacitive loads such as electrostatic loudspeakers. These include the





G.E.C. Periphonic cabinet and (inset) distortion cancelling loudspeaker mounting. On the left is shown the reduction of distortion in this loudspeaker system.

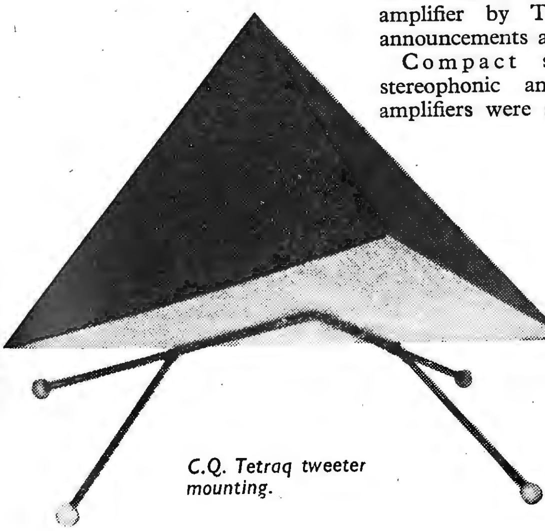


Expert 10- and 20-watt (0.1% distortion), the Decca 25-watt (0.05% distortion) prototype (due to its tertiary feedback winding on the output transformer), and the Rogers Senior Mark II 15-watt (0.1% distortion) amplifiers. Some information was released by Quad on the amplifier conditions under which their electrostatic speaker should be operated. The ideal amplifier source impedance would be equivalent to a 1-2-ohm resistor in series with a 40-μH inductance. The distortion should be low for resistive loads varying between 30 and 7 ohms, and on a 30-ohm load not more than 35 peak output volts should be available.

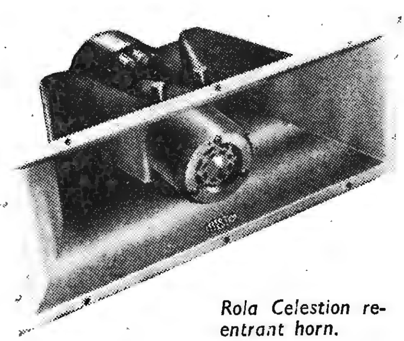
Although Grampian were showing a 40-watt (1% distortion) amplifier using ultra-linearly operated KT88s, high powers do not yet seem to have invaded the British market. The two Leak power amplifiers have however been modified to give power outputs of 12 and 25 watts for 0.1% distortion. The Armstrong A10 Mark II can also now give 10 watts at 0.1% distortion. A 60-watt public address amplifier by Trix was used for announcements at the fair.

Compact single-unit 10-watt stereophonic amplifiers and pre-amplifiers were shown by Connoisseur and Avantic. These, of course, include an extra control for balancing the two inputs, and the Avantic also has a knob labelled 3D and stereo to enable a single channel output to be fed to two loudspeakers, thus giving a much wider apparent sound source.

Loudspeakers.—A new method of mounting loudspeakers which greatly reduces the distortion at low frequencies was demonstrated in the G.E.C. Periphonic system. The loudspeakers are mounted front-to-back at a slight angle as close together as possible in a small V-shaped enclosure, as in the illustration. The slot in the enclosure is acoustically terminated in a rectangular bass reflex cabinet (42 in × 25 in × 15 in). The electrical inputs to the two loudspeakers are made out of phase. Because of the tight coupling between them the geometrical distortions of the loudspeaker cones are to a considerable extent cancelled out. These distortions are such that when the cone apex is moving towards its periphery the cone tends to open out, and when it is moving away it tends to collapse, much as a partially opened umbrella would. Very high air pressures are generated in the V-shaped enclosure, which possibly precludes its use to very strong cone loudspeakers such as the G.E.C. metal cone. This also necessitates considerable care in removing resonances from the reflex cabinet. Corrugated cardboard diaphragms are placed at suitable positions within the enclosure to break up any resonances of the air columns, and tapered slots are cut in the two vents to broaden the main air resonance. The diagram shows the reduction in the distortion achieved; it should be noted that the electrical input has been doubled to the two-speaker system. Three sets of the usual "presence-unit" tweeters are used in the complete system, placed at the front and the two sides of the cabinet. These are



C.Q. Tetraq tweeter mounting.



Rola Celestion re-entrant horn.

arranged so that either the front, or the side, or both sets of tweeters can be switched on, compensation being applied to keep the overall response level in all cases. By this means the apparent sound source can be made very large with only the side tweeters on (perhaps for relaxed listening or large-scale works), somewhat smaller with the front tweeters switched on as well, or smaller still with only the front tweeters switched on (for speech).

Wharfedale were showing their new free-standing three-speaker sand-filled baffle system (SFB/3) which is 34 in × 31 in. They have found that with the additional reflecting surfaces such as occur in a room corner the normal response of a loudspeaker mounted in a baffle is modified and extends about an octave lower than usual, but with the cut-off rate increased from 6 to 12 dB per octave. The two parallel-fed low-frequency units (W12/SFB, 10-in Bronze/SFB) have a very low resonance frequency due to the use of the new foam rim-suspension which is now fitted to all Wharfedale speakers. This also reduces distortion at large amplitudes and smoothes the response generally. The tweeter in the SFB/3 is a standard super 3/FS.

Rola Celestion have introduced a new middle and upper frequency (crossover points at 750 and 5,000 c/s) two-speaker system (415). The middle speaker uses a re-entrant horn as in the illustration, the tweeter being placed in the centre. Some more information was given about the Goodmans electrostatic speaker (103): the impedance at 400 c/s is 15 ohms and substantially resistive. C.Q. have added several alternative tweeters to their standard small (22 × 12 × 13 in) bass reflex cabinet with tunnel port. One of these is the Tetraq, which consists of a tetrahedron containing two 4-in-diameter tweeters mounted on different faces. This rests on a stand in any position thus easily giving a wide control over the treble distribution. Other small speaker systems were shown by Pye and Simon.

New 4-in tweeters were shown by Rola and Plessey. Two miniature speakers 1½ in in diameter and 1½ in × 2½ in for use in transistor sets have been added to the W.B. range. One of the Expert range of speakers uses a simple four-foot acoustic column with the single speaker mounted at the top. By this means acceptable results are obtained in a very small floor space (1 ft square).

Television Interference from Sea Reflections

By J. K. S. JOWETT,* B.Sc.(Eng.), M.I.E.E.

An Explanation of the Effects Observed at Kingsand and Cawsand

A PARTICULARLY interesting and troublesome case of beat interference to Band I television reception was reported in the March, 1957, issue of *Wireless World*. The predominant effect described was that of a fluctuating picture brightness which occurs rhythmically at a rate of between 35 and 50 per minute at reception points in Kingsand and Cawsand in Cornwall. These two places are heavily shielded by a local 400-ft hill from signals following the direct transmission path from the B.B.C. television transmitter at North Hessary Tor. When the beat effect is most pronounced it is accompanied by multiple ghost images of alternating polarity. Apart from a short period around sunset on summer days the phenomenon is present, to a greater or less extent, whenever television transmissions take place; no separate interference source which might have caused the trouble has been observed at times when North Hessary Tor was not transmitting.

This evidence strongly suggests that the interference is created by unwanted modes of propagation of the television signal, i.e., by reflections from some natural features or other obstacles which are not in the direct transmission path. The usual effect of such reflections is, of course, familiar to many viewers and takes the form of a permanent ghost or echo signal displaced from the main signal by an amount which is proportional to the time delay of the ghost signal relative to the primary signal. The rhythmic variation of picture brightness which occurs at Kingsand and Cawsand, however, could only be caused by such means if the path delay were subject to a regular and systematic change. As is well known such an effect can, for a short space of time, be caused by a moving object such as an aircraft; but the permanent nature of the present reported interference rules out an explanation based on aircraft reflections.

It was stated that this type of interference has been noted elsewhere at a number of coastal areas shielded from North Hessary Tor, between Start Point and Looe; but nowhere is its effect so pronounced as it is at Kingsand and Cawsand.

The original report quoted the opinion of the B.B.C. that the beat is caused by a reflection from the surface of the sea. The present writer is convinced that this can be the only explanation and, furthermore, that the rhythmic beat effect is in all probability due to the regular motion of waves on the sea surface. It should be borne in mind in this connection that although a radio wave may be reflected at the sea surface with a high coefficient of specular reflection—perhaps of the order of 0.8 or 0.9 or even more—there is inevitably some degree

* Post Office Engineering Department, Radio Planning and Provision Branch

of scattered reflection taking place. The sea acts, in fact, as a re-radiator of energy; by far the greatest part of the incident energy is re-radiated in an extremely narrow lobe in the forward direction but a very small amount of energy is scattered in all directions. There may be small side lobes of re-radiation in directions favoured by the corrugation of the sea surface and, where a large area of sea is "illuminated" by a strong incident field, the cumulative total of energy thus scattered may be far from negligible.

The same type of interference is, of course, met in the form of sea-clutter on centimetric radar displays. In this case the echoes forming the clutter are due to direct back scatter from the sea. Such back-scattering phenomena, both from sea and land, have also been conclusively demonstrated in recent research on the transmission of h.f. waves. It is this form of back-scattered reflection which no doubt generally accounts for the television beat interference at coastal areas where the reception site is badly shielded from the transmitter and where, also, the sea is in direct view of both the reception site and the television transmitter. In the special case of Kingsand and Cawsand, however, it would appear that the interference is largely due to "sideways" scatter from areas of water in Plymouth Sound rather than to back scatter from the English Channel.

Why should the problem be so pronounced at Kingsand and Cawsand? The primary condition that the direct path signal is severely attenuated by local high ground is, of course, fully met, but so it

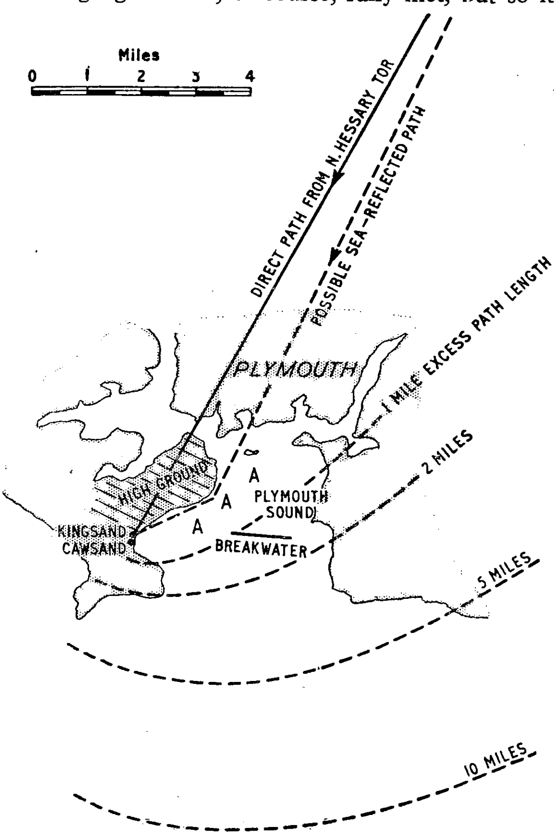


Fig. 1. Plan of the affected area and its environs, showing ellipses through reflection points giving various path differences.

is in many other places. The real aggravation of the problem here lies in the fact that Plymouth Sound and much of Cawsand Bay are in no way shielded from North Hessary Tor; they are, in fact, illuminated with radio fields that are at least 20-30 dB greater than the direct-path field set up at Kingsand. Moreover, this stretch of water lies in front of or to the side of the receiving aerial; not, as in the case of usual coastal sites, to the back of the receiving aerial. It is therefore less easy to provide discrimination by means of aerial directivity. The glancing angle at which the radio waves strike the water surface is also quite high—of the order of 1.5° to 2°—and as will later be seen this considerably assists the extent to which scattering takes place.

Possible Reflection Modes

It is useful to distinguish between three possible separate modes of sea reflections in this particular case, these are:—

(a) Quasi-specular reflection at oblique incidence from wave fronts in Plymouth Sound.
(b) Similar, but less oblique, reflections from rollers out to sea, and
(c) Scattered reflections from a wide area of the bay similar to the usual form of sea-clutter met in radar.

The first mode may well predominate at times and is therefore described here in some detail; it also illustrates very simply the way in which sea-wave motion can cause picture fluctuations. These oblique-incidence reflections from sea waves may be assumed to take place from region A marked on the map (Fig. 1), perhaps particularly from wave fronts advancing in a generally north-west direction, since such wave fronts are likely to give maximum reflections in the direction of Kingsand and Cawsand†. If we look at the situation in plan view, we see that reflection at the wave fronts is relatively oblique in this region; it is, therefore, more nearly specular and of larger amplitude than ordinary back scatter. Since, in addition, the reflected signal would arrive at Kingsand only 30° or so off the direct-path bearing it is likely that this mode of reflection is always effective. In so far as the mode is one of quasi-specular reflection from the advancing fronts of waves and breakers it is probable that the general area of reflection will depend on the height of the receiving aerial. If this height is only 50 feet above sea-level, effective reflections may be taking place little more than ½ mile away, whereas, with aerials 100-200 feet above sea-level, the area of most effective reflections may be one or two miles away from the receiving point. The delay of these reflected signals relative to the direct-path signals would be of the order of 1-2 microseconds only, and, while a diffuse form of ghost image might be seen, the main result would be to cause a fluctuation of picture brightness as the following reasoning shows.

Let us consider reflections from a single wave front advancing towards the coast to the north-east of Kingsand. At some point in the travel of this wave the reflected signals reaching Kingsand would augment the direct-path signal; a short time later, when the excess path length has decreased by just

† It is worth noting that, near the coast, sea waves travel faster in deep water; this causes wave-fronts approaching a coast-line, from whatever direction, to swing round so that they roughly follow the contours of the sea-bed and make their final approach in a direction parallel to the shore.

one half-wavelength of the radio waves, the reflected signals would be in phase opposition to the direct-path signal, thus reducing the picture signal level. Simultaneous reflections from a number of such sea waves would undoubtedly take place. They could not, of course, all be expected to be in phase with one another but neither would they all cancel out; there would virtually always be a substantial resultant causing a fluctuation of the total received signal.

Sea Wave Velocity

In support of this general contention it is possible, quite simply, to relate the picture fluctuation rate to the velocity of the sea waves causing the beating effect. The lowest observed picture fluctuation rate is 35 per minute or about 0.6 per second. In other words the excess path length of the reflected signals must be decreasing by 0.6λ per second or approximately 3.5 metres per second since the vision wavelength of North Hessary Tor is very nearly 6 metres. If we now refer to Fig. 2 we see that this excess path length, P, is given by:

$$\begin{aligned} P &= AC - DC \\ &= AC\,(1 - \cos 2\theta) \\ &= n \operatorname{cosec}\theta\,(1 - \cos 2\theta), \text{ since } AC = BC \operatorname{cosec}\theta = n \operatorname{cosec}\theta \end{aligned}$$

i.e. $P = 2n \sin\theta$, a very simple result.

Differentiating,

$$\frac{dP}{dt} = 2\sin\theta \cdot \frac{dn}{dt}$$

and since the angle 2θ is close to 30° for much of the region we are now considering, $\sin\theta \simeq 0.25$, and

$$\frac{dP}{dt} = 0.5\frac{dn}{dt}$$

In simple terms this means that the rate of change of excess path length (minimum value about 3.5 metres per second as deduced above) is just about one-half of the velocity of the advancing waves when these are approaching in the correct direction to give maximum reflections. Thus, in order to explain the reported rates of picture fluctuations, the minimum sea-wave velocity in and around region A must be about 7 metres per second (or 14 knots) while the maximum sea-wave velocity in this correct direction must be perhaps 9 or 10 metres per second (or 18 to 20 knots). The striking thing is that these velocities are very close to what would normally be expected in fairly shallow water. At low tide the water depth of region A is certainly below 5 fathoms (30 feet); let us assume an average low-water depth of around 15 feet, for which various authorities quote a wave speed of 13 knots. At high tide this depth would be roughly doubled and this would approximately increase the wave velocity by a factor of $\sqrt{2}$ to some 19 knots, either more or less, depending upon the strength and direction of the wind and other factors. An assumption that the average water depth was either 10 or 20 feet instead of 15 feet would have altered these results by less than 20%. It can therefore be said that the observed phenomena are consistent with the theory of wave-front reflections from this particular region. It would certainly be of interest to know whether the observed rate of fluctuation is generally a maximum around high tide, particularly under conditions when modes (b) and (c) might be less important than mode (a).

The possible effects in region A have been described in some detail. But it is clear that other areas of water do affect reception on occasions if not all the time; for example, multiple fluctuating ghosts are reported with such long delays that the corresponding excess path lengths must be of the order of several miles or more. In Fig. 1 are drawn parts of the ellipses joining points from which reflections would give excess path lengths of various values from 1 to 10 miles; this latter range corresponds to a time delay of about 54 microseconds or just over one-half of a line scan. It is clear that if sea reflections are to give the multiple long-delay ghosts which are reported they must come from the English Channel and the southern half of the bay.

There seems no reason to doubt that such reflections can take place, particularly when there is a heavy swell or sea occurs. But the fact that separate ghosts are visible would suggest that such reflections are "grouped" so as to give echo signals which are delayed by at least one or two microseconds from one another. For this to be the case it would seem that conspicuous reflections do not necessarily take place from all waves, but only from those which are spaced by perhaps as much as ¼ mile or ½ mile apart. This is by no means improbable in fairly high seas and it is an observed fact that sometimes a number of rollers advance as a group very close to one another and leave behind a long gap before any further substantial waves are met. This inference is supported by radar observations which occasionally show sea-clutter divided out into striations or ridges of echoes with intervening dark gaps representing distances of hundreds of yards between effective wave-scatterers. The velocity of such large waves or rollers at the entrance to the bay probably exceeds 20 knots. From Fig. 1 we should expect the distant waves to advance in a direction roughly normal to the delay ellipses, and for this reason separate fairly distinct echoes from a close group of waves might be expected. The effect might be particularly pronounced with winds between south and east and the polarity of these long-delay ghosts would alternate at a rate considerably faster than the reported picture fluctuations. The ghosts would not, of course, beat exactly in phase with one another and at any one instant some would appear white, others black, while the remainder would be in the process of changing their polarity. They would move steadily towards the primary image but at too slow a rate to be observed, especially in view of their constantly changing polarity.

Scattered Reflections

There remains to be considered the third mode, that of sea-clutter which, of course, could be taken to include the first two modes. Scattered reflections or "clutter" from nearly all parts of the bay must take place at all times to some degree. The effect would, one might expect, be especially marked in choppy seas but may be sufficient at nearly all times to give some of the observed effects. Some help on the present problem may be gained by studying the findings of radar research on sea-clutter, although in this case only back-scattered reflections from the sea's surface are involved.

Sea-clutter on centimetric radar screens is regularly observed out to ranges of several miles, and

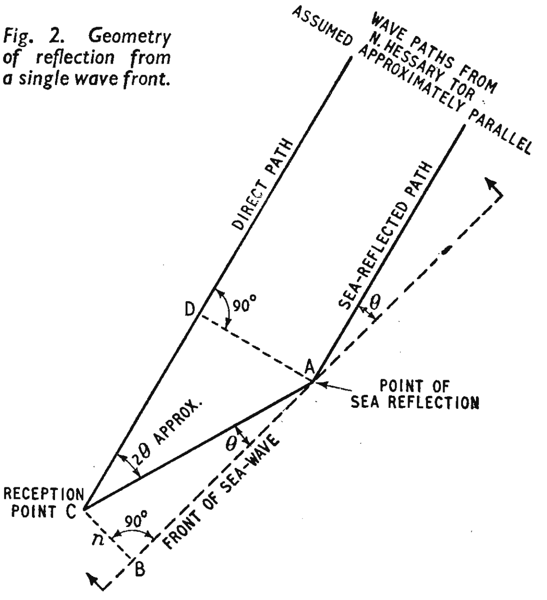


Fig. 2. Geometry of reflection from a single wave front.

to even greater distances when the sea surface is rough, especially in the windward direction. With vertically polarized radar the effect is more pronounced than with horizontally polarized radar especially, it would seem, for radars operating on metre waves. Of particular significance to us is the observed fact that the magnitude of sea-clutter depends markedly on the glancing angle α at which the transmitted wave meets the sea surface. For very low angles of α the back-scattered power was found to be proportional to $\frac{1}{\alpha^8}$ or $\frac{1}{\alpha^4}$; this means that the power scattered back at, say, $\frac{1}{2}°$ glancing angle might be less than 1% of the power scattered back at 2° glancing angle! It is not difficult to appreciate that this may be so, since the apparent "corrugation" or roughness of the sea, when observed at low angles, can rapidly decrease as the point of observation is lowered, any single large wave then tending to obscure from view other waves which follow. Various theories of sea-clutter have been advanced including the suggestion that spray droplets formed at "whitecaps" cause scattered reflections, but it seems probable that an explanation based upon scattered reflection from waves and ripples (or, more exactly, upon diffraction effects at an uneven surface) is likely to be proved the more correct.

These facts lend support to the idea that significant scattering takes place at the sea surface even on metre waves if vertically polarized signals are incident at an angle which is not too small. The general movement of waves at the surface would then give Doppler echoes which, if large enough, would produce resultant fluctuations in the amplitude of the received signal. Since the scattered echoes would arise from numerous wave fronts on the sea the total result would be an accumulation of small sea-reflected components arriving in random phase, but all causing periodic fluctuations of picture signal at rates of perhaps 20 to 60 or more per minute. Those echoes with the shorter delays would probably produce the largest beating effect and might congregate around a mean fluctuation frequency of 30 or 40 or 50 per minute, as has already been shown.

It is necessary to make a few more remarks concerning the originally reported effects. First, why is there a virtual disappearance of the phenomena for a short daily period around sunset in summer months? An explanation based upon a reduction of wind velocity and therefore, perhaps, of wave height at this time does not seem very convincing. It is possible, however, that an explanation involving the refractive index gradient in the atmosphere and, in consequence, the angle of incidence of the radio waves at the sea surface, may be correct. Thus the withdrawal of the sun's rays at the end of a summer day may cause quite rapid and pronounced changes in the state of the air over coastal districts. These may modify significantly the atmospheric refractive index gradient with height and thereby cause, for example, a change in glancing angle from 1.5° to, perhaps, 1.25° or even 1°. If such a change could occur, it could easily lead to a reduction of the order of 10 dB in the scattered signals if radar experience is any guide. Furthermore, it should be remembered that, near the Brewster angle, the phase and amplitude of specularly reflected vertically polarized waves undergo rapid changes. This angle appears to be around 1.5° in the case of 50 Mc/s waves incident at the sea surface and small changes in the incident angle may cause pronounced changes in the reflected components for this reason also. If these explanations of the sunset effect are near the truth the same basic causes might be invoked in part explanation of other observed effects such as the only occasional appearance of long-delay echoes and the variation of the interference with atmospheric humidity.

Other Areas

It is interesting to note that Tor Bay is less clearly illuminated by the North Hessary Tor transmissions than is Plymouth Sound; further, because of the greater distance, the glancing angle at which the radio waves meet the sea surface at Tor Bay is less than 1°. These facts are probably sufficient to account for the absence of reports of severe beating interference from that area. Nevertheless there is no doubt that the effects observed at Kingsand and Cawsand could be met in other parts of the country, although the conditions necessary for the beating interference to be severe will probably restrict occurrences to only a few localities. Not only must the direct path be badly screened locally but there must be a large local stretch of water, preferably in the forward-looking direction of the receiving aerial. This water must itself receive a high field strength by direct transmission and the radio signals should, if scattering is to be significant, be incident at an angle well above 1°; this, in turn, presupposes a television transmitter near to the coast-line. The necessary physical conditions could, perhaps, be met within 20 miles range of the B.B.C.'s Blaen Plwy (West Wales) and Sandale Fell (Carlisle) transmitters. But both of these transmissions are horizontally polarized and any effects should be less serious in consequence.

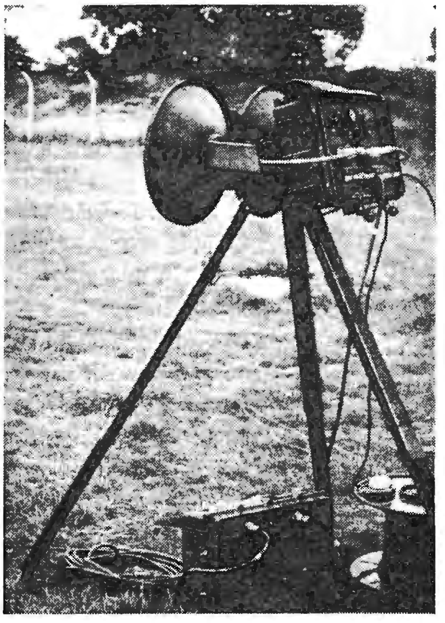
It remains to be seen whether the effect will be worse in Band III under similar circumstances. The amplitude of sea-reflected signals will probably be greater at the higher frequencies, but severe effects may be more localized and also more readily dealt with by the greater aerial directivity discrimination achievable at these frequencies.

These remarks, however, scarcely help the unfortunate viewers of Kingsand and Cawsand. If the explanations here advanced are correct it would appear that the best prospects of minimizing their difficulties lie in, so far as possible, avoiding sites which give a very open view of the bay. Aerials which are designed to give really effective discrimination against signals some 30°-40° off the true bearing may be of some help, but would not necessarily assist when moderate- or long-delay echoes are predominant.

The views expressed in this article are the personal ones of the author, who wishes, however, to acknowledge the helpful suggestions of a number of his colleagues in the Post Office.

Wideband Communications Systems

Travelling-wave Tubes Contribute to Simplification of Equipment



Marconi Type HP311 6.5-cm portable multi-channel communications equipment.

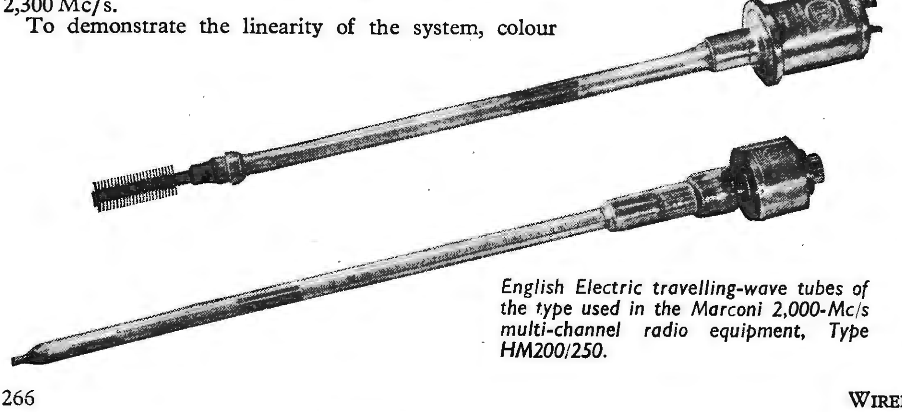
AN exhibition and demonstration of wideband metre and centimetre communications equipments was held recently by Marconi's Wireless Telegraph Company in association with certain other companies. Among these were the Automatic Telephone and Electric Company, the British Insulated Callender's Construction Company, the English Electric Valve Company, Siemens Bros. and the Telephone Manufacturing Company.

These equipments have been developed primarily for multi-channel telephony. Frequency modulation is used throughout and one of the equipments, the HM200/250 working in the 2,000 Mc/s band, has a potential capacity of 600 normal-width speech channels, or one high-definition television channel.

A special feature of the HM200 (terminal) and HM250 (repeater) equipments is the use throughout of some new types of travelling-wave tubes made by the English Electric Valve Company. These tubes are designed especially to meet the exacting requirements of wide bandwidth, linearity, freedom from phase distortion and high amplification at ultra-high frequencies. The last-mentioned characteristic has enabled the repeater stations to operate without demodulating the incoming signal prior to amplification. Signals are amplified at the working frequency of about 2,000 Mc/s, the frequency is changed slightly and after further amplification in a 3-stage travelling-wave tube amplifier is re-radiated at a power of about 10 W. Parabolic aerials are used with receiver and transmitter sharing a common aerial by means of diplexers. Distances of 2,000 miles or more may be covered by this equipment using suitably disposed unattended repeaters. All travelling-wave tubes used in these equipments are tested for linear operation over the frequency band of 1,700 to 2,300 Mc/s.

To demonstrate the linearity of the system, colour television pictures were sent over a 30-mile radio path, comprising one two-way repeater and a turn-round station. Direct comparison between the pictures before and after traversing the radio path, failed to reveal any loss in picture quality.

The various equipments displayed embraced a frequency range of 60 Mc/s to 5,000 Mc/s and for the higher order frequencies there was shown (and demonstrated) the Type HP311, a portable multi-channel system working in the band 4,580 to 4,860 Mc/s (6.5 cm) with a transmitter power of about 200 mW. This is intended to be a temporary or semi-permanent point-to-point communications system and, in conjunction with carrier-telephony equipment, will handle up to 12 speech channels. Distances of 20 miles or more, according to nature of the intervening terrain, can be covered in a single hop and the HP311 is usable as a repeater by locating two sets back-to-back with appropriate ancillary equipment.



English Electric travelling-wave tubes of the type used in the Marconi 2,000-Mc/s multi-channel radio equipment, Type HM200/250.

Components Exhibition

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

This report covers most of the exhibits at the Exhibition held in London from April 8th-11th by the Radio and Electronic Component Manufacturers' Federation. Valves and allied devices at the show are dealt with under a separate heading in the present issue, while test and measuring gear shown at this and other recent exhibitions will be described in the July "Wireless World"

Resistors.—A few new resistors made their appearance this year but generally speaking the main changes have been directed towards adapting existing ranges for printed circuits and for automatic assembly.

Dubilier had a new range of "BT" insulated resistors in $\frac{1}{2}$- and 1-W sizes. The $\frac{1}{2}$-W (BTS) measures only $\frac{1}{8}$ in in diameter and $\frac{3}{8}$ in long and is available from 390 Ω to 10 MΩ. The 1-W size (BTA) is somewhat larger.

A modified form of vitreous wire-wound resistor, in which the axial wires do not impose any strain at all on the fine resistance wire, was shown by Welwyn.

This firm were showing also a new type of potentiometer designed for use in flywheel sync circuits. Its particular feature is the embodyment of an on/off switch which is brought into operation by pushing in the control spindle. The potentiometer can then be rotated in the usual way, still maintaining the switch contacts closed.

A control, offering the same facilities but of quite different design, is the "Clarostat" model shown by A.B. Metal Products. In this design the switch, a single-pole change-over type, is directly connected to a small insulated knob; on pressing in the knob a dog-clutch engages with its counterpart on a potentiometer spindle and the control can be rotated as usual.

Television influence was seen in the design of small pre-set potentiometers intended for factory or dealer adjustment only. They are very compact and of inexpensive design and examples were shown by Welwyn and by Egen. The latter had three distinct types; for independent mounting, for printed circuits and for suspending in the wiring. They are rated at $\frac{1}{10}$ W and made in values of from 4.7 kΩ to 2.2 MΩ.

Some ingenious brackets have been evolved for fixing the smaller types of volume control potentiometers to printed circuit boards. Special contacting tags replace the customary ones and examples were seen on the stands of A.B. Metal Products, Egen, Plessey and several other firms.

In addition to the familiar button-type potentiometers with rim control, introduced originally for hearing aids, the orthodox pattern with spindles are now produced in miniature form for transistor equipment and wherever space is restricted. The Dubilier Type "Y" is a good example and Plessey have introduced a new one which is only $\frac{23}{32}$ in in diameter. Known as the Type MH2, it embodies a moulded resistance element rated at $\frac{1}{4}$ W. It is made in values of from 5 kΩ to 1 MΩ with a log law and 1 kΩ to 2 MΩ with linear law. It complies with Services' Specification RCS122 and is a high-grade component.

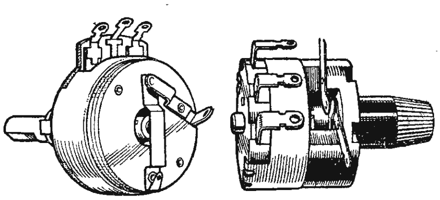
Manufacturers*: A.B. Metal Prod. (VC), British Electric Res. (W), Bulgin (W), Colvern (VC, W), Dubilier (C, HS, VC, W), Egen (VC, W), Electronic Comp. (W), Electrothermal (W), Erg (HS, W), Erie (C, HS, W), Morganite (C, VC), N.S.F. (VC), Painton (HS, VC, W), Plessey (VC, W), Salford (W), Welwyn (C, HS, VC, W), Zenith (W).

***Abbreviations:** C = composition, HS = high stability and carbon film, VC = volume control, W = wirewound.

Capacitors.—During the past year or so the design of fixed capacitors has been significantly influenced by the requirements of printed circuits and transistor equipment. This year sees these influences reflected in the design of ganged tuning capacitors. Jackson Bros. have introduced a midget twin gang, the Type "00", measuring only $1\frac{1}{32} \times 1\frac{3}{8} \times 1\frac{17}{32}$ in and having a single bank of moving plates instead of the usual two. The fixed plates are in two sections, but not divided by a screening partition as usual. They have unequal capacitances, the rear, or oscillator section, being 176 pF and the front 208 pF maximum.

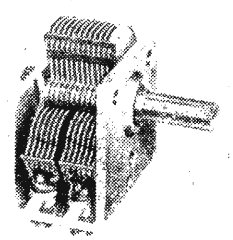
A midget Type "W" twin gang capacitor of similar form was included in the Plessey exhibit. It, also, has a single rotor section and unscreened stator sections, in this case of 111 pF and 229 pF respectively. Some tiny twin gangs were found on the Polar stand (Wingrove and Rogers), but in these both sections are of the same capacitance.

New fixed capacitors were reasonably plentiful and everywhere reflected the influence of the printed circuit. It has led Plessey to introduce a new moulded base for their

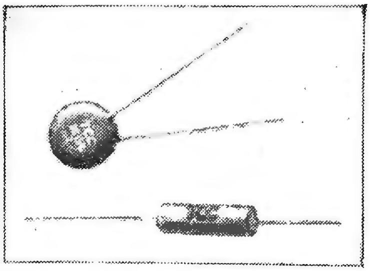


(a) (b)

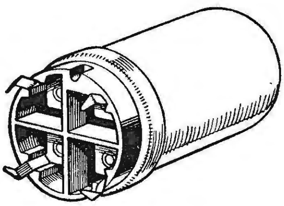
Potentiometers with press switch for flywheel sync circuits, (a) Welwyn "clutch" potentiometer and (b) A.B. Metal Products "Clarsotat."



Miniature Type "00" gang capacitor made by Jackson Bros.



Aerial isolating and "Ceramiseal" tubular capacitors made by T.C.C.



New moulded base for Plessey printed-circuit electrolytic capacitors.

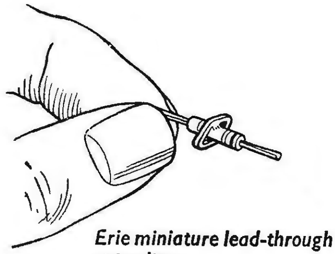
larger type electrolytic capacitors to enable replacement, should it be necessary, to be effected in a reasonably simple way. Normally all base tags, or wires, have to be heated simultaneously to melt the solder before the unit can be removed. The new base has springy tags which fit in rectangular slots in the printed circuit board, the slots being of such a size as to enable the spring lugs to be unsoldered separately and disengaged from the printed wiring.

Plessey were also showing some new paper-dielectric capacitors of small physical size for the capacitances achieved. There were three ranges known as "Plesmin", "Pleswax" and "Pleseal" respectively.

Dubilier have added some further models to their already extensive range of interference suppressors and they now include some 96 different types. One, a u.h.f. feed-through suppressor for power leads, has the "through" conductor sleeved with ferrite to provide a series impedance at u.h.f.

A tiny polystyrene capacitor, principally for use in miniature i.f. transformers, was shown by Suflex. It is only 7 mm long and 3 mm in diameter. Nevertheless capacitances of 100 pF at 350 V d.c. working and 50 pF at 500 V have been achieved.

Among the new capacitors recently introduced by T.C.C. is a small ceramic disc with radial wires which is intended for isolating the aerial in a.c./d.c. sets. It conforms with the safety requirements in



Erie miniature lead-through capacitor.

BS415-1957 and is made in five sizes with capacitances of from 470 pF to 20 kpF. The latter is for earth leads only. Another "aerial isolator", but of tubular ceramic form with side-entry wires, was shown by Stability Capacitors. It measures 0.7 in long, 0.2 in in diameter and conforms also with BS415. Normal values are 470 pF, 1 kpF and 1.8 kpF.

Some new temperature compensating capacitors made their appearance this year. T.C.C. had a range known as "Ceramiseals" in which some models with capacitances ranging from 2 to 600 pF are available with a wide variety of temperature coefficients ($-750 \pm 80 \times 10^{-6}$ deg C to 100 $\pm 60 \times 10^{-6}$ deg C). These are enclosed in ceramic tubes with sealed ends and axial wires. Stability Capacitors had a new range or temperature compensating ceramic capacitors. Nine varieties are available, ranging from P100 (positive) to N750 (negative) and in capacitance of 1 pF upward. Erie also had a number of models of this type.

Erie was showing as well a new miniature feed-through capacitor designed to withstand the effects of considerable heat without disintegrating, as might well happen when soldering it in position. It is made of very high "k" ceramic and so far is available in a 1-kpF size only, as its present application is in television and v.h.f. sets. A capacitor of a somewhat similar kind, and equally as small, was shown by L.E.M.

A novel Erie capacitor, unlike anything seen elsewhere and designed especially for printed circuit applications, takes the form of a small, thin, wedge-shaped plate of ceramic silvered on both sides. It is intended to be inserted into an appropriately shaped slot in the printed circuit plate and soldered in position. It is known as a "Spade Ceramicon" and is available at present only in a 1-kpF size.

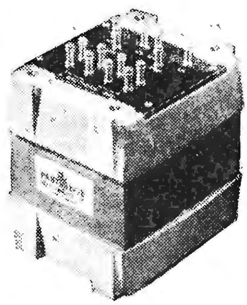
Adaptation to modern techniques was the highlight of Hunt's exhibit. Printed circuit capacitors were well in evidence and there was a bandolier strip assembly of capacitors of the kind used in automatic component assembly machines.

Manufacturers:* Bulgin (T), Cyldon (T, V), Daly (E), Dubilier (C, E, F, M, P, T), Erie (C), Hunt (C, E, F, M, P), J.B. (T, V), L.E.M. (C, M), Mullard (T, V), Plessey (C, E, F, M, P, T, V), Stability Capacitor (C, M), Static Cond. (P), Standard Telephones (M,P), Stratton (V), Suflex (F), Telegraph Cond. (C, E, F, M, P, T), Telephone Manuf. (F, M, P), Wego (M, P), Walter Instr. (T), Polar (T, V).

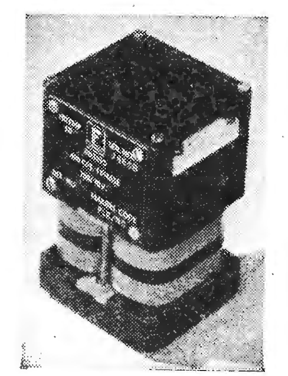
***Abbreviations:** C=ceramic, E=electrolytic, F=plastic-film and polystyrene, M=mica and silvered mica, P=paper and metallized paper, T=trimmers, V=variable and tuning capacitors.

Coils and Transformers.—As in other fields, new developments in wire-wound components have been influenced by the demand for miniaturization, for operation at higher temperatures, or both.

Transformers, even when of the miniature type, are the heaviest components which have to be inserted in printed circuit panels, and present problems of handling in the stages of production prior to dip soldering. Plessey have devised a system of "snap in" connecting tags of crimped spring material which holds the transformer securely without the necessity of bending over the tags at the back. A further advantage is that in the event of breakdown the connections can be unsoldered, one tag at a time, and the component replaced with no tools other than a soldering iron.



Partridge P5000 audio output transformer.



Ferranti "Hitemp" single-phase power transformer.

Transformers, and the transductors used in conjunction with servo-mechanisms, must be capable of operating at high temperatures in supersonic aircraft. The principal differences from conventional practice in transformers for these applications lie in the insulating materials and in the mechanical construction which is arranged to minimize internal thermal gradients. The Ferranti "Hitemp" series of transformers exemplifies this trend and is based on a maximum winding temperature of 250 deg C. This is the sum of the effects of ambient temperature and transformer loss and if the ambient temperature is not excessive advantage can be taken of the available balance to reduce weight and size in any application in which regulation is of secondary importance.

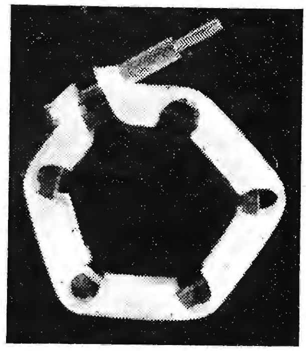
Wide-band, audio-frequency output transformers of the highest quality have generally been constructed with "C" cores, though the less expensive stacked laminations of the so-called "waste-free" grain-oriented type can be made to give a comparable performance. Partridge Transformers have introduced a series (P5000) with cores of the latter type in which the difference in performance has been still further reduced.

Toroidal cores in "Supermumetal" are now being produced by Telcon with a guarantee performance in terms of inductance per 1000 turns. They are supplied, ready for winding, in hermetically sealed nylon cases containing a silicone grease to protect the metal from mechanical shock or vibration.

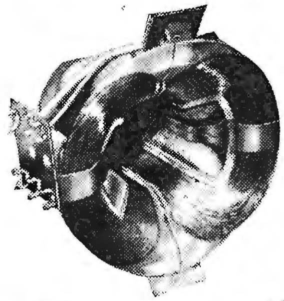
Manufacturers*: Richard Allan (AF, M); Sidney S. Bird (IF); Electro Acoustic Industries (AF); Electro Methods (TD); Ferranti (M, TD); Fortiphone (CH, AF, TD); Goodmans (CH, AF, M); Gresham (CH, AF, M, TD); Haddon (CH, AF, M); Parmeko (CH, AF, M, TD); Partridge (CH, AF, M, TD); Plessey (CH, RF, IF, AF, M); Reproducers and Amplifiers (CH, AF); Rola Celestion (CH, AF); Salford Electrical (TD); Standard Telephones (CH); Weymouth Radio (CH, RF, IF, AF, M); Whiteley Electrical (CH, RF, IF, AF, M); Woden Transformer (CH, AF, M, TD); Wright and Weaire (CH, RF, IF, AF, M); Wireless Telephone Co. (RF, IF); Zenith Electric (M).

***Abbreviations:** CH, a.f. chokes; AF, audio transformers; M, mains transformers; TD, transductors; RF, radio-frequency coils; IF, intermediate-frequency transformers.

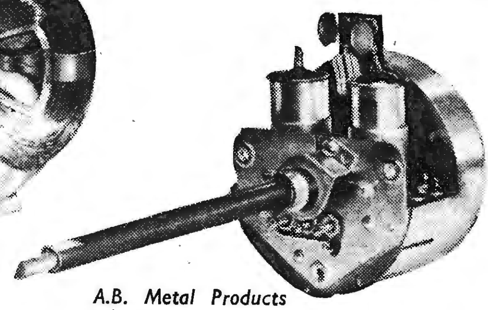
Television Components.—Now that the 21-inch c.r. tube with 90° deflection angle has obviously come to stay, considerable improvements have been made in scanning components for this wide-angle operation. The larger scanning power required calls for high efficiency in the magnetic deflection system, and this is particularly difficult to obtain at the lower frame frequency. Hitherto, the toroidal type of frame deflection coil has been used, but coupling between the coils has prevented the use of high-inductance windings. Now, Plessey have introduced an improved 90° deflection coil assembly with a castellated type of core for the frame coil, which has the high inductance of 128mH. This gives a better coupling between the winding and the core, while the high impedance of the coil permits a more efficient frame transformer to be used. Moreover, the core (made of "Caslam") locates the line and frame coils accurately and thereby ensures good consistency in picture shape. Improved focusing is also obtained. Any cross-talk between coils can be eliminated by damping resistors.



James Neill ion-trap magnet.



Plessey 90° scanning coil assembly.



A.B. Metal Products television tuner.

A new line output transformer for 90° scanning was also shown by Plessey. It has a wave-wound e.h.t. winding giving up to 18kV, a bracket for mounting the e.h.t. rectifier, and width and linearity controls incorporated in the base assembly. Another line output transformer, for 70° deflection and 14kV e.h.t., was intended for portable television sets.

Included in the range of focusing, ion-trap and picture-shift magnets shown by James Neill was a ring type of ion-trap magnet with a circular mounting clamp made of high-density polythene. This is designed to give improved locking on to the neck of the c.r. tube so that the magnet cannot move during transit. An aluminium version of the clamp is also available.

Manufacturers*: British Moulded Plastics (M); Electro Acoustic Industries (D, F); Goodmans (F); Long and Hambly (M); James Neill (F); Plessey (W, F, ST, D); Standard Insulator (M); Thermo-Plastics (M); Weymouth (W, ST); Whiteley (W. F. ST, D).

***Abbrevations:** D, deflector coils; F, focus units and ion-trap magnets; M, screen masks; ST, scan transformers; W, width and linearity controls.

Tuners.—A prototype television tuner notable for its small size and compactness was shown by A.B. Metal Products. Built in cylindrical form, it is only 2 inches deep and 3¼ inches in diameter. The small depth of the cylinder is obtained by using a flat switch plate instead of the usual coil turret. A further simplification is the use of a neutralized earthed-cathode single triode (2BN4) for the r.f. stage instead of the familiar double-triode cascode circuit. The other valve is a triode-pentode (5CG8) operating as a combined oscillator and mixer stage. Both of these valves have double base connections to the cathode to eliminate a common return path in the input and output circuits.

The "Teletuner" made by Sydney S. Bird has been modernized and now offers the additional facility of f.m. sound frequencies on Band II.

Manufacturers*: A.B. Metal Products (TT); Sydney S. Bird (TT, TC, PS); Brayhead (TT, TC); N.S.F. (TT); Plessey (TT, TC); Weymouth (FM).

***Abbrevations:** FM, a.m./f.m. tuners; PS permeability sound radio tuners; TC, television convertors; TT, television tuners.

Aerials.—Improvements in aerials this year are mainly confined to the mechanical details. As an example, Wolsey have introduced two new fixing devices of more than passing interest. One is a clamp for adding a Band-III aerial to the stand-off arm of an existing Band-I aerial.

It allows the high-band aerial to be separately orientated through a full 360° and it can be fixed to cranked or straight arms. The other is a universal-type wall bracket, for indoor or outdoor use, and its special feature is that the bracket can be fixed to a surface of any angle; it allows the aerial support arm to be pointed in any direction. It is known as the "Turret" wall bracket.

Time-saving designs, which cut the cost of erecting a v.h.f. aerial, were well in evidence this year and most of the leading makers had a number of examples under various names. For instance, Antiference call their design of collapsible aerials "Clik-Mec" models. The basic idea is the same throughout and consists of assembling the aerial at the factory, but collapsing and folding it into a conveniently sized package for dispatch. On the site it has only to be opened out and the elements snapped into position.

Aerial accessories were well in evidence again this year and Egen had two of more than usual interest. One was an adjustable attenuator only a little longer than an orthodox coaxial plug. It embodies a "pi" network with the series resistance network with the series arm adjustable in six steps, giving attenuation of from 6 dB to 36 dB. A number, indicating which of the six adjustments is in use, shows through a small window in the side of the attenuator case.

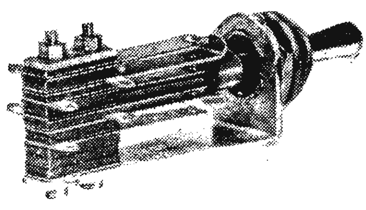
The other Egen accessory, a Bands I, II and III triplexer, is for feeding signals from the three aerials to a common feeder. Alternatively it can be used in reverse to separate the signals at the receiving end from a feeder common to three aerials.

Among the examples of printed circuits shown by T.C.C. were several aerial combining units; one, the "Trimatch Coupler," for Bands I, II and III aerials and a single feeder.

Coaxial plugs and sockets remain much as before except that Plessey have introduced some new miniature and sub-miniature types. The "MB" series has a bayonet-type fitting giving quick attachment and release and secure mating of plug and socket. The sub-miniature type is only $\frac{3}{32}$in in diameter and has PTFE insulation. It is so small that a special coaxial cable has had to be made for it as no existing type is suitable.

Manufacturers*: Antiference (A, AS), Belling-Lee (A, AS, C), B.I.C.C. (C), Egen (AS), Henley (C), J-Beam (A), Permanoid (A, C), Plessey (AS), Power Controls (AS), T.C.C. (AS), Telcon (C), Wandleside (C), Wolsey (A, AS).
***Abbrevations:** A=aerials, AS=plugs, sockets and accessories, C=feeder cables.

Switches.—Printed circuits have not produced any marked change in the design of switches except to make the tags into long thin fingers which can be readily soldered on to the copper conductors. Plessey had a whole range of switches—rotary, slider, push-button and piano-key—which could be supplied with either standard or printed-circuit contacts. One of the rotary segmented types had its printed-circuit contacts extended to form a straight row like the teeth of a comb, thereby allowing the switch to be mounted with its spindle parallel to the circuit board. Miniature piano-key switches, about half of the normal size, were also shown by this firm, and it was noticeable that in these a "push-push" action could be provided—the first key depression locking the mechanism and the second one, on the same key, releasing it.



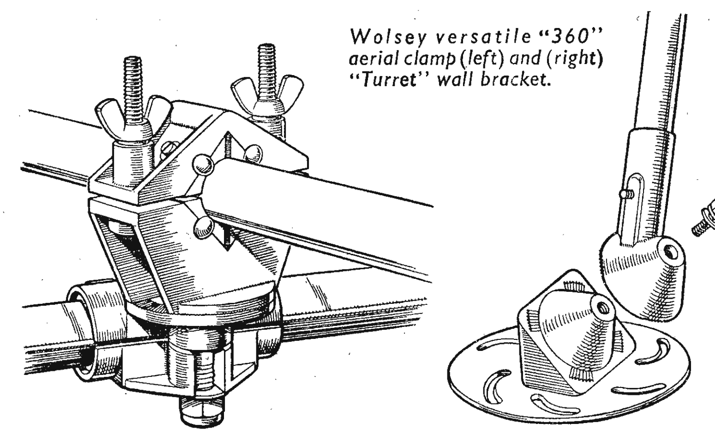
Bulgin key-type switch.

A new type of switch, with an action similar to a key type but in other ways resembling a toggle switch, was shown by Bulgin. The operating dolly has three positions, and it either locks firmly on the outside ones or returns to centre under bias, according to the model concerned. Pure silver contacts are used and the maximum load is 50W. This firm also had a new open-blade microswitch with an operating pressure of 1-2oz and initial travel of $\frac{5}{32}$ inch. It is available with various contact arrangements, biased and non-biased, and will carry a.c. up to 6 amps.

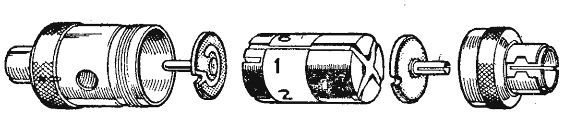
Film Industries were showing a tubular form of microphone switch designed for mounting between the microphone and its stand. It has three-pin plug-and-socket terminations at the ends, so that the microphone can be unplugged and the switch inserted very easily. The contact system uses gold-plated ball bearings and loading springs in a self-cleaning rotary action.

Manufacturers*: A.B. Metal Products (K, T, P, R, SL); B.E.R.C.O. (R, ST); Bulgin (K, T, M, P, R, SL, ST); Diamond H (T, R); Egen (R); Electronic Components (P, R, ST); N.S.F. (T, P, R, SL); Painton (T, P, R, ST); Plessey (K, T, P, R, SL, ST); Walter (T, P, R, SL); Wright and Weaire (R).

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

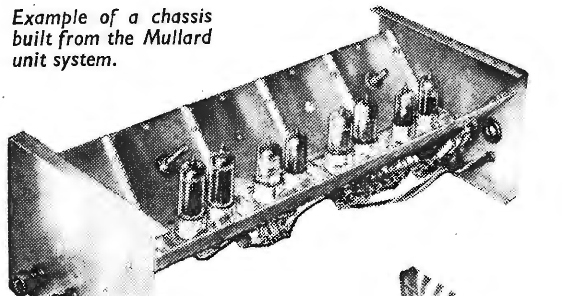


Wolsey versatile "360" aerial clamp (left) and (right) "Turret" wall bracket.

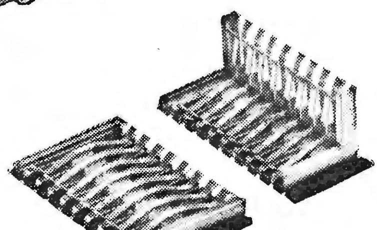


Egen six-step aerial attenuator in exploded form.

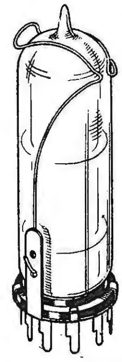
Chassis fittings.—Some of the more recent applications of printed circuits require connections to be made between circuit boards arranged at right-angles to each other, and several new connectors have been introduced for this purpose. One shown by Carr Fastener consists of a row of right-angled clips mounted on an insulator. The printed-circuit boards act as plugs at their edges



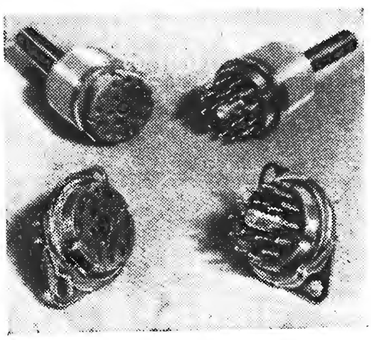
Example of a chassis built from the Mullard unit system.



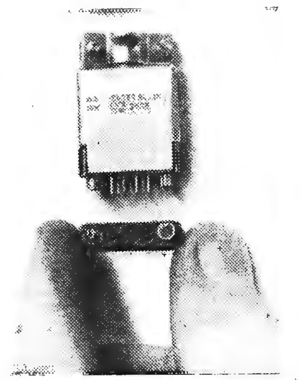
Carr Fastener printed-circuit connectors.



Spear valve retainer for printed-circuit holders.



McMurdo new 18-way radial type connector.



Electro-Methods sub-miniature 7-way connector.

and are pushed into the clips. Another right-angled connector on the N.S.F. stand made use of the "Varicon" type of contacts described in last year's report. Here the contact blades are actually mounted on the two circuit boards (on their blank sides) in such a way that the blades themselves mate at right-angles. Both of these firms showed corresponding connectors for boards in the same plane.

For equipment manufacturers who do not favour using the printed-circuit edge as a plug, Painton had a 10-pole connector which includes a plug part for fixing to the board (the socket part being free). The gold-plated contacts are staggered to prevent wrong-way-round insertion.

Amongst other connectors, McMurdo displayed a new 18-way radial type based on a B9A valveholder moulding (see illustration). It is light and inexpensive and is at present supplied with the customer's cables directly moulded in. This firm also showed a new octal printed-circuit valveholder, while Spear Engineering had a very simple valve retainer for printed-circuit valveholders (see sketch).

An interesting form of chassis construction, based on the "Meccano" principle, has been introduced by Mullard for "breadboard" experiments in development laboratories and training establishments. The basic unit is bridge-shaped chassis to which various valve mounting plates can be bolted (B7G, B9A or B8-O). The sloping sides are drilled to accept 10-way tag strips or terminal blocks for mounting components, and also have $\frac{3}{8}$-in diameter holes for potentiometers, switches, coaxial sockets, etc. End supporting plates can be used for lifting the chassis clear of the bench. The system permits of a good many variations, and, incidentally, can be fitted to a standard 19-inch rack.

Coaxial plugs and sockets for carrying e.h.t. voltages up to 30kV were shown by Lion Electronic Developments. They are moulded in polythene on to standard coaxial cables and are sealed against dampness.

Manufacturers*: Antiference (CPS); Ashdowns (DL, P); Bakelite (P); Belling-Lee (CPS, T, F, J, V); B.E.R.C.O. (DL, K); Brayhead (EFC); British Moulded Plastics (CR, CPS, ES, T, K); Bulgin (V, EFC, CPS, DL, ES, T, F, J, K); Carr Fastener (EFC, CPS, T, F, V); H. Clarke (T); Colvern (CPS); Cosmocord (K); Creators (EFC, G, T); Ediswan (CPS, T, V); Egen (CPS); Electro Methods (CPS, T); Electronic Components (CPS, DL); 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); Power Controls (CPS, T); Geo. Salter (EFC); 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); Geo. 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); Wright and Weaire (J, CPS).

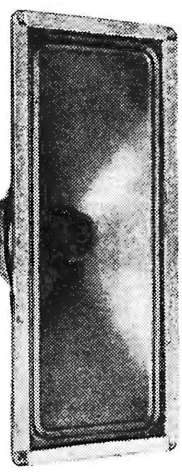
***Abbreviations:** CPS, connectors, plugs and sockets; CR, cabinets, racks and chassis; DL, dials; DR, drives; EFC, eyelets, fasteners and clips; ES, escutcheons; F, fuseholders; G, grommets; J, jacks; K, knobs; P, printed circuits; T, terminals and tag boards; V, valveholders.

Sound Reproducing Equipment.—Most of this was also shown at the Audio Fair and is discussed in our report on that exhibition. Some loudspeakers made for set manufacturers were, however, only shown at the R.E.C.M.F. This year, apart from improvements in materials and manufacturing techniques, several new trends were apparent in this field. For example, several manufacturers, such as Rola Celestion and Elac, now offer small-diameter (generally 4-inch) speakers for use as "tweeters." By this simple size reduction a high-frequency response up to about 15 kc/s is readily obtained. The increasing use of transistors offers good possibilities of doing without an output transformer. For use in this kind of circuit R. and A. were offering centre-tapped voice coils of impedances up to 60 + 60 ohms in their 7 × 4-inch loudspeaker. Plessey were also showing a high-impedance (80 + 80 ohms) centre-tapped loudspeaker of 3-in diameter.

For use in cases where it is important to save space Plessey were showing some "inverted" speakers with the magnet inside the cone angle. In some cases the magnetic flux return path was through the speaker chassis and ribbed structure in front of the cone. The same company were also showing a 9 × 4-inch loudspeaker with a rectangular cone.

The cone area, and thus low-frequency reproducing power, are equivalent to that of an elliptical speaker of, say, 8 by 5in. A new pressure unit for P.A. work (type LS9) which can be completely sealed against moisture was shown by Film Industries.

A very stylish-looking record changer with the usual facilities was shown by Staar Electronics. An experimental transistorized transmitter and receiver (which actuated a relay) gave remote-control rejection or repetition on this changer up to 25 feet away. The same company showed a small ($7\frac{1}{2} \times 6$-in baseboard) battery-operated 45-r.p.m. single record player. The current consumption is only 27 mA and a centrifugal governor ensures a constant turntable speed within 2% for supplies of between 6.2 and 3.5 volts. The pick-up is protected when not in use. Manual movement of the protecting shell cleans the sapphire stylus by means of a built-in brush and engages the motor idling pulley. Collaro were showing a new 4-speed record changer (the Challenger) where the crystal pick-up measures the diameter of the record before it is dropped and adjusts its lowering position accordingly. The mechanical construction has been considerably simplified.



Above : Plessey rectangular loudspeaker

"Scotch Boy" were showing a new instrumentation tape and also a strong PVC-base tape with the normal brown oxide coating. A new barium titanate turnover pickup cartridge was shown by Sonotone. The tracking weight is 9 grams and the compliance 0.8×10^{-6} cm/dyne. The output is 0.13 volts at 1 kc/s on Decca test record LXT269.

Manufacturers:
Loudspeakers:—Richard Allan, Elac, Film Industries, Goodmans, Plessey, R. and A., Rola Celestion, Truvox, Vitavox, W.B.
Magnetic Tape:—Scotch Boy.
Pickups and Microphones:—Collaro, Cosmocord, Film Industries, Garrard, Goldring, Lustraphone, Simon, Technical Ceramics, Vitavox, Walter, W.B
Tape Recorders:—Collaro, Simon, Truvox, Walter, Wearite.
Turntables:—Collaro, Garrard, Staar.

Materials.—Insulators and dielectrics for operation at temperatures of 500°C or higher have been investigated by S.R.D.E. (Ministry of Supply) and one of the most promising is boron nitride, which is a talc-like material normally available as a powder. It can be aggregated by hot pressing and the resultant mass has good mechanical strength, though this is anisotropic and the transverse strength perpendicular to the direction of pressing is less than the strength parallel to it. The dielectric loss (tan δ) decreases with frequency; at room temperature it is 0.0006 at 1 kc/s and 0.0001 at 100 Mc/s in a vacuum-dried specimen, though without special preparation it may be an order higher. There is an increase of about 10 in the loss at 500°C compared with room temperature. The permittivity is of the order of 4.7.

A co-polymer of styrene known as Styrene DVB was also shown by the Ministry of Supply. It has r.f. properties similar to polystyrene but greater resistance to solvents and a softening point at 130°C compared with 102°C for the normal polymer.

Right : Staar 45 r.p.m. battery record player and (inset) underneath view

Copper-clad, resin-bonded glass fibre sheeting now made by Thomas De La Rue (Delaron) for printed circuits has exceptional solder resistance and can be dipped for periods up to 2 minutes at 260°C.

Epoxy resins are being used more widely than ever, not only for encapsulation by gravity casting, but for coating by dipping. To save the time and cost of successive coatings Aero Research have developed a grade which will give the necessary thickness by a single immersion. An exceptionally long "pot life" is claimed for this new mix.

Ferrite magnetic materials, once virtually a monopoly, are now being produced by a number of firms. Ferranti have developed a manganese-magnesium ferrite (type F5X) for use in X-band waveguide isolators and switches. Its properties are: specific rotation 30°/cm; microwave loss 0.09 dB/cm; figure of merit 330°/dB; permittivity 12.

Permanent magnets of barium ferrite ($BaO.6Fe_2O_3$) are being produced by both Darwins and Swift Levick under the name "Feroba." The latter firm make two grades with remanence of 2000 or 3500 gauss coercivity of 1600 or 1400 œrsteds and $(BH)_{max}$ of 0.8 or 2.5 mega-gauss-œrsteds. Principal advantages of these ceramic magnets are their resistance to demagnetization, light weight (5gm/c.c) and the fact that they are electrical insulators.

Manufacturers*: Aerialite (C, IS, W); Aero Research (IM); Anglo-American Vulcanized Fibre (IM); Associated Technical Manufacturers (C, IM, W); Bakelite (IM); Geo. Bray (CE); B.I. Callenders (C, S, W); British Moulded Plastics (IM); Bullers (CE); Clarke (IM, IS); Connollys (C, IM, W); Cosmocord (CF); Creators (IM); Darwins (M); De La Rue (IM); Duratube and Wire (C, W); Ediswan (IM); English Electric (L); Enthoven (S); Ferranti (F); Fine Wires (W); Fortiphone (C); Hellerman (IM); Henley's (C, IM, W); Insulating Components and Materials, Ltd. (IM); Langley London (IM); Linton and Hurst (L); Lion Electronic Developments (IM); London Electric Wire and Smiths (W); Long and Hambley (IM, RP); Magnetic and Electrical Alloys (L, M); Marrison and Catherall (M, L); Mica and Micanite Supplies (IM); Micanite and Insulators (IM); Minnesota Mining (IM); Mullard (DC, F, M); Multicore (S); Murex (RM, M); Mycalex (IM); James Neill (M); Permanoid (C, IM, W); Salford (DC, M); Geo. L. Scott (L); Shell Chemical (IM); F. D. Sims (C, W); Standard Insulator (RP); S.T.C. (M); Steatite (CE); Suflex (IM, W); Swift Levick (M); H. D. Symons (IM); Technical Ceramics (PC); Telcon (C, DC, IM, L, M., RM, W); Telephone Manufacturing Co. (DC); Thermo Plastics (IM); Tufnol (IM); United Insulator (CE, IM); Vactite Wire (RM, W); Wandleside Cable Works (C, W); Whiteley Electrical (M); Henry Wiggin (RM).

***Abbreviations:** C, cables; CE, ceramics; DC, dust cores; F, ferrites; IM, insulating materials; L, core laminations and strip; M, magnets and magnetic alloys; PC, piezo-electric ceramics; RM, refractory metals; RP, rubber products; S, solder; W, bare or covered wires.

LETTERS TO THE EDITOR

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

Audio Fair

AS I fought my way round this year's Audio Fair I wondered increasingly how much valid judgment was possible on these occasions. With increasing perfection any weak link in the reproducing chain produces a greater effect, and the variability of recordings is also more apparent.

Thus, to give some examples, A's loudspeaker which you have every reason to expect should sound very similar to B's does not sound as good. But is the reproduction somewhat muffled because A has a smaller room than B? C's loudspeaker sounds rather boomy. But perhaps the boom is in the type of recording C likes, or has he been careless about recording compensation at the lowest frequencies? D's loudspeaker seems to have some distortion in the treble. Is this because he is using a slightly inferior pickup or has adjusted the tracking weight too low? E's new amplifier does not sound very good, but then one feels he is not using very good speakers.

It should be possible to settle on an amplifier and pre-amplifier good enough to please everyone. In that case we only need to test loudspeakers and pickups in the same large room, using the same records, the same pickup for testing loudspeakers and vice versa, with the same sound levels and the same position for each speaker. Allowance must also be made for the fact that, quite apart from auditory fatigue which may also occur, one's sensitivity to high notes varies at different times.

D. J. KIDD.

Edgware.

Quam Ridiculum Hoc Est

SOME of your light-hearted readers may be interested in my new definition of "j" which reads as follows:—

"The numerical value in ohms of a resistor which, when wired in series with a 1Ω resistor, provides twice the resistance of that resulting when these resistors are wired in parallel."

Proof:—

$$\frac{2R_1R_2}{R_1 + R_2} = R_1 + R_2$$

Then by substituting the values of 1 for R_1 and j for R_2

$$\frac{2j}{1 + j} = 1 + j$$

$$1 + 2j + j^2 = 2j$$

$$1 + j^2 = 0$$

$$\text{Hence } j^2 = -1$$

$$\text{and } j = \sqrt{-1}$$

with which no student will disagree.

Reading. W. CLARKE RIDDIFORD.

Television Coverage

THE B.B.C. Blaen Plwy television/v.h.f. sound transmitter, which has just started operations, serves a population of 72,000 at a cost of £250,000. Good luck to Wales, but we of the city of Sheffield could wish the B.B.C. would spend but a fraction of this amount to give a worthwhile service to a very large proportion of our half-million population.

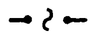
Situated at 18 miles from the main transmitter at Holme Moss, we have 107,000 TV licence holders for which at the new rate we shall pay £428,000 per annum. Our problem is multi-path reception owing to the topography of our terrain, and figures issued by the Post Office reveal that 55 per cent have satisfactory reception, 4 per cent have no reception and 41 per cent have need of directional aerials. These latter range from three-element to the double H, of which we have masses. A simple reckoning will show that at £10 extra for each aerial of 41 per cent of 107,000 and our city has met an excess capital outlay for aerials alone of over £½ million; further, it is no cure, but only makes the "ghosting" more bearable.

The 41 per cent mentioned are contained in three main areas and are sited favourably for coverage by a satellite transmitter with a five-mile radius. That seems the most economical solution of the problem, but perhaps your readers can think of something better.

Sheffield, 6. T. PAYNE.

Symbols and Nomenclature

THE recent inconclusive correspondence on the subject of symbols for equivalent current generators prompts me to make the following suggestions:—

The normal symbol for an alternating voltage source is  OR . The surrounding circle suggests the zero output impedance of the source. I suggest, by anology that, for an alternating current source, the symbol  OR  should be adopted. This has the advantages of (i) indicating the open-circuit nature of the source, (ii) being similar in character to the a.v. symbols, and (iii) being very simple. The sine wave could, of course, be set horizontal, but my suggestion has the advantages of keeping the two symbols more distinct, and also of not being far removed, at least in my handwriting, from the italic letters *v* and *i*, which are widely used as the corresponding algebraic symbols. The symbols I would suggest for direct voltage and current sources are then  AND , which are even more obvious in their derivation.

Cambridge. B. M. HARDISTY.

DISCUSSION about nomenclature in the field of transistor physics and engineering cannot be too long at this stage. As an experiment a small survey has been conducted to decide what is understood by transformer "turns ratio."

The question posed was:—

What do you understand by a turns ratio of (a) 1 : 3, in terms of number of turns, in the following cases?

Example 1.—A transformer designed to be fed from a single-phase supply and to provide h.t., a.c. supply to a bi-phase rectifier, e.g., the type of transformer generally found in radio mains supply units.

Example 2.—A transformer designed for phase-splitting between l.f. sections of an amplifier having a push-pull output stage.

And (b), what is understood by a turns ratio of 18:1

(in the same terms), in a transformer designed to match a push-pull stage to its load?

The replies showed that the expression of turns ratio simply as 1:3 or 18:1 was not sufficiently explicit. If the ratios had been expressed as 1:3+3, 1:3+3 and 9+9:1 respectively, and if this type of nomenclature had been in use since the innovation of the term "turns-ratio," probably the differences between replies would not have existed.

The simple example given shows that careful attention to the choice of nomenclature is of the utmost importance in the initial stages of development of new ideas. It also infers that, in some cases, even when techniques have been established for quite a long time, there is room for improvement in terminology.

Evesham. JOHN R. GREENWOOD.

The Short-circuited Screen

IN an article on the short-circuited turn in the March issue of *Wireless World* I suggested that there was something wrong with equation (87) on page 71 of Terman's "Radio Engineers' Handbook." Mr. E. A. W. Hoff of Welwyn Garden City has pointed out that by the use of two other equations given by Terman the error can be exposed.

On page 55 (*loc. cit.*), Terman gives for the low-frequency inductance of a single-layer coil an expression due to Wheeler:—

$$L = r^2n^2/(9r + 10l) \text{ microhenrys} \quad .. \quad (37)$$

Where r is the radius and l the length, in inches.

On page 71 (*loc. cit.*) Terman gives an expression for the mutual inductance between two solenoids:—

$$M = 0.0501 \frac{a^2n_1n_2}{g}\left(1 + \frac{A^2a^2}{8g^4}\left(3 - 4\frac{l^2}{a^2}\right)\right) \mu H \quad .. \quad (86)$$

Fig. 43 (*loc. cit.*), which shows the meaning of the various symbols, is slightly ambiguous because it looks as though $l/a = x/A$. $g^2 = A^2 + x^2$. In this expression the length is 2l.

Mr. Hoff suggests that we take $a = l$, $A = x$ and $a = pA$, so that

$$M = 0.05 \,.\, \frac{a^2h_1n_2}{a\,p\sqrt{2}}\left(1 + \frac{p^2a^4}{16p^4a^4}(3\text{-}4)\right)$$

$$= 0.05 \,.\, \frac{a\,n_1n_2}{p\,\sqrt{2}}\left(1 - \frac{1}{16p^2}\right)$$

Now we also have $L_a = a^2n_1{}^2/29a = a\,n_1{}^2/29$.

and $L_A = A\,n_2{}^2/29$.

The coefficient of coupling, k, is given by

$k^2 = M^2/L_aL_A$, and if we neglect the second term in the bracket for M:—

$$k^2 = \left(\frac{1}{20}\right)^2 \cdot \frac{a^2n_1{}^2n_2{}^2}{2p^2} \cdot \frac{(29)^2}{an_1{}^2\,.\,An_2{}^2} = \left(\frac{29}{20}\right)^2 \cdot \frac{1}{2p^3}$$

$$= 1.05 \,.\, \frac{1}{p^3}$$

Terman's equation (87) is given as $k = a^2l/A^2x$ ($= 1/p^3$). It seems pretty clear, therefore, that, as we suspected, it should read k^2.

THOMAS RODDAM

COMMERCIAL LITERATURE

Rectifier/Stabilizer for mains/battery portables using miniature valves with 25-mA filaments. Consists of two small selenium rectifiers on same insulated spindle, the first for obtaining l.t. from the mains transformer, the second acting as a filament voltage stabilizer. Two ratings are available. Booklet of 20 pages, giving characteristics and circuit design procedure with many curves, from Standard Telephones and Cables, Edinburgh Way, Harlow, Essex. Also a booklet on 10-mA tubular rectifiers.

Communal Aerial System for blocks of flats, hotels, etc., covering Bands I, II and III. The output of the master aerial array is fed through wide-band pre-amplifiers and cross-over filter units to distribution boxes, from which it is distributed to various coaxial outlets. Descriptive leaflet from Aerialite, Castle Works, Stalybridge, Cheshire.

Ex-Government Equipment of all kinds and radio control gear. An illustrated catalogue of 480 items for mail orders from Arthur Sallis, Radio Control, 93 North Road, Brighton, Sussex, price 2s including postage.

Materials Research Service offered by independent laboraties under conditions of secrecy. Activities cover electrical ceramics, ferrites, piezoelectric materials, ferroelectric crystals, scintillation screens, vacuum techniques, glass-to-metal bonding, hermetic sealing, resin encapsulating, capacitors, resistors, printed circuits and many others. Leaflet from G. V. Planer, Windmill Road, Sunbury-on-Thames, Middlesex.

Signal Strength Meter, covering Bands I, II and III, with meter indication in μV and mV up to 100mV. Uses a standard turret tuner, with 34-38Mc/s output, which can be used as a substitute for testing suspected tuners in receivers. Leaflet from Lab-Craft, 71 Netley Road, Newbury Park, Essex.

Servomechanism Equipment, comprising synchro transmitters, receivers and resolvers, tachometer-generators and induction motors. Performance figures and installation diagrams in an illustrated brochure from Ketay, Eddes House, Eastern Avenue West, Romford, Essex.

Air-Powered Drill, 6in long and weighing under 25oz. Is fitted with ¼-in Jacob's chuck and has built-in oiler. Runs on ball bearings at 3,000 or 5,000 r.p.m. (according to type). Descriptive leaflet from Consolidated Pneumatic Tool Co., 232 Dawes Road, London, S.W.6.

Radio and Electrical Books, also general physics, sound, light, mathematics and statistics. An Autumn, 1956, catalogue from Cleaver-Hume Press, 31 Wright's Lane, Kensington, London, W.8. Publications of Philips Technical Library are also included.

Bench Storage Trays for components used in assembly. Interlocking square types and new large polythene types illustrated in a leaflet from Precision Components (Barnet), 13 Byng Road, Barnet, Herts.

Plastics in Electronics is among the subjects dealt with in a booklet "Plastics Review" issued by Bakelite, Ltd., 12 Hobart Place, London, S.W.1.

Recording Oscillograph, primarily designed for seismic applications but with many other uses in the fields of vibration study and civil engineering, described in a leaflet from Seismic Instruments, Ltd., Granta Works, Cambridge. The firm is working in collaboration with Electro-Tech of Houston, Texas, whose seismic detectors are described in a separate pamphlet.

"Inexpensive Pre-amplifier."—A correction: In Fig. 3 the only earth connection between the playing desk and the pre-amplifier should be via the coaxial cable sheathing, and there should be a break in the heavy "earth" line at the bottom of the diagram; otherwise a loop is formed which may result in hum pick-up.

IN OUR NEXT ISSUE

The July *Wireless World* will contain reports on exhibits at the Instruments, Electronics and Automation Exhibition, and a survey of test and measuring apparatus shown at several recent shows.

The second instalment of the article "Portable Transistor Receiver," unavoidably held over from this issue, and details of a pre-amplifier designed for use with the "88-50" power amplifier (April issue) will also appear in the July number

Limiters and Discriminators for F.M. Receivers

By G. G. JOHNSTONE,* B.Sc.

4.—SOME LESSER-KNOWN DISCRIMINATOR CIRCUITS

THE discriminators most commonly employed in f.m. receivers, the Foster-Seeley circuit and the ratio detector, were discussed in earlier parts of this series. In the present article it is proposed to discuss some of the lesser-known types of discriminator. The chief of these is the gated-beam discriminator. Whilst it is not widely used in f.m. receivers, it is, however, used extensively in television receivers in the U.S. for the demodulation of the frequency-modulated sound carrier.

Gated-Beam Discriminator.—This class of discriminator relies for its action upon the phase relationships between the voltages developed across two loosely coupled circuits. The circuit is given

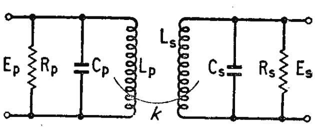


Fig. 1. Two coupled circuits; coupling coefficient k.

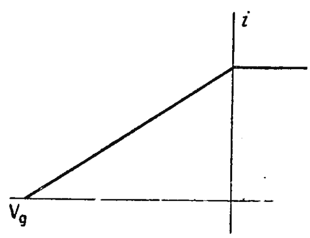


Fig. 2. Anode-current/grid-voltage curve of idealized valve.

in Fig. 1, and it was shown in the Appendix to Part 2 that the primary and secondary voltages are related by the expression

$$E_s = \frac{-jkQ_s\sqrt{L_s/L_p}}{1+jQ_s y} \cdot E_p$$

where $y=2\delta f/f_o$, f_o is the resonance frequency of the secondary circuit, and δf is the difference between the frequency of the applied signal and the resonant frequency. This relationship is true whether the primary circuit is tuned or not.

At the resonance frequency the secondary voltage lags on the primary voltage by 90°. At a signal frequency displaced by δf from resonance the phase shift increases to 90° plus an angle given by $\tan^{-1}-Q_s y$. This suggests that if it is possible to produce a signal with a magnitude dependent upon the phase angle between the two signals, a detector for f.m. signals will result. This is the principle embodied in the gated-beam discriminator. There is an additional complication in that both voltages tend to vary in amplitude with δf, so the detector must be insensitive to such variations. If this condition is met, the detector is similarly insensitive to a.m. of the original signal and no separate limiter stage will be required.

The properties required in the detector can be realized by utilizing two input electrodes of a multi-element valve, such as a pentode. Ideally, such a pentode should have a control grid and a suppressor grid which have characteristics of the type shown in Fig. 2. The grid base should be short, and in the positive region the anode current should not vary with the bias; additionally, grid current should be small, to minimize damping of the input circuit. In an ideal pentode, the control grid determines the space current (anode and screen) through the valve, whilst the suppressor grid controls the ratio in which this space current divides between anode and screen. As the suppressor grid is biased negatively, a retarding field is set up in front of the anode, and an increasing proportion of the space current is reflected to the screen grid. When the suppressor grid is driven positive, the anode current does not increase appreciably above its value for zero suppressor bias, because all the electrons which pass the screen grid mesh must travel to the anode; the total current is not affected since this is determined solely by the control-grid and screen-grid potentials. Thus the ideal characteristic is approached fairly closely by a practical anode-current/suppressor-bias characteristic. The ideal characteristic is difficult to realize at the control grid because of the grid current which flows when the grid is driven positive. To obtain the desired performance a special form of construction has to be adopted, as in the valve type 6BN6.

An alternative way of avoiding this difficulty is to employ a multi-electrode valve with two "suppressor" grids, neither of which is immediately adjacent to the cathode. Such a valve is the nonode type EQ80, which has nine electrodes, as shown in Fig. 3.

In addition to the control grid proper, there are

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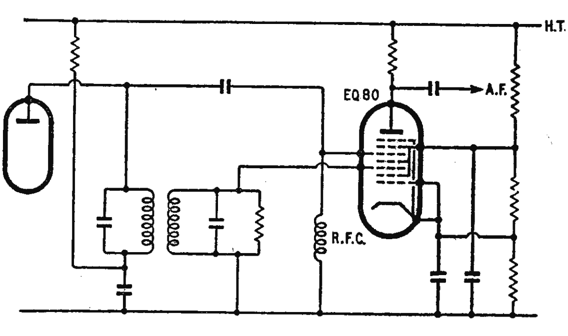


Fig. 3. Circuit for use with nonode discriminator.

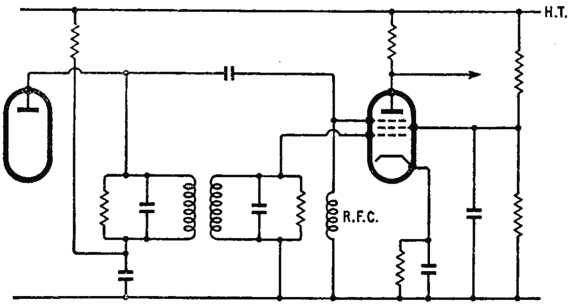


Fig. 4. Circuit for use with gated-beam discriminator.

two short-base grids, to which the input signals are applied. There are also three " screen " grids which serve to maintain the potential gradient through the valve and screen the input circuits from one another. The control grid may be biased to set the quiescent current through the valve.

The simple circuit employing an " ideal " pentode will serve to illustrate the method of operation of this type of detector; the circuit arrangement is as shown in Fig. 4. The quiescent bias at each grid is adjusted so that each is at the mid-point of its characteristic. The anode current of the valve is then one-quarter of the maximum value, which occurs when both grids are simultaneously at zero bias. The input signals applied to the two grids are taken from the primary and secondary circuits of the coupled pair. The coupling factor (kQ) is usually in the region of unity, so that approximately equal primary and secondary voltages exist at resonance. If the signal voltages are sufficiently large, both grids are heavily overdriven. Consider now an input applied to one grid alone; anode current will flow in pulses, having a mark/space ratio of unity, as shown in Fig. 5. However, with an input to both grids, anode current can flow only when the signal at each grid is within the grid base. This is shown in Fig. 6, which shows the effect of applying each signal separately and together. The period of anode current flow is proportional to the overlap of the two sets of pulses. The amplitude of each resultant pulse is constant and hence independent of the input signal magnitude, so long as the condition of overdriving at each grid is maintained. The period of overlap of the pulses is proportional to the phase angle between the two sine waves giving rise to the pulses. At resonance, the phase difference is 90°, i.e., one-quarter of the wave period. Hence the mean anode current is one-quarter of the maximum current, i.e., it is equal to the anode current in the absence of input signals.

When the frequency of the input signal changes, the period of overlap changes, and hence the mean anode current varies with the signal frequency. Thus the audio output is directly proportional to the departure of the phase angle between the two input signals from the 90-degree condition at resonance. It was shown earlier that this phase change is equal to $\tan^{-1} - Q_s y$, where $y = 2\delta f/f_o$. The graph of audio output plotted against frequency shift thus has the form shown in Fig. 7. In practice, the curve has turnover points, due to the selectivity of the tuned circuits, which reduces the drive to the grids. Typical turnover points are shown dotted in Fig. 7. From Fig. 7 it will be seen that the input signal frequency shift/output characteristic is not truly linear anywhere, but offers a fair approximation to linearity in the region near the centre frequency. For a fixed frequency deviation, improved linearity can be obtained if the value of Q_s is lowered. However, this process cannot be carried too far, or difficulties arise in obtaining sufficient input signal for satisfactory limiting.

The expression for the audio output may be expanded as a power series as follows.

$$E \propto \frac{-Q_s}{f_o}\,\delta f + \frac{1}{3}\left(\frac{Q_s}{f_o}\right)^3 \delta f^3 \ldots$$

With the EQ80 type of gated-beam discriminator an input of some 8 volts r.m.s. is required at each grid for satisfactory limiting to commence. This somewhat low sensitivity is probably one of the major reasons why this type of valve has not been more widely used. The audio output is of the order of 10 volts r.m.s. for a deviation of 75 kc/s; this is usually sufficient to drive an output stage directly without an intervening audio amplifying stage. The a.m. suppression ratio is between 25 and 30 dB, and this falls below the desirable limit of 35-40 dB. (The a.m. suppression ratio was defined in Part 3 as the ratio of the audio outputs due to the f.m. and a.m. components of an input signal simultaneously modulated by a.m. and f.m. to a modulation depth of 30 or 40 per cent.)

The 6BN6 gated-beam discriminator was discussed in detail in *Wireless World* (January 1957) by Lawrence W. Johnson, and reference should be made to this article for circuit details, operating conditions, etc. The a.f. output obtainable from this valve is of the order of 15 volts r.m.s. for a deviation of 75 kc/s. The input signal amplitude required at the control grid for limiting is 2 to 3 volts r.m.s. The a.m. suppression ratio is between 25 and 30 dB. This is below the desirable limit, and it would appear that the 6BN6 should be preceded by a further limiter. This reduces the attractiveness of the circuit, since its chief merit lies in its simplicity and cheapness.

The harmonic distortion can be evaluated approximately by means of the expansion for the a.f. output given previously. If the modulating signal is $f_d \cos \omega t$, the output is given by

$$E \propto \frac{-Q_s}{f_o} f_d \cos \omega t + \frac{1}{3}\left(\frac{Q_s}{f_o}\right)^3 f_d^3 \cos^3 \omega t$$

$\cos^3 \omega t$ may be expanded in terms of $\cos \omega t$ and

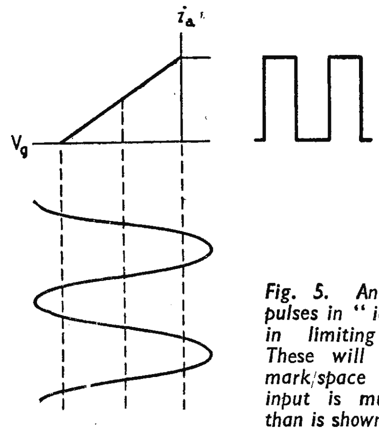


Fig. 5. Anode current pulses in " ideal " valve in limiting condition. These will have unity mark/space ratio if the input is much greater than is shown here.

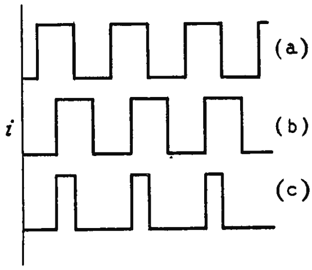


Fig. 6. (a) Anode current pulses due to input at control grid alone. (b) Anode current pulses due to input at suppressor grid alone. (c) Anode current pulses with inputs at both control and suppressor grids.

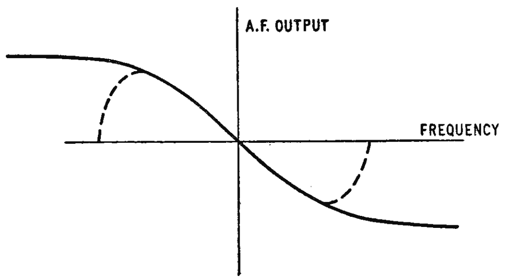


Fig. 7. A.F. output against frequency for gated-beam discriminator, assuming limiting at all frequencies. The dotted curve is that obtained in practice due to falling-off of signal amplitude with circuit selectivity.

cos $3\omega t$, and the percentage of third harmonic distortion shown to be

$$\frac{1}{12}\left(\frac{Q_s f_d}{f_o}\right)^2 . 100$$

With $Q_s = 35, f_d = 75$ kc/s and $f_o = 10.7$ Mc/s, the third harmonic distortion is approximately 2 per cent.

There is one feature of the 6BN6 circuit given by L. W. Johnson which is not immediately apparent: this is the mechanism of coupling between the primary and secondary circuits. The circuit arrangement is as shown in Fig. 8, and at first sight there is apparently no coupling between the two circuits. In fact, there is the equivalent of top-end capacitance coupling, with the somewhat unusual feature that the coupling capacitor is a negative capacitor, i.e., it has positive reactance, like an inductor, but the magnitude of the reactance decreases with increasing frequency, as with a capacitor.

The mechanism of coupling is as follows. The input "primary" circuit voltage controls the total electron stream through the valve, and hence the anode current flowing past the suppressor grid is modulated at the input signal frequency. Now if an electric charge is brought near a conductor connected to earth, there is a movement of charge to the face of the conductor tending to neutralize the field of the approaching charge. This is a familiar phenomenon in electrostatics. A positive change of grid potential increases the number of electrons flowing through the valve, and hence increases the number of electrons in the vicinity of the suppressor grid. There is then an increase of the positive charge on the suppressor grid, which is the conductor past which the electron stream is flowing; and there is a movement of electrons from the suppressor grid through the external circuit.

If a change of grid voltage dv produces a change of the charge dq, in the neighbourhood of the suppressor grid, we may write

$$dq = -\,a.dv$$

where a is a positive constant.

The reason for the negative sign is that a positive increment dv increases the number of electrons in the vicinity of the suppressor grid, and since these are negatively charged there is a negative increment of charge. The increase of the charge near the suppressor grid induces a proportional charge dq' flowing out of the suppressor grid, and we may thus write

$$dq' = b.dq$$

where b is a positive constant.

Thus

$$dq' = -\,a.b.\,dv$$

This may be compared with the relationship for a capacitor $Q = CV$.

From this it appears that the electron stream coupling is equivalent to a negative capacitor of magnitude $a.b$ connected directly between control grid and suppressor grid. This form of coupling occurs in all multi-electrode valves. In particular its effect has long been recognized in frequency changers where on short wavebands it may induce "pulling" of the local oscillaor frequency. In this application neutralizing is effected by means of a small (positive) capacitor connected externally between the electrodes.

The degree of coupling obtained by this means is insufficient in the 6BN6 to produce adequate voltage drive at the suppressor grid, and is supplemented by means of the undecoupled anode lead resistor R, shown in Fig. 8. This resistor is of low value, usually a few hundred ohms. Under working conditions,

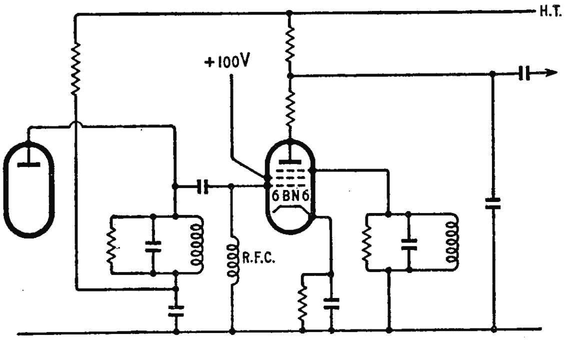


Fig. 8. Circuit used with 6BN6 gated-beam discriminator.

a voltage is produced across it which is in anti-phase with the control-grid voltage. We may write this anode voltage as

$$E_a = -\,c.\,dv$$

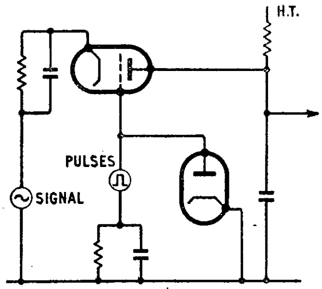
where c is the working gain of the valve at r.f. There is a physical capacitance which we may designate C_{a-su} between the anode and the suppressor grid, and hence current is fed through this capacitor to the "secondary" circuit. If the impedance of this circuit is Z, then the current i is given by

$$i = -\,c.\,dv/(Z + 1/j\omega C_{a=su})$$

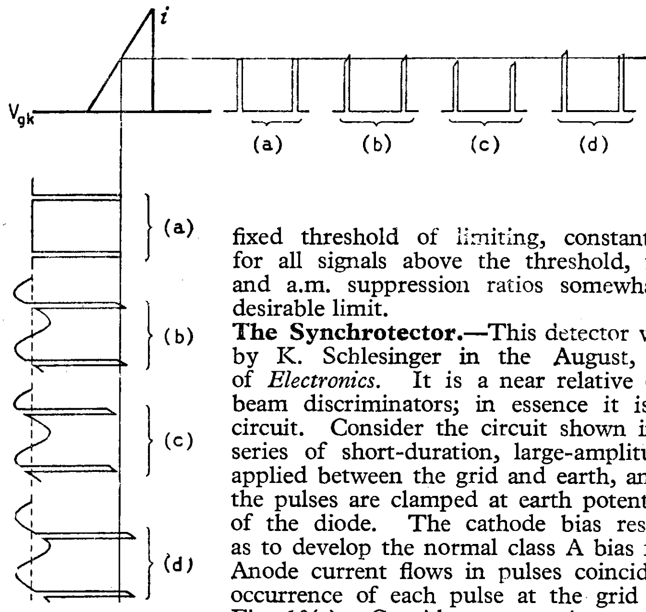
If the reactance of the capacitor is appreciably greater than Z, we may use the approximation

$$i = -\,c.dv.j\omega C_{a-su} = c.dv.j\omega(-C_{a-su})$$

i.e. this coupling also behaves like a negative capacitor connected directly between control and suppressor grids, and hence supplements the equivalent capacitance existing already.



Above: Fig. 9. Basic circuit of the synchrotector.



Right: Fig. 10. Showing how a.f. output from the synchrotector varies with phase angle between applied signal and sampling pulses; (a) no input signal (b) 90-degree phase shift (c) phase shift greater than 90 degrees (d) phase shift less than 90 degrees.

An important distinction exists between two circuits coupled together physically, and the two circuits coupled together by the electron stream of a valve, as in the 6BN6. In the former case, the energy in the secondary circuit is supplied from the primary circuit, and consequently the shape of the resonance curve of the primary circuit is affected by the coupling to the secondary circuit. The response exhibits "rabbit's ears" similar to those obtained across the secondary circuit when the coupling factor (kQ) exceeds the critical value. However, the primary circuit "rabbit's ears" are more widely spaced in frequency, and more pronounced. When the coupling is via the valve electron stream, the energy in the "secondary" circuit is supplied by the electron stream, and consequently the "primary" circuit resonance curve is unaffected by the presence of the "secondary" circuit. As a corollary of this, the resonance curve of the secondary does not develop "rabbit's ears" as the coupling factor increases, but remains single-peaked.

An interesting variant of the 6BN6 has recently appeared in the U.S. This valve is the 6DT6. This has sufficient internal coupling via the electron stream to produce adequate drive at the suppressor grid. At low input signal levels there is a gain from control grid to suppressor grid, and this fact is utilized to make the circuit self-oscillating at small signal inputs. The physical capacitance between the control and suppressor grids is made sufficiently large to maintain oscillation in the absence of an input signal, the suppressor grid functioning as an "anode." The oscillator is then of the tuned-anode, tuned-grid type. With a small input signal, the detector functions as a locked-oscillator limiter, as well as a detector. This action lowers the threshold value of input signal with which the detector will work; the 6BN6 requires an input of the order of 1 to 2 volts, whilst the 6DT6 requires an input of only 0.3 to 0.5 volts.

The properties of the gated-beam discriminators as a class may be summarized as good sensitivity, fixed threshold of limiting, constant a.f. output for all signals above the threshold, fair linearity, and a.m. suppression ratios somewhat below the desirable limit.

The Synchrotector.—This detector was described by K. Schlesinger in the August, 1956, issue of *Electronics*. It is a near relative of the gated-beam discriminators; in essence it is a sampling circuit. Consider the circuit shown in Fig. 9. A series of short-duration, large-amplitude pulses is applied between the grid and earth, and the tips of the pulses are clamped at earth potential by means of the diode. The cathode bias resistor is such as to develop the normal class A bias for the valve. Anode current flows in pulses coincident with the occurrence of each pulse at the grid as shown in Fig. 10(a). Consider now an input signal applied to the cathode, the frequency of the signal being the same as that of the grid pulses. The mean anode current will now vary according to the phase relationships between the applied pulses and the signal.

If the pulses occur at the instants when the signal amplitude is passing through zero, the anode current pulse is of the same amplitude as it is in the absence of the signal, as shown in Fig. 10(b). If the pulses occur when the signal is positive with respect to earth, the anode current pulses will be smaller in amplitude, because this condition is equivalent to a negative signal in the grid circuit, as shown in Fig. 10(c). Conversely, if the pulses occur when the signal is negative with respect to earth, the anode current pulses will be larger in amplitude, as shown in Fig. 10(d). Thus it is possible to construct a discriminator if the phase angle between the pulses and the applied signal can be varied with the signal frequency. A suitable circuit arrangement is that shown in Fig. 11. The grid pulses are now sine waves generated across a tuned circuit, fed by a small top-end capacitance from the applied signal source. As shown earlier, the phase relationship between the "secondary" circuit signal and the applied signal varies with the signal frequency, being 90° at a frequency near the secondary circuit resonance frequency. This can be shown simply for the top-end capacitor coupling circuit by Thévenin's theorem. The circuit of Fig. 12(a) is equivalent to that of Fig. 12(b), and it can be seen that the "secondary" voltage E_s is at 90° with respect to the "primary" voltage E_p when the secondary inductance is resonant with the capacitors C_s and C_t in parallel, i.e., at a frequency slightly below the resonance frequency of L_s and C_s alone.

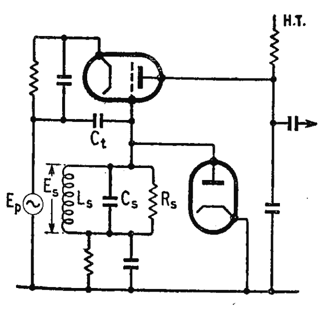
In the practical circuit the voltage at the grid is about 3 to 4 times that at the cathode, so that the periods when the valve is conducting are relatively short. By assuming the pulses to be very short, it is possible to derive an approximation for the variation of anode current with signal frequency. The amplitude of the anode current pulses is proportional to the sine of the angle between the zero value of the applied signal and peak value of the sampling pulse. Using $y = 2\delta f/f_0$ where δf is the difference between the signal frequency and the resonance frequency of the secondary circuit, this angle θ is given by

$$\theta = \tan^{-1} - Q_s y$$

Hence the amplitude of the anode current pulses is proportional to $\sin(\tan^{-1} - Q_s y) = -Q_s y/(1 + Q_s y)^{\frac{1}{2}}$. Provided that Q_s is small, the anode current is approximately linearly related to the signal frequency shift in a small region near the resonance frequency of the secondary circuit.

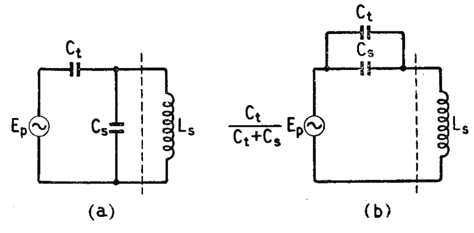
There is some degree of limiting action, since an increase of signal amplitude produces an increased amplitude of the "sampling" pulses. This results in the conduction period being shortened, which tends to reduce the increase of anode current which would otherwise occur. The circuit described by Schlesinger is shown in Fig. 13. The discriminator proper is driven from a locked-oscillator limiter. The circuit was designed for use with the U.S. television inter-carrier sound system, which employs a deviation of 25 kc/s at a carrier frequency of 4.5 Mc/s. The circuit is stated to give an audio output of 25 volts peak-to-peak, for an r.f. input to the driver stage of 6 millivolts. This represents a high conversion efficiency, being better than a comparable ratio detector circuit employing a driver stage and a double-diode-triode, the latter valve providing the detector diodes and a.f. amplifier. The circuit is claimed to have an a.m. suppression ratio greater than 40 dB.

Counter Circuit.—If the incoming signal can be converted to a train of constant-amplitude pulses, demodulation can be effected by means of a "counter" circuit, which gives an output proportional to the repetition rate of the pulses. This type of circuit was discussed in some detail in the April, 1956, issue of *Wireless World* by M. G. Scroggie. The basic circuit considered by Scroggie is shown in Fig. 14. The incoming signal is heterodyned to produce an intermediate frequency signal at 200 kc/s approximately. After amplification, the signal is applied to a limiter stage, which gives a square wave



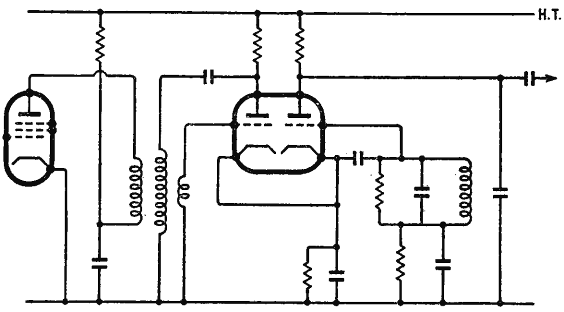
Left: Fig. 11. Circuit of synchrotector with sampling pulses derived from input signal.

Below: Fig. 12. Thévenin's theorem applied to circuit (a) to give circuit (b).

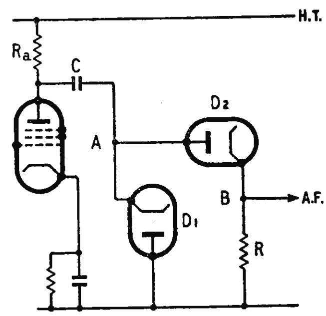


output. The pulses are then applied to the diodes D1 and D2.

Consider first the quiescent condition with the limiter stage cut-off. The anode potential is that of h.t., and there is no voltage across either diode, or the diode load resistor R. If now the limiter anode potential falls as its grid is driven positively, diode D1 conducts; diode D2 remains cut-off. Because of the high ratio of the resistance R_a to that (R_{di}) of the diode D1 when conducting, the cathode of D1 is not driven appreciably negative with respect to earth,



Above: Fig. 13. Practical circuit of synchrotector preceded by locked-oscillator limiter.



Right: Fig. 14. Basic "counter" circuit.

and capacitor C discharges through R_a and diode D1 is series until the cathode of D1 returns to earth potential. This is shown in Fig. 15(a). The discharging curve is exponential, and thus an infinite time is required theoretically for the cathode of D1 to reach earth potential; in practice the time constant $(R_a + R_{di})C$ is sufficiently small for the potential of D1 cathode to be indistinguishable from earth before the next part of the cycle. After a period equal to half the signal period, the anode of the limiter is driven positive, as its grid is driven negative to beyond cut-off. The anode potential then commences to rise to h.t. potential, and current flows through R_a, C, D2 and R in series; the voltage across R is shown in Fig. 15(b). The time constant of the combination is such that the voltage pulse developed across R has virtually disappeared before the next change of limiter anode potential occurs, when the cycle is repeated. There is thus a train of pulses developed across R, the area (volt-secs) of which is independent of the magnitude and frequency of the input pulses. However, the mean voltage output is equal to the area of these pulses multiplied by the rate at which they occur, and this rate is, of course, equal to the input signal frequency. Thus the output voltage is apparently linearly related to the input signal frequency.

The linearity is, however, not perfect because the capacitor C cannot charge completely through R and

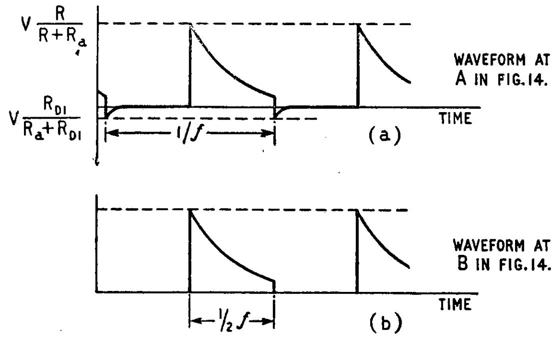


Fig. 15. Waveforms at points A and B of Fig. 14.

R_a in the half-cycle period, as required. If the time constant is made very short to approach this condition of perfection, the area of the pulses becomes smaller and the a.f. output decreases. In a practical circuit, the component values adopted must be a compromise between the requirements of good linearity and sensitivity. In addition, in the circuit described by Scroggie, there is a limitation placed upon the value of R_a by the limiter requirements.

The degree of non-linearity can be calculated as follows. If the signal frequency is f, then the time of one pulse cycle is $1/f$. The combination of R_a, C and R is thus charging for a period $1/2f$. If the amplitude of the voltage step at the limiter anode is V volts, then if the diode forward resistance is negligible, the voltage across R at the beginning of the charging period is $VR/(R + R_a)$. At the end of the period this voltage has fallen to

$$\frac{VR\, e^{-1/2fCR'}}{R + R_a}$$

where $R' = R + R_a$

The area of the pulse is given by

$$\frac{VR}{R+R_a} \int_0^{1/2f} e^{-1/CR't}\, dt$$

which is equal to

$$VCR(1 - e^{-1/2fCR'})$$

The a.f. output is equal to the product of this area and the signal frequency, i.e., $VCRf\ (1-e^{-1/2fCR'})$. This may be compared with the "ideal" output, $VCRf$, obtained if the time constant CR' is very small. Thus the second term within the bracket represents the departure from linearity. It is minimized if f, C and R' are small. However, the expression for the output voltage shows that if V, C, R and f are reduced to minimize non-linearity, the a.f. output will fall. Thus a compromise is required. The minimum value is further determined by the consideration that the signal frequency should not be allowed within the a.f. spectrum; thus with a deviation of 75 kc/s, the centre operating frequency must be above 90 kc/s, and preferably higher, to allow some margin for mistuning, drift, etc. Thus a centre signal frequency of 150–200 kc/s is usually employed. The use of a low-value intermediate frequency such as this brings other difficulties in its train, notably those of obtaining adequate i.f. selectivity, and the maintenance of second channel protection, since the second channel is only 300–400 kc/s removed from the wanted carrier frequency. The circuit response curve is markedly unsymmetrical, having a comparatively large linear portion in the direction of increasing frequency, and a comparatively small linear portion in the direction of decreasing frequency.

In the circuit described by Scroggie, the value of $R_a = R = 4.7\ k\Omega$, $C = 50\,pF$ and $V = 60$ volts. The centre frequency is 150 kc/s. With these values, the r.m.s. a.f. output for 75 kc/s deviation is 0.8 volt. Scroggie also plotted the departure from linearity against frequency; the curve obtained agrees well with the curve obtained from the calculation given previously. The distortion, computed by Scroggie, was about 0.5 per cent second harmonic at maximum deviation.

The degree of a.m. rejection cannot be specified, since it is a function of the limiter performance; in general, it should be possible to realize a satisfactory performance in this respect. With regard to sensitivity, the circuit compares closely with the Foster-Seeley circuit, requiring about 2 volts input at the limiter grid for an output of about 1 volt. It has a fixed threshold of limiting, and constant audio output for all input signals above this threshold. As with the Foster-Seeley circuit, the maximum degree of "downward" a.m. handling capacity is dependent upon the margin by which the signal at the limiter grid exceeds the limiter threshold.

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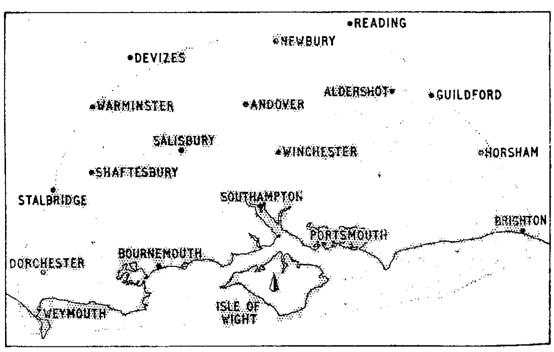
Southern I.T.A. Station



APPROXIMATE service area of the I.T.A.'s seventh transmitter, to be built at Chillerton Down, Isle of Wight, is shown shaded on this sketch map. It will probably come into service in the late spring of next year. No announcement has yet been made by the Post Office regarding the channel in which the station will operate. It is unlikely to use one of the three channels so far allocated to the I.T.A. owing to its geographical position in relation to the stations already operating in them.

Manufacturers' Products

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

Improved "X" Aerial

FITTED with a new centre insulator and completely assembled in the factory, but collapsed for packing and transport, the new "Unex" Band I television aerial has only to be opened out into the familiar "X" form on the site before erecting. The four elements are finally locked in position by captive wing nuts.

Electrically its characteristics are similar to the earlier models, namely 3 dB forward gain and 25 dB back-to-front ratio. The acceptance angle is 176 deg.

The makers are Aerialite, Ltd., Castle Works, Stalybridge, Cheshire, and the price is £2 for the aerial alone or £6 15s complete with 10ft mast and double chimney lashings. Shorter masts, cranked arms and single lashings are also available.

Miniature Micro-gap Toggle Switch

A NEW single-pole, on-off toggle switch of small dimensions for its rating (10 A at 250 V a.c.) has been introduced by Arcolectric (Switches) Ltd., Central Avenue, West Molesey, Surrey, and should find many applications in the larger types of electronic equipment.

Silver contacts are fitted and the design ensures a low contact resistance despite the very light operating pressure and micro-gap movement. It is well finished, and has a long pear-shaped dolly. The fixing bush is the customary toggle-switch pattern and requires a $\frac{1}{2}$-in diameter hole. An "on-off" marked plate is fitted. The single-pole switch costs 4s; a double-pole version will be available shortly.

Constant-heat Soldering Iron

THERMOSTATIC control to prevent overheating when not in use is a very practical way of prolonging the life of a soldering iron. The Ceco iron, made by the Cardross Engineering Co., Ltd., Woodyard Road, Dumbarton, embodies a device of this kind. Normal adjustment provides a working temperature of 230 to 250°C, which allows a comfortable margin over the melting point of 60/40 solder.

To alter the setting of the thermostat it is necessary to remove three screws and slide the wooden handle over the metal sleeve housing the heating element. The use of a solder thermometer, or its equivalent, is advised when changing the original setting.

The iron weighs $4\frac{1}{4}$ oz, is quick heating and embodies a 70-W element. The price is 85s.

Transistor Communications Receiver

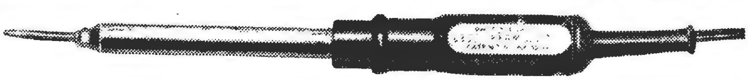
SHOWN in the illustration is a transistor communications receiver designed especially for use in small sea-going craft, such as fishing vessels and private yachts, requiring a robust, compact and weather-proof set for receiving coastal and Consol beacons, weather forecasts and broadcast.

Known as the "Homer" it is a t.r.f. set covering 150 to 420 kc/s and 650 to 1,550 kc/s in three bands. There are two r.f. stages, a diode detector, a.f. amplifiers, BFO and push-pull output. Four 1.4-V Mallory cells give 500 hrs operation with telephones and 250 hrs with a loudspeaker.

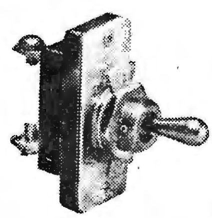
Provision is made for taking bearings on beacons using the "Heron" combined hand compass and ferrite-cored direction-finding aerial. This weighs only 17 oz and covers the beacon frequencies of 290 to 310 kc/s. For general reception an elevated aerial 20 to 60 ft long should be used.

The "Homer" receiver is hermetically sealed in a seawater-resistant light-alloy case measuring $8 \times 4\frac{7}{8} \times 2\frac{7}{8}$ in overall. Components are to Services specification with sealed control shafts. A dessicating material is included in the case and the battery compartment is accessible without breaking the main seal.

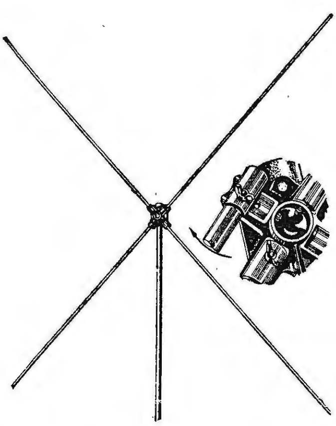
The makers are Brooks and Gatehouse, Ltd., Lymington, Hants. The set alone costs £37, and with "Heron" DF aerial £48.



Ceco thermostatically controlled soldering iron.



Arcolectric miniature micro-gap toggle switch.



Left: Aerialite new "Unex" Band I television aerial showing (enlarged) how elements collapse for transport.

Right: "Homer" transistor marine receiver and "Heron" DF compass aerial.

Valves and Semi-Conductors

DEVICES ON SHOW AT THE R.E.C.M.F. AND PHYSICAL SOCIETY'S EXHIBITIONS

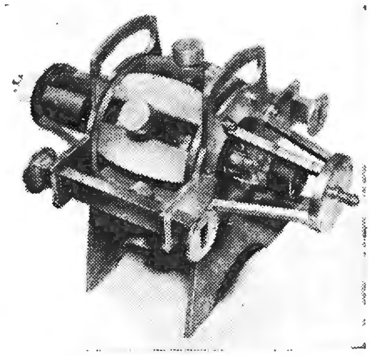
Receiving-type Valves.—The idea of using valves for the r.f. stages of a receiver and transistors for the audio stages has been given practical support by both Brimar and Mullard, who have introduced new valves which will operate with only 12 volts on the anode (see April issue, p. 179). Of course, these valves can also be used for car radio. Brimar have the 12AC6 variable-mu r.f. pentode, 12AD6 heptode frequency changer, 12AE6 double-diode triode and the 12K5 audio driver tetrode. Mullard were showing the EBF83 double-diode variable-mu r.f. pentode, the ECH83 triode-heptode frequency changer and the EF98 audio driver pentode.

For wide-band r.f. amplifiers, S.T.C. have introduced the 5A/170K beam tetrode, which is notable for its high initial conductance of 16.5 mA/V and is said to have almost twice the gain-bandwidth product of conventional high-gain pentodes. It is mounted on the B9A base and has gold-plated pins. This firm also had a new miniature voltage stabilizer tube, G55/1K, with the low maintaining voltage of 55 V for its striking voltage of 90 V. The current can vary between 2 and 30 mA, and the regulation over the range is 3 V.

A miniature tuning indicator, EM840, shown by Brimar, has the luminous target deposited as a vertical strip on the glass envelope itself. Each end of the strip luminesces, and on application of a control voltage the luminous areas extend inwards towards the centre. The indicator has a variable-mu characteristic and is therefore sensitive to weak signals. Brimar also had a miniature double triode, 5965, for digital computer circuits. It has a sharp cut-off characteristic and an ability to maintain its emission after long periods of cut-off operation.

Transmitting Valves.—A magnetron capable of producing the exceptionally high peak power of 1 megawatt under pulsed conditions was shown by Ferranti. Operating in the range 9,000-9,500 Mc/s at mean power levels up to 1 kW, it uses an electro-magnet and has a water-cooled anode with integral pole-pieces. The high mean power is made possible by a thorium-activated tungsten cathode which is heated to about 2,000°C by bombardment with an electron beam. An electron gun mounted in one of the pole-pieces provides this bombardment, and a beam current of 30 mA is required to obtain the correct temperature.

New travelling-wave tubes were shown by both English Electric and Mullard. The English Electric tubes range from 2 kMc/s to 4 kMc/s in operating frequency, while the latest Mullard type is for the 11-18 kMc/s band, over which it has a gain of 20 dB. Backward-wave tubes are related devices, but here the electron beam interacts with an electromagnetic wave travelling in the opposite direction. A wide frequency variation can be obtained in oscillators simply by altering the beam accelerating voltage. Two such backward-wave oscillators for the 1-5 kMc/s band were displayed by G.E.C. This firm also had a miniature magnetron on a B7G base, intended as a pulse test source.

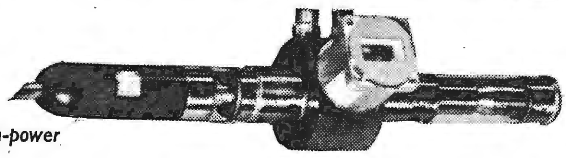


Mullard five-cavity klystron

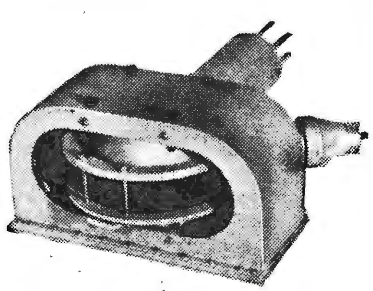
Mullard were showing an unusual klystron (development model) incorporating five successive tunable cavities. The gain is equivalent to four separate two-cavity klystrons. It works in the 3-cm band, giving outputs of up to 5 watts. Normally the cavities are all tuned to the same frequency, and here the gain is 70 dB for a 2.5-Mc/s bandwidth. They can, however, be tuned to give a broad band of 25 Mc/s, at which the gain is reduced to 30 dB.

Noise Generating Tubes are often used in microwave superhet receivers as standards against which the receiver noise can be compared in order to measure the noise factor. A version introduced by Ferranti, the TE10, is a gas discharge tube which strikes at 1,150 V and maintains at 50 V, 35 mA. Intended for noise measurement in the "X" band, it is supplied with a waveguide mount which is normally tuned to a centre frequency of 9.375 kMc/s, but can be varied from 8.5 to 10.5 kMc/s. Diodes are also used as noise sources, and G.E.C. had a coaxial type, CV2341, intended for use up to 1,000 Mc/s.

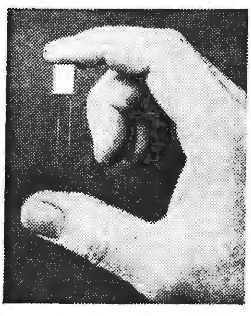
Power Transistors are limited in output by their power dissipation



Ferranti high-power magnetron



G E.C. backward-wave oscillator



Cathodeon miniature quartz crystal

ratings and hence by their ability to conduct heat away. Much attention is therefore being paid to the design of structures with low thermal resistance. One of the latest types, produced by Sylvania-Thorn, has a total dissipation of 5 watts. Intended for servo-mechanisms and other industrial purposes, it will operate with a collector current of 5 amps at 25 volts, the alpha cut-off frequency being 400 kc/s. The GET8 and GET9 are comparable types made by G.E.C. Working respectively at supply voltages of 12V and 24V, they are mainly intended for use in class-B audio output stages, and a pair in push-pull will give output powers up to 20 watts. The GET7, working at 6V under similar conditions, will give 10 watts output from a push-pull pair. All these transistors depend on having good thermal connections to chassis or "heat sinks."

Audio and R.F. Transistors.—Two new additions to the Mullard range are the OC65 and OC66, which are special sub-miniature types for hearing aids. They have common-emitter current gains of 30 and 50 respectively. The OC73, OC76 and OC77 are new types comparable with audio transistors but designed for switching and industrial applications. Improvements have been made in the ratings of the well-known OC70 and OC71, which will now dissipate 50 mW instead of 25 mW and operate with a maximum collector voltage of 15 V (30 V peak) instead of 5 V (10 V peak). In r.f. transistors, Mullard have added to their OC45 the OC44, which has the much higher alpha cut-off of 15 Mc/s and is intended for use in mixer/oscillator circuits (the OC45 is for i.f. amplifiers).

Rectifiers.—Selenium rectifiers are now undergoing considerable development, the most recent introduction being resin-encapsulated types (Salford and Westinghouse), and types for operation at high temperatures up to 125°C (Westinghouse). Germanium junction rectifiers are, however, supplanting metal rectifiers in many applications because of their high rectification efficiency. As an example, Sylvania-Thorn were showing an hermetically-sealed type, XGR511, capable of passing 100 A mean d.c. with a maximum peak inverse voltage of 50 V. Another one, the XGR411, could pass 10 A with a maximum p.i.v. of 50 V, and four of these were shown in a full-wave bridge circuit giving 20 A at 30 V. This firm also had a small wire-ended silicon junction rectifier giving 35 mA mean d.c. with the low reverse current of 1 μA at 100 V.

Quartz Crystals are being made to operate at higher and higher frequencies by the use of overtones; S.T.C., for example, had production models going up to 5.2 Mc/s and laboratory samples to 100 Mc/s. Usually the third or fifth overtone of the fundamental frequency is used. For v.h.f. applications where space is limited, Cathodeon have introduced an overtone model for frequencies between 20 Mc/s and 60 Mc/s which measures only 0.52 in × 0.42 in × 0.17 in. It is primarily for "packaged" and transistorized circuits.

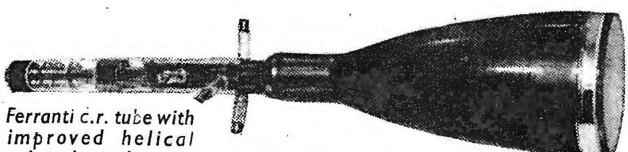
C.R. Tubes and Photoelectric Devices

R.E.C.M.F. AND PHYSICAL SOCIETY EXHIBITS

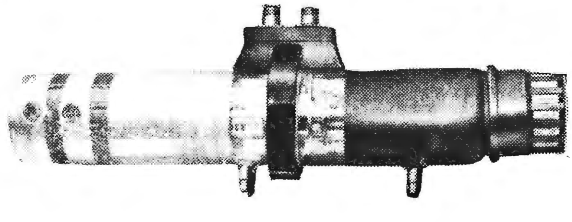
Oscilloscope Tubes.—When high-speed transient phenomena or u.h.f. signals are to be displayed, the main limiting factor is the time taken by the electron beam to traverse the Y deflection system. For example, in the Ferranti 5/62GM tube the Y-plate transit time of 2 millimicroseconds gives a response which cuts off above 1000 Mc/s and is 3 dB down at 400 Mc/s. A most unusual way of overcoming this transit-time effect was to be seen in the VCRX410 tube shown by G.E.C., which has a travelling-wave Y deflection system fed by a 70-Ω coaxial cable. The electron beam passes between the outside of a helix, as in a travelling-wave valve, and the inner surface of an enclosing cylinder. Thus the high speed transient, which would normally be too fast for the beam electrons in a conventional system, is made to travel as a wave alongside the electrons so that it can perform its deflecting function on them effectively.

This tube, intended for displaying pulse rise times of the order of a millimicrosecond, uses post-deflection acceleration (30 kV) to obtain adequate brightness with the extremely high writing speed. Recently a continuous helical ring of resistive material, with a high voltage applied across it, has come into fashion for the p.d.a. electrode. It gives a potential gradient increasing evenly towards the screen and so avoids the lens effect which occurs between separate rings and also the need for separate voltages. Examples were to be seen in tubes by Ferranti, G.E.C., Sylvania-Thorn and 20th Century.

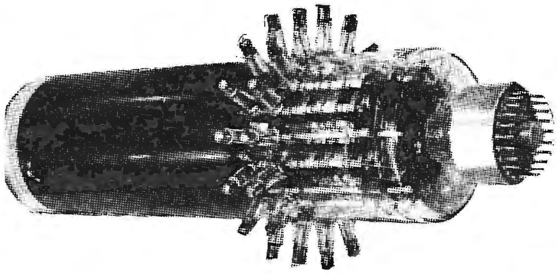
In one of the Ferranti tubes, a helical accelerator of novel design, becoming coarser in pitch towards the screen, gives a high deflection sensitivity which is substantially independent of the final anode voltage. Even with the high anode voltage of 7 kV a sensitivity 1 mm/V can be



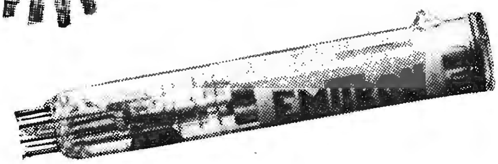
Ferranti c.r. tube with improved helical p.d.a. electrode



G.E.C. travelling-wave-deflection c.r. tube



20th Century eight-gun c.r. tube



E.M.I. photoconductive camera tube

obtained, and with 0.75 kV on the anode the remarkable figure of 1 cm/V is achieved. Frequencies to over 500 Mc/s can be handled.

20th Century Electronics, who have specialized in multi-gun tubes for some time, have now produced a 5-inch tube containing as many as eight guns. The deflection systems are independent and each gun gives full coverage of the screen. Operating with 4 kV on the final anode, it has a deflection sensitivity of 0.23 mm/V. The face is optically finished, while the numerous deflector-plate connections are brought out to side caps.

Photoconductive Devices.—Cadmium sulphide photo-cells are notable for their high sensitivity compared with selenium cells. Two types shown by G.E.C. had an efficiency of about 1 amp/lumen with an illumination of 2-3ft candles, the maximum ratio of photo to dark current being 10^6. A powder-layer type can be made to pass photo-currents in excess of 1 amp. The cells are slow in response compared with photoemissive types but can be made to operate relays directly. Selenium cells available in potted form were displayed by Megatron, while S.T.C. had some new and extremely small germanium junction photocells, intended for scanning punched cards and tape, with a diameter of only 0.08in.

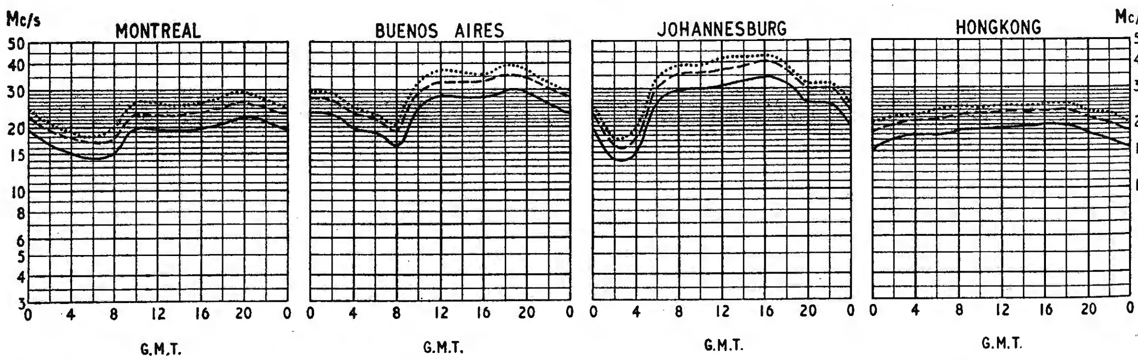
The photoconductive pick-up tube is now being used extensively in industrial television equipments, and E.M.I. were showing a 1-inch-diameter type which is physically interchangeable with the well-known Vidicon. It has a resolution in the centre of at least 1,000 lines and 600 lines at the corners, while the possible contrast range is 100:1. The sensitivity is high, as with all photoconductive tubes, and a high-light brightness on the scene as low as 21 ft-lamberts will give a minimum signal current of $0.2\,\mu$A with a lens aperture of *f*1.9.

Electroluminescent Cells, as described in our March issue, were demonstrated in principle by both B.T.-H. and G.E.C., while Thorn had some actual models in commercial form intended for use in a digital computer. These were mounted five in a row on small strips of insulating material and could be switched on and off individually by application of a 250-V, 2-kc/s supply obtained from a transistor oscillator. Examples of electroluminescent signs and indicators were also on view. The G.E.C. exhibit, incidentally, showed an electroluminescent cell used in conjunction with a cadmium sulphide photoconductive cell to form a light amplifier—not an image amplifier but one of the very small units intended as a two-state element in binary computing circuits (see p. 132, March issue).

Stroboscopic Light Sources based on c.r. tubes were shown by Ferranti. Short single flashes or flashes at high repetition rates can be produced with durations limited only by the phosphor decay time.

SHORT-WAVE CONDITIONS

Predictions for June



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

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

•••••••••• 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 Blocking Oscillator

A Bird That Needs a Separate Stone ?

By "CATHODE RAY"

BLOCKING oscillators are responsible for at least half the scanning in most television receivers. They perform equally essential duties in radar. Their place in the great new transistor empire already seems secure. Yet the authors of elementary —and even the not so elementary—books seldom have much to say about them. And what they do say isn't always quite as right as it should be.

For the blocking oscillator is one of those things that look simpler than they are. In a recent book, the author—one of the soundest authorities—confesses that in the previous edition his explanation of it was on the wrong lines. Other books I have consulted declare that the action of a blocking oscillator is so complex that a comprehensive analysis has never yet been made. Lately a whole book on it has appeared, but except for the warning that the usual explanation is inadequate I found it unsatisfying.

Before being too hard on technical writers for the present unsatisfactory information service on the subject, let's ask ourselves what we would do. Would we (1) explain it correctly and, therefore, complicatedly; (2) explain it simply and, therefore, incorrectly; or (3) not explain it at all. So far as I am concerned, having written the title at the head of the page, (3) is no longer open. Which of the other two I have gone in for, you will have to judge at the end; I hope the result will not be a hitherto unlisted combination—complicated and incorrect.

Fig. 1, subject to minor variations, is the circuit. We can see at once that it is simple. And so far as one can see from the diagram it is exactly the same as an ordinary "reaction coil" oscillator. With the addition of a variable capacitor for tuning, Fig. 1 could be used in almost any superhet. As regards both its simplicity and its resemblance to an ordinary continuous-wave oscillator, however, the circuit diagram is deceptive.

One of the principles of teaching is to make any one explanation cover as many things as possible. This spares both teacher and taught. Whichever of these roles I happen to be filling at any given moment, I entirely agree with the principle—provided it is correctly applied. The blocking oscillator, having essentially the same circuit diagram as an ordinary oscillator, clearly asks to be regarded as a special case of it. Such treatment is so very plausible.

It goes something like this. "When the coils L_1 and L_2 in Fig. 1 are inductively coupled in the appropriate direction, positive feedback causes continuous oscillation to be set up." Here follow a page or two, or even more, explaining this in detail. (The circuit diagram used will certainly show a capacitance across one of the coils, for the oscillations must have capacitance as well as inductance in which to circulate; but it is only fair to point out that a circuit made up as in Fig. 1 would nevertheless work, because of the existence of stray capacitance, not actually shown.) Next follows at least a long paragraph explaining the role of C and R and how they automatically cause an appropriate negative bias to be applied to the grid, directly oscillation begins. At that point, if the author has room to spare and feels in a chatty mood, he is likely to go on to mention that if the coupling between L_1 and L_2 is too close, and especially if at the same time R is rather high, the amount of bias developed at the start of oscillation may prove too great to allow oscillation to continue, so it stops until the charge on C has leaked off through R sufficiently to allow it to start again, whereupon the whole sequence repeats indefinitely, and instead of Fig. 2(a) one gets (b), and one says that the oscillator is squegging.

Then, if the author remembers that there are such things as radar and television, so that sooner or later he will have to say something about blocking oscillators, he may see a golden opportunity to kill this third bird with the same stone, in accordance with the teaching principle just mentioned. So he goes on to say that if the coupling is tightened still more a cut-off grid bias will be developed by the very first half-cycle of oscillation, and grid-current damping is so great that no more than this half-cycle remains

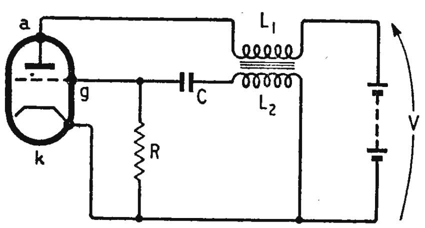


Fig. 1. Blocking oscillator circuit.

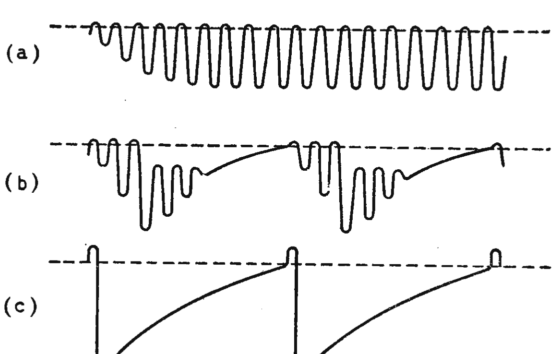


Fig. 2. (a) Start of oscillations in sine-wave oscillator in circuit very similar to Fig. 1 except for closeness of coupling. (b) Squegging condition obtained by increasing the coupling slightly. (c) Alleged result of tightening coupling to the limit.

per burst of oscillation; result, Fig. 2(c). "This saw-tooth shaped waveform finds application in oscilloscope time bases, radar, and—oh, yes!—in a little thing commonly called TV."

That—minus the lead-up on oscillators and squegging, which was taken as read—was more or less how the "pulse generator" was explained to me on the first "R.D.F." course in those hectic days of 1939. I remember being a shade doubtful even then about the "single half-cycle followed by heavy damping" theory; but there was no time to go into refinements, and any reasonably plausible explanation was reckoned to be better than none. The main thing was to have something that worked; if a convincing theory could be thought up to account for it, so much the better.

This is just one example of a big ethical problem in teaching. Is one justified in pitching a tale known to be inaccurate, because the best knowledge on the subject would be far above the head? Even if

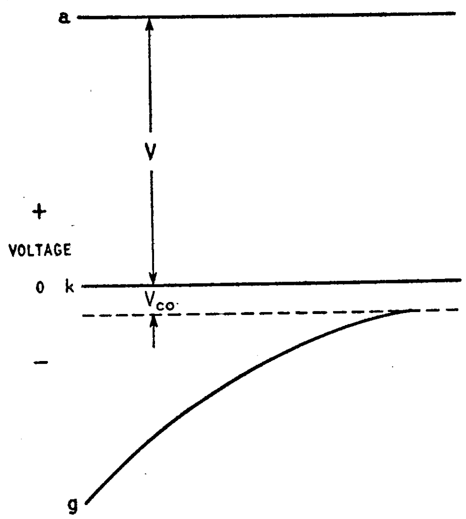


Fig. 3. Electrode potentials of valve in Fig. 1 during discharge phase of blocking oscillator cycle. The dotted line marks the minimum cut-off grid bias, V_{co}, when the anode is at $+V$ volts.

one knows that the Fig. 2 theory of the blocking oscillator doesn't hold water at every point, it is at least roughly true and capable of satisfying almost all except the specialists who design blocking oscillators (if, in fact, they ever are really designed!). So ought one not to give it, rather than a more academically correct theory that is generally agreed to be difficult and, therefore, only likely to confuse?

Well, it's not for me to pronounce on the general principle, but the object of this series is to look rather more closely into things than there is space for in the average book or teaching course, so let us try to find an approach that is not too far removed from truth on the one hand nor too complicated to follow on the other.

Now although the circuit of a blocking oscillator (Fig. 1) looks the same as that of a sine-wave oscillator, and although the derivation of one from the other along the lines of Fig. 2 has obvious attractions as regards plausibility and economy of effort, the explanation of continuous oscillation in the Fig. 2(a) case will not—if it was anything like a correct and adequate one—be found to fit very well when applied directly to the Fig. 2(c) case. In other words, acceptance of the statement that (c) shows half a cycle of the oscillations seen earlier at (a) is rather like accepting a conjuror's box containing a rabbit as the same box as the one we saw him pouring a jugful of water into a moment or two earlier.

One inconsistency is that sine-wave oscillation in Fig. 1 depends essentially on capacitance as part of the oscillatory circuit, whether it is provided by an actual capacitor or exists only as "stray"; whereas although stray capacitance inevitably exists and plays a part in a blocking oscillator, it is only a subsidiary part. A blocking oscillator, both in operation and in the nature of its waveform, really belongs to a different class; it is a relaxation oscillator*. So let us regard any resemblance between it and the sine-wave sort as purely coincidental and start afresh.

It was at this point I began gathering together the basic principles that govern relaxation circuits —the results of switching combinations of resistance and capacitance or resistance and inductance—and found that the review expanded into a full instalment, which was published last month. There was the well-known charge and discharge of a capacitor, leading to the definition of time constant; and the not quite so well known "charge" and "discharge" of an inductor, especially one provided with two close-coupled windings. I hope this review is at hand for reference, because there will not be room even to summarize it all. I will only re-emphasize that just as the voltage across a capacitor cannot change abruptly, but only as a result of current flowing into or out of it for a time, so the current through an inductor cannot change abruptly, but only as a result of voltage across it for a time. And that any change of current through it induces a voltage proportional to the rate of change and to the amount of inductance; and that where there are two or more close-coupled windings this change refers to the resultant of them all.

The only other thing we need is a very elementary knowledge of the behaviour of a valve at extremes of grid voltage. We can pretty well cover it by saying that when there is a large negative bias on the grid the valve is "cut off," so that there is no circuit through the valve from either grid or anode; but when a positive voltage is applied to grid as well as anode, both conduct freely to cathode.

We are now all set to consider Fig. 1 as a blocking oscillator, for in that role it is essential for the coils to be coupled tightly by means of an iron core, and it is quite usual for them to have equal numbers of turns (as conveniently assumed in our theory last month). Inequality of turns complicates the reckoning but in no way affects the general principle, so for that our simple preparations will do.

With a process that goes round and round in a circle, without any beginning or end, the first problem is to decide where to join in. The blocking oscillator cycle consists broadly of two phases: one of them is usually a small fraction of the whole and has lots of things happening very quickly, so doesn't make the easiest introduction. The preferred procedure is to start with the longer and slower phase, which we have already studied under the heading of discharge of a capacitor.

C in Fig. 1 is the capacitor, and it has previously

* April 1954 issue, p. 193.

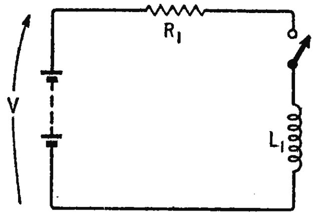


Fig. 4. The start of anode current at the end of Fig. 3 is equivalent to closing the switch in this simple circuit, discussed fully last month.

been charged, in what manner we shall see later, in such a way that the plate connected to the grid is negative. It is discharging through R, and because R is quite high—say 100kΩ—it damps out any tendency for C to form an oscillatory circuit with L_2. It is also large enough for nearly all of the voltage of C to appear across it, and therefore as negative bias for the valve. The amount of this voltage at the start of the discharge phase was far more than enough to cut the valve off completely. So the valve (and L_1) can be ignored during this phase. The only addition to the simple CR discharge circuit is L_2, and it is insufficient in comparison with the large R to make any vital difference. So we can copy our discharge exponential curve, upside down to represent the fact that the voltage is negative from the valve grid's point of view. Because there is no anode current, and since we are neglecting any voltage induced in L_1 by the slow rate of change of current through L_2, we can show the anode voltage as constant at +V. Fig. 3 tells the story. The dotted line marks the minimum negative bias (call it V_{co}) needed to cut off the valve at this anode voltage. Although C is not fully discharged by the time the negative bias it imparts to the valve has declined to the dotted level, we must regard it as the end of the phase, for directly it is reached things begin to happen—suddenly.

Seeing how gradually the grid potential eases towards the dotted line, and remembering how gradually anode current begins at its "bottom bend" even when the dotted line is reached, one might not expect sudden results. This, however, is the precise moment at which to bring on the second of the circuits we considered last month, repeated here as Fig. 4. V and L_1 we already have in Fig. 1, and the combination of switch and R_1 enables us to reproduce what the anode-to-cathode path is doing at this instant—changing over from infinite to finite resistance. It is true we don't know the value of R_1, and certainly can't assume it is constant, but our ignorance on these points doesn't affect the fact that at the moment of transition from one state to the other the whole voltage V appears across L_1.

Because L_2 has the same number of turns and is 100 per cent coupled to L_1, the same voltage necessarily appears across L_2. If the coils have been correctly connected as shown in Fig. 1 (so that the coil windings are in opposite rotation in the direction towards anode and grid) this secondary voltage equal to V makes the grid less negative, by that amount. Clearly this not only takes off the whole of the negative bias but makes the grid positive to the extent of V less only the cut-off bias V_{co}. This deduction is due to C, which at the instant being considered is charged negative-to-grid to that extent.

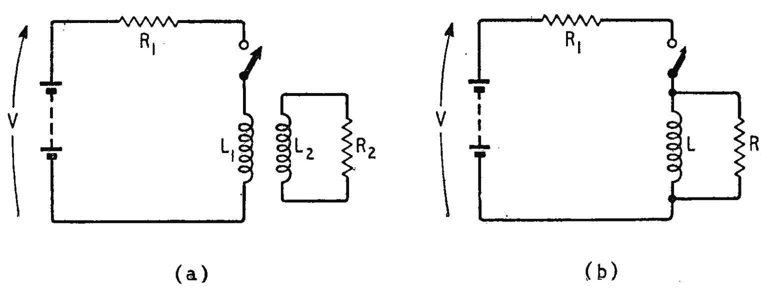
The effect of this positive grid is to make the valve conduct heavily from grid to cathode too. So (neglecting the relatively small counter-voltage of C) we pass instantaneously from Fig. 4 to the next circuit we considered last month—Fig. 5(a). As we saw then, this can (on the equal turns 100 per cent coupled assumption) be simplified to (b).

The consequence of this second stage of the process seems to contradict the first. Since R_2 is evidently of the same order as R_1, and may well be lower, it is clear from Fig. 5 that nothing like the whole of V can appear across L or L_1. This inconsistency arises because in the simple theoretical circuits it is possible for things to happen infinitely fast, but in any real circuit there are such complications as stray capacitances which restrict potentials everywhere to finite rates of change. For this reason the voltage across L_1 has to grow, and directly it exceeds the cut-off bias R_2 comes into existence. What happens then is that the values of R_1 and R_2 adjust themselves according to the characteristics of the particular valve, until a balance is reached more or less on the lines of Fig. 5. The difficulty (to say the least) of expressing the anode and grid characteristics of a valve over the whole range from below cut-off to highly positive grid as an equation is, I imagine, one of the reasons why making a comprehensive mathematical analysis of the blocking oscillator is not a popular occupation.

Since stray capacitances are normally only a few pF and the circuit resistances have now been brought down to the order of 1 kΩ, the time constants of these strays are of the order of small fractions of a microsecond. So, compared with the leisurely progress of the relatively large C charging through the relatively large R, the switch-over to Fig. 5 conditions is very fast; so fast that with a time-base speed that gets the whole of Fig. 3 on to the screen of an oscilloscope the next parts of the grid and anode traces (one upwards and the other downwards) look quite vertical.

Because of this high speed of transition we need not worry unduly about what is happening during it to C. When the balloon went up, if you remember, its charge had dwindled to V_{co} volts. Then, without warning, its terminal joined to L_2 gets a terrific kick positivewards. Even though at the same time the resistance in series with it is reduced from R to

Fig. 5. The start of anode current is instantly followed by the start of grid current, converting Fig. 4 into this equivalent, shown in two forms.



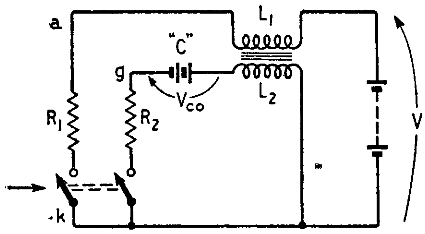


Fig. 6. The blocking oscillator circuit (Fig. 1) can be simulated quite well during its trigger phase by this working model, in which the valve is represented by R_1, R_2 and the two-pole switch.

perhaps a hundredth of that amount, its capacitance is normally so much larger than that of the strays that its response to this sudden charging voltage is comparatively slow. For the very brief duration of the switch-over, then, we can replace it approximately by a battery of V_{co} volts. Except that a lot of stray capacitances have to be imagined everywhere, Fig. 6 is a fairly good working model of Fig. 1 for this short period.

Relating it to Fig. 5, we see that the grid potential must shoot up by the same amount as the anode potential drops down. If R_1 and R_2 were equal, each would change by V/2 volts, leaving the anode V_{co} volts more positive than the grid. The final balance may well be about here; if the voltage amplitude were much less, then R_1 would be lower than R_2—the anode has a start of about V_{co} volts in the Conduction Handicap—and Fig. 5 shows that this would tend to increase the voltage pulse. If, on the other hand, it increased to much more than V/2, the grid would become more positive than the anode, increasing R_1 relative to R_2, and so reversing the trend.

In any case we may expect the anode and grid currents to become very large with equal suddenness. That is obvious, whether one explains the action as I have done, or in the more conventional manner by supposing the start of anode current to induce a voltage in L_2, which reduces the negative bias a little, which makes the anode current grow more rapidly, which takes off the bias quicker, etc., *ad lib.* Students who have not taken the trouble to prepare themselves as thoroughly as we have, but who do remember that the voltage induced is equal to L times the rate of change of current, are apt to get into a flap when they see the almost vertical front of the current pulse through either coil—known to have quite a large inductance. Their problem is how it can change so fast without a stupendous voltage. We, however, remember also that the magnetic flux, which is what induces voltages, is the net result of the currents through both windings; and when, as in this case, they are in opposite rotation around the core, they can rise as fast as they like so long as they are equal.

Fig. 7 (which continues Fig. 3) shows the position to date, with the equal and opposite anode and grid voltage pulse fronts, and the commencement of anode and grid current, also equal and (from the magnetizing point of view) opposite. Although the difference between them, which is the net magnetizing current, must start from zero, it must be changing at the rate needed to induce the voltage pulses. This is a slower action than the almost vertical pulse rises, so we shall now have to take into account what C is doing. It is being charged by the positive voltage from L_2, and because the resistance R that discharged it is now shunted by the much lower resistance of the positive-grid-to-cathode path its rate of charge is much faster than the rate of discharge graphed in Fig. 3.

The difficulty is that we don't know yet what is going to happen to the induced voltage. Let us see where we get if we assume it remains constant until further notice. Then we have the simple charging C circuit once more, with L_2 playing the part of the supply battery. Assuming in the meantime that the grid-to-cathode resistance also remains constant, we can tentatively sketch the next parts of the grid voltage and current as rapidly collapsing exponential curves (Fig. 8).

With typical components this rate of fall of grid current would by itself induce a higher pulse voltage than is necessary to keep everthing else right, so the anode current must also fall off, but at a slower rate so as to provide sufficient growth of net current to keep up the assumed constant induced voltage. It would in any case decline, as a result of the falling grid voltage. The actual waveforms will, of course, have to be such that the various currents and voltages are at all times related in conformity with the characteristics of the valve, so we can do no more than forecast the general tendency.

When the grid potential reaches zero, the grid current does the same. Remember, it was the decline of grid current at a more rapid rate than anode current that has been keeping the voltage pulse going in L_1 and L_2. The only thing that could keep it going now would be a reversal of the decline in anode current, and there is nothing to cause that, so inevitably the voltage pulse collapses. This is another trigger action, for directly the anode voltage tends to fall off at all it reduces the anode current, which induces a voltage in the opposite direction to the original pulse.

So we would expect the remaining anode current (which can be regarded as the net or magnetizing current that has accumulated during this charging phase, and whose steady growth has kept the voltage pulse going) to be suddenly cut off. This ought to be matched by an equal drop in grid current if there is not to be an enormous reverse voltage. But this time it looks as if that is impossible, for the grid current cannot go appreciably negative. What happens?

For the answer (and also to check the foregoing predictions) I had to go to the oscilloscope. It did corroborate Fig. 8 remarkably closely, and then went on to show that the collapse of the voltage pulse is indeed followed by a considerable reversal, but that it is preserved from being nearly infinite by an apparent drop in grid current nearly equal to the drop in anode current. I say "apparent" because it is pretty clear that in fact this current drop in L_2 is due to the very large voltage reversal charging the stray capacitances of L_2, C, grid, etc. It is therefore necessarily short-lived, being followed by a fairly rapid discharge (Fig. 9).

The large voltage change (which, of course, must be the same in both coils) brings the grid potential far below cut-off. The voltage induced in L_2 returns quickly to zero as the stray charges leak off, but the charge on the much larger C, which now has only the high-resistance R to leak through, takes a long time to go. And that is where we came in.

We have, then, these steep-sided narrow pulses, whose width is determined chiefly by C and the positive-grid-to-cathode resistance, spaced apart by intervals determined chiefly by C and R. Because V_{co} is usually quite a small fraction of V, the spacing interval is of the order of two or three times the time constant, CR. And so we can roughly calculate the component values for a required frequency of oscillation. Note that we have come across nothing resembling ordinary LC oscillation.

In practice the waveforms may differ considerably from those we have built up by theory, and it is interesting to trace why. There is not room left to do so here in detail, but you may like to follow up some clues. We have already had to fall back on stray capacitances to account for things. Then there are the resistances of the transformer coils, and their leakage inductances. These differences between the real transformer and our theoretical resistanceless 100%-coupled affair account for the most outstanding discrepancies—those between the theoretical and actual grid voltage pulses. Fig. 10 shows some typical oscillograms. Evidently the voltage actually induced in L_1 and L_2 is somewhere between the shapes observed at the terminals, and the internal resistive and inductive drops (due to the large current pulses) square the left shoulder of the L_1 pulse and slope it off still more in the L_2 pulse. This gradualness of rise allows C to charge considerably before the L_2 voltage has reached anything like its full amplitude, and so the maximum voltage actually reaching the grid is considerably less than predicted.

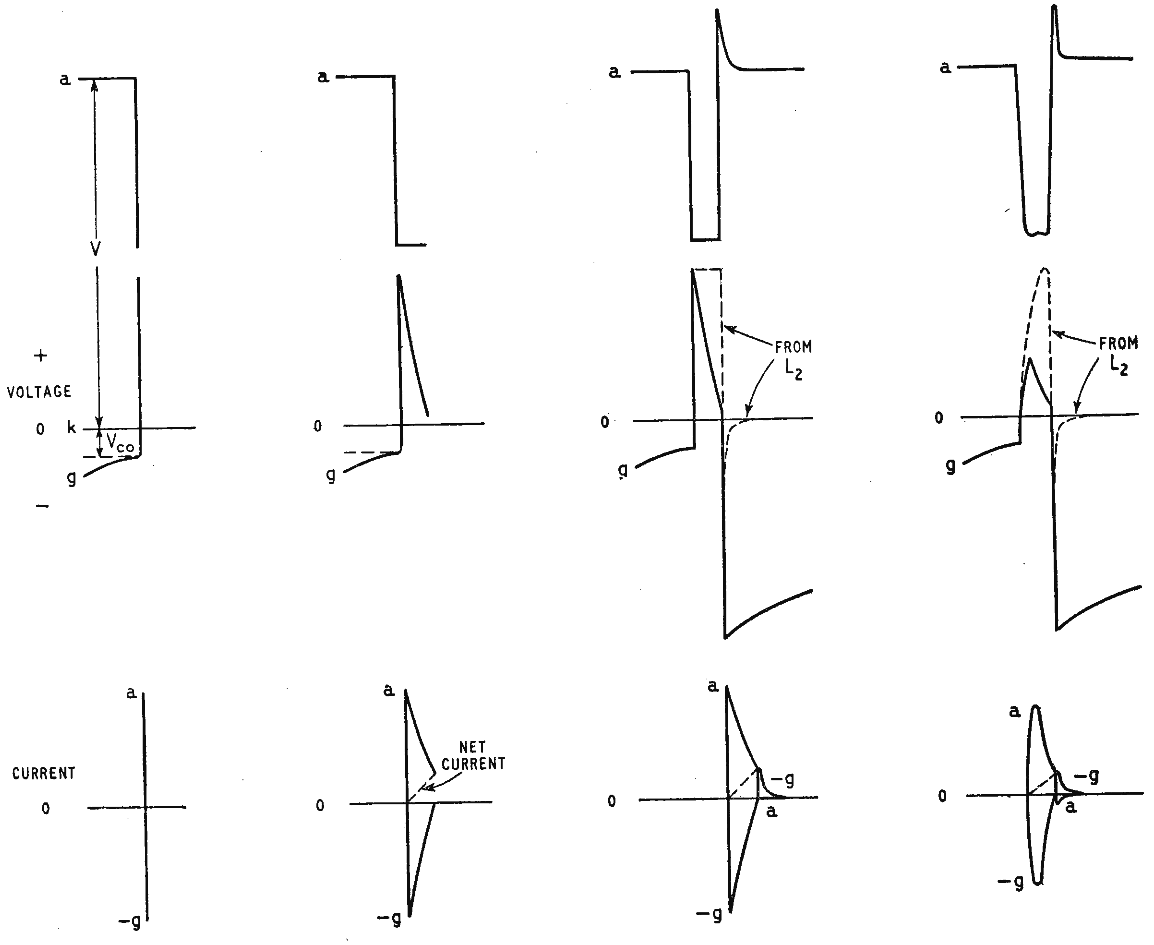


Fig. 7. Fig. 8. Fig. 9. Fig. 10.

Fig. 7. First stage of the continuation of Fig. 3: the trigger action " on."

Fig. 8. The pulse stage, during which C is charged by grid current. The dotted line in the current diagram shows the difference between the anode and grid currents, which is the net magnetizing current.

Fig. 9. Trigger action " off," started by the magnetizing current being no longer able to increase. The dotted line in the voltage diagram shows the voltage generated in L_2, equal and opposite to that in L_1. The difference between it and the full line shows the voltage across C.

Fig. 10. Waveforms observed in an actual blocking oscillator, arranged for comparison with Fig. 9. The differences are due largely to transformer resistance and leakage conductance.

Limiting Factors in Gramophone

2.—PICKUP DESIGN : CONTINUITY OF STYLUS-GROOVE CONTACT :

HAVING examined, in the first part of this article, the nature of record deformation and wear, we can consider the design of a suitable pickup. The limiting tracking weights are ½ gram for vinyl and 2½ grams for shellac. The lightest commercial pickups track at 2-3 grams for vinyl and 4-6 grams for shellac. It would be difficult to reduce the tracking weight to the desired value for vinyl, but it would be fairly easy to halve the tracking weight for shellac, as the design is in any case easier than for vinyl. If the desired low weight for tracking on vinyl could be achieved, the resultant pickup would doubtless be fragile, and have low output voltage, but before ruling out such a pickup as impossibly difficult and expensive, it should be remembered that only a few years ago pickup manufacturers considered that anything with a tracking weight of less than 30 grams was a fragile, expensive, specialists' instrument. With the advent of microgroove records, and the necessity of reducing tracking weights to about 8 grams, if reasonable record life was to be obtained, pickup manufacturers have produced, apparently without difficulty or complaint, pickups which not only operate at this weight but are fairly cheap and have a high output voltage; even record changers have been redesigned to treat records with more care.

The Arm.—This must have low friction and low inertia, particularly with warped records, and torsional resonance which will influence response must be avoided. A single vertical pivot bearing is at once the simplest and cheapest, is robust, has the lowest friction, and torsional resonance is avoided. If desired, an anti-vibration mounting can be used between head and arm to further reduce the effect of arm resonance. The only disadvantage of the single-point bearing is that very thin flexible leads must be used to reduce drag. To reduce the torque on the arm to a minimum, the armature should be positioned (at the correct angle for minimum tracking error) with the stylus on the axis of the arm (Fig. 4). To obtain the correct tracking weight the arm may be counterbalanced either by a weight or by a spring—in the case of a single pivot, a weight only is possible. The weight is much more convenient and more easily adjusted, but it is sometimes argued that a spring is better in that it saves weight and hence inertia of the arm. However, although the saving of weight is considerable, the saving of inertia is very small. Thus if the head is of mass m, distant l from the pivot, its moment of inertia about the point is ml^2; this must be counterbalanced by a mass of say $5m$, distant approximately $\frac{l}{5}$ from the point, having a moment of inertia of $5m \times (\frac{l}{5})^2 = \frac{ml^2}{5}$, i.e., for the convenience of using a counterbalance as opposed to a spring, there is an increase of only 20% in the inertia. As the inertia of the tube forming the arm has been ignored the increase in the total inertia will be somewhat smaller. As the inertia of the arm will usually be only a fraction of that of the head, particularly if a magnetic head is used, there is no point in making the arm absurdly flimsy.

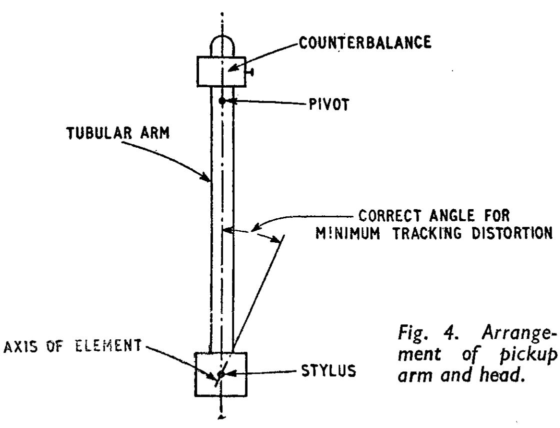


Fig. 4. Arrangement of pickup arm and head.

The Head.—The limiting weight of the head will depend on the degree of warping of the record to be played, the accuracy of the centre hole and the accuracy of the turntable. The inertia of a 60-gram head is not excessive at a tracking weight of 2 grams; it is thought, therefore, that at a tracking weight of ½ gram, a head weight of 15 grams would not be excessive. In a magnetic head it is doubtful whether this weight of magnet would give saturation in the size of gap likely to be used, but sufficient flux to give useful output should be obtainable. With shellac records, with the greater weight allowable, there should be no difficulty. Where a crystal movement is used there will be less difficulty in attaining a small head weight. The type of movement used is partly a matter of choice. The moving coil system is easily designed and has fewer objections than moving iron and crystal systems. The coil would preferably consist of several turns of fine wire giving a higher output voltage than a ribbon or single turn, so as to be well above the hum level picked up by the leads[7, 8]. The coil would preferably be a bifilar push-pull winding, feeding into a centre-tapped coupling transformer, thus reducing hum. A strain-gauge system in which the electrical resistance of a fine wire is varied by the strain it receives is attractive, as it is simple and can be made in small sizes. However, circuit arrangements are a little complex, and the signal level would almost certainly be so low that noise and hum would be serious problems. Carbon composition strain gauges would be unsatisfactory, due to self-generated noise. Other methods, such as magneto-striction and frequency modulation, would seem to offer no advantages. The recently

[7] Baxandall, P. J., Letter, *Wireless World*, Sept., 1950.
[8] West, R. L., Letter, *Wireless World*, Sept., 1950.

Reproduction

TRACING DISTORTION

By D. A. BARLOW, M.Sc.

introduced magnetomotive system[9] consisting of a moving magnet with a stationary coil on a soft iron core is attractive, as the moving parts are simple and robust and high impedance with high output voltage is obtainable without a coupling transformer.

The tracking weight has been discussed by Mallett[10]. It is governed by three factors, the lateral stiffness, the lateral inertia and the vertical stiffness. The lateral stiffness is operative at low frequency so that the inner surface of the groove will take most of the load; at high frequencies the inertia of the moving parts is operative and the outer wall of the groove takes the load. In a complex waveform stiffness or inertia may be operative over different parts of the wave, but the full load will be taken at any instant by only one groove wall, so that stiffness and inertia loads are complementary. The maximum stiffness load is reached at maximum amplitude; the maximum inertia load may not always be reached at maximum amplitude, depending on the waveform; the maximum load due to vertical stiffness when vertical amplitude is greatest is at the mid-point of the wave. These three components of load, therefore, lateral stiffness, lateral inertia and vertical stiffness, are largely complementary rather than additive. Vertical inertia is not in itself important as will be shown later. Longitudinal movement of the stylus must be a minimum, otherwise distortion and rounding off the steep wave fronts will occur. Lack of longitudinal rigidity is the probable reason for needles trailing rather than being set vertically[11]. A vertically set needle will judder longitudinally if it is not rigid in that direction. The maximum angle of the trace to the direction making a tangent to the groove at the stylus contact must be less than the half angle of the groove (approx. 45°), otherwise the stylus will ride up the groove wall regardless of tracking weight. The angle of the trace in the $33\frac{1}{3}$ r.p.m. extended play records appears to approach this limit as a result of the greater amplitudes employed.

Lateral Stiffness.—This must be such that the lateral load for the maximum recorded amplitude is not greater than the tracking weight, i.e., lateral compliances must be more than 6×10^{-6} cm/dyne for vinyl and 4×10^{-6} cm/dyne for shellac. This should not be difficult to arrange.

Resonances.—There will be a number of resonances due to the mass of the armature, head, etc., with the lateral, vertical, and longitudinal compliances of the suspension, and record-stylus. The armature should be sufficiently rigid longitudinally for resonances with this compliance to be ignored. The other resonances are examined below. Any damping material must be added with caution, as it may cause intermodulation distortion[12].

Lateral Low-frequency Resonance.—This is the resonance of the mass of the head and arm and the lateral stiffness of the movement, and the frequency is given by

$$f_1 = \frac{1}{2\pi\sqrt{M_p C_a}}$$

Where M_p is the lateral effective mass at the stylus of the head and arm (gm) C_a is the lateral compliance of the movement (cm/dyne).

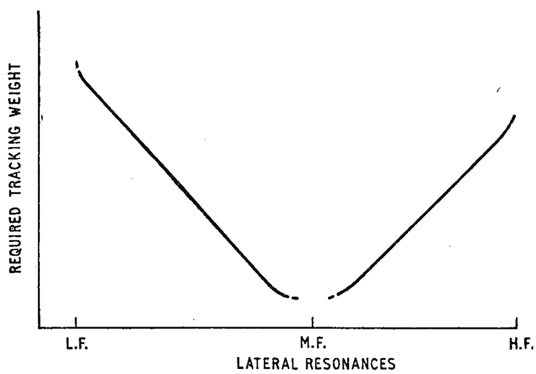


Fig. 5. Effect of lateral resonances on required tracking weight.

The effective mass at the stylus is:

$\frac{I}{l^2}$ where I is the moment of inertia about the particular axis, and l is distance of axis from stylus (cm).

This resonance has been used in cheap pickups to boost the bass; it should, of course, be below the recorded range in a high-quality pickup. For vinyl with a head weight of 15 grams, the resonance would be at about 17 c/s; for shellac with a 75-gram head, the resonance would be about 9 c/s.

Lateral Mid-frequency Resonance.—This is the resonance of the mass of the movement (coil or armature) with its own lateral stiffness (restoring force), and generally occurs at the mid-frequencies. Unlike most other resonances, it is not deleterious. It is a series resonance and at the resonance frequency the stylus point impedance tends to zero (Fig. 5.). It simply means that at this frequency no power is required to move the armature except that required by damping. The physical significance of this can be easily seen—the stylus will always try to move at this frequency so that at lower frequencies it tends to return to the mid-point faster than the trace allows, so that it is always pressing on the inner wall of the groove; at high frequencies

[9] Wittenburg, N., *Philips Tech. Rev.*, Vol. 18, Nos. 4/5 and 6, 1956/57.
[10] Mallett, E. S., *Electronic Eng.*, May, 1950.
[11] Rabinow, J., and Codier, E., *J. Acous. Soc. Amer.*, Vol. 24, No. 2, March, 1952.

[12] Roys, H. E., *Audio Eng.*, May, 1950.

it tends to return to the mid-point slower than the trace allows, so that it is always being forced back by the outer wall of the groove. This resonance is given by

$$f_2 = \frac{1}{2\pi\sqrt{M_a C_a}}$$ where M_a is lateral effective mass of element at stylus.

Lateral High-frequency Resonance.—This is the resonance of the mass of the element with the compliance of the record and stylus. It is well known that if this frequency is in the audio range, excessive noise will result from shock excitation of this resonance, and there may be accompanying distortion, even if the resonance is thoroughly damped. This resonance is given by

$$f_3 = \frac{1}{2\pi\sqrt{M_a C_n}}$$ where C_n = lateral compliance of stylus and record materials (cm/dyne).

For this resonance to be above say 20 kc/s, M_a must be less than about 1 milligram for vinyl and 3 milligrams for shellac.

Lateral Inertia.—The maximum accelerations recorded are about 1500 g for microgroove records and 500 g for 78 r.p.m. records[13]. The corresponding limiting lateral effective mass at the stylus is 0.33 milligrams for vinyl, which would be hard to achieve, and 5 milligrams for shellac, which would be easy to achieve.

Vertical Stiffness.—The need for vertical movement is of course to allow for the pinch effect. The groove is cut with a chisel-edged stylus and traced with a spherical stylus, as a consequence of which the stylus of an ideal pickup must move vertically at twice the frequency of the trace. The maximum vertical amplitude is about 1/9th of the lateral for microgroove and 1/6th for 78 r.p.m. records. The vertical stiffness must therefore be not greater than 9 times and 6 times the lateral stiffness respectively, i.e., a compliance of 0.67×10^{-6} cm/dyne in each case.

Vertical Resonances.—Although the pickup may not generate any voltage for vertical movement, vertical resonances are best avoided in the recorded range, or, rather, at twice these frequencies, as the vertical movement takes place at twice the recorded frequency of the trace. Where the lateral loads are not shared equally by each groove wall, as is always the case except at zero amplitude, any vertical forces will cause movement of the stylus not vertically but at some angle—in extreme cases up and down the side of one of the groove walls, and will thus generate a signal, even though true vertical movement generates no signal. The normal vertical movement may therefore generate a signal, although it may be very small, but vertical resonances may be serious.

Vertical Low-frequency Resonance.—This is not the resonance of the mass of the head with the vertical compliance of the movement or cantilever, and should be below the recorded range. It will be about 50 c/s for vinyl and 22 c/s for shellac (corresponding to lateral recorded frequencies of 25 and 11 c/s) for the pickup considered here.

Vertical High-frequency Resonance.—This is the resonance of the vertical effective mass at the stylus point with the compliance of stylus and record, and should be above the recorded range, i.e., above 40 kc/s (corresponding to 20 kc/s lateral). The vertical compliance of record and stylus is unknown, but will probably be about half the lateral, as the load is now taken by both walls of the groove. The limiting vertical effective mass at the stylus will thus be about 0.5 mgm for vinyl and 1.5 mgm for shellac.

The above two resonances will influence each other's frequencies slightly, but as they are a long way apart the interaction will be very small and can be ignored. With suitable design there will be no other vertical resonance, and the stylus will maintain contact with the groove at all times, except when severe tracing distortion occurs, due to overmodulation, when the trace radius approaches the stylus radius. When this occurs, and contact with the groove is not maintained, there will obviously be acoustic rattle or needle-talk, and the output may be affected. In addition, when the stylus point is free, there may be a further vertical resonance, falling in the mid-frequencies (see later). The vertical inertia of the system is not, in itself, of importance, as the high-frequency resonance is above the recorded range.

Cantilever Movements.—To achieve the above very small effective vertical masses in practice, a cantilever type of movement is essential, as only the cantilever and stylus contribute to the vertical mass, the axis of the generating element being vertical. In most other designs, the whole of the element must move vertically, and the total mass is limited to the allowable vertical mass. The cantilever movement has the added advantages that vertical movement is obtained with the minimum of longitudinal movement, and the system can be easily designed to minimize damage due to accidental dropping on the record. The use of a cantilever, however, introduces its own lateral, vertical and torsional resonances. The lateral resonance can probably be avoided, as the cantilever must be stiff laterally if appreciable signal loss is to be avoided. The torsional stiffness could be increased for a given cantilever mass by making it of tubular form, and its magnitude reduced by placing the stylus tip as near as possible to the axis of the cantilever. Vertical resonance of the cantilever will occur when the stylus is not in contact with the groove, and in any practical design this resonance will fall within the audio range. However, when the stylus tip is in contact with the groove, and provided the generating element itself has negligible vertical compliance, there will be no resonance in the audio range. Considering vertical movement only, the system has two degrees of freedom, Fig. 6(a), and the only resonances will be the low and high frequency ones already listed. If there is appreciable vertical compliance between armature and head, the system will have three degrees of freedom, Fig. 6(b), and there will be three resonances, the additional one of the mass of the armature with the cantilever compliance being within the recorded range. The armature vertical compliance can be made very small if the top end of the armature forms a cup-and-cone bearing with the head; in the case of a torsional crystal element it may be firmly fixed to the head.

The cantilever would best be made in a hard rigid

(*Continued on page 293*)

[13] Cosmocord Ltd., Private communication.

plastic, perhaps phenol-formaldehyde, as this would have the greatest stiffness/weight ratio of any practical material, this being proportional to modulus/(density)^2. Sapphire and diamond would be too heavy for tips, at least for microgroove, so that a one-piece replaceable plastic moulding could be used for stylus plus cantilever.

Soft Styli.—In passing, it should be noted that the usual objections to soft needles will not apply here; as the yield stress and modulus of the stylus will be appreciably greater than those of the record material, there will be no serious deformation of the stylus, and fairly accurate tracing with reasonable life would be obtained. Conditions would bear no relation to those of the conventional thorn under, say, 40 gm playing weight, under which the point is deformed to contact almost the whole of the groove, with consequent distortion and top loss. The other conventional objections to thorn are the possible embedding of either sharpening or other dust with consequent abrasive wear of the grooves, the thorn acting as a lap. The possibility of dust from sharpening being embedded is much exaggerated; every day in industry, millions of sand-papering and grinding operations are carried out on all types of material and particles of abrasive are virtually never embedded in the work. It is possible to get embedding of abrasive, particularly with certain soft and ductile metals, but it occurs only with unsuitable grinding conditions, and virtually never occurs with the free-working non-metallic materials. Regarding the embedding of ordinary dust, if the record is cleaned sufficiently well each time for the noise due to dust to be inaudible, it is difficult to see how such dust as remains could become audible, and the rate of wear, if any, would be extremely small. Further, it is by no means certain that abrasive wear by such means actually occurs; for lapping to take place, the lap must normally be much softer than the material to be lapped. In the present case, the plastic will be harder than vinyl or (unfilled) shellac.

The relatively low modulus of soft styli, compared with sapphire or diamond, will increase the stylus-record compliance, which will lower the lateral and vertical high-frequency resonances. Again, a high-modulus plastic must be chosen, when the effect will probably be slight, but, if necessary, a further reduction in mass at the stylus point must be made.

Tracing Distortion.—This is by far the most serious form of distortion in record reproduction. It can be very distressing on shellac records, and is tolerable on vinyl only by reason of the elastic deflection of the groove walls, which reduces the tracing distortion but introduces a further type of distortion which is less serious. Severe record damage will result from overmodulated traces, however light the pickup. When the trace radius is equal to or less than the radius of the stylus at the point of contact with the walls, the stylus is required to change its direction instantaneously, which requires infinite deceleration and acceleration thus giving groove deformation and rattling. On 78 r.p.m. records an elliptical stylus is essential to reduce tracing distortion to tolerable limits. Thus a 3-mil bottom radius/1-mil lateral radius stylus can be used, reducing the tracing distortion by a factor of 6; the tracking weight must be reduced to about half

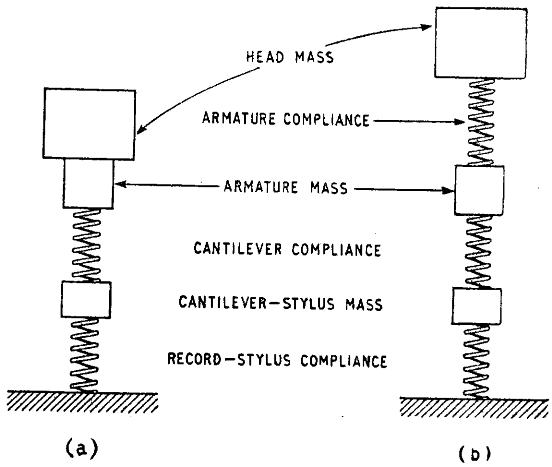


Fig. 6. Vertical systems with two and three degrees of freedom.

that for a 2.5-mil stylus. With microgroove records no such course is possible, and tracing distortion is more serious than on 78 r.p.m. records played with an elliptical stylus.

The high tracing distortion of microgroove records is due to the excessive high-frequency pre-emphasis used, as the de-emphasis in playback only partly offsets the distortion caused by pre-emphasis. The NAB characteristic, giving 16 dB rise at 10 kc/s is particularly bad—to quote Hunt, it "effectively guarantees excessive distortion." As a result, the A.E.S. standard curve, giving 12 dB rise at 10 kc/s, was adopted. The purpose of the pre-emphasis is of course to reduce surface noise; as the noise of good vinyl records is barely audible, it seems that even the 12 dB rise could be reduced without surface noise becoming objectionable. The noise level is reduced by about 6 dB for the 12 dB boost; if this were reduced to 6 dB, there would be an increase of 3 dB in noise level, which would be barely noticeable, with a reduction in tracing distortion by some factor approaching 4, which would be a very noticeable improvement. If there were no pre-emphasis, the noise level would be 6 dB higher than the A.E.S. standard, which would still be very much lower than shellac, and tracing distortion would be drastically reduced. This point has been well made by Viol[16].

An attractive alternative to dropping pre-emphasis would be 78 r.p.m. microgroove records—there would still be sufficient playing time per side that breaks would come between movements of symphonies, etc. The use of high-frequency pre-emphasis perhaps has more justification for shellac records where surface noise is high, but even here the gain may be largely offset by the increased tracing distortion. In any case, with a lightweight pickup, say less than 10-15 gm, there is no reason why 78 r.p.m. records should not be made in vinyl.

Dutton[17] has shown that for a given maximum level of tracing distortion, disc diameter, and average groove spacing, there is an optimum speed of rota-

[14]Watts, C. E., Reported in *Wireless World*, Dec., 1949.
[15]Pierce, J. A., and Hunt, F. V., *J. Acous. Soc. Amer.*, Vol. 10, No. 4, July, 1938.
[16]Viol, F. O., *Proc. I.R.E.*, Vol. 38, No. 3, March, 1950.
[17]Dutton, G. F., *Wireless World*, June, 1951.

tion of the turntable, giving the longest playing time. He states that at a groove speed of 16in/second, on standard 78 r.p.m. records, tracing distortion is apparent (this is rather an understatement), but that quality is not noticeably impaired at 22in/sec. The corresponding velocities for microgroove records (presumably allowing for high-frequency pre-emphasis, etc.) are stated to be lower by a factor of 1.6, i.e., 10in/sec and 13.75in/sec respectively; at this latter speed distortion is about 4% and it increases very rapidly to about 16% at 10in/sec. On the basis of a minimum speed of 10in/sec., a 12in disc gives a maximum playing time of 22 minutes at an optimum speed of about 33⅓ r.p.m. However, if we take the preferred minimum speed of 13.75in/sec., the maximum playing time is about 16 minutes at a speed of about 45 r.p.m.; 33⅓ r.p.m. gives a playing time of 15 minutes, and 78 r.p.m. gives 14 minutes. In other words, on the basis of work done by a well-known record manufacturer, if good quality is to be obtained, 15 minutes is about the limit of playing time, for a 12in disc, and the speed of rotation makes very little difference. In

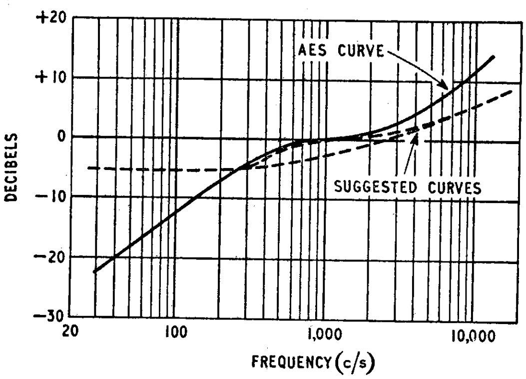


Fig. 7. Suggested revision of recording characteristics.

fact, the differences are so small that the trouble and expense of changing speeds and obtaining new turntables (usually more expensive than for 78 r.p.m., owing to the need to reduce rumble) was quite unjustified—the microgroove vinyl 78 r.p.m. record was the obvious choice, and speeds were doubtless changed only because the Americans had already done so. It has been argued that the slower speeds have the advantage of giving more margin for squeezing in an extra minute or so to enable the item to be completed; this is justified if the passage is a quiet one, but this does not often happen at the conclusion of a work. The fact that most 12in l.p. discs run for 20-25 minutes, and some for as much as 32 minutes, shows that this advantage is in fact a very serious disadvantage if high quality is to be obtained; with 78 r.p.m. microgroove discs, excessive squeezing in would be prevented by the label. There are even some gramophone enthusiasts who consider that on certain l.p.s, the musicians were persuaded to hurry through the work in order to squeeze it on to one side of a very long playing l.p. disc, when it would have been better to take two sides. If high-frequency pre-emphasis were not used on microgroove discs, it would be possible to go to a lower minimum groove speed, say 8½in/sec, for good quality, when a playing time of about 26 minutes would be obtained on a 12in disc, run at 22 r.p.m.

On the subject of recording characteristics, it is interesting to note in passing that Hunt[15] has pointed out that the maximum output for both speech and music drops off at rather more than 6 dB per octave below 250-300 c/s, i.e., the usual bass cut in recording is unnecessary. The advantage of no bass cut is obvious—less equalization required, i.e., less waste of precious output volts from the pickup, with the elimination of hum and rumble problems. There is some doubt about published curves for maximum output, as it is possible that transients and organ notes reach higher levels; nevertheless it would be interesting to know if bass cut is really necessary to avoid overcutting, or whether it is simply a hang-over from the days of acoustic recording, when the recording equipment unavoidably gave such a cut. The suggested recording characteristics are given in Fig. 7.

Returning to the problem of tracing distortion, together with pinch effect and the need for vertical motion of the stylus, the whole difficulty would disappear if the original groove were impressed with a spherical stylus, a duplicate of the reproducing stylus, instead of being cut with a chisel. As the area of contact of the groove with the stylus would now be greatly increased, deformation and wear from existing pickups would be almost eliminated. The limiting tracking weight for an impressed groove is difficult to calculate but would be about 0.9 gm for vinyl for *the elastic range*. With a comparatively slight reduction in existing tracking weights of the best pickups, there would be no damage whatsoever to record grooves and frictional wear of both groove and stylus would be very low. It might be necessary to use very close tolerances on dimensions of both recording and reproducing styli, to avoid an oversize stylus being forced into the groove, or an undersized one from "skating," but this would be a very small price to pay, especially as the reproducing stylus would be virtually everlasting for normal users. Alternatively, a V-groove could be impressed with a conical stylus, which would give a greater contact area and hence even higher limiting tracking loads. By making the bottom radius of the reproducing stylus larger than that on the recording one, skating would be avoided and a universal stylus becomes possible.

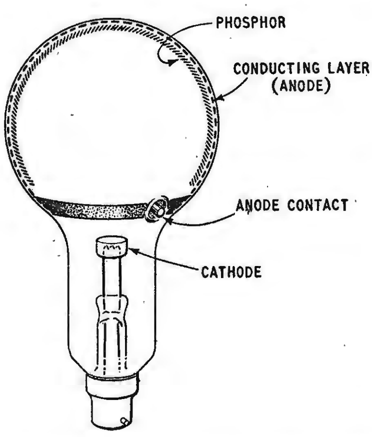
An impressed type of groove would doubtless require considerably more power for recording than a cut groove, but this might be offset by recording at a high temperature, either by means of a heated stylus or by heating the blank. Thus the normal hard type of recording wax or lacquer could be impressed while hot and soft. There are doubtless other difficulties, but the advantages to the record user would be so great that every effort should be made to produce impressed-groove records.

The impressed type of groove, with the high tracking weights possible without serious groove damage, makes the acoustic gramophone once more possible as a high-quality reproducer. Although there may be many limitations on the quality obtainable, some improvement in design is doubtless possible, and it should be remembered that the best acoustic gramophones have a clarity of reproduction which is not matched by many commercial radiograms.

Technical Notebook

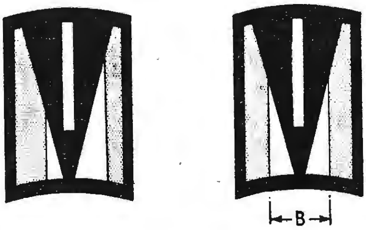
Kilowatt Pulse Transistor for switching purposes, developed by N. H. Fletcher, of the C.S.I.R.O. in Australia, is able to switch currents as high as 40 amps in times of the order of a microsecond. It can operate on voltages up to 30V. Normally, of course, switching transistors are restricted to low-current operation, while power transistors do not have the necessary frequency response. The requirements of high current gain at the operating current, low extrinsic base resistance and high alpha cut-off frequency have been obtained by an annular-ring construction of the emitter and base, with a covering collector. The well-known alloy process is used to form the junctions. Collector currents as high as 45A have been obtained with as little as 3A base current. Pulse rise times are fastest when a constant-current pulse is applied to the emitter in a common-base circuit. Mr. Fletcher has described the transistor and given references to earlier work in a letter in the April, 1957, issue of *Proc. I.R.E.*

Cathodo-Luminescent Lamps.—The old cartoon joke about people using the light of their television screens to read by will not be considered very funny by those who are developing electric light bulbs working on the very principle of the c.r. tube. Although this method of producing light is intrinsically efficient, the *actual* luminous efficiency obtained so far has been somewhat less than that of the tungsten lamp, and a great deal of work will be required to improve this at an acceptable anode voltage. The sketch shows



an experimental cathodo-luminescent lamp developed by L. S. Allard at the G.E.C. Research Laboratories. It was demonstrated to the Television Society at their 1957 Fleming Memorial Lecture.

Differential "Magic Eye" tube developed by Valvo of Hamburg has the important advantage when used as a null-indicator in bridge circuits that it will give the sign of the unbalance voltage. An electron beam of rectangular section produces a rectangular spot on a fluorescent screen on the inside of the valve envelope. The spot is deflected to left or right by two symmetrically mounted electrodes, to which the voltages to be compared are applied. When the bridge is balanced and the voltages are equal the spot is central. Unequal voltages cause a deflection to left or right according to the direction of the inequality, and this is made obvious to the eye by a black reference mask fitted on the outside of the tube as shown in the sketch.



At balance, the breadth of the spot, B (right), gives some indication of the mean value of the two voltages. Actually the two deflecting electrodes form the anodes of two built-in triodes which serve to amplify the applied deflecting voltages. The tube can be operated entirely from an a.c. supply, and various other masks can be used for different applications. A full description appeared in Vol. 18, No. 8, of *Philips Technical Review.*

Magnetic-Core Analogue Computing circuits have been devised by D. H. Schaeffer and R. L. Van Allen using square hysteresis loop magnetic cores in conjunction with switching transistors. The output is in the form of current or voltage pulses whose average values are a specific function of the input voltage. Many possible functions can be obtained, including square roots and other fractional powers, sines, arc sines and products of two inputs. Experimental data is given in D.S.I.R. unpublished report PB111900.

Directional Junction Photocell described by J. Torkel Wallmark in the April, 1957, issue of *Proc. I.R.E.*, is a semiconductor device based on a phenomenon known as the lateral photoeffect. Light directed on to the cell produces a voltage *parallel* to the junction as well as the normal voltage across it, and this can be picked up by two electrodes, on the same side of the junction, with the light falling between them. A point source of light focused on the cell will give zero signal at the electrodes if it coincides with the symmetry axis of the device, but if it deviates by a small angle in one direction or the other a voltage of one polarity or the other is generated. Thus the direction of a light source can be measured by a null method with great accuracy—in fact, to within 0.1 second of arc. An interesting feature of the cell is that the application of a bias voltage will produce the same effect as turning the cell and focusing lens away from the light source. The sensitivity is about 200μA/lumen, while the frequency response is roughly the same as that of a transistor.

Miniature Camera Tube of the photoconductive type with a diameter of only ½ inch has been developed by R.C.A. for use in a small transistorized camera (see picture). Measuring only slightly longer than a cigarette, it operates with voltages up to 300V, which are derived from a transistor convertor working from a 15-V supply. For scanning, the tube requires only 20 ampere-turns of deflection field, enabling small, low-power a.f. transistors to be used for waveform generation. A signal current of

0.1μA from the tube is amplified by a video amplifier using high-frequency junction transistors and having a bandwidth of about 4Mc/s. Focusing is done by a permanent-magnet assembly. The camera shown measures only $4\frac{1}{2}$in × $2\frac{3}{8}$in × $1\frac{7}{8}$in, and one of this type has been used with a portable 2,000-Mc/s transistorized television transmitter (known as a "Creepie Peepie") for reporting outside events.

New Ferroelectric Ceramics are being investigated as alternatives to the well-known barium titanate by M. Rose, G. T. Carter, C. G. Harmon and R. M. Gogolick. In particular, several compounds of sodium niobate have been found to be strongly ferroelectric (and piezo-electric after polarization). High dielectric constants have been noted, and electro-mechanical constants comparable with those of barium titanate. Studies are described in D.S.I.R. unpublished report PB117134.

Colour TV Vectorscope is an instrument developed by Marconi's for displaying and measuring the amplitude and phase of an N.T.S.C.-type colour signal on the screen of a c.r. tube. The N.T.S.C. colour signal is a sub-carrier modulated in amplitude to represent saturation and in phase to represent hue, so the vectorscope

indicates saturation by the radial distance of the c.r.t. spot from centre and hue as the angle subtended from a fixed phase reference on the screen. The signal to be tested is applied to a pair of quadrature demodulators, similar to those used in colour receivers, and the outputs of these, after suitable filtering and amplification, pass to the deflection plates of the c.r. tube. When used in conjunction with a colour-bar test signal, the vectorscope produces a pattern of bright dots corresponding to the tips of the various colour vectors and a pattern of lines corresponding to the transitions between the colours. Boxes indicating phase and amplitude tolerance limits are drawn on a transparent scale to provide a convenient indication of the quality of the signal—although these tolerances refer only to the sub-carrier information since the luminance information is removed first by a 1.3-3.3 Mc/s filter.

Simple Gamma Monitor, intended for measuring radiation in contaminated areas, has been designed by C. C. Klick, H. Rabin, J. J. Lambe, H. J. Peake and P. T. Cole. It comprises a cadimum sulphide crystal, a parallel combination of capacitor and neon flash lamp and a battery, and is sensitive over the range 0.1-1,000 Roentgens per hour—the neon flash rate being proportional to the gamma dose rate. Details in D.S.I.R. unpublished report PB111694.

Individual Temperature Compensation for components or sub-assemblies, rather than overall temperature control of equipment, is the idea behind a small "multi-purpose" oven, similar to a crystal oven, recently introduced by the Bulova Watch Company of New York. The manufacturers say that by eliminating costlier, less dependable and more complex temperature compensating equipment, a great deal of design effort can be saved; circuits can be

simplified, made more dependable and can have a far wider operating range. The oven is normally mounted on a standard octal base, weighs less than $7\frac{1}{2}$oz, dissipates an average of 5 watts after warm-up and has the high stability of ± 0.1°C.

Adhesive Copper Foil is now available in this country for making the "copper clad" used for printed circuits. Manufactured by the Rubber and Asbestos Corporation of Bloomfield, New Jersey, U.S.A., it is known as Plymaster Type "C" and is intended for application to insulating bases made of epoxide resin reinforced by glass fibre. The resulting "copper clad" is said to have an outstanding performance during and after exposure to silver and gold cyanide plating baths. The British agents are Omni (London), 35, Dover Street, London, W.1.

Turntable Tape Recorder, called the Selectophone T5, was one of the more interesting exhibits at the Photo Fair. Made in Germany by Standard, it is now being imported into this country by the Apparatus and Instrument Company. Magnetic tape 35mm wide is used, containing 70 tracks. The head moves automatically from one track to the next, giving a maximum of six hours' playing time at $3\frac{3}{8}$in per second. Two other tape speeds of $4\frac{9}{16}$in and $7\frac{7}{8}$in per second are also provided. These non-standard speeds were chosen in order that a turntable attached to the capstan spindle should rotate at 78, 45 and $33\frac{1}{3}$ r.p.m. The tape is supplied in cassette form, and positioning and selection of tracks is easy. Microphone and radio inputs with mixing facilities are provided, and the record being played can also be recorded. The audio output is three watts into an internal or external speaker.

Intestinal Telemetering has been demonstrated in the U.S.A. with the aid of a tiny f.m. transmitter in a plastic capsule measuring only 1.125in long and 0.4in in diameter. This "radio pill," as it is called, is swallowed by the patient and passes through the intestines, where changes in pressure are measured and transmitted by radio through the body to a nearby receiver. Designed by Dr. V. K. Zworykin of R.C.A., the "pill" contains an oscillator which is modulated in frequency according to the changes in pressure applied to the outside shell. The main components are a transistor, an inductor with a ferrite cup core and a battery, with a life of 15 hours, of a kind once used in anti-aircraft proximity fuses.

Cruciform Slot Aerial, with a pair of narrow slots crossed at right-angles, has been investigated by A. J. Simmons as a means of radiating and picking up circularly polarized waves. The cross is cut in the widest wall of a rectangular waveguide, to which it presents a very close impedance match. As a receiving aerial it can be used to discriminate between left-hand and right-hand circular polarization. Possible applications are suggested in D.S.I.R. unpublished report PB111904.

Unpublished Reports mentioned above come from various sources but can be obtained from the Technical Information and Documents Unit of the Department of Scientific and Industrial Research, 15, Regent Street, London, S.W.1.

National Gramophone Conference

VIEWS ON REPRODUCTION OF COMMERCIAL DISC RECORDINGS

A CONFERENCE organized by the National Federation of Gramophone Societies was held at High Leigh, Hoddesdon, from 5th-7th April. Seventeen talks or recitals on music or sound reproduction were given.

From the point of view of readers of this journal, perhaps the most interesting talk was given by Stanley Kelly. This dealt mainly with reproduction of commercial disc recordings. The overall picture which he drew of the ultimate quality obtainable was rather pessimistic.

The distortion due to pinch effect, which depends only on the geometrical factors of stylus and signal groove radius, can cause up to about 30 per cent third harmonic distortion at 10 kc/s on normal $33\frac{1}{3}$ r.p.m. microgroove records, especially at the inner grooves. These harmonics are, of course, inaudible but the associated lower frequency intermodulation products will not be. This intermodulation is aggravated by the normal practice of pre-emphasizing the high frequencies on recording. The extra harmonic distortion thus introduced—since harmonics are necessarily at a higher frequency than the fundamental—is removed when the corresponding de-emphasis is applied in playback; but again this does not apply to lower frequency intermodulation products. This distortion provides some of the "brilliance" often associated with "hi-fi" systems. From this point of view recording at 78 r.p.m. with a constant velocity characteristic at high frequencies had much to recommend it, and such recordings were known to give very good results. Unfortunately, even if customers could be persuaded to accept once again the shorter available playing times, the expense of the vinyl discs makes such recording commercially unattractive.

In Mr. Kelly's opinion the lightest practical cantilever arrangement would have an equivalent mass referred to the needle point of at least 1 milligram. The stylus mass itself will weigh about half a milligram. It is clear then, that with the tracking weights at present in use (of the order of 5 grams) accelerations of approximately 10,000 g which can be recorded will not be accurately traced on playback. Experiments on an inertialess "light-beam" pick-up gave very noisy results. This was probably due to roughness in the recorded groove which would be smoothed out by inertia effects in a normal pick-up.

Stylus Wear

Mr. Kelly stressed the importance of stylus wear —70 per cent of the complaints received by one pick-up manufacturer were found to be caused by worn styli. Dust is a very potent source of wear. Increases of sapphire lives of up to 30 times have been obtained by careful removal of residual dust by a brush accessory, by air conditioning, and by dispensing with coal fires! Intense local heat can be produced by the action of the stylus on groove asperities. Using a deliberately dirtied record evidence has been obtained of actual welding of dust particles to the stylus. The resulting uneven shape will produce rapid record wear. The main advantage of using a diamond stylus may be simply that it has a higher melting point, so that such welding is less likely. Wear could perhaps be reduced by lubrication but, owing to surface tension effects it is difficult to get the lubricant properly into the groove.

Faking Recordings

Mr. Lionel Salter gave a very interesting and profusely illustrated talk, mainly in support of the view that the recordings of certain works should, from artistic considerations, be deliberately "faked" so that they would not correspond to the recorded, or indeed to any actual performance. This view may be regarded as heresy, but Mr. Salter put it forward very persuasively.

One example is in the recording of concertos for instruments with a very weak tone, such as the harpsichord of fortepiano (a forerunner of the modern piano). If these instruments are played loud enough to balance the orchestra, they produce a very uninteresting sound. In Mr. Salter's view it was better for them to play at their normal level, and to amplify their sound using a separate microphone in recording. As a test piece for showing the difficulty of achieving a good recording balance he instanced Mozart's double concerto for fortepiano and harpsichord where the amplification necessary is different for each instrument.

Certain echo effects occasionally asked for by composers can be much more effectively produced by artificial reverberation. A very simple but convincing further case is where the choir is asked to fade away gradually singing a repeated phrase (such as at the end of "Neptune" in Holst's Planets Suite). This is very difficult to do perfectly naturally, but can be very simply produced artificially by gradually turning down the volume control to the recorder while the choir sings at the same level. The illustration was certainly better than your reporter has ever heard it sung at a concert.

Mr. Thurlow-Smith of Eroica Recording Services, Manchester, gave a very amusing yet instructive practical talk on "The uses and abuses of the domestic tape-recorder." The most important thing in tape recording was to label the tape! In Mr. Thurlow-Smith's opinion, for any serious recording, even with an ordinary tape recorder, it is necessary to use a good microphone.

"88-50" PRE-AMPLIFIER

It is regretted that the article describing the pre-amplifier designed for use with the "88-50" power amplifier (April issue) is unavoidably held over until next month's issue.

News from the Industry

"Empress of England."—Two entirely separate radar installations have been supplied by Marconi's for the new 25,000-ton Canadian Pacific liner, *Empress of England*. A special housing above the bridge accommodates the radar transmitting equipment. Two display units are fitted in the wheelhouse, and a smaller remote display in a radar plotting room. Marconi's are also supplying communication equipment and a direction finder. An echo sounder has been supplied by Kelvin & Hughes.

Marconi radio equipment has been ordered by B.O.A.C. for its fleet of long-range Bristol Britannias, some of which are expected to be in passenger service in a few months' time. Each aircraft will have a dual Marconi transmitter/receiver installation for multi-channel h.f. communication, a high discrimination receiver and a dual radio compass. The transmitter/receiver can be operated on any one of two hundred crystal-controlled channels, frequency changing being entirely automatic by self-tuning circuits. Similar equipment is also being installed in the new De Havilland Comets now on order for B.O.A.C. for its Australian, Far East and South African services. The Comet installations will include the selective calling system "Selcal" which relieves the pilot of the tedium of continuous listening. Marconi's are also fitting automatic direction finders in the Bristol Britannias to be brought into service by Hunting Clan Air Transport Ltd. next year.

Servo-mechanism.—To facilitate the translation of the servo designer's schematic into a working model, Vactric (Control Equipment), Ltd., have produced a slotted "breadboard" and a series of components for use with it.

Lustraphone transistor public-address equipment has been installed in a large number of patrol cars of the Lancashire Constabulary. The current consumption of the 12-volt amplifier is 200 mA quiescent and 1.5 A peak, and of the 28-volt model 100 mA and 750 mA, respectively.

Electronic Products (previously Electronic Production Company) recently took over additional premises at Lawrence House, Breakspear Road, Ruislip, Middlesex. Multiple coil-winding machines have now been installed, and random and layer winding of such items as relays and solenoids can be undertaken.

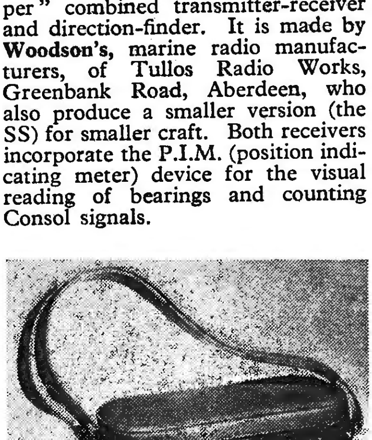
Ekco v.h.f. communication and d.f. gear and radar equipment is being installed at Fairwood Common Airport, Swansea.

Colour Coding.—Rejafix Ltd., of 81-83, Fulham High Street, London, S.W.6, manufacturers of industrial marking and printing machinery, have produced a machine which will in one operation put up to four different colour bands and one line of print on resistors, capacitors, fuses and similar components. It is available for hand or automatic operation. The separation between bands can be adjusted from $\frac{1}{32}$in to $\frac{3}{8}$in and the component can be up to $\frac{5}{8}$in diameter and 5in long.

Solartron are to manufacture under licence in this country the gunnery trainer made by the Rheem manufacturing organization of New York. The trainer is in many respects similar to the Solartron radar simulator.

Industrial television by Marconi is being used experimentally by the National Coal Board at the Manvers Coal Preparation Plant at Wath-on-Dearne, Yorks. It provides the control engineer with a view of the coal conveyor system at a strategic point in this plant where the output of four collieries is processed.

The latest addition to the Aberdeen fishing fleet, the motor trawler *Clovella*, is equipped with a "Clipper" combined transmitter-receiver and direction-finder. It is made by **Woodson's**, marine radio manufacturers, of Tullos Radio Works, Greenbank Road, Aberdeen, who also produce a smaller version (the SS) for smaller craft. Both receivers incorporate the P.I.M. (position indicating meter) device for the visual reading of bearings and counting Consol signals.



PRINTED CIRCUITRY is used in this four-valve Roberts' battery portable housed in a leather case. Access to the control panel and the batteries is gained by two zip-fastened covers. The current consumption is h.t. 10.4 mA, l.t. 125 mA.

High Definition Television, Ltd., are to supply twenty television receivers with 27-inch direct-viewing screens for installation in L.C.C. schools. Five similar models are also being installed in Edinburgh schools. Details of this receiver and a 21-inch model are given in a brochure "Television Receivers for Education" obtainable from 98, Highbury New Park, London, N.5.

Airtech, Ltd., of Haddenham, Bucks, have supplied a mobile v.h.f. direction finder for use on Christmas Island during the proposed Pacific nuclear tests. The vehicle is equipped with a Standard Telephones and Cables automatic cathode-ray direction finder. The station provides for remote selection of up to ten v.h.f. channels and the monitoring of two channels at a time.

Marconi Marine now provide a service at their port depots whereby specially adapted television receivers can be fitted in merchant ships for short periods whilst in port or permanently.

Kelvin & Hughes (Industrial) Ltd. have appointed J. R. Taylor as area engineer for the west of England. His address is "Garth," Edward Road, Walton St. Mary, Clevedon, Somerset. (Tel.: Clevedon 3535.)

Plastic Roller Shutter.—Extruded unplasticized p.v.c. slats half-an-inch wide, which interlock to form a roll-type shutter, suitable, for instance, for television and gramophone cabinets, have been produced by National Plastics (Sales) Ltd.

Vidor have made arrangements with Direct TV Replacements, of 134-136 Lewisham Way, London, S.E.14, for them to supply replacement line output transformers and deflection coils for their older television receivers.

New London headquarters for Thorn Electrical Industries, manufacturers of Ferguson receivers and Thorn lighting equipment, to be built in Upper St. Martin's Lane, W.C.2, will be 180ft tall.

Ambassador's London office has been transferred to Camp Bird House, Dover Street, London, W.1, with the acquisition of the Hartley-Baird group of companies by Camp Bird, Ltd. Also with the take-over of the group, E. M. Gamble has been appointed to the Board of Photo Printed Circuits, of Brookwood, Surrey.

Holiday & Hemmerdinger, Ltd., the wholesalers, have moved to 71, Ardwick Green North, Manchester, 12. (Tel.: Ardwick 6366.)

NEW COMPANIES

Semiconductors, Ltd., has been formed jointly by the Plessey Company, Ltd., of Ilford, Essex, and Philco Corp., of Pennsylvania, U.S.A., to manufacture in this country transistors and other semiconductors under Philco patents. Automatic equipment designed and manufactured by Philco will be used to begin the mass production of transistors early in 1958.

Radio Telephone Aerial Systems, Ltd., has been formed in association with J-Beam Aerials, of Northampton, and Sky-Masts, of London, to make aerial equipment for v.h.f. radio-telephone systems. It will have offices and workshops at Redan Street, London, W.14. (Tel.: Shepherds Bush 6426.)

Cossors have formed a wholly-owned subsidiary, Cossor Radio & Television, Ltd., to handle the domestic sound and television receiver side of their business.

OVERSEAS TRADE

Television transmitters for a further three stations in Denmark are being supplied by Marconi's, who have previously equipped three of the present four stations. The new stations, which will be at Aalborg, Vestjylland and Naestved, will each have 4-kW vision and 1-kW sound transmitters and a 16-stack aerial.

Sound Reproducing Equipment.—As a result of the North American tour undertaken by Harold J. Leak, chairman and managing director of H. J. Leak & Company, last autumn orders totalling over a quarter of a million dollars have been booked.

Cyprus.—The island's first television station, to be built near the sound broadcasting station of the Cyprus Broadcasting Service at Nicosia, will be equipped entirely by Marconi's. The equipment, valued at £38,000, will include 500-watt vision and 125-watt sound transmitters and studio equipment.

Marine Equipment.—The new Israeli luxury liner *Theodor Herzl*, built in Hamburg, has been fitted with Marconi Marine communication and public address equipment by Alhoutyam, Ltd., of Haifa.

Washington Show.—Automatic Telephone and Electric Co. was one of the few overseas exhibitors at the Armed Forces Communications and Electronics Association's annual exhibition in Washington (May 20th to 22nd).

Italy.—Equipment required for the next Olympic Games (Rome, 1960) includes sound reproducing gear, low-power transmitters and receivers. Particulars obtainable from Dott. Giovanni Poli, Comitato Olimpico Nazionale Italiano, Stadio Olimpico, Rome.

Paris Air Show.—Amongst the equipment being shown by British Communications Corporation, Ltd., at the 22nd Salon International de l'Aeronautique at Le Bourget (24th May-2nd June) is their multi-channel automatic recording system, which provides for the simultaneous recording of up to twenty channels on a single tape. They are also showing a variety of communications equipment.

Surveillance Radar.—Demonstrations of the mobile version of the high-power surveillance radar (CR21), recently introduced by Cossor Radar & Electronics, have been given during the past few weeks in Scandinavia. The equipment will also be seen at the Le Bourget International Air Show, after which the unit will tour Western Europe.

Airport Communications.—A contract for the supply of communications equipment for 39 airports has been awarded to Pye Telecommunications, Ltd., in a programme of modernization being undertaken by the Indian Department of Civil Aviation.

South African Agents.—Pye Telecommunications, Ltd., have appointed S.M.D. Telecommunications (Pty.), Ltd., P.O. Box 10013, Johannesburg, as sole distributors of Pye radio-communication equipment in the Union of South Africa, Bechuanaland, Swaziland and Basutoland, and Mozambique south of the Save River.

North American Market.—J. P. Coleman and J. W. Perkins, of Gresham Transformers, Ltd., are undertaking an eight-week tour of Canada and the United States to set up an organization to handle the North American business of the company and its associates, Lion Electronic Developments, Ltd., and Data Recording Instrument Co., Ltd.

Latin American Distributors, of 410 Cigali Building, New Orleans 12, Louisiana, are interested in receiving quotations and literature from United Kingdom manufacturers of 17-in and 21-in, 525-line, television receivers and also mains/battery sound receivers.

U.S.A.—The Standard Radio & Record Co., of 1028 E 65th Street, Seattle 15, wish to get in touch with United Kingdom manufacturers of amplifiers, loudspeakers, tone arms, turntables and pickup cartridges. They have hitherto handled U.K. equipment through New York agents, but now wish to import directly. Quotations should show both f.o.b. and c.i.f. prices in dollars.

Finland.—Elektriska Ab Hedengren, Fredriksgatan 65, Helsingfors, are interested in getting in touch with British manufacturers of tape recorders, including, if possible, a pocket battery-operated type.

RANDOM RADIATIONS

By "DIALLIST"

When, Oh When?

ALTHOUGH the Norwich television station has been using its permanent aerial since Christmas, East Anglians are still awaiting the inauguration of the permanent transmitters. So far only the temporary transmitters have been used which, even with the permanent directional aerial, give an e.r.p. of not more than 1.5 kW. I understand that, although the permanent transmitters are already installed, the G.P.O. has not yet given permission for them to be brought into use. The reason is that the station, with its permitted e.r.p. (depending on direction) of from 1 to 10 kW, would cause considerable interference in the service area of the Belgian station at Liège, which is temporarily working on low power. Near the east Suffolk coast the result of the continued use of the low-power transmitters means that people who bought receivers in anticipation of a reasonable signal in their area find that the field strength is around 100 μV/m instead of 500. And that, as you know, makes all the difference between a good picture and one that's "snowy" and always liable to get out of sync. It also means that with TV sets being run all-out every scrap of interference makes its unwelcome presence seen and heard. When Norwich will radiate on full power no man can say. But those who live in East Anglia and parts adjacent fervently hope that it won't be long.

Good Work!

FRANCE has given a lead which we would do well to follow in the matter of getting rid of interference from motor vehicle ignition systems. Within a year all users of such vehicles will be compelled to have them fitted with suppressors. Why we can't do the same thing I don't know: all that we've done so far is to make it an offence to sell a new car that has not been so treated. That's all very well, so far as it goes; but there are still large numbers of cars on the roads which were built before this regulation came into force. Not long ago I spent an hour or so checking the interference-producing proclivities of the cars and lorries which passed my window and found that quite a number of the newer ones were just as bad in this respect as the old-stagers. One wonders if some suppressors have been removed, which is, of course, an offence.

A Console Problem

MUCH AS I like television receivers of the console type, partly because those with full-length doors can be such attractive pieces of furniture but mainly because there's room enough in them for a good-sized loudspeaker, I've one quarrel with those who design them. If you want to view in comfort and to avoid eyestrain, as no doubt you do, the centre of the screen should be at just about the same height above the floor as is your eye when you're sitting in your favourite chair. Now, a typical centre-of-the-screen height for a console is about 28 inches. The height of your eye above the floor depends on what sort of chair you're using and how tall you are. But generally speaking it's likely to be between 35 and 40 inches. At any rate, it's a good bit more than 28 inches. This means either that you look down at the screen, or that you sit forward, bending your back and being liable to get a crick in the neck. Stands whose height is adjustable are, I believe, available for table models. Couldn't some ingenious designer of cabinets give us a console that would increase the comfort of viewing? I don't mean that the cabinet should be taller, for that would make it look ungainly. Wouldn't it, though, be possible to have the top compartment of the cabinet separate from the lower one and mounted on spring-loaded extending supports? Then when the doors were opened the screen could be raised to a pre-set height; at the end of the evening the upper part would be pressed down into place again and secured by closing the doors.

They Say . . .

SOME queer rumours get about, and it's surprising to find how quickly they spread, even amongst intelligent people. The other day a friend said to me: "I'm told that as soon as this v.h.f. scheme is completed all present wireless sets will be obsolete and useless." He would hardly believe me when I assured him that if he wanted to go on receiving with the long-wave and medium-wave set that he has, he'd be able to do so for many years to come. So convinced, in fact, was he that there was truth in the rumours that it wasn't until he'd written to the B.B.C. and had a reassuring answer from them that his mind was at rest. It's much the same with colour television; lots of people believe the absurd rumour that all existing receivers will have to be consigned to the dustbin if and when it comes along. Rumours such as these do a lot of harm. I've heard folk say: "It's no good buying a television set now, since colour will make it useless so soon." It's no use telling them that colour isn't just around the corner, or anything like it, and that existing sets will be as useful as they are now when it does come. They'd rather believe the know-alls (or know-nothing-at-alls).

OBITUARY

Canon H. R. Wilkinson

Dr. H. J. Denham, of Cossor's, writes:

BEST known to the public as the possessor of Cromwell's head, Canon H. R. Wilkinson, who died on April 13th, was, however, one of the first wireless enthusiasts. As far back as 1907 he was operating a full-size spark transmitter, working chiefly with a relation in the Navy who was engaged in developing Naval equipment. In those days he was Vicar of Stoke-by-Nayland in Suffolk, and his first aerial was slung from the tower of its noble perpendicular church on the hill top. His receiving equipment was on the grand scale, and his main inductance (200-3,000 metres) was, if the memory of a small boy can be trusted, about four feet long and a foot wide, rectangular in section. There were the remains of a magnetic detector of his own design, but he was using crystal detectors, molybdenum-zincite and zincite-copper pyrites, which burned out almost every time he transmitted in spite of a fantastically complicated key which short-circuited everything.

He was a brilliant mechanic, and his house was always full of ingenious contrivances which would have delighted "Free Grid." He served with the fleet as a naval chaplain, in the first world war, collecting several grants for ingenious gunnery inventions and an O.B.E. He never took up transmitting again, but retained his interest in radio till his death at the age of 85.

Among his many achievements was the wiring up of his Church for carbon microphones for the benefit of patients in a sanatorium five miles away, to which, with voluntary help, he ran a cable.

Last year he took up "hi-fi" with characteristic enthusiasm, because he could distort it to make up the deficiencies of his hearing-aid, and up to the age of eighty he made the rounds of his rural-deanery, on a motor cycle. A most remarkable man, and a well-loved priest.

UNBIASED

By FREE GRID

The Audio Unfair

THE TITLE I have given to this particular piece of unbiased comment might well have been applied to the Audio Fair, judging by the arbitrary, indiscriminate and random manner in which "invitations" were distributed. Even at the offices of *W.W.* admission tickets were, to use the jungle English of to-day, "in short supply," and many hundreds of readers who did not get one must be feeling aggrieved. It was certainly not the Editor's fault, however, as he did his best with the number he received, and even withheld one from me. As he rightly said, if I hadn't enough initiative to get in without one, I had no business to be writing for *W.W.*

I suppose everybody knows that, unless exhibitions are held in buildings provided with a sufficient number of exits and other precautions against fire, admission must be "by invitation only"; in other words, it is permitted to incinerate your friends but not your customers. For exhibitions in which a large number of more-or-less soundproof demonstration rooms are needed, an ordinary exhibition hall is out of the question, and only an hotel with its numerous bedrooms will suffice.

It has been suggested that the radio industry should build its own exhibition hall complete with demonstration rooms, and hire it out to other exhibition organizers when not wanted for radio or audio shows. But what other exhibition requires a hundred soundproof rooms? The answer is none. But surely, if every room had a built-in closed-circuit TV screen fed by a standard cinema projector, it could be used as a veritable cinema *de luxe*. The rooms would be booked up for weeks ahead by those self-respecting courting couples who are at present compelled to patronize the local cinema for their petting parties, to the annoyance and physical discomfort of those who have come along to see the films.

But I digress. I used my initiative as the Editor suggested, and got into the show with little difficulty.

I have left myself but little space to talk of the exhibits, and so, being a stereo fan, will content myself with referring to the realistic demonstration of the new stereo-on-disc records. The ease with which discs are changed put them a good step ahead of stereo-on-tape, but one or two firms are already pioneering with the idea of tape records in cassettes. In these the "record" consists of two spools housed in one container, like the cassette of a magazine-loaded ciné camera, which can be slipped into position as easily as a disc.

Influencing ERNIE

WHEN you read these words in the closing days of May I shall probably be sitting in an hotel in Lytham St. Annes, Lancs., working out final details for improving my financial position to the tune of, I hope, several thousand pounds in what I believe to be a perfectly legal and moral enterprise.

As you will know, the first draw in the Premium Savings Bond venture is to start at 9 a.m. on June 1. The gentlemen of the Press—which, believe it or not, includes me—are invited to be present while the £1,000 and £500 prizes, numbering about 250, are allocated by ERNIE, the electronic roulette wheel developed by Post Office engineers.

Technical details about ERNIE (Electronic Random Number Indicator Equipment) appeared in *W.W.* last September. Reading this description started me on my great venture which, to put it briefly, is to provide, from electronic apparatus concealed about my person, some not-so-random interference to try to influence ERNIE's numerical selections to my own pecuniary advantage. Obviously I can't reveal the details at this stage, but, briefly my equipment consists of a programmed pulse generator feeding into a miniature magnetron transmitter with a highly directional microwave dish built into my bowler hat. A flexible waveguide run up the back of my neck will be concealed by long hair specially grown for the purpose.

As for the moral issue as to whether I am justified in trying to influence ERNIE to show more favour to me than to others in the audience who may have bought bonds, I would point out that anybody is at perfect liberty to bring his own not-so-random interference generator and try to beat me at my own game.

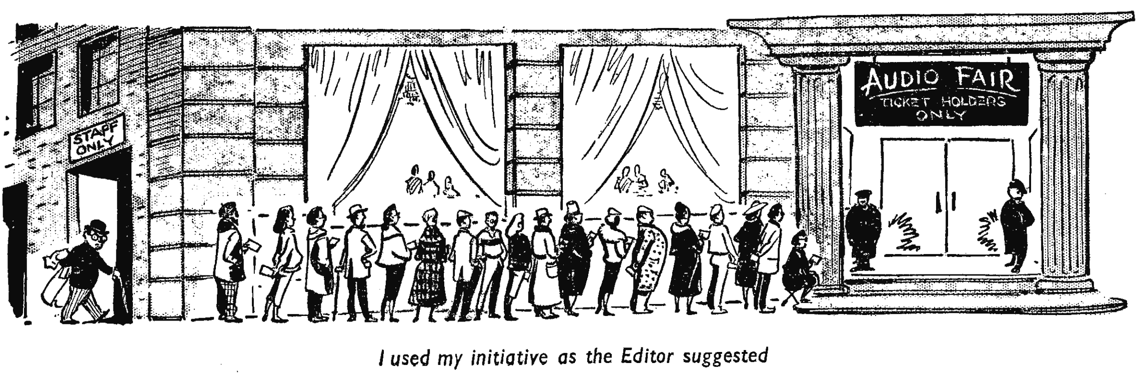
It then becomes a test of skill and not merely a game of chance. In fact, by turning a game of chance into one of skill I ought to earn approbation from high ecclesiastical authority rather than the censure which ERNIE'S progenitor has received.

Radio Pœdiatrics

IT MUST be over 30 years since details were first published in this journal of a baby-alarm consisting of a simple microphone hanging over the child's cot for conveying signals of distress to the radio set downstairs.

This old-fashioned device is still in use despite a suggestion made more recently that the child's cries could be fed to an electronic analyser which would, according to the result of the analysis, trigger off an automatic nappie changer or a lullaby-loaded juke box to restore peace to the night nursery.

The latest idea from the U.S.A. is to provide the child with a musical pillow. No details are given but I can only conclude that American babies are easily satisfied. Surely it would be improved if the pillow gave out the sound of the mother's recorded voice admonishing the child to silence. Why not arrange for the child's cries to release a pre-determined quantity of nitrous oxide such as the dentist gives us?



I used my initiative as the Editor suggested