SEPTEMBER 1957

Vol. 63 No. 9

Wireless World

# Copyright Anomaly

THE new Copyright Act 1956, which came into force on 1st June, goes far to remedy the deficiencies of earlier Acts and takes into account the interests of those who broadcast sound and television programmes as well as those who make recordings by "disc, tape, perforated roll or other device."

In most of its provisions the new Act is wise and benevolent, and there is clearly an intention to treat home recording less harshly than some of those who represent opposing interests may have wished. In principle, the permission of the holders of three distinct copyrights must now be obtained, as well as that of the performer of a work, before a recording can be made from a broadcast programme; but the Act makes it clear that no fair dealing with *the work itself* "for purposes of research or private study" shall be held to constitute an infringement;[1] that it shall be a defence in any proceedings brought by *the performer* of a work that recording was made "for private and domestic use only";[2] that the making of a recording of *a broadcast* otherwise than "for private purposes" is restricted by copyright.[3]

Although, in view of the precision of wording in other parts of the Act, one may deplore the variations used in expressing the concept of private use it is, nevertheless, gratifying to find these saving clauses in the sections dealing with the performer's rights and two of the copyrights which may be involved when a private individual makes a recording of a broadcast programme for his own use. It comes as something of a shock to find, therefore, that no such exception is made in the provisions granting copyright to *the maker of a sound recording*.[4] If a private recording is made from a "live" broadcast and the individual observes scrupulously the implied restrictions of private use, he is in the clear: if it is made from a "pre-recorded" broadcast he is not!

This seems to us to be a gross anomaly, and one which should be clarified at the earliest opportunity. If the omission of the "private use" clause is intended to protect the gramophone record-making companies from dilution of their sales by the making of illicit tape copies which are played back for recreation and enjoyment rather than for serious study or research, we have every sympathy with the intention of this Section of the new Act. But, this end would have been better achieved by the inclusion in the Act of some further specific provision rather than by the omission of a concession which is implicitly granted by all other parties holding copyright. It seems grossly unfair that the powers given to the maker of a record should be greater than those protecting either the creator of a work, the performer or, for that matter, the broadcaster.

An amendment which draws a clearer distinction between the rights in commercially published records and others, such as those made as an intermediate stage in the process of broadcasting, seems already overdue.

[1] Copyright Act 1956 [Section 6 (1)].
[2] Dramatic and Musical Performers' Protection Act 1925 [Sect. 1] as amended by the Copyright Act 1956 [Sixth Schedule, Part III].
[3] Copyright Act 1956 [Sect. 14 (4b)].
[4] Copyright Act 1956 [Sect. 12].

# European Radio Industry

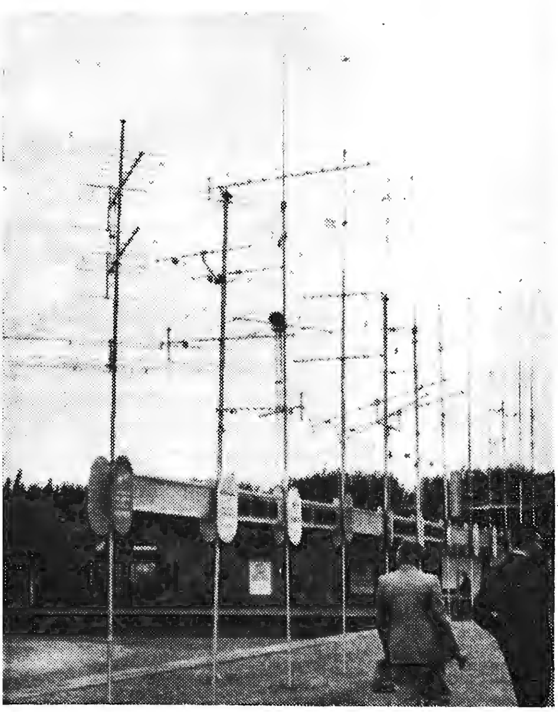
A RECENT visit to the German radio exhibition has convinced us that if the present rate of progress is maintained we should be well able to hold our own in a European Common Market as far as technical originality, "know-how" and quality of workmanship are concerned. Although the products of the British and Continental radio industries show many superficial divergencies, these arise from the choice of emphasis and timing in development rather than from any fundamental differences in technical capacity.

Ultimately, commercial success will depend on the anticipation of public demand and the creation of new markets by bold and imaginative changes of style and method. What Frank Murphy once did in England, and Braun is now doing in Germany, can be done again, provided always that there is a sound technical background.

# DIE GROSSE DEUTSCHE RUNDFUNK- FERNSEH-

THE title of this year's German radio exhibition is commensurate with its size. It was held in Frankfurt's permanent exhibition grounds which cover 87 acres and are centred round a Festival Hall seating about 8,000. This hall was used exclusively as a television studio for the special transmissions arranged for the week of the fair. About 200 exhibitors were housed in seven other halls, two of which were comparable in floor area with the large and small halls at Olympia. Four of the smaller halls were each taken by leading firms in the industry and another large hall was given over to the smaller stand holders. The wide gangways inside the halls and the open spaces in the grounds easily absorbed even the large week-end crowds of visitors.

*Collective exhibit by the German aerial manufacturers.*



Receiving aerials in Germany are generally of the multiple type with Band II and Band III, and in some cases even amateur band arrays on a single mast surmounted by a vertical whip for medium and long waves. There is as much difference of opinion as in Britain as to the forms which give the most efficient pick-up and this was emphasized by a collective display in the exhibition grounds of the designs of rival firms under the slogan "*Erst die gute Antenne bringt ein Gerät zur vollen Leistung*" ("Before all things a good aerial brings a receiver to full performance"). For the measurement of aerial performance a special calibrated test receiver (SAM316W) with a range of 3$\mu$V to 2V and 100Mc/s to 140kc/s is produced by Siemens and Halske. There can be no doubt that the Germans take the matter of aerial design very seriously.

Picture quality in the television receivers working on the stands showed similar variations to those seen at Earls Court, but the average performance, despite the supposed advantage of 625 lines, was not obviously superior. Most sets were placed in semi-darkness, but Siemens have introduced a selective light filter and showed their products under higher ambient lighting conditions.

The standard screen sizes are 43cm (17in) and 53cm (21in) with the latter in the ascendant. One or two firms are promising early autumn delivery of 61cm (24in) models. Printed circuitry is widely used, though in many cases it makes only a token contribution to the total assembly. Automatic gain control for both sound and vision is also well established, as is remote cable control of brightness, contrast and sound volume. In some Graetz receivers push buttons on the front of the set marked "Plastisch" (soft and rounded) and "Scharf" (sharp) give respectively a reduction or emphasis of the middle frequencies of the video spectrum, sometimes to correct faults in the transmission, but primarily to meet viewers' divergent tastes in picture quality. It is admitted that the effect is partly psychological and that widest acceptance is accorded to the choice of 2.7Mc/s as the mid-frequency for cut or lift. This is obtained by modifying feedback either by a parallel resonant circuit in series with the contrast control resistance or a series resonant circuit in parallel with it.

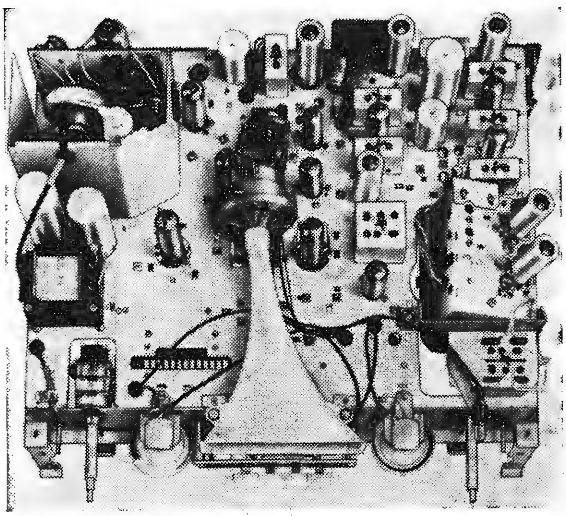
# UND PHONO-AUSSTELLUNG

**FRANKFURT-AM-MAIN**
**2nd-11th AUGUST, 1957**

Given a prominent place in the Grundig hall and claimed to be the sensation of the show was a portable television set, *"Der erster deutscher tragbarer Fernsehempfänger."* Of possibly greater interest to a British visitor was the demonstration by Schaub-Lorenz of reception of a live experimental Band IV transmission. Receivers marketed by this firm already have provision for the projected alternative German television programmes on Band IV.

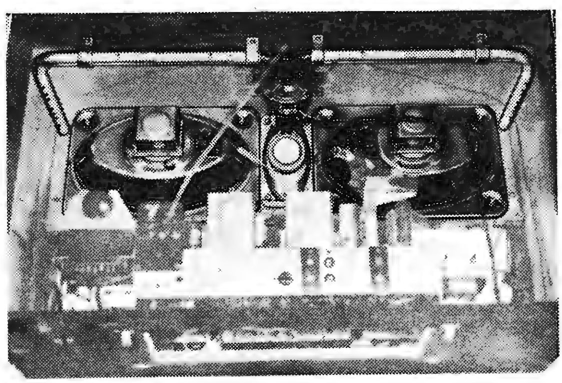
Although the basic design of German sound broadcast receivers has not changed materially there is still a lively interest in their performance—particularly in the effects of the array of piano key controls giving pre-set responses to suit different types of programme. It seems that the Germans—particularly the younger generation—are inveterate knob-twiddlers, and to satisfy this urge every set maker had arranged all his models in working order side by side on long tables or wall shelves, where they were continually besieged by visitors anxious to try their skill. The resulting pandemonium is no easier to describe than it was to endure.

Semi-silent alcoves or separate listening rooms were, however, provided for more mature assessment of the finer examples of *Musiktruhen* (literally "music-chests" i.e., high-quality radio-gramophones) which have not yet been displaced by any equivalent of Anglo-American "hi-fi." The German taste is for rich and pleasant musical sound, not necessarily an exact replica of the original, and has given rise to the cult of *raum klang* or three-dimensional sound. An interesting variant of the usual method of arranging several large and small direct radiator moving-coil loudspeakers to give omni-directional distribution through the front, sides and back of the cabinet is provided this year by Graetz with their *Schallkompressor* (sound compressor) system. (Incidentally, several firms this year are using horn-loaded pressure units for high frequencies and Graetz themselves use a flattened polythene horn for conducting high frequencies to the front of some of their television receivers.) For middle frequencies a horn takes up too much space, but the new Graetz pressure loading system is claimed to approximate the performance of an exponential horn and consists of two tubes of constant cross-section branching symmetrically from the driving unit. Pressure relief and radiation is graded along the tube,



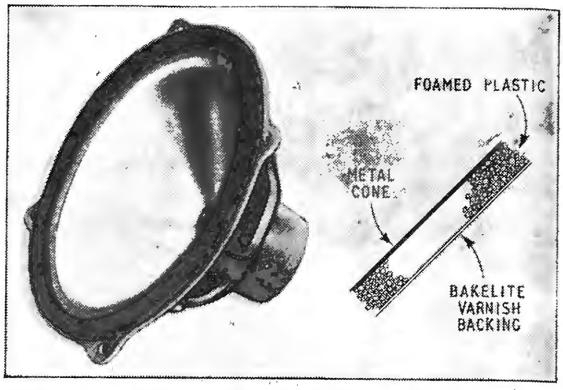
*Television receiver chassis (Graetz F37) showing horn-loaded h.f. loudspeaker.*

*Graetz "Schallkompressor" tubular loudspeaker giving the equivalent of horn loading with the addition of a time delay in the range 500-7,000c/s.*



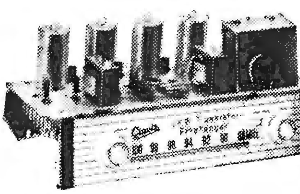
first by pairs of small circular holes and finally by slots at distances from the origin calculated to give a smooth response over a range of 500 to 7,000c/s. The rest of the acoustic spectrum is filled out by moving-coil loudspeakers of conventional design. A time delay associated with the passage of sound through the tube system gives a unique and very pleasing disembodiment of the apparent sound source.

Another loudspeaker which created a favourable impression by its performance was the "Zellaton" made by Dr. E. Podszus und Sohn of Nürnberg-Fürth. This is a moving-coil direct radiator with a "sandwich" diaphragm consisting of foamed plastic coated on the front by thin, soft metal and on the back by a resin varnish. The high internal damping should rapidly dissipate energy stored in flexural vibration and this conjecture was supported by the oscillograms of pulsed tones which showed very little "hang-over."

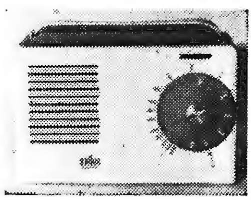



*Zellaton moving-coil loudspeaker with composite diaphragm.*

Apart from one or two "tweeters" there was no sign of any revival of interest in electrostatic loudspeakers, but this may be because the results obtained from combinations of moving-coil types are manifestly so good. In the Braun Lautsprecherbox L1, for example, a vented loudspeaker enclosure for a low-frequency unit is topped by a row of four medium- and high - frequency moving-coil units, and gave a performance which was in every way comparable with the best Anglo-American standards of "high fidelity." It is associated with a neat combined playing desk and radio receiver. The use of separate receiver - amplifiers and loudspeakers has much to commend it, both from the point of view of acoustics and flexibility in installation and this practice is followed also in the Braun "Atelier 1" in which the separate units are of matched design so that they can be stacked, or used apart. The external appearance of all the Braun receivers is attractively simple and functional and makes a refreshing change from the so-called "Continental" styles. The Braun portables are presented in the guise of measuring instruments or communication receivers, which give an impression of efficiency as well as of neatness.



*Prototype all-transistor v.h.f. receiver (Graetz).*



*Braun "Transistor I" mains/battery portable for long, medium and short waves, and (right) Braun "Exporter" battery portable for medium and long waves.*

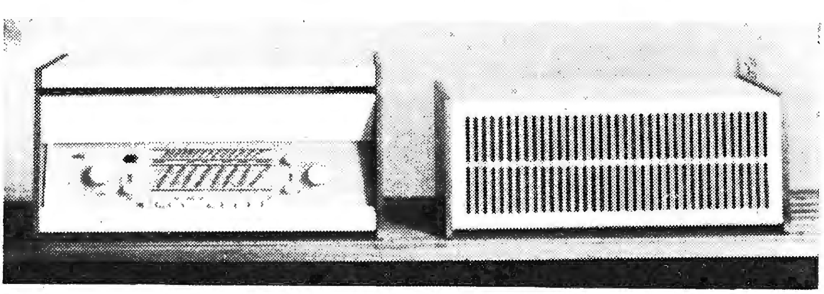
One or two all-transistor sets were shown, but the majority of German battery portables still use valves in the early stages and transistors only in the output stage. There is considerable interest in transistor developments and most firms are familiarizing themselves with the latest techniques so that they can go into production when specialized transistor prices fall to an economic level. Graetz, for example, were showing a working prototype of an all-transistor UKW (v.h.f.) receiver. A mixer-oscillator (100Mc/s downwards) is followed by two neutralized i.f. stages at 6.75Mc/s and a third i.f. limiter-amplifier (all 2N247s). The discriminator (0A5 diodes) is followed by an a.f. amplifier and a driver (0C71s) and a push-pull output stage (0C72s).

We joined the queue of "knob-twiddlers" for a chance to handle this set and found the sensitivity high and the signal/noise ratio by no means intolerable.

All the tape recorders on show conformed to the "streamlined" and somewhat colourful pattern already established, and the only development of note seemed to be the production by Telefunken (Magnetophon) of a portable recorder (KL65KS) with a built-in vibratory converter for use on 6- or 12-V battery supplies as well as 110-240V a.c. mains.

A well conducted and much appreciated feature of the television programmes transmitted during the show was a daily technical report (2.0 to 2.30 p.m.) of interesting features of the new receivers and components. Representatives of the firms concerned brought samples to the studio and discussed the finer points of design with an interviewer.

The total attendance at the exhibition was 493,000.



*The loudspeaker in the Braun "Atelier I" can be installed separately, or used as a base for the radio-gramophone unit.*

# WORLD OF WIRELESS

## *Scientific Radio Meeting*

A TWENTY-TWO man delegation is representing the U.K. at the twelfth general assembly of the International Scientific Radio Union, generally known as U.R.S.I. from its French title.

Delegates from twenty-five countries are attending the meeting being held at the laboratories of the National Bureau of Standards at Boulder, Colorado, U.S.A., from August 22nd to September 5th. They will discuss the reports of the Union's permanent commissions, which conduct continuous studies, and will plan future international programmes. There are seven permanent commissions covering, (1) standards and measurements, (2) troposphere, (3) ionosphere, (4) terrestrial noise, (5) radio astronomy, (6) radio waves and circuits, and (7) radio-electronics.

Among the members of the British delegation, which is led by J. A. Ratcliffe, of the Cavendish Laboratory, Cambridge, who is also president of commission 4, are Sir Edward Appleton, Dr. R. L. Smith-Rose (president of commission 2), Professor H. E. M. Barlow, Professor A. C. B. Lovell, Professor J. Sayers, Dr. W. J. G. Beynon, Dr. L. Essen, Dr. J. A. Saxton, R. Hanbury Brown, C. W. Oatley, and W. Proctor Wilson.

## *Audio Show*

THIS YEAR'S show of sound recording and reproducing equipment, the ninth organized by the British Sound Recording Association, opens at the Waldorf Hotel, Aldwych, London, W.C.2, on September 20th for three days. At this show, which, incidentally, marks the twenty-first anniversary of the Association, 36 exhibitors (listed below) are participating.

The show opens at 12.0 on the first day and at 10.0 on the other two days, and closes at 9.0, 6.30, and 6.0 respectively. Admission is by ticket obtainable from exhibitors, dealers or S. W. Stevens-Stratten, 3 Coombe Gardens, New Malden, Surrey.

Acoustical
Armstrong
B-K Partners
Beam-Echo
British Ferrograph
Dulci
E.M.I.
Expert Gramophones
Garrard
Goldring
Goodsell
Grampian
Grundig
Jason
Kelly
Leak
Lockwood
Long-Playing Record Library
Lowther
Lustraphone
Minnesota Mining & Mfg.
M.S.S. Recording
Musicraft
Pilot
Reslosound
Rogers Development
Rudman Darlington
Simon
Sugden
Tannoy
Thermionic Products
Truvox
Vitavox
Westrex
Wharfedale
*Wireless World*

## *Radio Exports*

PROVISIONAL figures for exports of radio equipment during the first six months of the year show an increase of 10% on the same period last year—£21.2M compared with £19.2M. It will be seen from the table that the largest percentage increase was in the export of sound reproducing equipment—33⅓%. This year's figure for capital goods excludes industrial r.f. equipment previously included. Likewise, test gear is excluded from this year's figure for components.

It is noteworthy that during the Jan.—June period the import of radio equipment fell from £5.2M in 1956 to £4.8M this year.

| | Jan.-June | |
|---|---|---|
| | 1957 | 1956 |
| Capital goods (transmitters, navigation aids, etc.) ... | 7.868 | 7.853 |
| Sound reproducing equipment ... | 4.803 | 3.645 |
| Components ... | 4.799 | 4.203 |
| Valves and c.r. tubes ... | 1.991 | 1.554 |
| Sound and television sets ... | 1.728 | 1.943 |
| | £21.189M | £19.198M |

## *Frequency Planning*

ON several occasions *Wireless World* has urged a more direct representation of the industry and users in matters of frequency allocation in this country. A step in the right direction was made last year when the R.C.E.E.A. formed the Frequency Planning Advisory Committee for liaison with the Post Office.

There now seem good grounds for believing that there will be a less autocratic system, for the Postmaster-General has decided to set up a new committee to advise him on the broad aspects of frequency allocation. Although its composition and terms of reference have not yet been settled it is understood that not only Government departments but the industry and users will be represented on the committee.

## *Two "Wireless World" Books*

A NEW book and another edition of a hardy annual make their appearance in time for the Radio Show. The first, "Transistor A.F. Amplifiers," by D. D. Jones and R. A. Hilbourne, deals systematically with the subject, giving circuitry and designs. It includes a simple but brief account of how the transistor works before going on to the principles of design and practical applications, which are illustrated by circuits of five amplifiers with outputs ranging from 1 to 20 watts. The book is based on work carried out at G.E.C. Research Laboratories. Price 21s (postage 8d).

The hardy annual is "Guide to Broadcasting Stations," which has been completely revised. This 1957-58 edition contains operating characteristics of the short-wave broadcasting stations of the world and of the long- and medium-wave stations in Europe, all stations being listed both geographically and in order of frequency. Other sections cover standard time, standard frequency transmitters, and television and v.h.f. sound transmitters in the U.K. The price is 2s 6d (by post 2s 9d).

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**Television licences** in the U.K. increased during the first six months of the year by 599,412, bringing the total at the end of June to 7,169,509. During the same period sound-only licences decreased by 445,087 to 7,418,943. The £1 excise duty on television licences announced in the April Budget was introduced on August 1st. Incidentally, this duty is not applicable to the Channel Islands.

**April Showers!**—Three shows in twelve days, two running consecutively and the third overlapping the other two, have been announced for next April. The dates of the I.E.A. exhibition at Olympia (16th-25th) and the Audio Fair at the Waldorf Hotel, London, W.C.2 (18th-22nd), have been known for some time. Now the R.E.C.M.F. announces its annual components show for the 14th-17th. It will again be held in two hotels—Grosvenor House and Park Lane House, London, W.1.

**Copyright Disputes.**—The offices of the Performing Right Tribunal are now at Someries House, Regents Park, London, N.W.1. (Tel.: Welbeck 1358-9.) The Tribunal, which was set up under the Copyright Act, has to determine disputes arising between licensing bodies and persons requiring licences to perform in public or to broadcast copyright works. It also has jurisdiction in the case of the public performance and broadcasting of records and the public performance of television broadcasts.

"**Research For Industry**" is the title of a survey of research being undertaken in technical colleges in London and the Home Counties for, or in collaboration with, industry, Government departments and research associations. It is issued by the Regional Advisory Council for Higher Technological Education and lists under each of some twenty-five colleges the nature of the research and for whom it is being undertaken. The twenty-page booklet is obtainable from the Council at Tavistock Square, London, W.C.1, price 1s 6d.

**Scholarships** open to British students for training in electrical and allied engineering are outlined in "Scholarships and Other Awards" issued by the British Electrical and Allied Manufacturers' Association. The scholarships and awards are grouped under the headings "Open to non-graduates," "post-graduates," and "study abroad for both graduates and non-graduates." The 48-pp booklet, which has been circulated to technical schools and colleges, is obtainable from B.E.A.M.A., 36 Kingsway, London, W.C.2.

**Queen's University,** Belfast, is again running a full-time day course for the post-graduate certificate in radio engineering. It begins on October 8th and is open to men and women graduates in either electrical engineering or physics. The subjects are radio theory, radio technics, circuit theory, servomechanisms, mathematics and physics.

**Higher Technological Education.**—Part-time day and evening courses, including radio and telecommunications, being conducted in London and the Home Counties, are listed in "Engineering Education in the Region," issued by the Regional Advisory Council for Higher Technological Education. It costs 2s 6d. The Council has again issued a bulletin of special courses in higher technology, being held in the region during the autumn term. The index ranges from acoustics to X-ray defraction embracing computers, electronics, microwaves, pulse techniques, radio telemetry, etc. It costs 3s. Copies are obtainable from the Regional Advisory Council, Tavistock Square, London, W.C.1.

**Amateur courses** in preparation for the Radio Amateurs' Examination are again being held at the Wembley Evening Institute, Copland School, High Road, Wembley (Mon. and Thurs.), and at the Isledon School, Upper Hornsey Road, London, N.7 (Mon.). Morse classes are to be held in connection with both courses.

**Information Wanted.**—Circuit details or instruction manual of the Bendix RA-10/DA receiver are required by a reader. Information should be addressed to S. M. Ashe, c/o the Editor.

**Correction.**—In the advertisement of G. & E. Bradley, Ltd., on p. 45 of the August issue one minus sign did not appear in the section dealing with r.f. output. This should read: "R.F. Output −7 to −83dBm., 8.5 to 9.6 KMc/s C.W. . . ."

**TV on Tape.**—The Ampex video tape-recording system will be described by Ross H. Snyder, of the Ampex Corp., at the Television Society's meeting on September 13th. The meeting will be held at 7 p.m. at 164, Shaftesbury Avenue, London, W.C.2. Visitors can obtain tickets from members or from the Society at the above address.

**Research Grant.**—The Paul Instrument Fund Committee has awarded £2,600 to Dr. C. N. Smyth and F. Y. Poynton, working at the Northampton Polytechnic, London, for the continuation of work on the construction of an ultrasonic microscope for which a grant was made in 1954. The committee, composed of representatives of the Royal Society, Physical Society, Institute of Physics and I.E.E. was set up in 1945 "to receive applications . . . for grants for the design, construction and maintenance of novel, unusual or much improved types of physical instruments and apparatus for investigations in pure or applied physical science."

**A two-day exhibition,** during which demonstrations of studio recording and reproducing equipment will be given, is being organized by the International Broadcasting Company. It will be held at their offices at 35, Portland Place, London, W.1, from 1.30 to 9.30 on September 28th and 29th. Complimentary tickets are obtainable from the I.B.C. or from Thermionic Products, Hythe, Southampton, or Lockwood & Co., Lowlands Road, Harrow, Middlesex.

**Government Computers.**—The Chancellor of the Exchequer recently announced that ten electronic computers are in use in Government departments on mathematical or scientific work. He added that a further five are being installed during the current financial year.

**Radio-Controlled Models.**—The number of transmitting licences issued by the Post Office for the radio control of models now totals 2,000. These licences cost £1 and remain in force for five years.

**Scottish I.T.A. station** at Black Hill, Lanarkshire, will be brought into service on August 31st. Tests on full power, giving an e.r.p. varying from 65 to 475 kW, were delayed owing to inclement weather which prevented final adjustments being made to the directional aerial 1,600ft above sea level. The transmitters and aerial, for operation in channel 10, were installed by Marconi's.

**I.T.A. in Wales.**—Preparatory to the anticipated opening of the I.T.A. station at St. Hilary, Glam., before Christmas, the programme contractors (T.W.W.—Television Wales and the West) are holding a week's exhibition in Cardiff. It will be held in the Sofia Gardens Pavilion from October 30th to November 7th, and will focus attention on set conversion for Band III reception. St. Hilary, which will operate in channel 10, is being equipped by Pye.

**Programme contractors** have been appointed by the I.T.A. for its station on Chillerton Down, Isle of Wight, which it is planned to bring into service by the summer of next year. The programme organization has been set up jointly by the Rank Organization, Associated Newspapers and Amalgamated Press.

**Forward Scatter.**—Contracts have been placed by the Supreme Headquarters Allied Powers Europe with two American companies for the supply of equipment for a communications system (combining both forward scatter and "conventional" radio relay links) between the allied countries in Europe. The headquarters will be in Paris.

**Norwegian TV.**—It is reported in the *E.B.U. Bulletin* that the Norwegian National Assembly has approved the plan drawn up by the broadcasting organization, Norsk Rikskringkasting, for the introduction of television in the country. Work on the construction of stations, linked to a studio centre in Oslo, is to begin immediately and it is planned to introduce a regular service in 1960.

**Standard-frequency transmissions** from Rugby on 60 kc/s (MSF) and 16 kc/s (GBR) are being discontinued from July 20th for several months while repairs to the long-wave aerial system are in progress. Some of those who normally use these transmissions may be able to employ the B.B.C. Droitwich transmission on 200 kc/s. Results of measurements made daily by the National Physical Laboratory on the MSF and Droitwich transmissions are given each month in our sister journal *Electronic & Radio Engineer,* and to assist users of Droitwich in obtaining the highest accuracy, the deviations of the transmission will now be given to 1 part in $10^9$ instead of 1 in $10^8$.

**T.I.D.U.**—The Technical Information and Documents Unit of the D.S.I.R. has now been merged in the Lending Library Unit of the Department and operates from 20 Chester Terrace, Regent's Park, London, N.W.1.

**F.M. broadcasting stations** in the United States, which in 1949 totalled about 750 and by the middle of last year had dropped to 546, are now showing a slight increase. According to figures published in the business edition of *Electronics* the total at the end of May was 555. In each of two cities, Los Angeles and New York, there are now more applicants for f.m. channels than there are channels available. In Los Angeles 17 of the 20 available channels are occupied and in New York 16 out of 18.

**S.I.M.A. Officers.**—At the A.G.M. of the Scientific Instrument Manufacturers' Association, P. Goudime (Electronic Instruments) was elected president. The secretary is L. A. Woodhead (Cossor Instruments), and the treasurer P. J. Ellis (R. B. Pullin & Co.). The representative of the electronics section on the council is A. W. Jones (Fleming Radio), and of the surveying and navigational section R. Broadbent (Sperry).

# PERSONALITIES

**O. W. Humphreys,** C.B.E., B.Sc., M.I.E.E., director of the G.E.C. Research Laboratories, Wembley, has been re-elected president of the Institute of Physics for a second term of office. He has been chairman of the International Special Committee on Radio Interference (C.I.S.P.R.) since 1953 and is chairman of the committee recently set up by the Postmaster General to advise him on the making of regulations covering radio interference from industrial, scientific and medical equipment.

**Paul Goudime,** M.A., managing director of Electronic Instruments, Ltd., of Richmond, has been elected president of the Scientific Instrument Manufacturers' Association. On leaving Cambridge University, where he took an honours degree in natural sciences, he worked on the design of aircraft navigational computers. He subsequently joined Simmonds Aerocessories where throughout the war he was head of the research department. In 1945 he formed Electronic Instruments, Ltd., and five years later the Minerva Detector Company, of which he is also a director.

**Donald G. Fink** has been nominated president of the American Institute of Radio Engineers. For nearly 20 years he was on the editorial staff of our New York contemporary *Electronics*, of which he was eventually editor. He resigned the editorship in 1952 to join the Philco Corporation as co-director of research operations.

**Rupert P. Browne,** O.B.E., B.Sc., Comp.Brit.I.R.E., has retired from the position of secretary of the Radio Industry Council owing to ill-health. In 1945 he became secretary of the R.I.C. on its formation in succession to the Radio Manufacturers' Association, of which he had been secretary for ten years. Mr. Browne, who is 60, had been associated with radio industrial organizations since 1924 when he joined the National Association of Radio Manufacturers.

**George B. Campbell** succeeds R. P. Browne as secretary of the R.I.C. He became assistant secretary of the Radio Manufacturers' Association in 1940 and has been acting secretary of the R.I.C. for some months.

G. B. CAMPBELL

**G. G. Roberts,** M.Sc., who joined Smiths Aircraft Instruments three years ago as head of the company's guided weapons department and became director of research at Cheltenham last October, has now been appointed technical director. On leaving the University of Wales he undertook some lecturing in London and then joined the Telecommunications Research Establishment where he was eventually in charge of the group responsible for airborne interception radar. In 1947 he joined the staff of the Guided Weapons Department of the Royal Aircraft Establishment, Farnborough, where he stayed until going to Smiths.

**W. I. Flack,** Assoc.I.E.E., has left T.C.C., where he has been for the past 14 years, and has joined the production engineering department of Radio and Allied Industries, Ltd., at Wexham Road, Slough. For the past two years he has been concentrating on the development of printed circuits. It may be recalled that he was the designer of the View Master television receiver and the Soundmaster tape-recorder.

**P. W. Faulkner,** O.B.E., who has been with the Plessey Co. since 1952 and a year later became general manager of the chemical and metallurgical division at Towcester, Northants., has been appointed an executive director of the company. He will continue to be in charge of the division. Mr. Faulkner is also a director of Technical Ceramics, Ltd., well known in the piezoelectrics field.

**Lawrence Dilger,** B.Sc., has joined the electronics division of Microcell, Ltd., at Camberley, Surrey, as senior designer responsible for the development of electronic computers.

**Derek Barlow** recently left Mullard, where he was in charge of research in the industrial control field, to become European editor of *Control Engineering,* published in New York by McGraw-Hill. Before joining Mullard he was for some time chief development engineer with Wayne Kerr Laboratories where he was concerned mainly with the development of radar and navigational trainers.

**M. Clough** has been appointed engineer-in-charge of the new B.B.C. television station at Rosemarkie, Inverness-shire. He joined the corporation in 1943 and after service at several sound transmitting stations has been on the staff of the Meldrum television station.

## OBITUARY

**Arthur Gay,** works manager of H. J. Leak & Co., died suddenly on June 28th at the age of 49. He had been associated with H. J. Leak, the founder of the company, for very many years and had been works manager since 1946.

# National Radio Show

## PREVIEW OF TECHNICAL EXHIBITS

THE 24th National Radio Show opens to the public on August 28th, after a preview day for overseas visitors and invited guests. It is essentially an exhibition of domestic sound and television equipment and about 75% of the 122 exhibitors manufacture receivers, components or ancillary equipment.

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Stress is again being laid by the organizers, the Radio Industry Council, on the opportunities for careers in the radio and electronics industry. On the first floor (Stand 308) will be found the "Careers in Electronics" display, covering the training and employment of engineers, technicians and servicemen.

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|---|---|
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| Aerialite | 7 |
| Airmec | 228 |
| Alba | 47 |
| Ambassador-Baird | [illegible]1 (D18)* |
| Antiference | 24 |
| Argosy | 2 |
| Avo | 62 |
| **B.B.C.** | 301, 302 |
| Barclays Bank | 101 |
| Belling-Lee | 55 |
| Bernards | 119 |
| Bowmaker | 211 |
| Brimar | 6 |
| *British Radio & Te evision Retailing* | 122 |
| British Railways | 202 |
| Bulgin | 59 |
| Burwell | 205 |
| Bush | 5, 37 |
| **Collaro** | 26 |
| Cossor | 29 (D38) |
| **Dallas** | 216 |
| Decca | 23 (D36) |
| Defiant | 4 |
| Design Furniture | 210 |
| Domain | 219 |
| Dubilier | 57 |
| Dynatron | 33 (D16) |
| **E.A.P.** | 9 |
| E.A.R. | 41 |
| E.M.I. Institutes | 307 |
| E.M.I. Records | 18 (D12) |
| E.M.I. Sales & Service | 108 (D11) |
| Econasign | 225 |
| Ekco | 44 (D19, D22) |
| *Electrical & Radio Trading* | 121 |
| Ever Ready | 31 |
| Expanded Metal | 124 |
| **Ferguson** | 14 (D5) |
| Ferranti | 36 (D25) |
| Field ("Record Housing") | 207 |
| Fund for the Blind | 311 |
| **G.E.C.** | 10 (D37) |
| G.P.O. | 306 |
| Garrard | 22 |
| Goodmans | 116 |
| **H.M.V.** | 12 (D8) |
| Hartique | 110 |
| Hobday | 123 (D7) |
| Hunt | 48 |
| **I.T.A.** | 303 |
| Invicta | 23 |
| **J.B. Cabinets** | 209 |
| J-Beam Aerials | 17 |
| Jokki | 208 |
| **K.B.** | 15 |
| Keith Prowse | 66 |
| Kerry's | 212 |
| **Labgear** | 217 |
| Linguaphone | 105 |
| Lintronic | 223 |
| Lloyds Bank | 218 |
| **McMichael** | 45 (D4) |
| Marconiphone | 50 |
| Masteradio | 35 |
| Meadow-Dale | 224 |
| Mercantile Credit | 204 |
| Midland Bank | 201 |
| Mullard | 39 (D32, D34) |
| Multicore | 61 (D17, D20) |
| Murphy | 53 (D35) |
| **N.I.D.** | 312 |
| National Provincial Bank | 112 |
| **Pam** | 42 (D24) |
| Perdio | 63 |
| Period High Fidelity | 106 (D13) |
| Peto Scott | 30 |
| Philco | 43, 305 (D31) |
| Philips | 20, 21 (D2, D3) |
| Pilot | 54 (D29) |
| Plessey | 125 (D9) |
| Plus-a-Gram | 109 |
| Portogram | 1 |
| *Practical Wireless* | 117 |
| Price | 120 |
| Pye | 13 (D6) |
| **R.A.F.** | 304 |
| R.C.A. | 114 |
| R.G.D. | 27 (D30) |
| R.M. Electric | 115 |
| R.S.G.B. | 309 |
| R.T.R.A. | 3 |
| Regentone | 8 |
| Roberts | 25 |
| Rola Celestion | 16 |
| **S.T.C.** | 60 |
| Siemens Edison Swan | 46 (D1) |
| Slingsby | 215 |
| Sobell | 19 |
| Sobell International | 56 |
| Spencer-West | 206 |
| Stella | 34 |
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| Wolsey | 40 |

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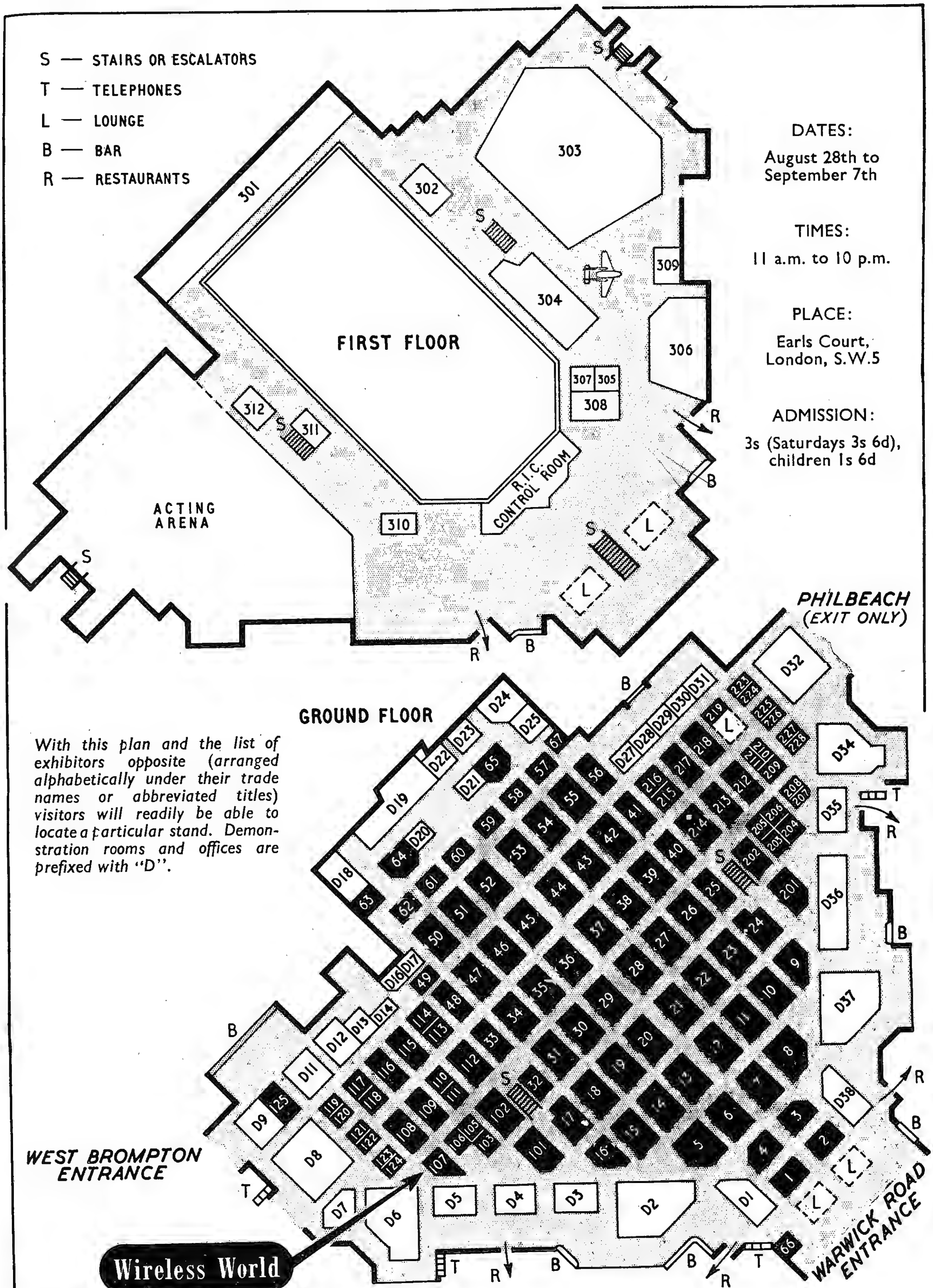


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ADMISSION:
3s (Saturdays 3s 6d), children 1s 6d

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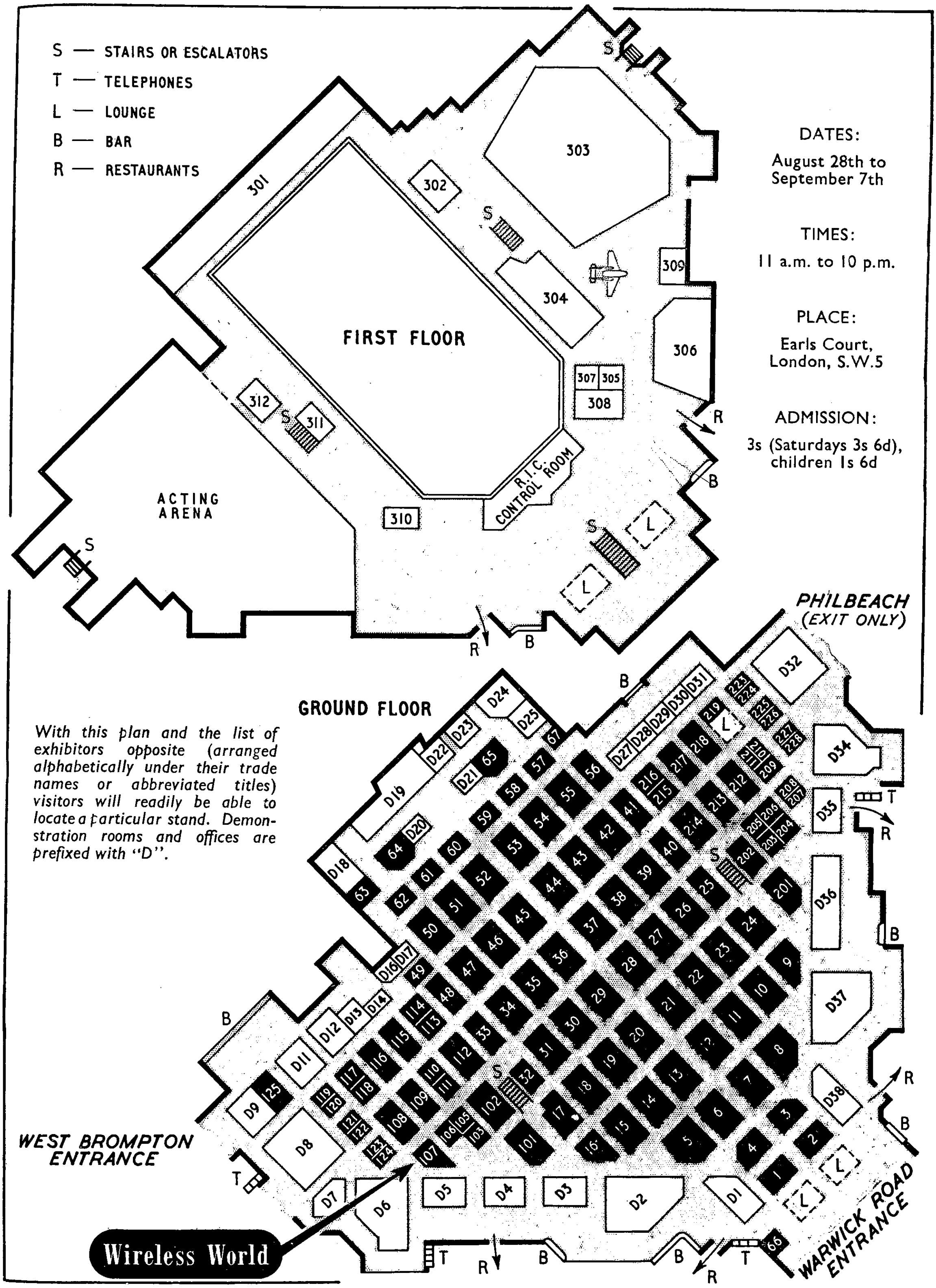


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# NATIONAL RADIO SHOW

# Guide to the Stands

### ACOS (213)

The new GP65 series of improved pickup cartridges which includes medium- and high-output models, as well as the usual wide range of replacement cartridges, are shown on this stand. An interesting feature is a projector showing pictures of good, badly formed and worn styli.

A newcomer to the range of piezo-electric microphones is the MIC-1. The overall length is only 4½in with a maximum diameter of 1⅛in. A new "Foldaway-Pack" microphone will also be on show.

*Cosmocord, Ltd., Eleanor Cross Road, Waltham Cross, Herts.*

### AERIALITE (7)

Several new separate B.B.C. and I.T.A. aerials, with the emphasis on wide spacing of elements in the Band-III models, will be shown this year. They will be accompanied by a comprehensive display of dual-band television models, included among which will be many factory-assembled types which only need opening out for erection on the site. Independent adjustment for directivity is provided.

Communal aerial equipment consisting of single and multi-band amplifiers and networks for distributing television and f.m. broadcast over a single cable in schools, hospitals, hotels and blocks of flats and Aeraxial low-loss cables are included in this firm's products.

*Aerialite Ltd., Castle Works, Stalybridge, Cheshire.*

### AIRMEC (228)

The portable Televet 877 and Radivet 211 test equipments will be demonstrated on this stand. These provide complete facilities for testing television, a.m. (long, medium and short waves) and v.h.f./f.m. receivers.

Each test set incorporates the appropriate signal generators (including a pattern and a.m. signal generator in the Televet), a wobbulator (for showing the overall response of resonant circuits), audio oscillator, oscilloscope and a.c./d.c. valve voltmeter. The Televet also includes an e.h.t. voltmeter (with probe).

*Airmec, Ltd., High Wycombe, Bucks.*

### ALBA (47)

The new Alba 14-in television portable weighs only 26 lb and makes use of a printed circuit. Several of the television models in the Alba range are this year fitted with v.h.f./f.m. sound receivers with switch selection of the Home, Light and Third programmes.

A new table model broadcast receiver also includes the v.h.f. band, and there is a series of bureau-style radio-gramophones. Other sound broadcast receivers include the "Happy Wanderer" portable which is available in mains- or battery-operated versions and a miniature receiver (Model C116) costing only 9½ guineas.

*A. J. Balcombe, Ltd., Tabernacle Street, London, E.C.2.*

### AMBASSADOR-BAIRD (51)

A special feature this year will be a new space-saving design of cabinet, for fitting into a corner of the room, which will house their latest 17-in and 21-in television receivers. Another attractive feature will be a complementary pair of sets in matching cabinets, one housing a 21-in television receiver and the other an a.m./f.m. radio-gram.

Record players and a high-fidelity recorder with an "ultra-linear" output stage are included.

*Ambassador Radio and Television, Ltd., Princess Works, Brighouse, Yorks.*

### ANTIFERENCE (24)

A new twin-band television aerial known as the "Antex Plus" is a combination of the Antiference "Antex," or "X" model, and a four-element Band-III Yagi, the two being interconnected in the factory for the most efficient operation with a single feeder. Each aerial section can be independently oriented.

Several of this firm's "Hilo" models now include an f.m. aerial element, thereby providing for TV and f.m. reception with a single aerial assembly, when, of course, the television receiver also embodies an f.m. band.

Overseas visitors will be interested in the display of "Export" aerials, some of which will be for Band IV.

*Antiference, Ltd., Bicester Road, Aylesbury, Bucks.*

### ARGOSY (2)

Described by the makers as a portable record player with built-in radio, rather than a radio-gram, is the new model PG19, which has an automatic record changer and incorporates medium- and long-wave reception. The G18 is another small table radiogram, while in the larger range is the G101 console model. Also a new exhibit is the AP3 record player.

A printed circuit is used in the battery portable receiver model P1.

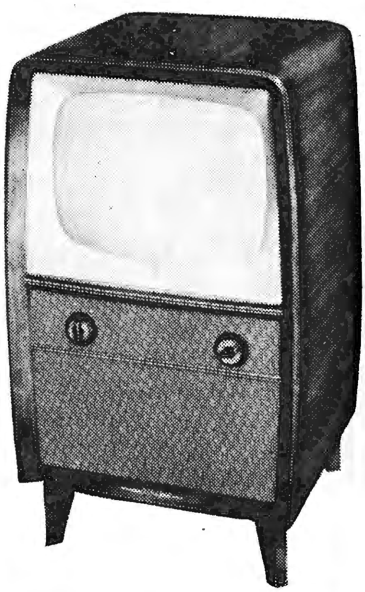
Amongst television receivers are two new 17-inch sets, 17C41 and 17K40, the latter being equipped for f.m. reception. A v.h.f. waveband is also provided now in the 21-inch receivers 21K40 (table model) and 21L40 (console).

*Argosy Radiovision, Ltd., Abbey Road, Barking, Essex.*

### AVO (62)

A comprehensive range of test equipment is shown. This includes a number of a.m. and f.m. signal generators giving full coverage of

*"Golden V" indoor television and f.m. aerial made by Belling-Lee.*



*Right: Alba T724/FM console.*

all the a.m., v.h.f./f.m. and television broadcast bands.

An interesting instrument which gives a clear and simple presentation of measurements is the LCR measuring bridge Type 1. The "Avo" d.c. amplifier will give a full-scale reading down to $3 \times 10^{-13}$ amp, and has been designed in conjunction with A.E.R.E., Harwell, and the N.P.L., Teddington, for standardization purposes.

*Avo, Ltd., 92/96, Vauxhall Bridge Road, London, S.W.1.*

**B.B.C. (301, 302)**

A large part of the engineering section of the B.B.C. stand is devoted to recording. Modern studio magnetic-tape equipment can be compared with the steel-tape recorder used in 1935. The latest piece of recording equipment is for use in the field and will handle up to four microphones. The equipment used for locating faults in "salvaged" magnetic tape can also be seen in operation.

Demonstrations of v.h.f. sound reception compared with that provided by a medium-wave receiver are again being given throughout the duration of the show.

A s.h.f. radio link is being used to transmit television from one end of the hall to the other.

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

**BELLING-LEE (55)**

An indoor aerial of compact and versatile design for reception of B.B.C. and I.T.A. television and f.m. broadcast is one of the latest additions to the Belling-Lee family of aerials. Known as the "Golden V" it has two elements which are adjustable for length and angle to provide the best reception on all three services.

A range of lightweight attic aerials made from strip and channel-section aluminium alloy is also new. The aerials are factory assembled and collapsed for transport, and the elements snap into position for erection.

In addition to a comprehensive display of outdoor TV and f.m. aerials there will be a wide selection of accessories including interference suppressors, connectors and terminals of all kinds.

*Belling and Lee, Ltd., Great Cambridge Road, Enfield, Middlesex.*

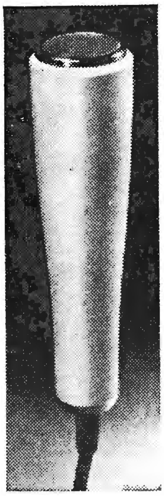
**BRIMAR (6)**

Special "Quality" valves in the "T" range of this firm will be featured in the display and also special-purpose valves for communications, transmitting and industrial purposes from the S.T.C. catalogue.

Among domestic types is a full range of a.c./d.c. television receiving valves covering Bands I and III, and valves for a.m./f.m. receivers.

New transistors will be shown, together with germanium diodes, Brimistors, thermistors and hermetic seals. In addition, there will be a selection of miniature and sub-miniature tantalum capacitors and a range of Permalloys including spiral tape cores. Quartz crystals and high-stability carbon resistors will also be on view.

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



*Acos MIC39-1 crystal microphone.*

**BULGIN (59)**

Several new components have been added this year to the extremely wide and comprehensive range of parts made by this firm. The total must now amount to several thousand separate items.

The additions include a new design of knob with coloured inserts for coding purposes on equipment having a multiplicity of knobs; neon signal lamps; panel signal-lamp fittings for 15 W lamps; cartridge fuses and switches of the type once known as key switches, but now called open-blade leaf switches. They have nickel-silver blades and pure silver contacts and are sufficiently small to justify the description "miniature".

Components designed for printed circuit applications are included.

*A. F. Bulgin and Co., Ltd., By-Pass Road, Barking, Essex.*

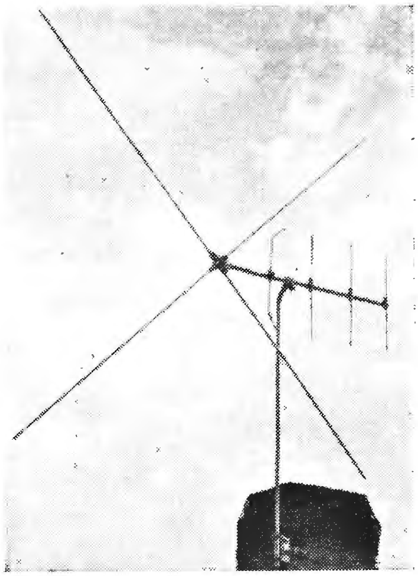
**BURWELL (205)**

The principal feature of this firm's display will be a range of television and f.m. aerials built up from one basic unit and a series of add-on units. Known as the "View-Well" series the basic unit is a 3-element Band-III Yagi. Additional Band-III elements can be added in the form of directors.

*Burwell Products, Ltd., 116, Blackheath Road, London, S.E.10.*

**BUSH (5, 37)**

A special stand for demonstrating television sets will provide seating accommodation for nearly 100 people.



*Antiference "Antex-Plus" twin-band television aerial.*

A new 21-inch set, TV79, heads the list of television receivers to be shown.

Sound receivers include a new v.h.f. set, the VHF62. It gives reception also on medium and long waves, and aerials for all bands are built in, though sockets for external aerials are provided as well. Piano-key switches are used for wavechange, gramophone and on/off. Another new set is a lightweight battery portable, BP61, for medium- and long-wave reception. It has a 5-in loudspeaker and the on/off switch is operated by opening and closing the lid. The weight, with batteries, is 6 lb.

This firm has recently started to produce record players, and on show will be a single player and one with an automatic changer, types RP20 and RP21.

*Bush Radio, Ltd., Power Road, London, W.4.*

**COLLARO (26)**

A range of four-speed gramophone record players including a new design of record changer, the "Conquest," is shown. Four types of crystal and one ceramic cartridge are available to suit the various output voltages which may be required.

The latest version of the tape "Transcriptor" (Mark III) includes a completely redesigned, lighter mechanical interlocking system for the push buttons. A revolution counter has also been fitted. This "Transcriptor" can now be supplied with a suitable pre-amplifier and power pack.

*Collaro, Ltd., By-Pass Road, Barking, Essex.*

**COSSOR (29)**

Printed circuits are widely used in this year's Cossor receivers and portable record players giving compactness, light weight and reliability. Typical examples are the Models 544 and 545, the latter being a radio-gramophone.

A larger radio-gramophone, the Model 529 is provided with a v.h.f./f.m. range and has three loudspeakers with crossover networks. The perennial "Melody Maker" table model receiver is available in two forms both of which make provision for v.h.f./f.m. programmes.

The chassis of the Cossor television receivers (17 in and 21 in) have been redesigned for better performance, easier maintenance, and long-range versions for fringe areas are available.

Cossor Instruments will be showing kits of parts for constructing oscilloscopes, etc.

*Cossor Radio and Television, Ltd., Cossor House, Highbury Grove, London, N.5.*

**DALLAS (216)**

This firm of wholesalers will be showing also their own proprietary range of "Scala" portable electric gramophone reproducers. Six models are available from a 1½-watt single-valve (plus rectifier) amplifier with 4-speed turntable (Model SP/1) to one with an 8-watt push-pull output.

*John E. Dallas and Sons, Ltd., Clifton Street, London, E.C.2.*

**DECCA (28)**

Occupying a prominent place on this stand will be the Model 555, a television/radio-gram fitted with a 17-in tube, automatic record changer, twin-loudspeaker system and full-range tone control. The radio is for v.h.f.

The Model RG200 radio-gram is also a new model and it covers four wavebands including v.h.f. A triple-loudspeaker system is embodied together with 4-speed automatic record changer and turnover crystal pickup. This and the Model 500 are housed in contemporary-styled cabinets.

The range of television receivers includes 14-in, 17-in and 21-in models, some of which provide for v.h.f. radio reception.

There will be a new "Deccalian" record player with four-speed automatic changer and high-fidelity sound amplifier.

*Decca Record Co., Ltd., 1-3, Brixton Road, London, S.W.9.*

**DEFIANT (4)**

The redesigned range of television receivers has turret tuning, improved focusing and noise limiting and a.g.c. on both sound and vision. A 21-in model has been added to the range of table receivers and some 17-in television models are now available with provision for the reception also of the B.B.C. v.h.f. sound service.

Two new radio-gramophones—one in the "Continental" style of cabinet —are to be shown; both have 4-speed automatic record changers.

Most of last year's sound broadcast receivers are retained, but a car radio receiver and a new midget receiver are interesting additions.

*Co-operative Wholesale Society, Ltd., 1, Balloon Street, Manchester.*

**DESIGN FURNITURE (210)**

Record storage cabinets with flexible roll-front doors, and tables for television receivers are the principal features of the display. A special table designed for the Murphy V310 and V320 receivers is worthy of note.

*Design Furniture, Ltd., Carnwath Road, London, S.W.6.*

**DOMAIN (219)**

This firm specializes in metal trolleys for electronic equipment, and also stands for television receivers. A new range has been designed which goes up to sizes for the largest sets.

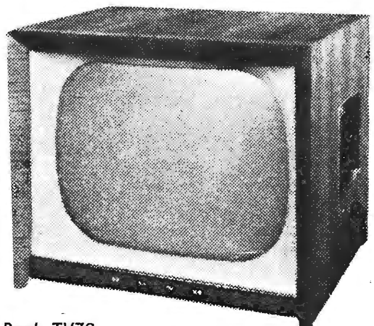
*Domain Products Ltd., Barnby Street, London, N.W.1.*

**DUBILIER (57)**

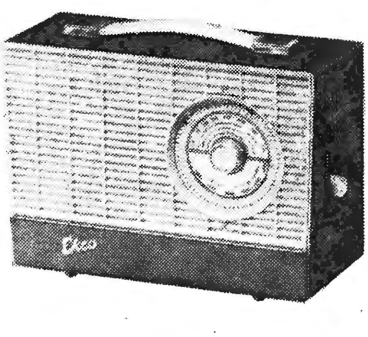
Fixed capacitors for receivers, transmitters and power-factor correction, fixed standard and precision resistors and volume controls will form the backbone of Dubilier's exhibit. Some miniature carbon-track volume controls will repay examination and there will be a comprehensive display of interference suppressors to be shown as complete units and also as separate components, such as miniature r.f. chokes and capacitors, for incorporating in small domestic electrical appliances. Some are designed especially for TV interference suppression.

Encapsulated, precision wire-wound resistors are another Dubilier product. A special feature will be made of capacitors and resistors for printed circuits.

*Dubilier Condenser Co. (1925), Ltd., Ducon Works, Victoria Road, North Acton, London, W.3.*



*Bush TV79.*




*Ekco Model BP321 ("Companion").*

**DYNATRON (33)**

A new 17-in combined television and f.m. receiver known as the "Knightsbridge," or alternatively as Model TV30CK, accompanied by a new radio-gramophone styled the "Edinburgh" (Model RG14) will occupy prominent places on this stand. The RG14 is an 11-valve set covering a.m. and f.m. transmissions and embodying a bass-reflex loudspeaker system. Another new item is a transportable record player designed for high-quality sound reproduction.

The exhibit will include 17-in and 21-in TV sets all with v.h.f. radio.

*Dynatron Radio, Ltd., The Firs, Castle Hill, Maidenhead, Berks.*

**E.A.P. (9)**

A new tape recorder, the "Triple Three," is an addition to the "Elizabethan" range. The amplifier incorporates a six-watt "ultra-linear" output stage which feeds either the internal speaker system of one 9-in × 5-in elliptical bass speaker and two 3-in-diameter tweeters, or any 15-ohm external speaker. Signals can be reproduced and recorded simultaneously, a "magic eye" providing recording level indication. A ribbon microphone is supplied. The "Elizabethan de Luxe," an improved version of the "Elizabethan" tape recorder, and the "Elizabethan" v.h.f./f.m. tuner are also shown.

*E.A.P. (Tape Recorders), Ltd., 9, Field Place, St. John Street, London, E.C.1.*

**E.A.R. (41)**

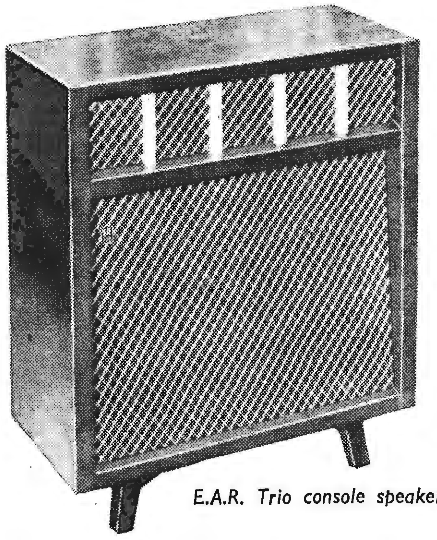
A wide range of console record reproducers as well as portable electric gramophones are shown. A new model is the "Concert Reproducer," which includes four loudspeakers in a reflex chamber sealed off from the amplifier, control unit and record player.

The range of high-fidelity units now includes a version of the "Triple Four" amplifier for use with low output variable reluctance pickups, a separate three-speaker system, and a switched v.h.f./f.m. tuner.

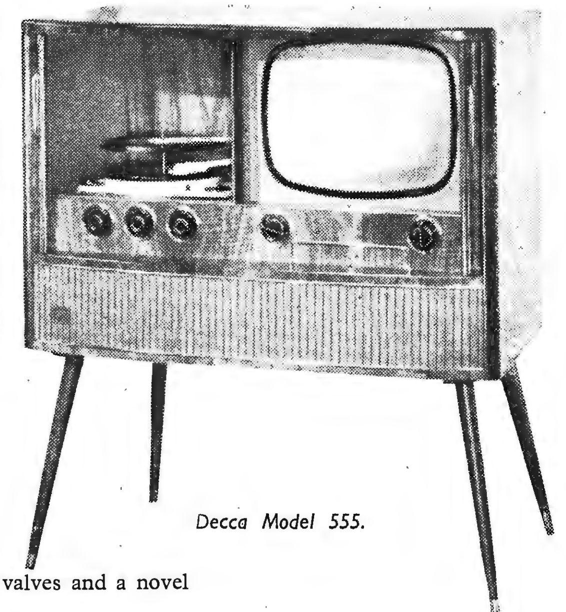
*Electric Audio Reproducers, Ltd., The Square, Isleworth, Middlesex.*

**E.M.I. (18, 108)**

Three types of "Emitape" are available; the "Long Play 99" which gives a 50% increase in recording time over the general-purpose "88" for a given spool size, and also "77" which is specially



E.A.R. Trio console speaker.



Decca Model 555.

tested for professional and scientific use. The range of seven spool sizes which can be obtained now includes $8\frac{1}{4}$ in. The specially made 5-ft-diameter spool which is shown holds 33,000 ft of 4-in-wide "Emitape." An accessory kit for tape editing purposes is also available. Magnetic recording "Emifilm" can be obtained in 35-, 17.5- and 16-mm sizes. The oxide coating is polished to reduce wear on the record and replay heads. "Emidisc" lacquer recording blanks in four grades and sizes are also on show.

Professional recording equipment shown consists of the L2 battery-operated portable recorder, the transportable TR51, and the TR90.

*E.M.I. Sales and Service Ltd., Hayes, Middlesex.*

#### E.M.I. INSTITUTES (307)

The Institutes' postal tuition courses, with which components for the home construction of equipment are provided, are featured on this stand.

*E.M.I. Institutes, Ltd., 43, Grove Park Road, London, N.4.*

#### EKCO (24)

Among the new Ekco sets to be seen this year will be the Model TC315, a 21-in television receiver with f.m. radio. It embodies an aluminized tube, multi-channel turret tuner, flywheel sync, spot wobble and automatic picture and sound control. It will be accompanied by another 21-in model (T312), available either as a table set or, fitted with legs, as a floor-standing model. It does not provide f.m. reception but has many of the features of the TC315.

Included among new sound receivers will be a six-valve a.m./f.m. model (A320) with twin loudspeakers, self-contained aerials and a 7-watt output stage. The latest "Companion" battery portable (Model BP321) has a printed circuit, low-consumption valves and a novel tuning scale.

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

#### EVER READY (31)

A number of battery portables by Ever Ready and the associate company Berec (Radio), Ltd., are shown. The Berec "Skyscraper" (Mark II) is a seven-valve superhet battery model covering medium and short waves (up to 30 Mc/s). Each company will be showing two portable transistor receivers. A nine-valve a.m./f.m. set. is also shown by Ever Ready.

A number of dry batteries which have been specially developed for transistors are shown in addition to the usual very wide range made by Ever Ready.

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

#### EXPANDED METAL (124)

Fifteen vertical and thirteen chevron patterns in expanded aluminium mesh provide a change from the plain diamond array often seen in metal loudspeaker grilles. Anodization in 12 different colours is possible.

*The Expanded Metal Co. Ltd., Caxton Street, London, S.W.1.*

#### FERGUSON (14)

A number of recent additions to the range of radio or television receivers and radio-grams are shown. These include a lightweight battery portable, the "Flair," and a 3-valve (plus metal rectifier) a.c./d.c. mains transportable, the "Fame." The new radio-grams include the "Fantasia II," an a.m./f.m. model incorporating a push-pull output stage and 3-speaker system consisting of a 10-in bass unit, 6 × 4-in elliptical speaker and 4-in tweeter. The 305T and 307T are new 17- and 21-in television fringe reception sets incorporating electrostatically focused tubes and keyed a.g.c. circuitry. Another new addition is the "Fortune" 2-valve record player with a 6-watt push-pull output stage and $6\frac{1}{2}$-in twin diaphragm speaker.

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

#### FERRANTI (36)

This firm has now brought out a record reproducer for the first time. It is a 4-speed transportable, model RP1008, in a lightweight case.

The range of television receivers includes a new 17-in console model, the TC1004, which has flywheel synchronization, and an automatic interference inverter. It incorporates a v.h.f. sound waveband.

Another new television set is the 21-in table model T1006. The cabinet forms a shell which can be removed from the base to expose the chassis and tube for servicing. Others in the range are the 14-in and 17-in table models T1001 and T1002, both of which are for a.c./d.c. mains, have turret tuners and automatic interference inverters.

*Ferranti Radio and Television, Ltd., 41-47, Old Street, London, E.C.1.*

#### FIELD ("RECORD HOUSING") (207)

The "Nordyk" line and other record storage carrying cases or cabinets, and also a number of hi-fidelity equipment units are available in both traditional and contemporary styles. A resistively loaded bass reflex loudspeaker cabinet can also be obtained.

The "Simplex" and "Royal" record indexing systems are useful accessories.

*N. and S. B. Field and Co. Ltd., "Record Housing," Brook Road, London, N.22.*

### FUND FOR THE BLIND (311)

A live demonstration shows how blind people can be employed on the production and testing of radio equipment. Specially adapted test and measuring instruments are available for the use of the blind.

*Greater London Fund for the Blind, 2, Wyndham Place, London, W.1.*

### G.E.C. (10)

Six germanium transistors and one germanium diode are used in the portable transistor sound receiver, BC1650, introduced by this firm. It is built on a printed circuit, has a ferrite-rod aerial for the two wavebands, medium and long, and uses a class-B push-pull output stage to drive the 7in × 4in elliptical loudspeaker. Power is from four unit cells, giving operation for about six months at four hours a day. Also on show will be the battery portable BC1452 and a.c./d.c. transportable BC6447, both with printed circuits.

In television receivers the latest sets are two 17-in table models BT8742 and BT2748, both of which incorporate v.h.f sound and have a new type of 12-position turret tuner of light construction designed for clip-in-coils. Three positions on this turret are used for v.h.f. programmes.

Transistors will be featured in a display showing their construction and possible applications. There will also be a demonstration of the new "Periphonic" loudspeaker system.

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

### G.P.O. (306)

The part played by the G.P.O. in providing and maintaining the links between the sources of programmes and the transmitters is featured on this stand. Among the equipment being demonstrated is an 11-stage video repeater capable of equalizing up to 60dB cable loss at 3 Mc/s. A waveform generator for lining up cable pairs is also shown. This produces a standard line period of approx. 100 $\mu$sec containing negative-going 10-$\mu$sec sync pulses, a positive-going sine-squared pulse and a positive-going bar of 40 $\mu$sec duration. The shaped waveform is fed into the cable pair and the video repeater adjusted until the received and sent waveforms are as nearly identical as possible.

*General Post Office, St. Martin's-le-Grand, London, E.C.1.*

### GARRARD (22)

In the RC98 record changer an electrical speed control and switch click suppressor are provided in addition to the standard features of the RC88 four-speed model. Other four-speed single record players and changers, and also the miniature battery-operated 45-r.p.m. BA1 are shown.

The range of crystal pickups available includes high-output or high-compliance models. A specially designed transcription pickup arm, the TPA10, has the Garrard moving coil GMC5 pickup head fitted.

*Garrard Engineering and Manufacturing Co., Ltd., Swindon, Wilts.*

### GOODMANS (116)

The Goodmans 315 reproducer is designed round a standard 12-in Audiom 60 bass speaker and the middle- and upper-frequency, horn-loaded pressure units introduced last year. The bass speaker is housed in a lagged reflex chamber loaded by an "Acoustical Resistance" unit. Constant-impedance attenuators giving 2dB steps up to 12dB are provided for the mid-range and treble units. Interesting, too, is a full-range electrostatic loudspeaker which will be demonstrated. A number of standard single- or two-speaker systems are also shown.

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

### H.M.V. (12)

Most of the sound broadcast receivers and radio-gramophones in the H.M.V. range this year are capable of receiving the v.h.f./f.m. transmissions as well as the normal medium- and long-wave stations. Emphasis is on quality of reproduction and special elliptical loudspeakers have been developed to make the best use of the improved performance of f.m. stations.

A transportable television receiver (Model 1864) with a special lightweight chassis has been introduced and a new "fringe" model television receiver (Model 1867) also incorporates a v.h.f./f.m. sound broadcast receiver.

*The Gramophone Company, Ltd., 21, Cavendish Place, London, W.1.*

### HARTIQUE (110)

A wide choice of television tables and record storage cabinets is offered by this firm in period and contemporary designs. The "Stayrite" all-purpose folding table will accommodate the largest television receivers.

*Hartique Products, 243, Upper Street, Islington, London, N.1.*

### HOBDAY (123)

Distributors to the trade of television and sound receivers, record players, tape recorders, etc.

*Hobday Bros., Ltd., 21/27, Great Eastern Street, London, E.C.2.*

### HUNT (48)

This firm specializes in the manufacture of fixed capacitors of all kinds, including miniature types. Improvements in some of their electrolytic types has enabled the upper limit of operating temperature to be raised to 85°C without reduction in the working voltages. Reduction in size for a given capacitance and voltage rating is another line of development and the results in the form of new miniatures and sub-miniatures will be shown on the stand. Among the dielectric materials used in Hunt capacitors will be found paper (metallized), plastic film, mica and ceramic of various kinds. Some of these materials will figure in the range of capacitors produced especially for printed circuits.

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

### I.T.A. (303)

This stand is largely devoted to the activities of the programme contractors — Associated-Rediffusion and Associated Television—but there is an information section where technical as well as organizational questions are dealt with.

*Independent Television Authority, 14, Princes Gate, London, S.W.7.*

### INVICTA (23)

New models which have been produced since the last Radio Show are mains transportable, battery, and battery/mains receivers, and also one 17- and two 21-in television sets. The complete range includes a nine-channel Band III converter.

*Invicta Radio, Ltd., 100, Gt. Portland Street, London, W.1.*

### J. B. CABINETS (209)

Radio, television and radio-gram cabinets for the trade are available.

*J.B. Manufacturing Co. (Cabinets), Ltd., Howard Way, Harlow, Essex.*

### J-BEAM AERIALS (17)

The distinctive type of "skeleton slot" developed by this firm is now used as the main element in a basic Band-III aerial described as a "Double Four." This consists of slot, two reflectors and four directors and where more gain than the basic unit provides is required additional units are added. These are termed "Plus" units, and take the form of extra directors.

*J-Beam Aerials, Ltd., Westonia, Weston Favell, Northampton.*

### JOKKI (208)

A new system of record filing consists of strips of flexible plastic in several colours, cut with a groove to fit the edges of any size standard record, or the sleeves of microgroove records. Ready cut self-adhesive labels on which the titles can be written are available for sticking on the backs of the strips.

*Power Judd and Co. Ltd., 94, East Hill, London, S.W.18.*

### K.B. (15)

A low-priced transportable receiver for a.m. sound reception, the "Minuet" is one of the new exhibits this year.

Reception of v.h.f. sound radio is a feature of the new "Majestic" 21-inch television receiver. A console model, it has a 90° c.r. tube, flywheel synchronization and a 10-inch high-flux loudspeaker. In the "New Queen Special" 17-inch set an internal aerial is provided.

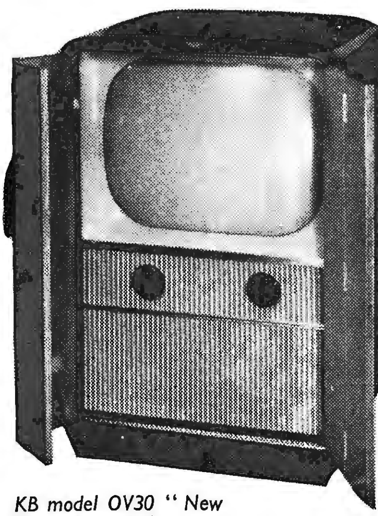
The compactness of the new "Minor" radio-gram will make it attractive to those with restricted living space, its detachable legs allowing it to be used as either a console or a table model. Equipped for reception of v.h.f., as well as long and medium waves, it has a 6-watt output into a 9 in × 5 in elliptical speaker. Another new exhibit is the "Tunetime" 4-speed portable record player, which has a printed circuit, a 7in × 4in elliptical speaker and an automatic changer.

*Kolster-Brandes, Ltd., Footscray, Kent.*

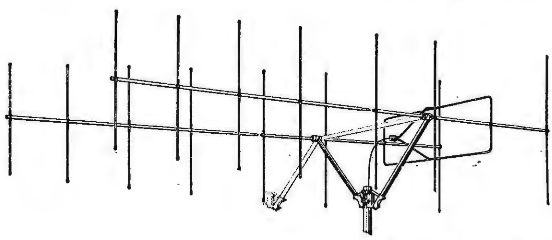
**KERRY'S (212)**

Wholesale distributors of many of the leading makes of receivers, electric gramophones, tape recorders and also of some makes of test instruments.

*Kerry's (Great Britain), Ltd., Warton Road, London, E.15.*

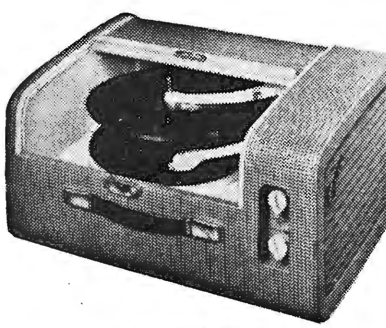


*KB model OV30 "New Queen Special."*



*One of the new Band III "Double Slot Beam" arrays made by J-Beam Aerials.*

*G.E.C. transistor portable (BC1650).*



*Left: Ferguson "Fortune" record reproducer.*

**LABGEAR (217)**

Unorthodox designs of television aerials have been a feature of this firm's display at previous exhibitions and to them this year is added the "Diamond" indoor aerial, known also as Model C11. It covers all 13 TV channels and has provision for "peaking" the local station.

The "Bi-Square" principle of design is this year extended to an f.m. aerial giving, in compact form, a power gain of 10 dB compared to a plain dipole.

A range of test instruments is included this year. There is a precision television alignment generator, a signal-strength meter primarily for testing TV aerials, milli-voltmeter and a range of instrument kits. These include an oscilloscope, and a multi-range a.c./d.c. meter kit.

*Labgear (Cambridge) Ltd., Willow Place, Cambridge.*

**LINTRONIC (223)**

A portable 30-watt public address unit complete with 12-in loudspeaker in a carrying case 22 in × 14 in × 12 in forms a basic unit for use with a microphone, electronic musical instrument or records. A twin-input mixer is provided.

A four-channel electronic mixer (HF101) with headphone monitoring is suitable for use with a tape recorder or power amplifier.

*Lintronic Ltd., 149, Strand, London, W.C.2.*

**McMICHAEL (45)**

The centre-piece of attraction on this stand will be a new 17-in table model television receiver (M71T) of compact design and having the controls grouped in a recess in the right-hand side of the set with the loudspeaker just above them. It covers all the television channels.

Introduced this year is a new full-depth console cabinet with large double doors and concealed castors. It is used to house a 17-in television receiver.

*McMichael Radio Ltd., Langley Park, Slough, Bucks.*

**MARCONIPHONE (50)**

The new 17-in electrostatically focused Emiscope tube is used in the Model VC151 and Model VT153 television receivers and there are three other models including one with a 21-in tube. Most of the Marconiphone sound broadcast receivers and radio-gramophones this year have provision for v.h.f./f.m. reception in addition to medium and long waves. Model T62DA has a loudspeaker specially developed for f.m. reproduction and is housed in a maroon plastic cabinet. The new ARG57 series radio-grams are notable for their use of printed circuitry.

*The Marconiphone Company Ltd., 21, Cavendish Place, London, W.1.*

**MASTERADIO (35)**

At least eight new receivers will be shown by Masteradio. Three are basically television sets, two radio-gramophones and two sound receivers. One television set, the Model THG17, is fitted with a 17-in tube, a multi-speed automatic record changer and high-fidelity sound-reproducing equipment. There is also a 21-in TV set which, among other features, embodies automatic focusing and neither focus nor ion-trap adjustments are required. A turret tuner gives all-channel coverage. This is the model TH21T.

The RG369 radio-gram for a.c. mains is a de luxe model with a.m./f.m. radio, multi-speed automatic record changer and large record storage space.

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

**MEADOW-DALE (224)**

An aerial which cannot fail to attract attention will be the Dale parabolic model for Band III. It consists of a dipole backed by eight reflectors arranged on a parabola and it gives, relative to a dipole, a gain of 14 dB with a high front-to-back ratio and the comparatively narrow acceptance angle of 20°.

Shown also will be a range of "Convertible" aerial units which build up from a Band-I dipole to elaborate triple-band systems.

*The Meadow-Dale Manufacturing Co., Ltd., The Dale, Willenhall, Staffs.*

**MULLARD (39)**

While the main stand is devoted chiefly to electronic novelties, designed to illustrate more serious applications, there will also be a Home Constructor Centre adjoining demonstration room D34. Here, constructors will be able to consult some of the company's engineers on technical matters and see examples of equipment built around Mullard valves, transistors and c.r. tubes. Demonstrations of high-quality sound reproduction equipment will be given, including amplifiers built to Mullard circuits.

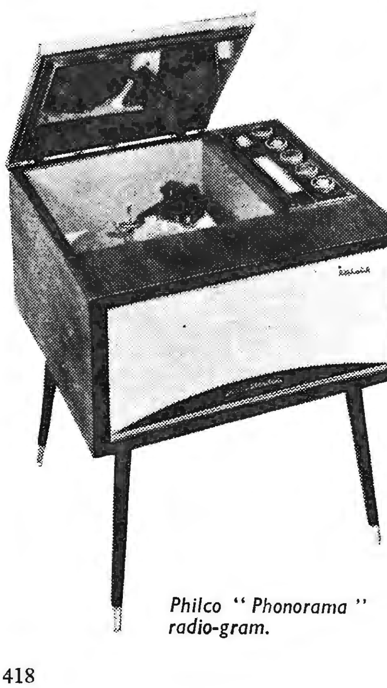
In the valve displays special emphasis will be placed on transistors and the new 90° deflection c.r. tubes.

*Mullard, Ltd., Mullard House, Torrington Place, London, W.C.1.*

**MULTICORE (61)**

To demonstrate the use of "Savbit" solder alloy, which has been compounded to reduce the absorption of copper and so lengthen the life of soldering bits, a replica of a section of the Decca Radio factory has been erected on the stand and will be producing record player amplifiers.

The interests of the home constructor have not been overlooked and a special pack of 22 s.w.g. 60/40 alloy for home soldering of printed circuits has been introduced.



*Philco "Phonorama" radio-gram.*

Established lines such as the Bib wire stripper, the solder thermometer and the recording tape splicer are being continued.

*Multicore Solders Ltd., Hemel Hempstead, Herts.*

**MURPHY (53)**

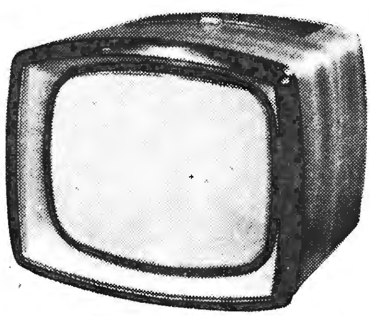
Fine tuning control has been eliminated from the latest range of table television receivers and only the four-position turret tuner has to be operated. The V320 is a 21-inch model while the V310 and V310C have 17-inch screens—the last-mentioned being pivoted in a decorative U-shaped stand. A flap on top of these receivers covers the controls and loudspeaker, and when raised it switches on the set and acts as a reflector to direct sound forward. Adjustable vision interference limiters are provided and also sound interference suppression.

Sound receivers will include six a.m./f.m. models. There are three table receivers, a console with emphasis on high-quality reproduction and two radio-grams with three-speed automatic changes.

*Murphy Radio, Ltd., Welwyn Garden City, Herts.*

**N.I.D. (312)**

The varied aspects of the work of the Institute on behalf of the deaf and hard-of-hearing are portrayed. Remote control devices enabling the



*Murphy model V310*

deaf to hear sound and television receivers without discomfort to other members of the household, hearing aids, and a machine for conversing with the deaf-blind are being demonstrated.

*National Institute for the Deaf, 105, Gower Street, London, W.C.1.*

**PAM (42)**

A complete range of television receivers using printed circuit chassis has eight models in all, built round a 17- or 21-in chassis—a fringe model being obtainable in both cases.

Radio receivers include two a.m./f.m. and two a.m. only models. The six-transistor 720 portable is the successor to last year's model 710.

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

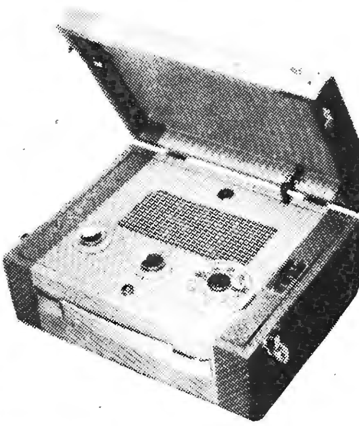
**PERDIO (63)**

A pocket receiver measuring $3\frac{1}{4} \times 5\frac{3}{4} \times 1$in and weighing 13 oz has five transistors and a printed circuit. The life of the pen-type batteries is said to be about 115 hours with intermittent operation. It covers the medium broadcast wavelengths.

*Perdio Ltd., Dunstan House, St. Cross Street, Hatton Garden, London, E.C.1.*

**PERIOD HIGH FIDELITY (106)**

These newcomers to the industry specialize in period styled furniture to house television, radio or high



*Invicta 29 mains/battery portable.*

fidelity equipment; and any style of period or contemporary cabinet can be supplied.

*Period High Fidelity Ltd., 28, South Street, London, W.1.*

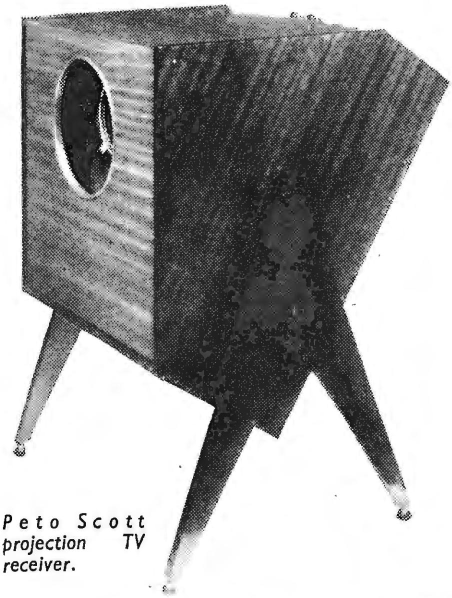
**PETO SCOTT (30)**

A transistor portable sound receiver is one of the more topical exhibits on the stand. Other sound equipments will include a 4-speed record reproducer, RC33, and a high-quality amplifier with a 10-watt output.

The new 17-inch television sets TV1722 and TV1723 contain several interesting features: a switch giving a choice of direct or flywheel line synchronization; independent Band-I and Band-III contrast controls; remote control sound muting switch; delayed a.g.c. on sound and vision; regulated e.h.t.; and a maskless picture tube.

In addition there will be a projection receiver using a $2\frac{1}{2}$-inch tube. A forward-projection model gives a 4 ft × 3 ft picture on an external screen and a back-projection model a 2 ft × $1\frac{1}{2}$ ft picture on a screen in the cabinet.

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



*Peto Scott projection TV receiver.*

**PHILCO (43, 305)**

Optional remote control of station selection is a feature of many of the television receivers in the Philco range. Among sound receivers there are many models with v.h.f./f.m. coverage and at least two for f.m. only. Of these the new "Phonorama" radio-gramophone is of special interest on account of the two-stage acoustic loading provided for the loudspeakers in order to achieve the widest possible frequency range in a cabinet of reasonable size. There is a rotatable aerial for v.h.f. and provision, if desired, for feeding a.m. signals to the amplifier from an external tuner unit.

Another new production is the 3755 portable transistor record player making use of the Staar 3-speed battery-driven turntable.

*Philco (Great Britain), Ltd., 30/32, Grays Inn Road, London, W.C.1.*

**PHILIPS (20, 21)**

The latest a.m./f.m. sound receiver, the G75U, has 7 valves and 3 wavebands. It uses a ferrite aerial for a.m. and an internal loop for f.m. Housed in a plastic cabinet, it has a 5-inch loudspeaker and works from a.c. or d.c. mains. Two other a.m./f.m. sets will be shown, and for a.m. only, a printed-circuit transportable, a battery portable and a 12-V or 6-V powered car radio.

In sound reproduction equipment there is a new version of the "Disc Jockey Major" portable record player with a re-styled carrying case in a two-colour combination. Also on show will be the "Novosonic" high-quality sound equipment and a range of radiograms.

Automatic gain control and fly-wheel sync circuits are incorporated in the 21-inch television set model 2157U, which is a console type and uses a 10-inch loudspeaker. The range also includes 17-inch and 21-inch table models with 90° tubes.

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

**PILOT (54)**

This year high-quality sound reproduction equipment is one of the main features of the Pilot exhibit and will be demonstrated. The HFA11 is a neat 10-watt amplifier incorporating a control unit for record frequency characteristic compensation, separate tone controls and switched "scratch" and "rumble" filters. The HFA12 with 12-watt output has a separate control unit (HFC12) and is notable for the inclusion of a muting switch for use with record changers.

Portable record reproducers include a new a.c./d.c. mains version of the "Encore," and the "Modernaire" radio-gramophone.

An f.m./a.m. table receiver (T91) and two portables—the "Little Maestro" and a newcomer, the "Poppet"—are the principal sound broadcast receivers, and the television range is notable for a new 17-in model (TV111) and a special fringe area receiver (TV110F).

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

**PLESSEY (125)**

It would be impossible to do justice in a selective exhibit to the wide range of components, parts and accessories of various kinds which this firm supplies to the radio and electronics industry, but their stand will form an office where trade representatives from home and overseas will be able to obtain information on all Plessey products.

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

**PLUS-A-GRAM (109)**

A number of portable record reproducers and also a record player will be shown. These can play standard or long-playing records, and most of them can be operated with the lid open or closed. The new "Dansette Conquest" incorporates two speakers.

*J. and A. Margolin, Ltd., 112-116, Old Street, London, E.C.1.*

**PORTOGRAM (1)**

The TR/100 console is a three-speed tape reproducer incorporating a reflex loaded loudspeaker, and large storage compartment. There is also provision for a record reproducer and f.m. feeder unit.

The HF/65 console record reproducer has an 8-watt amplifier with push-pull output stage.

*Portogram Radio Electrical Industries, Ltd., St. Rule Street, London, S.W.8.*

**PYE (13)**

No fewer than eleven sound broadcast and ten television receivers are listed in the range of current models, and the possibility that others may emerge during the period of the Show is not precluded. All requirements are catered for, from the smallest personal portable to a radio-gramophone (Fen Man II RM) with provision for home recording as well as record playing from a 4-speed changer and radio reception of f.m. and a.m. stations.

Representative of the television receivers are the CW17 and CS17 models (with twin loudspeakers). Another notable receiver is the 14-in portable which has a high-sensitivity circuit.

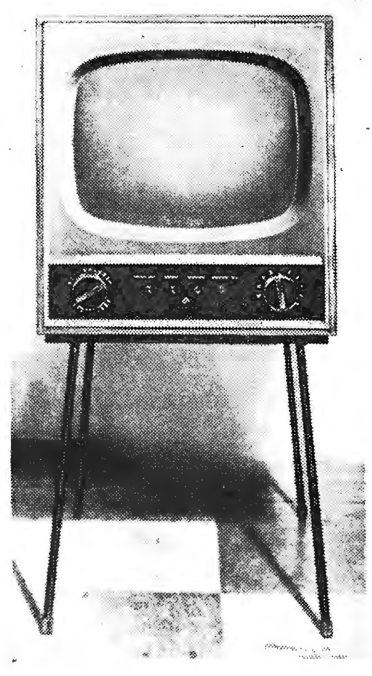
High-quality reproduction from records, either through the "Black Box" range of players or by equipment assembled from a choice of amplifiers and loudspeaker units is another activity of the Pye organization, which has assumed growing importance.

*Pye Ltd., Cambridge.*

**R.A.F. (304)**

Radio aids to navigation of military aircraft and the part played by electronics in the operational use of guided weapons are shown either by models or actual equipment. Among the equipment to be seen is the beam approach system Babs, Mk. 4, a

*Pye Model CS17.*



radio altimeter (Mk. 8) and the ground installation for I.L.S. A section of the stand is devoted to activities of the R.A.F. Amateur Radio Society.

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

**R.C.A. (114)**

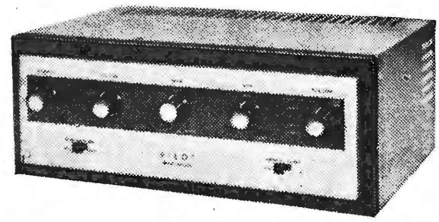
Two new high-quality "phonographs" have been introduced in addition to the Standard "New Orthophonic" complete range of units.

The "Vice-President" table or chair-side model is fitted with a four-speed record changer. The five-watt amplifier has separate bass, treble, and loudness controls and feeds a speaker system comprising a 10 in × 6 in elliptical speaker and two 4-in tweeters arranged for good sound dispersion.

The "President" is a larger single cabinet instrument with 20 watts output available from the amplifier. The speaker system comprises one 12-in and two 4-in units housed in an infinite baffle chamber.

*R.C.A. Great Britain, Ltd., Lincoln Way, Windmill Road, Sunbury-on-Thames, Middlesex.*

R.G.D. "200 FM" radio-gram.



Pilot HFA11 amplifier.

**R.G.D. (27)**

Two 17-in television receivers (one a fringe area model) and a 21-in model incorporating an f.m. receiver for sound broadcasting are being produced by this company and there are several new radio-gramophones to choose from including the "200 FM" with built-in ferrite rod and dipole aerials for medium, long and v.h.f. transmissions. In the "Cambridge" and "300 FM" models three loudspeakers cover bass, middle and treble frequencies, in the "Roxburg" four loudspeakers are used, two for the bass, and in the "1000" an additional mid-frequency unit brings the total up to five. A portable record player (Model "708") is fitted with a two-stage amplifier and a four-speed changer.

*Radio Gramophone Development Co. Ltd., Eastern Avenue West, Romford, Essex.*

**R.M. ELECTRIC (115)**

The full range of "Strad" receivers available includes radio-grams, a 17-in table television set, record player and portable battery radio. The "Woodberry" radio-gram incorporates a 6-valve circuit for medium and long waves, and v.h.f./f.m. A 4-speed record changer is used. The television set includes a.g.c. and fly-back suppression circuitry.

*R.M. Electric, Ltd., 21, Seaton Place, London, N.W.1.*

**R.S.G.B. (309)**

The emphasis is on home construction and examples of equipment constructed by members of the Society are shown. These include a transistor record player, a simple communications-type receiver, mobile equipment and test gear.

*Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.1.*

**REGENTONE (8)**

The v.h.f./f.m. version of the Model 99 radio-gramophone is notable for its drop-down scale front which gives access to a record player in a lighted compartment. A newcomer to the radio-gram range is the ARG81 which is a low-built model with a v.h.f./f.m. range in addition to medium and long waves, and a 4-speed record changer.

Two new television receivers (T17.7 and T21) with 17-in and 21-in tubes are available either with or without the addition of a v.h.f./f.m. sound broadcast range.

*Regentone Radio and Television, Ltd., Eastern Avenue West, Mawneys, Romford, Essex.*

**ROBERTS (25)**

A new battery portable (R77) resembling a leather field-glass case follows the firm's tradition of high-quality workmanship. It is a four-valve superhet for medium and long waves with printed circuit and ferrite rod aerial. It measures $9\frac{1}{2}$ in × $3\frac{1}{2}$ in × 6 in and with batteries weighs $4\frac{1}{2}$ lb.

The R66 and RMB mains/battery portables and the RP4 battery model are being continued.

*Roberts Radio Co. Ltd., Creek Road, East Molesey, Surrey.*

**ROLA CELESTION (16)**

An interesting new loudspeaker is the 415 which employs two pressure-driven units to cover audio frequencies from 350 c/s upwards, the lower frequency unit driving a re-entrant horn.

Some additions have been made to the wide range of loudspeakers for radio and television manufacturers.

*Rola Celestion, Ltd., Ferry Works, Thames Ditton, Surrey.*

**S.T.C. (60)**

Silicon junction rectifiers have advantages over conventional rectifiers because of their greatly improved power/weight and power/volume ratios and ability to operate at high temperatures. A new 5-amp diffused-junction type will be shown, as well as 1-amp and 0.5-amp versions. Improved construction and higher voltage elements, giving savings in space, weight and cost, are the main feature of the recent Series 400 selenium rectifiers. Also shown will be contact-cooled selenium types and germanium junction photocells.

*Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2.*

**SIEMENS EDISON SWAN (46)**

Miniature valves with low-consumption 25-mA and 50-mA filaments are a prominent feature of the valve display, which includes types for a.m. and f.m. receivers and a preferred range of television valves. The complete range of r.f., i.f. and a.f. hermetically-sealed transistors will also be shown.

Industrial valves and c.r. tubes will include the Vapatron, and a display will illustrate the methods of cooling this by vaporization of water.

*Siemens Edison Swan, Ltd., 155, Charing Cross Road, London, W.C.2.*

**SLINGSBY (215)**

Equipment for handling and transporting television sets and radio-gramophones is the principal exhibit which includes light-tubular metal tracks and metal runways to facilitate van loading. Aluminium section ladders suitable for aerial installation work are also shown.

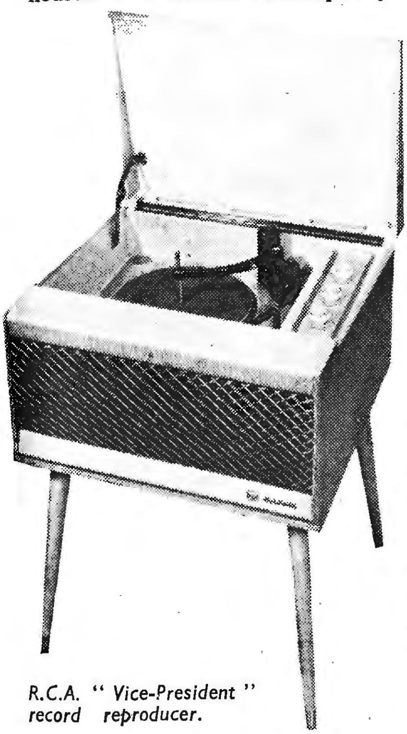
*H. C. Slingsby, Ltd., 89, 95, 97, Kingsway, London, W.C.2.*

**SOBELL (19)**

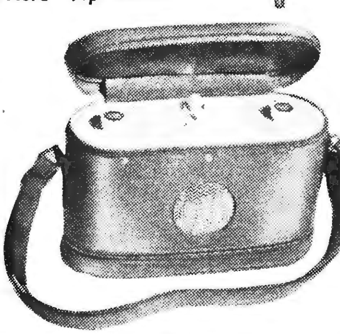
Shown this year are 14-in, 17-in, and 21-in television sets in table and console cabinets, sound receivers and radio-gramophones. The Model TPS147DL is a new 14-in transportable TV set finished in beige and maroon leather-cloth. It embodies an all-channel tuner and normally uses a telescopic aerial, but an external one can be employed.

A 7-valve a.m./f.m. radio-gramophone, Model FMG708, with four-speed automatic record changer and push-button waveband selection, housed in a modern contemporary bureau-style cabinet with drop-down front, is also new.

*Radio and Allied Industries, Ltd., Langley Park, Slough, Bucks.*



*R.C.A. " Vice-President " record reproducer.*



*Roberts R77 portable.*

**SOBELL INTERNATIONAL (56)**

The centre of attraction on this stand will be a combined television set, radio-gram, tape recorder and cocktail cabinet. A 21-in tube is fitted and the radio-gram unit has a 4-speed automatic record changer. High-fidelity audio techniques have been applied. It will be accompanied by a representative selection of export-model sets, mains/battery portables and sound receivers.

*Radio and Allied Industries, Ltd., Langley Park, Slough, Bucks.*

**SPENCER-WEST (206)**

Weighing only 17 lb, the latest portable television set produced by this firm has a 9-inch screen and measures $15\frac{1}{2}$ in × $11\frac{1}{2}$ in × 11 in. It has a 12-position turret tuner, fitted with wafers for local Band-I and Band-III stations, and gives a sensitivity better than $30\mu$V. Automatic vision gain control and noise suppression circuits are incorporated, and the construction is based on printed circuitry. Optical enlargement is provided by a plastic window in front of the picture tube.

Aerial distribution amplifiers for Bands I, II and III are available and provision is made for interconnecting the amplifiers to supply the three services on the same wiring system. A range of Band-III convertors and pre-amplifiers will also be on show.

*Spencer-West, Ltd., Quay Works, Great Yarmouth, Norfolk.*

**STELLA (34)**

Two new a.m./f.m. sets are on show this year, the ST239U and ST236A, both with seven valves and moulded plastic cabinets.

An f.m. waveband is provided in the ST312A radio-gram, which has a four-speed record changer, a dual-stylus pickup and push-button controls.

The latest wide-angle 90° c.r. tubes are used in two new television sets, the ST8617U 17-inch table model, with side-mounted controls and loudspeaker, and the ST5721U 21-inch console, which has its controls and speaker at the front.

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

**T.C.C. (58)**

Among the many capacitors to be shown by T.C.C. this year will be a new range with p.t.f.e. dielectric. Their special features are ability to operate at temperatures up to 200°C, high insulation resistance and good power factor. The T.C.C. range of tantalum electrolytics has been extended to include some new miniature types designed especially for aircraft instruments and transistor equipments.

Interference suppression capacitors, chokes and networks of various kinds will be on view, together with a very comprehensive display of printed circuits for sub-assemblies, accessories, amplifiers and receivers.

*Telegraph Condenser Co., Ltd., North Acton, London, W.3.*

**TAPE RECORDERS (111)**

The "Playtime Twin" portable record reproducer incorporates a four-speed turntable with high output turnover crystal pickup feeding two loudspeakers via the two-valve audio amplifier. The "Sound" three-speed tape recorder is an improved version of last year's model.

*Tape Recorders (Electronics) Ltd., 784-788, High Road, London, N.17.*

**TAYLOR (32)**

Among the new instruments shown is the 94B television waveform and alignment generator. This incorporates a pattern, a.m. and f.m. signal generators, and a television sweep oscillator, all covering frequencies from 4 to 220 Mc/s. Synchronizing waveforms for 525 (F.C.C.) and 625 (C.C.I.R.) line standards are available. An addition to the range of test meters is a new pocket-sized model, the 122A.

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

**TECHNICAL SUPPLIERS (103)**

A new TSL a.m./f.m. tuner has a high sensitivity with one r.f. and two i.f. stages on a.m., and three i.f. stages on f.m. The "Savoy" a.m./f.m. receiver incorporates a 12-watt push-pull audio output stage.

The "Geruphon Omni-D" resonator is a $4\frac{1}{2}$-in-diameter 16-in-long tube containing an asymmetrically mounted loudspeaker. The "Concert Soundcorner" two-speaker system utilizes a room corner, and is mounted several feet from the floor.

*Technical Suppliers, Ltd., 63, Goldhawk Road, London, W.12.*

**TELENG (227)**

A new signal level meter (SL3B) with a range from 25 $\mu$V to 250 mV incorporates 12-channel turret tuning for measurements on cables or television aerials at frequencies between 40 and 220 Mc/s.

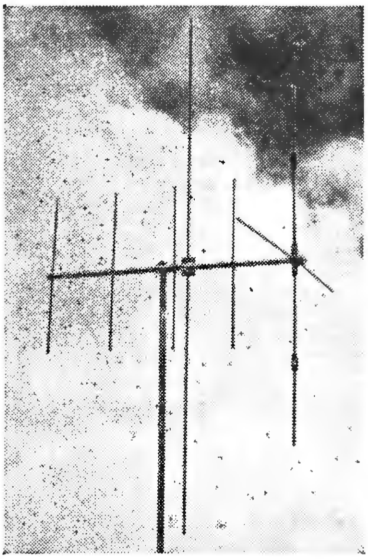
A wide range of other television equipment is also exhibited. This includes mast booster units for television distribution systems, wide-band amplifiers, and two turret conversion kits. A number of coaxial cable devices are also shown.

An item outside the television range is a three-valve superhet car radio receiver.

*Telefusion (Engineering) Ltd., Church Road, Harold Wood, Romford, Essex.*

**TELEQUIPMENT (226)**

A new portable calibrated oscilloscope, the "Serviscope," makes use of an automatically synchronizing time base. Triggering facilities are



"*Triple Hi-Max Five D*" *television and f.m. aerial made by Telerection.*

provided. Another calibrated oscilloscope, the 720, is also on show.

The WG44 television pattern generator covers two bands from 40 to 70 Mc/s and 170 to 220 Mc/s and gives both sound and vision signals. Four different types of picture modulation are available.

*Telequipment Ltd., 313, Chase Road, Southgate, London, N.14.*

**TELERECTION (38)**

A series of combined FM/TV aerials described as "Hi-max Triple-band" types is the latest addition to this firm's range of v.h.f. aerials. The main element is a Band-I dipole divided into three Band-III sections by means of miniature tuned circuits called phase correctors. This element functions efficiently on Bands I and III and reflectors and directors are added according to the overall gain required. To this combination is now added a horizontal f.m. dipole. All three systems share a single feeder.

*Telerection Ltd., Antenna Works, St. Pauls, Cheltenham, Glos.*

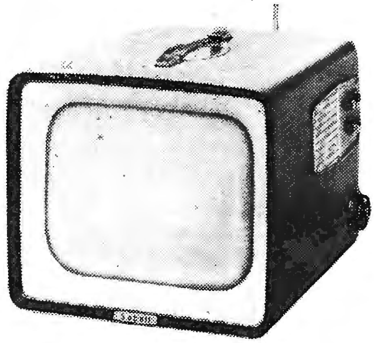
**THOMPSON, DIAMOND & BUTCHER (214)**

Manufacturers of "Convertogram" record players, "National Band," "Meritone" and "New World" electric gramophones and "Lamplifier" loudspeaker-amplifier units, and distributors of many of the leading makes of domestic receivers.

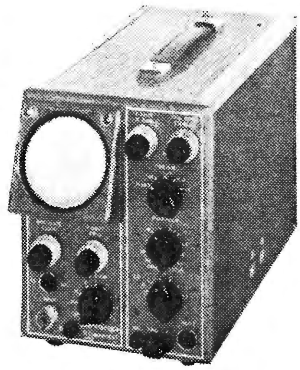
*Thompson, Diamond and Butcher, Ltd., 5-9, University Street, London, W.C.1.*

**ULTRA (11)**

Two new 21-in television sets have been introduced, the V21-50A table model and the WR21-62 console which also provides for v.h.f. reception of the B.B.C. sound broadcasts. There are also new 17in receivers



*Sobell Model TPS147DL 14-in transportable television set.*



*Telequipment* "*Serviscope.*"

in both standard and fringe area versions either in table cabinets with optional matching stand or in console form. All these sets have built-in v.h.f./f.m. sound receivers.

The "Troubador" small transportable sound receivers are new versions of a popular model, one for v.h.f reception only and the other for a.m. on medium and longe waves. Both sets are produced by the printed circuit technique.

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

**VALRADIO (118)**

Power conversion units for supplying a.c. mains-operated television receivers, radio-gramophones, tape recorders and other electronic equipment from d.c. supplies (including batteries) is the speciality of this firm. These now include transistor-type converters and a typical example operates "all-dry" portable receivers from car or boat batteries.

*Valradio, Ltd., Browells Lane, Feltham, Middx.*

**VIDOR (52)**

A number of battery portable models are shown. These include the "Vanguard" for a.m. and v.h.f./f.m. which incorporates internal ferrite rod and f.m. dipole aerials, a six-valve circuit, and a 7in × 4in elliptical loudspeaker. The "Marquisa" and "Lady Anne" can also be operated from a.c. mains. New transistorized battery portables are also on show.

The wide range of dry batteries includes units for radio receivers, torches, hearing aids and photo-flash equipments.

*Vidor, Ltd., Erith, Kent.*

**WALTER INSTRUMENTS (49)**

In the 303 portable tape recorder a single tape speed of $3\frac{3}{4}$in/sec is provided, the overall response being 40 to 10,000 c/s, with a signal-to-noise ratio better than 35 dB.

*Walter Instruments, Ltd., Garth Road, Morden, Surrey.*

**WESTINGHOUSE (113)**

Selenium rectifiers will be shown in various types of assembly to illustrate the methods of cooling and chassis mounting now possible. Contact-cooled rectifiers include the new edge-cooled type in which heat is removed by three edges of each square element, the fourth being left for connections. Conventional rectifiers with double-voltage elements (p.i.v. of 42V per element) will be displayed, and also miniature tubular types capable of withstanding high peak inverse voltages and copper-oxide types suitable foı moving-coil meters.

Some new automatic chargers on view are designed expressly for recharging the batteries of radio-equipped vehicles.

*Westinghouse Brake and Signal Co., Ltd., 82, York Way, London, N.1.*

**WHITELEY ELECTRICAL (65)**

The ready-to-assemble range of cabinets in traditional and contemporary styling now comprises four models for housing complete equipments, and eight speaker cabinets.

The wide range of loudspeakers available with diameters from $2\frac{1}{2}$ to 18in, and incorporating the patented cambric cone, includes a number of models specially designed to cover the middle and upper frequencies.

A new control unit for the WB12 amplifier now gives a choice of two units for this amplifier. The WB v.h.f./f.m. tuner has three wide-band i.f. stages, limiter and Foster-Seeley discriminator.

The industrial and Services section includes permanent magnets, transformers and cores, wavemeters and other components. A section is also devoted to components for the home constructor.

*Whiteley Electrical Radio Co., Ltd., Victoria Street, Mansfield, Notts.*

**WOLSEY (40)**

A new Wolsey twin-band television aerial, known as the "Twin Super," is designed for mounting on the skirting board, or suspending from the picture rail, whichever is the more convenient. It is designed to provide more gain on Band III than on Band I.

Another new model is the "Interceptor 5" introduced for use in weak-signal areas. A range of aerial assessories together with communal aerial systems will be included.

*Wolsey Electronics Ltd., Cray Avenue, St. Mary Cray, Orpington, Kent.*

# THE GYRATOR

## I. Introduction to a Theoretical Concept which Preceded the Practical Device

*By THOMAS RODDAM*

ONE of the accusations made against engineers by laymen is that they use jargon. When I say that microwave plumbers use ferrites in gyrators I expect to be told that this is jargon. It isn't, of course. According to Quiller-Couch, the two main vices of one of his characters, J, are circumlocution and the use of vague woolly abstract nouns instead of concrete ones. What engineers do, however, is use new, though well-defined words. The microwave gyrator is a practical device, a thing, although if you are not an active follower of microwave practice you may not know much about it. One of its more attractive features is that the idea of a gyrator is a rather abstract one and preceded the invention of the actual device by some years. Things don't usually happen that way: usually someone makes something which works after a fashion, theorizes about it and thus improves it.

In these two articles I have adopted an historical approach. In the first one I have drawn heavily on a paper by B. D. H. Tellegen,* who is the man who really brought the gyrator to light and named it.

Before the war most of us would have been pretty confident that although we should have new inventions, new circuit theory and a whole bag of other novelties, the basic bricks of our theoretical world were complete, for good or bad. Resistance, inductance, capacitance and the ideal transformer formed a neat quartet with which we could build up our dipoles and two-terminal pairs. Then not long after the war the gyrator appeared on the scene, though it had not yet, I think, made its way into the textbooks. It is difficult to see now why it took so long before anyone saw the need for the gyrator because, as we shall see in this article, it is an obvious theoretical concept. Once it appeared as an idea, several practical, though not, of course, ideal embodiments followed, one of which is of very great importance.

### Terminals and Terminations

In the course of this first article it will be necessary to look at the absolutely basic ideas fairly precisely. Already, in the previous paragraph, the reader will see that I have referred to a two-terminal pair. This is not just pedantic observation, a description which usually means " I don't understand it and I'm not going to let you know I wish I did." A four-terminal system, which is what the theoretician's black box is often called, has, obviously, four terminals. Usually, however, the black box also carries two labels, saying " In " and " Out ", or something equivalent. Some of our theory applies perfectly well to the general black box with four terminals, but it is much easier, and therefore much commoner, to deal only with the special " In-Out " case, which we therefore call by a special name, the two-terminal pair.

Let us deal first with the two-terminal network, which some people call a one-terminal pair. The circuit is shown in Fig. 1 and I shall not feel responsible if " Cathode Ray " uses this as a peg on which to hang a couple of articles. Now, if this network is to be one of those we deal with in ordinary circuit

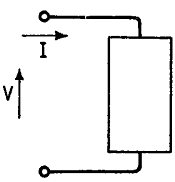



*Fig. 1. Basic two-terminal network.*

theory it must satisfy three rather important conditions. It must be linear, which means that although the equation relating V and I can contain terms in $dV/dt$ and $dI/dt$, $d^2V/dt^2$ and $d^2I/dt^2$, and so on, it cannot contain terms like $I^2$. Rectifiers, silicon carbide resistors, both of them passive elements, are non-linear and are barred from our basic study. The reason for this is quite easily seen: the behaviour of non-linear elements is tied up with the actual sizes of currents, voltages and the devices themselves. Cannon balls and golf balls accelerate in the same way under gravity (linear theory) but produce quite different effects if they fall on your head (non-linear theory).

The network elements must be constant. You wouldn't get very far measuring the capacitance of a condenser microphone (which I suppose we should call a capacitor microphone, but who does?) in a boiler shop. Finally, the network must be passive: no valves, no generators, no concealed energy sources of any kind are permitted. This clearly means that our resistances must be positive, because, as has been shown in these columns, the only way to get a negative resistance is to use some sort of amplifier: anyway, a negative resistance is capable of pumping energy into a positive resistance, and the more rigid definition of " no energy sources " obviously applies.

The sort of equation we can finally write down must be made up of basic equations like:

$$v_1 = Ri,$$
$$v_2 = L di_2/dt$$
$$C dv_3/dt = i_3$$

Here $v$ and $i$ are the voltage and current in small bits of the network, and all we have to do is combine them. Quite a lot has been written on methods of getting from the V–I equation to a network which

*Philips Tech. Review*, Vol. 18, p. 120 (1956). For further references see *Philips Research Reports*, Vol. 3, p. 81 (April, 1948).

will satisfy it: this is a much more difficult problem than getting from the network to the V–I equation, for which we can use Kirchhoff's laws, Maxwell's circulating currents (a variant) or some other more elaborately simple methods like matrix algebra.

Whatever we do, however, we are limited to our three basic bits, the resistance, capacitance and inductance which are so familiar. Even the literature of two-terminal networks using only two kinds of element is pretty extensive: I am writing this with no references available and I will not try to guess how many papers have appeared this month, all over the world, on just this limited subject, but I am pretty certain that if you check up you will find a few.

We cannot spend more time on this, however, and must get on to our two-terminal pair. The basic circuit, shown in Fig. 2, is not unfamiliar, though there are differences of opinion about which way to draw $I_2$. There are considerable advantages in drawing all the currents flowing from left to right in the upper arms; the same currents flow back in the opposite direction in the lower arms. Even this detail is sometimes rather important. In this particular connection, actually, it would be rather more convenient to draw $I_2$ the other way round, and many of the textbooks do this. The disadvantage is that when you come to connecting four-terminal networks in tandem the minus signs start creeping in. Let us start the way we mean to go on, even though it means that we will have to use minus signs here.

One way of discussing the behaviour of the network is by the impedance equations:

$$V_1 = Z_{11}\, I_1 + Z_{12}(-I_2)$$
$$V_2 = Z_{21}\, I_1 + Z_{22}(-I_2)$$

This pair of equations is found in most of the books, I think. To see what the various Z's are it is necessary to impose arbitrary conditions to simplify the equations. Suppose, for example, we make $I_2$ zero by leaving the right-hand side open. Then

$V_1 = Z_{11}\, I_1$ and $V_2 = Z_{21} I_1$

Thus $Z_{11}$ is the open-circuit impedance looking in at the left, and $Z_{21}$ is the trans-impedance from right to left. Trans-impedance is another word, more useful and possibly more common, for mutual impedance, a term to make the women novelists shudder. By looking in at the right and leaving the left-hand terminals open we can see that $Z_{12}$ is the trans-impedance from left to right.

## Reciprocity

Now we come to the point where the textbooks push you out on a limb. In their various ways they tell you without much explanation that $Z_{12} = Z_{21}$, a condition which they describe as the reciprocity theorem. This is certainly true if the network contains nothing but resistance, capacitance and inductance elements. Since a real transformer can be represented by an equivalent network of inductances when considered as a two-terminal pair, though obviously not by the same network if you have a true four-terminal network, all the elements we usually consider leave us with the reciprocity theorem safe and sound. Our textbook writers have been on pretty safe ground until recently and the reciprocity theorem has become a matter of faith, not reason.

The transformer, the ideal transformer, enables us to start probing more closely into the basis of our ideas. For the ideal transformer we can write:

$$V_1 = nV_2$$
$$I_1 = I_2/n$$

where $n$ is the transformer ratio. Not surprisingly

$$V_1 I_1 = V_2 I_2$$

meaning that the energy we put in is equal to the energy we get out again. If this were not true, it would not be an ideal transformer. Suppose, for no particular reason at the moment other than as a mathematical exercise, that we write down the equations of an ideal black box for which:

$$V_1 = sI_2$$
$$I_1 = V_2/s$$

Here again the relationship $V_1I_1 = V_2I_2$ holds, so that this black box is ideal, passive, linear, constant. But now we have

$$V_1 = \quad -s(-I_2)$$
$$V_2 = sI_1$$

and if we compare this with the impedance equations we wrote down earlier we see that $Z_{12} = -Z_{21}$. Obviously, therefore, this ideal black box does not satisfy the reciprocity theorem. It is indeed an anti-reciprocal network. Suppose that we connect a second similar black box in tandem. Then for the second one

$$V_2 = sI_3$$
$$I_2 = V_3/s$$

so that for the two boxes in tandem:

$$V_1 = V_3$$
$$I_1 = I_3$$

Two of these anti-reciprocity boxes in tandem thus bring us back to a one-to-one ideal transformer. This property of the anti-reciprocity box is in some ways rather like that of our old friend the square root of minus one. Multiply a real number by $j$ and you have an imaginary number: repeat the process and you are back in the realm of real numbers again, even though you are faced by a negative number instead. For this reason, which was, I suppose, not too deplorable before the anti-reciprocity box was officially named, it has been called an imaginary ideal transformer. Now, however, it is called a gyrator. Let us look at some of its properties.

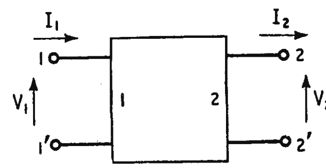



*Fig. 2. Basic two-terminal pair.*

Suppose that we open-circuit the right-hand side of our gyrator. Then $V_2$ must be zero. This means that $I_1$ must be zero too, from the defining equations:

$$V_1 = sI_2$$
$$I_1 = V_2/s.$$

Thus $V_1$ is finite and $I_1$ zero, $V_1/I_1$, the input impedance is infinite and the short-circuited gyrator looks like an open-circuit. Make $I_2$ zero by open-circuiting the right-hand terminals and $V_1/I_1$ becomes zero; a short circuit.

Now let us connect an inductance across the right-hand terminals.

$$V_2 = j\omega L . I_2 \text{ so that}$$
$$\frac{V_1}{I_1} = \frac{s^2}{j\omega L} = \frac{1}{j\omega L/s^2}$$

This expression is just what we should expect if we

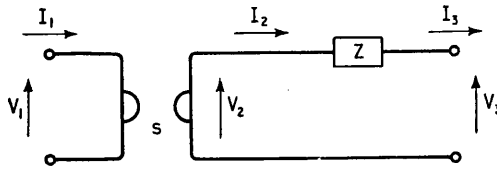



*Fig. 3. A gyrator and a series impedance Z.*

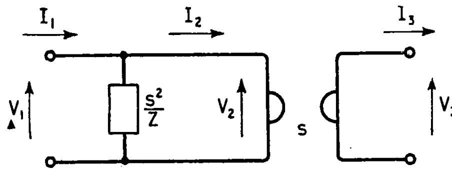



*Fig. 4. A gyrator and a shunt impedance $s^2/Z$.*

had a capacitance $L/s^2$ connected across the left-hand terminals, so that the effect of interposing the gyrator is to convert an inductive impedance into a capacitative impedance. Similarly, if $V_2 = I_2/j\omega C$, $V_1/I_1 = j\omega Cs^2$ and a capacitance has been transformed to an inductance. If $V_2 = RI_2$, $V_1/I_1 = s^2/R$, so that, as we might have expected by now, a resistance becomes a conductance. These results must be looked at rather more closely, and for this purpose we need a symbol for the gyrator, so that we can draw Fig. 3, which shows a gyrator and a series impedance Z. For this system we have:

$$V_1 = sI_2$$
$$I_1 = V_2/s$$

and

$$V_2 = V_3 + I_3Z$$
$$I_2 = I_3$$

giving us

$$V_1 = sI_3$$
$$I_1 = V_3/s + I_3Z/s$$

Now let us look at Fig. 4. For this system

$$V_1 = V_2$$
$$I_1 = V_2Z/s^2 + I_2$$

and

$$V_2 = sI_3$$
$$I_2 = V_3/s$$

giving us

$$V_1 = sI_3$$
$$I_1 = V_3/s + I_3Z/s.$$

The final equations for the network of Fig. 4 are thus just the same as those we obtained for the network of Fig. 3; the gyrator acts as a "dualizer," turning any impedance into its dual.

All this is no doubt very interesting the reader may, and I hope does, think, but what is it all about? Here is a rather theoretical black box, which lends itself to a little mathematics, but what good is it, and if it is of any use at all, where can I get one? This first thing to do is to see what good it is and then hunt around to see if we cannot produce a reasonable approximation to an ideal gyrator. Let us look at Fig. 5. A gyrator and a resistance R are connected in series. We can write down the impedance equations for this circuit. They are:

$$V_1 = R(I_1 - I_2) + sI_2 = RI_1 + (s-R)I_2$$
$$V_2 = R(I_1 - I_2) + sI_1 = (R + s)I_1 - RI_2$$

Suppose that we choose $R = s$. Then

$$V_1 = RI_1$$
$$V_2 = 2RI_1 - RI_2$$

Although $V_2$ depends on $I_1$ as well as any termination applied to the right-hand side of the system, $V_1$ is completely independent of $I_2$.

Fig. 6 shows another way of combining a gyrator with a resistor. For this circuit we write down the admittance equations rather than the impedance equations. We find that:

$$I_1 = \frac{V_2}{s} + \frac{V_1 - V_2}{R} = \frac{V_1}{R} + \left(\frac{1}{s} - \frac{1}{R}\right) V_2$$

$$I_2 = \frac{V_1}{s} + \frac{V_1 - V_2}{R} = \left(\frac{1}{s} + \frac{1}{R}\right)V_1 - \frac{V_2}{R}$$

Once again, then, if $s = R$ we have $I_1$ independent of $V_2$ although $I_2$ depends on $V_1$.

A practical black box which does this is a most important device. Quite of lot of microwave generators are connected directly to an aerial feeder with no protective buffer amplifier. If the aerial does not provide an exact match for the feeder an echo is sent back and may interfere with the satisfactory operation of the oscillator. Of course the valve designer tries to make his valve as insensitive to pulling as possible, but how much easier his life would be if a small black box could be put in between valve and aerial to stop the reflections reaching the valve. It is not wasteful of energy, either. Suppose we terminate the system of Fig. 6, for which the last equations apply, in a resistance $R_2$ on the right. Then

$$V_2 = I_2R_2$$

$$I_2 = \frac{2V_1}{R} - \frac{V_2}{R} = \frac{2V_1}{R} - \frac{I_2R_2}{R}$$

so that $I_2\left(\frac{R + R_2}{R}\right) = \frac{2V_1}{R}$

or $I_2 = 2V_1/(R + R_2)$.

For the case $R = R_2$ we have just $I_2 = V_1/R_2$, so that the applied signal $V_1$ produces in the load a current equal to that which it would produce if connected directly. Nothing is lost in the resistance R unless we send in from the right, when all the energy goes into R and none out to the left-hand terminals.

The practical device which really started off the

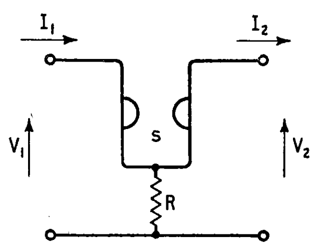



*Fig. 5. Analysis of this circuit is the key to the utility of the gyrator.*

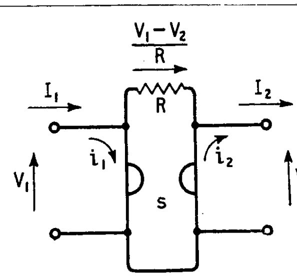



*Fig. 6. Another way of considering a gyrator and a resistor.*

whole idea of the gyrator and which was the origin for its name was not an electrical black box at all, but a mechanical one. You can draw a mechanical equivalent circuit for an electrical one, or an electrical equivalent for a mechanical circuit. If the mechanical circuit is a rotary system, with torque for voltages and velocity for currents, a perfect pair of gears is the equivalent of a perfect transformer. The gears may be bevel gears but the theory is the same even though the shafts have gone round through 90°. Now let us mount a gyroscope in suitable gimbals, which I will not try to draw. As you know by experience, if you try to turn the axis of the gyroscope it insists on turning, not the way you want it to turn but at right angles to your twist. At first sight, therefore, the gyroscope is doing just the same as the pair of bevel gears, but if you do the mathematics you will find that instead of the primary torque being transferred as a secondary torque, the torque at the second shaft is proportional to the velocity at the first shaft. This is just the equivalent of our gyrator equations, with

$V_1 = sI_2$ replaced by
$T_1 = sv_2$ and
$V_2 = sI_1$ replaced by
$T_2 = sv_1$, where T and $v$ stand

for torque and velocity.

The paper on the gyroscope† triggered off a number of others including one showing the one-way-only property we have already analysed. Here was an important application: in the second article we shall see how a practical device was made.

†Bloch, *Phil. Mag.*, Series 7, Vol. 35, p. 315 (1944).

# Sequential Colour Again

## NEW FRENCH SYSTEM GIVING SIMPLER AND LESS CRITICAL RECEIVERS

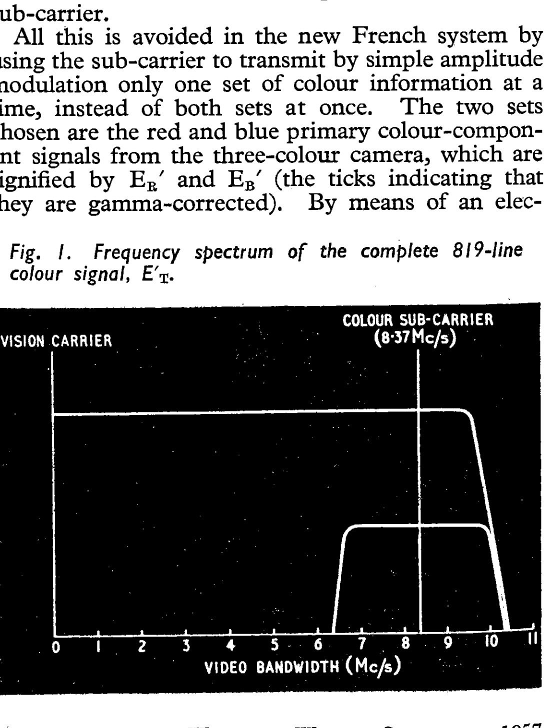
ALTHOUGH the frame sequential system of colour television was abandoned as a possible contender for public service in the U.S.A. on account of its non-compatibility, the general idea of sequential colour transmission has never been entirely killed. It has too many good points for that. The frame sequential system, for example, is notable for the quality of its colour reproduction and for the simplicity and non-critical nature of the transmitting and receiving equipment. And even though simultaneous colour transmission has been established in the U.S.A. in the shape of the N.T.S.C. system, the sequential process still persists in rearing its head in such devices as the Chromacoder* and the "Apple" and Chromatron single-beam colour c.r. tubes† where the colour phosphors are selected in turn.

Now we have a sequential method of transmitting colour information in a new French system—a compatible system, it should be said—which has been devised by M. Henri de France and developed at the research laboratories of the Société Nouvelle RBV—La Radio Industrie. *Wireless World* saw it demonstrated in Paris recently on the occasion of the International Colour Television Symposium. In this system the main purpose of the sequential transmission is to simplify the receiver circuitry by eliminating the need for complicated expedients such as synchronous detection which are necessary with simultaneous transmission of the N.T.S.C. type.

It is well known that in the N.T.S.C. system the colour information is conveyed by two colour-difference signals (or derivations of them) which modulate two components in quadrature (90° phase difference) of a single sub-carrier frequency. At the receiver the recovery of these colour difference signals demands a synchronous detection system, using a local oscillator of sub-carrier frequency with appropriate phase-displaced outputs. The arrangement is somewhat critical because the correct reproduction of transmitted colour information depends on accurately maintaining the frequency and phase synchronization of this local oscillator, and a complete regulating system is necessary for the purpose. Indeed, it appears from subjective tests that some receivers will not tolerate phase drifts of more than ±5°, which is more critical than the ±10° tolerance allowed on the B.B.C. test transmissions themselves! In addition, of course, there is the danger of possible cross-talk between the two components of the colour sub-carrier.

All this is avoided in the new French system by using the sub-carrier to transmit by simple amplitude modulation only one set of colour information at a time, instead of both sets at once. The two sets chosen are the red and blue primary colour-component signals from the three-colour camera, which are signified by $E_R'$ and $E_B'$ (the ticks indicating that they are gamma-corrected). By means of an elec-

*Fig. 1. Frequency spectrum of the complete 819-line colour signal, $E'_T$.*




*A device for converting the output of a frame sequential camera to simultaneous transmission. See *Wireless World*, November 1954, p. 540.
†See *Wireless World*, January 1957, p. 2.

tronic switch these signals are applied alternately to the sub-carrier modulator at line frequency, so that in the first frame of a picture, red, say, is transmitted during line 1, blue during line 3, red during line 5 and so on, and in the second interlaced frame, blue is transmitted during line 2, red during line 4 and so on.

A separate luminance (brightness) signal is transmitted to provide the black-and-white signal for existing monochrome receivers, giving the compatibility feature in the same way as in the N.T.S.C. system. The multiplexing of the single-colour signal with the luminance signal is also achieved in the same way as in the N.T.S.C. system—by frequency interleaving the sidebands of the colour sub-carrier in the gaps in the sideband spectrum of the main video signal, at the same time making the sub-carrier frequency as high as possible to reduce the visibility of the resultant dot pattern on the receiver screen. For this interleaving purpose the sub-carrier has to be made an odd multiple of half the line scanning frequency, and actually it has been placed at 8.37 Mc/s in the 10-Mc/s video band, as shown in Fig. 1.

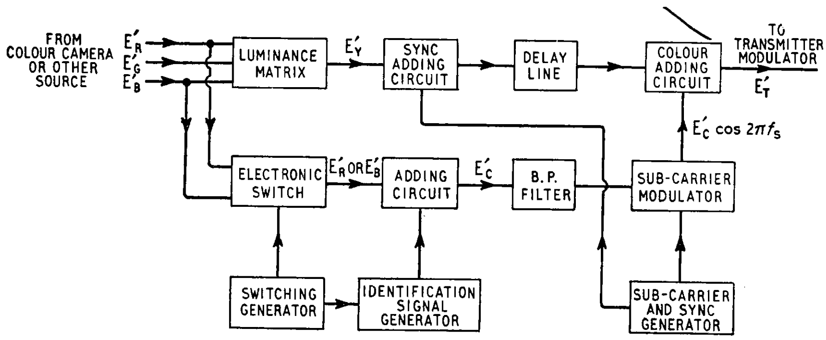



*Fig. 2. Block schematic of the coding equipment at the transmitter.*

The French system, in fact, has a number of features in common with the N.T.S.C. system and might therefore be regarded as a modified version of it. For example, it takes advantage of the well-known limitations of the eye in colour vision by transmitting only the low frequencies of the red and blue primary-colour components to give a narrow-band colour signal. This actually has a bandwidth of 2 Mc/s, as can be seen from Fig. 1. Another point of similarity is the method of recovering the green primary-colour component (which is not transmitted as such) at the receiver by subtracting the red and blue signals from the luminance or "white" signal. On the other hand, in the French system it is only necessary to transmit two sets of information simultaneously, the luminance signal and one colour signal, whereas three sets have to be transmitted simultaneously in the N.T.S.C. system.

The feature which is really characteristic of the French scheme, however, is that the sequential method of colour transmission is made possible by taking advantage of the fact that 819 lines provide a vertical colour definition greater than the subjective requirements of the human eye. It will be realized that the advantages gained by the sequential, time-division multiplex, method of colour transmission must be paid for in the sense that the information available for display is reduced by a factor of two. Of the 737 active lines in the 819-line picture, one half, 368.5, are used for transmitting the red information and the other half for transmitting the blue information. This does not matter, however, because, as already mentioned, the 819-line system can afford to lose a great deal of vertical colour definition before the eye notices any difference.

The only difficulty with this line sequential method—as with all sequential systems—is that it produces stroboscopic effects at the receiver c.r. tube. This, however, has been overcome in the colour receiver by an artificial means of obtaining a simultaneous display on the three-gun c.r. tube. It is a storage technique, which takes advantage of the fact that statistically there is very little difference between the information on two successive lines of a television frame. The red information transmitted during, say, line 1 of a frame is displayed on that line but is also passed through a delay device so that it emerges one line later and is displayed again along with the blue information on line 3. Thus two sets of information, red and blue, are available simultaneously for line 3 (the third simultaneous green signal being derived as already explained). Similarly the blue information on line 3 is delayed so that it is displayed simultaneously with the red information on line 5 . . . and so on with the rest of the frame and the following interlaced frame.

For correct reproduction of colours it is, of course, necessary for the receiver to "know" when red is being transmitted and when blue is being transmitted. To distinguish between them an "identification signal" is transmitted during the "back porch" of the sync pulse in front of every blue line. Actually there is a residue of sub-carrier imposed on the black level and the identification signal takes the form of a suppression of this residue preceding every blue line. At the receiver this is used for controlling an electronic switch which sends the red and blue signals to their appropriate electron guns in the tri-colour c.r. tube.

## The Transmitter

A simplified block schematic of the transmitting end of the system is shown in Fig. 2. Here the gamma-corrected red, green and blue primary-colour components $E'_R$, $E'_G$ and $E'_B$ from the camera are first of all applied to a matrix (proportional adding circuit) which, by a linear combination of the three signals, provides the luminance signal $E_Y'$. Actually $E_Y' = 0.59\ E'_G + 0.3\ E'_R + 0.11 E_B'$ as in the N.T.S.C. system. After the sync waveform has been added, the luminance signal passes through a delay line, necessary to keep the luminance and chromaticity information in phase, and then through another adding circuit which superimposes on it the modulated colour sub-carrier.

The two signals $E_R'$ and $E_B'$ are also applied to an electronic switch which is operated at half the line frequency by the switching generator and produces the signals in alternate sequence at the output. The emerging signal, $E'_R$ or $E_B'$, then receives the identification signal—a negative pulse which later serves to block the sub-carrier modulator during the "back porch" period, as already explained. At this point the low-frequency components of the red and blue signals are selected by means of a band-pass filter, these components being called $E_r$ and $E_b$. The resultant chromaticity signal, $E'_C$, has the value $E'_C=0.07+0.18$ ($E_r$ or $E_b$), and is applied to the sub-carrier modulator. If the sub-carrier frequency is $f_s$, then the modulated sub-carrier signal is $E'_C \cos 2\pi f_s$. This output from the modulator is finally superimposed on the luminance signal $E'_Y$, as already mentioned, to give a total video signal $E'_T=E'_Y+E_C' \cos 2\pi f_s$, the actual frequency spectrum of which is shown in Fig. 1. The complete video signal is then, of course, passed to the modulator of the television transmitter.

## The Receiver

At the receiver the signal $E_T'$ is obtained at the output of the video detector, and here the problem is to reconstitute from this the three signals $E_R'$, $E_G'$ and $E_B'$ in their original simultaneous form. In order to do this two special expedients are necessary. The first is the storage principle mentioned earlier. The second arises from the method used of transmitting a narrow-bandwidth colour signal so that for very fine detail the colour information is suppressed and only luminance information is available. Although the transmitted colour signals provide only low-frequency information, as far as the viewer's eye is concerned, it is possible to reconstitute in effect the original $E_R'$ and $E_B'$ full-band signals by adding to $E_r$ and $E_b$ suitable proportions of the high-frequency components of the luminance signal $E'_Y$. This is the well-known principle of "mixed highs."

Fig. 3, then, shows the block schematic of the receiver in which these expedients are incorporated. Considering first the luminance channel, the total video signal $E_T'$, obtained from the output of the video detector, is first of all passed through a luminance amplifier and then through a subtraction matrix. Here suitable proportions of the reconstituted $E_R'$ and $E_B'$ signals are subtracted from the luminance signal $E_Y'$ in order to recover the green signal $E'_G$, as already explained, which is applied to the green electron-gun of the tri-colour tube. Also from the $E_T'$ signal, a filter is used for extracting the high-frequency components of the luminance signal, which will be designated $e_y$, and the colour sub-carrier. The sub-carrier is amplified and detected so as to recover $E'_C$, and the colour identification signal is taken out to control the switching generator.

Electronic switch No. 1 directs the $E'_C$ signal alternately at line frequency into two channels, which thereby become identified as red and blue channels. The signals in these channels are, of course, discontinuous, but by means of the storage technique mentioned earlier the gaps are filled in with repeated information. This is the purpose of the delay line, which is adjusted to the exact duration of a scanning line. By means of the second electronic switch it feeds in parallel the red and blue channels so as to fill in the gaps produced by the first switch. In this way continuous red and blue signals are obtained.

Finally, the continuous signals are passed through adding circuits, where the high-frequency components of the luminance signal, $e_y$, are added to them, and then to the appropriate electron-guns of the tri-colour tube. The actual value of $e_y$ here corresponds to the following combination of high-frequency components of the original red, green and blue signals: $e_y=0.59\ e_g + 0.30\ e_r + 0.11\ e_b$. From this it can be shown that if the subtraction matrix is adjusted to obtain the linear combination $1/0.59\,[E'_Y - 0.30\,(E_r + e_y) - 0.11\,(E_b + e_y)]$ then the required green signal $E_g + e_y$ is obtained correctly.

Regarding the picture quality of the system, it has been mentioned that the vertical colour definition for a complete picture is reduced by a half on account of the time-division multiplex method of transmission. On the other hand, one can see that the vertical information is completely preserved if four successive frames are assembled for the construction of a picture. (It will be realized from earlier remarks that whereas the luminance information is interlaced in the normal 2 : 1 fashion, the chromaticity information, because of the breaks introduced by the sampling at line frequency, is interlaced 4 : 1.) Consequently, the designers say, it is difficult to give an exact figure for the vertical colour definition. Moreover, the situation is complicated by the

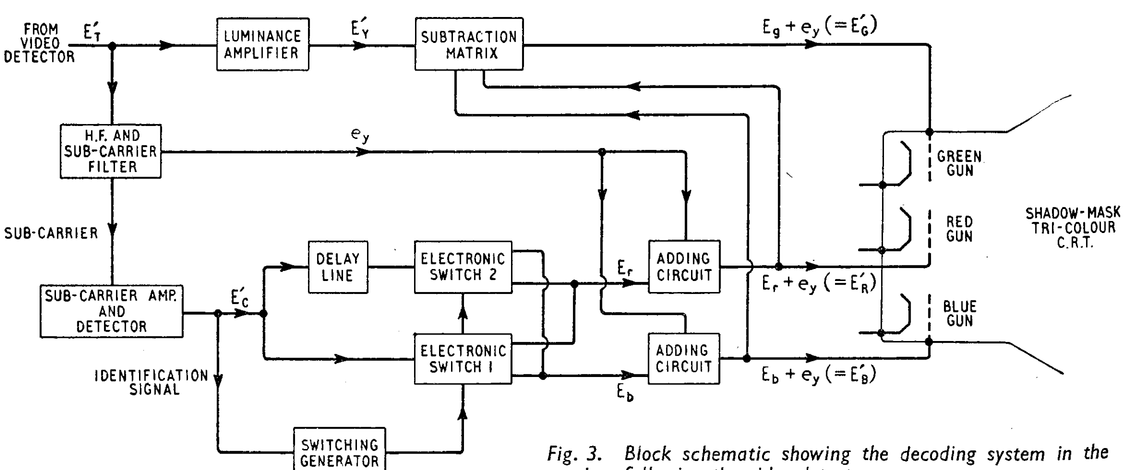



*Fig. 3. Block schematic showing the decoding system in the receiver following the video detector.*

fact that in the receiver each set of chromaticity information is displayed on two successive lines of a frame (e.g., line 1 and line 3) as a result of the storage technique, giving in effect one "thick" line as might be obtained by spot-wobbling. The associated effect, of "mixing up" slightly uncorrelated red and blue information along each line, may also affect the horizontal definition, depending on the nature of the subject being transmitted. At any rate the designers estimate that the vertical colour definition is still a good deal better than that obtained horizontally, and is probably in the region of 350 lines.

At the demonstration witnessed by *Wireless World*, the subject material consisted of slides, film, a monochrome test card and colour bars. The received colour picture was shown on an R.C.A. 21-inch shadow-mask tube, and a compatible monochrome picture on a 17-inch tube. In addition, the original $E'_R$, $E'_G$, $E'_B$ picture, as it appeared before transmission, was displayed on a 15-inch R.C.A. shadow-mask tube for comparison purposes.

The received colour picture was in many respects very fair, and compared favourably with the $E'_R$, $E'_G$, $E'_B$ picture, although both were somewhat desaturated. The subjective impression of horizontal resolution was inferior to that of a 405-line system at its best, although the test card showed the limiting resolution to be higher than 500 lines (on the monochrome receiver). It was perhaps as much as 10 dB down at 400 lines but trailed on up to 600 lines or more as a limit. Since the R.C.A. tube will not resolve more than 400 lines the picture appeared in colour to be somewhat soft. There was a colour error on the received picture in that small areas of high contrast tended to go green. This was said to be an instrumental fault and not an inherent feature of the system. Otherwise the colour picture was quite good and not very noisy.

The compatible monochrome picture broke up into 405 lines interlaced in areas of saturated colour but this was obvious only on colour bars or on close inspection of normal pictures. Line strobing effects were visible on the monochrome display but were completely cured in the colour receiver by the delay-line storage system. As demonstrated, a reverse compatible picture turned out to be pure green, but a receiver would normally have a switch to connect all three tube grids together when colour was not being radiated.

On the whole the system is probably capable of giving similar performance to that of the N.T.S.C. system on 819 lines. It would probably be inferior if applied to 405 lines on account of the 200-line break-up which would occur on the monochrome display in saturated regions. From the engineering point of view, it is not so elegant as the N.T.S.C. system. The colour receiver is certainly simpler and less critical in operation than an N.T.S.C. receiver, and requires extra valves only for the amplification and detection of the sub-carrier, for the electronic switching and for the operation of the delay line. Moreover, some of the adding and subtracting operations shown in Fig. 3 can be achieved in the grid-cathode sections of the c.r. tube, thereby obtaining a further simplification. On the other hand, the delay line itself is a very expensive item to manufacture, and as a result the total cost of the colour set is likely to be about the same as that of an N.T.S.C. receiver.

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# LETTERS TO THE EDITOR

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

## *Gramophone Reproduction*

I AM grateful for the clear statement by E. S. Mallett (August issue) on the components of the tracking weight, even if it makes the design of the proposed pickup more difficult.

It might still be possible to design a pickup with the desired tracking weight, if the lateral and vertical stiffness components are made very low compared with the lateral inertia, which should be fairly easy to arrange (the inertia being already near the practical limit). The head weight should be as high as possible, consistent with playing slightly warped records, so that the low-frequency vertical resonance is as low as possible, thus reducing the vertical lift, described by Mr. Mallett, to a minimum. The chief practical difficulty is that in reducing the vertical stiffness of the cantilever, care must be taken to avoid torsional resonance, and this may necessitate an oval tubular cantilever.

In passing, Mr. Mallett remarks that the vertical inertia is unimportant, not because it is not operative but because its contribution to the tracking weight is small. The implication is, presumably, that although the low- and high-frequency vertical resonances may be outside the recorded range, there is a vertical mid-frequency resonance, analogous to the lateral mid-frequency resonance, which does not affect frequency response, but below which frequency stiffness is operative, and above, inertia. This resonance would be that of the vertical effective mass at the stylus with the vertical cantilever compliance, and in any practical design will fall within the audio range. As there is no positive record groove drive downwards, the stylus will fail to follow the vertical motion above this frequency, and needle talk and second harmonic distortion will be produced, perhaps combined with general irregular movement of the stylus, as it will no longer be in contact with both groove walls at all times. In existing pickups, the resonance will not be higher than about 10 kc/s, corresponding to a lateral trace frequency of 5 kc/s. The needle talk will presumably be above 10 kc/s and may, therefore, be largely inaudible, although proper tracing is not obtained. I had suspected previously that this was the case and, if correct, it means that correct tracing with the stylus always in contact with both groove walls can never be obtained (although damage may be largely eliminated). The alternative is to use a very high vertical stiffness to drive the resonance up to 40 kc/s; this means increasing the tracking weight up to 4 gm or so, regardless of how small the other components of the tracking weight may be.

I am glad that Mr. Mallett agrees that tracing distortion due to over-modulation is by far the worst distortion in record reproduction. It is a sad commentary on commercial records that many record lovers prefer certain pre-war recordings to modern pressings, because of lower tracing distortion.

If all this gives a depressing picture, it should be remembered that the solution is comparatively simple—impressed groove records with less high-frequency pre-emphasis.

With reference to Mr. Voigt's letter, I am pleased to note that his company, and presumably others, did not play the original wax before processing. The general principles of record production are well known, but the actual details are not, so that authoritative statements like Mr. Voigt's are to be welcomed. My impression that monitoring of the wax was usual was heightened by an actual case where I am told that this occurred. However, if it is pleasing to know that the originals are not monitored, it is disconcerting to learn, as I have done recently from Mr. C. E. Watts, that it is very difficult to find a pressing, itself unplayed, which does not show signs of playback at some stage of manufacture—impressed tracks with piled-up edges can be seen at extremes of acceleration, indicating that the fully plastic range has been reached or approached. The desire to monitor at various stages of manufacture is understandable, but the damage could be avoided by the use of thorn or plastic styli. In this connection, Mr. Briggs ("Sound Reproduction," Third edition, p. 311) refers to the playing of metal matrices with sapphire and diamond styli.

Banbury. D. A. BARLOW.

## Colour Television Aerials

MANY local authorities have decreed that only indoor aerials of certain narrowly specified types shall be permitted for television reception in their Council estates. If this restriction is to be held in force for colour television, it will obviously have a big influence on the choice of a system—always presuming, of course, that the future colour service really is intended for mass consumption. The N.T.S.C. system, for example, does not show up at all well under conditions of severe or even moderate "ghosting."

Perhaps the B.B.C. would like to demonstrate the N.T.S.C. system to the Television Advisory Committee in the "Dockland" areas of London, using indoor receiving aerials of this kind?

London, N.7. O. G. MINTER.

## Picture Quality

YOUR correspondent, S. Gould (July issue), has unconsciously put his finger on a great truth. He stated that tests he has carried out show that home movie viewers demand a larger minimum size of screen for colour pictures than for black and white. He adds that this fact indicates a way to pull colour TV out of the doldrums.

The truth of the matter is this: the nearer any representation approaches reality, the more critical the viewer becomes. This is shown forcibly in the attitude taken by viewers of stereo photography. If an ordinary black-and-white print of rippling water is shown, it is accepted readily, and may even be praised on the grounds of atmosphere, texture, etc. If, however, a colour stereo photograph of a similar subject is shown, the viewer's reaction is unfavourable, and the inevitable remark is made about the water's looking "frozen" or like "jelly."

This is clearly because the stereo photograph is so nearly real, i.e., it has colour, depth and actual size (if viewed in a properly constructed viewer) that the idea of immobile rippled water can no longer be accepted. The same argument applies to stereo photographs of any subject involving movement.

This principle will also operate with colour TV, which is one step nearer reality than black and white, but in this case the size and depth are wanting, instead of the movement. An improvement would be an increase in picture size, and this was found by the viewers mentioned by Mr. Gould to be more acceptable.

London, W.14.

E. W. ELLIOT.

## Picture Height

I DISAGREE with "Diallist" and "Free Grid." I think the height of a console television receiver is just right. To look *up* at a picture soon makes one's neck ache.

"Free Grid" says the television receiver of the future will be of the projection type with the tube and associated equipment built into one wall and the screen in the opposite wall.

And shutters over the windows to darken the room? Amateur cinematographers will assure you that the picture on the screen from even the most powerful projector lacks brilliance, unless the room is really dark.

Hounslow.

O. V. WADDEN.
Wadden & Hill, Ltd.

## Picture Resolution

AS a user of a large-screen forward-projection television receiver I read Mr. Jesty's article in the July issue with very great interest. I have a simple method of improving the disparity between horizontal and vertical resolution. A simple change of aspect ratio by reducing the frame amplitude gives picture dimensions more in keeping with those becoming increasingly adopted in the cinema and gives a very acceptable compromise between lininess and disproportion.

It seems likely that a change of proportion in a rectangular tube is a simpler proposition than increasing time base frequency. Also existing receivers will still obtain an acceptable picture and can be brought to standard at a time of tube renewal. Obviously a change of time base frequency would render conversion imperative and we are none too sure of the difficulties or expense of modification.

London, N.2. I. G. ABELSON.

## Cleaning a File

"DIALLIST" has blotted his copybook at last (in the July issue). Nothing will ruin a file quicker than scrubbing it with a "file card"; the finer the file the quicker its destruction.

The "claws" of a file card are made of spring steel, and the fine cutting edges of a file are rapidly blunted by it.

The correct way to clean a clogged file is to take a piece of metal—preferably brass—some half-inch or so in width and of any thickness and convenient length, and push it across the width of the file at an angle of about 30 degrees; after the first stroke or two the corner of the brass assumes a contour identical with that of the file teeth, and it is then capable of removing every vestige of clogging material. It is true that there are difficulties where files other than flat files are concerned, but they are not insuperable.

Wimborne. R. F. EAGLE.

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**"88-50" Pre-amplifier.—A Correction.** The British Standard referred to in the footnote on page 316 of the July, 1957, issue is Amendment No. 1, July, 1954, to B.S. 1568:1953 (not B.S. 1968).

# More About Potential

*By "CATHODE RAY"*

APPLICATION TO SEMICONDUCTOR THEORY

LAST month we set out to discover the principle underlying the construction of the potential diagrams commonly used to show how transistors work. We got no further than considering what potential means, and how it comes about that potential diagrams with their hills and valleys make such good mechanical models of electrical devices. The reason is that potential and height are so closely analogous that it is possible for the same definition to cover both. Just as a mass in a gravitational field experiences a force proportional to the height gradient, so a charge in an electric field experiences a force proportional to the potential gradient. Because "positive" is conventionally regarded as "up" and "negative" as "down," and like charges repel, the force on positive charges is "downwards." So they are analogous to masses in the gravitational analogy. Negative charges on the contrary "fall" upwards, like gas-filled balloons.

We saw, too, why equipotential lines, analogous to map contour lines, are everywhere at right-angles to lines of force, which are used to mark the directions along which a field acts.

Since field strength in any direction is proportional

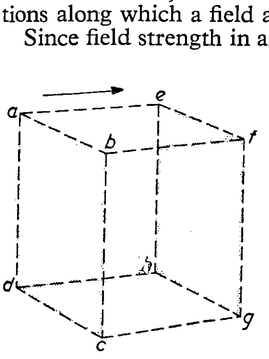


*Fig. 1. This is a small cube marked out in a parallel electric field, in such a way that the edges ae, bf, etc., lie in the direction of the field. If the amounts of field passing through the two shaded faces are unequal, the cube must enclose a charge.*

to (and therefore, with a suitable choice of units, equal to) potential slope in that direction, it is easy to draw a graph of field strength, given a graph of potential. In fact, the idea of slope is so familiar—in connection with valve characteristics, for instance—that one hardly needs to draw a separate graph just in order to see how the field strength varies. The only catch is that by convention the field is positive in any direction when it urges a positive charge in that direction. So it is positive *down* a potential slope. Consequently the field strength is reckoned as equal to *minus* the potential slope.

To solve our problem, however, we have to know how potential is related to the charges giving rise to it. The clue to this is that charges are the starting and finishing points for the imaginary lines of force representing the field. So if an intelligent microbe taking its daily walk happened to notice that the number of lines of electric force lying alongside its path increased at the rate of $n$ for every millimetre of the journey it would conclude that it was moving through a space charge of $n$ units per millimetre. Of course, such a conclusion would only be valid if all the lines of force were lying parallel with the microbe's path, and its range of vision extended a definite distance all around at right-angles covering an area of say one square millimetre. Then the increase in lines of force per millimetre of path would be a measure of the space charge density per cubic millimetre.

## Charge and Field Strength

If you reject the idea of intelligent microbes counting lines of force, on the ground that such microbes are imaginary, I would say yes, no wonder, for the lines of force are imaginary! I only brought them in because so many people seem to find it difficult to visualize fields without them. It would be better to refer to Fig. 1, showing a millimetre cube marked out in a parallel electric field having the direction *ae*. We could rightly say that if the field strength at the face *abcd* was $E_1$ and that at *efgh* was $E_2$, then the charge inside the cube must be $E_2 - E_1$ units. Note that this specifies the polarity of the charge, because conventionally the direction of the field (which in this case is from *abcd* to *efgh*) is from positive to negative. So if more were entering *abcd* than was emerging from *efgh* it would be because the charge inside the cube was negative. This is what the formula would indicate, for if $E_1$ was greater than $E_2$ then $E_2 - E_1$ would be negative.

On the average, then, the space charge density is proportional to (and therefore, with a suitable choice of units, equal to) the rate of change of electric field strength, or what we might call field slope or gradient through the space. Remember, we are confining our attention to parallel fields, because if the field were converging or diverging some of it would pass through the sides of the cube in Fig. 1 and upset the reckoning.

The interesting conclusion from all this is that charge is related to the field it creates in the same sort of way as the field is related to the potentials it sets up. Take the simplest possible example: the uniform field between the two parallel plates of an air capacitor. Fig. 2(a) shows an enlarged view of a sample; somewhere well inside, so as to be clear of edge effects. The thin horizontal lines represent the field, and their direction shows that the left-hand plate is charged positive. Because the field is parallel and there are no charges in the space, its strength

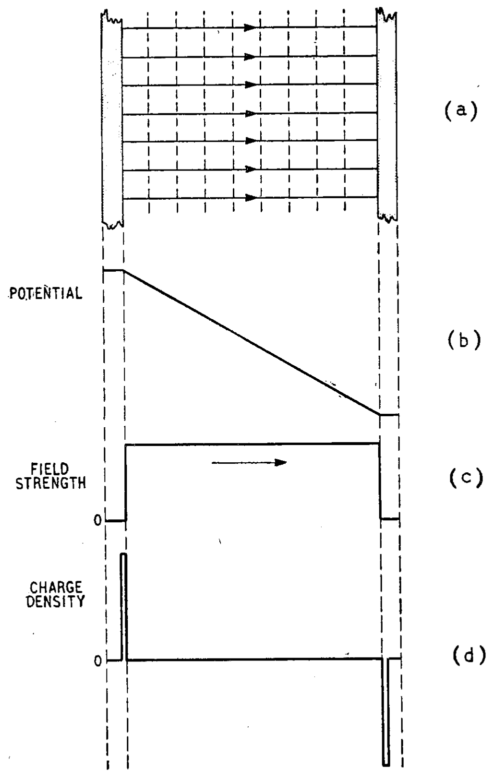


*Fig. 2. Enlarged view of some of the space between parallel capacitor plates (a), with graphs of potential (b), field strength (c), and charge density (d). The arrow in (c) is to show that the field is being reckoned from left to right.*

is the same everywhere in that space. This means that the potential gradient is the same everywhere, which is indicated by drawing the dotted equipotential lines at equal intervals all the way across. If these lines represent 10-volt intervals, we see that the capacitor must be charged to 90 volts.

We can easily draw the various graphs: (b) is the graph of potential, which is derived from the equipotential lines in (a) exactly as a section is derived from a contour map. There are, of course, no appreciable differences of potential inside the metal plates themselves. There would not be much point in marking a zero level on this graph unless we wanted to indicate the potentials relative to earth; the main thing is the p.d.—the difference between upper and lower levels.

A zero mark is needed for the field-strength graph (c) however, because (b) tells us where the field is zero—inside the metal. Since the field strength is reckoned as minus the potential gradient, which in this case is downwards from left to right, and constant, it is positive and constant. (If we reckoned from right to left, the potential gradient would be up, so the corresponding field-strength graph would go negative, indicating the negative field from right to left. That is the reason for the left-to-right arrow.)

Lastly, the charge. The only places where the field strength has any gradient at all are the inner surfaces of the plates, and there it is very steep indeed—apparently infinite. That represents the fact that the opposite charges, being attracted to one another, crowd on to those inner surfaces, so the charge density is very great. It cannot be infinitely great, however, because charges of any one kind repel one another, so they do spread out a little. The steep upward gradient on the left of (c) calls for a large positive charge there, and the downward one on the right a large negative charge, as shown at (d). (The *same* result would be obtained from a right-to-left *negative* field graph.)

Now let us take an example of a space charge. Suppose the potential graph for the space was Fig. 3(a). Here the downward gradient at first is zero, increases steadily to a maximum midway, then decreases steadily to zero again. Plotting minus this gradient at (b) shows the field strength from left to right.

The gradient of (b) is positive and constant from left to midway, and negative and constant from midway to right; when plotted this indicates the distribution of charge in the space (c).

## Potential by Trial and Error

This two-stage gradient method enables the charge distribution corresponding to any potential pattern to be found quite easily. Our problem, however, is precisely the reverse: knowing the distribution of charges, to derive the potential diagram. (The reason for wanting the potential diagram, of course, is that it makes a good mechanical model for giving an idea of how loose charges would tend to move. Fig. 3(a), for example, would show that if the charges represented at (c) were free to move they would tend to mix up, positive going to the right and negative to the left.) In general it is more difficult to work backwards; in fact, it really amounts to trying various potential patterns until one is found that agrees with the given charge distribution.

Mathematical readers may be boiling over by this time, having long ago realized that in their language the charge density is given by minus the second differential of the potential, and the potential is minus the second integral of the charge density, so if the potential variation is given as an equation one need only differentiate twice and reverse the sign to get

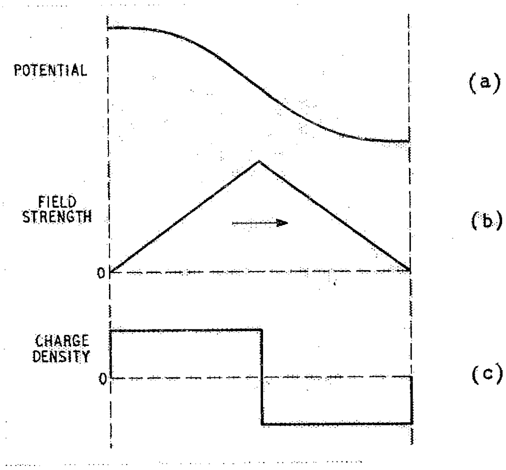


*Fig. 3. These graphs apply to a situation where the only charge is in the space.*

the equation of charge density, and given the equation of charge density one need only integrate twice and reverse the sign to get the equation of potential. The fact that the latter process can, by making use of well-known rules, often be accomplished is not really inconsistent with what I said about its being by trial and error, for this is how the well-known rules were originally found. Familiarity with the differential and integral calculus* makes everything we have done so far absurdly easy. The sorts of distribution likely to arise in elementary theoretical explanations of semiconductor phenomena are so few and simple, however, that even those who know nothing of the calculus should have no difficulty in dealing with them as we have been doing.

The first example showed that an abrupt change in the potential gradient indicates a charge concentrated on a surface at right-angles to the direction chosen for graphing. (Incidentally, it is really superfluous to specify the surface in this way, for the direction chosen for graphing is along the lines of force, and because a highly conducting surface is necessarily an equipotential surface these lines are bound to emerge at right-angles to it.) The second example showed that a gradual change in potential gradient means a distributed or space charge in that region.

These examples also show that where the potential graph is convex (i.e., sticking out) upwards the charge there is positive, and where downwards it is negative.

## Uniform Clouds of Electrons

Suppose the space between two parallel plates is filled with a uniform cloud of electrons, so that the charge graph is as in Fig. 4(c); what does the potential graph look like? The field graph must have a gradient that is constant and negative, so must look like Fig. 4(b). But we don't know where its zero level is. The reason for that is lack of information about the difference of potential between the plates. Let us suppose the plates are uncharged; then the charge pattern is symmetrical and the field is zero at midway, as shown. Finally, the potential graph (a) must be such that its gradient starts at maximum downwards, levels out midway, and returns to maximum upwards at the right. The mathematicians will tell us that the required shape is a parabola—a square-law curve. And to comply with our assumption it starts and ends at zero. Note that at these points the potential graph is abruptly convex upwards, showing that there is a positive charge on the inner surfaces of both plates, attracted there by the negative space charge. The graph also shows (if we didn't know already) that negative charges in the space are attracted towards the plates, so even if the assumed distribution shown at (c) were achieved it couldn't last for a moment; the electrons would instantly disperse towards the plates.

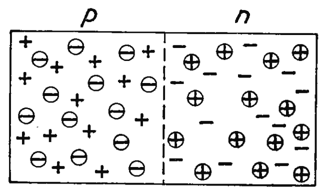


*Fig. 5. Usual kind of diagram showing the sorts of mobile and fixed charges in a p-n junction.*

The situation inside solids such as semiconductors is complicated by a framework of fixed charges. In *n*-type germanium, for instance, there is a space charge of electrons, but this charge is neutralized by the equal number of fixed positive charges constituted by the atoms from which the electrons have become detached. So unless one works on such a magnified scale that account is taken of individual atoms and electrons, one sees no charge density, so no field and no potential differences. This situation is shown diagrammatically on the right-hand side of Fig. 5. In *p*-type germanium it is the loose charges that are positive ("holes") and the fixed ones are negatively charged atoms, as on the left-hand side.

When a single crystal of germanium comprises *p* and *n* regions, as in Fig. 5, representing a junction diode, the uniform distribution shown there does not last. Because the piece is all one crystal, the dotted line exists only on the diagram and means nothing to the electrons and holes. In their random movements, some are sure to cross it unawares. Directly a hole does so it leaves behind in the *p* region an

* For a simple introduction, see Chap. 27 of "Second Thoughts."

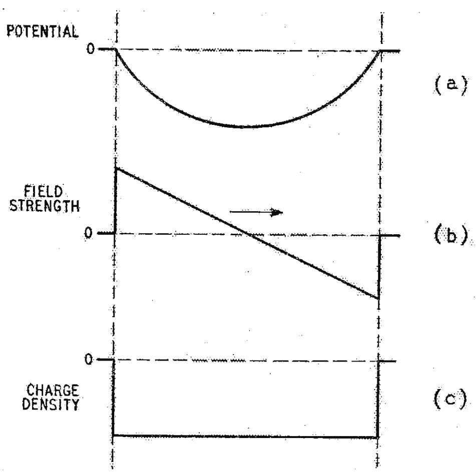


*Fig. 4. Another example of space charge, this time all of one polarity—negative.*

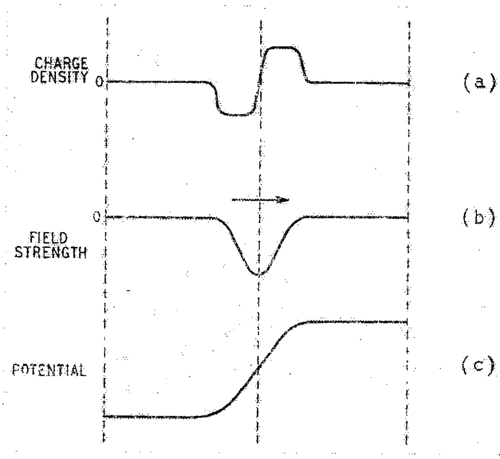


*Fig. 6. Graphs applying to Fig. 5 after the mobile charges near the boundary have migrated and built up a potential difference.*

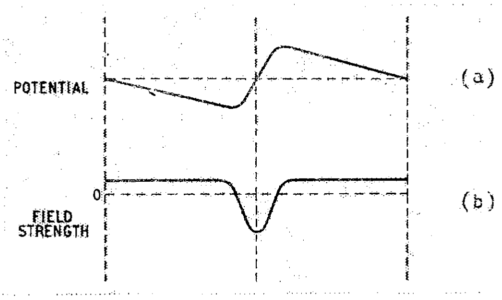


*Fig. 7. If Fig. 6 (c) is modified to bring the terminals to the same potential, the effect on 6 (b) is as shown, and there is no need to modify 6 (a) at all.*

unpartnered negative charge. Similarly, electrons straying across the line leave behind in the *n* region some positive charges, which are augmented by the immigrating holes. The result is net positive charge on the *n* side of the border and a negative charge on the *p* side, as shown in Fig. 6(a).

## Potential Cliffs

According to another way of looking at it, holes crossing the boundary cancel out electrons there, leaving only the immovable positive charges; and similarly a belt of immovable negative charges is left on the left. Of course, the potential cliff thus created, and shown at (c), tends to prevent any further transfer of movable charges either way. A balance is reached when the height of the cliff has reached rather less than a quarter of a volt in germanium, and in silicon rather more.

Fig. 6(c) makes it look as if the terminals of the junction would be at different potentials, so that a current would flow from *n* to *p* if joined by a wire. I have been unable to detect any p.d. however, using a valve voltmeter with an extremely high input resistance. If one assumes that the potential curve is like Fig. 7(a), so that there is no terminal p.d., the field curve (b) is practically the same except for being shifted bodily upwards, and this difference doesn't come out at all in the charge curve, so the same distribution of charges would cover Fig. 7(a).

When an external voltage is applied, if it makes the *n* end positive it increases the height of the potential cliff, ensuring that no current can cross the boundary. The only charges having the correct polarity to respond to the applied voltage are fixed, so cannot flow. If the *p* end is made positive, the cliff is lowered, so mobile charges flow both ways and carry a continuous current.

This story takes no account of what are called minority carriers—the electron and hole pairs released by heat and light energy regardless of whether the semiconductor is *p* or *n* type. The p-n junction action as described would nearly fit the facts if the material was at a very low temperature. But at normal room temperature—and still more so when heated up—there are appreciable quantities of free electrons in the *p* region and holes in the *n*. These tend respectively to slide up and down the boundary cliff, causing a flow of current even when external voltage is applied in the direction that would otherwise stop current altogether. So a junction diode passes a certain amount of "reverse" current, and that amount increases steeply as the temperature is raised.

But this is not supposed to be a treatise on semiconductor physics; the only object is to enable such treatises to be followed more intelligently. The thing to do now. therefore, is to re-read one and see if it is any clearer. If not, let me know and I'll try to do better next time.

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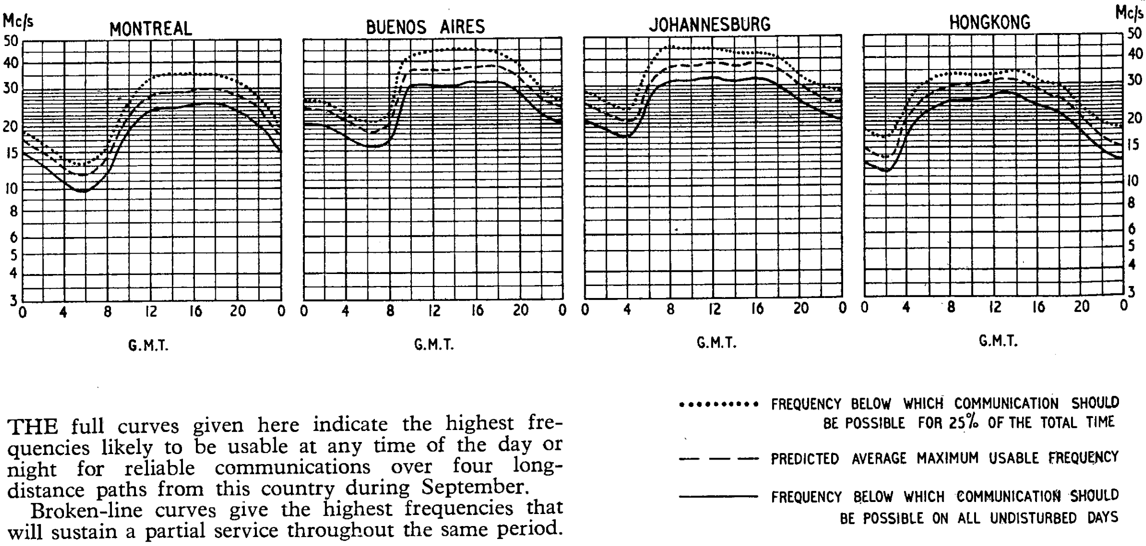
# SHORT-WAVE CONDITIONS

*Prediction for September*




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 September.

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

# How Little Distortion Can We Hear?

## Effects of Ear Distortion and Masking

*By M. LAZENBY, M.A.*

IN this article the smallest amount of non-linear distortion that can be detected by ear is calculated from known non-linear hearing effects. The result is compared with the directly measured value. The method of calculation is to determine the extent to which non-linear hearing effects produced by the fundamentals will hide any distortion products which may also be present.

This concealment may occur in two ways. In the first place the usual spurious frequencies produced by non-linearity are produced in hearing. Secondly, the fundamental raises the hearing threshold level for other frequencies where distortion products may be present. The original threshold level, and the extent to which this level is raised by noise present even in very quiet surroundings must also be taken into account. When the hearing of one frequency raises the threshold level for another, the latter frequency is said to be "masked".

**Masking Effects: Harmonic Distortion.** It is convenient to consider threshold level effects first. The various results obtained for the increase in the threshold level produced by a given frequency may be summarized approximately as in Fig. 1 for fundamental frequencies between 400 and 4000 c/s (0 dB corresponds to the standard sound pressure of $2 \times 10^{-4}$ dynes/cm$^2$). It is necessary to consider also the increase in the threshold level caused by harmonics produced in hearing. However, from results on the level of these harmonics given later, it can be shown that for second and third harmonics the level is raised less due to harmonics produced in hearing than due to the fundamental. (This may not be the case for the higher harmonics, particularly at high fundamental levels.)

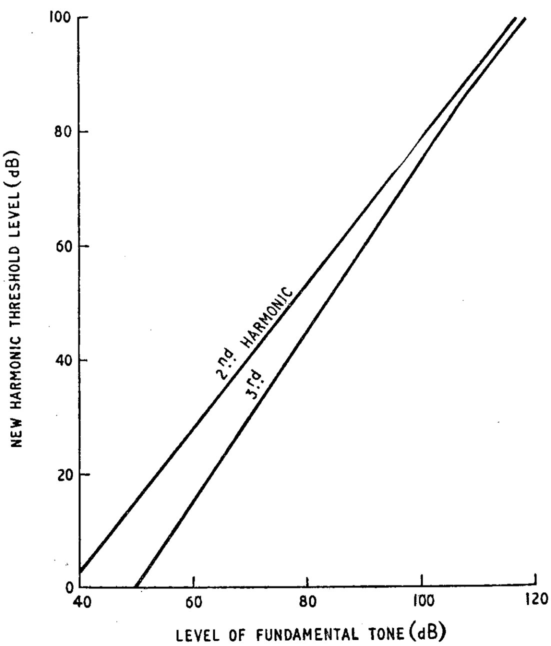



*Fig. 1. Change in threshold level produced by fundamentals between 400 and 4,000 c/s.*

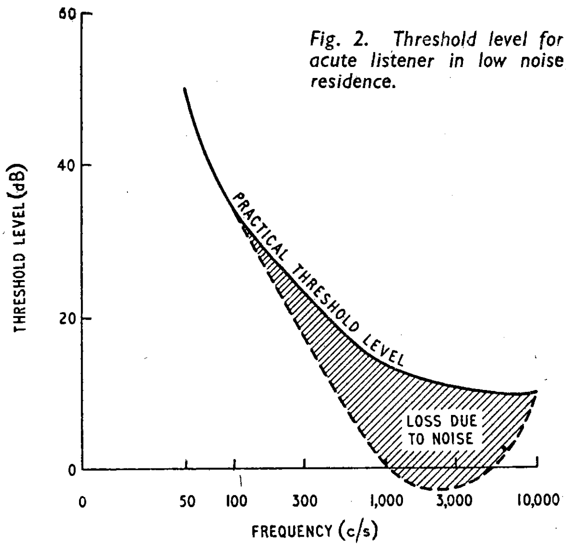



*Fig. 2. Threshold level for acute listener in low noise residence.*

It is necessary to know also the practical threshold level in the absence of any applied sound. This is given in Fig. 2 for a person with very acute hearing, in a very quiet residence (total noise level only 33 dB).[1] The increase in the threshold level produced by the masking action of the noise which still remains even in these circumstances is also illustrated in Fig. 2. For frequencies between 400 and 10,000 c/s the threshold level is between 10 and 20 dB.

From data given by Sivian and White[2] the threshold level in the absence of noise is $\approx 10$ dB lower for binaural listening. However, because of the masking effect due to noise (illustrated in Fig. 2) the practical threshold level of Fig. 2 will also apply to binaural listening for frequencies above 100 c/s. Below 50 c/s the results of Ref. 2 indicate that this effect of binaural listening disappears.

Any harmonic distortion present in the applied signal will not be detected unless it is above the actual threshold level under the conditions of detection. For this threshold level we must take the raised level produced by the fundamental (given in Fig. 1), or the original level (given in Fig. 2), whichever is the greater. Considering threshold level effects only, we thus obtain the minimum level of harmonic distortion which can be detected. By comparing this with the fundamental level, the smallest detectable percentage distortion is obtained. For example, at a fundamental level of 60 dB the raised threshold level for the second harmonic is 28 dB, from Fig. 1. This is greater than the initial threshold level of 10 dB. The smallest detectable second harmonic distortion at a fundamental level of 60 dB is thus $60-28=32$ dB down on the fundamental. This corresponds to a distortion voltage of $(\text{antilog}_{10} 1\cdot 6)^{-1}$ of the fundamental, i.e. 1/40 of the fundamental, i.e. $2\frac{1}{2}\%$. The complete results are shown in Fig. 3 for both 10- and 20-dB no-signal threshold levels.

At frequencies lower than 800 c/s the smallest detectable distortion will increase for two reasons. In the first place, from Fig. 2 the initial threshold level is higher at such frequencies. When this higher threshold level is used in Fig. 3 the smallest detectable distortion is increased. Secondly, the few available data on the masking produced by low frequencies indicate that this is also greater.

For masking frequencies above 4000 c/s the few available data indicate a decrease in the masking. However, the threshold level in the absence of any applied sound increases above 10,000 c/s (which is the second harmonic of 5000 c/s). Thus it is not clear what will happen to the smallest detectable distortion. In any case the harmonics will pass outside the audible range for fundamental frequencies greater than about 8000 c/s.

**Relation Between Harmonic and Intermodulation Distortion.** To extend this analysis to intermodulation distortion it is necessary to discuss the relation between such distortion and harmonic distortion, following Warren and Hewlett.[3] Supposing for simplicity that the distorted transfer characteristic has only square and cube-law distortion terms, we may put $e_o = a_1e_{in} + a_2e_{in}^2 + a_3e_{in}^3$, where $e_{in}, e_o$ are the sine wave input and output voltages respectively, and $a_1, a_2, a_3$ constants. $a_2e_{in}^2$ and $a_3e_{in}^2$ are the square and cube-law distortion terms respectively. Considering only two intermodulating sine wave signals we can write $e_{in} = A\sin a \pm B\sin b$. Evaluating $e_o$ we find

$$\begin{aligned} e_o = {} & A\,(a_1 + {}^3/_4a_3(A^2+2B^2))\sin a - \frac{A^2a_2}{2}\cos 2a \\ & -\frac{A^3a_3}{4}\sin 3a \\ & \pm B(a_1 + {}^3/_4a_3(2A^2+B^2))\sin b - \frac{B^2a_2}{2}\cos 2b \\ & \pm\frac{B^3a_3}{4}\sin 3b \\ & \pm ABa_2(\cos(b-a)-\cos(b+a)) \\ & \mp\frac{3A^2Ba_3}{4}(\sin(b-2a)+\sin(b+2a)) + \frac{3AB^2a_3}{4} \\ & (\sin(2b-a)-\sin(2b+a)) \end{aligned}$$

Considering harmonic distortion, in this simple case the square-law distortion term gives rise only to second harmonic distortion, and the cube-law term only to third harmonic distortion. Considering intermodulation distortion the square-law distortion term gives rise to intermodulation products of frequencies $f_1 \pm f_2$ only, and the cube-law term to frequencies $2f_1 \pm f_2$, $f_1 \pm 2f_2$ only, where $f_1$, $f_2$ are the input frequencies ($a=2\pi f_1t$, $b=2\pi f_2t$).

The analysis is simplified if we confine it to cases where only one type of distortion (square or cube-law) is present. This is not in practice a great restriction. Square and cube-law distortion alone

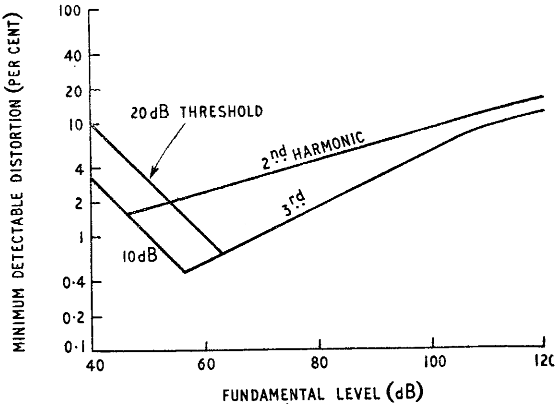



*Fig. 3. Smallest detectable distortion (considering threshold level masking) for fundamentals between 400 and 4000 c/s.*

occur to a fair approximation in single-ended and push-pull amplifiers respectively.

Using the subscripts $h$, $i$ for the particular values of A, B when considering harmonic or intermodulation distortion respectively the harmonic distortion *fraction* of the fundamental divided by the intermodulation distortion *voltage* at any one frequency is equal to

$$\frac{1}{a_1}\cdot\frac{A_h}{2A_iB_i} \text{ or } \left[\frac{1}{a_1}\cdot\frac{A_h^2}{3A_i^2B_i} \text{ or } \frac{1}{a_1}\cdot\frac{A_h^2}{3A_iB_i^2}\right]$$

considering square or cube-law distortion alone respectively. (This assumes that ${}^3/_4a_3(A^2+2B^2)$ and ${}^3/_4a_3(2A^2+B^2)$ can be neglected in terms of $a_1$. This will usually be possible in practice.) The relative magnitudes of different types of distortion will be significant if the same peak input voltage is applied in each case, i.e. if $A_h = A_i + B_i$. Thus, for equivalent distortions, the harmonic distortion fraction of the fundamental divided by the intermodulation distortion voltage at any one frequency is equal to

$$\frac{1}{a_1}\cdot\frac{A_i+B_i}{2A_iB} \text{ or } \left[\frac{1}{a_1}\cdot\frac{(A_i+B_i)^2}{3A_i^2B} \text{ or } \frac{1}{a_1}\cdot\frac{(A_i+B_i)^2}{3A_iB_i^2}\right]$$

considering square or cube-law distortion alone respectively.

From this particular analysis we can convert intermodulation distortion data to harmonic distortion data and vice versa. Distortion figures for audio systems and the smallest detectable distortion have generally been given in terms of harmonic distortion, even if it is the equivalent intermodulation distortion that is fundamentally concerned. Moreover we are considering intermodulation arising practically. In this case the intermodulating frequencies and amplitudes may not be the standards for intermodulation distortion measurement. Thus we shall continue to refer to the equivalent harmonic distortion even though we will be concerned with the intermodulation frequencies produced at the same time by non-linearity.

**Masking Effects: Intermodulation Addition Frequencies.** We can now return to the smallest detectable intermodulation distortion. Considering only square and cube-law distortion, the addition frequencies arising in intermodulation distortion ($f_1+f_2$, $2f_1+f_2$, $f_1+2f_2$) lie between one and three times the higher fundamental frequency. Now the masking decreases fairly uniformly between one and three times the masking frequency. Thus the method used to obtain the results of Fig. 3 can also be applied to the *addition* frequencies arising in intermodulation distortion. In cases where a *difference* frequency lies between one and three times one of the fundamental frequencies the same reasoning will also apply. The amount the threshold level is raised in these circumstances will depend both on the ratios of the intermodulation product frequency to both fundamental masking frequencies, and on the amplitudes of these fundamental frequencies. Thus there are too many variables to allow calculation of the results in a simple form.

Certain facts however suggest the conditions under which the smallest detectable addition intermodulation distortion is a minimum. Suppose that, due to masking, the threshold voltage level at an addition frequency becomes $T_a$. The smallest detectable intermodulation level is then $T_a$ or $T_o$, the threshold voltage level, whichever is the greater. The smallest detectable equivalent harmonic fraction is thus

$$\frac{A_i + B_i}{2A_i\, B_i}\left(\frac{T_a \text{ or } T_o}{a_1}\right)$$

$$\text{or}\left[\frac{(A_i+B_i)^2}{3A_i^2B_i}\left(\frac{T_a \text{ or } T_o}{a_1}\right) \text{ or } \frac{(A_i+B_i)^2}{3A_iB_i^2}\left(\frac{T_a \text{ or } T_o}{a_1}\right)\right]$$

considering square or cube-law distortion alone respectively.

A simple first approach to determine the conditions under which these values are a minimum is to minimize either the functions of $A_i$ and $B_i$, or $T_a$, separately. For a given $(A_i+B_i)$, $T_a$ is a minimum when $f_2$ is as large as possible compared with $f_1$, and $B_i$ small compared with $A_i$. $f_1$ then produces little masking at the addition frequency due to the large frequency difference between the two. $f_2$ is so small that it also produces little masking even at the comparatively near addition frequency. Alternatively, for a given $(A_i+B_i)$,

$$\frac{A_i+B_i}{2A_iB_i}\ ,\quad \frac{(A_i+B_i)^2}{3A_i^2B_i}\ ,\quad \frac{(A_i+B_i)^2}{3A_iB_i^2}$$

are a minimum when $B_i=A_i$, $A_i/2$, $2A_i$ respectively. The minimum values are then $1/A_i$ , $3/2A_i$ , $3/4A_i$ respectively. In these last cases $T_a$ is also a minimum in practice when $f_2 \approx f_1$.

Approximate calculations suggest that the smallest detectable equivalent harmonic distortion fraction is less if we minimize the functions of $A_i$ and $B_i$ and take $f_2 \approx f_1$, than if we minimize $T_a$ alone. At some levels (which depend on the type of distortion) the difference can amount to a factor of 2 or 3 to 1 for square and cube-law distortion respectively.

Using these relations between $B_i$ and $A_i$ and the condition $f_2 \approx f_1$, the smallest detectable harmonic distortion fraction is $\frac{2(T_a \text{ or } T_o)}{a_1(A_i+B_i)}$ or $\frac{9(T_a \text{ or } T_o)}{4(A_i+B_i)}$ for square and cube-law distortion respectively. The masked addition frequency is twice and three times the fundamental respectively. Considering the *addition* frequencies arising in intermodulation distortion the smallest detectable equivalent harmonic distortion is then 2 and 9/4 times the values given in Fig. 3 for square (2nd harmonic) and cube-law (3rd harmonic) distortion alone respectively.

The ratios used above are not the same as those usually quoted for measured intermodulation to harmonic distortion percentages (3.2 and 3.8 for second and third harmonic alone respectively[3]). This difference will appear again in the complete analysis. It arises for several reasons. In the first place we are concerned with detection at one frequency at a time rather than addition over all distortion frequencies. The fundamental amplitude ratios we have considered are also not those standard for intermodulation distortion measurement. Finally, additional complications can arise in actual hearing.

**Hearing Distortion Effects: Intermodulation Difference Frequencies.** Masking decreases rapidly if the masked frequency is reduced below the masking frequency. At any frequency below about 0.7 of the masking frequency the increase in the threshold level is much less than the values considered previously (given in Fig. 1). The masking is also much less than that given in Fig. 1 at frequencies many times the masking frequency.

For fundamental frequency ratios between 1/1.7 and 1.7 or 1/2.7 and 2.7 for the square-law or one of the cube-law distortion difference frequencies respectively, these difference frequencies are less than 0·7 of either of the fundamental frequencies. In some other cases a difference frequency arising in intermodulation distortion may be many times one of the fundamental frequencies, and less than 0.7 times the other.

In these cases then, the masking at the difference frequency due to either fundamental is very much less than the masking considered previously. In evaluating the smallest detectable distortion for such difference frequencies, the intermodulation produced in hearing becomes more important.

The *harmonics* produced in hearing were measured by Fletcher[4] and the results are given in Fig. 4.

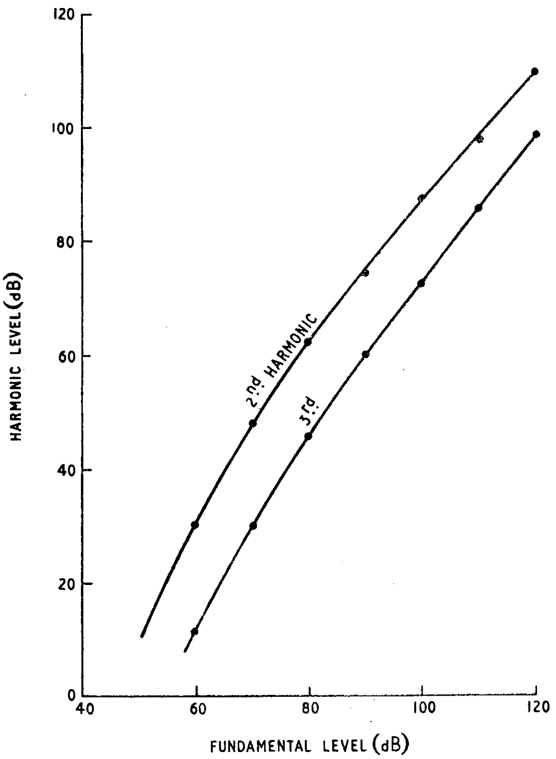



*Fig. 4. Level of harmonics produced in hearing*

In this figure the harmonic levels correspond to the absolute external sound levels which at the same frequency produce equal sensation levels to those of the harmonics produced in hearing. Fletcher reported that these results were independent of frequency. They agree with some measurements made at 650 and 900 c/s by Moe[5]; and with second harmonic distortion measurements made at various frequencies by Lawrence and Yantis,[6] or at a single frequency by Egan and Klumpf,[7] or Békésy.[8]

The paper by Egan and Klumpf suggests that the method of "best beats", which has been used to measure harmonic levels by all the authors cited, gives too high a value for these levels. This error is due to masking by the fundamental, and becomes considerable when the harmonic level is near the masked threshold level. This happens with the second harmonic at low levels, and with the third harmonic at all levels. Furthermore, no measurement of a harmonic level by this method should ever give a value lower than the masked threshold level. However, results on the levels of the cube-law distortion difference frequencies obtained by Moe[5] do not seem to depend at all on whether these difference frequencies are above or below the fundamentals, although a similar error should occur only in the former case. Moreover, Moe measured levels of addition frequencies which are well below the masked threshold level which would be expected.

These harmonic distortion data can be converted into intermodulation distortion data by Warren's method of analysis considered earlier. This method assumes that hearing may be considered as a unity for all frequencies. However, the exact parts of the ear used in hearing are not the same for all frequencies. Thus there may be less interaction between different frequencies in hearing than is suggested by the distortion produced at one frequency. In this case the intermodulation produced in hearing would be less than Warren's type of analysis would

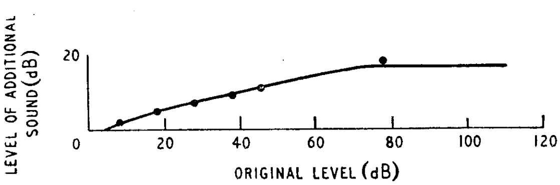



*Fig. 5. Level of additional sound (in dB below the original level) to give a just noticeable change for frequencies between 500 and 8000 c/s*

suggest. However, if this effect occurs we should expect the interaction to increase to the value given by Warren's analysis if the interacting frequencies are brought close together. Thus the smallest detectable distortion may be less than the value to be calculated using Warren's method; though with the fairly close frequencies we are considering (of ratios less than 2.7 to 1) the disagreement should not be large. The measured levels of the *difference* frequencies produced in hearing by fundamentals of 690 and 950 c/s (ratio 1.37 to 1) obtained by Moe[5] do agree with those to be expected on this analysis from the harmonic levels also measured; although the corresponding *addition* intermodulation frequencies appear to be about 10 dB lower.

Fletcher[9] also gives data on the smallest noticeable sound-level change at various levels and frequencies.

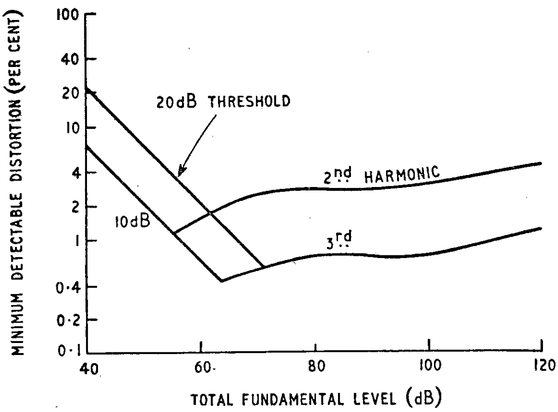



*Fig. 6. Smallest detectable distortion (considering intermodulation produced in hearing) for distortion frequencies between 500 and 8000 c/s.*

The results for any frequency between 500 and 8000 c/s are very similar and are presented in Fig. 5. From the level of the intermodulation produced in hearing the smallest external intermodulation level which will produce a noticeable change can be found from these data.

If the second and third harmonic voltage levels produced in hearing are $L_2$, $L_3$ the corresponding intermodulation levels are

$$\frac{2A_iB_i}{(A_i+B_i)^2}L_2,\ \left[\frac{3A_i^2B_i}{(A_i+B_i)^3}L_3 \text{ or } \frac{3A_iB_i^2}{(A_i+B_i)^3}L_3\right]$$

The smallest noticeable external intermodulation level will be some fraction 1/N of these (given from Fig. 5), or the threshold level $T_0$, whichever is greater. From Fig. 5, N is a maximum (and thus the smallest noticeable distortion a minimum) when the hearing distortion-level is a maximum. For a given $A_i+B_i$, (and thus $L_2$, $L_3$),

$$\frac{2A_iB_i}{(A_i+B_i)^2}L_2,\ \frac{3A_i^2B_i}{(A_i+B_i)^3}L_3,\ \frac{3A_iB_i^2}{(A_i+B_i)^3}L_3$$

are a maximum when $B_i=A_i$, $A_i/2$, $2A_i$ respectively. (Equivalent conditions arose in the discussion of addition intermodulation distortion.) The equivalent just noticeable second and third harmonic fractions are then $\frac{L_2}{Na_1(A_i+B_i)}$, $\frac{L_3}{Na_1(A_i+B_i)}$ for square and cube-law distortion only respectively. This is provided that the just noticeable intermodulation level is not below the threshold level. If it is below the threshold level the equivalent just noticeable second and third harmonic fractions are

$$\frac{A_i+B_i}{2A_iB_i}\cdot\frac{T_0}{a_1},\ \left[\frac{(A_i+B_i)^2}{3A_i^2B_i}\cdot\frac{T_0}{a_1} \text{ or } \frac{(A_i+B_i)^2}{3A_iB_i^2}\cdot\frac{T_0}{a_1}\right]$$

respectively. For a given $(A_i+B_i)$ these fractions have minimum values (as above) when $B_i=A_i$, $A_i/2$, $2A_i$ respectively. The minimum values for the equivalent just noticeable second and third harmonic fractions are then $\frac{2T_0}{a_1(A_i+B_i)}$ or $\frac{9T_0}{4a_1(A_i+B_i)}$

These various equivalent just noticeable harmonic fractions are plotted in Fig. 6 as percentages. Fig. 6 thus gives the smallest detectable distortion consider-

(*Continued on page 439*)

ing the intermodulation produced in hearing. It applies to the detection of *difference* frequencies arising in intermodulation between fundamentals of certain frequency ratios which have been evaluated above.

At low frequencies the smallest detectable distortion is again greater, both due to the increased threshold level as before, and also because the smallest noticeable sound level change is greater. Data on the smallest noticeable sound level change at 50 c/s (from Ref. 9) are given in Fig. 7. Taking the threshold level at 50 c/s as 50 dB from Fig. 2 the smallest detectable equivalent percentage harmonic distortion is given in Fig. 8 by the same method as before. An important point is that from the method of calculation this smallest detectable distortion applies to *distortion* frequencies of 50 c/s. This corresponds, for example, to intermodulation between 60 and 110 c/s.

Each distortion curve in Fig. 8 has a peculiar "kink" in it. This arises because the just noticeable energy change at 50 c/s alters suddenly at the threshold level. From Fig. 7 it can be seen that at low levels slightly above threshold the additional sound to give a just noticeable energy change is considerably greater than the original sound. However, if the original signal is below the threshold level presumably as usual any additional sound above the threshold level will be noticeable. Thus, for signals just below the threshold level the additional sound to give a just noticeable change is only slightly greater than the original sound.

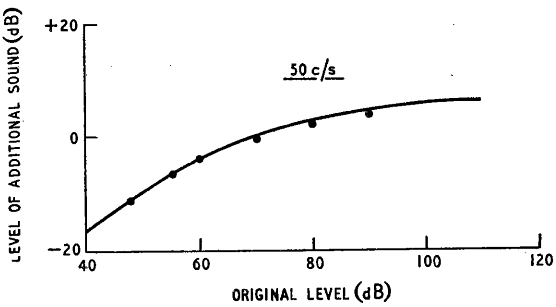



*Fig. 7. Level of additional sound (in dB below the original level) to give a just noticeable change at 50 c/s.*

**Random Uncertainty of These Results.** The various results on masking summarized in Fig. 1, and the harmonic distortion measurements of Lawrence and Yantis,[6] show a spread of up to about ± 10 dB about their mean. Thus our various results on the smallest detectable percentage distortion may in particular cases be in error by up to a factor of about 3.

**Optimum Conditions for Distortion Detection.** From our results the ear appears to be most sensitive to difference intermodulation distortion produced by roughly equal fundamental frequencies, next most sensitive to harmonic distortion; and least sensitive to addition intermodulation distortion. For all types of distortion the maximum sensitivity occurs at fundamental levels of about 50 to 70 dB. Intermodulation distortion of all types is best detected at particular ratios of fundamental frequencies and powers which are near to unity. The standard conditions for the measurement of intermodulation distortion, on the other hand, involve considerably different frequencies and powers.

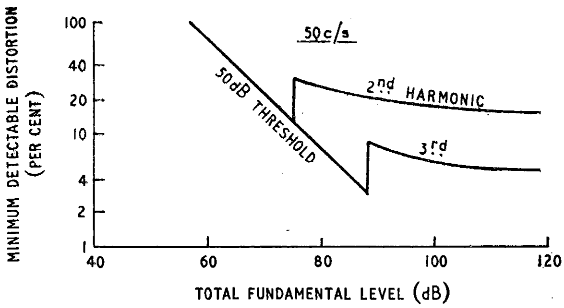



*Fig. 8. Smallest detectable distortion (considering intermodulation produced in hearing) for distortion frequency of 50 c/s.*

**Practical Results on the Smallest Detectable Distortion.** For music Olson[10] obtained a figure of about 0.7% total harmonic distortion for mainly second, and for both second and third harmonic distortion. The noise level was stated to be 25 dB and the peak electrical power 3 watts. Assuming a normal acoustic efficiency of 3% this peak power would produce sound levels of about 90 dB in a normal living room as used by Olson. This author also states[11] that the ear is most sensitive to distortion for sound levels of 70 to 80 dB. Brittain[12] was able to detect 0.4% total harmonic distortion, no levels being stated. For sine waves at 1000 c/s and second harmonic distortion Braunmühl and Weber[13] give 0.7%; using two tones they obtained 1.3, 0.7 and 0.5% for frequency ratios of 1.05, 1.12 and 1.50 to 1 (lower frequency fixed at 800 c/s) respectively. On the other hand, these authors [13] quote a figure of 4% for music, for both square and cube-law distortion.

The above results agree reasonably well with our calculations, but a number of observers using single or only a few sine tones have obtained lower values. Those of Newman, Stevens and Davies[14] for the minimum detectable second harmonic distortion of 370 c/s (average for two observers) are reproduced in Fig. 9. Using two tones of frequency ratio 1.5 to 1 at a level of 60 dB Haar[15] obtained 0.3 and 0.5% for square and cube-law distortion respectively at frequencies between about 1000 and 4000 c/s. In this case then, square-law distortion was easier to detect than cube law. The threshold level was 0 dB

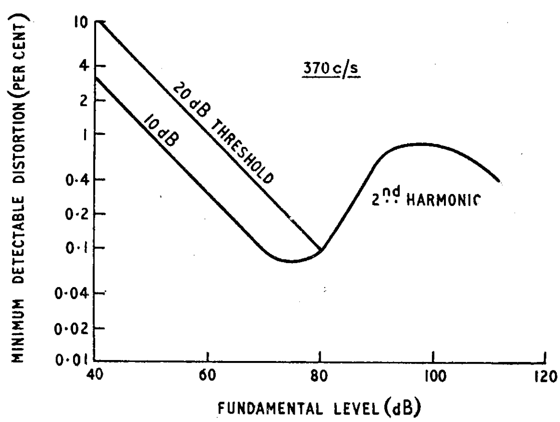



*Fig. 9. Practical results of Newman, Stevens and Davies for 2nd harmonic distortion of 370 c/s.*

at 1000 c/s, i.e. there was apparently no masking by noise.

Detailed sets of results for both square and cube-law distortion at various frequencies and levels have been given by Haar[15] and Feldtkeller[16, 17]; those of Haar being for single frequencies (corresponding to Fig. 3), and those of Feldtkeller for two frequencies of ratio 1.5 to 1 (corresponding to Fig. 6). At levels up to about 60 dB both these sets of results agree quite well with our calculations if we insert a suitable threshold level, and this level turns out to be within about 6 dB of the stated level in each case. At levels above 60 dB the results are fragmentary, but appear to disagree with our calculations in two ways. Thus at a given level the smallest detectable distortion decreases with increasing frequency up to at least 1000 c/s (in Haar's results up to at least 2000 c/s). The smallest detectable distortion at about 3 kc/s also appears to decrease with increasing level up to at least 80 dB, the lowest figures quoted by Haar and Feldtkeller being 0.5 and 0.3% respectively.

The results of references 13, 15, 16 and 17 all show an increase at low frequencies. Thus Braunmühl and Weber[13] give 2% for second harmonic distortion of 100 c/s; and Haar's[15] results show a minimum at about 70 dB of 7% and 3% for second and third harmonic distortion of 100 c/s respectively. Haar's results for 100 and 150 c/s together at a level of 70 dB are directly comparable with our Fig. 8. His values of 5.2 and 1.8% for square and cube-law distortion respectively are however much lower than those in Fig. 8. Feldtkeller's results[16] for the same frequencies show similar values of about 5% and 1% (average for two observers) at their minima around 70 dB.

Extending our various calculations shows that the hearing sensitivity to distortion due to higher harmonics increases rapidly with increasing harmonic number. This effect is well known. It may explain another observation by Olson,[10] that if the higher frequencies are removed the sensitivity to total distortion is decreased.

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# Commercial Literature

**Aircrew Headset** intended for pilots of aircraft who must have both hands free. The connecting cable is attached to one side of the headphones and passes back over the shoulder to avoid fouling the aircraft controls, while the small microphone is mounted on a light movable "boom" arm in the right position for the mouth. Leaflet from Amplivox, 2 Bentinck Street, London, W.1.

**Ship Stabilizer Control,** an electromechanical computer which senses five components of ship movement, combines them in the required ratio to take care of any sea condition and gives a signal to operate the hydraulic drive of the stabilizer fins. Outlined in a leaflet from Muirhead and Co., Beckenham, Kent.

**Transistorized Batch Counter** consisting of an amplifier, Dekatron counter tubes and a coincidence and relay unit. Is operated from a photocell or other device and gives a signal when a predetermined number of units have passed by this. Leaflet from Gate Electronics, Tudor Grove, Hackney, London, E.9.

**Insulating Materials,** including vulcanized fibre, mica, ebonite and laminated Bakelite sheet, tube and rod, press-board, cloths and tapes. Tables of properties, and sizes in which materials are supplied, given in an illustrated catalogue from the Anglo-American Vulcanized Fibre Company, Cayton Works, Bath Street, London, E.C.1.

**Electronic Measuring Instruments,** for sound, noise and vibration; non-destructive testing; and pulse/time techniques, including a very low-frequency c.r.o.; also stabilized power supplies, static neutralizer and oscillator-amplifiers. Short form illustrated catalogue from A. E. Cawkell, 6-8, Victory Arcade, Southall, Middlesex.

**"Variacs" with Fuses,** for use in laboratories, with the fuse fitted in the output (brush) circuit. The 230-V input voltage types have an output variable over 0-270V (at 2A or 3A) and the 115-V types have an output variable over 0-135V (at 5A or 6A). Leaflet from Claude Lyons, Valley Works, Hoddesdon, Herts. Also leaflets on a two-signal radio generator for intermodulation distortion measurements; a pulse, sweep and time-delay generator; and a klystron oscillator—all three being General Radio products.

**Battery-operated Tape Recorder,** the German-built Butoba TPR2, has a spring motor giving 22 minutes' running at $3\frac{3}{4}$ inches/sec and 40 minutes at $1\frac{7}{8}$ inches/sec. The motor can be rewound while recording. Standard 5-inch reels can be used. Consumption is 400mA from a 1.5-V battery and 28mA from a 90- or 100-V battery. Frequency response is 50c/s—9kc/s$\pm$3dB. Input voltage for full output at 1kc/s is 1.5mV. Leaflet from the distributors, Henri Selmer and Co., 114-116 Charing Cross Road, London, W.C.2.

**Band-III Pre-Amplifier** for insertion in aerial downlead to television receivers. A single cascode stage, covering any one of Channels 8, 9 and 10, gives a gain of 15dB with a bandwidth of 3.5Mc/s. The power supply is incorporated. Leaflet from Labgear, Willow Place, Cambridge.

**Transmitting and R.F. Heating Valves,** including power rectifiers, magnetrons, klystrons, travelling-wave tubes; also thyratrons, voltage stabilizers, transistors, c.r. tubes and television camera tubes. An illustrated catalogue containing abridged data from the English Electric Valve Company, Chelmsford, Essex.

**German Test Instruments** by Rohde and Schwarz, including voltmeters and level indicators; valve voltmeters; wide-band amplifiers; noise and distortion meters; field strength meters; wattmeters; attenuators; bridges; oscillators and signal generators; frequency meters; noise, square-wave and television generators; and various accessories. Brief specifications and prices in a catalogue from the agents, Aveley Electric, Aveley Industrial Estate, South Ockendon, Essex.

# Overcoming Line-Scan Ringing

## Experimental Transformers with Tuned Leakage Reactance

By K. G. BEAUCHAMP, A.M.Brit.I.R.E.

IN a previous issue of *Wireless World* the author described a number of methods for reducing line-scan resonances or "ringing" associated with the line-scanning transformer of a television receiver.* It was shown that the most serious of these resonances is due to the leakage inductance of the e.h.t. overwind, which is necessarily large because of the method of construction of this coil. A simplified circuit of a line output stage, showing the transformer leakage inductances and stray capacitances, is shown in Fig. 1.

A large and rapid change of current takes place at the collapse of the scan when both V1 and V2 are temporarily rendered non-conductive due to a large negative voltage at the grid of V1 and consequent rise of V2 cathode potential. This current change through the transformer windings will shock-excite the numerous tuned circuits existing in Fig. 1, which are now free to resonate.

At the end of this retrace period, V2 is rendered conductive and should hold point 3 constant to enable a linear rise of current in $L_y$ to take place. However, at the moment of V2 conduction some energy will remain stored in $L_5$ and the resonances set up during the flyback will continue during the first part of the scanning period around the path $L_5C_5L_3$V2 so as to cause a "ringing" potential to be developed across $L_3$ and modulate the current through the diode V2.

The resulting ripple superimposed on the linear rise of scanning current will produce velocity modulation of the trace, which will be seen as alternate light and dark striations at the left-hand side of the screen, continuing with diminishing intensity towards the screen centre.

The methods described previously were all directed at suppressing these resonances, preferably with little effect on the fundamental and lower resonant frequency of the main magnetic flux circulating around the transformer core. As a consequence of this "damping" technique some energy must be abstracted from the transformer and results in an overall loss of circuit efficiency. It has been shown previously that this loss can be made quite small, but where the scanning angle approaches 90°, as is now becoming common in the larger-screen receivers, then any methods leading to reduced efficiency in this section of the receiver can have a profound effect on the final design and materially increase its cost.

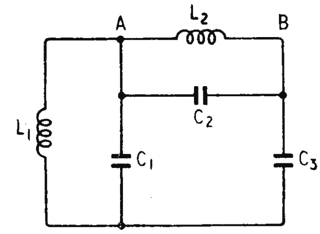


*Fig. 2. Equivalent circuit of a line scan transformer.*

A very attractive solution to this problem has been arrived at† where not only are the deleterious effects of these unwanted resonances reduced but use is made of them to bring about certain improvements in the operation of the scanning circuit. Fundamentally the method consists of ensuring that the transformer is capable of resonating simultaneously at several frequencies; these frequencies having a definite numerical relationship with each other.

Reference to Fig. 2 will make this clear. This shows one simplified equivalent circuit for a line scanning transformer where only one leakage re-

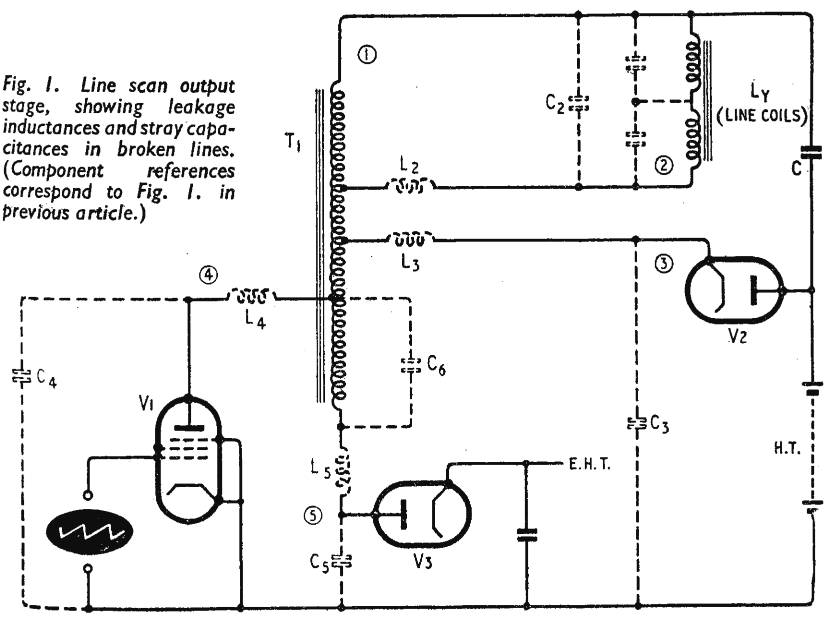


*Fig. 1. Line scan output stage, showing leakage inductances and stray capacitances in broken lines. (Component references correspond to Fig. 1. in previous article.)*

*"Spurious Line Scan Resonances," by K. G. Beauchamp, March, 1955.

†"High Efficiency 90° Cathode-Ray Sweep System," by C. E. Torsch, *Tele-Tech*, June, 1953.

sonance is considered, that of the e.h.t. overwind. In this diagram:

$L_1$ = equivalent inductance of transformer windings and coupled scanning coils.
$L_2$ = leakage inductance of the e.h.t. overwind coil.
$C_1$ = equivalent lumped capacitance of transformer windings, scanning coils, valves, wiring, etc.
$C_2$ = equivalent lumped capacitance tuning $L_2$.
$C_3$ = capacitance of e.h.t. rectifying diode plus wiring capacitances.

Now if the natural resonant frequency of the leakage branch $L_2C_2$ is made certain multiples of that of the main transformer resonance $L_1C_1$, then the ringing potential of the leakage inductance can be made zero at the termination of the retrace period. This is because both resonant circuits will commence to ring at the same time (at the end of the scan period) and if their frequencies are arranged so that both oscillatory potentials pass through a null point at the cessation of the flyback, shown as point B in Fig. 3, then, as the boosting diode conducts at this point, no further energy will be supplied to the leakage circuit and further resonances will be avoided. This gives the necessary zero energy storage condition in the leakage inductance in order to prevent the continuance of ringing during the scanning period.

This minimum ringing condition exists for more than one ratio of resonant frequencies. The two lowest of these will be the third and fifth harmonic resonances of the leakage circuit relative to that of the main magnetic circuit. The condition where the frequency ratio is 3 : 1 is shown in Fig. 3. The resonances during the retrace period due to $L_1C_1$ and leakage reactance resonances $L_2C_2$ are shown separately, and their combined effects at two points on the auto-transformer winding are indicated by the dotted lines.

It will be seen that the resultants give a lower peak voltage at the anode of the line output valve and an increased peak potential at the e.h.t. rectifying diode. The reversal in polarity bringing about these different

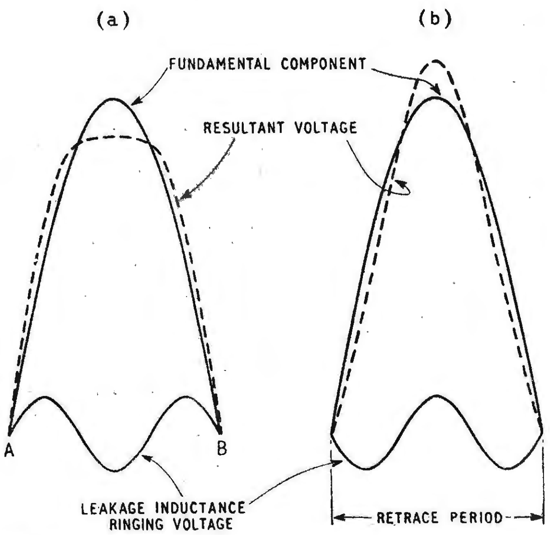


*Fig. 3. Effect of tuning the e.h.t. overwind leakage reactance: (a) voltage at the anode of V1, (b) voltage at the anode of V3.*

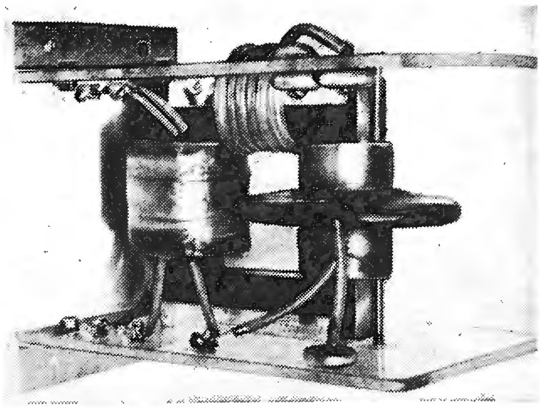

*Fig. 4. Practical form of the experimental tuned-leakage-reactance line scan transformer.*

effects is, of course, due to the disposition of the two valve anodes on either side of the leakage reactance resonant circuit. Quite apart from the absence of ringing in the displayed picture, this technique is of value in allowing the output valve and the boosting diode to operate under less stringent peak potential conditions. A reduction of up to 20% in peak potential may be obtained in this way.

The case where the frequency ratio is 5 : 1 is of less practical interest. Here the peak potential at the output valve anode is increased whilst that applied to the e.h.t. rectifier is reduced. However, as the resultant waveform applied to the rectifying valve is now becoming more rectangular in shape, an improved e.h.t. regulation can be expected.

Before considering the practical applications of the theory given above, it is as well to mention that the ratios actually required deviate slightly from those given previously. This is due to the boosting diode not becoming fully conductive until its cathode reaches a slight negative potential relative to the anode. This extends the realizable retrace period to rather more than one half cycle of the fundamental resonance, and in order to ensure zero energy storage ratios of approximately 2.7 and 4.4 were found necessary.

Considering now the transformer design, this must obviously be modified to give a higher leakage reactance for the e.h.t. overwind in order to reduce its resonant frequency to a smaller multiple of that of the fundamental transformer resonance.

Modern line scan transformer design invariably takes advantage of the reduced eddy current and hysteresis losses inherent in the use of ferrite core materials, and a "double-U" core of this material is usually adopted. With this arrangement the e.h.t. overwind may be placed on one limb of the transformer and the remaining windings on the opposite limb, as shown in Fig. 4. This will result in a very low coupling coefficient for the e.h.t. overwind and hence a large leakage reactance. Variation of this leakage reactance can be brought about by introducing controlled coupling between the two windings in the manner suggested in Fig. 5. The link-coupled coils $L_3$ and $L_4$ each consist of a small winding fairly tightly coupled to the main windings $L_1$ and $L_2$ respectively.

This is a convenient way of demonstrating the improvements resulting from tuning the leakage reactance. The ringing will be seen to go through a minimum as the inductance $L_5$ is varied, while in the case of a 2.7 ratio the e.h.t. produced reaches its maximum.

With careful design, however, it is possible to obtain the correct resonance ratio more simply. The procedure is to design the transformer with its e.h.t. overwind on a separate limb as previously suggested. The main transformer resonance is then adjusted by variation of an additional capacitor, $C_1$, tapped at a convenient point across the transformer windings (say, across the scanning coil connections). This adjustment is carried out until "ring-free" conditions are observed on the screen, consistent with increased rectified e.h.t. potential.

The addition of capacitance in this way will, of course, reduce the peak potential across the winding. Schade‡ has shown that the relationship $V_{peak} \propto 1/\sqrt{C}$ is obtained. What is looked for, then, is a peak of e.h.t. superimposed on this gradual reduction in e.h.t. as C is increased.

If the necessary value of $C_1'$ is found to be too large, giving rise to a lengthy retrace period and causing loss of picture information, then the e.h.t. wave winding will have to be redesigned to have a smaller self-capacitance. This can often be achieved by selecting suitable gear-ratios in the wave-winding machine to give a larger number of "cross-overs" per turn of the coil. The resultant diameter of the overwind will increase, but this is now of less importance as the peak potential between this winding and the corresponding windings on the other limb will be less than that existing in a conventional design between e.h.t. overwind and opposite transformer limb.

The price paid for this reduced potential gradient will be the increased insulation required between the inner turns of the overwind and the limb upon which it is wound. A former of Perspex or other material can be used here and must be capable of withstanding the peak potential existing at the anode of the line output valve during the retrace period.

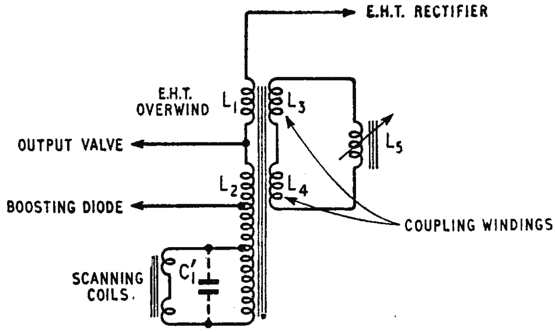


*Fig. 5. Suggested method of varying the leakage reactance of the e.h.t. overwind by the use of coupling windings.*

‡"Characteristics of High Efficiency Deflection and High-Voltage Supply of Kinescopes," by O. H. Schade, *R.C.A. Review*, March, 1950.

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# Transistor Oscillator Stability

## Simple Frequency Drift Tests with R.F. Transistors

**By *M. G. SCROGGIE,* B.Sc., M.I.E.E**

THE experimenter has by now been supplied with copious information on the use of transistors as amplifiers, but surprisingly little on transistor oscillators. One gains a general impression that their frequency stability is poor, but as to how poor one is left to guess. The tests now to be described may have been rather sketchy, in that they do not provide precise data on the relationship of frequency stability to circuit parameters, but a rough idea may be better than none.

Several types of transistor were tried, chiefly the Ediswan XA102 and the Mullard OC45, which have comparable characteristics, with cut-off frequencies of several megacycles and, therefore, suitable for use in the medium-frequency broadcasting band. Frequency variations were measured by beating the transistor oscillations against the carrier wave of the London Light Programme (1,214 kc/s) and comparing the audible beat frequency with a calibrated audio oscillator by the slow-beat method.

The oscillator was driven by a $1\frac{1}{2}$-volt cell and enclosed in a tin-plate screening box (Fig. 1). To the mouth of a small hole in this screen was brought the end of a lead connected to the aerial terminal

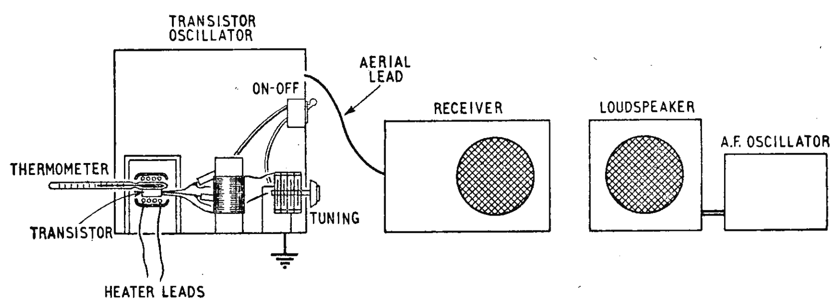



*Fig. 1. Apparatus used for measuring frequency variations of transistor r.f. oscillator.*

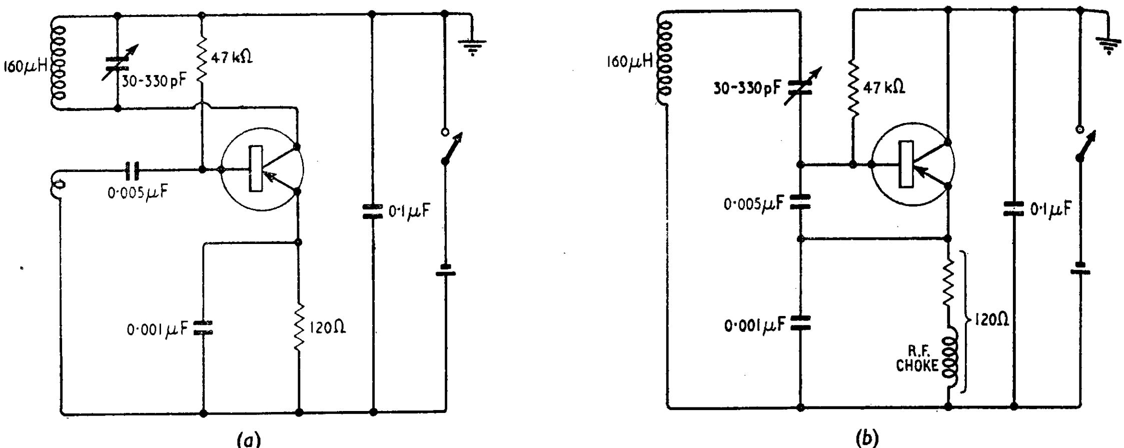



*Fig. 2. The two oscillator circuits used in the tests: (a) ordinary "reaction coil" circuit, and (b) Gouriet circuit.*

of a receiver; this lead was sufficient also to pick up the London programme. Another small hole allowed the scale part of the thermometer used for measuring the temperature of the transistor to project outwards. The thermometer bulb and transistor were wrapped together with a heater coil, covered with insulation tape and mounted in a wooden housing. When connected to the l.t. winding of a transformer, the heater raised the temperature about 8°C.

Fig. 2 shows the two oscillator circuits used for the tests: (a) an ordinary "reaction-coil" type, and (b) a Gouriet (or Clapp) circuit. In changing over from one to the other, as much of the circuit as possible was left common to both. Only quite a rough calculation was made of suitable values for emitter and base biasing resistors, and the same values were used for all transistors. The 160μH coil was a single-layer solenoid $1\frac{1}{8}$in in diameter and $1\frac{1}{2}$in long. Only 10 turns, loosely coupled, were required in (a) to cause oscillation of about the same amplitude as in (b), judged by the collector current —about 0.5mA in each circuit. The power consumption was, therefore, less than 1 milliwatt.

A number of runs, often lasting several hours, were made with each circuit and each transistor, noting various causes of frequency variation, such as ambient temperature, transistor temperature, battery voltage (for which a controllable source was arranged), and residual effects. Ambient temperatures were mainly in the range 14—20°C. The details would be tedious, but the following is a summary of the conclusions.

Measured under conditions of substantially constant ambient temperature, the transistor temperature coefficient was of the order of $-500$ in $10^6$ per °C for circuit (a) and $-50$ for circuit (b). The great superiority of the Gouriet circuit (which in effect is a loose-coupled Colpitts circuit, the triode being "tapped down" on the capacitance side instead of on the inductance side as in a Hartley), compared with even a loosely-coupled reaction-coil, was clearly demonstrated. Although the individual figures for transistors covered a nearly 2:1 range, the 10:1 ratio for any one transistor in the two circuits was remarkably consistent. Whereas the temperature coefficient of the transistor could be objectionable on this waveband in a superhet receiver using circuit (a), the effects would be negligible in circuit (b).

Frequency variation due to varying supply voltage was found to be quite negligible, even over much larger variations than those that would occur in practice. The fact that within the range of voltage used (1.20—1.55) the coefficient reversed in sign resulted in a fairly flat curve.

The only other material frequency variation observed—and it was very material, amounting to thousands in $10^6$—was an approximately exponential drift having a time constant of one to two hours, with certain samples of transistor. This time constant is far too long to be due to internal heating of the transistor junction (and was not observable at all in other samples), and the effects of ambient changes of temperature and voltage changes were eliminated in the tests. The cause has not yet been found, but is being sought.

Except for this last effect, which presumably is abnormal, the results seem to show that in broadcast receiver oscillators, and other applications with no more stringent requirements, there is no need to worry about the transistor as a cause of frequency instability, so long as a suitable choice of circuit is made.

## CLUB NEWS

**Birmingham.**—A demonstration of the Eddystone 888 receiver will be given by Stratton & Co. at the meeting of the Slade Radio Society on September 13th. At the meeting on September 27th A. E. Robertson, assistant-head of the B.B.C. engineering training department, will give a lecture on microphones. Meetings are held at the society's headquarters, Church House, High Street, Erdington, Birmingham, 23, at 7.45. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

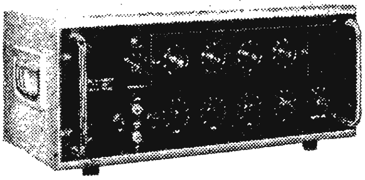
**Bury.**—The September meeting of the Bury Radio Society will be held on the 10th, when B. Barrett (G3DZU) will talk about the "Panda" transmitter. The meeting will be held at 8 at the George Hotel, Kay Gardens, Bury. Sec.: L. Robinson, 56, Avondale Avenue, Bury.

**Kensington.**—At the first meeting of the winter session of the Science Museum Radio Society, Major G. Watson (VP8BP) will give an illustrated talk entitled "Radio in Antarctica." The meeting will be held at 6 on September 10th at the Science Museum, South Kensington. Membership of the society is limited to civil servants. Sec.: G. C. Voller (G3JCK), The Science Museum, London, S.W.7.

**Nottingham.**—Meetings of the Nottingham Amateur Radio Club re-start today (August 27th) after a two-weeks' break. The club meets on Tuesdays at 7.15 at Woodthorpe House, Mansfield Road, Nottingham. Sec.: F. V. Farnsworth, 32, Harrow Road, West Bridgford, Nottingham.

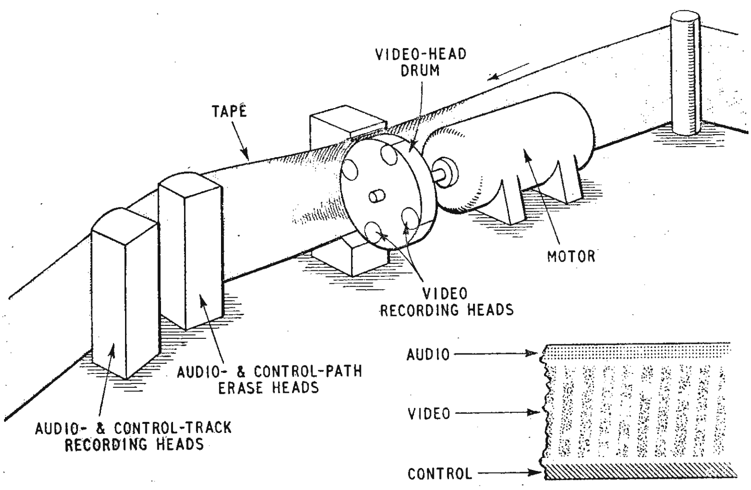
# Technical Notebook

**Paralysis Circuits** are sometimes used in electronic counters for blocking the action after each count so that there is no danger of counting spurious pulses, which may be produced, for example, when a photo-electric input is actuated by irregularly shaped objects on a conveyer belt. Seven different paralysis times are made available in an industrial batch counter recently introduced by Ericsson Telephones. This machine has a maximum speed of 350 pulses per second and will count into batches of any given number. The

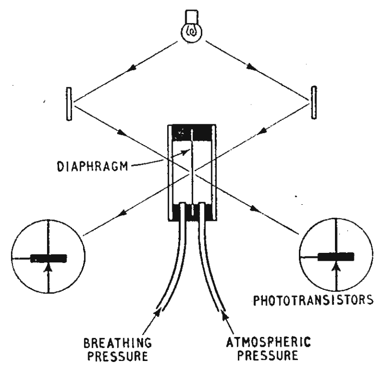


display is on Dekatron tubes, and the required count per batch (anything up to 10,000) is set up on rotary switches. When the selected count per batch is completed the instrument automatically resets itself and begins counting another batch. Various ancillary devices can be supplied. One is a unit which supplies alternate output pulses, each having the duration of a batch; these pulses are suitable for alternately operating a pair of solenoids for controlling two chute flap mechanisms.

**Video Tape Recording** of television programmes by the American Ampex machine achieves a low tape speed of 15 inches/sec, as is well known, by means of a rotating head assembly and a concave tape guide, giving transverse tracks across the 2-in wide tape (see sketch). The 2-in diameter video-head drum rotates at 240 r.p.s., and each of the four heads records one complete track in about 1 millisecond. This gives an effective tape speed of about 1,500 inches/sec. The tracks themselves have a centre-to-centre spacing of approximately 0.015in, and are 0.01in wide, allowing about 0.005in between the edges of adjacent tracks. As can be seen, the video signal is erased from the two edges of the tape to provide paths for the longitudinal recording of the audio and system control tracks. This leaves slightly more than 90° of arc of recorded information to allow for a continuous flow of information during playback. The same heads are used for playback, and their synchronization with the pattern on the tape is achieved by adjusting a vernier tracking control, the correct state of operation being indicated by the lock-in of a Lissajous figure on an oscilloscope. A 4,800-ft reel of tape will give 64 minutes playing time. One complete 525-line picture occupies about ½ inch of tape length and there are approximately 16 lines recorded in each track. A horizontal resolution of 320 lines is specified for the reproduced picture, although this can be increased. Further points are discussed by C. P. Ginsburg in *I.R.E. Transactions* PGBTS-8 for June, 1957.

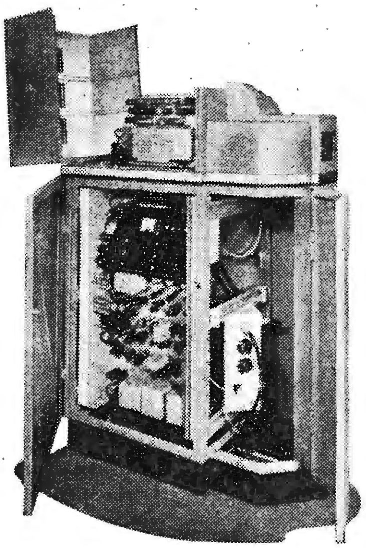



**Aluminized Terylene** is used as a light-reflecting diaphragm in an electronically controlled artificial respirator for new-born babies devised by the Midwifery Department of Glasgow University and the Physics Department of the Western Regional Hospital Board, Glasgow. The machine does not impose a regular breathing rhythm but whenever the infant makes the initial effort to breath it responds with a supply of air or oxygen which forces the lungs into full operation. The slight change of pressure resulting from this initial effort is conveyed by a face-mask and tube to the left-hand side of the chamber shown in the sketch, the right-hand



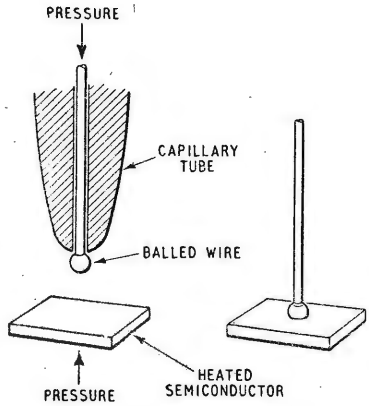

side being at atmospheric pressure This causes a slight flexure of the diaphragm, which produces an angular deflection of the light beams reflected on to the phototransistors. The resultant push-pull change of current through the phototransistors is then used to control the operation of a valve supplying air to the baby's face mask. Incidentally, if the baby stops breathing for a dangerously long time, the machine changes over to an automatic cycle and delivers regular doses of air.

**Vidicon Colour Film Scanner** recently developed by Marconi's uses a camera containing three photoconductive pick-up tubes instead of the usual flying-spot system. One advantage is that the storage characteristic of the tubes avoids the need for fast pull-down of the film and for synchronous running. Moreover, by means of an optical multiplexing system the same camera can be used for televising from several film and slide projectors in sequence. In the equipment (which does not include the film projector) the division of light into three primary colour components is performed by two dichroic filters mounted as a

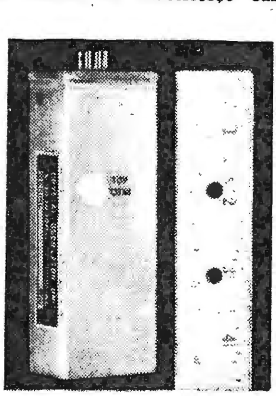


"V". Red light passes straight through, while green and blue are deflected to opposite sides, the light paths then being brought back into line by front-silvered mirrors. Further shaping of the spectral response of each channel is performed by a combination of dichroic and conventional colour filters. Neutral density filters are inserted in the individual light paths to the three Vidicons to ensure that they are operated over similar parts of their characteristics. The focusing and deflection yokes are made to close tolerances, and individual as well as common controls of height, width and centring are provided for accurate registration of the three component images. Switching facilities on a monitor in the operating console allow the individual pictures to be superimposed for this purpose. A degree of registration equivalent to 500-line definition at the centre and 400-lines in the corners is said to be achieved. Individual shading controls are provided to compensate for non-uniformity of sensitivity over the scanned area of the pick-up tubes.

**Semiconductor Pressure Welding** for attaching soft-metal leads to transistors and other semiconductor devices is being investigated at Bell Telephone Laboratories by O. L. Anderson, H. Christensen and P. Andreatch. The process appears to be similar to the cold pressure welding developed by G.E.C. (our May, 1951, issue, p. 181) except that a certain amount of heat is applied as well as pressure, though not enough to affect the semiconductor material. One method has been to use a heated element such as a wedge, a flat or a point, to press the metal against the heated semiconductor with a pressure sufficient to cause a slight deformation of the lead. Adhesion occurs within a matter of seconds. Another method consists in butting the balled (or headed) end of a wire against the heated semiconductor by means of a capillary tube, as shown in the sketch. Bell Telephones claim that this "thermo-compression bonding," as they call it, has a number of advantages over other methods of attaching leads to semiconductors. The bond is stronger, they say; the technique is more readily adaptable to mass-production; no chemical flux or other chemical contaminant is involved in the process; and leads may be attached to much smaller areas—which, of course, would be invaluable in manufacturing high-frequency transistors. Adhesion takes place in seconds with pressures of a few thousand pounds per square inch. A gold-germanium bond appears to be the easiest to make, but gold, silver, aluminium and a number of alloys can be readily bonded to either germanium or silicon.

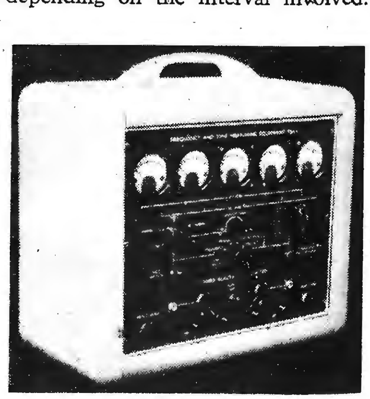



**Packaged Crystal Oscillators,** measuring only 4in × 1½in × 1in, are being produced by the Bulova Watch Company of New York for airborne applications. A range of output frequencies from 180kc/s to 50Mc/s is available, with stabilities of up to ±1 part in $10^6$ and harmonic contents less than 5%. Circuits using either valves or transistors can be supplied, and the units can be mounted on 7-pin plugs or other arrangements.



**High-speed Correlation Computer,** developed by the Ramo-Wooldridge Corporation for their data reduction centre at Los Angeles, shortens considerably the time required for analysing a signal recorded on a length of magnetic tape by automatically scanning the tape in sections. In orthodox correlation computers the entire length of tape has to be run through for each spacing of the two playback heads (giving correlation values at different time intervals) as explained in our March, 1955, issue, p. 137. In the Ramo-Wooldridge machine, however, each section of tape to be analysed is held stationary on a drum while the playback heads rotate about it. At the same time the heads are automatically displaced in steps to produce points in the correlation function graph. Both auto-correlation and cross-correlation analyses can be performed on the computer, which uses Ampex tape equipment.

**Repeated Counting Measurements** can be obtained automatically with a versatile frequency and time measuring equipment recently introduced by Venner Electronics. An automatic timer is fitted, which enables a count to be held on the decade display (pointer instruments) for an adjustable period of 0.5-5 seconds, after which the decades are reset to zero and counting begins again. The instrument, which is based on transistorized plug-in units, will measure frequencies (by counting cycles) in the range 10c/s-50kc/s, periods of waveforms in the range 0.00001c/s-10kc/s and time intervals between pulses from $1 \times 10^{-4}$ second to 11½ days. For frequency measurement the period of counting cycles can be set to 0.1 second, 1 second or 10 seconds. For measuring waveform periods, the cycles of an internal 10-kc/s crystal oscillator are counted, while in the case of pulse interval timing any one of six internal frequencies can be selected for counting, depending on the interval involved.



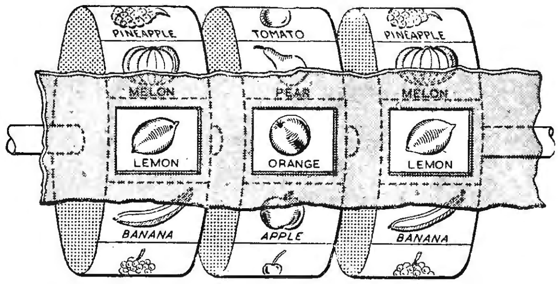



*Fig. 1. Rotating drums of the mechanical fruit machine.*

Simple Game of Skill Based on Pulse Techniques

# Electronic Fruit Machine

***By G. L. SWAFFIELD***

THE electronic fruit machine described here is a game whose operation is analogous to that of the mechanical gambling device known both as the "fruit machine" and as the "one-armed bandit." The playing of this last-mentioned machine for cash prizes is illegal in this country, since the device is merely a game of chance. In it the player, after inserting a coin, pulls a lever (the "one-arm" of the nickname) to rotate three independent drums around the peripheries of which are printed pictures of different fruits. A viewing window in front of the machine presents the pictures of three fruit passing at any given instant, one on each drum. The general appearance of the arrangement is illustrated in Fig. 1.

A brake button on one version of the device permits the drums to be stopped in quick succession after predetermined intervals to display any combination of three fruit, while a list on the front of the machine indicates winning combinations, prize money being delivered automatically *via* a coin chute. The "jackpot," for example, is generally delivered with a winning combination of three lemons.

It is doubtful whether any skill can be acquired playing a machine of this sort, due mainly to the difficulty of distinguishing the fruit while the drums are still rotating. Its electronic counterpart, however, can be played in either of two ways: in the first, as before, only chance will yield a win, but in the second it will be beaten by a skilful player.

If, in the mechanical version, wins other than the "jackpot" are disregarded, then the operation of the fruit machine can be considered in terms of pulse trains.

With eleven different fruit around the periphery of each drum, of which only the lemon contributes towards a win, the appearance of the lemon can be represented by one pulse in a waveform whose recurrence frequency equals the angular frequency of the drum. Furthermore, the presence of the lemon for one-eleventh of the total periodic time determines the mark-space ratio of the waveform, in this case the ratio will be 1 : 10. In point of fact the p.r.f. will decrease gradually due to the natural decelerations of the drums, but for a limited number of revolutions an approximately constant p.r.f. will be maintained, making the graphical representation of the pulse trains in Fig. 2 legitimate.

The action of the brakes is also shown here. When the button is pressed the drums are stopped in sequence, and in the diagram the arrows illustrating the action of the brakes show that the first and last drums are stopped when a lemon is visible in each of the respective windows. The second drum however is stopped halfway between "lemons." This result is shown pictorially in Fig. 1, and on the basis of the "'jackpot' only" win, no prize would be delivered with this combination. This sequential operation of the brakes is simulated in the electronic model when the last-mentioned is played for a chance win.

In the new arrangement three flashing neon lamps replace the three rotating drums, being triggered by pulse trains of the type already discussed. The neon lamps all flash at regular intervals individually, no attempt being made to simulate slowing-down of drums. Their recurrence frequencies however are not harmonically related. Since the mark-space ratio of each train is constant at 1 : 10, the duration of a flash is equivalent to the time a lemon would take to pass the appropriate viewing window in the mechanical machine with ten other fruit on the drum. The electronic version is therefore a "'jackpot' only" machine.

A fourth flashing lamp is controlled by a push button. When held down continuously the button allows the lamp to flash at the same mark-space ratio (i.e. 1 : 10), but at a lower p.r.f. than the other

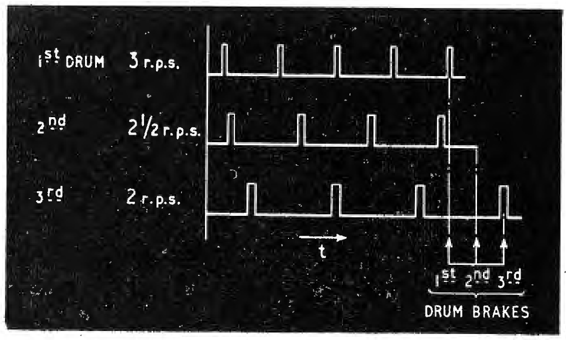



*Fig. 2. Pulse-train analogy of the operation of the machine illustrated in Fig. 1.*

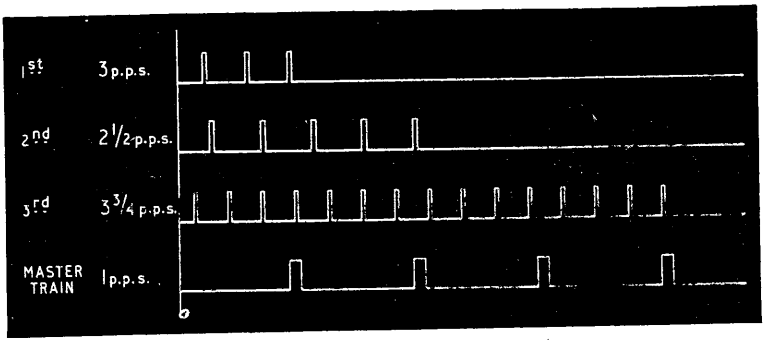



*Fig. 3. Pulse trains used in the electronic version, showing coincidences between the first three and the master train.*

piece triggering the three flashing lamps. Because the time limit only commences from the instant that the button is first pushed, a limitless period elapses during which the player can learn the "rhythm" of the machine.

A coin divider, associated with the 3d piece slot mechanism, arranges that half the coins inserted are delivered to the cash-box of the machine, and the remainder to the "jackpot," which, in the demonstration model illustrated, is visible through a window in the front of the machine. Normally, of course, the "jackpot" would be hidden from the player as an empty "kitty" would offer little incentive for further play.

three lamps. Push-button control commences only after a coin has been inserted and is limited to a fixed period of time after the first push, say approximately ten seconds.

If this fourth lamp flashes at the same instant as the first of the others, then the last-mentioned is permanently extinguished. Similarly, if during the fixed interval of ten seconds the fourth lamp flash coincides with that of the second, then that too is extinguished. Finally if by the same process the third lamp is extinguished still in this time limit, then the "jackpot" has been won, and a relay automatically trips to pour the appropriate win into the player's hands.

A win by such a means would obviously be by chance, no skill being required of the player.

The similarity of operation between this version and its mechanical origin can be seen in Fig. 3, where pulse trains produced by the neon lamps are presented in their correct time relation to one another. In this figure the lowest wave train, representing the push-button controlled or master neon flashes, is seen to coincide with the first pulse train at the master's first flash. With the first lamp now extinguished, the output from the master neon lamp source is free to work on the second train. The second master pulse is also successful, and play is now concentrated on the third and final pulse train. The third master pulse is ineffective, however, and not until the fourth pulse occurs is the final pulse train eliminated. This example demonstrates a win obtained three seconds after the button has been first pushed, this being the instant from which the time limit is started.

The element of skill is introduced by using the push button intermittently, thereby making the fourth lamp flash only when required. An experienced player will note the periodicity of the first lamp's flashes and use the button accordingly to make the flashes of the first and fourth lamps coincide. This same procedure is repeated to extinguish the second and third lamps within the prescribed time limit. To prevent the task of winning from becoming too easy, however, the circuit associated with the fourth or master neon lamp is arranged to have a finite recovery time equal to its normal or continuous periodic time. In Fig. 3, for example, where the master neon lamp flashes at 1 p.p.s., a maximum of ten manually controlled flashes could be obtained in the ten seconds' time interval.

The device is coin-operated, insertion of a 3d

From an operational point of view this simple version of the device has one major disadvantage when compared with its mechanical parent in that it is possible to win only one prize. In fact a second model of the fruit machine has been designed delivering other prizes, but the modification involved is elementary from a circuit viewpoint, the additional detail being merely an extension of the mechanical design.

A second disadvantage is purely psychological. The absence of the mechanical noises that are normally associated with the operation of the parent machine detracts to a certain extent from the pleasure of the game—at any rate, until a win is achieved.

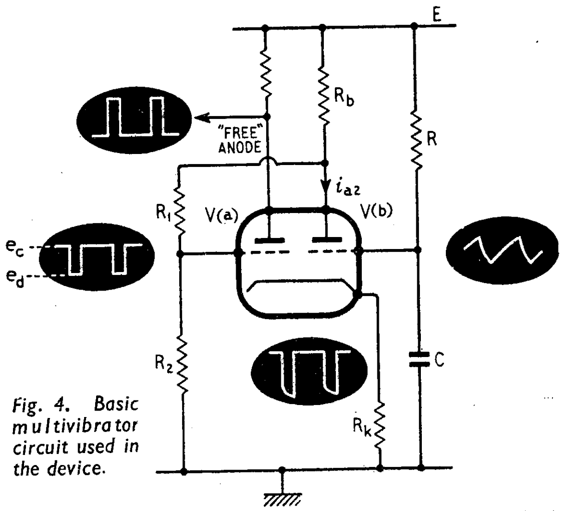



*Fig. 4. Basic multivibrator circuit used in the device.*

However, the compact size of the arrangement (it measures approximately 10 in × 10 in × 4½ in), its mechanical simplicity, and the more rewarding type of play it provides are advantages which, it is felt, more than compensate for these drawbacks. Even as a novel way of saving 3d pieces the device commends itself.

**Average Time for a Chance Win.**—The switching circuits associated with the neon lamps are so arranged that when any portion of one pulse coincides in time with the other, a triggering action takes place and the appropriate lamp is extinguished. The limiting condition for extinction will there-

(continued on page 449)

fore be given by the two pulses being adjacent. It follows that the total period of time during which coincidence can occur is $t_1 + t_m$ seconds, where $t_1$ and $t_m$ are the durations of the first and master pulses respectively.

The average number of first lamp pulses occurring is the ratio of master and first lamp's periodic times, $T_m/T_1$, and hence the total favourable time interval $\tau$ for extinction is

$$\tau = \frac{T_m}{T_1} \times (t_1 + t_m) \text{ seconds}$$

Because this favourable time interval can occur once every $T_m$ seconds the probability $p$ of extinguishing the first lamp is $\tau/T_m$. Hence.

$$p = \frac{t_1 + t_m}{T_1}$$

The average number of attempts necessary to achieve coincidence will be the inverse of this probability value, and since each attempt takes $T_m$ seconds, the time taken to extinguish the first lamp will be

$$T_m \times \frac{T_1}{t_1 + t_m} \text{ seconds}$$

Replacing the suffix 1 by 2 and 3 respectively will give the times taken to extinguish the second and third lamps in turn, and the sum of these three times gives an average overall time for the operation:

$$T' = T_m \times \left( \frac{T_1}{(t_1 + t_m)} + \frac{T_2}{(t_2 + t_m)} + \frac{T_3}{(t_3 + t_m)} \right)$$

seconds.

Substituting the values given in Fig. 3 for the periodic times and assuming equal mark-space ratios, the average overall time in the demonstration model is 8.2 seconds. This result shows that a time limit of ten seconds is very generous.

The expression for T′ makes it quite plain that for a practical commercial version of the machine the value of $t_m$ should be reduced and that of $T_m$ increased to make wins by chance less frequent. If for example $t_m$ were made negligible compared with the other pulse durations, and the remainder of the values left as in Fig. 2, the value of T′ would approach 33 seconds.

The circuit arrangement lends itself easily to being modified to offer odds to suit any requirements.

**Circuit Details.**—The circuit uses eight of the

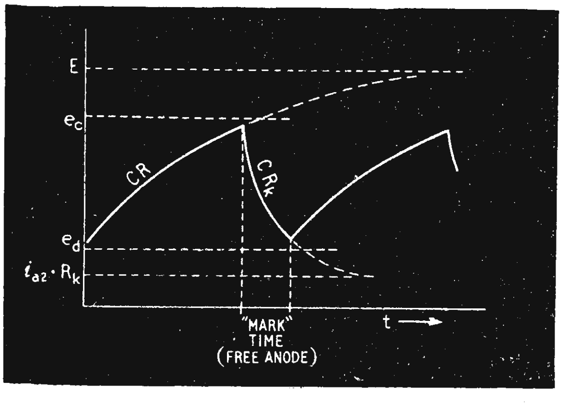
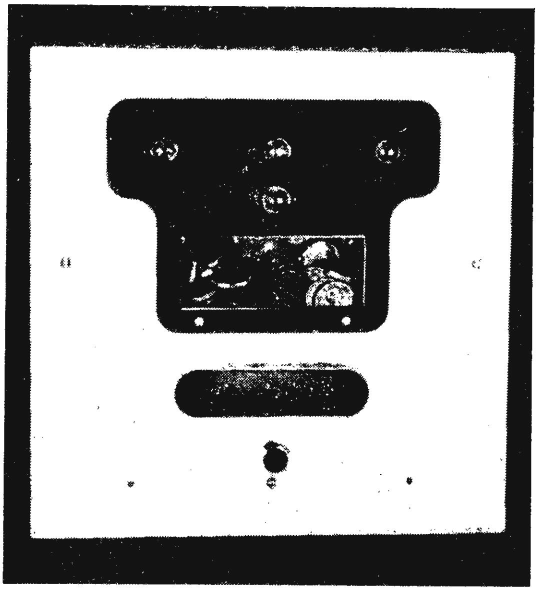



*Fig. 5. Charge and discharge cycle at the grid of V(b) in the multivibrator circuit Fig. 4.*



*Front view of a demonstration model of the electronic fruit machine, showing the neon lamps and the "jackpot" container.*

6J6 or ECC91 type of valve which is readily available on the "surplus" market for a few shillings. The envelope, mounted on a B7G base, contains two triodes sharing the same cathode.

Four of the valves function as multivibrators, three more as adaptations of the well-known Schmitt trigger circuit[1], and the final one as the time delay circuit.

The basic multivibrator [2, 3], Fig. 4, is worthy of comment as it is seldom encountered. The circuit is astable, and depends for its operation on the charge of capacitor C through resistor R towards the supply potential E, and the subsequent discharge of this capacitor through the cathode load resistor $R_k$ via the diode formed by the grid and cathode of V(b). During the charging cycle, when V(b) is cut off, V(a) grid, and hence the cathode, is at a fixed positive potential $e_c$ determined by the resistance chain $R_b$, $R_1$ and $R_2$. As C charges, however, it reaches a potential where V(b) can draw current. By doing so the anode potential of V(b) falls and the grid of V(a) drops to a new level, $e_d$.

The resultant cathode potential drop is sufficient to leave the grid of V(b) well positive with respect to the cathode, while at the same time V(a) is cut off. The cathode potential is therefore due solely to the much smaller anode current $i_{a_2}$ and the discharge current of capacitor C. The last-mentioned thus starts to discharge towards a nearly constant potential, $i_{a_2}R_k$ and for the discharge period the cathode voltage follows the grid voltage to within a grid-base of $e_d$. At this level V(a) is again able to contribute to the cathode current. The ratio of the anode resistors is so chosen that the current provided by V(a) is much the greater, and this ensures the rapid rise of the cathode potential as V(a) starts to conduct, cutting off V(b).

The cycle of operations is now ready to be repeated. Fig. 5 shows these cycles in graphical form, while the waveforms produced at the relevant electrodes are illustrated in Fig. 4.

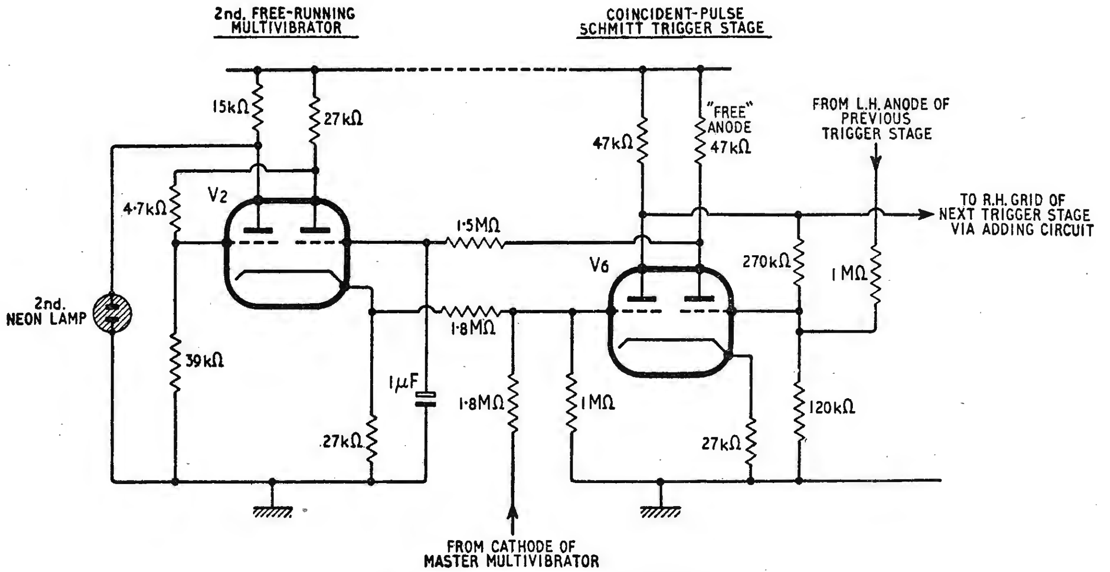



*Fig. 6. The second pulse-train generator.*

Fig. 6 shows the connections between the multivibrator producing the second train of pulses and its associated Schmitt trigger stage. The first and third pulse trains are produced in a similar manner, and to avoid circuit diagram congestion are therefore omitted here.

Connected to the "free" anode of each multivibrator is a neon lamp which will flash for the majority of the "mark" time. Normal persistence of vision creates the illusion that the lamps are triggered for a longer period than in fact they are, making the game appear simpler than it really is.

The first three multivibrators are astable and the fourth is of the same basic design as these but is controlled by a push button. It can either "free-run" when the button is held in continuously, or produce one or more pulses at its normal p.r.f. when the button is held in for short periods, depending on the duration of the last-mentioned.

At the instant that any of the first three neon lamps is triggered, the negative-going pulse produced at the cathode of the appropriate multivibrator is fed to the first grid of its associated Schmitt trigger stage *via* an adding circuit.

The negative-going pulse appearing at the cathode of the fourth multivibrator is fed to each of the three Schmitt trigger stages also *via* the adding circuits.

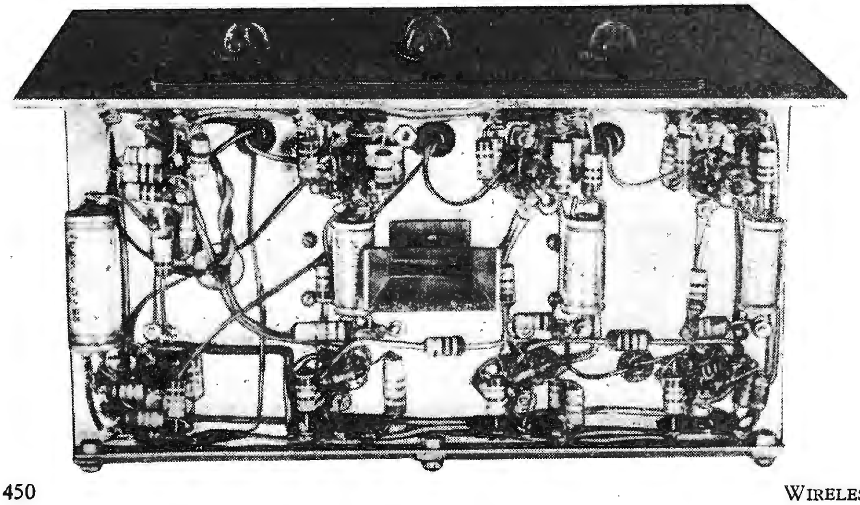
Now the first trigger circuit is arranged to operate only when a pulse from its associated multivibrator is coincident in time with that from the fourth multivibrator.

This condition also applies to the first grids of the two successive Schmitt trigger stages, but connections to their second grids (i.e., the right-hand grid of the trigger stage in Fig. 6) from the previous Schmitt valves permit the triggering action only when the previous stage, and hence lamp, has been switched off.

This switching process is achieved by coupling each multivibrator charging circuit to its associated Schmitt trigger "free" anode, the potential of which is reduced sufficiently to stop the multivibrator working when the trigger stage operates.

It follows that each multivibrator, and thus lamp, must be extinguished in numerical order, and in fact the circuit functions rather as a rotary switch.

In the "free" anode of the third and final Schmitt stage a relay is connected. Its purpose is twofold: first, it performs the relatively unimportant electrical task of switching off the third multi-



*Top view of the machine, showing component layout and coin slot in the middle. The valves hang downwards from the underside of the chassis.*

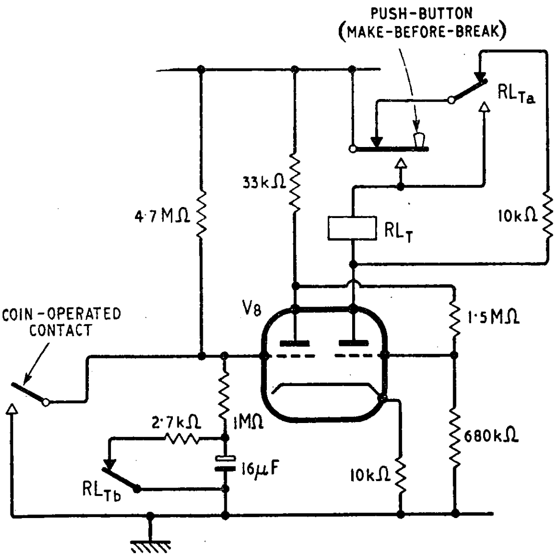



*Fig. 7. Coin-triggered time delay circuit.*

vibrator, giving an audible or visible indication of a win at the same time; and second, the action of the relay armature closing releases the catch holding the tray with the "jackpot" in position.

The final stage in the circuit controls the time of play. Here a compromise is made between electronic and electromechanical circuitry to satisfy the requirements that the stage must fulfil. These may be summarized as follows:

(1) The push button must be inoperative until the coin is inserted.

(2) Insertion of the 3d piece must make the push button functional and reset the trigger circuits and multivibrators for further play.

(3) The time limit must only commence from the instant that the push button is first pressed.

Fig. 7 shows the arrangement that satisfies these conditions and once again the Schmitt trigger circuit forms the basis of the design.

Just prior to the insertion of a coin, the left-hand valve of the double-triode combination will be conducting, and the right-hand valve cut off. As the coin is dropped in the slot, however, one of two pairs of contacts closes, to earth the left-hand grid momentarily, and the circuit triggers. Anode current to the right-hand valve will now flow *via* the push button and relay contacts $RL_{Ta}$, through the 10-kΩ anode load. Meanwhile the other pair of coin-operated contacts (not shown on the diagram) acts in a similar way to earth the grid of the first Schmitt trigger, thereby resetting the three multivibrators. This operation satisfies requirements 1 and 2, and play may now commence.

When the push button is pressed, the changeover contacts in the diagram, which are of the "make-before-break" type, divert the anode current from the 10-kΩ load to the coil of the relay $RL_T$. The coil is thus energized and the relay will be self-holding due to its contacts $RL_{Ta}$. At the same time, the contacts $RL_{Tb}$ in the left-hand grid circuit will open, and the 16μF capacitor will commence to charge towards h.t. potential through the 4.7-MΩ and 1-MΩ resistors in series. When the grid potential has risen to within a grid-base of the cathode potential, however, the reverse switching action occurs, and relay $RL_T$ is de-energized, resetting the circuit. The 16μF capacitor is rapidly discharged through the 2.7-kΩ current-limiting resistor and the whole device is left in a state of suspended animation to await the pleasure of the next player. During the waiting period, lamps that have been successfully extinguished within the time limit will remain off until reset by the next coin.

Purely as a harmless game no more can be said for the electronic fruit machine than that it represents a rather novel application of conventional pulse techniques. It certainly cannot be said to offer any serious rivalry to ERNIE, and in a country where the making of "easy" money is the modern-day trend, deplorable though the fact is, a device which requires some skill in the operator should provide a welcome change.

As a last redeeming feature the similarity between the device and a "piggy" bank can be stressed. In fact, with its paying-off ability, perhaps a better title for the machine would be the "Poor Man's ERNIE."

**REFERENCES**

[1] O. H. Schmitt. "A Thermionic Trigger," *Journ. Sci. Insts.*, 1938, 15, p. 24.

[2] Webb and Morgan. "Simplified Television for Industry," *Electronics*, June, 1950, p. 70.

[3] C. H. Banthorpe. "A Time-Base Oscillator," *Elect. Eng.*, April 1954, p. 168.

## New "Wireless World" Book

*"Basic Mathematics for Radio and Electronics,"* by F. M. Colebrook, B.Sc., and J. W. Head, M.A., is a third and revised edition of the well-known *"Basic Mathematics for Radio Students,"* in which two additional chapters at a more advanced level have been added.

The first seven chapters cover elementary algebra and geometry, logarithms, trigonometry and the calculus (both differential and integral). They include such comparatively advanced subjects as series and limits, and give a thorough grounding in the use of vectors. The last chapter of this section deals with actual radio applications.

The new chapters (contributed by J. W. Head, mathematical consultant to the B.B.C.) deal with more advanced topics such as the Heaviside operational calculus, matrices arising in linear four-terminal networks, linear differential equations, and random variations with associated least squares techniques.

The mathematics outlined has many applications outside the field of radio so that the usefulness of this book is actually wider than the title might perhaps indicate.

The book has 359 pages including 90 diagrams and costs 17s 6d. It is issued by our publishers, Iliffe and Sons Ltd., Dorset House, Stamford Street, London, S.E.1.

**"Prefabricated Chassis."** Since the article on page 390 of the August issue went to press, we have been informed that an improved version of T. K. Cowell's original design (September 1955 issue) has in fact been put into commercial production, and that supplies are obtainable from Cowell Developments, 67 Long Drive, East Acton, London, W.3.

# Further Notes on the Portable Transistor Receiver

By S. W. AMOS*, B.Sc.(Hons.), A.M.I.E.E.

DETAILS OF PRACTICAL LAYOUT

THE articles in the May and July issues on the design of a portable transistor receiver aroused much interest and many requests have been received for more information on the practical layout of such a receiver and details of the screening required in the i.f. amplifier. It is hoped that this short article will provide the answers to these requests.

The arrangement of the components of the receiver is by no means critical and a large variety of different layouts is possible. The form of construction adopted in one receiver is illustrated in the accompanying photograph. This is a rear view of the receiver with the back removed and shows the components mounted on a vertical Paxolin panel with the Ferrite-rod aerial at the top and the battery at the bottom. The volume control and the combined wave-change and on-off switch are not visible in this photograph because they are situated in the 1-in gap between the Paxolin panel and the front of the cabinet. They are secured to the cabinet front as is also the loudspeaker. The loudspeaker magnet projects through a hole in the panel and is visible in the photograph. The gap between the panel and the cabinet front also accommodates a tuning scale, pointer and epicyclic slow-motion drive arranged as shown in the accompanying sectional drawing.

The best way to ensure stability in the i.f. amplifier would be to provide screening cans for all four i.f. coils, but a somewhat simpler method is used in the receiver illustrated here. The first and second i.f. coils, which are coupled to form a bandpass filter, are placed close together and are contained in a rectangular copper box with an open top; the top edge of this box is visible in the photograph. A similar open-topped box is used to screen the third i.f. coil and to reduce coupling between the third and all the other i.f. coils in the set, the third i.f. coil is mounted on the opposite face of the Paxolin panel with the open top of the box facing the front of the cabinet. The third coil is thus not visible in the photograph, but the Bakelite screw securing it and the screening box to the Paxolin panel is indicated by an arrow. With this screening arrangement complete stability is obtained without screening the fourth i.f. coil.

If the first and second i.f. coils are placed as in the photograph they are coupled by a mixture of capacitive and inductive linkage by virtue of their close proximity. By suitable choice of spacing this combined linkage can be made to give the degree of coupling necessary for the required bandpass characteristic, the 2.7-pF top-end coupling capacitor shown in the circuit diagram (July issue) being then unnecessary. The coupling due to proximity can be substantially altered by reversing the connections to one of the tuned windings, presumably because the capacitive and inductive linkages can be aiding or opposing depending on the sense of the connections. For this reason, and also because the coupling is affected by the proximity of the screen to the pot cores, it is not possible to state how far apart the first and second i.f. coils should be to give the required passband.

The spacing can be determined empirically in the following manner. Start with the pot cores wide apart; say 2 in between their centres. With the coils still inside the screening enclosure gradually reduce the spacing while noting the output of the receiver with a very

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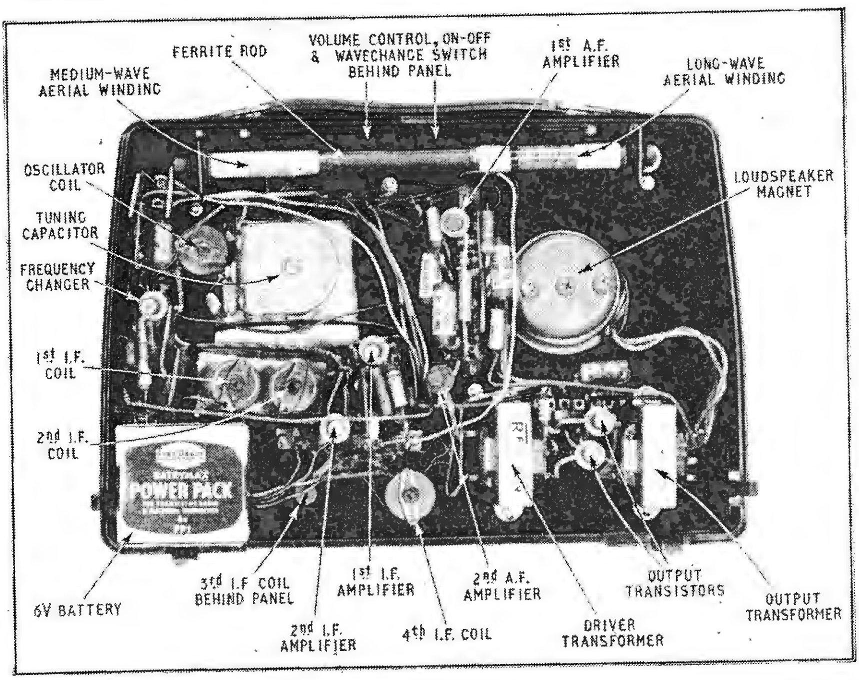
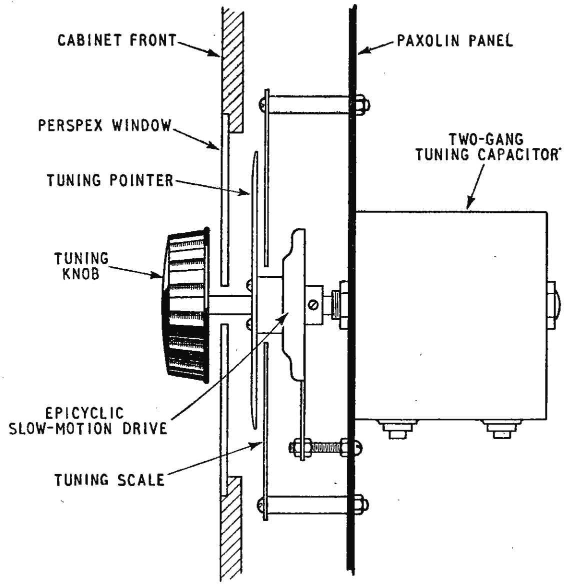



*Layout of the portable transistor receiver described in the text. Components are marked to accord with the circuit diagram in the July issue.*

weak signal injected into the aerial. The output will rise to a maximum as optimum coupling is reached; further decrease in spacing will widen the passband without significant change of gain. Fix the spacing at the widest value which gives the maximum output.

Since the original articles were published it has been found possible to simplify the construction of the i.f. coils without significant change in performance. The change is to omit the 99-turn tuned secondary windings and to tune the primary windings instead. To give the required Q values the primary winding should be wound with Litz and, as there is now plenty of room for it on the former, silk-covered 7/44 Litz wire may be used. If the original specification of 25 turns for the primary windings is adhered to, the capacitance required to tune the primary winding to 465 kc/s is $(99/25)^2 \times 200 = 3{,}150$ pF, but this is a non-standard value and it is preferable to use a primary winding of 26 turns and to tune with a close-tolerance 3,000-pF mica capacitor. The tertiary windings should remain as specified and the 30 k-ohm resistors shown across the primary windings of the first and second i.f. coils are still necessary. If simplified i.f. transformers of this type are used the top-end coupling capacitor between the first and second i.f. coils should now bridge the primary windings and the value should be 47 pF. Alternatively, of course, no coupling capacitor need be used and the required coupling can be obtained by placing the two pot cores in close proximity as described above.

**Reminder:**—As was pointed out on page 377 of the August issue an 8-$\mu$F electrolytic capacitor, to be marked $C_{23}$, should be inserted in the lead from the volume control ($R_{14}$) to the earth line in the circuit diagram on page 341 in the July issue. This capacitor must be connected with the positive lead to earth.




*Details of the pointer, scale and epicyclic slow-motion drive for the tuning capacitors.*

# Books Received

**An Introduction to Junction Transistor Theory,** by R. D. Middlebrook, M.A., M.S., Ph.D. Theoretical treatment from basic to general practical aspects and including a new equivalent circuit. Pp. 296; Figs. 139. Price 68s. Chapman and Hall, 37, Essex Street, London, W.C.2.

**Tape Recorders and Tape Recording,** by H. D. Weiler. Includes general principles, recording and editing techniques, sound effects, servicing and synchronization with film. Pp. 190; Figs. 114. Price 24s. Radio Magazines Inc., Mineola, New York. Available in this country from A. F. Bird, 66, Chandos Place, London, W.C.2.

**Copyright in Sound Recordings,** by P. Ford, Ll.B., F.R.S.A., Barrister-at-Law. Revised and reprinted from *Sound Recording and Reproduction,* January, 1957. Pp. 10. Price 1s. British Sound Recording Association, 3, Coombe Gardens, New Malden, Surrey.

**Nachrichtentechnische Fachberichte, Vol. 6.** Forty papers by various authors on general signal theory, communication networks, broad band directional aerials, and miniature components. Pp. 192; Figs. 265. Price 18 DM.

**Nachrichtentechnische Fachberichte, Vol. 7.** Seven papers by various authors on long-distance line communication techniques. Pp. 36; Figs. 69. Price 6 DM.

**Nachrichtentechnische Fachberichte, Vol. 8.** Nine papers by various authors on network synthesis problems. Pp. 68; Figs. 94. Price 4 DM.
The above Nachrichtentechnische Fachberichte volumes can be obtained from F. Vieweg and Sons, Postfach 185, Braunschweig, Germany.

**Radio Research 1956.** Report on the work of the Radio Research Station, Slough. Covers propagation in relation to l.f. and v.l.f. navigational aids, forecasting transmission conditions, the effect of the ionosphere and troposphere on h.f., v.h.f. and u.h.f. waves, general ionosphere characteristics, and atmospheric noise; and also includes research on semiconductors and ferrites. Pp. 47; Figs. 4. Price 3s. Department of Scientific and Industrial Research, 5-11, Regent Street, London, S.W.1.

**V.H.F. Radio Manual,** by P. R. Keller, B.Sc., A.M.I.E.E. Covers principles and practice in v.h.f. (30-450 Mc/s) transmitting, receiving and communications equipment for a.m., f.m. or video modulation. Pp. 216; Figs. 194. Price 30s. George Newnes, Ltd., Tower House, Southampton Street, London, W.C.2.

**Radio Control Mechanisms,** by R. F. Stock. Compiled from articles in the *Radio Constructor,* and covers mechanical coupling methods between various radio systems and the controls of small models. Pp. 64; Figs. 67. Price 4s 6d. Data Publications, Ltd., 57, Maida Vale, London, W.9.

**Fixed Paper-Dielectric Capacitors for D.C.** for use in Telecommunications and Allied Electronic Equipment. B.S. No. 2131: 1956. Pp. 10. Price 3s 6d.

**Flexible Insulating Sleeving** for Electrical Purposes. B.S. No. 2848: 1957. Includes test methods. Pp. 29. Price 6s.
The above British Standards Specifications may be obtained from the British Standards Institution, 2, Park Street, London, W.1.

# News from the Industry

**Nash & Thompson, Ltd.,** the scientific instrument makers of Oakcroft Road, Chessington, have been acquired by Thorn Electrical Industries. Founded in the early 1930s, Nash & Thompson were largely responsible for the development and production of radar scanners for H2S—the bomber radar—during the war. Two new directors have been appointed, B. C. Fleming-Williams, general manager of the Sylvania-Thorn Colour Laboratories, and D. Talbot.

**Cosmocord, Ltd.,** of Waltham Cross, Herts., manufacturers of Acos pick-ups, cartridges and microphones and also of some plastics mouldings, have been acquired by Pena Copper Mines, Ltd. It will be recalled that this mining company announced earlier this year that it was entering the field of electronics and has recently acquired Peto Scott Electrical Instruments.

**Simon.**—A controlling interest in Simon Equipment, Ltd., which incorporates Simon Sound Service and Simon Development, has been acquired by Harland Engineering Co., electrical and mechanical engineers, of 20 Park St., London, W.1. The two organizations have been closely associated for some time on the development and application of electronic control equipment. R. W. Simon continues as chairman of the company, and K. H. Williman as managing director. A modified version of Simon's multi-channel recording equipment, designed originally for ground-to-air communications at airports, has been supplied to three of the I.T.A. programme contractors. The modified equipment provides a single-channel recording for 32 hours without changing the tape.

**P.C.D., Ltd.,** is the name under which two members of the Camp Bird Group—Photo Printed Circuits, Ltd., and P.D.C., Ltd.—will be known now that they have been merged. The company will operate from Bisley, Surrey. The new managing director is S. W. Hobday who, for the past six years, has been oscillograph development engineer at Southern Instruments, Ltd.

**British Radio Corporation, Ltd.,** is the name adopted for the company which, as announced in our May issue, was being formed jointly by E.M.I. and Thorn Electrical Industries for the design and marketing of all domestic sound and television receivers under the Ferguson, H.M.V. and Marconiphone trade marks.

**Elliott Brothers,** of Century Works, London, S.E.13, and the Associated Automation group of companies, which includes Electroflo Meters Co., National Automatic Machines, Panellit, and Sauter Controls (all of London, N.W.10), and James Gordon & Co., of Stanmore, Middlesex, are being merged.

**Wolsey Electronics, Ltd.,** is the new name adopted by Wolsey Television, of St. Mary Cray, Orpington, Kent.

**Expert Gramophones, Ltd.,** of Great North Road, London, N.2, has been acquired by Wolsey Electronics. Since its inception Expert Gramophones has been under the technical direction of D. Phillips and he has been appointed technical director of the new board. The company, which specializes in the manufacture of sound recording and reproducing equipment, will no longer deal direct with the public but through dealers. Wolsey is a member of the Gas Purification Group, which also includes Grundig, Staar Electronics, and Electric Audio Reproducers.

**A.B. Metal Products.**—New directors of A.B. Metal Products, the firm recently acquired by the Gas Purification & Chemical Company, are J. R. Sorsbie, H. J. Kroch and Lewis Woolf, who was formerly sales manager of the company and will now be sales director.

**Marconi's** are to supply transmitting equipment worth approximately £160,000 for four new I.T.A. stations. The installations at each station include two 4-kW vision transmitters, two 1-kW sound transmitters, combining units and ancillary equipment. The first installation will be at Chillerton Down, Isle of Wight, which is planned to come into service next summer, and the other equipment has been ordered in readiness for future stations.

**"Walkie-Talkie"** f.m. transmitter-receivers have been supplied by Ekco Electronics, Ltd., for use by the members of the Sheffield University expedition climbing Mt. Kilimanjaro, Tanganyika. The expedition, organized by the Tanganyika Geological Survey, will also undertake work as part of the I.G.Y.

**Replacement Components.** Production and distribution of replacement components for non-current Peto Scott television receivers is now being undertaken by Direct TV Replacements, of 134-136, Lewisham Way, London, S.E.14.

**Carr Fastener Company,** of Nottingham, has opened new factories at Sutton-in-Ashfield and Worksop to increase production and, often more important, to give greater flexibility in the execution of orders for a wide variety of valveholders, terminal strips and connectors. The Sutton-in-Ashfield plant includes the latest types of automatic moulding presses and at Worksop the assembly lines are designed to be readily adaptable for long or short production runs.

**E-V Limited,** formerly Sapphire Bearings, now a member of the Camp Bird Industries Group, has acquired a factory at St. Ives, Cornwall, in addition to the existing factory at Bletchley, Bucks., where the production of sapphire gramophone styli now approaches 10 million a year. With the introduction of the new factory production of ceramic cartridges, which now exceeds 30,000 a week, is planned to reach 60,000 per week by the end of the year. Direct and indirect exports absorb about 80% of the company's cartridge production.

**Mullard's** contributions to the recently announced "Firestreak" air-to-air guided weapon include exceptionally sensitive infra-red photocells and sub-miniature valves.

**Kolster-Brandes** have opened a sound and television service depot at 41, Bent Street, Manchester, 8 (Tel.: Blackfriars 3939).

## FOREIGN AGREEMENTS

**Solartron Electronic Group** entered into an agreement a few months ago with the Rheem Manufacturing Company, of New York, on the production of electronic equipment and the two companies have now formed a joint research and development organization, Rheem-Solartron, Ltd. Research will be centred at Dorking, where C. E. G. Bailey, of Solartron, will be in charge of research and development of electronic reading machines, on which the new company will initially concentrate.

**Anglo-French Radar Co-operation.**—Compagnie Française Thomson-Houston (C.F.T.H.), and Decca Radar Ltd., have concluded an agreement by which both firms will co-operate in the design and production of radar equipments for European air defence. An agreement has also been concluded between Decca and Société Nouvelle d'Electronique, an affiliated company of C.F.T.H., under which radar aerial systems developed by the Société RBV Radio-Industrie will be available for use by Decca.

**Wayne Kerr Laboratories,** of Roebuck Road, Chessington, Surrey, have entered into an agreement with the Robertshaw-Fulton Controls Company, of Pennsylvania, under which the two companies will have a joint development programme in the field of industrial process control. The products resulting from this co-operation will be manufactured by both companies. The American company is also licensed to use existing Wayne Kerr patented measurement techniques. Under the agreement Robertshaw-Fulton will be responsible for the promotion and distribution of Wayne Kerr products in the U.S.A., and an intial $100,000 order for measuring instruments has been placed by the American company.

## COMPANY REPORTS

**Associated Television, Ltd.,** the programme contractors for the I.T.A. London (weekends) and Midlands (week days) stations record in their report for the year ended April 30th that the net profit for the year was £201,716, compared with a loss of £602,715 last year. The report records that the number of homes capable of receiving I.T.A. programmes rose during the year by 1,952,000 to 3,330,000.

**Ekco.**—In his annual report for the year ended last March the chairman of E. K. Cole, Ltd., stated that domestic television and sound radio continued to contribute the larger portion of the company's turnover and net profit, which totalled £758,574.

**Ferranti.**—Reference was made at the annual general meeting of Ferranti, Ltd., to the surface-to-air guided missile "Bloodhound," for which the company developed and produced the radar and electronic control equipment. It is also reported that the company has supplied the navy with the first equipment forming a new blind-approach system for landing aircraft on carriers.

## OVERSEAS TRADE

**Scientific Instruments.**—Twenty-three member firms of the Scientific Instrument Manufacturers' Association are participating in a combined display of scientific and industrial equipment at Interkama, the International Congress and Exhibition of Measuring Instrumentation and Automation being held in Dusseldorf from November 2nd-10th.

**Finland.**—Among the exhibitors at the British Trade Fair at Helsinki, which opens on September 6th, are several radio manufacturers including Bush, Collaro, E.A.P., Pye, Smith's Motor Accessories, Tape Recorders, and Taylor Electrical Instruments.

**Meteorological Radar.**—Decca windfinding radar is being supplied to a number of forecasting and research stations of the Argentine National Meteorological Service. It is understood that 80% of Decca's production of windfinding radar is being exported.

**Airborne Search Radar,** Type E120, supplied by Ekco Electronics Ltd., is being installed in the Bristol "Britannia" airliners shortly to be delivered to the Mexican airlines, Aeronaves de Mexico, S.A.

**True-motion radar** installations are being supplied by Decca for three new vessels being brought into service by the Texas Company, of the United States.

**Canada.**—In the fifth edition of the "CABMA Register 1957-58 of British Industrial Products for Canada," which is prepared annually by the Canadian Association of British Manufacturers and Agencies, emphasis has been placed on capital and industrial goods. The Buyers' Guide lists alphabetically some 3,200 British products, a directory of over 3,700 British firms gives details of distribution arrangements in Canada, and there are directories of proprietary names and trade marks. The 624-page register is published jointly by Kelly's Directories and Iliffe & Sons for the Association; price 15s post free.

**"Who Represents Who."**—A firm of French publishers, Editions Sopal, 16 rue St. Marc, Paris 2e, have asked the British Embassy in Paris for assistance in finding out the names of United Kingdom firms represented in France together with those of their representatives. The information is required for inclusion in a guide called "Qui Représente Qui." The publishers claim a circulation of 17,000 copies. A copy of the guide is available for inspection in Room 753 of the Export Services Branch, B.o.T., Lacon House, Theobalds Road, London, W.C.1.

**Chilean Agency.** — International Electronic Engineering, Ltd., Ahumada 254, Oficina 1203, Santiago, wish to represent United Kingdom manufacturers of a wide variety of communications equipment ranging from pack sets to transmitters.

**Instruments.**—The French firm of Paris-Labo, 7 rue du Cardinal Lemione, Paris 5me, are interested in representing United Kingdom manufacturers of scientific instruments, particularly electronic laboratory equipment.

# RANDOM RADIATIONS

**By "DIALLIST"**

## *Earls Court Hopes*

THERE are quite a few things I hope to find at this year's Radio Show and by the time this appears in print I'll know whether they're there or not. First and foremost, genuine a.c.-only sound and television sets with double wound mains transformers. The conversion of the remaining d.c. districts is going ahead so rapidly that it shouldn't be long before there's little need for the a.c./d.c. receiver. It's a bit cheaper to manufacture a universal set, I know; but the difference in cost can't be all that much and I feel that the man in the street would gladly pay the extra, if it were dinned into him that a.c.-only models were definitely safer. I'd like also to see fewer control knobs tucked away at the back of the TV receiver. The front is the proper place for them and they needn't be unsightly if they're neatly covered by a hinged panel. And there's another thing that I mentioned a month or two ago. Lots of consoles are too low for comfortable viewing. The ideal arrangement is for eyes and screen centre to be at about the same level. It might be difficult to achieve this in a console without spoiling the proportions of the set; but table models with detachable screw-in legs are now very popular and something could be done with them. Why not make these legs telescopic? Any set owner could then adjust the height of his screen exactly to his liking.

## *Other Ideas*

Those 3-position, pre-tuning, press-button v.h.f./f.m. receivers for which many readers and I myself have been pining for so long should be at Earls Court and I think there will be many more TV sets with a Band II range. In these the heaters of the audio valves should be able to be switched on while those of the vision circuits are off. If we can't have a.c.-only sets, separate heater chains for audio and video valves shouldn't be difficult to contrive. I hope to see a good deal more use made of spot wobble in sets with screens of the larger sizes. There doesn't seem to me to be much point in buying a whacking great set if, to avoid lininess, you have to sit so far from it that its screen subtends just the same angle at your eye as that of a smaller set seen at its correct viewing distance! Has any manufacturer tried spot elongation, or astigmatism? Neither this nor spot wobble lead to serious loss of definition and the use of either means that a bigger TV set really gives you a bigger picture.

## *What a "Vac" Can Do*

A FRIEND who lives not far from me has been having a very trying time as regards television reception for a long while now. At entirely unpredictable intervals terrific interference suddenly came on, completely wiping out his picture. Before making a report to the Post Office he kept a very careful log; but this showed that the trouble might occur at any time during programme hours—or it might be completely absent for days on end. Sometimes it lasted only a minute or two; sometimes it just went on and on. The P.O. engineers were awfully good about it, paying visit after visit to his home. But, as so often happens, the screen was perfectly clear whenever they were there. Then just a few days ago the interference began while one of the engineers was having a cup of tea with him. Laying down his cup, he dashed out with his instruments and soon returned in triumph. The culprit proved to be a small and rather ancient vacuum cleaner belonging to the very-house-proud next-door neighbour. The large modern cleaner used daily by her "lady what obliges" had been properly suppressed and was quite harmless. But she kept the other in a cupboard in her drawing room and dived for it at any moment if she saw so much as a crumb or a speck of dust. It hadn't been suppressed. It has now, though no less than three suppressors had to be fitted before it could be silenced.

## *The Very Short Waves*

IT SEEMS to me that we've a lot to learn about the propagation of waves of the centimetre—or even millimetre order. At present they're used for radar and over comparatively short distances for radio and television links; but I believe we'll soon be able by means of new techniques to send them much farther afield. It's only a short time, you know, since it was "proved" to the satisfaction of all the big noises in the scientific world that wavelengths not much under 100 metres were useless for long-distance communications. They were thought to be of so little commercial value that they were handed over to the amateurs to play with. It was only when they began to report regular communication with places as far away as New Zealand by means of fly-power transmitters and home-made receivers that the aforesaid big noises started to sit up and take notice. As a result a complete revision of short-wave theory and practice took place. And not only that. Had it not been for the development of metre-wave techniques, we couldn't now have found room in the ether spectrum for television. I'm sure that there's a big future for the still shorter wavelets, once we've learnt how to use them.

## *Hearing Electrically*

THE account of an entirely new method of making a stone-deaf patient hear which has been tried out in France impressed me enormously. Briefly, the secondary of a minute a.f. transformer was placed under the skin near the ear, one end of the winding being embedded in the auditory nerve and the other in a muscle. The primary, outside the skin, is worn in a position immediately over the secondary. A conventional microphone circuit completes the arrangement. What it comes to is that sounds are converted into electric impulses, applied directly to the auditory nerve. It is, I believe, agreed that the brain receives the messages conveyed by any of our nerves by being stimulated by tiny electric currents. In this instance the experiment of, so to speak, short-circuiting a completely inert eardrum and applying the impulses direct to the nerve seems to be showing very promising results. One wonders whether in the future something on similar lines may not be applicable to blind people—provided that the optic nerve has not been destroyed.

## *It Isn't Where It Was*

REFERRING to my recent paragraph suggesting that it might be impossible to fix the exact position of any point on this coast because of tidal and other movements in its apparently solid surface, a kind reader writing from Scholes, Leeds, calls my attention to Wegener's theory of continental drift, according to which Greenland, for one, is moving westward at the rate of 30 metres a year. In other words, no matter how exactly you measure the position of any point by radar or other methods, you can't say precisely where it was at the instant when the measurements were made! Part of the programme of the International Geophysical Year is concerned with more precise determination of latitude and longitude at more than 20 stations and a comparison of the values obtained with results from future I.G.Y.s may ultimately settle these questions.

# UNBIASED

By FREE GRID

## *Transistorized Tarantelle*

ALTHOUGH I am a bit of a fiddler I am not entitled to describe myself as a violinist, as an officious police sergeant once told me in my younger days when seeking to know my profession or occupation for entering on the charge sheet.

Possibly owing to the devastating effects of my own amateurish efforts at fiddling, I hold very strong views about it. To my mind nothing sounds so cacophonous as the sound of a tyro trying to make music by scraping the intestines of a defunct cat. It is even worse than the sound of the nocturnal love calls made by the owner of the intestines in its lifetime. By comparison, few solo musical instruments give me greater pleasure than a violin in the hands of a competent player.

Some of the more offensive of the screech-producing fraternity are to be found among street musicians. I was all the more surprised, therefore, when recently I heard sounds of what appeared to be really inspired violin playing coming from the corner of the street. Hastening my footsteps, I suddenly came across a crowd of people standing spellbound before a deft-fingered catgut caresser standing in the gutter.

Presently I spied in the crowd somebody who was obviously a music critic listening intently to the performance. His status in the musical world was made obvious by the mingled look of distaste and admiration on his face; admiration at the faultless technique of the kerbside disciple of Paganini and distaste at the sugary, sentimental type of music which he was playing and which is anathema to all true musicians.

*Soul searing strains.*

Suddenly, to my surprise, the critic shot out his hand, grasped the neck of the violin and jerked it from the grasp of the player. To the intense astonishment of the crowd—and momentarily, I confess, of myself—the violin continued to sob out its soul-searing strain while held at arm's length by the critic.

Needless to say, the police were soon on the scene to prevent a breach of the peace, and full explanations were forthcoming. As you can guess, a miniaturized and transistorized v.h.f. receiver was built into the hollow neck of the violin, the body being used to house the loudspeaker. The transmitter, playing desk and stock of records were being manipulated by an innocent-looking barrow boy a little way down the street.

## *Electronics in the Office*

A FEW weeks ago I dropped into the Business Efficiency Exhibition at Olympia, being attracted by a good deal of ballyhoo in the lay Press to the effect that the modern efficient office had been completely "electronicized."

I must confess that on the whole I was very disappointed. There were one or two electronic computers, but the main "electronic" exhibit appeared to be a great variety of recorders. I have deliberately refrained from using the expression "tape recorder" because, with one or two exceptions, all the machines were of the disc type, using modern unbreakable records that were, as one exhibitor put it, completely typist-proof, as not even the most ham-handed Harriet could miss a day's typing by dropping the records. I was told also that discs were easier and quicker to handle than tapes for office work.

There was no sign at the exhibition of the "Electronic Typist," which we have been told will one day displace the more human type.

One thing which certainly did interest me in the exhibition was the electric typewriter to which could be coupled a slave typewriter—or any number of them—in another room. It was, however, not made quite clear to me in which way this system of producing a duplicate copy was better than the use of carbon paper.

But there is one obvious use for a slave typewriter which occurs to me. A girl will no longer fill in a spare ten minutes by rattling off a letter to "Darling George" if she realizes that her Ovidian rhapsodies are being monitored by an acidulous-looking female office supervisor in an adjoining room.

## *Psychiatrist's Corner*

I HAVE a mania for collecting odd, unusual and mostly worthless facts about radio, and the desire to collect them comes over me in waves. This phenomenon is well known to psychiatrists and is, I believe, due to some "fixation" formed in childhood.

Thus, when very young, I collected useless things like matches and cigarette cards. But the mania soon gave way to one for collecting birds' eggs and stamps. This lasted until adolescence when naturally I started to collect blondes and brunettes, but eventually this proved as worthless and unsatisfactory as the cigarette cards and other things.

At present I am collecting worthless wireless facts. Can any of you tell me when we started to measure our wavelengths in metres instead of in feet? It may surprise some of the younger readers of *W.W.* that we ever did so, but I can assure them that we did; when it is remembered that this country was the cradle of wireless it is not so surprising.

When ships began to be fitted with wireless soon after the death of Queen Victoria, the wavelength of 2,000 feet became a recognized standard. The reason was very simple; it was found that the distance between a ship's masts was such that an aerial slung between them radiated at maximum efficiency when this wavelength was used. Later this 2,000 feet was turned into the famous 600-metre international ship's wavelength. But when did this change from feet to metres take place? I believe it was after the first international wireless conference which was held in Berlin in 1903 and I want you, if you can, to confirm or correct this quite useless piece of information.

Another worthless fact I want to know is this. We all know that the P.M.G.'s jurisdiction in the ether extends to an upper limit of three million megacycles, thus leaving us free to use a morse lamp without a wireless licence. But is there a lower limit to the P.M.G.'s control over the etheric spectrum?

I used to listen to the old Bordeaux-Lafayette station transmitting on a wavelength of 30,000 metres. But suppose I wanted to try to transmit on a wavelength ten times as long? I know the difficulties of erecting an aerial large enough to be an efficient radiator would stop me, but could the P.M.G. do likewise? A useless piece of information, I know, but, as I have said, I have a mania for collecting these things.