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Wireless World

The "Ideal" Receiver?

ARGUMENTS as to whether this year's Radio Show was better, as good as, or worse than last year's have subsided without leaving any conclusion which is not to some extent coloured by prejudice. Our own view would be that it was a better show, but by a margin too small to justify any claim for recognition as a landmark in any future history of the development of broadcast receivers. Although, as our review elsewhere in this issue points out, most of the changes seen this year are developments of trends already discernible a year or more ago, there has been ample food for thought in the rate at which some of these changes are taking place, and the reaction of the buying public to the new types of set which are offered to them.

Take, for example, the combined television and v.h.f./f.m. sound receiver. From the technical point of view this is a particularly neat and logical combination, since not only the audio-frequency amplifier but also the early intermediate-frequency stages can be made to fulfil dual functions. There is no more economical way, either in first cost or in the space taken up in the living room, of making provision for the reception of all the domestic broadcast services in this country. In spite of this, according to reports published in the trade Press, there has been no spectacular swing in popular favour towards this type of receiver, though there were more sets to choose from this year than last. According to some dealers, many of their customers still want medium and long waves if only for the reception of the popular Luxembourg programmes; others point to the fact that some members of the same family may wish to receive the sound programmes while others are viewing television—clearly a case for separate sets in different rooms. Even those for whom these objections do not carry any weight may still argue that the small power outputs and loudspeakers which are perfectly adequate for the sound accompaniment to television and, indeed, for many of the sound programmes themselves cannot do full justice to all the qualities of the B.B.C.'s v.h.f./f.m. service.

The truth is that no single receiving system can completely satisfy all the varying tastes and requirements of all sections of the community and, at the same time, fall within the price limits that most people can pay. Accordingly, manufacturers produce a range of sets giving permutations and combinations of those features which they judge will make the widest appeal. For economic reasons it is obvious that such a range cannot be expected to be complete, and that some potential customers must go without or put up with a set which to them is second best.

As a way out of this impasse there is, in our view, a case for a return to unit construction; but, before the indulgent smiles of the conservative body of the radio industry give place to ribald laughter, let us hasten to add that we do not visualize a return to the block system, which we in this journal are old enough to remember, in which every stage was built as a separate unit, but rather to an extension of the ideas which have found favour with the "hi-fi" enthusiasts. The basic unit would be a vision receiver with alternative input tuners and a plug-and-socket take-off point for sound which would go either to a small internal conventional rectifier/discriminator/amplifier and loudspeaker, or to an external high-quality sound-reproducing system. No system other than one based on units could hope to satisfy the individuality expressed by those with strong ideas of what constitutes good sound reproduction, and to any who may think that a unit system must look like a laboratory test bench we commend the many fine examples of "custom built" sectional furniture which have recently been introduced. There is no need for the "electronics" to be any more apparent than they are in a conventional receiver, and for those who are prepared to pay the cost, even knobs and dials can be discreetly tucked away behind panels or concentrated in neat remote-control units.

By these means it should be feasible to give the man who wants, say, television with high-quality sound all that he wants without forcing him to buy also an automatic record changer and a cocktail cabinet.

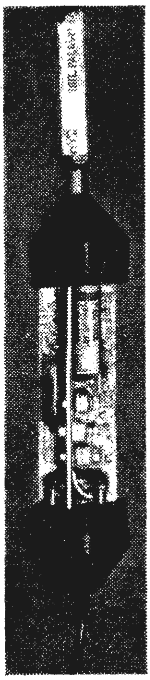
We know only too well that there will always be those who want to combine X's amplifier with Y's tone-equalizer and Z's loudspeaker, but we have every reason to believe that an experienced dealer will have either the technical knowledge to help the customer to do this or the arguments to persuade him to stick to one make.

Farnborough Air Show

DEVELOPMENTS IN RADIO AND ELECTRONICS

As in most technological industries and services, electronics plays a significant and, in some cases, a dominant part in all branches of aviation. Manufacturers make use of computers for design, vibration generators and strain gauges for testing, and computers again for the more advanced flight data instruments. None but the smallest light aeroplanes may fly without v.h.f. communications equipment and long distance radio communication and radar are essential aids to the flight controller.

Developments in ground-to-air communications equipment are toward the provision of a wider selection of channels and greater flexibility in selection. In the new Murphy MR370 transmitter a decade switching system tunes to any of 622 channels at 90kc/s separation (56 at 100kc/s) in the 100-156Mc/s band. In the Murphy airborne v.h.f. receiver (MR300) 44 channels (100kc/s) are available and with the Standard Telephones STR9X conversion kit to give 44 channels with automatic tuning instead of the former 10, is now in full production.



Ultra SARAH transistorized rescue beacon with cover removed.

Redifon have brought out a new medium-frequency (200-525kc/s) beacon, the layout of which is designed to reduce routine maintenance time. It is available as a dual installation where continuity of service is essential together with an automatic change-over and alarm unit.

Two developments in air rescue beacons were noted. Burndept have introduced a crystal-controlled u.h.f. beacon transmitter ("SARBE") in two forms with or without two-way speech facilities, and Ultra are making an inexpensive version of "SARAH," with built-in transistor h.t. supply, for use on small fishing vessels.

With the growing density of traffic, the work of the air traffic controller is becoming increasingly onerous. Much thought has been given to ways and means of simplifying his task and in a new Decca display system now under development the controller is presented only with the essential information required to make decisions. All radar and flight report material is sifted by a team of operators before appearing on his screen. The basis of the display is a 405-line projection television plan of the airport and its approaches, derived from a transparency in the outer control office by the "Deccafax" system (described on p. 470 of this issue).

Superimposed on this "static" display are moving symbols indicating all aircraft in the area. Small numbered squares represent aircraft under radar observation, while circles indicate movements, based on reports, of aircraft not yet in radar range.

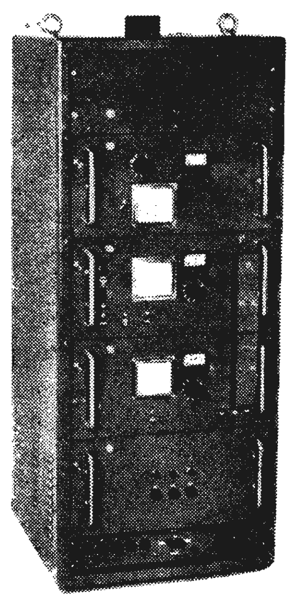
The method of generating, controlling and displaying the flight symbols is ingenious. The symbols and numbers are first selected from a monoscope tube with a store of 100 digits by a 20-line spiral scan and are fed into the main radar display tube during the flyback period between each radial sweep. Their position is determined by "gated" currents in auxiliary horizontal and vertical deflection coils and normally the symbols are stored in a row at the top of the tube. When a target is identified it is "boxed" by one of the symbols, first using manual control of deflection, and is then followed by putting on a traverse with the right speed and direction. Adjustment of the rate may be required from time to time to keep the target "boxed"; but it is hoped later to incorporate auto-following. The video signals corresponding to the symbols and their position co-ordinates are repeated on a separate c.r. tube which is scanned at 405 lines, synchronized and mixed with the "static" Deccafax information and applied to the controller's projection display tube.

Unwanted permanent echoes in a radar screen are reduced in the Cossor CR21 surveillance radar by a cancellation technique and rain echoes by the use of circular polarization in conjunction with a quarter-wave filter plate in the radar beam. This equipment, which was shown in prototype form last year, has recently undergone extensive official trials and in its mobile form has been widely demonstrated abroad.

Marconi's have introduced a high-power (3MW peak), 10-cm radar (Type SR1000) for long-range civil and military requirements which breaks new ground in combining transmitter, receiver and all power supplies in a single compact cabinet measuring only 87 in × 81 in × 40 in.

Doppler Navigation

Where navigational assistance from ground stations is either impracticable or inexpedient the Doppler system of independent course tracking by the change of apparent frequency of radio reflections from the ground is without a serious rival. The general principles were described in our May issue (p. 225) and since then more details have been disclosed of the equipment developed by the Ministry of Supply and the Marconi Company for use by the R.A.F. This employs a four-element slotted waveguide aerial system switched to direct downward-pointing beams, forward to port and aft to starboard or alternately forward to starboard and aft to port. The use of simultaneous fore and aft beams gives an increase in the Doppler frequency shift and compensates for small changes in the transmitted frequency. The Doppler



Murphy MR370 v.h.f. transmitter/receiver.

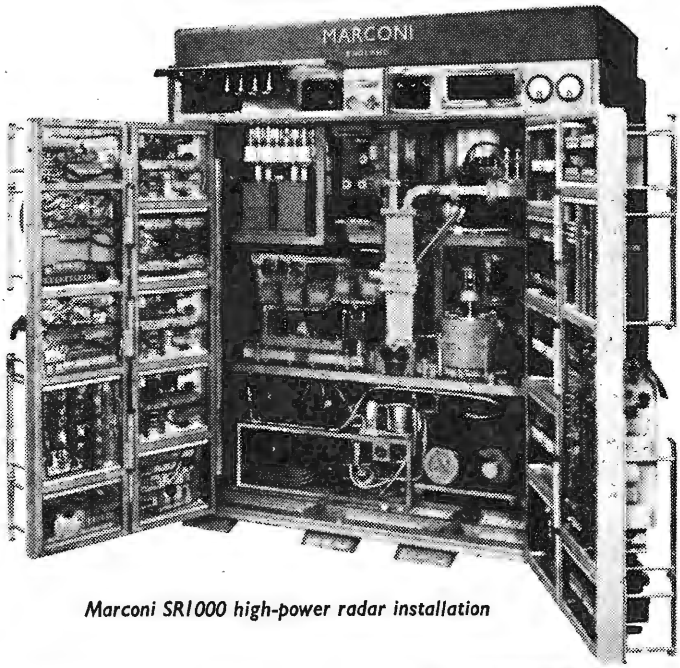
shifts given by the alternating beam positions are the same only when the axis of the aerial system is in line with the aircraft's track over the ground; any frequency difference can be used as an error signal to turn the aerial system automatically into the line of flight, and so indicate the drift angle.

Since the beam widths are finite there are multiple reflections from the ground, each with a slightly different frequency shift and this gives a whole spectrum with a Gaussian distribution about a centre frequency of maximum amplitude. In the Marconi AD2000 (military) and AD2300 (civil) Doppler Navigators phonic wheels are synchronized with and follow the Doppler centre frequency and are used to drive a computer which gives the pilot accurate information of course and distance flown, or his instantaneous position in latitude and longitude.

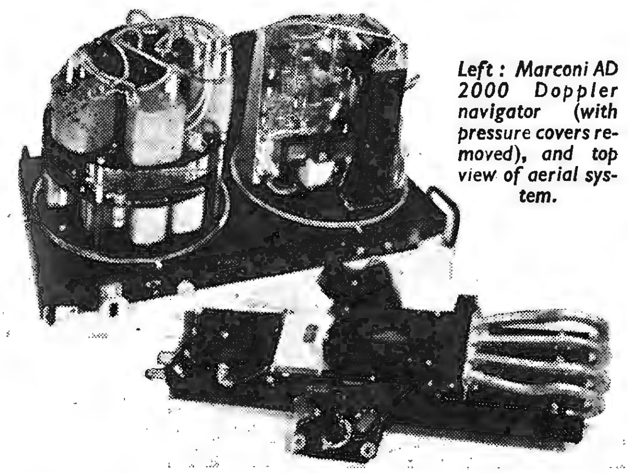
Ekco have introduced a drift unit (Type 153) for use with their E-120 airborne search radar which is relatively simple. It makes use of the single forward beam of the search radar (with the scan stopped in the forward and downward position) and displays the ground responses on a small c.r. tube with a single horizontal time base ("A" scope). Beating between component frequencies of the Doppler response spectrum causes amplitude modulation and "fuzziness" of the trace. The beam can be deflected through a servo system from a dial on the display unit calibrated in degrees of drift and is adjusted until the "flutter rate" of the display is a minimum (when the beam is pointing along the ground track). The angle between the aircraft heading and the track is then read off the scale. Accuracy depends on the operator's skill in estimating the null, but is stated to be generally of the order of ±1°.

The four-beam method has been adopted by Decca for their Doppler radar unit, since it lends itself to integration with the Decca Navigator and Dectra hyperbolic systems. A complete navigation system incorporating all the necessary computers and known as "DIAN" (Decca Integrated Airborne Navigation system) is now under development.

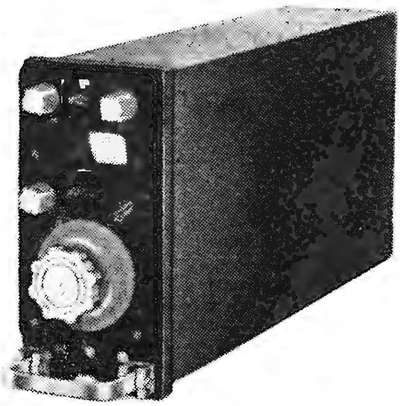
Electro-mechanical computers of small size are being used to simplify the preparation and presentation of flight data such as air speed, Mach number, vertical speed, altitude, etc. Hitherto these quantities have been measured and displayed by separate instruments, but



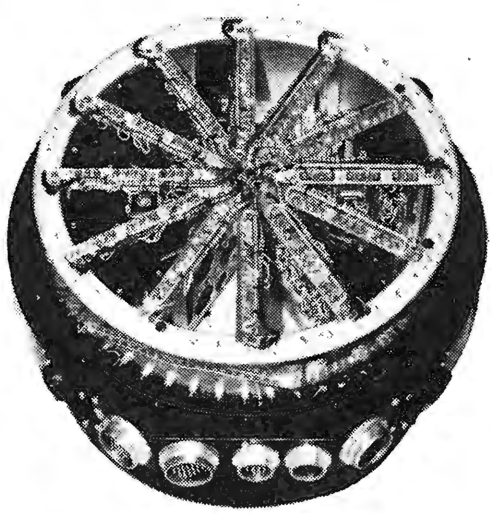
Marconi SR1000 high-power radar installation



Left: Marconi AD 2000 Doppler navigator (with pressure covers removed), and top view of aerial system.



Ekco Type 153 Doppler drift indicator.



Elliott air data computer.

can now be derived from a two-capsule pressure transducer giving electrical analogues of static and dynamic pilot tube pressures. The calculations made by the computer take into account temperature and are based on the characteristics of a "standard atmosphere." Development has been initiated by the Ministry of Supply and practical interpretations were shown by Elliott Brothers and Kelvin-Hughes. An interesting feature of the displays used in these instruments is the fixed-pointer, moving-band type scale giving greatly increased length. In the Elliott computer there are 12 transistor amplifiers and these are arranged radially in the cylindrical pressurized container.

Many other interesting items were noted including an intercomm. system with long trailing leads and special headphones for use by ground servicing crews under severe ambient noise conditions (Ultra); a capacitance bridge sensitive enough to measure the dilation of rotors under centrifugal force (Wayne Kerr); a "breadboard" system for assembling and testing prototype servomechanisms (Vactric); new types of aircraft wiring cables for continuous operating temperatures up to 240°C (B.I.C.C.); a magnetic tape data recording system for analogue, PDM or FM signals (Solartron); and a vibration generator, Model VG109, developing a thrust of 8,000lb (Goodmans).

WORLD OF WIRELESS

Valves and C.R. Tube Restrictions

REGISTERED agreements relating to the supply of valves and c.r. tubes are among those recently referred by the Board of Trade to the Restrictive Practices Court, which has to decide "whether the restrictions which have made an agreement registrable are contrary to the public interest or not." Anyone who can furnish information from his own experience of the effects of these agreements covering exclusive dealing arrangements between manufacturers, dealers and users, the fixing of maximum discounts and restrictions on imports, is invited to communicate with the Solicitor to the Registrar of Restrictive Trading Agreements, Chancery House, Chancery Lane, London, W.C.2. (Tel.: Chancery 2858.)

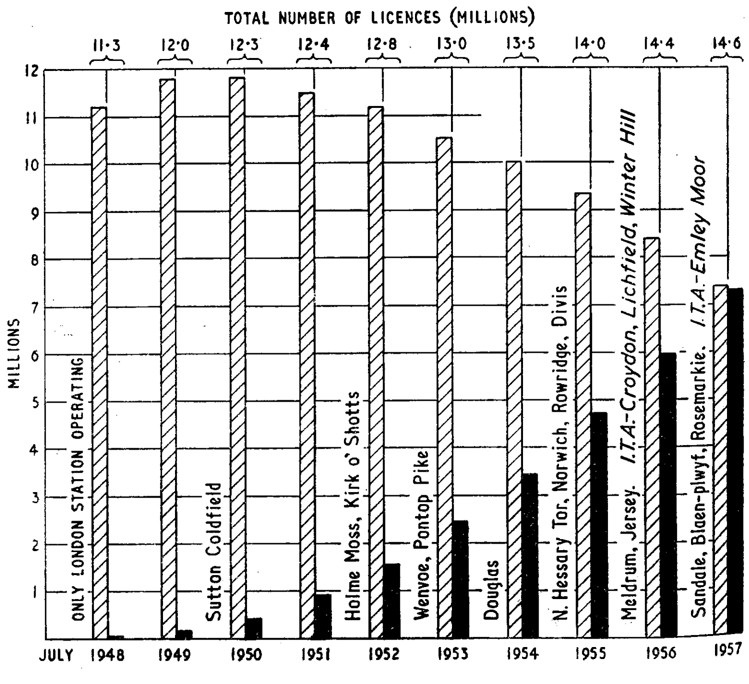
Cabinet Styling

ABOUT 60 manufacturers of cabinet materials, accessories and "embellishments" are exhibiting at a three-day trade show organized by the British Radio Equipment Manufacturers' Association. The exhibition, which is to be international, will be held at the Royal Hotel, Woburn Place, London, W.C.1, from October 1st to 3rd. Admission to the show, which is open from 2.0 to 6.0, is limited to *bona fide* trade visitors, who can obtain invitation tickets from B.R.E.M.A., 59, Russell Square, London, W.C.1.

Receiving Licences

ALTHOUGH the figures for August are not available at the time of going to press it is pretty certain that television licences in the U.K. now exceed the number of sound-only licences. The July figures are, sound-only 7,374,865, television 7,269,748. If, however, the 319,163 licences for car radio current in July are deducted from the sound-only figure the resulting total of 7,055,702 for *domestic* sound licences was already some 200,000 below the television figure.

The thermometers in this chart show the gradual rise and fall of the two groups of licences during the past ten years. The figures given are those at July each year. The additions to the number of television stations for each twelve months are also indicated on the chart.



What is a Technician?

THE confusion caused in the minds of laymen by the indiscriminate use of the words engineer and technician must have been still further confounded by the recent announcement in the lay press that pay increases averaging £125 were to be given to all "television technicians from the top existing rate of £1,600 a year downwards." The announcement concerned the agreement signed by the I.T.A. programme contractors and the Association of Cinematograph, Television and Allied Technicians on behalf of its members who include supervisory engineers, maintenance and control engineers, camera operators, technical assistants, etc. It is understood the Association will be negotiating for a similar agreement, which covers not only pay increases but overtime rates and conditions of employment, with the B.B.C.

Schools Television

IT has been estimated that scholars in about 1,000 schools will be viewing when the B.B.C.'s schools television service opens to-day, September 24th. All B.B.C. transmitters will radiate the programmes (designed for the 11s to 15s) from 2.5 to 2.30 on school days.

Television transmissions for schools are also being radiated from two I.T.A. stations, Croydon and Lichfield, from September 23rd. They are being organized by Associated-Rediffusion, the programme contractors, and will be transmitted on Mondays to Fridays from 2.45 to 3.10 and repeated from 3.25 to 3.50.

As we mentioned some months ago, the Association of Education Committees (10, Queen Anne Street, London, W.1) has issued a report on television equipment for schools which lists a number of "approved" receivers

Brit.I.R.E. Awards

THE Clerk Maxwell premium, the senior award of the Brit.I.R.E., is to be presented to Dr. K. D. Froome of the N.P.L. Metrology Division. The 20-gn. award is made for his paper "Microwave determinations of the velocity of light."

The Institution's 20-gn. Heinrich Hertz premium, awarded for the most outstanding paper dealing with the mathematical or physical aspect of radio, goes to Dr. A. G. Edwards (A.E.I. Research Laboratories) for his paper "The effects of atmospherics on tuned circuits." K. E. Harris, Cossor Radar's research director, receives the Brabazon 15-gn. premium (awarded for a contribution on radio and electronic devices for aircraft safety) for his paper "Some problems of secondary surveillance radar systems."

Both the Louis Sterling (15gns.) and the Marconi (10gns.) premiums go to overseas engineers. The first to Dr. A. van Weel (Philips, Eindhoven) for "Some remarks on the radio-frequency phase and amplitude characteristics of television receivers," and the second to Professor P. M. Honnell (Washington University, St. Louis) for "Prescribed-function vibration generator."

H. J. Leak receives the 5-gn. Norman Partidge Memorial Award for "High fidelity loudspeakers: the performance of moving-coil and electrostatic transducers."

"*Sandwich*" *and Special Courses*

NEARLY 70 colleges in all parts of the country are now offering sandwich courses—consisting of alternate periods of work in industry and college—leading to advanced-level awards such as the Higher National Diploma or Certificate or the recently introduced Diploma in Technology. A list of sandwich courses was published early in September by the Ministry of Education (H.M.S.O., 1s 4d).

In addition to the regular full-time and part-time courses for recognized awards provided by technical colleges and polytechnics, a large number of them are conducting short-term specialized courses. Among those beginning this term are the following:

Transistors and Allied Devices.—Twenty lectures (Tuesday afternoons or evenings beginning October 8th) at Borough Polytechnic, Borough Road, London, S.E.1. (Fee 50s.)

Pulse Techniques.—Twenty-two lectures on the fundamental principles (Monday evenings, beginning October 7th) and a 12-week laboratory course (Monday afternoons or Thursday evenings, beginning October 28th) at Borough Polytechnic. (Fees 50s and 20s respectively.)

Transistor Physics and Applications.—Eight lectures on successive Wednesday evenings from October 23rd at South East London Technical College, Lewisham Way, London, S.E.4. (Fee 20s.)

Operational Calculus.—A course of 20 evening lectures on applications to electric circuit theory begins at South East London Technical College on October 22nd (Fee 26s.)

Control Engineering.—A series of courses covering industrial instrumentation, mathematics of feedback systems and automatic process control are being given at Battersea College of Technology, Battersea Park Road, London, S.W.11, during the Autumn and Spring terms. They begin in the week commencing September 30th.

Linear Servomechanisms. — A one-year evening course (Mondays) begins at Battersea College of Technology on September 30th. (Fee 20s.)

Pulse Circuit Design.—Twenty-two evening lectures begin on Thursday, October 10th, at Twickenham Technical College, Egerton Road, Twickenham. (Fee 40s.)

Higher technology courses at Southall Technical College, Beaconsfield Road, Southall, Middlesex, include radio telemetry (12 lectures, beginning September 30th), digital computers (12 lectures, October 1st), transistors (12 lectures, October 2nd), and pulse techniques (18 lectures, October 10th).

Essentially for Layman.—A course on elementary theory of electrical and electronic engineering, including some radio and television servicing, on Mondays and Wednesdays at the Wesley Evening Institute, Wesley Road, London, N.W.10. (Fee 30s.)

2,600 miles on 2 metres is the record set up by two amateurs in California and Hawaii in July, according to a note in the *R.S.G.B. Bulletin.* The Californian station, W6NLZ, near Los Angeles, used a 13-element, 24-ft Yagi and the Hawaiian station, KH6UK, at Kahuku, Oahu, employed an array consisting of four 24-ft Yagis in a box formation. Both transmitters had an output of 1kW. With such arrays what were the e.r.p.s?

A fourth channel in Band III has now been cleared. The first station to operate in it will be the I.T.A. Chilterton Down, Isle of Wight, transmitter, which, when opened next summer, will serve central Southern England. The carriers in channel II will be 201.25 Mc/s (sound), and 204.75 Mc/s (vision).

Radio Hobbies Exhibition is the new title given to the annual amateur radio show organized by the Radio Society of Great Britain. The emphasis at the show, which opens at the Royal Horticultural Old Hall, Vincent Square, London, S.W.1, on October 23rd for four days, will be on home construction. Admission to the exhibition, open daily from 11.0 to 9.0, costs 2s.

B.S.I.R.A.—The series of "open days" at the headquarters of the British Scientific Instrument Research Association at Southill, Elmstead Woods, Chislehurst, Kent, originally arranged for October 7th to 11th, has been extended to include the 14th also. Enquiries for invitation tickets should be addressed to the director.

Isle of Man is to have a v.h.f. transmitter on the same site as the permanent Douglas television station now being completed at Carnane. Initially it will transmit only the Home Service.

For R.E.T.M.A. read E.I.A.—The American Radio-Electronics-Television Manufacturers' Association, which through the years has grown from R.M.A. through R.T.M.A. to R.E.T.M.A., has now changed its name to the all-embracing Electronic Industries Association.

Air Communications.—A five-week meeting of the communications division of the International Civil Aviation Organization opened in Montreal on September 10th. It will be concerned primarily with radiotelephone facilities and procedure (especially in relation to the introduction of the selective calling system). It will also consider the formulation of international technical standards for air traffic control radar equipment.

Canada's fourth Decca Navigator chain, covering the Quebec area, will be opened in October. The third chain, centred at Nova Scotia, was opened in August, and two other chains (Newfoundland West and Newfoundland East) are under test by the Canadian Department of Transport. Two of the stations in the Western Newfoundland chain are also used for the North Atlantic Dectra long-range navigational system.

Personalities

Lord Brabazon, president of the Radio Industry Council in succession to **Sir Edward Appleton,** is a director of Electric & Musical Industries, Ltd. For some time before the war he was president of the now defunct Radio Manufacturers' Association. Unfortunately sickness prevented him from performing his first public function as R.I.C. president—the opening of the Earls Court Radio Show.

Sir Thomas Spencer, M.I.E.E., on September 9th completed 50 years' service with Standard Telephones and Cables, of which he is chairman and managing director. Sir Thomas, who is also chairman of Standard Telecommunication Laboratories, Kolster-Brandes, and International Marine Radio Company, was founder and first chairman of the Telecommunication Engineering and Manufacturing Association.

Sir Leonard Owen, C.B.E., has been appointed managing director of the Industrial Group of the Atomic Energy Authority in succession to **Sir Christopher Hinton,** K.B.E., F.R.S., who has become chairman of the Central Electricity Generating Board. Sir Leonard, who obtained his degree of Master of Engineering at Liverpool University, has been engaged in the development of Britain's atomic energy programme since 1946 and for the past three years has been director of engineering and deputy managing director of the Industrial Group.

Rear Admiral P. Dawnay, M.V.O., D.S.C., who in January takes up the appointment of Flag Officer Yachts, is a signals specialist and was at one time captain of the naval signal school H.M.S. *Mercury*. From 1941-43 he was signal officer to the Admiralty Delegation in Washington and the combined chiefs of staffs, and in 1945 was signal officer at the Yalta conference of heads of States. In 1946 he was promoted captain and for two years, 1948-50, was deputy director of the Signal Division at the Admiralty.

H. E. Cornish, O.B.E., M.C., B.Sc.(Eng.), A.C.G.I., M.I.E.E., succeeds **Sir Archibald Gill, K.B., B.Sc.(Eng.),** M.I.E.E., as general manager of British Telecommunications Research, Ltd., the research establishment jointly set up by Automatic Telephone & Electric Company and B.I. Callender's Cables, at Taplow, Bucks, some ten years ago. Sir Archibald, who now becomes chairman of B.T.R., which he joined last year, was engineer-in-chief of the Post Office until his retirement in 1951. Mr. Cornish has been Postmaster General of Sarawak since 1951 and previously held telecommunications engineering and administrative posts in Nigeria and Malaya.

C. G. Mayer, M.I.E.E., has relinquished the post of managing director of R.C.A. Great Britain, Ltd., to which he was appointed in July last year, and has become special representative for Europe of the parent company, Radio Corporation of America. His office is in Eagle House, 109, Jermyn Street, London, S.W.1. **P. A. Turnor** resumes the position of managing director, which he relinquished last year.

R. S. Roberts, M.Brit.I.R.E., until recently senior lecturer in the department of radio and musical instrument technology at the Northern Polytechnic, Holloway, London, N.7, which he joined in 1937, has been appointed executive technical director of Wolsey Electronics, Ltd. Prior to entering the teaching profession he was for 14 years with Wright & Weaire, where he was in charge of the technical department. For three years during the war Mr. Roberts, who is 51, was seconded to the Ministry of Aircraft Production for work on the development of radar equipment. During his career as a lecturer he has also worked as a consultant and was for some years an examiner in advanced radio engineering for the Brit.I.R.E. graduate examination.

W. E. Miller, M.A.(Cantab.), becomes assistant managing director of the Trader Publishing Co., publishers of *Wireless & Electrical Trader*, of which he is managing editor. **H. E. Craddock** becomes managing director of the company. Mr. Miller started his journalistic career in 1925 when he joined the staff of *Experimental Wireless*, now *Electronic & Radio Engineer*, and a year later joined the *Trader* as technical editor. He was president of the British Institution of Radio Engineers from 1952-54 and is honorary secretary of the Radio Industries Club.

J. M. Dodds, O.B.E., M.A., B.Sc.(Eng.), Dr. Ing., has succeeded **B. G. Churcher,** M.Sc., as manager of the research department of Metropolitan-Vickers. Dr. Dodds, who joined the company in 1928 and after two years as a college apprentice went into the research department, was one of the first two industrial engineers to be taken fully into the confidence of the Government on radar—the other was **L. H. Bedford.** Dr. Dodds has been assistant manager of the research department since 1953.

L. Roullier, A.M.I.E.E., is appointed head of the recently-formed Electrical Division of Aluminium Laboratories, Ltd., of Banbury, Oxon. He has been transferred from Aluminium Union, Ltd., London, where he was engaged on development engineering associated with the use of aluminium in electrical apparatus. He joined the Aluminium Group of Companies in 1954 after six years with Johnson & Phillips, Ltd., with whom he served a post-graduate apprenticeship course.

R. W. Fane, M.Sc., A.Inst.P., author of the article on thermionic cathodes, graduated from University College, Exeter (now the University of Exeter). Following National Service he returned to Exeter where, after taking a Diploma in Education, he carried out research on thermionic emission and was awarded an M.Sc. by London University in 1951. He joined Marconi's as a lecturer on post-graduate courses at Marconi College, transferring to the Research Laboratories in 1954 to work on problems relating to high current density electron beams.

Thomas W. G. Calvert, B.Sc., who, on page 505, writes on the use of ferrites for f.m., is a graduate of University College, London. For two years prior to coming to London in 1954 he was a student at Portsmouth Municipal College. He is 21 and has now joined the metals division of I.C.I.

R. A. Burberry, of the radio division of Standard Telephones & Cables, was recently awarded a prize by the Royal Aeronautical Society for his paper "Aerial systems for aircraft" published by the Society. He joined S.T.C. in 1947, after five years at the T.R.E. (now R.R.E.), Malvern, and is now head of a group working on aircraft aerials.

John G. Elting, formerly with Ultra Electric as production engineer, has joined Simon Equipment, Ltd., as works manager.

OBITUARY

Dr. Irving Langmuir, who in 1950 retired from the associate directorship of the physical chemical research laboratories of the American General Electric Company in Schenectady, died on August 16th at the age of 76. Dr. Langmuir, who was awarded the Nobel chemistry prize in 1932, is perhaps best known in our field for his researches on surface chemistry and the emission from hot filaments in gases which led to the invention of the gas-filled lamp and rectifier. He received numerous awards, among them the Hughes Medal of the Royal Society.

Radio Show Review

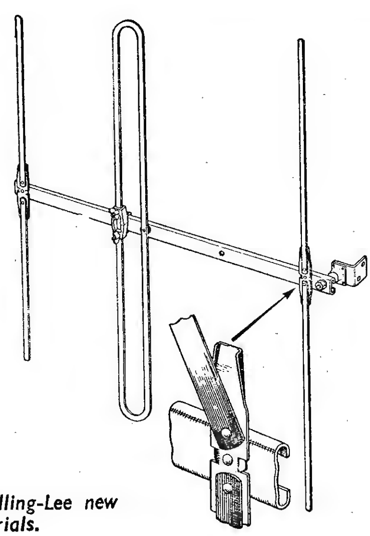
Trends as Seen by *Wireless World* Technical Staff

AERIALS

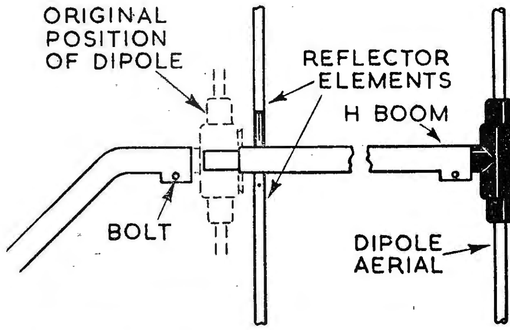
A NEW development with interesting possibilities is the idea of standardizing a limited number of aerial units or "aerial bricks" and using them as the occasion demands to assemble aerials for any location or for any service or combination of services it is possible to envisage. If well planned the "aerial bricks" will enable either single-band or multi-band aerials to be assembled with very little difficulty and the dealer benefits by having fewer parts to stock; the listener benefits as his particular requirements can easily and cheaply be met and the manufacturer benefits as he has to concentrate only on production of a limited number of standard parts. Prices and installation costs should be reduced all round.

Belling-Lee call this a "Unit Plan" and say it offers the choice of over 200 different outdoor aerial combinations and many more indoor varieties. A similar arrangement is adopted by Burwell for a new range described as "View-Well" aerials. In this case there is a basic unit consisting of a three-element Band-III aerial with a folded dipole adjustable for length, one reflector and one director. The elements are mounted on a cross-arm with swivel fittings at each end for attachment of additional units. These can be either extra Band-III directors or Band-I or Band-II systems, or a combination of all three can be assembled as a unified aerial system.

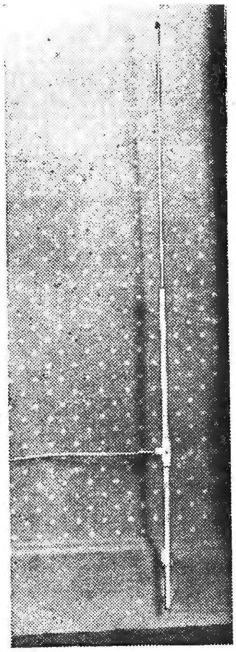
Provision for adding extra director elements to a basic aerial unit forms part of the J-Beam Aerial's policy. The main unit is a slot-beam Band-III aerial having a skeleton slot with four directors and two reflectors forming the equivalent of a double four-element broadside aerial. It is supported by a "Y"-shaped fitting attached to the twin cross-arms supporting each end of the slot and the side arrays of parasitic elements. Additional units, in the form of directors, are added when it is necessary to increase the gain and/or directivity of the system and with



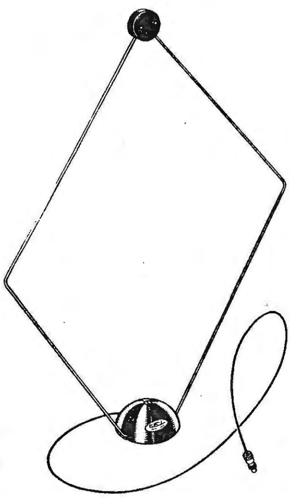
One of the Belling-Lee new Band-III loft aerials.



Meadow-Dale units for converting Band-I dipole to an "H."



Wolsey "Twin-Super" indoor television aerial.



Labgear indoor "Diamond" twin-band television aerial.

these the equivalent of a 16-element aerial can easily be built up. The basic aerial does not have to be disturbed other than for the assembly of the extra director units.

A step towards standardization has also been taken by Wolsey with their "Turret" wall bracket and universal aerial clamp. The latter allows the separate parts of a combined Band-I/Band-III aerial to be oriented through 360° and the wall bracket permits the whole system to be pointed in any direction relative to the wall or joist on which it is fixed. These two fittings were illustrated in our June issue as they made their appearance at this year's R.E.C.M.F. components show, but they are mentioned here in order to complete the picture of the latest trend in the design of v.h.f. aerials and accessories for television and f.m. sound broadcast reception.

Meadow-Dale aerials are designed with an eye to easy conversion from one type to another while utilizing all the parts of the original aerial. For example, if a plain dipole is found inadequate for any particular purpose, reflections causing ghosts for example, it can easily be changed into an "H" by means of the conversion parts. The insulator is removed from the supporting arm, it is replaced by a short boom having identical fittings carrying a reflector element and the insulator with its dipole fitted into the other end of the extension boom. All fittings are interchangeable.

Indoor television aerials have received quite a lot of attention lately and have emerged as two quite distinctive types. There is the "in-the-room" type and the loft or attic type and their principal differences are that the former must be reasonably small, pleasing to the eye and serve for both the high and the low television bands. These often stand on top of the set, like the Belling-Lee "Golden V," and the Labgear "Diamond," or alternatively they can be mounted inconspicuously like the Labgear "Spiral" or again be fixed, in one way or another, to the wall like the Wolsey "Twin-Super."

The Belling-Lee "Golden V" consists of two short telescopic rods with provision for swivelling in several directions and can be used as an ordinary dipole mounted on a picture rail if desired. It provides for reception on both television bands and also on the f.m. band, but should favour the 200-Mc/s band as the rods will not extend to a full-length Band-I or Band-II dipole, the total length being adjustable from 20 in to just over 32 in.

Labgear's new contribution, the "Diamond," is virtually a full-wavelength loop on Band III and a tuned loop on Band I, tuning on Band I being effected by a small pre-set capacitor housed in the top insulator, as shown in the drawing, and some loading inductance in the base. The capacitor enables the loop to be adjusted on any of the Band-I channels. It is directional and should be useful in suppressing ghosts due to multi-path reception. It is said to be effective up to about 20 miles from a station.

A novel twin-band aerial is the Wolsey "Twin-Super" designed for mounting on the wainscot or suspended from a picture rail. It consists of a half-wave Band-III dipole and an approximately three-quarter wavelength Band-III element telescoped into one end, as shown in the photographic illustration. These function as two collinear half-wave dipoles on Band III, the quarter-wave telescoped section serving to produce the necessary phasing to bring the currents in both dipole sections into phase for single-lobe response in the horizontal plane. The aerial is mounted vertically, of course, for vertical polarization. The result of this form of construction is that an appreciable gain, it is said to be about 2.7 dB, is obtained on Band III. The aerial is pleasing to the eye, being covered with a cream-coloured plastic material.

Loft, or attic, aerials need not be so tastefully finished as room aerials, also size is not so important, and full-length multi-element Yagis are permissible for Band III. Consequently for Bands II and III they take orthodox forms, but are made of light-weight materials and have simple types of insulators as they are not exposed to the weather. Belling-Lee have a new indoor range of this kind which includes 3-, 6- and 9- element types made of flat strip with channel-section light-alloy supporting arms. All are factory assembled and folded flat for transit, and this renders them very convenient for passing through small trapdoors and into lofts. For erection the elements are opened out and snap into place. Only one wing nut has to be tightened and this is for fixing the aerial in position after it has been correctly oriented on its support. The short support is fixed to a joist, or rafter, by two screws.

Band-I loft aerials are invariably contracted in one way or another since few lofts will accommodate a 10 ft or more vertical aerial. No notable changes have been effected in this type, however, which, in general, are made the same as formerly. The Labgear "Bi-Square" is an exception, but it was introduced last year and so strictly speaking is not new.

The "Bi-Square" idea, however, has now been extended to Band II and as the aerial for this band measures about 2 ft 6 in cube, and is said to have a power gain of 10 dB relative to a plain half-wave dipole, it should make an excellent loft aerial. It goes together quite easily, all parts being secured by nuts and bolts.

With the exception of the Labgear "Bi-Square" f.m. aerials call for little comment as they are the familiar types, such as plain dipoles, horizontal "Hs" and 3-element models. Folded dipoles are used in some of the last mentioned models.

Combined aerials embracing the two TV bands and the f.m. band were somewhat more numerous this year, an understandable progress perhaps as provision is now made for f.m. sound reception in several of the new television receivers. The extra aerial at present adds very little to the technical problems involved in multi-band aerial design, as in most cases it takes the form of a simple dipole connected to the common feeder, or a simulation of this effected by adding horizontal quarter-wave elements to an existing Band-I dipole or "H" aerial.

One interesting example is the Telerection range of "Hi-Max" phase-corrected triple-band models. The simplest is a single Band-I dipole broken up into three phase-corrected collinear Band-III dipoles as described last year. To this is now added the Band-II horizontal dipole and this composite three-band unit is used with Bands-I and -III reflectors and directors to build up a variety of types to satisfy different conditions of reception.

Several firms now have adaptor elements which clip on to an existing Band-I television aerial and adapt it for f.m. sound broadcast reception in much the same way as provision was made for Band-III reception in the early days of I.T.A. Meadow-Dale call them "Convertorods." Antiference supply them for attachment to their range of "Hilo" twin-band television aerials and Belling-Lee supply rods easily attached by a wing-nut casting.

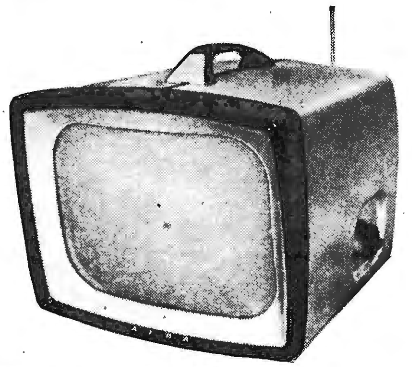
Outstanding among the Band-III only aerials was the "Dale Parabolic" model consisting of a single vertical dipole backed by eight vertical reflector elements arranged on a parabola. It provides a gain of 14 dB relative to a dipole, has a front-to-back ratio better than 36 dB and an acceptance angle of 22° measured from the centre-line of the aerial to the half-power points. Its impedance is 70 Ω so that a good match is achieved with a nominal 75-Ω cable.

TELEVISION

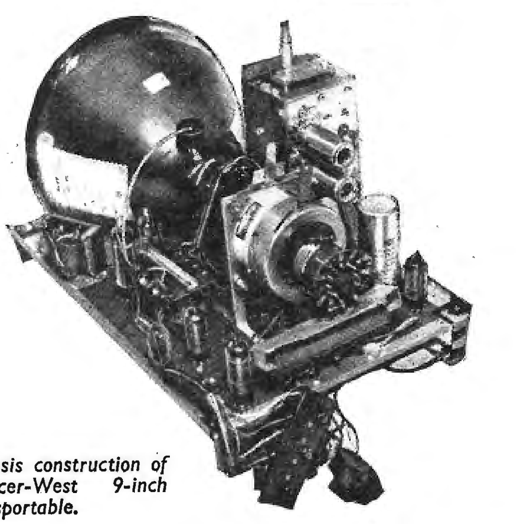
LAST year in our Show Review we gave a general description of a "standard" television receiver circuit which might well have applied to almost any set on view at the exhibition. This year the same circuit description was still valid. We would not like to suggest, however, that only the cabinet designers have been busy while circuit technicians have been taking a rest. The old gibe about the Radio Show being just a "furniture exhibition" has never been entirely justified. On this occasion, for example, one could see that the engineers had been actively engaged on problems arising from such recent techniques as 90° scanning and from the new forms of the television set—the transportable, the receiver incorporating v.h.f. sound, the combined radio-gram/television set. At the same time, there was evidence of quite a number of refinements to the basic circuit and to the overall mechanical design.

Although many more 21-inch sets were on view this year—practically all manufacturers have them now—the sales statistics still show the 17-inch screen to be the most popular size. In the past half year 67% of receivers sold had 17-inch screens, while only 7% had 21-inch screens (the remainder being largely 14-inch receivers). Does this mean that the 21-inch set is too expensive? Or perhaps too big for the average living room?

If one takes the theoretically correct viewing distance of ten times the picture height, one should sit at least 11 ft away from a 21-inch screen—but in how many living rooms is this really convenient or possible? At the more practical viewing distances, the gaps between our 405 lines become



Alba 14-inch transportable set with single rod aerial.



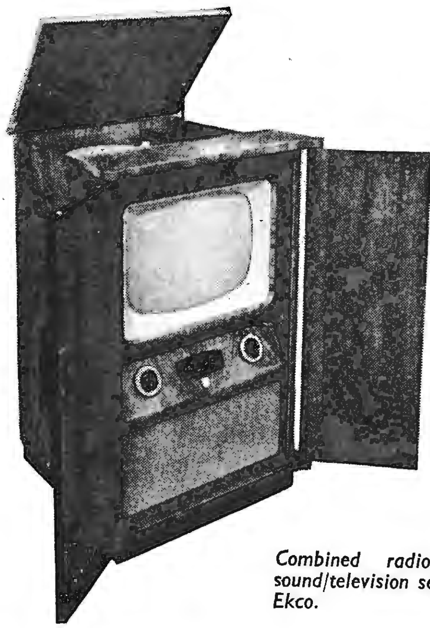
Chassis construction of Spencer-West 9-inch transportable.

painfully obvious on a 21-inch screen. If this size of picture is correct for school classrooms (judging from the schools' models on show) then it is certainly too big for the home.

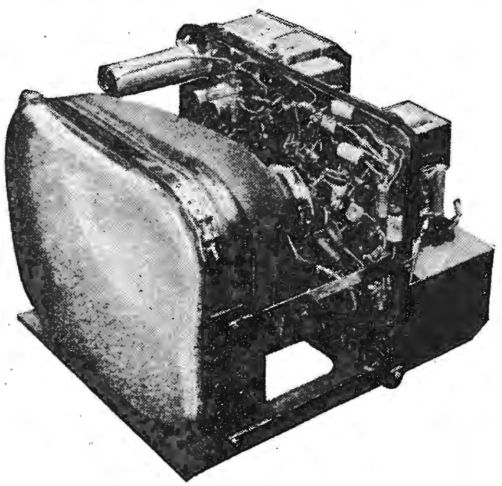
Nothing daunted, two firms were showing re-receivers with 24-inch screens this year. Even though there may be very little danger of implosion these days, the idea of sitting directly in front of one of these monsters is somewhat alarming—not to mention the possibility of X-rays generated by the use of 17kV on the final anode!

The 14-inch screen seems to have almost disappeared in the latest ranges of conventional table models, but is obviously coming back as a "standard" size for the new transportables, of which about ten makes were on show. This type of receiver, which is smaller, lighter and less expensive than the equivalent table model, is intended as a "second set" for carrying about to other parts of the home. It may, however, prove attractive as a "first set" to many people, in which case it could become a serious competitor to the conventional type of receiver.

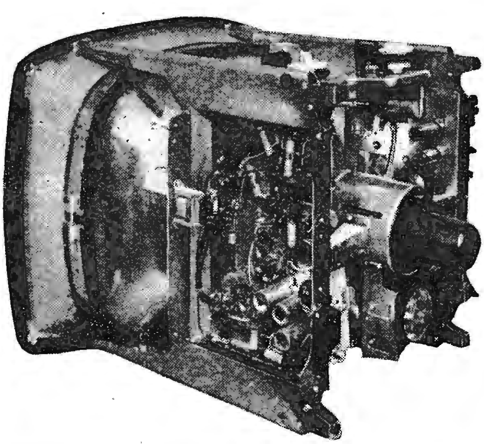
The situation is not quite the same as in the U.S.A., however, where price competition is very fierce and the transportable has been introduced primarily to undercut all other models. To achieve such a low price the circuit performance has had to be reduced, in addition to the economies practised on the external design. In Britain, however, there has been no attempt to economize in size, weight or price, at the expense of the performance. The circuit, in fact, is practically the same as in conventional table models, only packed physically into a much smaller space.



Combined radiogram/v.h.f. sound/television set made by Ekco.



Vertical chassis in Sobell 14-inch transportable.



Two vertical chassis in Murphy 21-inch receiver.

Considerable ingenuity has been shown in chassis design in order to achieve this compression. A vertical type of chassis is common, arranged either as one complete section parallel with the tube face (the tube neck passing through its centre), or in two sections parallel with the sides of the cabinet. Printed circuits are used in some models. The problem of positioning chokes, transformers and loudspeakers to keep their magnetic fields away from the c.r. tube becomes acute, and in one case the loudspeaker has been specially designed from this point of view to allow it to be mounted close to the tube neck. High-permeability cores are used in line output transformers to reduce their size. The aerials are telescopic rod types, fixed at the back of the set. Some models have a pair of these elements to form the dipole, while others use only one and rely on the chassis to provide the lower element. Ball joints allow the rods to be adjusted for optimum pick-up in one receiver.

Vertically mounted chassis were seen also in some of the large 21-inch receivers. Here it is the geometry of the tube, with its sharp 90° flare, which makes this type of construction particularly convenient and allows plenty of room for servicing. A new Bush set had the chassis arranged parallel to the screen, while a Murphy receiver used two vertical chassis parallel with the sides. This style of construction is usually accompanied by a "wrap-around" type of cabinet of very simple design which either slides off, like a matchbox cover, or—notably in the transportables—comes apart in two halves.

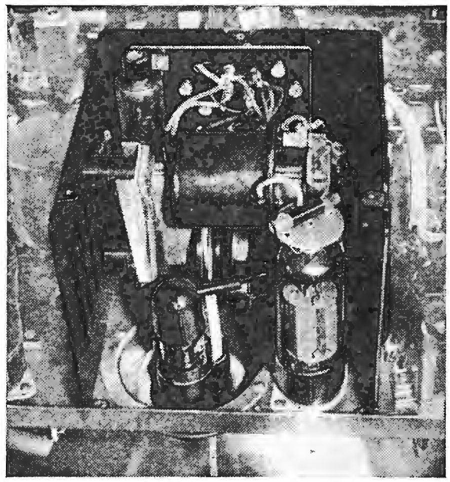
There were many more television receivers incorporating v.h.f. sound on show this year. Since the

Band-II tuning can easily be incorporated in the existing type of television multi-channel tuner, and only a discriminator and perhaps one other valve have to be added in the sound channel, the whole thing can be achieved very conveniently, at an extra cost of only a few guineas. In some models there is just one position on the multi-channel switch for Band II, and the Home, Light and Third programmes are selected by means of the fine-tuning control. This means that the fine tuning must cover a band of about 8 Mc/s instead of the usual 3 or 4 Mc/s required for television. Other models have three separate positions on the tuner for the Home, Light and Third programmes.

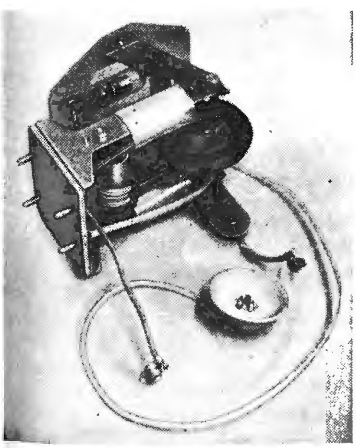
The sound take-off point is in the usual place after the common vision-sound i.f. amplifier. Then follow two sound i.f. stages and the f.m. discriminator, one diode of which may also serve as the a.m. sound detector for television. Owing to the loss of gain in the f.m. discriminator, the output of the television a.m. detector normally has to be attenuated to keep the two sound levels balanced when switching between television and v.h.f. programmes. For this reason, some models have to use an extra audio amplifier stage. One maker provides a magic-eye indicator to assist in f.m. tuning.

Having provided a reasonably high quality audio output for these television/f.m. sets, some makers have obviously argued that one might as well make further use of it by adding a gramophone turntable and pickup. Since no separate radio chassis is required, this has resulted in a v.h.f./radiogram/ television set which, unlike the combined models of the past, is notable for its compactness and reasonable price. The examples on view were no bigger than an ordinary console television set or radiogram.

Vision a.g.c. circuits are still fairly equally divided between the mean-level system and the gated system (which maintains a constant black level). There have been various refinements, however. Peto Scott have introduced a mean-level system in which the a.g.c. bias voltage is applied to the common i.f. stage and also to the r.f. amplifier. The r.f. voltage, however, is delayed with respect to the i.f. voltage. This prevents an excessive voltage from being applied to the i.f. stage and so causing cross-modulation between vision and sound. Thus in fringe areas the a.g.c. operates only on the i.f. stage, leaving the full r.f. gain available for amplifying the weak signal, while in strong-signal areas any increase in signal above a certain level is taken care of by the delayed a.g.c. on the r.f. stage, to which it is possible to apply the larger bias voltage without encountering difficulties. Incidentally, the Peto Scott arrangement incorporates separate contrast controls for B.B.C. and I.T.A. which can be pre-set to give correct balance when switching from one programme to the other.



Line output transformer with Bakelite cups in Bush 21-inch receiver.



Philco plug-in replaceable line output transformer.

An experimental system of gated a.g.c. shown by Mullard was designed to avoid the situation when the receiver falls out of synchronization and the gating pulse (which is derived from the line timebase) consequently does not sample the black level but some other part of the video waveform. First of all the video waveform is inverted, so that the sync pulses appear on top, then the sync pulses themselves are inverted again. The resultant waveform is passed to a peak detector which gives a steady output voltage corresponding to the black level. Since this black-level voltage is continuous it can be sampled at any time by the gating pulse so that loss of synchronization will not affect the correct operation of the a.g.c. system.

As for synchronization methods themselves, the two principal systems are still the direct-locking technique and the flywheel sync system, which indirectly controls the frequency of the line timebase. There was, however, some evidence of a refinement to direct-locking circuits which the manufacturers describe as a simple form of flywheel sync. The line timebase oscillator incorporates an LC resonant circuit which produces a "flywheel" effect at the line frequency. Thus the timing of the individual line sweeps is not entirely dependent on the incoming sync pulses but is controlled partly by the natural period of the LC circuit. It is said that this considerably improves the performance on weak signals, when the sync pulses are distorted by noise, and generally reduces ragged edges on the picture. One receiver, incidentally, had a switch to allow the sync to be changed from direct-locking to flywheel according to circumstances.

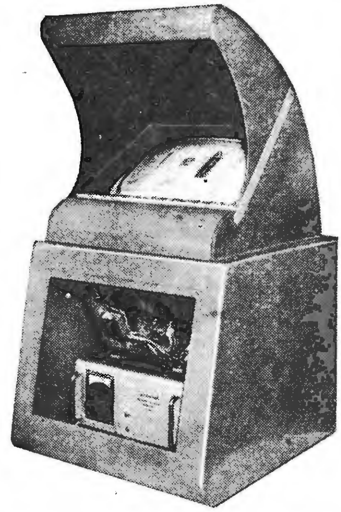
The requirement of higher scanning power for the new 21-inch tubes with their 90° deflection angles has brought with it a number of incidental difficulties. For example, the geometry of these tubes does not allow the frame coils to be as large as would be desirable. Consequently they tend to run warm and the resulting change of resistance causes an alteration in frame amplitude and picture height. This has been overcome by means of thermistors in series with the frame coils.

Radiation from line deflection coils is a good deal worse, of course. Most receivers have shielded scannning assemblies to reduce this, but one maker (K-B) has gone further by arranging the line output transformer to drive the line coils in such a way that they are balanced about earth. This reduces the electrostatic field radiated to such an extent that no metal foil screening is required inside the cabinet. As a result it has been possible to build a plate type of internal aerial into the receiver—the chassis forming the lower element of the dipole.

Another safety measure, noted in the line scanning section of a Bush 21-inch set, was the use of Bakelite cups to enclose the windings of the line output transformer. The idea here is to retain the wax impregnation of the coils when they become warm, so that the risk of breakdown is avoided. Line output transformers being notoriously susceptible to breakdowns, it was interesting to see that at least one maker uses a plug-in type which can be very quickly replaced when a fault is suspected.

One of the most interesting television exhibits at the Show was basically nothing to do with domestic reception, though in fact it may eventually enter this sphere. Shown by Decca under the name of Deccafax, it was a facsimile transmission system utilizing the flying-spot principle, by which transparencies (diagrams, patterns, photographs, written messages, etc.) could be sent instantaneously over a video-frequency link. A standard unit is used for both transmitting and receiving, so that a two-way channel can be set up, and the outputs of several units can be mixed to form composite pictures. The system works on 405-line standards and an ordinary television set can, if desired, be used as a receiving unit.

For scanning the transparencies the flying-spot tube has to have a short-afterglow screen phosphor. This gives a bluish light, and a corresponding colour filter is used in front of the photocell mounted in the hood. Since the short-afterglow phosphor by itself produces an unpleasant flicker at the receiving end it is mixed with long-afterglow components giving red and yellow light outputs. These reduce the



Deccafax equipment with Telequipment pattern generator for producing still test pictures.

flicker in reception but do not enter the photocell during transmission because of the blue filter (which incidentally helps to filter out tungsten-lamp room lighting), so that the transmission scanning is done entirely by the short-afterglow component.

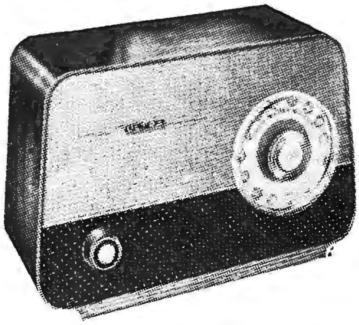
The possible connection with domestic television receivers lies in the fact that Telequipment were demonstrating the use of a single Deccafax unit, in conjunction with one of their own pattern generators, as a means of generating still television pictures for servicing and other purposes. The pattern generator supplies the sync and blanking waveforms to the flying-spot scanner and also accepts back the video signal from the photocell for modulating its own r.f. output. In this way, a complete television picture (which can be a test pattern or any other photographic transparency suitable for the Deccafax) can be generated locally on either Band I or Band III for feeding to the aerial socket of a receiver.

It has also been suggested that television relay companies could use the same equipment for transmitting their own test patterns, or even details of programmes and local advertisements. What the legal position is on this remains to be seen. At any rate, it would probably be quite legitimate for radio dealers to use the equipment to insert their own "commercials" between programmes displayed on receivers in their showrooms—even on Band I!

SOUND RECEIVERS AND REPRODUCERS

MOST of the differences from last year resolve themselves on closer examination as developments of trends already noted at previous shows, for example, the increase in the number of transistor battery portable receivers. The basic design of transistor sets, however, has not yet become stabilized, though to obtain adequate sensitivity a superheterodyne circuit with two i.f. stages is nearly always used. Self-oscillating mixer transistor circuits are generally adopted. As the usable upper frequency limit for commercially available transistors is still only of the order of 1 Mc/s, greater ease of operation and gain can sometimes be obtained by reducing the i.f., and thus reducing the generating frequencies. The i.f.s used this year range from 250 kc/s in the Peto Scott set to the standard 465 kc/s used by K-B and Vidor.

As regards the output, the choice lies between a single-ended stage giving only about 30mW, or a class-B push-pull stage giving about 300mW and corresponding to a small valve battery set. In general, single-ended stages were used in the smallest transistor sets, an exception being the use of a push-pull stage in the small (6in × 3in × 1¾in) Peto Scott model. The impedance of transistors being less than that of valves there are better possibilities of avoiding the use of an output transformer with, in this case, the important advantage of saving space and weight. Such an arrangement was seen in the Pam and Pye sets. Two examples of reflexing, with consequent saving in transistors, were noted in the Cossor and Peto Scott models. In the former, the second i.f. transistor also acts as the first l.f. amplifier; and in the latter, detection, l.f. amplification and



Ultra " Troubadour " f.m. only radio.

d.c. amplification (to provide amplified a.g.c.) are all carried out in the same transistor.

Transistor circuits easily lend themselves to extreme miniaturization. An experimental t.r.f. model built by Siemens-Ediswan was contained in an ordinary 20-cigarette box without difficulty. Besides the Peto Scott set already mentioned, very small commercial models were shown by Perdio ($5\frac{3}{4}$in × $3\frac{1}{4}$in × 1in) and Cossor (6in × $3\frac{1}{8}$in × $1\frac{1}{2}$in). A useful accessory supplied with the latter (particularly in view of its 30mW power output) is an insert earpiece to enable reception to be confined to the hearer.

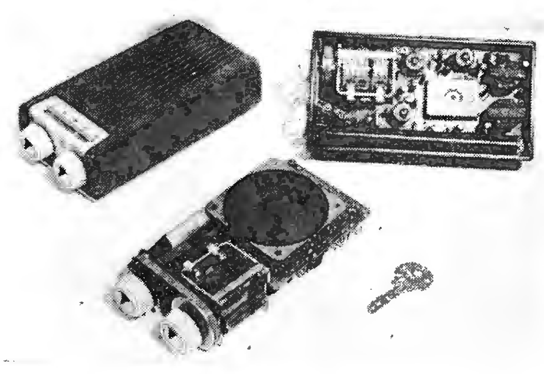
An interesting hybrid battery portable set shown by H.M.V., the 1410 "Mini-sette," uses transistors only in the push-pull output stage. The current consumption is normally greatest in this stage so that it is here that the low consumption of transistors offers the maximum advantage.

Though there were also few changes in a.m./f.m. sets the design of these is not so stabilized as the standard four valves plus rectifier arrangement in a.m. sets. This is due to the somewhat differing amounts of ingenuity thought worth while to enable valves to be used both for a.m. and f.m. reception; and to the occasional adoption of separate pentode r.f. amplification on f.m., instead of using a double-triode to provide both r.f. amplification and mixing. Sets for f.m. only, with which the Ultra "Troubadour" FM950 may now be included, remain rare, perhaps corresponding to the relative scarcity of push-button three-station a.m. sets.

Unlike table record players or radio-grams, not many table receivers offer improvements in the audio specification such as multiple speaker systems, improved speaker loading, or a push-pull output stage. This difference between receivers and record players is somewhat surprising as such improvements can be taken advantage of in v.h.f./f.m. reception as well as in the reproduction of modern gramophone records.

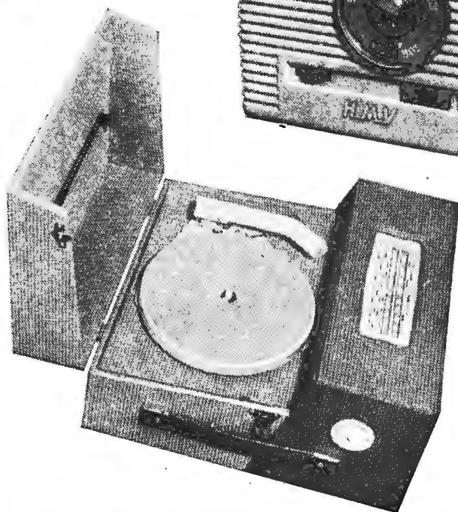
Record Players and Radio-grams.—Like sound receivers, the accentuation of previously noted trends provides most of the change. For example, almost every exhibitor now markets one or more record players. Transistor battery models are also now common, push-pull output stages being invariably used in this case. Multi-speed full-size transistor models were shown by Philco (A3755) and Pye, the latter using a Goldring variable-reluctance pickup. Although a transistor radio-gram is now an obvious possibility, only one, the Cossor 545 (45 r.p.m.) model, was seen.

As we have already mentioned, table record players and radio-grams with improved audio speci-

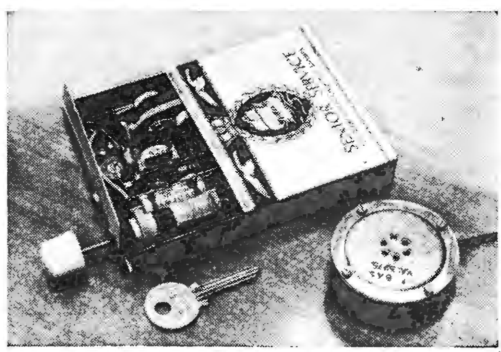


Peto Scott transistor receiver.

H.M.V. valve and transistor " Mini-sette."

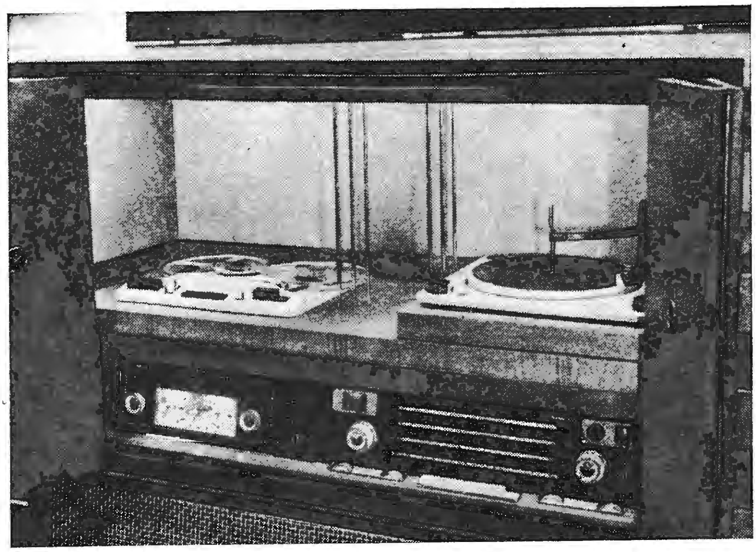


Cossor transistor radio-gram.



Siemens-Ediswan prototype t.r.f. transistor set.

fications can readily be obtained. For example, in the Philco A3764 "Phonorama," when the heavy lid is closed over the record player an airtight seal is formed which completes a resistively loaded reflex cabinet for the 8-in speaker, to give a response down to 60 c/s. The a.m./f.m. tuner and 8-watt



Ferguson radio-gram with tape recorder and clock switch.

"ultra-linear" push-pull amplifier are placed in the (large) port tunnel. A diffuser spreads the radiation from the 4-in tweeter. An economical circuit, noted in the Ferguson 393G "Fortune" record player, uses two triode-pentodes to provide amplification (sufficient to allow useful negative feedback) and phase-splitting from the triodes, and about 5 watts push-pull output from the pentodes.

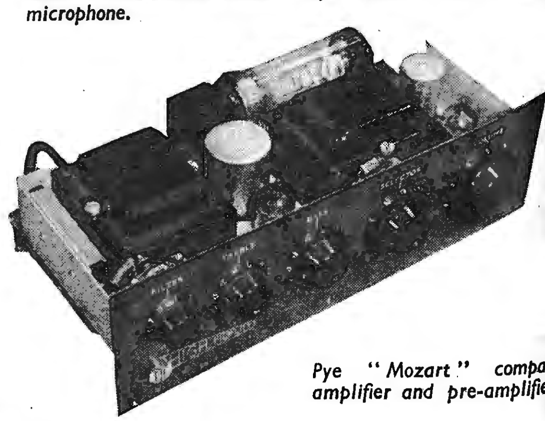
Multiple speaker systems giving a large apparent sound source (3D) and, it can be claimed, reducing intermodulation distortion, remain very popular. A simple, often used arrangement, is to capacitively couple one or more small (3- or 4-in diameter) moving-coil tweeters to the audio output. Five speakers (one 12-in Goodmans Audiom 60 bass unit, two 8-in × 5-in elliptical mid-frequency units and two 5-in tweeters) are used in the R.G.D. "Victoria" radio-gram, the Audiom 60 being fitted in a resistively loaded bass-reflex enclosure. In this set a 16-watt push-pull amplifier with separate bass and treble controls is also incorporated, and a variable reluctance pickup with diamond stylus is used.

In the loudspeaker used in the H.M.V. 1134 a.m./f.m. table receiver two cones are attached to the same voice-coil. Another way of improving reproduction is to operate two similar speakers in parallel, as in the Sobell RPS77 record player. Since each speaker then handles only half the output, the speaker distortion for a given output is reduced. In addition, if they are placed close together, their mutual interaction will produce a rise in efficiency at low frequencies, leading to a further reduction in distortion (see article "Loudspeakers in Parallel" by J. Moir, in this issue). Irregularities in response will also tend to be smoothed in the overall output. Alternatively, two dissimilar speakers may be operated in parallel to compensate for deficiencies in each other's response as, for example, in the Bush RG66 a.m./f.m. radiogram (also fitted with a 4-in tweeter).

Tape Recorders and Reproducers.—A number of new models were seen. In the E.A.P. "Elizabethan Essex" (the new name for the "Triple Three" mentioned in our Show Guide) a push-pull bias oscillator offers a reduced d.c. component in the output with consequent decrease in the recording noise level. The 6-watt push-pull "ultra-linear" stage feeds a 9-in × 5-in bass speaker and two 3-in tweeters. A ribbon microphone is provided. In the Winston "Thoroughbred" volume controls on both the low (2mV) and high (200mV) level inputs allow full mixing facilities between these two sources. Two double-electrode small electrostatic tweeters are included (also noted in the Bush VHF64 a.m./f.m. table radio). The Baird recorder is unusual in having a single-ended "ultra-linear" output stage. As has been shown by Leakey (*Jnl. of the B.S.R.A., May,* 1957) such feeding of a pentode output valve's screen from a tapping on the output transformer has certain advantages even if the output is not push-pull. The above three recorders used the Collaro 3-speed tape deck.

R.C.A. showed a stereophonic tape reproducer whose external appearance matched that of their "Vice-President" record player, the amplifier and speaker in both units being intended to be used together in stereophonic reproduction. A 3-speed tape deck with two stereophonic heads is used, one for recording and one for monitoring. Single-channel recording and playback facilities are also provided.

E.A.P. "Elizabethan Essex" tape recorder with ribbon microphone.



Pye "Mozart" compact amplifier and pre-amplifier.

Stereophonic reproduction was also demonstrated using versions of the G.E.C. "Periphonic" system. Four "Presence Unit" tweeters in a horizontal line are used in each of the two systems, the input levels to the individual tweeters being differently graded in each case. This produces suitable high-frequency angular responses to give the differential intensity differences required for stereophonic reproduction (see Brittain and Leakey, *Wireless World*, Vol. 62, p. 208, May, 1956).

With increasing activity in tape recording some of the radio-grams shown, such as the Portogram TR100 (f.m.-only model), also included a tape recorder. In the Ferguson 403 tape radio-gram, a clock switch enables recordings from the a.m./f.m. receiver (which is automatically allowed 7 minutes' warming-up time) to be made at any preselected time within a minute, the apparatus being switched off when the tape unthreads from the emptied spool. The Ferguson 403 also includes a 10-watt push-pull amplifier with bass and treble controls, which can be switched out so that an immediate estimate of their effect is possible. The sound level from the three 4-in tweeters, relative to that from the 13-in $\times$ 8-in bass speaker, can be varied by a three-position control.

New Units for Sound Reproduction.—A somewhat unusual speaker mounting on a board placed across the corner of a room near the ceiling was seen in the T.S.L. "Concert Sound Corner." Back radiation downwards being blocked by an attached board at right angles, such radiation passes upwards to the corner, and is then reflected downwards into the room. This provides some approximation to horn loading.

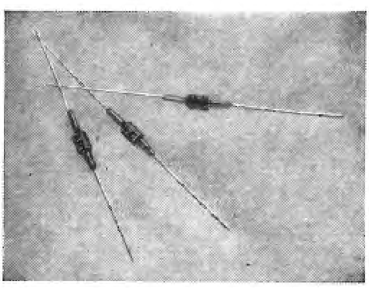
A compact ($10\frac{1}{2}$in $\times$ 5in $\times$ $3\frac{3}{8}$in) combined amplifier and pre-amplifier, the "Mozart" HF10, was shown by Pye. For an input of 10mV the output is 9 watts with 0.3% distortion. Bass and treble controls and four treble filter cut-off frequencies are provided. Simple compensation for different pickup sensitivities and impedances is also available. Another new 15-watt amplifier and pre-amplifier, the Lintronic "Wessely HF15," includes controls to give a continuously variable treble cut slope at two alternative frequencies, and to alter the relative levels of treble and lower frequencies (presence control).

The latter amplifier was also used in the "Wessely Symphonette Royale" record reproducer, which also incorporates a Garrard 301 transcription turntable, B.J. "Super 90" pickup arm with Tannoy variable reluctance cartridge and Thermionic Products "Microlift" pickup arm control, and also the "Dust Bug" anti-static dust remover.

A new ceramic pickup cartridge, the E.V. "Power Point," is designed to be very simply replaceable as a whole in the mechanism (turnover, turnunder or fixed alternatives are available). Response is within $\pm$5dB of 250mV output from 50 c/s to 10 kc/s, the compliance being 10^{-6} cm/dyne. The needle is connected directly to the ceramic generating element.

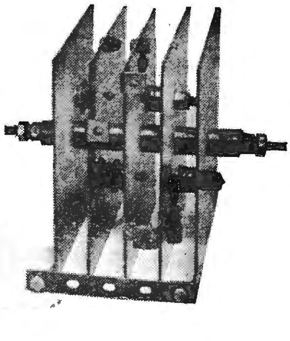
A prototype single-ended transistor audio amplifier using a new type of sliding bias to give almost doubled output was shown by Mullard. A rectified fraction of the output is fed back to shift the working point as the drive increases, this resulting in an increased output for a given dissipation or size of heat sink. If this fraction is fed back to the driver stage, rather than to the output as is usual, the increased gain allows much better d.c. gain stabilization. Moreover, the feedback time constant can be made so short that transient distortion due to this cause is virtually eliminated.

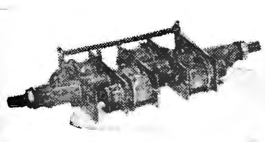
RECTIFIERS, VALVES AND C.R. TUBES



Group of S.T.C. silicon Zener diodes.

G.E.C. germanium diode GEX541 in two arrangements for power rectification.





SEMICONDUCTOR junction diodes, both silicon and germanium, are threatening very seriously the supremacy of the conventional metal rectifier in some power-supply applications. The reasons are their greatly superior rectification efficiency and extremely small size for a given power rating. As a striking example of what can be done, S.T.C. were showing a 17-inch television receiver in operation with its entire h.t. supply of 220mA derived from an experimental silicon diode about the size of a $\frac{1}{2}$-watt resistor. In the same receiver the efficiency diode was made up of four of these units, handling altogether 240mA mean at 4.5kV.

S.T.C. have, in fact, three ranges of these silicon diodes—a $\frac{1}{2}$-amp range, a 1-amp range and a 5-amp (development) range—all being available with peak inverse voltage ratings of 50, 100 and 150 volts. Being silicon, they will operate at ambient temperatures up to 100°C. The $\frac{1}{2}$-amp types do not require "heat sinks," but the larger ones do, and have threaded studs for mounting on to cooling fins.

Germanium power rectifiers were represented by a new junction diode, GEX541, on the G.E.C. stand. This can be used in various series, parallel and series-parallel arrangements to provide d.c. supplies of anything up to about 30kVA, and will operate successfully at ambient temperatures up to 55°C. An example on show was a 3-phase bridge rectifier giving a d.c. output of 74 volts at 7.5 amps from an a.c. input of 55 volts r.m.s. This firm also had a range of four silicon diodes and a new power transistor, the GET15, suitable for audio output stages. Two of these transistors operated in Class-B push-pull will give an output of 1 watt, using a 6-volt power supply.

Both S.T.C. and G.E.C. were also showing some special semiconductor junction diodes intended for voltage reference purposes. Known as Zener diodes, they have a low breakdown voltage in the reverse direction, with a fairly sudden turnover and a small slope resistance after the turnover point. If the Zener diode is biased in the reverse direction to just beyond the turnover point, any increase in reverse current will result in an almost constant voltage being developed across the device—the actual variation of voltage depending on the slope resistance. This reverse characteristic can therefore be used as a voltage reference or for voltage stabilization.

In receiving valves, the most notable exhibit this year was a new double triode from Mullard, the PCC89, intended for use as a cascode r.f. amplifier in television multi-channel tuners. The valve has a variable-mu frame grid construction to assist in the reduction of cross-modulation effects, and in the normal cascode series connection the mutual conductance is as high as 12.5mA/V for an anode current of 15mA. This permits a considerable increase in r.f. gain. Another new double triode was the Brimar type 5965, intended for use in two-state circuits in digital computers.

The electrostatically focused cathode ray tube is now coming into much wider use in television receivers. It saves the extra weight and cost of magnetic focusing assemblies, and requires no adjustment once it is set because there is practically nothing to cause drift. The focusing is achieved by a short cylindrical electrode which surrounds a gap in the long final-anode cylinder. A fairly low potential is applied to this electrode (anything between 0 and 400 volts, according to the c.r. tube) which therefore produces an electrostatic lens action between itself and the two high-voltage ends of the final-anode cylinder. The configuration of equipotential lines is such as to bring the electron rays to a focus at the screen. New c.r. tubes of this kind were shown by both Siemens-Ediswan and Brimar.

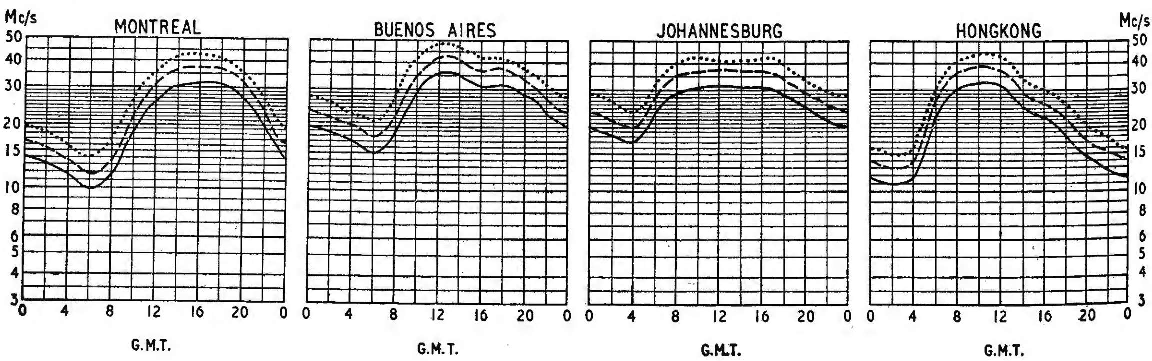
Mullard low-noise pentode, UF86, for 100 mA a.c./d.c. operation.

The 24-inch tube mentioned earlier under the heading of "Television" is also a Brimar product. Known as the C24KM, it has a pentode electron gun with three anodes—a first anode, a pre-focus anode and a final anode. It does, however, require magnetic focusing as well. The final anode voltage is 17kV. Incidentally this firm has recently introduced a range of c.r. tubes in which a substantial increase in screen brightness is obtained by the use of a phosphor containing a new type of activator.

As an aid to the servicing technician, G.E.C. have produced a 6-inch "setting-up" c.r. tube which can be plugged into any popular television set using a 14-inch, 17-inch or 21-inch tube. Owing to its small size and weight, compared with the normal tubes, it is very convenient to handle, and when plugged in leaves a good deal of extra space, which is useful in gaining access to other components. It is available in two versions, one for magnetic focusing and the other for electrostatic focusing.

SHORT-WAVE CONDITIONS

Prediction for October



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 October.

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

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

——— PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

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

"Nearest Approach" Calculator

Rapid Interpretation of Marine Radar Screen Information

By A. L. P. MILWRIGHT*

IF a mariner wishes to determine the closest passing distance of his ship from any other ship by means of radar, it can be done quite simply by plotting the ranges and bearings of the other vessel's echo. The line joining the plotted positions indicates the relative course of the other vessel and by extending the relative course line the closest passing distance can be measured.

With the existing method of measuring bearing by means of a mechanical cursor, with its attendant possible inaccuracies, it is necessary to plot a number of positions and draw the relative course line as a mean through the plotted positions. The time taken to establish the nearest approach is therefore comparatively long (approximately 3 minutes if the "target" vessel is some distance away). If an electronic bearing cursor were to be used the time to determine the nearest approach could be reduced since the accuracy of the measured bearings would be higher, and fewer measurements would be required.

It may however be inconvenient to move from the radar screen to the plotting table and if plotting is done on the face of the p.p.i. or a reflection plotter the accuracy may be poor, particularly if the nearest approach is determined by extending a relative course line formed by two plotted positions close together, using a blunt wax pencil.

In the case of a true motion radar the nearest approach is not so readily available as with the relative display, and the operator will have either to construct a relative plot from his true plot or change the picture to a relative picture and from that construct a relative plot.

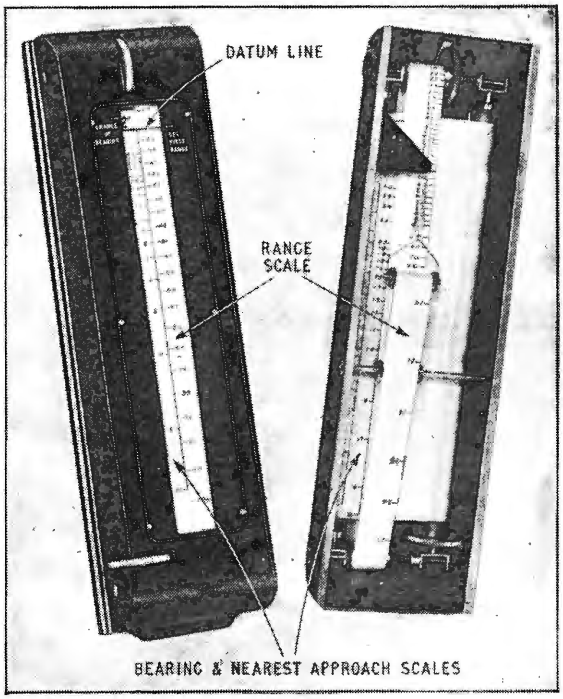


Fig. 2. Front and rear views of the A.S.R.E. "nearest approach" calculator.

A Direct Answer

Various methods have been suggested notably by Topley[1] and Wylie[2] of determining the nearest approach without having to plot by using two radar ranges and a change of bearing, but both these methods present the information as a percentage of the initial pick-up range of the target. This may require the mariner to do an annoying little sum, e.g., 18% of 4.9 miles. To provide a simple method of determining nearest approach when using a true motion display the Ministry of Transport and Civil Aviation's Research group at the Admiralty Signal and Radar Establishment have developed a simple calculator.

The principle of the calculator is as follows. Suppose an incoming vessel is first observed at range R_1 (Fig. 1) and that after a short period of time the range has changed to R_2 and its bearing has changed by an

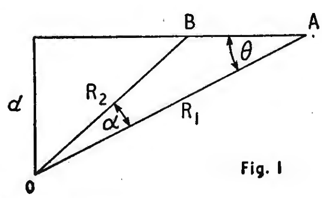


Fig. 1

angle α. Let the nearest approach distance be d and let θ be the angle BAO.

$$\text{Then } d = R_1 \sin\theta \text{ and } \frac{\sin\theta}{R_2} = \frac{\sin\alpha}{AB}$$

$$\text{also } \cos\theta = \frac{R_1 - R_2\cos\alpha}{AB}$$

$$\therefore \sin\theta = \frac{R_2\sin\alpha}{AB} = \frac{(R_2\sin\alpha)}{(R_1 - R_2\cos\alpha)}\cos\theta$$

$$\therefore d = \frac{(R_1R_2\sin\alpha)}{(R_1 - R_2\cos\alpha)}\cos\theta$$

For small values of α, $\cos\alpha$ can be taken as unity, and if d is much smaller than R_1, $\cos\theta$ can be taken as unity since $\cos\theta = \sqrt{1 - \frac{d^2}{R^2_1}}$

$$\therefore d \approx \frac{R_1R_2\sin\alpha}{R_1 - R_2}$$

$$= \frac{\sin\alpha}{\frac{1}{R_2} - \frac{1}{R_1}}$$

Suppose we plot a scale (A) where the lengths

*Admiralty Signal and Radar Equipment.

(denoted by R_1R_2) from some fixed point (datum) are proportional to $\frac{1}{R_2}$, $\frac{1}{R_1}$ then the length between R_1 and R_2 will be proportional to $\frac{1}{R_2} - \frac{1}{R_1}$. If this length is now measured from the datum the scale reading obtained would be $\frac{1}{\frac{1}{R_2} - \frac{1}{R_1}}$.

By having a second scale B placed alongside A and calibrated such that the lengths denoted by R_1R_2, etc., on scale "A" are denoted by $R_1 \sin \alpha$, $R_2 \sin \alpha$, etc., then the operation $\frac{\sin \alpha}{\frac{1}{R_2} - \frac{1}{R_1}}$ can be carried out as follows:—

1. Set the first range R_1 on scale A, opposite the datum of scale B.
2. Note the reading on scale B opposite the reading R_2 on scale A.

The reading so obtained is equal to $\frac{\sin \alpha}{\frac{1}{R_2} - \frac{1}{R_1}}$ which as has been shown is a very close approximation to the nearest approach distance. A series of "B" scales would be required for each value of α.

Since the answer provided by the calculator is only an approximation, let us examine the error involved.

Let the actual distance of nearest approach be d and that obtained using the calculator be $d_{\text{calc.}}$

Then $d = \frac{R_1R_2 \sin \alpha}{R_1 - R_2 \cos \alpha} \cos \theta$

$$d_{\text{calc.}} = \frac{R_1R_2 \sin \alpha}{R_1 - R_2}$$

$$\therefore \frac{d}{d_{\text{calc.}}} = \frac{R_1 - R_2}{R_1 - R_2 \cos \alpha} \cos \theta$$

$$= \frac{1 - R_2/R_1}{1 - R_2/R_1 \cos \alpha} \cos \theta$$

$$= \frac{1 - \frac{\sin \theta}{\sin (\theta + \alpha)}}{1 - \frac{\sin \theta \cos \alpha}{(\sin \theta + \alpha)}} \cos \theta$$

$$= \frac{\sin \theta \cos \alpha + \cos \theta \sin \alpha - \sin \theta}{\cos \theta \sin \alpha} \cos \theta$$

$$= \left[1 - \tan \theta \left(\frac{1 - \cos \alpha}{\sin \alpha} \right) \right] \cos \theta$$

Assuming a limiting case when $\alpha = 5°$ then

$$\frac{1 - \cos \alpha}{\sin \alpha} < 0.044.$$

$\therefore$ in the limiting case

$$\frac{d}{d_{\text{calc.}}} = (1 - 0.044 \tan \theta) \cos \theta$$

$$= \cos \theta - 0.044 \sin \theta$$

Since $\sin \theta = \frac{d}{R_1}$ we have a relation between d, $d_{\text{calc.}}$ and R_1. Giving R_1 the values 12, 8 and 4 miles the values of d corresponding to chosen values of $d_{\text{calc.}}$ have been calculated and are shown in the table.

R_1 = 12 miles		R_1 = 8 miles		R_1 = 4 miles	
$d_{\text{calc.}}$	d	$d_{\text{calc.}}$	d	$d_{\text{cacl.}}$	d
3.0	2.872	2.0	1.914	1.5	1.366
2.0	1.957	1.5	1.461	1.0	0.957
1.0	0.993	1.0	0.987	0.5	0.493
0.5	0.499	0.5	0.498	0.25	0.249

As can be seen from the table the accuracy of the calculator is high, particularly when the nearest approach is small.

The calculator can be constructed in a number of forms and a preferred type is shown in Fig. 2. This consists of two endless belts moving at right angles to each other and operated by the knurled knobs at each end. The range scale on the right (in the front view) is calibrated from 2 to 15 miles. The scale on the left is the nearest approach scale and ten such scales are provided at half-degree intervals for bearing changes of between 1 degree and 5 degrees. The bearing change is shown in the upper left-hand corner of the window.

In order to use the calculator all that is necessary is to proceed as follows:

1. When an echo is seen on the radar screen set the bearing cursor over the echo and measures its range.
2. Rotate the upper knurled knob of the Calculator until this measured range is coincident with the datum line (marked "set first range").
3. Wait until the bearing has changed and then measure the *change* of bearing and the new range.
4. Rotate the lower knurled knob until the bearing change appears in the upper corner of the window.
5. Read off nearest approach distance on the left-hand scale opposite the second range of the target on the right-hand scale.

Provided both ships do not alter course the nearest approach distance can be checked for various bearing changes without having to reset the range scale.

REFERENCES

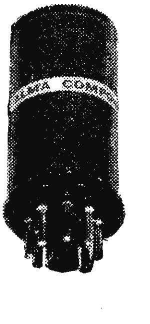
Topley, H. "Estimating Nearest Approach by Radar." *Journal of Inst. of Navigation*, Vol. VIII, p. 50 (1955).

Wylie, F. J. "The Region of Collision." *Journal of Inst. of Navigation.* Vol. IX, p. 161 (1956).

Precision Plug-in Wirewound Resistors

AN unusual type of precision wirewound resistor has been introduced by Alma Components, Ltd., 165, Ossulston Street, London, N.W.1. It has a standard octal-valve plug-in base and can be supplied with up to six tappings which, by suitable external switching or interconnection, provides a wide choice of values with any one component. The plug-in feature enables this whole family of values to be instantly changed.

The resistance wire is non-inductively wound on an eight-slot, ceramic former securely fixed to the base and finally "potted" in a non-hygroscopic resinous compound. Resistors are wound to specific requirements and in values up to 5 MΩ, with tolerances of from ±5% down to ±0.1% as required, normally at 25°C. The rating is $\frac{1}{8}$ W per section.



Alma plug-in, tapped, precision wirewound resistor.

New Radio Telescope

OPENING OF THE MULLARD OBSERVATORY AT CAMBRIDGE

THE new Mullard Radio Astronomy observatory outside Cambridge was opened on July 25th by Sir Edward Appleton. The project has been financed jointly by Mullard, Ltd., the Department of Scientific and Industrial Research, and Cambridge University itself. The Mullard contribution of £100,000 provided more than half of the total sum required.

The methods used for measuring very low-level signals[1] (even below receiver noise) after they have been collected by the aerial remain relatively unchanged. For this reason and also more obviously because of their size and expense, the aerials usually excite the main interest at such observatories. In addition the two aerial systems at this observatory use a new technique known as "aperture synthesis"[2] to provide the maximum resolving and collecting power for a given structure size and weight.

The output voltage from a normal aerial such as a mirror may be regarded as being obtained by the appropriate combination of the voltages from a number of elementary aerial subdivisions of the mirror. The new technique is to use small movable aerials to take up in turn the positions of the various elements of a much larger aerial. Then, from the measured voltages given by the small aerials, the voltage which would be received by the large aerial can be calculated. The large aerial is then said to have been "synthesized." Since the combined output voltage involves vector products of the elementary voltages, it becomes necessary to use two elementary aerials.

Two additional factors give a considerable reduction in the total number of observations necessary. In the first place, in many of the element pairs the aerial elements are in the same relative position (have the same spacing and orientation), and all such similar pairs will give identical voltages. Thus the voltages need only be measured for each different relative position of the two elements, provided that we multiply the voltages for each different relative position by a factor proportional to the number of times that relative position occurs in all the possible element position pairs. Secondly, by suitably altering the phases of the voltages from the elementary aerials the synthesized aerial lobe may be rotated to give a maximum response anywhere within the lobe of one of the elementary aerials. Thus, once the elementary aerial voltages have been measured, it is possible to compute the voltage which would be given by the synthesized aerial in a number of different orientations. A similar technique for rotating the lobe of an aerial without physically moving any of its elements is often used in radar communication systems.

There is no need for the two elementary aerials to be the same size. In

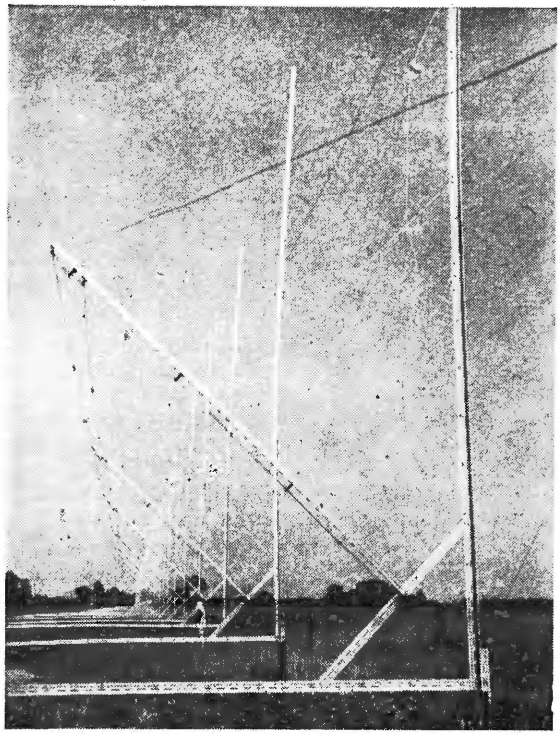


Fig 2. Part of the fixed aerial for use on 7.9m in synthesizing a single aperture.

[1] See for example *Wireless World*, July 1951, Vol. 47, p. 275.
[2] Described in "The Mullard Radio Astronomy Observatory, Cambridge," by M. Ryle, F.R.S., *Nature*, July 20, 1957, Vol. 180, p. 110.

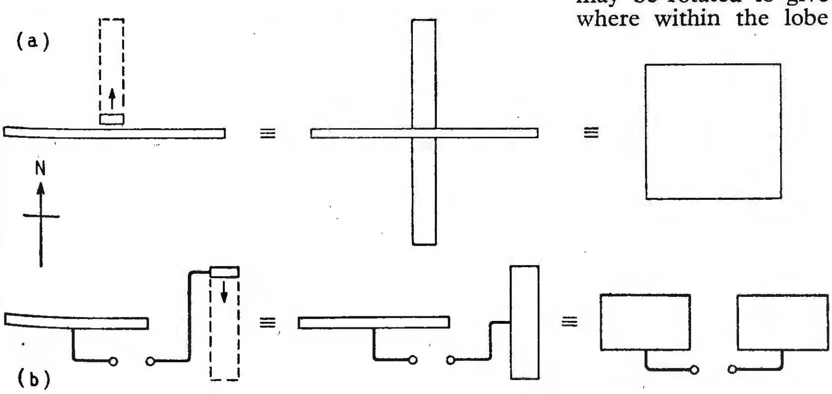


Fig. 1. The synthesis of (a) a single aperture, and (b) an interferometer; using one long fixed and one moving aerial. (Adapted from Fig. 2 of Reference 2).

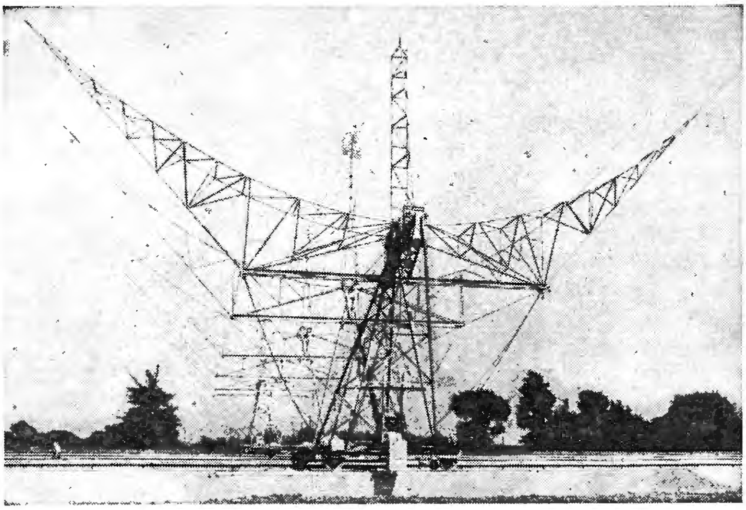


Fig. 3. Moving aerial of the radio star interferometer for 1.7 metres

the new systems one of the aerials is made comparable in size with the synthesized aerial so that it need not be moved at all. This also simplifies the measurement and computation process. A large aerial can be most economically built as a long line, since rotation about the long axis can be achieved without the need for a high or sturdy structure. If this aerial is arranged to run east to west, then, as the earth rotates, it also rotates in a plane at right angles to its long axis. All the different relative spacings of the elementary aerials can then be obtained if the small aerial moves at right angles to the long fixed one. According as to whether the path of the moving aerial cuts the long fixed aerial or not, the resulting effective synthesized aerial is a single aperture, or two apertures separated by a fixed distance forming an interferometer. These alternatives are shown schematically in Figs. 1a or 1b respectively. The lobe width in the equatorial plane and the earth's rotation rate fix the total time available for observation of any one source, or for "integration" of its signal. This imposes some restriction on the relative size and shapes of the two aerials in an optimum design.

Both of these two types of synthesis will be used in the new observatory. The arrangement for synthesizing a single aperture (Fig. 1a) will be used at a wavelength of 7.9 m to measure the galactic background radiation, and thus study galactic structure. The fixed east-west aerial is 3,200 ft long; the other is 110 ft long and can be moved over a distance of 1,700 ft. Each aerial is in the form of a corner reflector with an aperture of 40 ft. Part of the fixed aerial is shown in Fig. 2. For readers who are more used to reflecting surfaces, such as ordinary astronomical mirrors, which "look like" reflectors, it should perhaps be pointed out that the reflecting surfaces for both these aerial systems are formed by conducting wires spaced out on suitable frames. If this spacing is a small fraction of the wavelength used, then, at this wavelength, the wires will give nearly perfect reflection. The synthesized reception lobe on the 7.9 m aerial will be about 1 degree square, and the equivalent collecting area about 2×10^5 sq ft. The number of elementary positions of the movable aerial is about 75, so that a complete set of observations in a given rotation position will take at least this number of days. In a plane at right angles to the long axis the lobe width of the individual aerials is about 60° so that only three (or perhaps four to allow some overlap) rotation positions about this axis are necessary. The angle of rotation about the long axis is determined simply by the length of guy wires supporting the corner reflectors.

The arrangement for synthesizing an interferometer (Fig. 1b) will be used at a wavelength of 1.7 m to study sources of small angular diameter (radio "stars"). This wavelength was chosen as a compromise between the requirements of sensitivity (both the flux from the source, and the sensitivity of the receivers used, increase with increasing wavelength), allowable constructional errors (these are proportional to the wavelength), and gain and resolving power (both of which increase with decreasing wavelength for a given aerial). The fixed east-west aerial for 1.7 m is 1,450 ft long: the other is 190 ft long and can move up to 1,000 ft on railway lines. Both aerials are cylindrical parabolas with an aperture of 65 ft. The movable aerial is shown in Fig. 3. The synthesized reception lobe will be about 25 by 35 minutes of arc and this will contain an interference pattern in the plane of the equator with a lobe width of about 8 minutes. The equivalent collecting area will be about the same as the other aerial system—1.9×10^5 sq. ft. The number of elementary positions of the movable aerial is about 20. The lobe width of the individual aerials in a plane at right angles to the long axis is only about 4 degrees. Thus many rotation positions about this axis are necessary, and more precise mechanical methods of rotation have been adopted than those used for the other aerial system.

Although the operational wavelengths of the two aerial systems are not essentially fixed, altering these will involve changing the considerable number of full-wave receiving dipoles along the long axes of the aerials.

The large amount of computation involved in the synthesis method will be handled on EDSAC.

National Lending Library

WITH the ever-growing volume of scientific and technological journals published throughout the world the task of maintaining a really comprehensive library in an industrial organization is a major problem, and a considerable amount of material is therefore destroyed from time to time. The Department of Scientific and Industrial Research will be glad to receive such material for the recently formed National Lending Library. Offers of journals (not U.K. publications), which should cover at least six years and, if unbound, be 80 per cent complete, should be sent to the D.S.I.R. Lending Library Unit (20 Chester Terrace, London, N.W.1), of which the Technical Information and Documents Unit, which issues the "unpublished reports" referred to in "Technical Notebook," is now a part.

Loudspeakers in Parallel

By J. MOIR, M.I.E.E.*

INCREASE OF APPARENT SOURCE SIZE NOT ONE OF THEIR ADVANTAGES

MANY of the advantages of a stereophonic sound reproducer are due to the impression of source size that is transmitted, and it is natural (though quite wrong) to believe that the use of multiple speakers on a single channel will increase the apparent size of the source and thus have the same advantages. Two loudspeakers are clearly twice the size of a single speaker, and it is easy to fall into the error of thinking that our ears take the same "view" as our eyes. However, this is one of the few instances where plain common sense is quite wrong, for two loudspeakers with their voice coils in parallel (or series) convey the same impression of size as a single speaker, however they are mounted or spaced.

This is not to suggest that two loudspeakers in parallel have no advantages over a single speaker, it is just that the advantage of an increase in the apparent size of the source is not obtained. The merits of paralleled speakers will be discussed after considering this source size anomaly.

If two similar loudspeakers are spaced 8-10 ft apart (as they might be in a domestic stereophonic system, but with their voice cells in parallel), the apparent position of the sound source will depend on the listener's position with respect to the speakers, and on the relative polarity of the voice coil connections. With the voice coils in phase (both cones moving in the same direction) a listener seated on the median line, as in Fig. 1 (a), will always locate the sound source on the same line somewhere behind the loudspeakers. With a single artiste the lateral position is quite sharply defined, and, though the definition is less sharp with a large source such as an orchestra, it is important to note that the apparent size of the orchestra is the same as is given by a single speaker. The reproduced orchestra appears to occupy about two cubic feet of space about the centre line, giving the subjective impression that one is listening to a very small reproduction of a large-sized orchestra.

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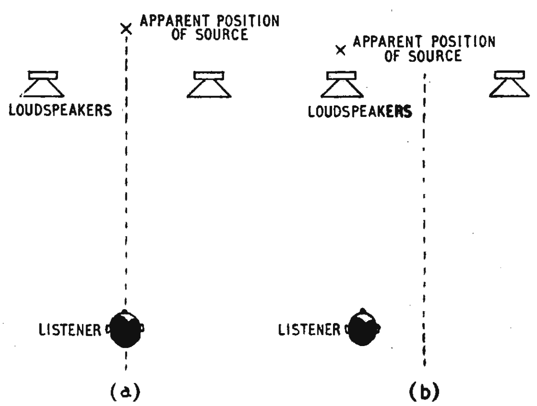

Fig. 1. (a) To a listener on the axis, the source of sound appears to be on this axis, but behind the speakers. (b) To a listener off the axis, the source of sound appears to be slightly behind the nearer speaker.

Effect of Moving Off Centre

If the listener moves off the median line, as shown in Fig. 1 (b), the virtual artiste starts to move with him in the same direction, but after a movement of only a few inches the source moves fairly sharply to just behind the nearer loudspeaker, and the remote loudspeaker apparently ceases to sound.

If the listener moves some way to the right, all the sound appears to come from the right-hand speaker, and the left-hand speaker seems to contribute nothing to the acoustic picture.

Though there is a strong subjective impression that the remote loudspeaker is making no contribution to the total effect, open circuiting its voice coil produces a sharp increase in the acoustic definition of the sound source, and places the virtual artiste at the position of the single speaker. Thus the use of a second speaker only appears to add "vagueness" to the apparent position of the artiste. This is a lesson that the film sound engineer learnt the hard way back in the early 1930's, when several of the film equipment companies endeavoured to obtain complete coverage of a large theatre by the use of a multiplicity of cone speakers mounted on flat baffles round the perimeter of the picture screen. Though superficially attractive, and technically sound from some points of view, the performance is poor, so this solution has been abandoned by all film sound engineers.

The previous discussion began with an indication that the speaker voice coils were connected in phase, for when they are out of phase the effects are quite different. With the listener seated on the centre line, as in Fig. 1 (a), reversal of the connections to one voice coil produces a well-defined impression that the artiste has been bisected and one half moved out to each of the loudspeakers. Further experience leaves the listener quite unable to decide where the artiste is supposed to be, presumably because the listener is presented with an acoustic experience which never occurs in real life. When listening to an actual performance, all the frequency components below about 1 kc/s must arrive with the same phase, or at least the same polarity, at both ears, irrespective of the position of the sound source. Signals from a reproducer system that arrive with opposite polarity at the two ears serve to confuse the hearing system and render it unable to fix the position of the sound source, though it is easy to bias the brain by presenting it with some clues from the other senses.

The effects of a polarity reversal are less well marked to a listener seated off the speaker system centre line, for all the sound appears to be emitted by the nearer speaker, an illusion that is strengthened as the listener moves further from the centre. Further consideration of the effects of polarity reversal will be deferred as not being germane to the argument. Instead, consideration will be given to the apparent acoustic disappearance of the remote speaker when the listener is off the system centre line.

This is an effect that has been known as a nuisance by sound engineers for many years though the explanation is only of relatively recent origin. A typical situation where this nuisance occurs is in cinemas and theatres where it is necessary to mount the public address speakers on each side of the proscenium opening. Down the centre of the theatre there is a sharply defined line along which both speakers are heard and any artiste appears to be standing in the centre of the stage irrespective of his actual position. A slight movement of the head to one side of the centre line, often by only a few inches, moves the artiste over to the nearer loudspeaker while the sound from the further one seems to vanish. This is, as one might expect, the exact counterpart of experience in domestic surroundings.

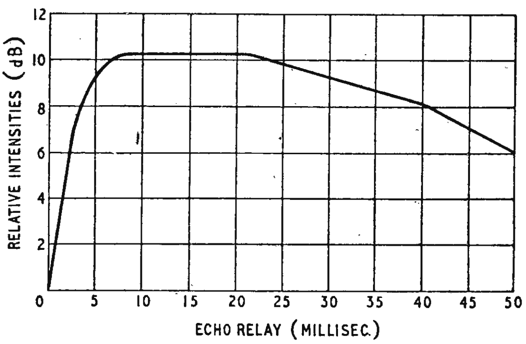

Fig. 2. Relative intensities for equal loudness as a function of the echo delay time.

This vanishing loudspeaker phenomenon is a simple example of the so-called "Haas effect," a subjective reaction that is of great importance when considering the influence of the hearing system. Working at Göttingen University, Haas discovered that the apparent position of the sound source in a multiple speaker installation is fixed at the position of the nearest loudspeaker, though all the loudspeakers contribute to the total loudness. This unsuspected result is due to the important part played by time of arrival differences when similar sound energy spectrum patterns arrive at the ears. A signal arriving at the ears from the nearest loudspeaker reduces the response to any similar signal arriving slightly later in time, the amount of the reduction being a function of the time of arrival difference of the two identical sound patterns. More precise information is given by the data in Fig. 2, which indicates the relative intensities of the two signals for both to sound equally loud when they differ in arrival time. Thus, for time of arrival differences between about 5 and 30 milliseconds, the second signal to arrive at the ears must be about 10 dB higher in intensity before it sounds as loud as the first signal. The velocity of sound in air is sufficiently close to 1,000 ft/sec (actually it is 1,125 ft/sec) to make it possible to substitute "path length difference in feet" for "echo delay in milliseconds" without any serious error. Where similar loudspeakers are connected in parallel the sound outputs will generally have sufficiently similar intensities and responses to make the data in Fig. 2 applicable. Thus the sound from the second speaker will appear to vanish at a path length difference of less than one foot, corresponding to a time interval difference of less than one millisecond. This is in accordance with practical observations.

If the time interval difference increases above about 40-50 milliseconds, the sound from the remote speaker, though not consciously appreciated as a second signal, begins to reduce the intelligibility of the first signal; and with still further increases in the delay time it appears as a separate echo. For all time differences greater than about one millisecond, it makes the apparent position of the nearer loudspeaker increasingly vague without actually moving this apparent position.

Thus the Haas effect is responsible for the fact that two loudspeakers radiating the same signal do not appear to be any larger than a single speaker. Though this is not quite so obvious, it is also the reason for an 18in speaker sounding little larger than an 8in speaker.

In marked contrast, a good stereophonic reproduction of an orchestra using the same two speakers at the same spacing will appear to fill the whole of the space between them. This is achieved because the two signals differ both in timing and in frequency content. Because of these differences reversal of the connections to either voice coil does not, in general, have the same drastic effect on the apparent position of the sound source.

Advantages of Paralleled Speakers

Two speakers in parallel do have appreciable advantages over a single speaker of the same size, and, in fact, have some advantage over a single speaker having the same cone area as the two speakers together. A 12in speaker of the normal type has an efficiency of about 1%, i.e. it converts about 1% of the electrical energy input to the voice coil into sound. This abysmally low figure is in large measure due to the very considerable disparity between the density of air and the density of those materials which are mechanically suitable for speaker cones. It is roughly true to say that if we could double the density of the air we could double the efficiency of our loudspeakers. This seems impossible, but it is in fact easily achieved, for when two speakers are mounted in close

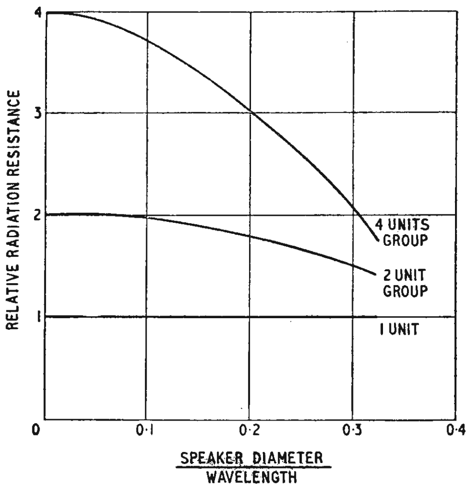

Fig. 3. Relative acoustic radiation resistance "seen" by each speaker of a closely spaced group.

proximity, each speaker benefits from the presence of the other. As the cone of one speaker moves forward it encounters, not free air, but air of a higher density due to the fact that the other cone is also moving forward and compressing the air in front of it.

Quite clearly any advantage due to this mechanism requires that the two cones be near together, for ideally the pressure variations produced by one speaker must be in phase with those produced by the other. This will only be achieved if the spacing between speakers is a fraction of the wavelength of the sound being radiated. Wolfe and Malter, and also Klapman, have made theoretical investigations of this problem and produced the curves shown in Fig. 3, from which it will be seen the radiation resistance seen by each speaker diaphragm is proportional to the number of such diaphragms in use. Thus two loudspeakers in parallel produce twice as much acoustic power when they are close together as they do when they are far apart. As the separation is measured in wavelengths and not in feet, this means that the power advantage is gained only at the low frequency end of the range. It is no mere academic advantage, for the addition of a second speaker produces an increase in the low frequency response that is immediately obvious even to the untrained ear.

Distortion Reduction

Paralleled speakers also have a significant advantage in reducing amplitude distortion. This distortion arises in loudspeakers due to non-uniformity of the field distribution over the depth of the gap in which the coil moves, and to non-linearities in the stiffness of the cone suspension. Both forms of distortion are similar in that the deflection of the voice coil for a given current is constant for small movements, but decreases rapidly, either as the coil moves out of the gap, or as the cone approaches the end of the travel permitted by the surround and centring

Paralleling a second speaker and adjusting circuit constants to give the same overall acoustic output as with one speaker means that the cone movement becomes less than that required by a single cone to give this acoustic output. The relative reduction in distortion can be much greater than the factor by which the cone movement is reduced.

Dissimilar speakers may be used in parallel to extend the frequency range. Alternatively, if the units are only slightly dissimilar, they may be used to smooth out the low frequency response, the intention being that dips in the response of one speaker should be filled by peaks in the response of the other. In every instance it is wise to use units having their bass resonances about 10 c/s apart, for when they are connected in parallel the overall impedance curve is significantly smoothed. At the resonant frequency of one cone the impedance of that speaker may rise by a factor of ten or twenty times. The combined impedance of the two speakers cannot do more than double, for the second voice coil appears in parallel and being "off resonance" has a low impedance. There are few better ways of achieving a good damping factor.

Thus we may summarize by saying that while two speakers in parallel have several advantages, the increase in source size that appears so obvious at first thought is not in fact achieved, two speakers being no larger in the acoustical sense than a single speaker.

My thanks are due to Chapman & Hall for permission to use illustrations from my book "High Quality Sound Reproduction."

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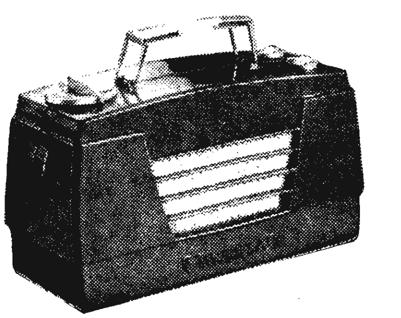
PROSPECTOR'S PORTABLE



The idea of combining a geiger counter with a portable radio receiver is one which should have a wide appeal to Canadians who have prospecting in the blood. The "Lodestar", made by Canadian Aviation Electronics of Montreal, weighs only 5lb and is housed in a tough plastics case, for which a polythene shoulder strap is available. In addition to normal wave-band selection, two switch positions give aural indication from the loudspeaker or visual indication in a neon flasher if the set is affected by the emanation from radioactive material of sufficient strength.

Component Developments

Trend of Design of Electronic Components Used by the Services

By **G. W. A. DUMMER***, *M.B.E., M.I.E.E.*

At present most components used in Service electronic equipment conform to the specifications in the Radio Components Standardisation Committee's (R.C.S.C.) lists[1] of fully tested and approved components which have been effectively standardized in this country for the past eighteen years. Many developments, however, are now in progress both at government Research establishments and in industry which will affect the future standardization of Service electronic components.

It may not generally be realized that Great Britain was the first country in the world to standardize Service radio components. In the 1920s Joint Service "K" specifications were drawn up under the aegis of the Wireless Telegraphy Board for $2\frac{1}{2}$-in and $3\frac{1}{2}$-in ammeters and voltmeters. These specifications laid the foundations for the dimensions of most of the $2\frac{1}{2}$-in and $3\frac{1}{2}$-in flush and projecting type instruments seen in Britain today.

The 1939-1945 war made it essential to produce large quantities of components quickly, the scale of increased production amounting to approximately three times the normal peace-time output. This led to severe rationalization of components by Joint Service Standardization Committees which are now the R.C.S.C. An example of the success of this rationalization is that in 1942 there were 1,500 different plugs and sockets in use in the Ministry of Aircraft Production alone and after rationalization only 200 were retained by the three Services. In addition, some 10,000 resistor types were reduced to 1,300 approved items; 8,000 fixed capacitor types were reduced to 750 preferred items, and 700 types of transformer laminations were reduced to 32 preferred items.

It is worth emphasizing that the situation on electronic components is constantly changing. There is a time delay in introducing new components because of the necessity for thorough approval testing, and it is difficult to withdraw components from Service use because of the world-wide organization of the Navy, Army and Air Force. It would be useful if it could be generally realized that there is a "standardization life" for every component, which may be 10 years or more.

There are many specifications for the Services and industry and, to the user, these may seem confusing. There are at the present time specifications for Service components prepared by the R.C.S.C., R.C.S., etc. (now D.E.F.), in addition to N.A.T.O. specifications, whilst for industry there are the Radio Industry Council (R.I.C.), International Electrotechnical Commission (I.E.C.) and British Standards Institution (B.S.I.) specifications. It would seem desirable for some of these specifications eventually to be merged into one Service and one international, or British industry, specification. As a long-term policy it is conceivable that these specifications may converge into one N.A.T.O. specification with individual country specifications agreeing with the main N.A.T.O. specification (at present concerned mainly with interchangeability) for the Services, and one I.E.C. specification for industry, with the individual countries agreeing with the I.E.C. specification as shown below:—

N.A.T.O.	Great Britain	R.C.S.C. and D.E.F. specifications
	France	C.C.T.U. specifications
	United States of America	J.A.N. or M.I.L. specifications
	Canada	J.C.N.A.A.F. specifications
	Belgium	National Defence specifications
	Denmark	" " "
	Netherlands	R.C.S.S. and M.I.L. specifications
	Italy	National Defence specifications

I.E.C.	Great Britain	B.S.I. specifications
	France	Industry specifications
	United States of America	R.E.T.M.A. specifications
	Canada	Industry specifications
	Belgium	" "
	Sweden	" "
	Denmark	" "
	Netherlands	" "
	Norway	" "
	Italy	" "
	Austria	" "
	Japan	" "
	Switzerland	" "
	Portugal	" "
	Spain	" "
	South Africa	" "
	Yugoslavia	" "

New Component Developments:—Operational requirements have changed greatly in the post-war years and new developments such as guided missiles, automation techniques, high-speed aircraft, etc., are influencing component development considerably.

The single range of Service-type approved components may diverge in the future into several differing categories, which might be classed as:—

1. The reliable component
2. The transistor circuit component
3. The high temperature component
4. The short life, or guaranteed life, component
5. The very long life component

For some years there may be no clear definition between these types, but it is useful to discuss these developments in more detail.

1. The Reliable Component:—With the increasing complexity of electronic equipment used in the Services the need for increased reliability becomes more essential. It has now become accepted that in war the lives of a complete aircraft crew, tank crew or sea-going vessel crew may become jeopardized if the radio, radar or navigational systems fail at a crucial moment. The success of a complete operational mission, even a major battle, can depend on the electronic equipment.

*Royal Radar Establishment.

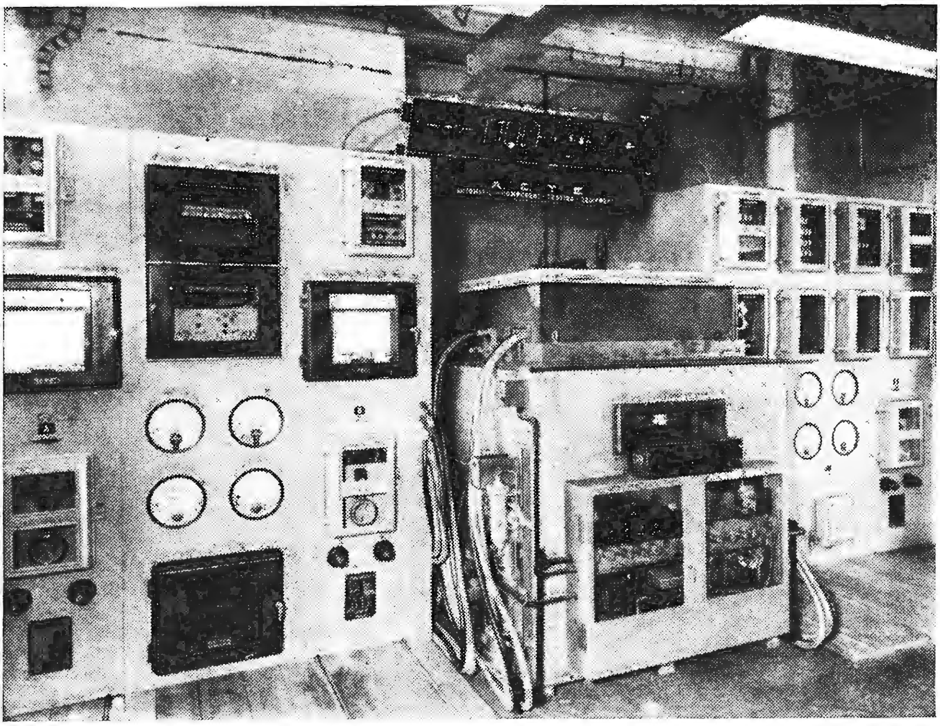
It is not easy to assess reliability of equipment under Service conditions, but from many sources of information failures in electronic components appear to occur in the following order[2]:—

(1) Valves
(2) Resistors
(3) Capacitors
(4) Transformers
(5) Switches
(6) Plugs and Sockets, etc.

This does not necessarily mean that resistors and capacitors have high fault rates, but that they are the main causes of failure because large quantities are used in equipments.

The reliability of an equipment depends also on the environmental operational conditions under which it is used. From analyses, the author would estimate that the fault rates with Service equipments are from ten to twenty times those of home radio and television sets, which use basically similar components.

It is now being suggested by the author that the fault rates of these common components, such as resistors and capacitors, should be of the order of 0.01% per annum under laboratory conditions. In order to attain this low rate of failure it is essential that improved process control in manufacture and a higher standard of inspection of materials should be obtained. In addition, an important point arising directly from this requirement for increased reliability is that of mass testing. In order to evaluate failure rates of this order it is necessary to test very large quantities of components (of the order of 1,000); a machine designed by a British firm is about to go into operation at the Royal Radar Establishment for the automatic testing of 1,000 resistors. It is possible to feed instructions on coded tape to this machine for any series of tests it is required to make for any length of time up to six months. The coded signals control the sequence of testing and the appropriate climatic conditions in the test chamber. Rotary switches select each resistor in turn. They are measured on an automatic impedance bridge and recorded as change of resistance against the particular test conditions. The accuracy of measurement and recording is of the order of 0.5%. This is one of the first examples of automation in testing. Modifications of this machine, or further machines of this type for testing capacitors and other components, may be developed.



Modern equipment for the automatic testing of electronic components.

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2. The Transistor Circuit Component:—In this type of component physical size comparable with that of the transistor is of importance, together with maximum reliability. Life times may well be of the order of 10,000 hours for Service equipment. The reduction in size of the transistor equipment is possible because of the lower voltages and currents used in transistors and many sub-miniature components have already been developed[3]. The danger to be avoided is extreme miniaturization affecting reliability, particularly for Service requirements.

In the United States of America a maximum voltage of 50 has been chosen for all transistor components and in this country a similar maximum voltage is being discussed by the Joint Service authorities. It is possible that agreed voltage figures may evolve to which all future Service transistor circuit components will be designed. At the moment these figures are 1.5, 3, 6, 9, 15, 30 and 50, but these are not yet finalized and await the outcome of discussions with the component industry. It would, however, be a most useful step to standardize voltages at this stage for all future transistor circuit components.

Considerable development is taking place in America and in this country on the design and development of these miniature components.

3. The High Temperature Component:—This requirement arises mainly in radio and radar equipment installed in high-speed, high-performance aircraft, although it is also required in guided missiles and in some of the miniature high-power Army radio transmitters. In recent years considerable advances have been made in miniaturizing components. The use of these extremely small components in sealed assemblies aggravates cooling problems since there are smaller surface areas available to transfer waste heat to the surroundings, coupled with a general increase in power dissipation per unit volume as against conventional designs.

Various methods of cooling miniature equipments have been adopted, notably on airborne equipment. It is obvious that where components are available which can operate at the maximum temperature of, say, 150°C, in a confined space without cooling arrangements, considerable gains can be made.

The problem is particularly acute in airborne radar equipments where it is no longer possible to use the aeroplane itself as a heat sink. With the increased speeds of modern aircraft the temperature due to aerodynamic heating effects, such as friction, etc., becomes high and the rise in temperature in the Fairey D_2 during its record-breaking-speed flight was stated to be 100°C.

Some developments in high temperature components are described in detail in a recent publication[4], but in general the design of components for use at high ambient temperatures precludes the use of organic materials, such as paper or the currently known plastics, and requires the use of inorganic materials, such as glass or ceramics. Certain plastics, such as p.t.f.e., and materials, such as silicones, can be used with advantage. Some recent developments in resistors and capacitors are described in a series of books currently being published[5].

Testing components at temperatures of 100° to 150°C may also present difficulties, as handling them may need tongs or asbestos gloves.

4. Short Life Component:—This type of component is required for guided missiles, shell fuses, etc. Components must be extremely reliable and they may have a life of approximately 100 to 1,000 hours. This is not the flight time of the missile but the testing time necessary to set up and check the missile allowing for stand-by periods. Components must withstand high temperatures, vibration and long periods of storage, without deterioration.

They are expendable and whilst at the moment R.C.S.C. type-approved components are being used, because of the need for maximum reliability, in time reliable short life components may be developed which are comparatively inexpensive. It is possible that components with "guaranteed lives" may be produced.

A programme of work is being initiated by the R.R.E. on the relationship between life and ambient temperature of components in an attempt to establish initial data on a typical range of components such as resistors, capacitors, etc. The components will be tested to destruction and the information obtained will be valuable in improving the understanding of the effects of high temperature on the life of components.

It is, for instance, possible that certain types of impregnated paper-dielectric capacitors normally rated at 85°C can have a guaranteed life of 50 hours at a temperature of 150°C, with a slight increase of capacitance at this temperature.

5. The Very Long Life Component:—The laying of the transatlantic cable and of other long-distance cables has necessitated considerable study of long-term corrosion, electrolytic action, silver migration and general degradation of materials used in components. The life expectancy of the standard components used in the repeater amplifiers of these cables is of the order of 20 years[6]. The lessons learned in these studies will be of great importance in improving the reliability of the R.C.S.C. range of Service components and also of those components used in the Atomic Energy Research Establishments, etc., where a component failure may affect a very long-term experiment and render it useless.

The Influence of Automation Techniques on Components:—Although as yet few automatic assembly machines are available in this country it is probable that the shape of components may be affected when assembly machines of this type are used in increasing quantity.

In the United States of America several automatic component assembly machines are in use which are capable of assembling up to 10,000 sub-units per day[7].

Some proposals affecting future components are being made by Government authorities to the appropriate component manufacturers' committees such as:—

(a) In order to fit the insertion heads of these machines it is desirable that all future components, wherever possible, should be cylindrical in shape and should have axial leads.

(b) As holes are punched in the printed wiring chassis through which the components are inserted, the diameter of the leads becomes important. It has been suggested that all components should have two standard diameters, i.e., 20 s.w.g. and 26 s.w.g., with the possible introduction of 30 s.w.g. for miniature transistor components.

(c) Most Service components have, at the moment, lead lengths of 1½ to 2 in. In component insertion machines only a fraction of this length is used, the rest being chopped off in the machine. The proposal is now being made for all components to be made with lead lengths of 1¼ in. This is already being standardized in America.

(d) One of the most important points in component design for automation techniques is the ease of soldering of the connecting leads. The success of the dip-soldering operation which accompanies automatic machines depends entirely on this and solder coated or plated component leads are an advantage.

In addition to the tubular, axial-lead type of small component it is possible that a range of larger components, such as transformers, electrolytic capacitors, switches, relays, etc., may be developed which can be inserted by "snap-in" methods prior to dip soldering.

Conclusions:—It would appear that the trend in component development for Service use is away from single standard range into divisions or branches of the standard "reliable" range to suit particular and increasingly severe operational requirements.

With the general trend towards transistor constructions and automatic assembly techniques it may well be that the electronic equipment of the future will need components much smaller in size, extremely reliable for a given life period, and capable of being automatically inserted in printed-wiring chassis.

With the rapid development of transistors and semi-conductor materials, film resistors, etc., it may even be possible to envisage future electronic equipment as a solid block with no connecting wires. The block may consist of layers of insulating, conducting, resistive, rectifying and amplifying materials, the electrical functions being connected directly by cutting out areas of the various layers.

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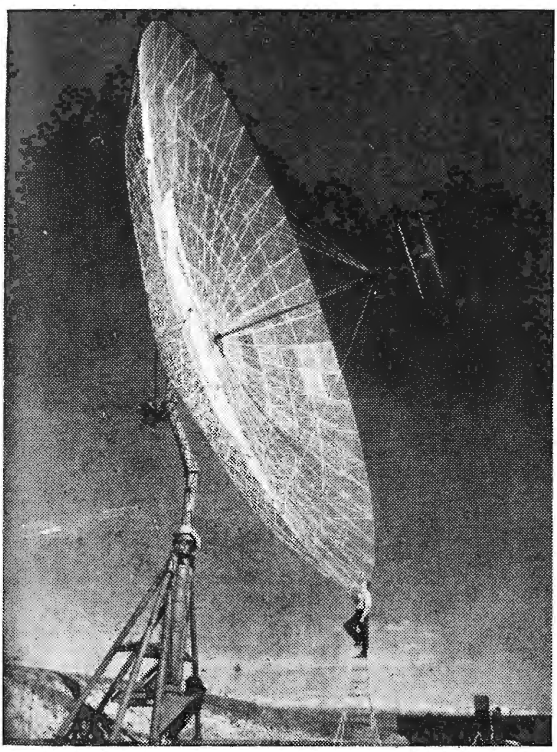

Specially designed 61-ft parabolic aerial system erected by the Stanford Research Institute, California, for gathering data on scattering and reflection of radio signals from meteor trails, and ionization associated with the aurora borealis, in the frequency range 100 to 1,000 Mc/s. Pulse transmitters of 50 to 70 kW output will be used initially in the 100 to 400 Mc/s range. A similar aerial has been erected also near Fairbanks, Alaska.

More Jobs for Computers

Recent Applications and Installations

Ever since computers came on the market as commercial products and computing time could be bought at so much an hour, the applications of these machines have been multiplying at a very fast rate, sometimes in the most unexpected directions. The following is just a random list of recent uses of both analogue and digital machines, and makes no attempt to present a balanced picture. It may, however, give some idea of the expansion which is likely in this branch of the electronics industry—already recognized by the formation of an Electronic Data Processing Section in the R.C.E.E.A. and the holding of a computer exhibition next year.

Payrolls continue to be the most popular application of digital computers, following the success of Lyons with their LEO I at Cadby Hall, London. Now, LEO I is also handling the payroll for 19,000 employees of the Ford Motor Company, while a LEO II machine is being installed at the Corby offices of Stewarts and Lloyds for their payroll and other work as well. The G.P.O. has ordered a system comprising two National-Elliott " 405 " computers for a payroll of 112,000 employees, amounting to £70,000,000 per annum.

Road Vehicle Suspension.—The effect of uneven road surfaces on vehicle suspension systems is being simulated by a Short Brothers analogue computer at the Brunswick Technical High School, West Germany.

Weather Forecasting.—An entirely new method of forecasting the pressure distribution for 24 hours ahead by calculation has been developed by the Meteorological Office, treating the movement of the atmosphere as a problem in classical hydrodynamics. To handle the heavy computation in less than the three hours it takes at present a Ferranti " Mercury " digital computer is being installed at the Dunstable forecasting office.

Aircraft Design provides an enormous list of applications for both analogue and digital machines, too detailed to be covered completely. For processing wind-tunnel data Armstrong Whitworth are using a Ferranti " Pegasus " digital computer, and other machines of this type have been installed by Hawker's, Vickers-Armstrongs and the Royal Aircraft Establishment. Short Brothers are using one of their own analogue computers for simulating aircraft take-off problems, while Metropolitan-Vickers have a system for simulating kinetic heating in aircraft and missiles which incorporates their " 950 " transistor digital computer.

Biophysical Research.—The task of calculating the positions of atoms in the complex molecules of living tissue has been undertaken by a biophysics laboratory of London University, using a digital machine at I.B.M.'s London computing centre. Large numbers of alternative structures have been calculated for correlation with the results of observational methods. In this way it is hoped to establish that the atoms are arranged in particular patterns which can be represented mathematically.

Motor Racing Results.—An electronic computing centre using I.B.M. digital machines was set up at Le Mans this year to work out the placings of the cars during every hour of the race. It also provided accurate placings at the end of the contest.

Town and County Councils.—A National-Elliott " 405 " digital computing system is now calculating and printing rate demands in the City Hall, Norwich, and will also be used for other accounting work. Orders for " Hec " digital machines have been received by the British Tabulating Machine Company from the County Councils of Middlesex, Nottinghamshire and West Riding, from the Brighton and Derby County Borough

Councils, from Birmingham Corporation and from Durban City Council.

Educational Establishments.—To celebrate the higher technological status of the Northampton College of Technology (formerly Northampton Polytechnic) a Ferranti "Pegasus" digital computer has been installed. One of these machines is due also for Sheffield University (the purchase being shared with the United Steel Company). The Royal Air Force College at Henlow has installed an Elliott G-PAC analogue computer for use in the study of guided missiles.

Rail Distances.—The British Transport Commission has recently used LEO I at Cadby Hall for working out distances between all possible pairs of railway stations and goods depots in Britain for the purposes of their new freight charges scheme. The 7,000 stations and depots gave 50,000,000 permutations, but they were reduced to 4,000 groups to simplify the task.

Fuel Systems and allied problems are being studied by H. M. Hobson, of Wolverhampton, with the aid of an Elliott G-PAC analogue computer, and Dowty Fuel Systems of Cheltenham have ordered a similar machine for the same purpose.

River Water Levels.—A I.B.M. "650" digital computer at the company's London computing centre has been used to calculate water levels at 30 points along the River Nile over a period of 48 years, the object being to study the relative merits of irrigation and hydro-electric power schemes.

Management Information, leading to better managerial control, is said by the Morgan Crucible Company to be one of the chief advantages derived from the "Hec" digital computer (British Tabulating Machine Company) installed at their Battersea headquarters. Accounting and mathematical computation is also being handled.

Insurance Policy Records will be maintained by the South African Mutual Life Assurance Society at Cape Town using a large electronic data processing system called "PERSEUS" which has just been ordered from Ferranti.

Technical Consultancy Service operated by Stenhardt Ingeniörsfirma, a small and specialized engineering company in Stockholm, has recently extended its facilities by the installation of a Short Brothers analogue computer.

Sales Statistics will be handled, among other things, by an Elliott "405" digital computer at Littlewoods Mail Order Stores, and by a Ferranti "Pegasus" at I.C.I., Blackley. Both machines are on order.

Flame Cutting Control.—New developments in oxygen cutting of metal plates by the British Oxygen Company have involved the application of Ferranti's methods of controlling machine tools by digital computers.

Hydromechanical Research.—For processing data from a water tunnel, and other uses, an English Electric DEUCE digital machine has been ordered by the Mechanical Engineering Research Laboratories at East Kilbride, Scotland.

The Dawn Chorus

A New Type of Audio-frequency Atmospheric

INTEREST in audio-frequency "whistler" atmospherics[1] has been considerable since it was realized that observations at various latitudes could give information on the electron density at heights well above the (at present) highest known ionospheric layer (F2). The recent discovery of a high-latitude form of whistler[2] offers prospects of also determining the strength of the earth's magnetic field at such great heights.

A recent paper[3] describes results on another type of audio-frequency atmospheric, which has been called the "dawn chorus" since it consists of many rising (typically from 2 to 4 kc/s) tones, sounding rather like a distant rookery; and it occurs most often in the early morning. This is in contrast to the single falling tone of "whistlers," which occur throughout the day.

Records are obtained as before, simply using an aerial (orientated for minimum local hum pick-up) feeding a band-limited (1 to 7 kc/s), high-gain (80 dB) audio amplifier. The output of this amplifier is for convenience recorded on magnetic tape for four minutes every three hours, two days a week.

Observations at Wellington, New Zealand, show good correlation between the strength of the dawn chorus and the amount of magnetic activity. When data from three American and two New Zealand stations were compared, good correlation was found between dawn chorus activities at stations which, though far apart, lie on approximately the same line of force of the earth's magnetic field. Observations were also made to determine whether the same dawn chorus is heard at different stations. Unfortunately, individual rising tones are weak and difficult to identify, so that occasional sudden bursts were used instead. These were received apparently simultaneously at Wellington and at Unalaska (Aleutian Islands), which lie on neighbouring magnetic lines of force. These results suggest that dawn chorus signals are propagated along magnetic lines of force, as are whistlers[4].

No correlation could be observed between dawn chorus and whistler activity. Also, no audible forerunners of dawn chorus signals, like the "clicks" generated by lightning which can often be correlated with whistlers, have been found. Thus it is unlikely that such signals originate in the lower atmosphere.

Results from various stations also show a pronounced daily variation in the strength of dawn chorus signals, the time of greatest signal strength remaining unchanged throughout the year. However, this time of maximum signal does vary with the geomagnetic latitude, and in a manner consistent with the idea that dawn chorus signals are initiated by positively charged particles which approach the earth in its (magnetic) equatorial plane, and are deflected by its magnetic field. Because of the correlation of dawn chorus with magnetic activity, and the daily variations in signal strength which occur at the same time throughout the year, such particles presumably come from the sun.

The rising tone cannot be caused by propagation effects as these are responsible for the *falling* tone of whistlers (the higher frequencies travel faster than the lower). A possibility is, however, that the frequency of a particular source increases as the incoming particles penetrate to lower heights. Proton plasma oscillations can perhaps produce suitable frequencies, in which case the lowest frequency in the chorus should increase as the observation station approaches the equator.

[1] Storey, *Phil. Trans.* A246, p. 113 (1953). Storey's results are also described in *Wireless World* Vol. 49, p. 338 (July 1953).
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LETTERS TO THE EDITOR

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

Colour Television

I WOULD like to point out that your report on the Paris Colour Television Symposium (August issue) when referring to the comparative performances and costs of colour display devices misquotes me to such an extent that it completely reverses the meaning I had intended.

The order of performance that I gave was: (1) three-tube projection with best performance, (2) three-gun shadow-mask tube, (3) beam-indexing tube, (4) three-gun focus-grid tube, and (5) beam-switching tube with lowest performance. The order of increasing cost was: (1) beam-switching tube at the lowest cost, (2) beam-indexing tube, (3) three-gun focus-grid tube, (4) three-gun shadow-mask tube, and (5) three-tube projection with the highest cost.

CHARLES J. HIRSCH,
Hazeltine Research Corporation.

New York.

Projection Television

FROM the remarks of your correspondent O. V. Wadden in the September issue, it is obvious that he has never had the opportunity of seeing a forward projection television receiver in the home. I have been using for two years now a slightly modified Philips 1800 chassis throwing a picture 32 in × 24 in on a screen made from hardboard sprayed with aluminium paint. Far from having to darken the room, I can use 450 watts and still view comfortably.

I think that manufacturers have "missed the bus" by neglecting forward projection and concentrating on bigger, unwieldy and expensive direct view c.r.t.s. Everyone who has seen my picture says, "Where can I buy one like it?" I am a television engineer and see them all, but I would never go back to direct viewing.

Mr. Wadden's condemnation of forward projection probably arises from the fact that most demonstrators of these receivers are too greedy in screen size, with a consequent serious loss of light. For the same reason "Free Grid's" idea (July issue) of the projector in one wall of a room and the screen in the other is equally absurd unless, of course, he lives in a cupboard!

A. G. TUCKER.

London, N.W.6.

Transistor Oscillator Stability

MR. SCROGGIE'S reference, in his article on "Transistor Oscillator Stability," in your September issue, to a long-term frequency drift surprised me considerably as I have never seen any indication of this effect in an OC45, or for that matter in any other Mullard transistor. I should therefore be most interested to know if Mr. Scroggie did in fact observe this effect on any Mullard transistor.

L. P. MORGAN,
Mullard Research Laboratories.

Salfords, Surrey.

The author comments:

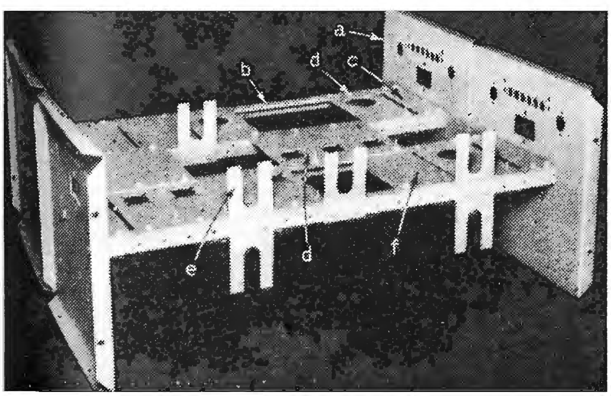
I would assure Mr. Morgan that I, also, did not observe the long-term frequency drift in any Mullard samples. The effect was no doubt an abnormality attaching to one or two experimental samples I used in my tests.

M. G. SCROGGIE.

Standard Chassis

THE improved version of the pre-fabricated chassis described in the September 1955 *Wireless World*, and said in our September issue of this year to be available in commercial form, is supplied as a kit of parts for assembling a chassis measuring 16 in × 7 in × 7 in. As the illustration shows, two such units can be joined together to provide a large chassis and any number, within reason, can be joined together in a similar way.

A single kit consists of 2 end plates (a), 2 runners (b), 2 brackets (c), 6 small and 3 large valveholder plates (d), 6 potentiometer brackets (e) and 6 blank plates (f). The various parts are made of cadmium-plated steel and the end plates have provision for mounting power-supply connectors, jacks, toggle switches and terminal strip.



The chassis kit is obtainable from Cowell Developments, 67, Long Drive, East Acton, London, W.3, and a single kit costs 45s complete with all necessary screws.

Transistor Audio Amplifiers

THIS is one of those subjects on which up-to-date information is rather scattered. However, a *Wireless World* book which has just been published covers practical and theoretical aspects of this field from the latest viewpoint. The authors, D. D. Jones and R. A. Hilbourne, are engaged in transistor developments at G.E.C.

The book deals mainly with germanium p-n-p transistors as these are the only type commercially available in Great Britain at present. An introductory chapter on this type of transistor has sections on its various equivalent networks. Small signal amplifier design is then discussed including such points as signal to noise ratio and tone controls. The chapters on power amplifiers evaluate the relative advantages of class A or class B operation, and also deal with mismatching and other causes of distortion. A number of practical small and large signal amplifiers are also discussed.

"Transistor A.F. Amplifiers" is obtainable from our publishers, Iliffe and Sons Ltd., price 21s (postage 8d).

Modern Thermionic Cathodes

Review of the Main Types and Their Relative Merits

By R. W. FANE*, M.Sc., A.Inst.P.

DURING and since the second world war the problem of obtaining thermionic cathodes yielding high current densities with long life has been the subject of intense research and development. The difficulties in the most commonly used oxide coated cathodes have become more and more apparent with the increased interest shown in microwave valves operating under extreme conditions.

Investigations into alternative methods of producing cathodes capable of withstanding ionic bombardment, gas poisoning, mechanical and thermal shock and at the same time yielding a high and stable current density (amperes per square centimetre) have led to some very interesting results. An outline of the most important developments and an assessment of their relative merits is given in the following pages.

The choice of material for use as a thermionic emitter is chiefly governed by considerations of melting point, ease of fabrication and the work function. This latter quantity appears in the well-known Richardson equation relating "saturated" or "temperature limited emission" to the absolute temperature, viz:—

$$I = AT^2 \exp. (-\phi/kT)$$

where I is the saturated emission in amperes per sq cm, A is a constant, amperes/cm²/deg², T is the temperature in °K, k is Boltzmann's constant, 8.6×10^{-5} e.v./deg, and ϕ is the work function measured in electron volts (e.v.), ranging from rather less than 1 to 5 e.v. The value of I is difficult to determine experimentally as the emission, particularly in the case of oxide cathodes, is never truly saturated, an increase in anode-cathode voltage always giving rise to some increase in emission current (Schottky Effect). The value often taken (see Fig. 1) is that at which the current versus voltage curve departs from the space-charge-limited line (3/2 power law). Alternatively a logarithmic plot of the portion beyond the "knee" of the characteristic is extrapolated to zero volts to give the required value. The current which may be drawn using microsecond pulses is, in general, considerably higher than the d.c. rating and is considered to be the true emission for work function calculations.

For the purpose of this review all cathodes are considered as belonging to one of the following groups:—

(i) pure metals,
(ii) atomic films,
(iii) oxide emitters.

Pure Metals.—Tungsten has held pride of place in the first group for many years. As it is not readily fabricated into sheet its use is restricted to directly heated filaments and where robustness is of prime importance, giving some 500 mA/cm² at 2300°C with $\phi = 4.5$ e.v. and A=60 amperes/cm²/deg². The expected life under such conditions is 10,000 hours. For unipotential cathodes, tantalum ($\phi = 4.1$) is preferred. The high temperature required makes radiation heating impracticable and such cathodes have been heated by bombardment with electrons from a subsidiary tungsten filament. Such a system has been used in some high power klystrons.

Atomic Films.—The characteristics of the second group are mainly determined by a thin film, believed to be one atom thick, of barium or thorium on a refractory metal. Some of the most important recent advances belong to this category, their behaviour being analogous to thoriated tungsten. In the first instance about 1% of thorium oxide was added to tungsten wire during manufacture to improve its mechanical properties. Later it was found that metallic thorium, produced by the reduction of the oxide at high temperature, diffused to the surface and formed an electric double layer with positive charge outermost reducing the work function to 2.6 e.v. Owing to the strong forces of adhesion the cathode can be operated at high temperatures without undue evaporation of active material. Further improvement is shown if the outer layer of the tungsten is converted to tungsten carbide. The active life of the filament depends upon the maintenance of the thorium layer and many thousands of hours are obtained at 1600-1800°C drawing 1-5 amperes/cm². While such filaments have been used extensively in medium and high power transmitting valves they cannot be used in microwave valves utilizing an electron gun structure where a planar cathode is necessary.

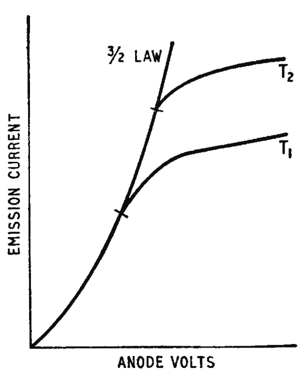


Fig. 1. Diode characteristics for two temperatures, T_1 and T_2, showing departure from the space-charged-limited line.

Similar properties are obtained with monatomic films of barium on tungsten, but in this case the work function is 1.6 e.v. Such a layer is, however, relatively unstable. An adsorbed layer of oxygen between the barium and the tungsten lowers the barium evaporation rate but some method of replenishment is necessary to make such a cathode of practical value. This has been achieved in the "L" type dispenser cathode announced by the Philips Laboratories in 1949[1]. In this, and other types to be described, porous tungsten is an essential part of the structure. This is produced by pressing tungsten powder at 50-100 tons/in² in a steel die and then sintering the compact at high

*Research Laboratories, Marconi's Wireless Telegraph Co.

temperature in a protective atmosphere. The porosity (ratio of pore volume to total volume) is 20-50%.

Fig. 2 shows the basic construction of a planar "L" cathode. A double-ended molybdenum cylinder is closed at one end by a porous tungsten plug. The cavity so formed contains barium and strontium carbonates. Heating the cathode to 1100°C in vacuum converts the carbonates to oxides. Continued activation at a higher temperature results in the reduction of barium (and strontium) oxide by the tungsten, yielding barium (and strontium) which diffuses to the surface and is continually replenished from the reservoir. Some controversy exists at present as to the exact nature of the emitting surface. At 1100°C the d.c. saturation current density is 2-3 ampere/cm². At 1000°C and a current density of about 1 ampere/cm² lives of 8-10,000 hours are obtained. Good performance has been given by such cathodes in microwave valves, particularly klystrons. Little has been published regarding the use of "L" cathodes in travelling-wave tubes, but the smooth surface should be of advantage in low-noise tubes although this is somewhat offset by the high operating temperature. A further consequence of the high temperature is the difficulty in mounting the cathode in a vacuum tube; for example mica supports have to be replaced by alumina ceramics.

The impregnated cathode[2], a modification of the above type, has simplified the structure by eliminating the need for a gas-tight weld round the tungsten plug, at the same time improving the temperature distribution and reducing the processing time. In this case the pores of the tungsten are filled with normal and basic barium aluminates, Ba Al_2O_4 and $Ba_3Al_2O_6$, the cavity containing the carbonates being dispensed with. The aluminates gives rise to barium oxide on heating, the behaviour of the cathode then being identical in all respects to the "L" type. A further improvement has been obtained by adding a small quantity of calcium oxide to the aluminates[3]. At 1100°C a d.c. saturation emission of 4 or 5 amperes/cm² is obtained, the peak microsecond pulsed emission being about 12 amperes/cm². A considerable reduction in the barium evaporation rate is also claimed which should result in considerably longer life.

The latest modification of the impregnated cathode has recently been described by Hughes and Coppola[4]. The improved impregnant, in powder form, is mixed with 50-50% molybdenum-tungsten alloy powder, pressed into a retaining molybdenum cylinder at 70 tons/in² and sintered at 2000°C in a hydrogen atmosphere. In a well processed valve d.c. emissions comparable with pulsed values can be drawn and the authors claim lives of 5,000 hours drawing a current density of 10 amperes/cm² at 1130°C. This simplified technique of producing such cathodes makes them an attractive commercial proposition. As with the types mentioned previously, exposure to atmospheric pressure after activation causes no permanent damage and repeated reactivation can be achieved.

Finally, the cathode described by Beck and his associates[5] is considered as belonging to the second group. A mixture of about 70% nickel and 30% barium and strontium carbonates is used. As pure nickel will not reduce barium oxide, some reducing agent, in this case zirconium hydride, is used (about 1%). After pressing into a metal retaining cylinder the cathode is mounted in the valve and heated to about 1100°C, causing the carbonates to dissociate and the nickel to sinter into a strong matrix. In general the temperature required for a given emission is about 100°C higher than that of an oxide coated cathode but resistance to poor vacuum conditions enables larger d.c. currents to be drawn. Although no evaporation rate information is available, lives of 5,000 hours at 1000°C and 1 ampere/cm² have been recorded. At this temperature a pulsed emission of 10-30 amperes/cm² could be obtained. Again, use can be made of such cathodes in demountable vacuum systems and the authors claim good results when used in klystrons and television cathode ray tubes.

Oxide Emitters.—The most important and oldest member of the final group is the oxide coated cathode. This consists of a coating of barium and strontium (and often calcium) carbonates on a nickel base. The reduction of the oxides, subsequently formed in vacuum, by impurities in the nickel (in particular silicon, magnesium and titanium) produces an excess of barium (and strontium) in the oxide crystals and is thought to be responsible for the cathode activity. The low work function, about 1 e.v., and long life (20-50,000 hours) accounts for the very extensive use of such cathodes in all low-power valves requiring some tens of mA/cm². As mentioned previously, however, resistance to ionic bombardment and gas poisoning is poor and the electrical properties of the coating limit the d.c. emission current density to less than 500 mA/cm² (at about 850°C) for a reasonable life. In pulsed operation with low-duty cycle the emission is from five to ten times higher than the d.c. values but a limit is ultimately set by arcing and a disruption of the coating. Some improvement in mechanical properties can be achieved by welding a nickel mesh to the base metal before applying the coating, thereby improving the bonding. The alkaline earth oxides are, however, employed as the basic active material in all modern types of cathodes, thermal efficiency having been somewhat sacrificed in favour of other desirable features.

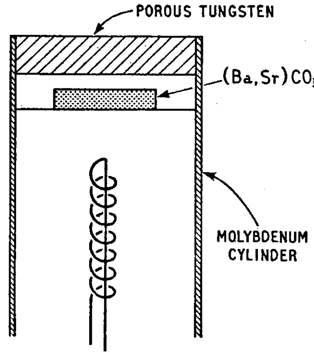


Fig. 2. Construction of the "L" type dispenser cathode.

Using oxide cathode materials in powder form, namely, nickel and alkaline earth carbonates, MacNair, Lynch and Hannay[6] have briefly described "molded" or nickel matrix cathodes made by the pressing and sintering technique. Although d.c. current densities as high as 10 amperes/cm² at temperatures of about 1000°C are reported, no life-test studies have been made at such high currents. Lives of 5,000 hours with cathodes operating at 850°C and 500 mA/cm² have been obtained using high anode voltages. The pulsed emission is approximately six times the d.c. values. Conditions of ionic bombardment which produced a fivefold decrease in the emission from an oxide cathode caused no significant change in the "molded" cathode.

Cathodes with similar properties but with a slightly different method of preparation have been developed at the Honeywell Research Centre[7]. In this case the carbonates have been chemically precipitated into the pores of a previously formed nickel matrix. The work function is 1-1.25 e.v. No life-test information is recorded. Although the above nickel cathodes appear to behave in a similar manner to oxide cathodes, results are largely empirical and the mechanisms involved are not completely understood. There have been no reports of such cathodes having been used in practical devices but they are likely to find application where a few amperes/cm² d.c. or tens of amperes/cm² pulsed emission are required at operating temperatures little above those of an oxide cathode.

Research into the thermionic properties of materials other than the alkaline earth oxides has yielded little of practical value, with the possible exception of thorium oxide. Coatings of this oxide on tungsten, tantalum or molybdenum have been used, for example, in power tetrodes and magnetrons, where a rugged cathode is required even at the expense of extra heater power. The life at current densities greater than 1 ampere/cm² has, however, been disappointing. A sintered mixture of molybdenum and thoria, called the "Cermet" cathode, has also been used, particularly in magnetrons, where electron bombardment would damage any conventional coating and the higher heat dissipation can be used to advantage.

Conclusion.—Some of the work which has been done on the various types of cathodes has necessarily been omitted but the most important parts of each section have been discussed to indicate the developments round which future valves, particularly those in the microwave field, will be designed. The scanty life-test information at present available and the relatively small number of valves which have been made incorporating the various cathodes make it impossible to give more than a tentative assessment of their relative merits.

Several very important features, such as recovery from gas poisoning, machinability and mechanical strength, smooth surfaces and low electrical resistance are, however, common to the various derivatives of both the atomic film emitter and the oxide cathode. For all ordinary low current applications the oxide cathode is still preferred.

The nickel matrix cathodes follow next as regards thermal efficiency and have many interesting features to commend them, including easy machinability—with tungsten special techniques have to be employed. Emission of 1 or 2 amperes/cm² d.c. at 830-900°C with a good life can be expected. Lives in excess of 5,000 hours have been obtained in these laboratories from cathodes of a similar type operating at 830°C drawing 1 ampere/cm² d.c. at high anode voltages.

The "L" cathode, and particularly the latest pressed type, are likely to find widespread use, although the more expensive mounting techniques and higher heater wattage required will limit their use to the more expensive high-power and microwave valves requiring high continuous current densities.

The utility of all the above-mentioned cathodes in low-noise travelling-wave tubes is not yet clear. Non-uniformity of emission over the cathode surface still remains a problem. Improved surface coverage by the barium in the case of the atomic film emitters and a finer and more even pore distribution in all cases may do a great deal to improve the noise characteristics.

Operating conditions of the various cathodes with an indication of expected life are summarized in the following table:—

Type	Operating Temp. (°C)	D.C. Emission (amperes/cm²)	Life (Hours)
Tungsten	2300	0.5	10,000
Tantalum	2100	0.5	10,000
Thoriated tungsten	1750	1–3	15,000
"L" and impregnated	1000	1	10,000
Improved impregnated and pressed	960–1130	0.5–10	>5,000
Nickel matrix ..	850–900	1	>5,000
Oxide coated ..	830	0.5	5,000

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Electronic Telephone Exchange

ALTHOUGH much development work has been done on electronic telephone exchanges they are not likely to come into widespread use in the public service for some time. There is no reason, however, why they should not be used extensively for private automatic installations in offices, factories, and so on. Here they offer the important advantages of small size and absence of moving parts, which are often a source of trouble. As an example, Pye Telecommunications have just produced a 10-line private automatic exchange which measures only 20in × 19in × 12in. The switching is done by Z50T cold-cathode valves, with two thermionic valves for shaping the incoming dialling pulses. It has an interesting storage feature by which if a wanted extension turns out to be "engaged" it is automatically rung again as soon as the person there replaces his handset.

Stabilization of A.C. Supplies

A Comparative Review of Methods of Voltage Control

By O. E. DZIERZYNSKI

THEORETICAL circuits and commercial apparatus for stabilizing a.c. power supplies are not so well known as those for d.c. supplies. A possible explanation is that a.c. voltage stabilization circuits demand certain special components for the degree of stabilization achieved to be comparable with that obtainable in d.c. systems. The power handling capacity (and consequently size) of a.c. stabilizers is also often greater than that normally required. However, it frequently happens that d.c. stabilization is not good enough owing to a.c. valves heaters being affected by mains voltage variations, with consequent uncertainty in gain.

In this article it is proposed to give a very general survey of possible a.c. stabilizing systems, pointing out their advantages and disadvantages.

Performance Requirements.—There are four main requirements for a mains voltage stabilizer. The first of these is the accuracy of stabilizing action.

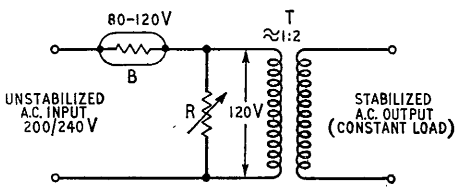


Fig. 1. Barretter stabilizer (constant load).

The requirement for this can be within $\pm 0.05\%$ up to within say $\pm 2\%$, but stabilization to better than $\pm 0.5\%$ can be considered as very good. As an illustration of the meaning of this requirement, if the required mains voltage is 200V to within $\pm 1\%$, the stabilized voltage can be allowed to drift between 198V and 202V, without any action being performed by the stabilizer. As soon as the voltage drops down to say 197.5V, the stabilizer will act to raise the voltage until the level is close to 200V. In an ideal case, the voltage should be set back to exactly 200V. Normally the value reached is somewhat higher—say 201V; but in a well designed stabilizer it should not come too close to the upper limit of 202V as overshooting effects may be experienced. Alternatively, the voltage may not be reset enough, and it would reach only say 198.5V.

The second requirement for a stabilizing system is the speed of response, which is defined as the accuracy of the system divided by the time taken to reset the voltage for a change equal to this accuracy (the regulating time); i.e. in the last example the time taken to reset upwards from 198V, or downwards from 202V. For instance, if this resetting time is 1 sec., the speed of response would be 1%/sec. The majority of a.c. voltage stabilizers do not act fast enough to deal with sudden mains voltage changes such as those produced by switching electrical apparatus.

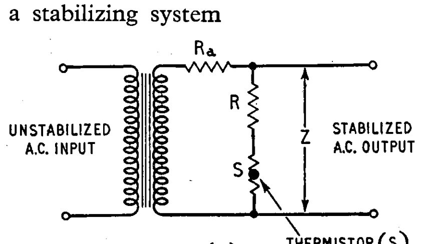
It is important to realize that both these factors (speed of response and accuracy) are in practice interdependent. If, for instance, our voltage limits are set closer, say to within ± 1V, with the same speed of response, the regulating time would be only 0.5 sec. Increasing the accuracy in stabilizing systems generally necessitates a slower response speed; otherwise overshooting and hunting effects will be unavoidable. Response speeds can be up to 5%/sec. in motor-driven systems (1/5 sec. for 1% change), but magnetic reactor stabilizers offer much higher figures (1/200 sec. for 1% change).

The third requirement associated with stabilizing systems is the output waveform. In certain applications it is important to have the power supply free from distortions of the original sinusoidal waveform. Unfortunately stabilizing circuits using non-linear elements, as for example saturated inductances, introduce such distortions. They can be removed by using low-pass filters, but this is rather a cumbersome remedy as the mains frequency is comparatively low so that filter elements (condensers, inductances) have to be large, and consequently expensive.

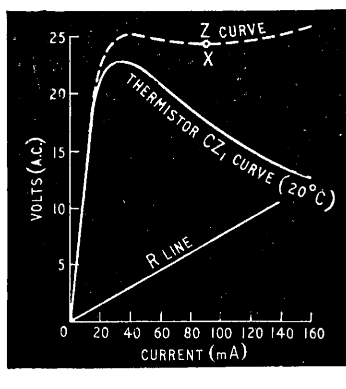
The stabilized power needed is the fourth and last requirement to be discussed. When these powers are large (say over 0.5 kW) motor-driven variable voltage transformers are preferred, as the cost of such regulating equipment rises very slowly with the controlled power, which is not the case for stabilizers with no moving elements.

Simple Stabilizing Circuits.—If we consider the case where a stabilized a.c. source is supplying a constant load, a quite simple stabilizing device can be designed (see Fig. 1). The barretter B is inserted in series with the primary of the step-up transformer T, and this stabilizes the current drawn from

Fig. 2. Circuit of thermistor stabilizer and current/voltage relationships in the branch Z.



(a)



(b)

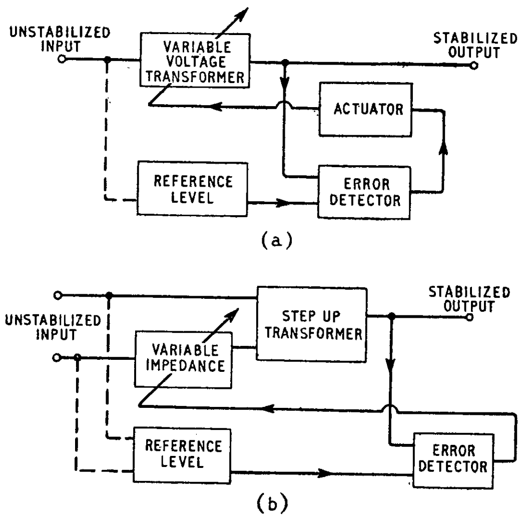


Fig. 3. General block diagrams of complex stabilizers.

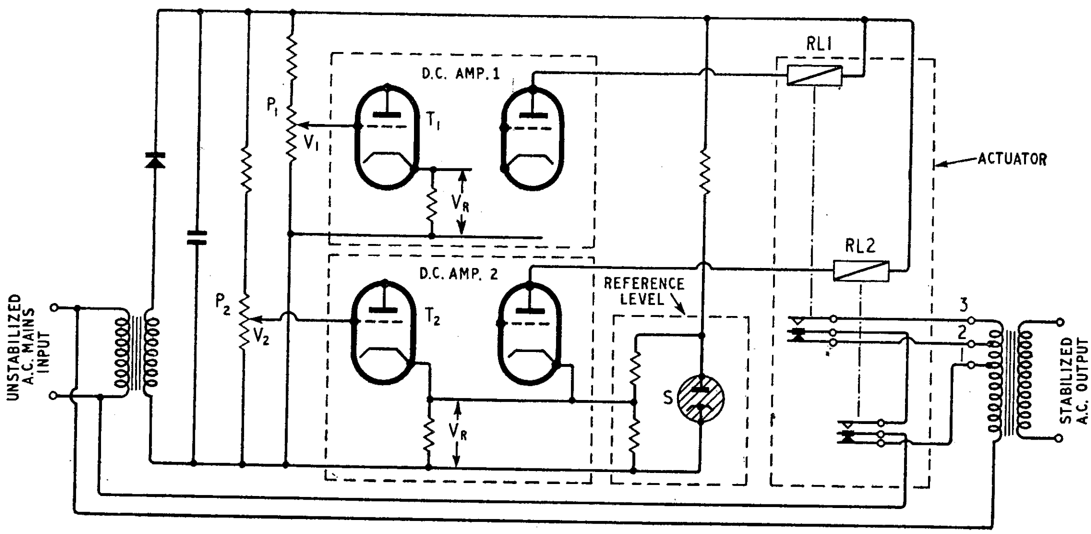


Fig. 4. Stabilization in steps using relays and tapped transformer.

the mains. With a constant load, the primary and secondary voltages will then be stabilized, and any voltage variations will occur across the barretter.

This method works quite successfully providing that the power required is not too large and, as previously stated, that the loading conditions are constant. The maximum available stabilized power can be calculated as follows. Assuming that, for instance, a barretter type 301 (G.E.C.) is employed, the required voltage drop across the latter would be about 100 volts, and the rated current 0.3 amps. Hence there would be about 120V (assuming 220-V mains) on the primary of the transformer, and the power delivered to the load would be given by

Power $= 120 \times 0.3 \times$ efficiency of T $\approx 120 \times 0.3 \times 0.8 = 29$ watts.

The transformer in such a circuit should have a step up ratio of about 1 : 2. Furthermore, the primary winding should be calculated for the actual barretter current, otherwise it is necessary to shunt the primary by a resistor R to secure a sufficiently high current through the barretter. In certain applications such a resistor R can be made variable (possibly in steps) to allow for varying loading conditions. It is obvious that, if the load is taken off, the shunting current in R must be made larger to maintain a constant voltage across the primary; so that R has to be set to its minimum value. Conversely with increasing loads, R has to be set to a higher value.

Another simple stabilizing system is the saturated core mains transformer. Even with only a small load on the secondary, the magnetic flux reaches saturation when the a.c. current approaches its maximum, and the output waveform is flattened. With increased loads, the waveform approaches a square wave shape, and consequently the output is rich in odd harmonics; though its r.m.s. value remains practically constant. As stated previously, if a better waveform is required, a filter can be provided. Even so this system still has the disadvantage of the heat developed in the saturated transformer, which resutls in a rather low efficiency, an important factor if large powers are required.

Fig. 2 (a) shows the use of a thermistor as a non-linear device for stabilizing a low a.c. voltage. An impedance Z connected across the load, consists of an ordinary resistor R and a thermistor S connected in series.

In Fig. 2(b) the voltage/current characteristic of a thermistor type CZ_1 (S.T.C.) is shown. The straight line on this graph represents the voltage/current characteristic of the resistor R. The third curve (dotted line) gives the resulting characteristic of the compound impedance Z. It can be seen from this curve that, by choosing a suitable value for R, the " dynamic resistance " at a point such as X on the impedance Z curve can be made very small.

The stabilizing action of the circuit in Fig. 2(a) then follows, assuming that for an average mains voltage of say 220V the stabilized output voltage corresponds to the point X on the impedance Z curve. Any tendency of the output voltage to vary is nullified by large current changes in Z (due to its low "dynamic resistance") acting through the resistance Ra in series with the load.

The thermistor CZ_1 combined with a resistor R of 69 ohms will deliver only 25V stabilized a.c. If a normal stabilized a.c. mains supply is required (say 225V) 9 thermistor CZ_1's and a 620-ohm resistor could be connected in series.

Stabilizing action of this sort is very similar to that of reference tubes in d.c. circuits and gives good results, particularly when only low powers are needed.

Complex Stabilizing Systems.—Fig. 3 represents the basic functional diagrams of two more complex systems. In both of these circuits a reference level and the stabilized output feed the error detector. In the system of Fig. 3(a), the error detector output varies the stabilized output voltage through the variable voltage transformer by mechanical means. In Fig. 3(b) the output voltage is altered using a variable impedance (inserted in series with the primary of the step-up transformer) which is controlled by the error detector output purely by electrical means (no moving parts). The reference level device (voltage or current) is usually fed from the a.c. input. However, this is not essential, and in certain cases a dry battery might be employed; and therefore in Figs. 3 connections between the a.c. input and the reference level block are shown by dotted lines.

The "actuator" in Fig. 3(a) could be either a servomotor (including relays energized from the error detector) driving the variable voltage transformer continuously, or two (or more) relay systems switching different tappings on the mains transformer. Obviously, this second system can only regulate in steps. A more detailed treatment of such a circuit is given below.

Stabilizing Systems using Moving Parts.—Fig. 4 represents a stabilizing circuit employing two driving relays, RL1 and RL2. The reference voltage V_R derived from the d.c. reference tube S is connected in opposition with V_1, a fraction of the unstabilized a.c. voltage (obtained from the potentiometer P_1), in the grid circuit of the first valve T_1 of the d.c. amplifier No. 1. Similarly, in the grid circuit of the input valve T_2 of the second d.c. amplifier voltages V_R and V_2 are connected in opposition. Potentiometers P_1 and P_2 are adjusted so that V_1 is slightly greater than V_2, and, for mains voltages below 220V, both first valves T_1 and T_2 do not conduct ($V_R > V_1 > V_2$), and thus both the output relays RL1 and RL2 are energized.

As can be seen from the circuit, two sets of contacts on RL1 and RL2 are connected so that when both relays are energized, the mains lead is connected to tap No. 1 on the output transformer. For mains voltages between 220 and 240V, valve T_1 starts conducting, RL1 is de-energized and the mains are switched over to tap No. 2. Finally, for mains voltages higher than 240V, both T_1 and T_2 are conducting, both relays are off, and the mains are connected to tap No. 3. This method of mains stabilization, though rather crude, secures a mains voltage stable within limits of ± 5%, providing that the input voltage does not fall below 200V or rise higher than 260V. The d.c. amplifier used in this system could be similar to that described by the author in the September 1956 issue of *Wireless World* (p.441).

Figs. 5 and 6 show two circuits of stabilizers also belonging to the group of Fig. 3(a). In Fig. 5 the reference voltage is V_o (d.c.) obtained by rectification of the a.c. supply from the transformer T which has a barretter B in series with its primary. The d.c. voltage V is of the same order as V_o and connected in opposition with it. Consequently, with V_o equal to say 400V, and V_s for a mains voltage of 220V also equal to 400V, the potential across

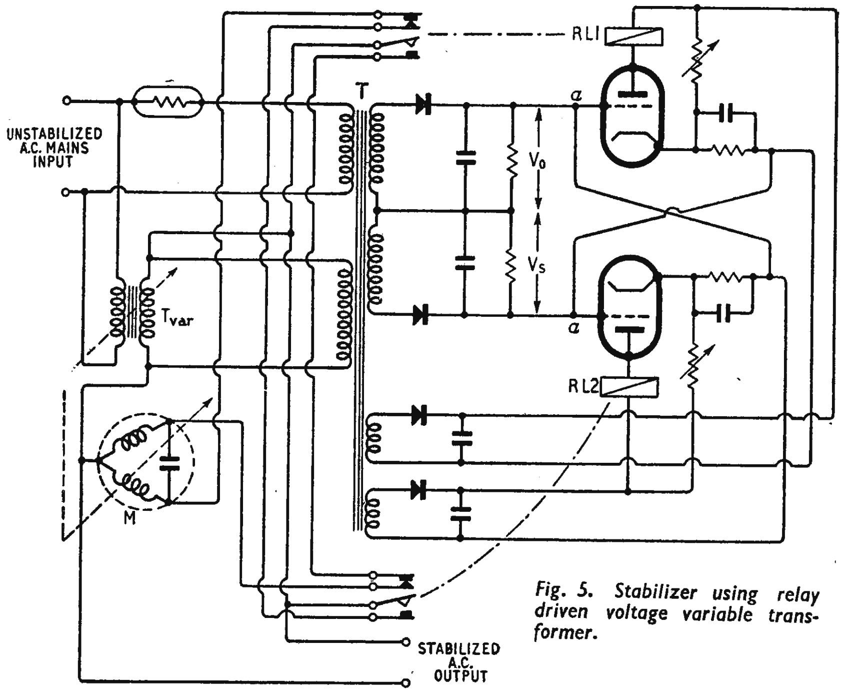


Fig. 5. Stabilizer using relay driven voltage variable transformer.

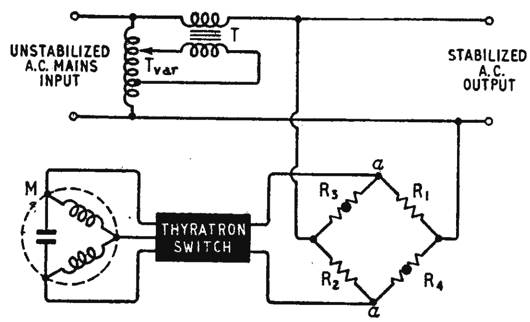


Fig. 6. Stabilizer using thyratron switched voltage variable transformer.

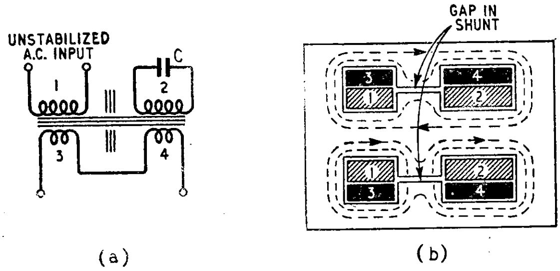


Fig. 7. "Sola" saturated transformer stabilizer.

$a-a$ is zero and valves T_1 and T_2 are balanced. The relays RL1, RL2 are just about to trip, as the initial bias for each valve is set slightly above cut-off. If the mains voltage now changes, a d.c. voltage appears across $a-a$ and, according to its sign increases the anode current in one of the valves and completely cuts off the other. This causes one relay to close its contacts and to switch on the induction motor M, which drives the voltage variable transformer T_{var} until V_s is restored to the value V_o. The relay then opens, and M is switched off.

The most important feature of this system is that, by boosting the voltages V_o, V_s (up to several hundred volts d.c.), it is possible to improve the sensitivity quite considerably, without using a two-stage d.c. amplifier. A certain amount of inconvenience is experienced with the h.t. supplies for the two valves as these have to be completely separate, as is shown in Fig. 5.

Thyratron Circuits.—Instead of a d.c. amplifier, thyratron circuits sensitive to the phase of an a.c. signal are sometimes employed. Fig. 6 shows a basic circuit of this type. Two ordinary resistors R_1 and R_2 and two thermistors R_3 and R_4 form a bridge. When the output voltage alters, owing to the non-linear voltage/current characteristics of the thermistors R_3 and R_4, an error a.c. voltage appears across the diagonal $a-a$. This voltage is proportional to the mains voltage variation, and its phase obviously changes when the error sign changes. A tapping on the voltage variable transformer T_{var} (driven by a reversible induction motor M actuated by relays in the thyratron switching circuit) supplies an auxiliary transformer T connected in series with the mains, and corrects the final output to the required constant level.

Stabilizing Systems with no Moving Parts.—The block diagram of Fig. 3(b) gives the most general representation of such systems. Its basic principle has already been mentioned, and as varying an inductance through its degree of saturation is the most efficient way of changing a series impedance such systems are usually the best. Very many circuits of this type have been developed, some of them similar to the previously mentioned simple saturated transformer.

For instance, Fig. 7(a) represents the circuit of a magnetic stabilizer made by the American firm Sola. Here the secondary winding No. 2 resonates with a condenser C. The core of the transformer contains a magnetic shunt with a special gap (as shown in Fig. 7(b)), and works close to saturation with a normal transformer load. Under these conditions the voltage across winding No. 2 reaches a high value at resonance. As the flux in the core approaches the saturation point, flux lines linking the primary winding with the secondary tend to be diverted through the gap, thus decreasing the effective transformer voltage ratio—see lower part of core in Fig. 7(b). Thus an increase in the primary voltage raises the secondary voltage only very slightly. The final stabilized output could be taken from winding No. 4 (windings 2 and 4 are in fact a step-down transformer). Winding No. 3 comprises a few compensating turns connected in the opposite way to those on No. 4, thus finally reducing voltage fluctuations across the output terminals to zero; or even making the output characteristic slightly negative, i.e. causing a decrease of output voltage with increasing mains input.

Fig. 8 illustrates another American stabilizing system comprising two reactors in series, one of which is bypassed by a condenser, which in this case does not resonate. Stabilization is produced by interaction between the non-linear characteristics of reactor R_2 and the linear characteristic of the condenser C (8b), and the consequent changing phases in the circuit. Considering the voltage/current curves in Fig. 8(b) it can be seen that, if the mains voltage drops from E_{02} to E_{01}, and causes a voltage drop across R_2 and C from V_2 to V_1, then the current delivered to R_2 and C becomes more leading as it flows more through the condenser C. As a result, the voltage on the primary of R_1 actually increases from V_{p2} to V_{p1} (see vector diagram Fig. 8(c)). With suitable choice of components, the output voltage E_2 or E_1 which is the sum of V_2 or V_1 and the corresponding secondary voltage V_{s2} or V_{s1} on

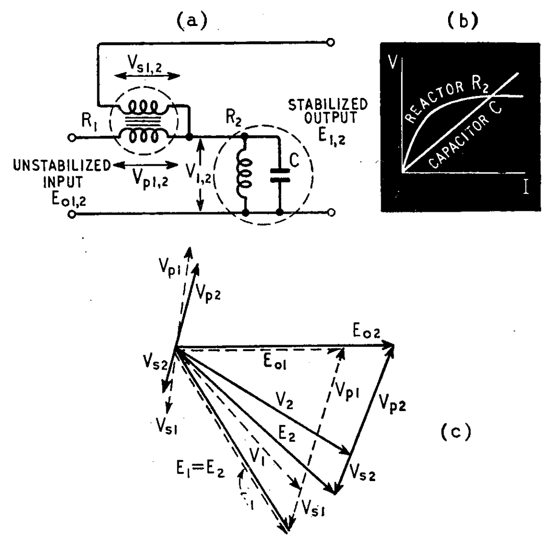


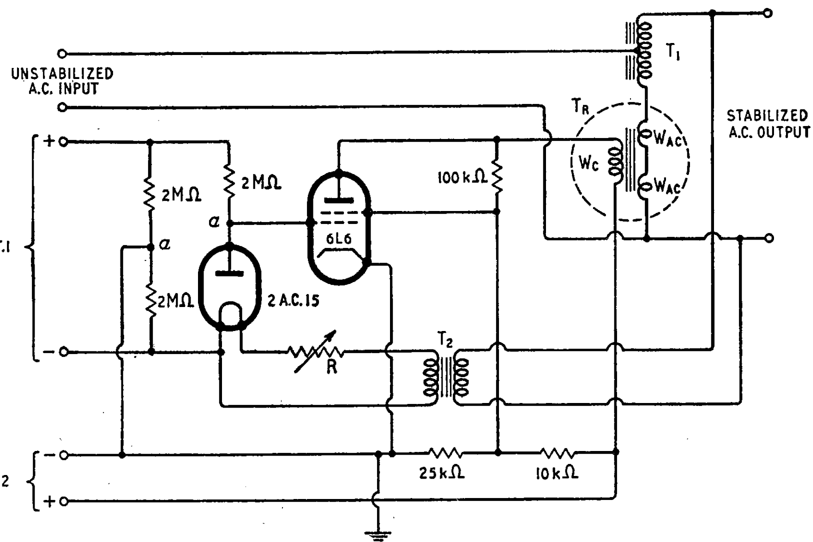
Fig. 8. Stabilization by vector interaction between non-linear reactor and condenser.

transformer R_1 will remain constant, as shown in the vector diagram.

Electronically Controlled Saturable Reactor.—An example of a mains voltage stabilizer using a saturable reactor controlled by an electronic valve is shown in Fig. 9. The auto-transformer T_1 has a series connected variable inductance W_{AC}/W_{AC} forming the a.c. winding of the transductor T_R. The inductance of the windings W_{AC}/W_{AC} can be controlled by varying the anode current of the 6L6 valve, which flows through the winding W_c. Three

(*Continued on page* 495)

Fig. 9. Stabilizer using saturable reactor controlled by valve anode current.



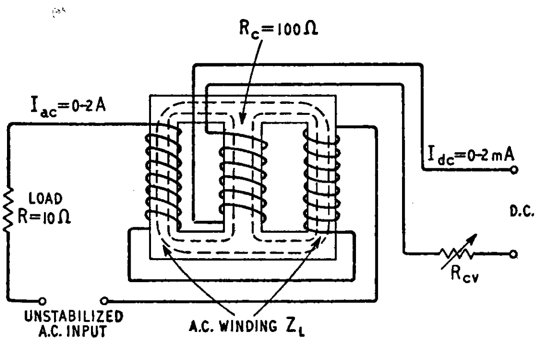
2MΩ resistors and the anode resistance of the 2AC15 diode are connected in a bridge (supplied by H.T.1). In a state of balance, i.e. when the output voltage has the required value V_2, the anode resistance of the 2AC15 is 2MΩ so that no voltage appears across the diagonal *a—a*, and consequently the grid voltage of the 6L6 is zero. Now, if the output voltage V_2 rises, the heater of the diode (which is fed by a transformer T_2 from this voltage) increases its emission, and the diode's resistance falls. The bridge then becomes unbalanced, and the grid of the 6L6 is driven negative. This reduces the current in W_c, and the inductance of W_{AC}/W_{AC} increases. As a result, the auto-transformer step-up ratio decreases and the output voltage remains almost unchanged. A similar action, but of course in the opposite sense, happens with a decrease in mains voltage.

This type of stabilization is quite rapid, as the delay with properly designed components is only of the order of 50 to 100 msec. The variable resistor R in the heater circuit of the 2AC15 is for obtaining different output voltages if required.

The Magnetic Amplifier.—The basic difference between a voltage stabilizer using the anode current of an electronic valve as a variable inductance controller, as just described, and systems using magnetic amplifiers, lies in the replacement of the electronic d.c. amplifier by a magnetic amplifier. The chief advantages obtained are the very high power gains possible (up to 10^6), greater robustness and other advantages due to the absence of valves, and high efficiency.

Fig. 10 represents the basic circuit for the magnetic amplifier. The impedance of the a.c. winding Z_L is high for zero (or very small) d.c. currents in the control winding (resistance R_C). The unstabilized

Fig. 10. Elements of a magnetic amplifier.



a.c. input and the output load R are connected in series with Z_L.

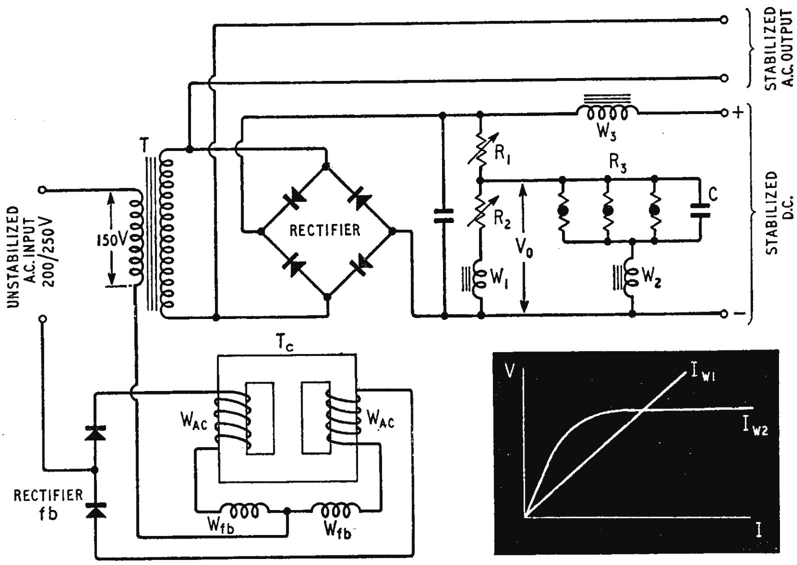
Assuming that the initial conditions are with no d.c. current in the control winding (R_{cv} open circuit) the initial output power in the load R will be rather low ($R << Z_L$). Now even a small d.c. current I_{dc} in R_c will cause a sudden drop in the value of Z_L by saturating the transductor core (flux lines shown dashed). The current I_{ac} through the load R is thus increased much more than the d.c. control current I_{dc}.

By using a high-permeability, square B/H curve magnetic core a few milliamperes change in I_{dc} can cause a change of up to several amps in I_{ac}. Assuming that the control winding has a d.c. resistance of say 100 ohms and the incremental control current is say 2 mA, the control power will be equal to 400 μW. This power could cause a change in a.c. current of 2 amps with an a.c. winding resistance of say 10 ohms, the a.c. power in R then equalling 40 W. Thus the power gain in this case would be 10^5.

If the a.c. power delivered to the load is rectified a high-gain d.c. amplifier can be obtained with this circuit.

Circuits Using Magnetic Amplifiers.—Fig. 11 shows the full circuit of a mains stabilizer using a magnetic amplifier.* The secondary voltage of the step-up transformer T is rectified, and the d.c. voltage fed into the error detector network formed by R_1, R_2, R_3 and C and the two control windings W_1 and W_2 (wound on the middle leg of the transductor core T_c). The essential feature of this network is that currents in W_1 and W_2 (which have the same number of turns) are arranged to act in opposition; and an increase in the current in W_2 decreases the flux in the core T_c. In a state of balance R_2 and R_3 are equal, so that the currents in W_1 and W_2 are equal. Consequently, there is no control flux in the transductor core, and the inductance of the a.c. winding is maintained fairly high. The word "fairly" is used as there is an additional feedback winding W_{fb} (also located on the central leg of the transductor core) which has some polarizing d.c. current derived

*See "Proceedings of the National Electronic Conference," (Chicago) Vol. 6, Sept., 1950, p. 45.



(a) (b)

Fig. 11. Stabilizer using a magnetic amplifier.

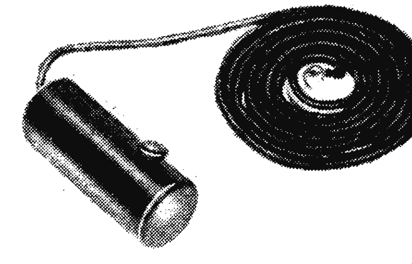
from the rectifiers fb. The result is that, even without a control flux from W_1 and W_2, the a.c. voltage drop across W_{AC}/W_{AC} is not very large, thus maintaining the required voltage on the primary of T (say 150 V). The second important feature of the error detector is that while R_1 and R_2 are linear, resistors R_3 are non-linear (thermistors).

Fig. 11(b) shows the d.c. currents in W_1 and W_2, I_{w1} and I_{w2} respectively, as a function of V_0 and thus of the stabilized voltage. It is obvious that even a small increase in V_0 would cause a much larger increase in the current in W_2 than that in W_1 (owing to the thermistors in series with W_2). Thus, as in a magnetic amplifier, the impedance of W_{AC}/W_{AC} would suddenly rise owing to the decrease in the saturation in the transductor core. As a result, the voltage drop across the primary of T would show only a very small increase, thus maintaining the a.c. output almost constant. A similar but opposite action compensates for a decreasing mains voltage.

The winding W_3 is a small compensating d.c. winding on the central leg of T_c to prevent fluctuations in the output voltage due to a varying load. In this way the stabilizing action is speeded up, as in this case the transductor is controlled not by the network W_1, W_2, R_1, R_2 and R_3 (which would give a slight delay due to the slowly changing voltage on condenser C), but directly by changing the current in W_3.

Historic Hearing Aid

The original bone conduction instrument made by C.M.R. Balbi in 1919 while engaged on development work for S. G. Brown has recently been presented to the Science Museum. This was the prototype of the Brown "Ossiphone" which was used in the Marconi "Otophone," believed to be the world's first commercial valve hearing aid. Mr. Balbi who has spent a lifetime in research into the problems of hearing is now living in South Africa where he has been working on direct stimulation of the auditory nervous system.



Commercial Literature

Television Aerials, for Bands I and III, v.h.f. aerials for Band II, and various accessories. A comprehensive illustrated catalogue of all types made by Aerialite, Hargreaves Works, Congleton, Cheshire.

Variacs (continuously adjustable mains auto-transformers). The complete range of types, with load ratings from 0.58 kVA to 7 kVA and input voltages of 115V and 230V, is given in an illustrated catalogue from Claude Lyons, Valley Works, Hoddesdon, Herts. Also included are Variacs with motor drive, ganged assemblies, portable types with carrying handles and types for permanent fixing to walls or benches.

Signal Strength Meter for television frequencies, with three ranges directly calibrated in microvolts and a decibel scale for comparison purposes. Has a self-contained stabilized power supply and a thermistor temperature compensation system. Leaflet from Radio-Aid, 22, Market Street, Watford, Herts.

Switches and Signal Lamps, a catalogue including new miniature toggle switches for 250V, 10A a.c. with a light snap action similar to that of microswitches. From Arcolectric (Switches), Central Avenue, West Molesey, Surrey.

Electrolytic Capacitor Bridge, for measuring capacitance between 0.1μF and 11,000μF. A continuously variable polarizing voltage supply of 0-600V is incorporated. Meters indicate direct-reading capacitance, polarizing voltage, leakage current and bridge balance. Power factor is read from dials. Specification on a leaflet from British Physical Laboratories, Radlett, Herts.

THE GYRATOR

By THOMAS RODDAM

2. A Modern Microwave Device with a Classical Physical Ancestry

IN the first part of this article on the gyrator I adopted a quasi-historical approach and dealt with the way we thought about this problem in the rather short period 1944-46. The previous article showed that a rather abstract concept, a two-terminal pair "black box," could have impedance equation in which the transimpedances Z_{12} and Z_{21} were not equal, but satisfied the equation $Z_{12} = -Z_{21}$.

A device of this sort is passive, linear and constant, but it is not reciprocal. Combined with a reciprocal network it can produce a system which transmits freely in one direction and not at all in the other. This last property is the one which really made people sit up. As you know, one of the great problems of microwave radar systems was the need to use the same aerial for transmitting and receiving. This involves putting the enormous transmitting power, kilowatts or even megawatts, into the feeder or waveguide system which must also include the receiver mixer crystal. The literature is extensive and designs of TR boxes, anti-TR boxes and I don't know what abound. Non-linearity was the key to their design: the transmitted pulse ionized the gas in a special sort of valve and thus switched in some protection for the receiver. But this would only work with pulses and wasn't really too good at that. A completely linear and passive device, with no gas to get absorbed, offered tremendous advantages.

The first thing that any young beginner should do when he has some completely new idea, especially if it is in the field of wave propagation, is turn to the collected papers of Lord Rayleigh. In 1901* Lord Rayleigh described an optical one-way transmission system based on the Faraday effect. We must look back down the arches of the years to our school physics and see if we can recall what we learnt then about polarized light. As a digression, I can't let this opportunity go by without pointing out how important it is that technical education should be broad based rather than devoted to what some people call practical matters. Here we are on a microwave problem, and the basic theory is made up of two parts, why your bicycle stays upright (gyroscopic forces) and what you would see if you wore sun glasses to visit Elsie, Lacie and Tillie, the three sisters in *Alice in Wonderland* who lived in a treacle well in the Dormouse's story (polarized light). The sisters, as it happened, drew everything that begins with an M—such as memory and muchness. Had Lewis Carroll lived in this era he might well have added microwave devices.

Let us return to our polarized light. As you remember, if you pass ordinary light through a sheet of Polaroid it is sorted out and only the radiation of one polarization is allowed to pass. The usual picture shows a man shaking a clothes line vigorously in circles, a grating through which the line passes and a nice clean, parallel-to-the-grating wave going off beyond the grating. Before Polaroid was invented a device called a Nicol prism was used. This was a special arrangement of two bi-refringent crystals stuck together in such a way that for one polarization the light just got through the join while for the other it was totally reflected to one side.

Having polarized our light, we now look at it through a second piece of Polaroid and we find that when the axes are parallel the light passes through, but if the axes are at right angles most of the light is stopped. This is the background to the use of polarized glasses for snow and seaside sun glare. When electromagnetic waves (light or radio) are reflected from a plane surface there is one particular angle, the Brewster angle, at which almost all the reflected electromagnetic radiation is of one polarity, and at other angles there is quite a lot more of one than t'other. Polarized sun glasses absorb most of the reflected light and get rid of the glare.

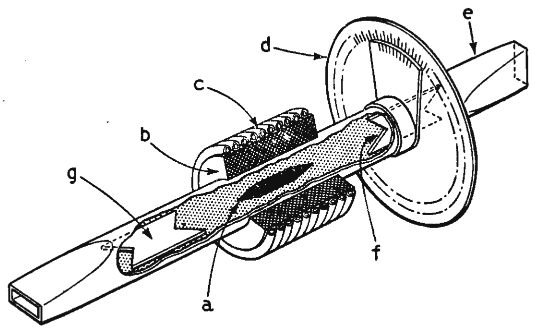


Fig. 1. Experimental arrangement for measuring Faraday rotation. (a) ferrite specimen, (b) winding, (c) cooling coils, (d) stationary protractor, (e) rotatable waveguide section, (f) radial vane to absorb vertically polarized waves, (g) radial vane to absorb horizontally polarized waves.

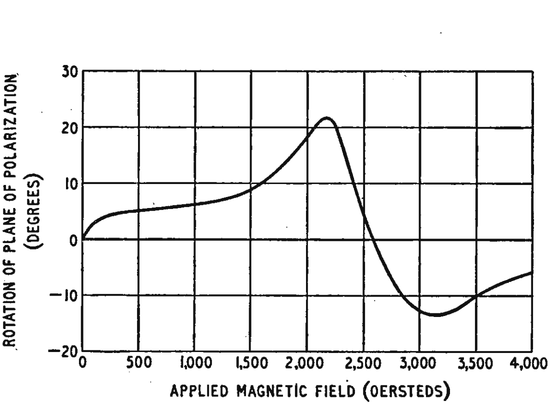


Fig. 2. Faraday rotation in a cylindrical specimen of ferrite. Frequency 8950Mc/s.

**Nature,* Vol. 64, page 577.

But to return to our optical bench. We have a light at one end, a polarizer next to it and then, a bit further down, another polarizer and an eyepiece. Usually we put in some lenses, too, so that we have a clean source of parallel light, but these we can regard as frills. The first stage of the experiment is to turn one polarizer until the light reaching the eyepiece is a minimum: the polarizers are now said to be crossed. Now we put between the polarizers a tube filled with a solution of dextrose, which is a sort of sugar, and we find that light is streaming through the eyepiece. To get darkness again we must turn our viewing polarizer. Dextrose, therefore, rotates the plane of polarization and indeed owes its name to the fact that it produces a right-hand rotation. Now obviously a cylinder of liquid will have much the same properties whichever way we look through it and we find, if we care to test it, that our dextrose solution produces a right-hand rotation whether light travels from east to west or west to east. If we reflect the polarized light back, therefore, it will swing back to the original plane of polarization.

The next experiment is to turn out the dextrose, fill the tube with nitrobenzene and wind a solenoid round the tube. When a current flows through the solenoid the plane of polarization is rotated, but if we reverse the current, and thus reverse the magnetic field, the rotation of plane of polarization is in the opposite direction. I imagine that we should all have expected this because if a field H produces an effect θ, a field $-$H will probably produce $-\theta$. Here, of course, I am relying on intuition to tell me that the whole operation is a linear one, but it seems a reasonable expectation, even if you haven't, as I have, checked it. This magnetically controlled rotation of the plane of polarization is called the Faraday effect, and it was discovered by Faraday in 1845.

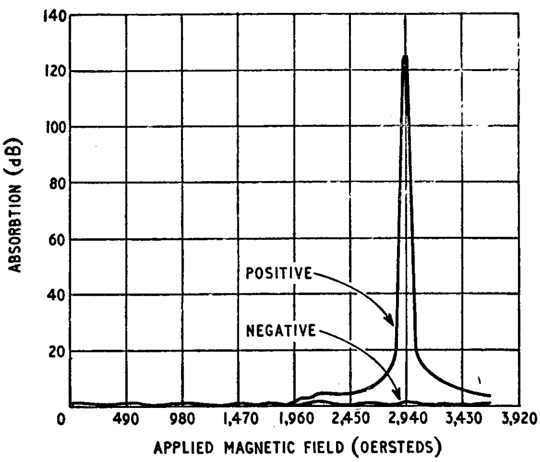


Fig. 3. Selective absorption of the positive and negative circularly polarized components of microwaves (9455Mc/s) with variation in the magnetic field.

In a system showing the Faraday effect a traverse from north to south will produce a rotation of θ°, but a traverse from south to north will produce a rotation of $-\theta^\circ$. A normal polarization rotator will produce a rotation of θ° whichever way the light is going.

Any reader who has turned up the reference to Lord Rayleigh's one-way system and has not started immediately on the construction of a one-way telescope for use at the seaside is invited to look now at Fig. 1 (based on Fig. 17 of "The Elements of Nonreciprocal Microwave Devices," by C. Lester Hogan, *Proc. I.R.E.*, Vol. 44, pp. 1345-1368, Oct., 1956). Here we have most of the optical bench of Fig. 2, apart from the side arms, but now it is something rather nearer home, a microwave guide system. A small cylinder of ferrite with coned-off

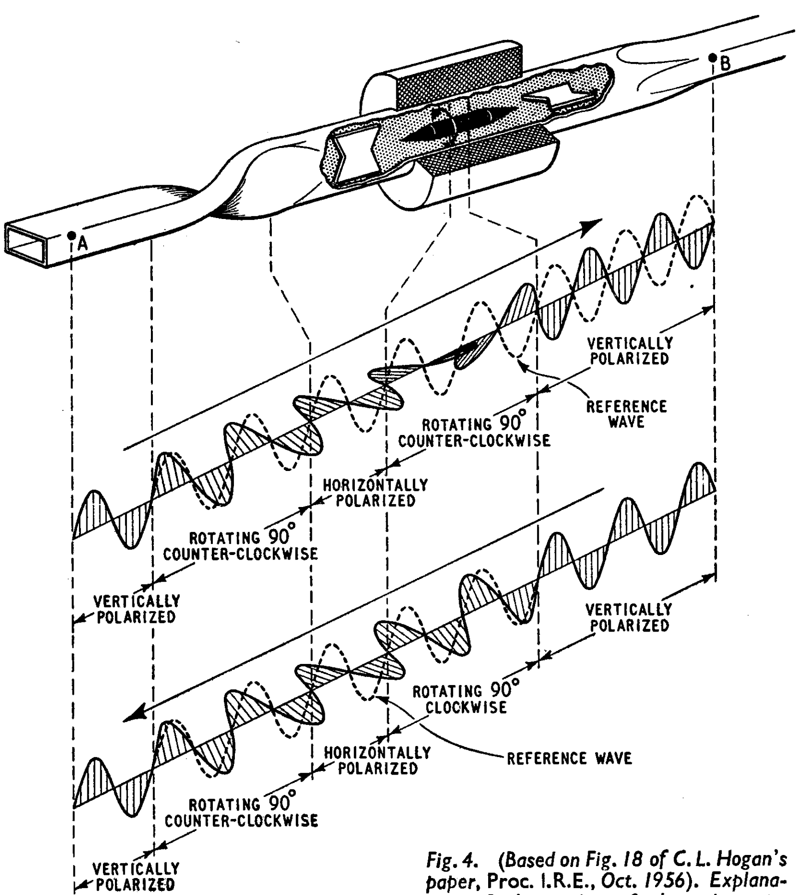


Fig. 4. (Based on Fig. 18 of C. L. Hogan's paper, Proc. I.R.E., *Oct. 1956). Explanation of the action of the microwave gyrator.*

ends to reduce reflections produces the Faraday effect and Figs. 2 and 3 (based on Figs. 15, 16, loc. cit.) show the amount of rotation and the cost in attenuation. These curves are for different sample sizes of different materials. In weak fields there is a fair amount of rotation for very little loss. It, therefore, becomes possible to make up devices similar to that shown in Fig. 2, but, of course, using ferrites and operating at, say, 9,000 Mc/s.

A typical system is that shown in Fig. 4 (Fig. 18, loc. cit.) and I don't think I can do better than quote Mr. Hogan's own words:

"The anti-reciprocal property of the Faraday effect affords a means of realizing a microwave circuit element which is analogous to Tellegen's gyrator. Such a gyrator is illustrated (in Fig. 6) along with diagrams which help explain its action. Beneath the gyrator are construction lines which indicate the plane of polarization of a wave as it travels through the gyrator in either direction. On each diagram is a dotted sine wave for reference only which indicates the constant plane of polarization of an unrotated wave. It is noticed that for propagation from left to right, the screw rotation introduced by the twisted rectangular guide adds to the 90° rotation given to the wave by the ferrite element making a total rotation of 180°. For a wave travelling in the reverse direction these two rotations cancel each other, producing a net zero rotation through the complete element. The unique property of the Faraday rotation becomes immediately apparent from this diagram. In the case of the rotation induced by the twisted rectangular guide, the wave rotates in one direction in going from left to right through the twisted section, and rotates in the opposite direction when it traverses the section from right to left. For the case of the rotation induced by the ferrite element, the direction of rotation is (the same) for either direction of propagation. The important characteristic of the element is the time phase relation between two points such as *A* and *B* in the upper diagram. It is seen with the help of the diagrams illustrating the rotating waves that the

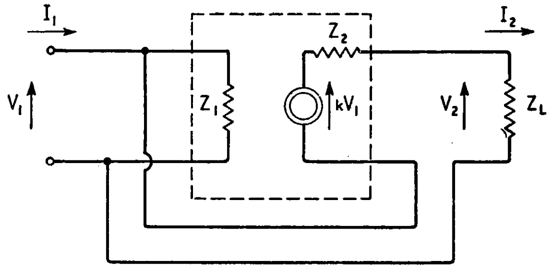


Fig. 5. An amplifier with feedback which can be designed to give impedance inversion. This is the first stage of equivalent gyrator design.

field variations are in phase at points *A* and *B* for propagation from left to right and they are 180° out of phase for propagation from right to left. In other words, the transmission line is an integral number of wavelengths long between *A* and *B* for propagation from left to right and is an odd integral number of half-wavelengths long for propagation from right to left.

"If the rectangular wave guides on each side of the ferrite are rotated about their common axis so as to make an angle of 45° with each other, then a one-way transmission system can be created which is similar to Lord Rayleigh's one-way transmission system of optics. This one-way transmission system can be used, for example, to isolate the generator or detector from the wave guide in microwave systems. In this application it has the great advantage over the attenuators which are presently used for this purpose in that it can be made practically lossless for the direction of propagation which is desired but the reflected wave will be completely absorbed and hence more complete isolation can be effected."

I do not think it would be very profitable to try to explain in words just why ferrites have this particular property. Essentially, however, the reason is that the waves travelling in the ferrite are coupled to the myriads of tiny gyroscopes, the electrons. Small as an

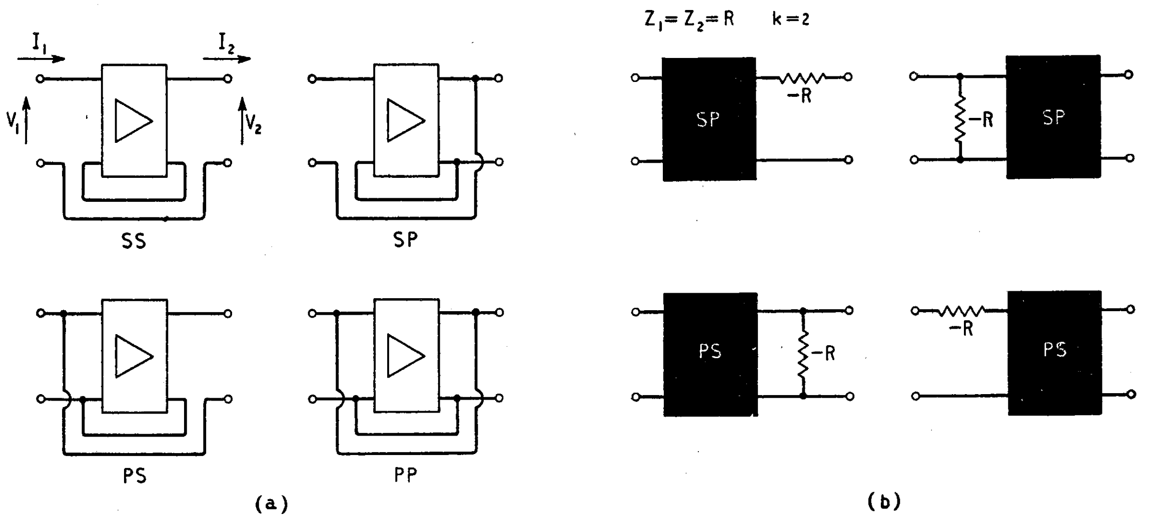


Fig. 6. (a) The four connections of feedback round the amplifier of Fig. 5 (S = series, P = parallel). Putting one of these complete units into circuit we have the four possible gyrator circuits shown at (b).

electron is, it is spinning about a central axis. In a magnetic field the electron axis precesses round the field axis and also pulls in towards it. Now there is a rather odd thing about systems which are kept stable by gyroscopic forces: a little friction may make them unstable. I think it is possible to find examples of this when bicycling. In any event, the direction of the magnetic field due to the signal has a very important effect on the electronic gyroscopes. Remember that the gyro axis is nearly along the axis of the steady magnetic field and that this is the direction of propagation. The signal field is linear, in a plane at right angles to this axis, but it can be split into two circularly polarized components in this plane, one clockwise and one anticlockwise. These two components interact quite differently with the electron and are, in simple language, shifted in phase relative to each other. Combining them again, this phase shift appears as a rotation of the polarization.

The fuller development of devices based on the ferrite gyrator involves much more microwave theory and practice than is appropriate to these columns. Indeed, having passed from "black box" to gyroscope to practical systems using sub-atomic gyroscopes, let us go on, or back, to some more "black boxes."

The circuit we shall consider is that shown in Fig. 5. The dotted box contains an amplifier with input impedance Z_1, output impedance Z_2 and gain k times. A feedback loop is shown, together with a load Z_L.

The input current is obvious given by:

$$I_1 = V_1/Z_1 + I_2 = V_1/Z_1 + (1+k)V_1/(Z_2 + Z_L)$$

and the output current

$$I_2 = V_2/Z_L$$

The input impedance is given by V_1/I_1 and is

$$\frac{Z_1(Z_2+Z_L)}{Z_2+Z_L+Z_1(1+k)}$$

We can make k anything we please, within reason. In particular, let us make $k+1 = -Z_2/Z_1$, which means k must be negative. An odd number of valve stages will do this. Also, let Z_L be small compared with Z_2 so that $(Z_2+Z_L) \approx Z_2$. The input impedance then becomes

$$\frac{Z_1 Z_2}{Z_L}$$

This means that if $Z_1 Z_2 = S^2$, the input impedance S^2/Z_L, is just the inverted form we met with the basic gyrator "black box." It looks, therefore, as though we are offered the possibility of making a gyrator with the aid of valves or transistors.

I must confess that I am not very certain whether there is any point in producing a gyrator system using valves and am almost as doubtful about the value of transistorized gyrators. I do not, therefore, propose to go further with the analysis which shows that a special case of the impedance inverter combined with a negative resistance (another valve), will produce a gyrator. The configurations are summarized in Fig. 6. These circuits are analysed by Bogert*, who gives the conditions required for what we might call "gyration."

It is very difficult at this stage to assess the overall future of the gyrator. We must, at the moment, look at it as a triad of almost completely detached character. The microwave Faraday effect devices are already with us. They will undoubtedly stay with us for some time, growing first of all more complex and then, later, more simple. The purely artificial, contrived gyrator is a less certain bet. It is possible, for example, to sketch out a circuit for an echo suppressor based on the gyrator, but will it be simpler, cheaper, more reliable than the straightforward circuits now in use? At first sight the answer is no. In any event, the echo-suppressor of the long physical telephone line is a device almost certainly doomed to vanish as the improvements brought about by ferrite cores and transistors make it profitable to operate shorter and shorter circuits as carrier systems. Purely passive gyrators may find a home in colour television transmission systems, if anyone can produce gyrators for the appropriate frequencies. Coloured rings and ghosts are obviously more annoying than the familiar black-and-white variety, and echo suppression can do a lot to reduce them. But can we make gyrators below the kilomegacycle range?

On the theoretical side, the gyrator has got rid of an anomaly and has cleared up our theoretical foundations. Although this may seem rather remote, it is ultimately of benefit to us all if we start off with no skeleton in the cupboard, and these oddities of failure of reciprocity certainly were skeletons in the network theorist's cupboard.

It is a wide traverse, from gyroscopes to electromagnetic-electrostatic couplings, to ferrites, to feedback circuits: all are linked together by a common theoretical concept, a common very simple pair of equations.

* "Some Gyrator and Impedance Inverter Circuits" by B. P. Bogert, *Proc. I.R.E.*, Vol. 43, page 793, July, 1955.

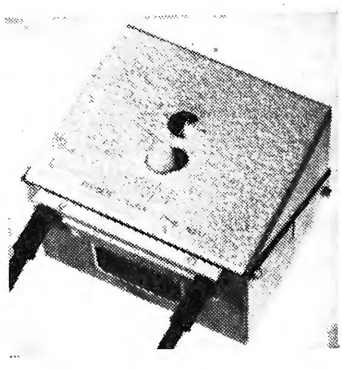
Process Control Timer

TWO ranges of 1 to 10 and 10 to 100 seconds are provided in the new Airmec N237 timer. The "start" signal can be either an open or short circuit, long or short pulse; and resetting is automatic. Two or more timers can be arranged to operate themselves successively, or, by returning the last timer to the first, an indefinitely continuing process is possible.

Scale calibration accuracy is within ±3%, the repetition accuracy being considerably higher. A change of mains input voltage of up to 10% affects the interval time by less than 5%. The full resetting time is roughly 1½ seconds, but a reset time of 1 second causes a timing error of less than 5%.

An alternative model to the one illustrated has a sealed screwdriver slot timing adjustment to prevent tampering.

The maker's address is Airmec, Ltd., High Wycombe, Bucks. The timer costs £14.



Airmec N237 process control timer.

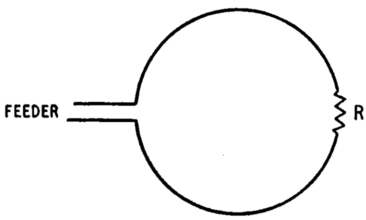
Technical Notebook

"Tandem" Particle Accelerator being made by Metropolitan-Vickers for the Atomic Energy Research Establishment has the novel feature that acceleration is achieved in two stages. Negative hydrogen ions at earth potential, formed in a high-frequency gas discharge, are extracted by preliminary accelerating electrodes, which produce a 6-MeV focused beam of circular cross-section down the centre of a main accelerating tube. Electrons are "stripped" from the negative ions by passing them through an extremely thin foil. This leaves the ions still moving in a forward direction with a net positive charge but with energy almost unchanged. The second stage of acceleration in the main tube is achieved by bringing the positive ions back to earth potential, so that the total energy communicated to them is 12 MeV. In this way the ions are accelerated to an energy twice as great as could be achieved in a single stage, while the insulation problems remain exactly the same as in a single-stage machine. On emerging from the lower end of the accelerating tube, the beam passes through a magnetic field which deflects the ions through a right angle and brings them to a focus on the target being used. Negative ions are more difficult to form than positive ions, so the beam current is smaller in the tandem machine than in a single-stage type, but this is a small price to pay for the saving in insulation.

Lenticular Colour Display for frame sequential colour television systems, performing the same sort of function as a rotating colour filter in front of the c.r. tube, has been devised by E. Allard of the French firm Société Telco. It consists of two identical and parallel lenticular plates with a vibrating colour filter in the focal plane between them. This filter is built up of groups of interlaced red, green and blue primary-colour elements corresponding to the lenticular pattern, and is driven by an electric motor and reciprocating mechanism. The arrangement is such that during the filter's cycle of movement the system transmits, over its whole surface, each of the primary-colour components in turn. The light efficiency is said to be the same as that of a rotating disc, but, of course, the arrangement is more compact. It makes possible flat filters for large c.r. tubes and is particularly suitable for projection purposes.

Arbitrary Waveform Generator described by C. B. House in D.S.I.R. unpublished report PB121157, will produce periodic waveforms in which the magnitude, slope, polarity and points of inflection can be controlled at will by simple resistance or voltage changes. It uses standard magnetic cores, diodes and switching transistors. When incorporated in an analogue computing system, the device will provide output transfer functions which can be adjusted to any desired complexity.

Unidirectional Loop Aerial.—The loop aerial, with its bi-directional figure-of-eight radiation pattern, is a familiar object to radio engineers. It is not generally known, however, that the device can be made unidirectional. This can be done in



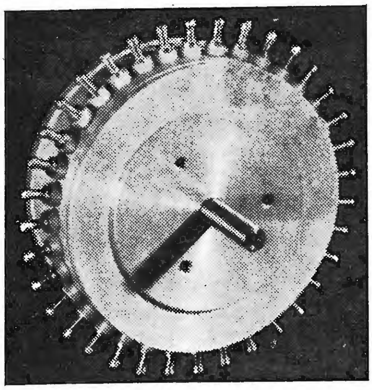
the case of a single-turn circular loop by breaking the conductor opposite the feed point and inserting a suitable terminating resistor, as shown in the sketch. A mathematical analysis and some practical results are given in the September issue of *Electronic and Radio Engineer*. Measurements were made at 110Mc/s on loops with circumferences of $\frac{1}{2}\lambda$ and $\frac{3}{4}\lambda$. Front-to-back ratios in excess of 5 to 1 were obtained using terminating resistors of 400-500 ohms.

Light Velocity Measurement by means of electron multipliers is suggested as a possibility by R. Gerharz in the *Journal of Electronics* for March, 1957. Use would be made of the extremely short ($\approx 10^{-8}$ sec) light pulses found to be emitted as a side effect of the impact of electrons on the magnesium oxide film on the dynodes of electron multipliers. A single pulse could be reconverted to electrical form by means of a photomultiplier, then amplified and used to initiate a new pulse. Thus a succession of pulses could be produced at a repetition frequency determined by the total electronic and optical delay time. The optical path would be via a mirror forming part of an interferometer. By moving this mirror, the length of the optical path, and hence the optical delay time, would be altered, and this would change the pulse repetition frequency. From accurate measurements of this frequency change (about 1.5kc/s), of the original frequency (about 20Mc/s) and of the mirror displacement (using the interferometer) the velocity of light could be determined.

Millimetre Wavelength Measurement by a new method is described in D.S.I.R. unpublished report PB111909 by M. B. Rapport, E. W. Ward and W. W. Balwarz. The method uses an intermediate medium interposed between a source of waves and a receiving aerial to create an interference phenomenon which provides a measure of the free-space wavelength. The results are independent of the aerial patterns and Fresnel zone effects, and are not appreciably affected by the orientation or position of the interposed medium. Results accurate to approximately 1% can be readily obtained.

New Type of "Maser" using gyromagnetic resonance in ferrites has been operated recently by Dr. M. T. Weiss at Bell Telephone Laboratories in the U.S.A. The ferrite sample is placed in a microwave cavity which can resonate at two frequencies (in one case both near 4,500Mc/s). A d.c. magnetic field of the correct strength and direction to cause gyromagnetic resonance at the sum of these frequencies (9,000Mc/s) is applied, and microwave power at this same sum frequency is also fed in As a result of non-linear coupling in the ferrite, and depending on the amount of r.f. power fed in, both amplification and oscillation at the two resonant frequencies (around 4,500Mc/s) can occur. Frequency changing between these two resonant frequencies is also possible.

Non-Linear-Function Pot'meter recently introduced by Salford Electrical Instruments is basically a *linear* potentiometer with its element tapped at 10° intervals and the connections brought out to turret-type terminals spaced around the body. These tappings allow fixed resistors to be shunted across sections of the element so that non-



linear functions can be constructed as desired. The main idea of this design is to avoid the need for the shaped-card type of potentiometers commonly used for producing non-linear functions, which are often difficult to replace when faulty. The new multi-tap potentiometers can be held in stock as standard items aad adapted to particular functions as the need arises.

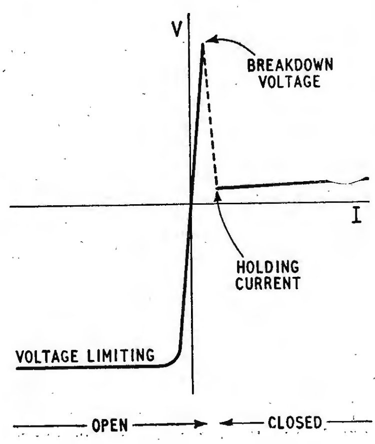
Optical Noise Filter might be a suitable description for an interesting subjective phenomenon mentioned at the recent Paris Colour Television Symposium. A speaker remarked that if television pictures are viewed through a small aperture about the size of a pinhole the noise seems to disappear, and, moreover, there is an apparent improvement in contrast and resolution. Another speaker, commenting on this, suggested that the small aperture might be comparable with a narrow-band filter, and mentioned in passing that the "reality" of television pictures is sometimes heightened by viewing them through a tube.

Inexpensive Digital Plotter for working at medium speeds is described by P. M. Kintner and E. A. White in an unpublished report, PB121056, available from the D.S.I.R. The system is built around a commercially available stencil cutting machine and, actuated by logical circuitry, will plot six points per second on a stencil suitable for reproduction by mimeograph or offset process.

Centimetre - Wave Semiconductor.—A new semiconductor device being tried out experimentally by Raytheon in America is said by *Electronics* for August 1957 to be "leading the way to reliable amplification at frequencies up to 10,000-Mc/s". Known as the "spacistor", it consists of a pellet of semiconductor material with collector and base connections made to opposite ends and with two other intermediate connections called an injector and a modulator. The high-frequency response is obtained by utilizing a high field strength across a reverse-biased junction to accelerate the current carriers so that their transit time is greatly reduced. The transit time is, of course, the thing which mainly determines the alpha cut-off frequency of conventional transistors. In the "spacistor" the injector, modulator and collector are biased positively with respect to the base. The input signal is applied in series with the modulator bias battery, while the output is obtained across a load in series with the collector battery. At low frequencies the power gain is said to be over 70dB. Earlier discussion of the principles appeared in *Proc. I.R.E.* for March 1957.

Soldering Stainless Steel, normally very difficult with conventional soldering fluxes, is facilitated by a new solder paint called Epatam 3311. It is made by Perdeck Solder Products, who claim that it allows stainless steel to be tinned and soldered as easily as copper or bright mild steel. The paint is merely applied straight from the tin, undiluted, and then heated to the normal soldering temperature. If used on brass or copper it can be slightly diluted with water for greater economy. It can also be used to advantage on surfaces with heavy contaminations such as iron welding scales, rust and grease. A pure-tin variety is available as well as the usual 40/60 and 60/40 tin-lead compositions.

Four-Layer Silicon Diode with bi-stable properties, suitable for use in waveform generation, switching and computing circuits, is the first product of the Shockley Semiconductor Laboratory of Beckman Instruments, California, U.S.A. It is a two-terminal device made by diffusion techniques.. The two states are an "open" or non-conducting state of 10-100MΩ and a "closed" or conducting state of 3-30Ω, and switching from one to the other is effected by the voltage applied. If this voltage is made to exceed a certain critical "breakdown" value (see diagram) the diode is switched from the "open" state to the "closed" state, and remains closed provided there is sufficient current to hold it there. If the current is reduced below this "holding" value (see diagram) the diode switches back to the "open" state again. A typical value for the breakdown voltage is 30V, with a current of several hundred micro-amps, while the voltage required to maintain the minimum holding current is about 1-2V. The physical action of the device is complicated, being explained on the basis of an equivalent structure containing two transistors and an avalanche diode. A full exposition, as well as several circuit applications, appeared in the August 1957 issue of *Electronic Industries.*



Travelling-Wave Frequency Multiplication is described by D. J. Bates and E. L. Ginzton in *Proc.I.R.E.* for July, 1957. Two helices in series are used. After "bunching" at the fundamental frequency in the first helix the electron beam enters the second helix. Here the harmonic components of the r.f. current induce fields on the helix. By making this second helix dispersive a particular harmonic may be selectively amplified by adjusting the helix voltage (with respect to the cathode). The experimental tube was designed to multiply frequencies from 0.5 to 1.0 kMc/s to frequencies from 2 to 4 kMc/s, and conversion gains of the order of 10 dB were obtained. The advantages of this method lie in these two factors of wideband operation and good conversion ratio.

Two-way Damping of the resonances in bass reflex loudspeaker enclosures is described by E. de Boer in *Audio Engineering* for July, 1957. The lower "vent" resonance is damped in the usual way by putting acoustically resistive material (such as layers of porous cloth) in the vent. But in addition, the upper "enclosure" resonance is damped by separating the loudspeaker and vent from the main enclosure volume by further resistive material. By thus controlling the resonances in more than one way, greater flexibility in cabinet design should be possible.

Magnetic-Core Delay Cable described in our August issue (p. 398) is actually made by Hackethal of Germany. In this country it can be obtained from the representatives, W. Wykeham and Company, 17-19, Cockspur Street, Trafalgar Square, London, S.W.1, who can deliver bulk supplies or sample uncalibrated lengths of five available types from stock. Columbia Technical Corporation are the representatives in the U.S.A.

Scientific Theories

By "CATHODE RAY"

" . . . the question is not whether they are true or false but whether they help or hinder"

DO you find this "second thought" business rather irritating? I don't mean my own efforts, which must be irritating enough, but the habit of scientists never to leave well alone. Having worked out a nice tidy explanation for something, they ought to be contented, one would think; but what do they do? Just when one has satisfactorily learnt their explanation, they come out with a new one which is far more complicated and probably quite incomprehensible. Worse still, several eminent scientists may invent quite different (but all very complicated and incomprehensible) theories, the only thing they have in common being rejection of the nice tidy common-sense explanation one has taken the trouble to learn.

This deplorable habit was well taken off in J. C. Squire's sequel to Pope's couplet:

Nature and Nature's laws lay hid in night
God said, *Let Newton be!* and all was light.

* * *

It did not last: the Devil, howling *Ho!*
Let Einstein be! restored the status quo.

Can you remember when the transmission of radio and light was explained by the existence of an all-pervading æther? Just as the speed of sound waves through air, water or steel depends on the density and elasticity of the air, etc., so it was quite easy to calculate the density (very small) and elasticity (very great) of the æther. It seems obvious that some sort of medium must exist, even though it must needs be such an odd one as æther; otherwise how could radio power be conveyed from one place to another! It would be as absurd as supposing one man could punch another on the nose without coming anywhere near him. But after further consideration the scientists announced that there was no such thing as æther. As if that were not enough, the definite and understandable light waves turned into something unimaginable, behaving sometimes like waves and sometimes like particles.

The younger students will no doubt wonder why their elders shy at present-day theories, which *may* seem just as straightforward to them as the now discarded ideas did to us. But their time will come.

The less sophisticated may wonder why it is that when an explanation has been found and proved by the test of engineering practice to be right there should be any need to upset everybody by looking for another, especially when it turns out to be far-fetched.

These thoughts ran through my mind while I was contemplating a return to the subject of semiconductors. If the account I gave last summer was all right, why make it more complicated? Well, that story, simple though it was compared with what you will find in many of the books, might have seemed complicated to anyone brought up on the simple picture of conduction as a sort of sap flow through the solid stem of the conductor. But this simple conduction picture fails entirely to account for such things as metal rectifiers.

On a grander scale, Newton's "laws" were satisfactory for a century or two, but the wider range and greater accuracy of modern measurements have shown some discrepancies. That is not to say that they must be scrapped and the newer laws substituted everywhere. It would be a great nuisance always to use a very general and difficult theory when dealing with everyday affairs where a much simpler one is good enough, even though known to be unsound.

While agreeing that it may be expedient to use things known to be wrong, some people perhaps feel slightly conscience-striken about it. They may feel that one ought really to rely always on the truth, or at least what is believed to be the truth or the nearest known approach to it.

Understanding Natural Processes

I don't want to attempt an answer to Pilate's "What is truth?", or get involved in philosophy, metaphysics or religion; this is meant to be a strictly engineering discussion. Einstein (who, contrary to common impression, could talk and write with crystal clearness) said "It is difficult even to attach a precise meaning to the term 'scientific truth'." He also said "When we say we have succeeded in understanding a group of natural processes, we invariably mean that a constructive theory has been found that covers the processes in question." Quite so, you may say, but having found a theory that covers everything why not let it be?

Someone supplied the answer by remarking that while a billion observations in accord with a theory cannot prove it, a single contrary observation is enough to disprove it. So no theory is final. People can only invent theories on the basis of observations they and others made, and nobody will ever have knowledge of every event in nature. Moreover, all the observations are conveyed indirectly to the mind through sense organs and nerves; there is no direct contact with "reality."

I put the word in inverted commas, because it is doubtful what it means. One is apt to draw a distinction between an analogy, such as the old water pump for an e.m.f., and the real thing itself. But is this distinction clear? In a way, aren't all scientific explanations analogies? To explain crystal structure by talking about valency bonds is pure analogy and metaphor; one might almost say poetry. Words like "bonds" convey ideas that may help us to picture crystal structure, and even to predict quite correctly how it will behave in certain circumstances. So do descriptions of electrons being "knocked out" of atoms by "collisions." But calling them electrons instead of tiny billiard balls doesn't really make the thing less metaphorical or more scientific. What is an electron? Just a concept. The word "electron" is shorthand for the continually changing collection of theory designed to fit the increasing collection of experimental evidence. Don't imagine we shall ever be able to say that now we know exactly what an electron is!

You see, it is a relatively simple matter to describe or define something complicated. One can specify a house in terms of bricks, boards, pipes, etc., because it is taken for granted that these are familiar things. If we are asked to say what a brick is, we may describe how it is made by baking a particular kind of clay, and if we are well up in chemistry we might give some formulæ. Asked then to say what the silicon in it is, do we consider the enquiry has gone far enough? Even if we happen to remember that the silicon atom has 14 electrons round a nucleus, we suspect we may be pressed to explain what an electron is, and saying it is (or has) a mass of so much and a negative electric charge of so much doesn't really explain it. Our predicament, sooner or later, is summed up by the rule in logic that it is futile to define the obscure in terms of the more obscure. So we can go on explaining only as long as there is something simpler and more easily understood to fall back on.

A Long Drink

But what *isn't* obscure? Do you *really* understand how the water pump works, in the e.m.f. analogy? How would you explain the process of drinking lemonade through a straw? Some would just say the drinker sucks it up. Another would say he produces a partial vacuum in his mouth, which draws it up. Another, perhaps, that the pressure of the atmosphere pushes it up. But what is the pressure of the atmosphere? It is explained as the result of the bombardment of the surface of the lemonade by countless air molecules continually whizzing about in all directions. But what makes them whizz? Here the discussion begins to get highly involved and can go on for a long time.

Even if we take that as read, however, isn't the bombardment story just another analogy? It sounds plausible because we know that intense bombardment of an unlatched door by snowballs would exert pressure on it, probably enough to push it open. But we have no right to assume that air molecules are like snowballs or any other missiles of which we have experience. They do not behave in the same ways as the larger objects we can see. Scientists may use less crude analogies, but I suspect they are still only analogies, for the reasons we have already considered.

That is not to say that analogies, even our crude ones, are to be despised. (If they were, I might as well give up.) The massive technical progress of this century is due to people who are guided by mental pictures or concepts—of such things as electric currents—that for the most part are probably quite crude and remote from reality. Any resemblance between electrons "bombarding" an anode and bullets hitting a target may be purely coincidental, but in practice it is quite helpful, and in my opinion legitimate so long as it isn't allowed to run away with one's intelligence.

The fact that many different explanations can be given of a single phenomenon such as lemonade flowing up a straw doesn't mean that one of them is right and the rest wrong; it all depends on how much is taken for granted. The delightful simplicity of the first will do if sucking is accepted as one of the basic principles of the universe. Shockley's classic book *Electrons and Holes in Semiconductors* is divided into three parts, which are three different treatments of the same subject, suited to different readers—or the same reader at different stages of progress.

That is an example of several different but legitimate accounts of the same thing. There can also be different accounts as it were side by side rather than one on top of another. Recently we saw that potential could be defined in two very different ways, one depending on the concept of field strength and the other on the concept of work. With regard to field strength, some people rely on lines of force. These lines are only a concept; that is to say, a way the mind has of seeing something. Other people are content to think of just fields. But fields too are a concept; a way of imagining and referring to the supposed causes of certain effects. Others discard fields and consider only the velocities and accelerations of charges. I have no doubt that if there are beings of equal or greater intelligence elsewhere in the universe they will have quite different concepts for electromagnetism. Among concepts the question is not whether they are true or false but whether they help or hinder. The field concept seems to have been a great help; but later might it be seen to hinder, by excluding some more fruitful concept?

Sometimes there have been lengthy scientific arguments about which of two concepts was right. For instance, some scientists held that when a spectroscope produces coloured light when white light is passed into it, this proves that white light is composed of light of all colours. Others contended that white light is entirely random, and the spectroscope creates coloured light from it, almost as a valve oscillator creates a.c. of various frequencies from d.c. As Eddington said about this, "The mistake was . . . in claiming that we could decide experimentally between two equally permissible forms of description."

So far I haven't even mentioned the word "mathematics," which omission some readers may count as grave as "Hamlet" without the Prince of Denmark. The more "advanced" the treatment of a subject, the more mathematical it is likely to be. In fact, there is a tendency to elevate mathematical equations to a supreme status in science, as if they were the language of ultimate reality itself. This seems to be like enthroning electronic computers as the intellectual lords of the universe. Mathematical symbols are just shorthand for concepts, and mathematical operations are shorthand for reasoning about them. The same results could, theoretically, be obtained by the use of words, but this would often be far too laborious and involved to be practicable. Calling a thing "F" instead of "force" doesn't in itself add to what we know about the nature of force, but it may make it practicable, as nothing else would do, to arrive at certain conclusions about it. While on the one hand it would be silly to regard, say, mechanical transport as the answer to everything, it would be equally so to despise it when undertaking a long journey. I hope the analogy is clear!

Ferrites for F.M.

FREQUENCY MODULATION USING FERRITE-CORED COILS

By *T. W. G. CALVERT, B.Sc. (Eng.).*

UNTIL recently, frequency modulation and control in electronic apparatus has nearly always been effected by means of a reactance valve circuit. Due to the development of new materials, however, there are now several alternatives to this method. For example, the discovery of ferro-electric materials has made it possible to vary the capacity of a condenser by applying a voltage. Another capacity which can be voltage controlled is that of a germanium p-n junction. Ferrites have made it practicable to make use at radio frequencies of the change of inductance which occurs when a magnetic flux is applied to the ferromagnetic core of a coil. In this article the use of ferrite-cored coils for frequency modulation and control is described.

It is well known that the permeability of a ferromagnetic material changes when a magnetic field is applied to it. Also, that if a coil is wound on the material, its inductance changes with the permeability, and thus with the magnetic field. When the coil is part of a resonant circuit, it is possible to change the frequency of oscillation by applying a magnetic field to the core.

A remote tuning unit, which depended for its operation on the change of permeability of a magnetic material subjected to a changing magnetic field, was described by Boucke in 1936, and a similar system was described by Kramolin in 1938[1]. These devices made use of an iron-dust, or laminated nickel-iron core to carry the winding. Their use was limited because of uncertain operation, low power sensitivity, and the ability to operate only at low radio frequencies.

The last decade has seen the development of magnetic ferrites. These are non-metallic substances which combine good magnetic properties (initial permeabilities between 10 and 3,000), with a very high resistivity (0.1-1,000 ohm-metres). Other magnetic materials, such as laminated nickel-iron or powder-dust cores have resistivities of the order of 0.1-1 microhm-metres, which may be increased only at the expense of the permeability. The high resistivity of ferrites enables them to be used up to very high frequencies as core material for coils.

From the literature on the ferrites made by Mullards under the trade name Ferroxcube, it was decided that grade B4 would be suitable for this application. This grade of Ferroxcube is available in many sizes, but rods 2in long and 0.25in diameter were found to be convenient.

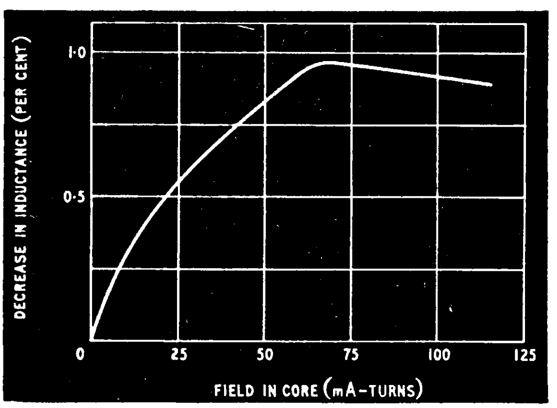


Fig. 1. Change of inductance when the control current is passed through the r.f. coil.

Applying the Field

A varying field in the ferrite core of an r.f. coil may be produced in three main ways, namely:—

(1) By passing a modulating or control current through the r.f. winding of the core.

(2) By passing a similar current through a separate winding on the core.

(3) By producing the field externally and applying it to the core.

The first two methods, (1) and (2), have been investigated by the author, and the third, (3), was fully described by Slater in 1954[2].

(1) A coil of 46 turns of 28 s.w.g. wire was wound on the 0.25-in diameter ferrite rod and its inductance measured. The change of inductance at 1 Mc/s which was observed when direct current was passed through the coil is shown in Fig. 1. This direct current must be obtained from a high-impedance source if the Q of the coil is not to be appreciably affected. In this case it was found to be convenient to connect the r.f. coil in the anode circuit of a pentode valve.

It is seen from Fig. 1 that a linear change of the order of 1% may be obtained. A series of coils were now wound with 40, 20, 10, 5, 2, and 1 turn respectively of 28 s.w.g. wire, and tests carried out over a range of frequencies from 1 to 50 Mc/s. It was found that up to 14 Mc/s the percentage inductance changes were similar to those obtained at 1 Mc/s, but above 14 Mc/s the amount of change began to decrease, reaching zero at 45 Mc/s. As might be expected, the current required increased as the number of turns was reduced, but the ampere-turns required remained fairly constant up to 14 Mc/s.

The fall in inductance change as the frequency was increased above 14 Mc/s could be due to losses in the core. However, as B4 Ferroxcube can be

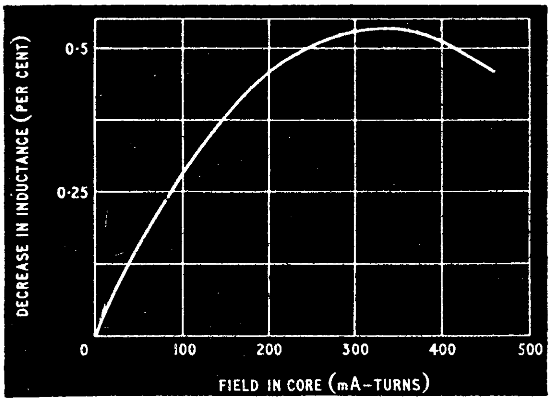


Fig. 2. Change of inductance when the control current is passed through a separate interleaved coil.

used as a core material up to 100 Mc/s, this seems improbable. It is more likely that, since the number of turns falls as the frequency increases, the approximation to a solenoid becomes less valid, and the flux produced by the control current is not in the ferrite core, but in the surrounding air, so that it has no effect on the permeability of the core.

(2) The control flux in the ferrite core may also be produced by passing a current through a separate winding on the core. This is clearly a simplification, since the control current need not be derived from such a high impedance source as with a combined r.f. and control winding. Initially, a control coil of 50 turns was wound on top of the r.f. coil of 46 turns of 28 s.w.g. wire already wound on the ferrite rod. This, however, decreased the Q of the r.f. coil so much that no inductance measurements were possible. With a control coil of 300 turns split into two sections, and wound on either side of the r.f. winding, the inductance of the coil was measured, but no change could be detected when current was passed through the control coil. The only arrangement which did give an appreciable change of inductance was that in which the r.f. and control coils were interleaved bifilarly. The results, which are shown in Fig. 2, are similar to those for (1), shown in Fig. 1, but the maximum inductance change was only 0.6% as compared with 1%, and nearly 10 times as many "control ampere-turns" were required for a given inductance change.

These results suggest that it is necessary to have very close coupling between the r.f. and control windings, so that the control flux passes through the part of the core associated with the r.f. coil. Thus, the best results were obtained when the two windings were combined, as in (1), giving the closest coupling possible; smaller inductance changes were obtained when the two windings were closely coupled by interleaving them; and no inductance changes at all were detectable when the control winding was wound in two sections on either side of the r.f. winding.

(3) An alternative to producing control flux by passing current through windings on the ferrite core, is to place the ferrite, with an r.f. coil wound on it, in the gap of a permanent or electro-magnet.

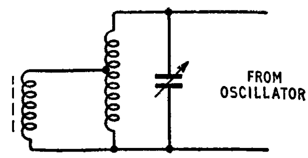
When a ferrite core carrying an r.f. winding was placed in the gap of a powerful permanent magnet, the inductance of the winding was reduced by 55%. This large change, which is more than 50 times greater than the maximum obtained in earlier tests, is consistent with the results of Slater[2], who recorded inductance changes of more than 60%. Slater used an r.f. coil wound on a small ferrite core, placed in the gap of a stack of U-shaped nickel-iron laminations which carried control windings, thus forming an electromagnet. With such a large change of inductance, there was an appreciable hysteresis effect.

From the results described above, it is seen that when the flux in the core of a coil is produced externally to the core, i.e., the magnetic circuit is complete, then the inductance changes which result are of the order of 50 times greater than those obtained when the flux is produced by a coil on the core itself, and the magnetic circuit is incomplete. The great difference between the two sets of results is thought to be due to the demagnetizing effect of an incomplete magnetic circuit, which causes the flux in the ferrite core to be diluted.

Thus there are three systems, two of which are very simple, in that there is no associated electromagnet, but which give maximum inductance changes of only about 1%, i.e., a frequency change of about 0.5%. The third system, which is more complicated, requires the control winding to be wound on a subsidiary core of nickel-iron laminations, but inductance changes of up to 60% are obtainable, i.e., frequency changes of up to 30%.

All three methods of applying flux to the core become ineffective as the frequency is raised, i.e., as the number of turns on the r.f. coil is decreased. This may be avoided by using the circuit shown in Fig. 3, where the ferrite-cored coil is tapped onto another coil. The total inductance is reduced without reducing the number of turns on the ferrite-cored coil. The disadvantage is that the percentage inductance change of the combination will be less than that of the ferrite-cored coil alone.

Fig. 3. A method of producing frequency modulation at v.h.f. The flux in the core may be produced either by passing current through the coil on the core, or by placing the core in the gap of an electromagnet.



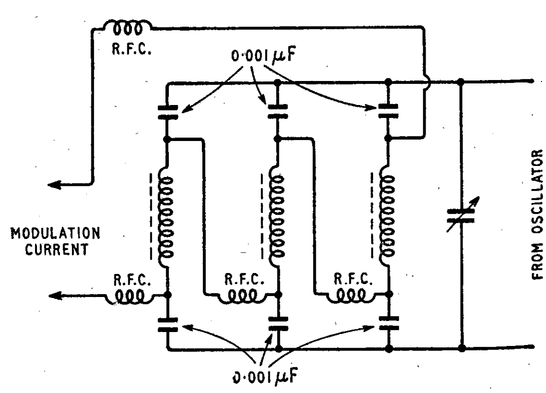


Fig. 4. This circuit provides modulation at v.h.f. without reducing the maximum frequency deviation. More ferrite cored coils must be added as the frequency is increased.

Fig. 4 shows an alternative circuit which enables the inductance to be reduced without reducing the percentage frequency deviation. The essential point of this circuit is that the ferrite-cored coils are connected in series at modulating frequencies and in parallel at radio frequencies. This circuit would function in an oscillator, giving total frequency deviations even at very high frequencies of up to 0.5%.

The first two systems, giving frequency changes of $\pm 0.25\%$ and $\pm 0.15\%$ respectively, are suitable for an f.m. signal generator. (The $\pm$ 75 kc/s maximum deviation of the B.B.C. v.h.f./f.m. signals represents a change of less than $\pm 0.1\%$.) They could also be used to apply a.f.c. to a radio receiver. However, as a simple ferrite-cored coil will not give any frequency change above 45 Mc/s, for v.h.f. such as the 90 Mc/s f.m. broadcast band it would be necessary either to use the third or fourth harmonic of the local oscillator, or one of the circuits shown in Figs. 3 and 4. The author has used method (1) to provide frequency sweep in a wobbulator. (A wobbulator enables the response curves of tuned circuits, e.g. i.f. transformers, to be displayed on a cathode-ray oscilloscope.) The wobbulator was built for use with a short wave receiver tuning over the range 4.5-15 Mc/s. Since the receiver had an i.f. of 465 kc/s, the frequency deviation of ± 25 kc/s, obtainable at a typical input frequency of 10 Mc/s, was quite sufficient to show the whole response curve of the i.f. transformers.

Although the system which produces the control flux in an auxiliary Ni-Fe core is more complicated, and therefore more expensive, there is the advantage that the control current need not be derived from a high impedance source. Scroggie used a method similar to this to provide automatic frequency correction in an f.m. receiver[3]. With a possible frequency change of 30%, this method is very suitable for control applications, such as the remote tuning of a radio receiver. It also gives linear frequency modulation of up to $\pm 2\%$, which is a much greater deviation than is easily obtainable by other methods.

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(2). F. Slater. "A Ferrite Frequency Modulator," *Marconi Instrumentation*, No. 8, p. 186 (1954).

(3). M. G. Scroggie. "An Unconventional F.M. Receiver," *Wireless World*, Vol. 62, p. 258 (June, 1956).

Books Received

An Introduction to Automatic Digital Computers, by R. K. Livesley. Describes in general terms the sort of facilities available in stored-programme "mathematical" machines and concentrates mostly on principles of programming, with particular emphasis on routine engineering problems. Pp. 53; Figs. 10. Price 8s 6d. In the Cambridge Engineering Series. Cambridge University Press, Bentley House, Euston Road, London, N.W.1.

Modern Computing Methods, by the staff of the N.P.L. Mathematics Division. Numerical methods of solving mathematical problems suitable for computing machines, with worked examples. Covers linear equations and matrices, differential equations, roots of polynomial equations, latent roots of matrices, finite-difference methods and relaxation methods. Pp. 129; Figs. 18. Price 10s. 6d. H.M.S.O., York House, Kingsway, London, W.C.2.

Ceramic Insulators for Telecommunication Purposes. A revised specification defining tolerances on ceramic insulators used as bushings or in radio and electronic components in high- low-voltage and r.f. circuits. An appendix gives guidance to engineers and draftsmen on the design of ceramic insulators for most economical production. Pp. 15; Figs. 4. Price 1s. R.E.C.M.F., 21, Tothill Street, London, S.W.1. Price 1s.

Guide to the Specification and Use of Quartz Oscillator Crystals. Pp. 40; Figs. 11. Price 5s. Radio Communications and Electronic Engineering Association, 11, Green Street, London, W.1.

Propagation des Ondes Electromagnetiques de Haute Fréquence, by J. Ortusi. The first volume in the series "Collection des Annales de Radio-électricité" covers in its first-part general waveguide theory, waveguide junctions and discontinuities; including guides containing ferrites and dielectrics. A second part discusses u.h.f. terrestrial propagation, and has some useful nomograms. Pp. 320; Figs. 110. Price 3,240 fr. (French). Société Française de Documentation Electronique, 12, rue Carducci, Paris 19.

Valve and Television Tube Equivalents, by B. B. Babani, covers British, American, European and Service types of receiving and transmitting valves. Pp. 66. Price 5s. Bernards, The Grampians, Western Gate, London, W.8.

T.V. Fault Finding, by the staff of the *Radio Constructor*. Revised edition with many illustrations from TV screens gives circuit details of, and correction methods for the various types of fault. Pp. 104; Figs. 112. Price 5s. Data Publications, Ltd., 57, Maida Vale, London, W.9.

Understanding Hi-Fi Circuits, by Norman H. Crowhurst. Deals simply with various amplifier and pre-amplifier stages, overall feedback and damping, and crossover networks and other speaker sound distribution systems. Pp. 224; Figs. 179. Price 2.90 dollars in soft cover edition. Available in Gt. Britain from The Modern Book Co., 19-23, Praed Street, London, W.2. Price 23s.

Transistor Engineering Reference Handbook, by H. E. Marrows, contains a large amount of data on commercial American transistors, components for use with transistors, and transistor circuits, and includes a classified bibliography and manufacturers' directory. Pp. 286; many figs. Price 80s. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2.

Industrial Rectifying Tubes, by members of Philips Electron Tube division. Vol. 13 in the Philips technical library series on electron tubes deals with construction, operation and applications (battery charging and industrial) of hot-cathode gas-filled rectifiers. Pp. 126; Figs. 100. Price 15s. Cleaver Hume Press, Ltd., 31, Wrights Lane, London, W.8.

Receiving Aerial Systems, by I. A. Davidson, B.A., discusses generally television and radio aerials, including their mechanical design and installation, and also cables and accessories. Pp. 152; Figs. 70. Price 21s. Heywood and Co., Ltd., Tower House, Southampton Street, London, W.C.2.

Subjective Colour for Television?

Experimental Film Based on the Benham's Top Principle

By ***C. E. M. HANSEL*, M.A.***

IT is well known that people watching certain television "commercials" on ITV have observed colour effects on their receiver screens. As the same colours were reported by a number of independent observers there is no reason to doubt that they did experience sensations of colour, and it is of interest to see how these could arise.

It has long been known that colour sensations can be aroused by viewing a black and white top rotating in white light. Benham's top (Fig. 1) is the best known means by which these colours can be produced. If Benham's top is rotated in monochromatic illumination from the middle part of the spectrum it is still possible for an observer to experience a variety of colours.

The effect was demonstrated by Helmholtz. He showed that if a simple top (Fig. 2) in which one half is black and the other white is rotated, there appears to the observer to be a blue fringe behind the black as it leaves the white area and a red fringe extending into the black area as it advances into the white area. These colour fringes were attributed to differences in the retinal action times of the photoreceptors bringing about the sensations of blueness and redness, for the time taken for the sensation of blueness to arise after onset of illumination is known to be less than that for redness.

* Department of Psychology, University of Manchester.

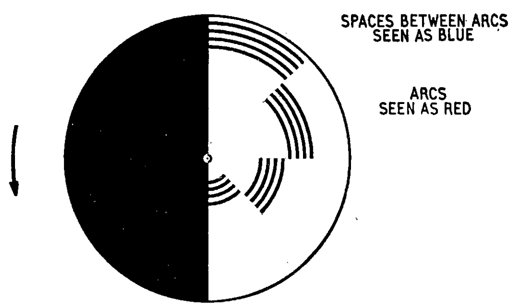


Fig. 1. Structure of the well-known Benham's top

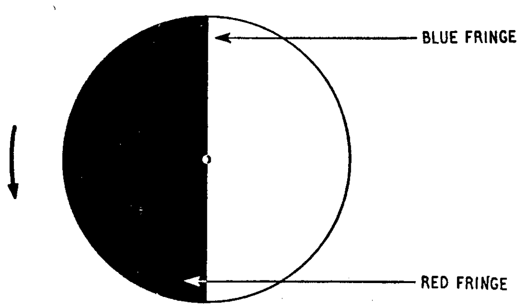


Fig. 2. Simple top used by Helmholtz to demonstrate subjective colours.

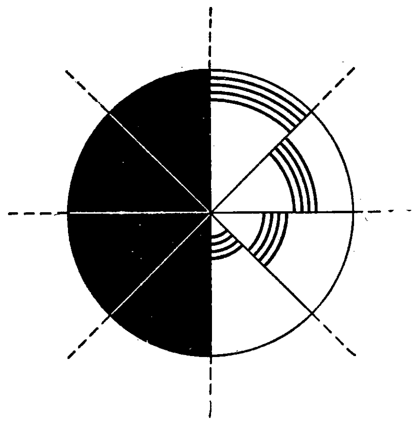


Fig. 3. Benham's top shown divided into eight segments.

As the white area of the top advances into the black area, light strikes the corresponding part of the retina but as the sensation of blueness is aroused more quickly than that of redness, a blue fringe is seen at the leading edge of the white area. Similarly, a red fringe is seen where the black area advances into the white area.

Benham's top is a modified form of Helmholtz's top in which the area of the edge is increased by means of the arcs and, as we should expect, the blueness extends over the white area between the arcs, whereas the redness is seen in the arcs themselves. These colour effects can be obtained in monochromatic light provided that the photoreceptors which normally evoke the sensations of blueness and redness have sensitivities extending over the wavelength being used.

In 1951 I suggested to the B.B.C. that they might produce colour effects in normal television transmitters by utilising this principle, and for this purpose a black and white film was constructed which, on projection, gave the impression of objects of different colours against a coloured background†.

A simple technique was developed which utilized the principle of Benham's top but which enabled the colours to be superimposed on drawings. Ben-

† The B.B.C. did not follow up this suggestion but demonstrations of subjective colour effects by means of tops were given on American television in 1953.

ham's top may be divided into eight segments (Fig. 3). Areas shaded in accordance with these eight segments are projected successively on to a screen, but the segment containing the arcs is replaced by a system of dots, thus increasing the length of the black-white boundary areas, on which the effect is to some extent dependent.

The desired colour effect for a particular area is obtained by shading the area on successive frames to conform with the code shown in Fig. 4(a). Projection at the rate of 24 frames per second‡ then gives three complete cycles per second and is accompanied with a coarse flicker. In order to decrease the flicker effect the coding may be modified as in Fig. 4(b). A particular area may also be split up into sub-areas, giving further decrease in flicker.

The sequence of 8 frames to a cycle may be modified and 6-, 4- or 3-frame cycles used. With 24 frames per second as used in film projection, a cycle of 8 frames has been found to be too long, and one of 4 frames is more effective, although in this case colour effects are not so pronounced (see Fig. 5).

By using these techniques it is possible to construct cinematograph films which, on projection, will appear coloured. Sets of cards are prepared with the different areas shaded in accordance with the code for the desired colour effect and these are photographed in sequence on successive frames of the film. A similar technique could be used on photographs of natural objects. In this case the dot pattern would be replaced by the actual area of the photograph (which would have to have some lines or shading added if these were not already present).

‡ For television film scanning, of course, this would have to be increased to 25 frames per second, since the film frame rate has to be related to the television standards.—Ed.

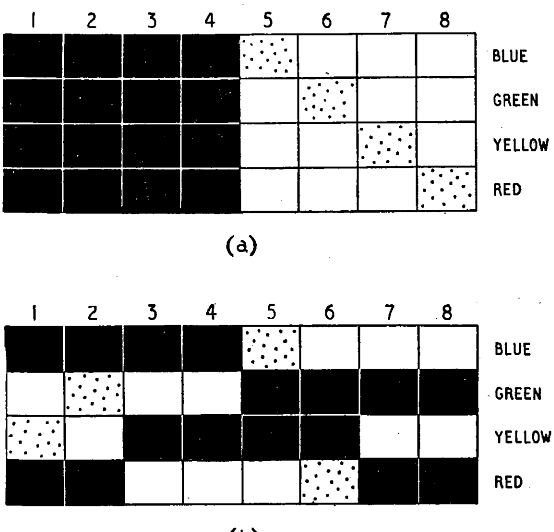
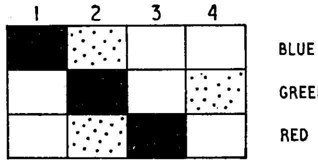


Fig. 4. (a) Adaptation of the 8 segments of the top in Fig. 3 to a cycle of 8 successive film frames. A different sequential pattern is used for each colour, and dots replace the arcs of Fig. 3. In (b) are modified code patterns used for reducing flicker.

Fig. 5. Simplified 4-frame coding system for use at a film projection rate of 24 frames per second.



In television, where a single scanning spot is used on a c.r. tube, a particular area of the screen is illuminated for only a small fraction of the total presentation time for each frame. The cumulative action of the eye largely compensates for this, however, and it is possible that more effective means of obtaining colour effects could be devised by utilizing the fact that the image is traced out by a small moving illuminated area. Special techniques could be developed which would utilize the full 50-c/s scanning rate of the interlacing odd and even lines, rather than the 25-c/s scanning rate which would result from using film.

It was reported by the viewers on ITV that a person was seen wearing a blue tie with white spots. Although we should rather expect that a blue tie with black spots should be seen, there is no reason to doubt that the colours were subjective and were produced by characteristics of the film approximating to those described above.

CLUB NEWS

Bexleyheath.—At the October 10th meeting of the North Kent Radio Society, E. Hasted (G3BHF) will speak about filter circuits The club meets fortnightly at 8.0 in the Congregational Hall, opposite Bexleyheath Clock Tower. Sec.: D. W. Wooderson (G3HKX), 39 Woolwich Road, Bexleyheath, Kent.

Birmingham.—Mullard films "Mirror in the sky" and "The principles of the transistor" are being shown at the October 25th meeting of the Slade Radio Society at 7.30 at the Y.M.C.A. Sec.: C. N. Smart, 110, Woolmore Road, Erdington.

Bury.—The October meeting of the Bury Radio Society will be held at 8.0 on the 8th at the George Hotel, Kay Gardens. "Matching matters" is the title of the talk to be given by R. Hammans (G2IG). Sec.: L. Robinson, 56 Avondale Avenue, Bury, Lancs.

Dorking.—A film show will be given at the next meeting of the Dorking and District Radio Society at 7.45 on October 8th at the Star & Garter Hotel, adjacent to Dorking North station. Sec.: J. Greenwell (G3AEZ), Wigmore Lodge, Beare Green, Near Dorking, Surrey.

Reading.—The next meeting of the newly formed Reading Amateur Radio Club will be held at 7.30 on September 28th at Palmer Hall, West Street, when Roland Page (G5TP) will describe and demonstrate "A table-top 150-watt transmitter." Sec.: L. R. Mitchell (G3BHK), 965 Oxford Road, Reading.

PUBLICATION DATE

Owing to a temporary rearrangement of our printing schedule the publication date of the November issue of *Wireless World* will be advanced to October 15th.

News from the Industry

E.M.I.—With the merging of E.M.I.'s domestic radio interests with those of Thorn Electrical and the recent setting up of a new company (E.M.I. Records, Ltd.) to handle the marketing of records, E.M.I. Sales & Service, Ltd., has been reoragnized. R. J. T. Hewitt is appointed general manager and will act as deputy to the recently appointed managing director, H. A. Lewis. There are two main divisions within the company, one handling consumer products (household appliances, reproducers, car radio and components) and the other capital goods (magnetic tape, professional tape-recording equipment and sound and vision distribution equipment). The divisional managers are F. W. Goodman (consumer products) and P. H. Wetherill (capital goods). A. Thorpe is appointed works manager.

H.M.V. and Marconiphone.—Consequent upon the agreement between E.M.I. and Thorn regarding the manufacture and marketing of receivers under the trade names Marconiphone, H.M.V. and Ferguson, the British Radio Corporation, Ltd., was formed to merge these interests. Now two new marketing companies have been formed, "His Master's Voice" Radio and Television Sales, Ltd., and Marconiphone Radio and Television Sales, Ltd., with offices and showrooms at 21, Cavendish Place, London, W.1. The directors of both companies are F. W. Perks (E.M.I.) and S. T. Holmes and G. J. Strowger (Thorn). The marketing of Ferguson receivers will continue through Ferguson Radio Corporation.

English Electric are to supply a DEUCE computer to the Mechanical Engineering Research Laboratories (East Kilbride, Scotland) which is part of the Department of Scientific and Industrial Research. This will be the fifth DEUCE computer in Government service and will be employed mainly in calculations in hydro and thermo-mechanical problems. It will be the first machine of the series to be equipped for high-speed paper tape and punched card inputs.

Texas Instruments, Ltd., the British subsidiary set up nine months ago by the American Texas Instruments, Inc., open a factory at Dallas Road, Bedford, on October 1st. It is initially concentrating on the production of silicon rectifiers and transistors.

OVERSEAS TRADE

Television film recording equipment (telerecording) has been ordered from Marconi's for the Prague studios of the Czechoslovakian television service. The equipment is similar to that mentioned in our March issue (p. 137), the outstanding feature being the "fast pull-down" film mechanism, which enables each frame of film to be moved into position during the blanking period between television frames—from 1.4 to 1.8 msecs. The Prague installation will have a number of additional features, including a waveform monitor and facilities for separate synchronous magnetic sound recording.

EXACTING STANDARDS of cleanliness are observed in this dust-free, air-conditioned zone of the AVO factory, at Douglas Street, London, S.W.1, within which instruments are built, calibrated and tested.

Helsinki.—Among the 450 representative United Kingdom products shown on the Council of Industrial Design stand at the British Trade Fair at Helsinki (September 6th-22nd) were two television sets (Ekco portable and Pye console), three sound receivers (Bush MB60 portable, Philco A3655 and R. M. Electric "Minitone" portable), and two record reproducers (E.A.R. "Chairside" and Pilot "Music Master").

Echo sounders, including the new MS30 open-boat type for inshore fishermen, are being shown by Kelvin Hughes at the International Fisheries Trade Fair at Copenhagen (September 27th to October 6th).

Vienna Trade Fair.—Products of the various companies in the Pye group, including domestic television and sound equipment, industrial and underwater television, scientific instruments, communications gear and components, were exhibited at the International Trade Fair held in Vienna from September 8th to 15th.

Netherlands.—Although no British radio manufacturer has an individual stand at the Radio Fair in Amsterdam (September 19th to 26th) U.K. products are on many of the stands. Some of the well-known names quoted in the preview of the show published in our Dutch contemporary *Radio Bulletin* are: Avo, Bakers-Selhurst, Belling-Lee, Colvern, Daly, E.M.I., Egen, Ferguson, Ferranti, Goodmans, Gresham, Leak, Morganite, Muirhead, Pam, Painton, Pamphonic, Pye, Q-Max, Racal, Truvox, W.B., Wharfedale and Wingrove & Rogers.

Angola.—The British Consulate in Luanda has prepared a report on the domestic receiver market in Portuguese East Africa. Whereas in 1949 the U.K. supplied over 1,000 receivers, which was 40% of the country's purchase, last year's figure of 740 was but 6% of the imports. The Netherlands supplied 40% of last year's receivers, U.S.A. 30% and Germany 20%.

Central American agency of U.K. manufacturers of components, accessories and test equipment is being sought by Henrique Stol Representaciones, Frontera 115 Dept. 303, Col. Roma, Mexico D.F. Among the accessories listed are pickups and cartridges, microphones, speaker magnets and cones, car aerials, amplifier and record-changer kits, and recording blanks.

Miniature Soldering Iron.—Oryx Electrical Laboratories, Ltd., of 98, Dominion Road, Worthing, Sussex, manufacturers of the Oryx sub-miniature soldering iron, are making a change in their sales policy and invite inquiries from overseas for exclusive agencies.

NEW ADDRESSES

Minnesota Mining and Manufacturing Co., Ltd., have moved their offices to a new building, to be known as 3M House, in Wigmore Street, London, W.1. (Tel.: Hunter 5522.)

Antiference, Ltd., have opened a new factory on the Bicester Road, Aylesbury, Bucks. (Tel.: Aylesbury 2511), where all sales, service and accounts matters are now being dealt with.

Anders Electronics, Ltd., manufacturers of test and measuring equipment, have transferred their office to 103, Hampstead Road, London, N.W.1. (Tel.: Euston 1639.) The dispatch department and warehouse remain at 91, Hampstead Road.

Marine Aerials, Ltd., manufacturers of the "Marinette" indoor television aerial, have moved from Deptford High Street, to 17a, Clifton Rise, New Cross, London, S.E.14. (Tel.: Tideway 3066.)

Electronic Products, of Ruislip, has been merged with Nesco Products, Ltd., of 149, Stanwell Road, Ashford, Middlesex (Tel.: Ashford 3555). K. B. Hobday is the managing director of the combined company, which will continue to make Nesco public-address loudspeakers and is specializing in the automatic assembly of components on printed circuit boards.

OCTOBER MEETINGS

LONDON

3rd. I.E.E.—Address by T. E. Goldup (president) at 5.30 at Savoy Place, W.C.2.

4th. Television Society.—"Recent investigations into the operation of image orthicon camera tubes" by Dr. R. Theile (Institut für Rundfunktechnik, Nuremberg) at 7.0 at 164 Shaftesbury Avenue, W.C.2.

15th. Institute of Physics (Electronics Group).—"In electronic beams" by Dr. D. Meltzie at 5.30 at 47 Belgrave Square, S.W.1.

15th. Physical Society (Acoustics Group).—"Present state of acoustic theory as applied to small rooms" by J. Moir at 5.30 in the Physics Department, Imperial College.

15th. Institution of Post Office Electrical Engineers.—"Thirty years of radio development in the Post Office" by H. G. Beer at 5.0 at the I.E.E., Savoy Place, W.C.2.

16th. I.E.E.—"Some radio aids for high-speed aircraft" by Dr. J. S. McPetrie at 5.30 at Savoy Place, W.C.2.

16th. Radar Association.—Lecture at 7.30 at the Anatomy Theatre University College, Gower Street, W.C.1.

17th. Television Society.—Discussion on servicing modern television receivers at 7.0 at 164 Shaftesbury Avenue, W.C.2.

18th. B.S.R.A.—"Plastic deformation and wear of gramophone records" by Dr. D. R. Barlow at 7.15 at the Royal Society of Arts, John Adam Street, Adelphi, W.C.2.

23rd. British Kinematograph Society.—"Simple techniques in television film production" by John Lamont, R. Evans and W. H. Cheevers (Associated-Rediffusion) at 7.30 at the Royal Society of Arts, John Adam Street, W.C.2.

28th. I.E.E. — "Domestic high-fidelity reproduction" by J. Moir at 5.30 at Savoy Place, W.C.2.

31st. Television Society.—"Performance of television receiver turret tuners" by K. H. Smith (Siemens Edison Swan) at 7.0 at 164 Shaftesbury Avenue, W.C.2.

CHELTENHAM

4th. Brit.I.R.E.—"Radio engineering" by C. T. Lamping at 7.0 at the North Gloucestershire Technical College.

GLASGOW

10th. Brit.I.R.E.—"Reception problems of Scottish television" by W. Boyd at 7.0 at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent.

25th. Society of Instrument Technology.—"Computer control of machine tools" by A. A. Lodge at 7.15 at the Scottish Building Centre, 425 Sauchiehall Street.

MANCHESTER

3rd. Brit.I.R.E.—"High-quality sound equipment" by K. Davin and F. C. Gibson at 6.30 at Reynolds Hall, College of Technology, Sackville Street.

9th. I.E.E.—Address by K. J. Butler, chairman of N.W. Radio and Telecommunication Group at 6.45 at the Engineers' Club, Albert Square.

NEWCASTLE

21st. I.E.E.—Address by W. Gray, chairman of N.E. Radio and Measurements Group at 6.15 at King's College.

SHEFFIELD

9th. Society of Instrument Technology.—"Computers in heavy industry" by Dr. C. M. Wilson at 7.0 at the University, St. Georges Square.

WOLVERHAMPTON

9th. Brit.I.R.E.—"Transistors—circuits and applications" by M. D. Cooper at 7.15 at the Wolverhampton and Staffordshire Technical College, Wulfruna Street.

LATE-SEPTEMBER MEETING

27th. R.S.G.B.—"Trends in aerial design for the amateur" by S. Kharbanda, G2PU, (Labgear) at 6.30 at the I.E.E., Savoy Place, London, W.C.2.

RANDOM RADIATIONS

By "DIALLIST"

Good Going

WITH five transmitters (Croydon, Lichfield, Winter Hill, Emley Moor and Black Hill) already at work, the Glamorgan station due to come into action before the end of this year, the Isle of Wight transmitter scheduled for completion by next summer and a station in the North East by the end of 1958, the Independent Television Authority can't be said to have let the grass grow under its feet in the comparatively short time that it has been in existence. Over 85% of the population will then be within the I.T.A. service areas. The Authority plans that its programmes should cover almost the whole of the country within the next three years. The task wasn't an easy one when a beginning was made, for little or nothing was known about the propagation of vertically polarized television transmission in Band III and it was expected that there would be reception snags due to such things as blind spots and ghost-producing reflections. Actually, the service areas have mostly proved to be rather larger than was expected. Some of the good beyond-the-fringe reception that has been reported from many places is undoubtedly due to sunspot pranks and is not likely to last indefinitely. But, taking them by and large, all of the Band III stations are putting up a good show.

Polarization Problems

AT the time of writing Black Hill's test transmissions have been playing up in the matter of polarization. Outside the main service area a strong *horizontally*-polarized signal is found to be coming in some places. I'm not really surprised. When I lived in Hertfordshire some 50 miles from Wrotham I found quite accidentally that its transmissions could be very well received with a vertical dipole. And, if you remember, I gave some account in these notes a month or two ago of the experiences of a Lancashire reader who was regularly receiving Wrotham and found that it didn't seem to matter two hoots whether the apology for a dipole that he had made was arranged horizontally or vertically. I've just heard from a reader living in Launceston, in Cornwall, that before North Hessary Tor came into action on full power he used frequently to receive the f.m. transmissions from Wenvoe and Wrotham by means of his vertical channel-5 television aerial, normally used for receiving Wenvoe. Wrotham, as I've remarked before, seems to hold the B.B.C. record for long-distance v.h.f. reception. A kind correspondent tells me that during a recent visit to Germany he had no difficulty in receiving Wrotham with a 3-valve Grundig set using a simple home-made dipole.

Fringe Area TV Sets

I AM glad to see that so many firms this year are producing fringe-area TV receivers as counterparts to their standard sets. A very large number of the inhabitants of these islands live just outside the service areas of both B.B.C. and I.T.A. transmitters. Such people receive a weak signal, and one of their most common complaints is that the line scan won't stay locked. The reason is, of course that the sync pulses received in such areas aren't of sufficient amplitude to hold the ordinary sync separator-differentiating circuit-oscillator line scan to its correct frequency. Various forms of fly-wheel sync have been introduced, and these can be a very great help. The trouble, though, about many of them is that they mean extra valves and bits and pieces, and so add considerably to the cost of the sets.

The Synchroguide System

One method of keeping the line timebase running at exactly the right speed greatly takes my fancy. This is the synchroguide, which was originally developed in the U.S.A. and is now being used to a considerable extent in this country. Only two triodes are needed, and these can be in the form of a double triode. The first is the control valve, to whose cathode are applied negative-going sync pulses. This valve is biased back so far that only the tips of the pulses make it conductive. Valve number two is a blocking oscillator. The positive-going pips of its grid-voltage waveform are applied to the grid of the control valve. When the timebase speed is correct these pips coincide with the leading edges of the sync pulses. Anode current then flows, and both its amplitude and duration are conditioned by the phase relationship of the sync pulse and the pip. From this current is derived a voltage which is applied to the grid of the blocking oscillator. Should it be running too slowly the pip is late in arriving at the cathode of the control valve; anode current flows for a longer period and the biasing pulse is lengthened, so speeding up the blocking oscillator. If the speed is too high, the resultant biasing pulse is shortened and the oscillator slowed down. Like so many ingenious ideas, it's beautifully simple. And it works well, provided that the TV set has effective a.g.c.

VHF/FM Comes Into Its Own

IT'S good to see that the majority of sound receivers, other than battery portables and the less expensive kind of mains sets, are provided this year with a Band II range for the reception of f.m. transmissions. Only the more expensive sets with high-quality audio stages will be able to do full justice to the excellent quality of the B.B.C.'s now almost country-wide system; but all will confer the advantage of freedom from almost every kind of interference. You get a silent background and, if you have an outdoor dipole, complete freedom from all sorts of interference. Some sets have a built-in ferrite aerial for Band II. That's all right, if you happen to live at the top of a high building (as I do), or in a place where there is little interference from the ignition systems of motor vehicles. But if you try to use the v.h.f. range with a built-in ferrite aerial on the ground floor of a house, or near a road carrying no small volume of motor traffic, you're liable to disbelieve the "no interference" claim made for the service. Give it a fair chance and you'll have no complaints to make.

FM and TV

WRITING from Rawthorpe, near Huddersfield, a reader sends me an interesting account of reception of both f.m. from Holme Moss and the a.m. sound from the Emley Moor television station on his f.m. set. The transmitting aerials of both stations can be seen from windows in the upper part of his house. By detuning from the Holme Moss Home Service frequency (93.7 Mc/s) towards that of the Third Programme (91.5 Mc/s) he can bring in the I.T.A. sound (196.25 Mc/s). His set has a.f.c., which enables him to "drag" the transmission further away from the Home. Then, by reducing the h.f. reproduction by means of the tone control, he can cut down the background noise until it's quite inoffensive. When the set is tuned to the Home Service there is no interference from Emley Moor. Have any other readers had similar experiences?

UNBIASED

By FREE GRID

Canned Concerts

I HAVE previously pleaded in these columns for manufacturers to give us a wireless set with a built-in tape recorder and a time switch so that if some programme to which we wish to listen clashes with an important "date" we can arrange for it to be bottled in our absence.

There is obviously no technical difficulty whatever in producing such an instrument, but probably there is a legal snag in connection with recording rights and that is why nothing has been done about it so far. I was glad to see, however, that a start was made in the right direction with a tape recorder at the 1955 Radio Show with space for a v.h.f. radio receiver, and some of the German sets that are on the market in this country approach the problem in a remarkably sensible way.

German manufacturers have obviously realized that a set with a built-in tape recorder would be very expensive and one of them has therefore produced a receiver in which there is provision for adding the tape recorder afterwards, and I understand that others are doing the same thing. This particular manufacturer also makes a tape recorder and he has left a space for housing it. You may say that there is not much to shout about in a mere space and nor is there until you buy a tape recorder to fill it up. It is at any rate a beginning. Maybe in next year's model we shall see a space left for a time switch.

Another point I like about all these "hi-fi" sets from the fatherland is that they all have a special outlet socket for coupling up a tape recorder so that you can feed straight from the diode into the amplifier of the recorder, so by-passing the set's amplifier with its "non-recordogenic" (horrible but apt expression) characteristics.

Telly Nellie

BECAUSE of the intuitive flair women have for diagnosing trouble in bawling babies I have always held the opinion that they would make far better radio service technicians than men. I recollect once spending a convivial evening with a young doctor when his wife was out. Their sleeping baby upstairs suddenly let out a piercing yell. We both went upstairs to see what was the matter and although we, metaphorically, "turned all the knobs" we failed to reduce the howling by a single dB.

Eventually the youthful medico got out his stethoscope and was about to carry out a thorough examination when his wife came home, angrily pushed us aside and without more ado diagnosed the trouble intuitively. I don't recollect exactly what the trouble was but I know safety pins came into it.

Some time ago I told you of a dealer who employs girls as service technicians, finding their intuitive faculties cheaper and quicker than an oscilloscope but recently I came across a far more remarkable instance of the same sort of thing. I was visiting friends in a small village which lies just within the fringe area of the London TV stations. Each house had a very complex aerial array and I was told that sets have to be kept up to concert pitch in order to get good results. I was also informed that consistently good reception in that and neighbouring villages is only made possible by the activities of a girl who has fitted up a small motor van as a mobile service station.

To obtain her services it is only necessary to telephone her HQ a few miles away and if already out on a job a message is sent to her in the van by a mobile radio link. She is known throughout the countryside as Telly Nellie and uses the slogan "Send for Telly Nellie." When her van arrives at a customer's house she runs a long cable to plug into the mains in the house and removes the set to her mobile test bench for first-aid work. In the case of a serious fault she takes it to her HQ.

I had the good fortune to see her when her van drew up in the village street and had a chat with her. She is not only a competent service technician but also an extremely attractive girl and I was not surprised to learn that many of the lads of the village were having constant trouble with their TV sets. There seems to be much scope for this sort of service in country districts and also for alternative names such as Radio Rita and Video Vera.

Ernie's Innards

I WAS informed by the P.R.O. of the Lead Development Association that Ernie's innards were encased in lead and in reporting this in the August issue I said I wondered if this was because he might be a bit radio-active. A G.P.O. engineer now writes telling me that Ernie is not encased in lead but, like a good civil servant, he is conventional in his attire. He assures me that the only lead in him is the normal lead sheathing of connecting cables.

Competent and comely

Seeing While You Soak

IF any of you are thinking of taking my tip (Oct., 1956, issue) to instal bathroom TV, you will at once be confronted with the problem of steaming up of the screen. However, there is no need to adopt a Spartan regime of cold baths as all you need to do is to instal a car windscreen wiper to keep the TV screen clear.

Recently I moved into a new house and asked the local electricity authority, if, whilst installing an immersion heater in the bathroom, they would mount on the skirting board an outlet socket. They were adamant in their refusal.

After much argument, however, they agreed to instal a step-down transformer under the floorboards to provide a six-volt feed to a skirting board socket for my electric shaver which has an optional six-volt input.

Technically speaking there ought to be no difficulty about operating a television set from a six-volt a.c. supply provided that I can find a TV set manufacturer enterprising enough to fit to his product a power transformer with a six-volt input winding. Maybe a set with this special power-input arrangement exists already.

Another great advantage of my six-volt idea is, of course, that you can shave in comfort and cleanliness as one of the greatest objections to certain electric shavers is that they act like a mowing machine without a grass box and tend to bespatter your chest with facial fungus. For those of you who only want to shave in the bath and not to enjoy TV I would point out that all you need is an inexpensive bell-ringing transformer as its voltage output is just right, although quite inadequate, of course, for a TV set.