Wireless World

OCTOBER 1955 VOL. 61 No. 10

Too Little and Too Late

IN our last issue we expressed doubts whether the new Post Office regulations, which came into force on September 1st, would in fact have any significant effect in reducing the prevailing intolerably high level of man-made interference with radio reception. These fears were strengthened by statements made by the Postmaster-General at a conference held shortly after our last issue appeared.

Administrative complexity is only one of the difficulties. According to the P.M.-G.'s own admission "these regulations can only be enforced through very elaborate legal processes, which are laid down in the Wireless Telegraphy Act." That sounds to us like an under-statement. Take the regulations affecting small motors. They *seem* clear enough; all users are required to restrict conducted and radiated interference to limits that are precisely laid down. But it is not really so simple as that; in fact, the user of a motor producing strong interference does not feel the weight of the regulations until several steps have been taken. First the Post Office must have a complaint from a neighbour who is suffering from the interference; then the complaint must be investigated and traced to its source by P.O. officials; finally a notice must be served on the owner of the offending motor requiring him to fit suppressors. Failing a complaint, the owner need do nothing; put rather crudely, he commits no offence until he is caught—or, more accurately, until he refuses to obey an order requiring him to fit a suppressor. And in the majority of cases, the complaint needed to set in motion the complex P.O. machinery will be lacking.

Unfortunately, the history of compulsory interference suppression has been a long story of "too little and too late." The P.M.-G. was given the powers—admittedly somewhat limited—to take active steps by the Act of 1949, but did nothing until 1953, when regulations for ignition suppression came into force. These regulations were somewhat half-hearted, and in any case were out of date when they were issued. They did not cover broadcasting Band III, in which arrangements had already been made to start an alternative television service.

The truth of the matter seems to be that the present procedure is too slow and cumbersome for a rapidly growing art like ours. Before the P.M.-G. can act he must be advised by a committee faced with the difficult tasks of reconciling strongly conflicting interests and, harder still, of laying down precise limits of interference on data that is never complete or fully up to date. *Wireless World* is increasingly in sympathy with those who contend that anti-interference legislation should be on a simpler basis, requiring merely the observance of "reasonable precautions."

Although the latest regulations may be ineffective, they may at least serve to draw attention to the general subject of interference, and so have an indirectly beneficial effect. To coincide with them, the British Standards Institution has just issued two booklets. The first is a revised edition of "Components and Filter Units for Radio Interference Suppression" (BS615:1955; 6s). An important feature of this publication is that it deals at length with capacitor requirements and tests. All too often, unsuitable capacitors have been used and, naturally enough, frequent breakdowns have prejudiced makers and users of electrical appliances against suppressors in general.

The second B.S.I. publication is "General Aspects of Radio Interference Suppression" (CP1006:1955; 10s). This is intended as a working guide for radio and electrical dealers and their service technicians on the fitting of suppressors. For this purpose it constitutes a very useful and detailed survey of accepted good practice in dealing with the usual sources of interference.

We are glad to see that in the CP1006 booklet a fair amount of space is given to the question of receiving aerials, even though this subject might be thought irrelevant. Without being entirely defeatist over the powers of the Post Office to protect its broadcast receiver licencees, it is as well to remember that "Heaven helps those who help themselves." Is there not a thought in this for broadcast receiver manufacturers? Although the public now refuse to put up good aerials for a.m. sound reception, they will do so for television; they might be persuaded to do the same for v.h.f. sound.

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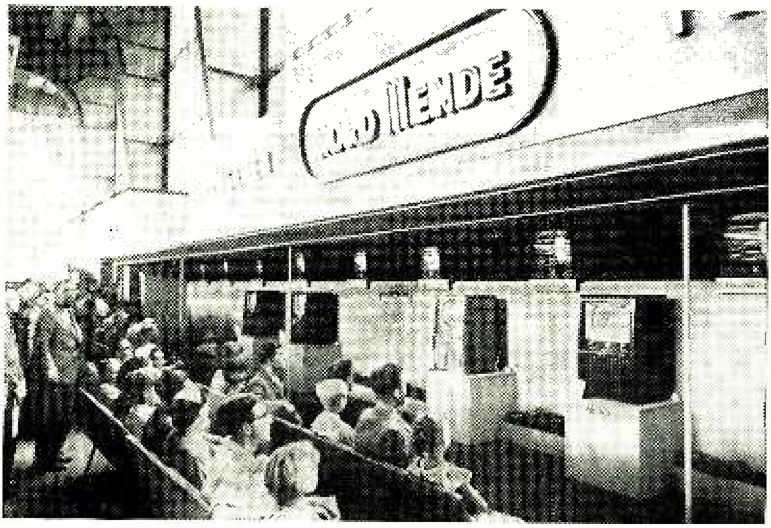

GERMAN

Correspondents' Impressions of Broadcast Receivers and Test Equipment at the Düsseldorf Exhibition

WHILE the British radio show was in progress at Earls Court, another exhibition, larger and more varied, was taking place on the bank of the Rhine at Düsseldorf. A tour of the stands, and conversations with the helpful and enthusiastic attendants, soon showed that real development had taken place in German vision and sound radio since the last exhibition in 1953.

Owing to the post-war lack of medium-wave channels the German v.h.f. service in Band II has expanded more rapidly than in Great Britain, and trends in Germany may well influence future design here.

All German receivers must now be approved by the Post Office as sufficiently free from radiation, and the cheap designs of the immediate post-war years have disappeared. The v.h.f. input circuit used in nearly all receivers consists of a neutralized triode r.f. amplifier followed by a self-oscillating triode frequency-changer. Further, to reduce radiation, the output from the r.f. amplifier is coupled into the frequency-changer grid circuit at a tapping point of low oscillator voltage.

Ratio detectors are now used in all receivers, often with germanium rectifiers. The standard i.f. of 10.7 Mc/s is used except in combined sound/television receivers, which have an i.f. of 5.5 Mc/s, the TV sound being produced by the difference-frequency principle to be mentioned later.

Multiple Loudspeakers.—There is great interest in high-quality reproduction, resulting from the introduction of v.h.f. and of high-quality records. Most receivers, including table models, have more than one loudspeaker, spaced round the front and sides of the cabinet. The intention is to diffuse the sound into the room, and also, with the larger assemblies, to give a three-dimensional effect. Six loudspeakers are used in some radio-gramophones, including electrostatic types for the higher frequency range.

Practically no receivers are without a v.h.f. range. Most cover v.h.f., medium and long waves, or v.h.f., short, medium and long waves. Interest in medium-wave reception, despite the heavy interference on many German frequencies, is shown by the fitting in some receivers of ferrite rod aerials, rotatable by a control knob on the front panel.

The German television standard is 625 lines and f.m. sound. The total channel width is 7 Mc/s, and the separation between sound and vision carrier-frequencies is 5.5 Mc/s. This higher definition system probably accounts for the larger screen sizes popular in Germany, the tendency being to concentrate on 17-in and 21-in tubes, while two models with 27-in tubes were on show, the picture tubes being American. Certainly the larger screens could be comfortably viewed at a distance at which the lines would have been prominent on the 405-line standard.

Television Receiver Design.—German television is transmitted on a number of channels in Bands I and III, and turret tuners are generally fitted. Many receivers use cascode r.f. amplifiers and careful screening is used to prevent oscillator radiation. A common wide-band i.f. amplifier is employed for both sound and vision. It appears that earlier designs using a separate i.f. chain for sound had given trouble because of oscillator drift on Band III which caused detuning and distortion of the f.m. sound. The difference-frequency system is now commonly used, by which the sound and vision i.f.s are amplified together and applied together to a diode detector. The products of rectification include the video frequency signal, and the beat frequency of 5.5 Mc/s between the sound and vision carriers. This frequency of 5.5 Mc/s, which is dependant only on the difference between the sound and vision r.f. carrier frequencies, is filtered out and fed into the f.m. sound circuits.

At the moment there are rather fewer than 200,000 television receivers in use in Germany, and a rapid increase is expected. The German manufacturers are also very interested in the export market, and at least two firms had on show a 4-standard receiver which would receive 819- or 625-line systems, with positive or negative vision modulation, a.m. or f.m. sound, to suit the several systems of Northern France, Holland and Belgium.

Internal rotatable aerials are fitted in these receivers. They consist of a butterfly-shape of metal foil on an insulated disc about 20in across, mounted under the top of the cabinet with a small projection backwards for rotation; with the cascode r.f. stage they appear to give very satisfactory reception in regions of good field-strength. However, I noticed that the German Post Office stand featured a display stressing the

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desirability of an external aerial to combat interference.

Band IV Television.—It is expected that Bands I and III will be fully occupied by television within two years, and plans are already being made for operation in Band IV. Several television receivers have space ready for a Band IV convertor, and in at least one receiver, one position of the turret switches the cascode r.f. stage and the pentode mixer to straight-through operation at the i.f. Thus, when a Band IV convertor is fitted, a high-gain low-noise i.f. amplifier will be available.

There was a larger variety of radio-gramophones and tape-recorders than at Earls Court, including massive instruments that include both functions. However, the only item of particular technical interest was the Tefifon.

Tefifon recordings are in the form of a spiral groove on an endless belt or tape of flexible plastic, rather less that one inch wide. A special diamond pickup head is employed and the tape speed is 19 cm/sec. The maximum duration of the recordings is four hours. Any desired part of the recording may be selected by moving the pickup head across the tape, and no rewinding is required.

A comprehensive display of v.h.f. aerials was on show, particularly for Band III. At one stand an enquiry whether they had much demand for the erection of Band I aerials elicted the reply, "*Nein, Gott sei dank!*" But, if they did not like working on large Band I aerials, they did try to meet any requirement on Band III. Yagis with up to ten elements are available with a bandwidth of one channel (7 Mc/s), in vertically stacked pairs to reduce interference from below, and side-by-side to reject reflections from the side. Vertically stacked dipoles backed by a reflector plane of wires are available for locations with strong interference or reflections from behind, and these aerials have the advantage of a wide bandwidth.

TEST AND MEASURING GEAR

THOUGH the Düsseldorf show was predominantly a display of domestic broadcast receivers, many of the foremost German instrument firms were represented. One of the senior firms in the German instrument industry is Rhode & Schwarz, whose products are now becoming known in this country. In quality of workmanship their gear is equal to anything made anywhere in the world, and their range includes instruments rarely encountered in other catalogues. Amongst them are a variety of signal generators covering the v.h.f. range with disc seal triode valves and going right through the microwave region with klystron generators. In fact, signal generator coverage can be given from 1 Mc/s to 20,000 Mc/s with varying types of modulation. Other items seldom seen in Britain were field-strength measuring sets covering the range up to 1,000 Mc/s and a calibration receiver of instrument quality in the same frequency band with an aerial system for which remote drive for orientation is provided. V.H.F. impedance and power measuring devices were also well represented. The general impression of the firm is one of immense technical competence.

Medium-priced Equipment.—A smaller firm and one less known to most of us is Klemt. Here prices are below the dizzy heights of Rhode & Schwarz, and the equipment, while still very well made and finished, has not quite the same air of *haute couture*. Technically the range is most interesting and the majority of the exhibits fit neatly into gaps in the British manufacturers' ranges. The most ambitious instrument is a factory production limit bridge which automatically sorts capacitors into five tolerance groupings at the rate of 2,600 an hour. A close relation to this is an automatic balancing 1-Mc/s capacitance bridge which also measures small phase defect angles. The Klemt range proceeds through a variety of television wobbulators with built-in markers, display and pattern generators and a rather fine flying spot scanner, to equipment with more appeal to the servicing technician. Foremost here is a television field-strength meter covering 40-225 Mc/s with a voltage range of 5 μV-100mV/metre. This, while being comparatively low in price, has sufficient performance to make it suitable for many other uses.

Another of the big names in German test gear is Siemens and Halske of Munich. Their exhibits were confined to a few oscilloscopes on the Siemens radio stand, although their range is probably the most comprehensive in Germany, particularly in the audio and carrier telephony frequency range.

There was a large number of firms showing such things as multi-range meters, valve testers and comprehensive service kits—little attaché cases containing a meter, a small generator, an oscilloscope and a range of trimming tools. Most of the instruments shown in this category have British-made equivalents.

V.H.F. Signal Generators.—In view of the leeway that Germany had to make up after the war in the v.h.f. and microwave fields, the number of instruments available compared with the variety in this country is most surprising. The early start with an f.m. broadcasting system, on the other hand, is well reflected by the comparatively wide choice of f.m. signal generators. The general standard of manufacture and finish is at least as good as our own and in one or two cases rivals the best available here. Prices vary enormously from the expected in both directions, but tend on average to be high. Deliveries are rather better than we normally expect over here.

Represented on the Telefunken stand were Hienz Gunther Neuwirth with a range of f.m. signal generators. A few of these are already in use here and are highly thought of. One of them, the MS4/U, covers the useful frequency range of 4-250 Mc/s on fundamentals and is one of the best liked examples of that rare breed, the professional quality f.m. signal generator.

Diversity of Standards.—One disadvantage of buying German instruments in this country lies in the different standards used. The standard r.f. output impedance, for example, is 60 Ω and, although easy enough to pad up, is rather a nuisance, while the standard r.f. plug is yet another to add to one's already large collection of conversion leads or adaptors. All instruments have frequency calibrations in Hertz or

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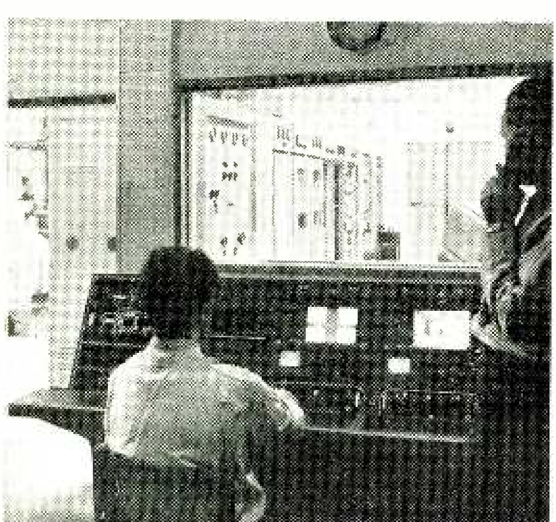
MHz (where fortunately the conversion factor is simple!) but many have controls marked in nepers, which is not so good. To set against these drawbacks it should be said that the German manufacturers are far more willing to meet one's requests for detail changes than are the majority of British firms.

The general conclusion would seem to be that we are much better served by our own industry in the choice of everyday instruments such as valve voltmeters and audio oscillators, but that the German technician has a much greater chance of buying an instrument for a rather unusual measurement or in an "unpopular" frequency band.

I.T.A. London Transmitter

SIGNALS radiated from the new commercial television station at Beulah Hill, Croydon, are on exactly the same standards as the B.B.C. transmissions, but the method of producing them is somewhat different because of the much higher frequency (194.75Mc/s vision). Coaxial line techniques are used for the r.f. amplifiers, and the valves are mounted inside vertical cylinders looking rather like drain-pipes which constitute the tuned circuit elements. The r.f. section of the vision transmitter actually comprises a crystal drive unit, two triode r.f. amplifiers working in earthed grid circuits, a tetrode modulated amplifier and a final triode amplifier which handles the modulated signal and gives an output of 10kW peak. The valves are air-cooled.

On the video side, the incoming signal from the studios, after passing through various amplifying, control and correction circuits, goes to the modulator, where the actual process of modulation is done on the grid of the tetrode r.f. amplifier by a cathode follower output stage. The black level of the signal is maintained constant by means of a feedback circuit which monitors the amplitude of the transmitted sync pulses



The control desk at the station, with the actual transmitter seen through the window.

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 18th. The subsequent issues will continue to appear as scheduled on the fourth Tuesday of the month.

(at a point in the aerial feeder) and uses this information for correction purposes.

The outputs from the 10-kW vision transmitter and the $2\frac{1}{2}$-kW sound transmitter are fed to a combining unit in the transmitter hall which also contains a vestigial sideband filter to give the correct characteristics. From there the signals go by feeder to the eight-stack aerial array, which is mounted on a mast at a height of 175ft and has sufficient gain to give an effective radiated power (on vision) of 60kW. The height of the transmitter site itself is actually 375ft.

Marconi's, in collaboration with I.T.A. engineers, have designed the transmitter, and it is actually the prototype equipment which they have installed because of the extremely short time available to do the job—seven months since February. A standard production model will follow later. Film scanning equipment made by Cintel has also been put in, to provide local programme material if there is a failure of the video signal coming from the studios.

Commercial Television Studios

WHEN advertisers are paying several hundred pounds a minute for "spots" on commercial television the need for split-second timing of programmes is of paramount importance. The facilities needed to achieve this are perhaps the most outstanding feature of the equipment which Marconi's have installed at the Wembley studio centre of Associated-Rediffusion (the Monday-to-Friday programme producing company in London). The process of switching from camera to camera, for example, is all done by relays under the control of a bank of push-buttons, and the person in charge of "vision mixing" has to develop much the same kind of skill as a typist or calculating machine operator. Moreover, because of the large number of filmed inserts used in programmes, it has been necessary to provide the "vision mixer" with a very rapid means of bringing in the film-scanning equipment, and this is done by a remote control system, again worked by push-buttons.

Such is the precision demanded for changing programmes on time that apparently the human operator is not to be relied on, and eventually the job will be done automatically by a time switch!

In the same room as the main film scanners (made by E.M.I.) is another equipment (R.C.A.) in which either films, slides or caption cards can be scanned by a small Vidicon camera. A whole succession of caption cards (or even solid objects) can be fed through it automatically on a belt, like cartridges going into a machine-gun, while the slides are presented in succession on rotating discs—the complete mechanism

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being again under remote control. Further speed of operation is achieved with yet another remote control system for raising and lowering studio lamps on telescopic mountings, while on the sound side the gramophone turntables have optical calibration systems which enable the pick-up to be lowered straight into a groove selected beforehand.

Image orthicon cameras are used throughout (incorporating the improved 4½-in pick-up tube described in our May, 1954, issue) and with these it has been possible to utilize fluorescent lighting a good deal.

Another important feature of the Wembley establishment is its structural planning and layout. The four studios (five eventually) are arranged on either side of a long, central section built in three storeys which contains all the control rooms and, in fact, the entire technical installation and its staff. This technical "nerve centre" is therefore kept very compact and isolated from the programme production activities, but at the same time is well placed to see what is going on.

Vision control room for one of the studios. Here pictures are selected from the cameras and also from the film-scanners, which can be remotely controlled from this position.

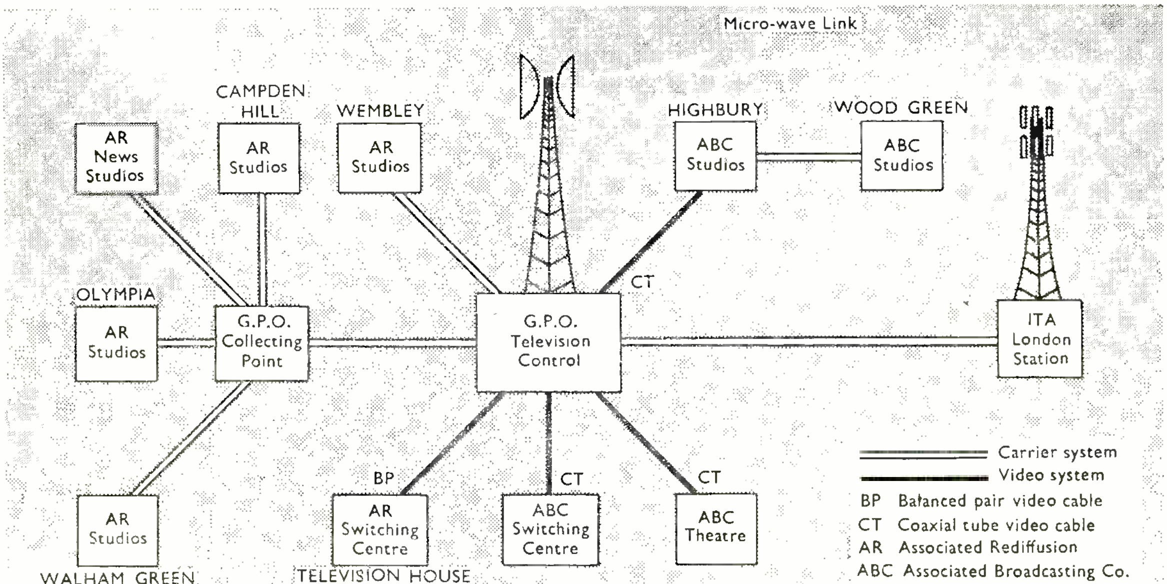
Distributing I.T.A. Programmes

WHEN the B.B.C. extended its television service to the provinces the Post Office established a control centre in London to look after the complicated network of lines, cables and radio links connecting the various studios, o.b. points, and the transmitting stations. Through this centre, located in the Museum telephone exchange buildings, passes practically all the B.B.C.'s television programmes. With the inauguration of the I.T.A.'s service its programmes will also pass through this centre.

A further network of lines and cables connecting the studios of the new programme companies and the London transmitting station has, therefore, been built up and some idea of the complexity of this new network can be obtained from the accompanying schematic drawing. It does not, however, give quite an exact picture as some of the links consist of multiple cables containing either coaxial tubes or balanced pairs. The system of transmission over the cables will be either a modulated carrier centred on about 6 Mc/s or the actual video signal. Where the carrier system is used, as shown by the twin-line connecting links in the diagram, the lower sideband only will be transmitted with complete suppression of the carrier. The bandwidth of the system is 3 to 7 Mc/s.

The microwave relay system set up to carry the B.B.C.'s television programme to the Midlands before the coaxial cable was laid, and which was described in the December, 1949, *Wireless World*, is being renovated and brought up to date so that it can be used when the I.T.A. opens its Midlands station.

Schematic drawing of the G.P.O. programme distribution system planned for the I.T.A.



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WORLD OF WIRELESS

450-Mc/s Band for Mobile Radio ✦ American TV Stations ✦ V.H.F. Broadcasting ✦ S.O.S. Alarm Signal

U.H.F. Mobile Radio

THE Ministry of Transport and Civil Aviation has been asked to vacate at an early date part of the 420-460 Mc/s band (at present used for radio altimeters) as it is needed for private mobile radio and other services. Initially the top 10 Mc/s only are to be used for mobile radio.

At the Atlantic City conference this band was allocated, so far as the European region was concerned, to aeronautical radio-navigational aids and amateurs, priority being given to the first. It has, however, always been understood that the radio-altimeter service would be transferred to bands around 2,000 and 4,000 Mc/s when suitable equipment became available.

So far as amateurs are concerned, the Radio Society of Great Britain recently stated that it anticipated that eventually in this country the band 425-440 Mc/s would become an exclusive amateur allocation, whilst the 5 Mc/s below and 10 Mc/s above would be shared with other services.

U.S. Broadcasting Stations

ACCORDING to figures issued by the Federal Communications Commission there were 3,665 broadcasting stations operating in the United States at the end of July. Of this number 2,719 were medium-wave a.m. stations, 499 f.m. transmitters, 437 commercial television and 10 educational television stations. It is worth noting that 109 of the television stations are operating in the u.h.f. band (above 470 Mc/s) and that a further 119 of the 180 under construction will also operate in this band.

According to *Tele-Tech*, although only a handful of the commercial television stations can originate their own colour programmes, the majority of the 364 network stations operating in 241 cities are equipped to relay colour transmissions.

Applications for permission to build a further 209 a.m., 11 f.m. and 157 television stations were outstanding at the end of July.

Wrotham on Full Power

ALL three v.h.f. transmitters at Wrotham are now working on full power, the e.r.p. of each being 120 kW. During August the second half of the Home Service transmitter together with the aerial combining units were installed and the setting up of the final aerial arrangements completed.

The completion of the installation means a 3 dB increase in the effective radiated power of the Light and Third Programme transmitters and a 6 dB increase for the Home Service.

If present plans materialize, the stations at Pontop Pike (Co. Durham), Divis (Northern Ireland) and Meldrum (Aberdeenshire) will be brought into service by the end of this year. The three transmitters at each of the stations will have an effective radiated power of 60 kW.

Marine Distress Calls

AN internationally recommended alarm signal to improve the distress service on 2,182 kc/s is being introduced in this country. The signal consists of two tones (2,200 and 1,300 c/s) transmitted alternately each quarter of a second for up to one minute before the distress call. The first two British coast stations to be equipped with electronic equipment for generating and receiving the alarm were North Foreland and Niton which introduced the signal on August 16th when some French coast stations also started using it.

The alarm signal, which on vessels may initially be generated by means of a whistle, can be readily distinguished through heavy interference and can be used to actuate receiving equipment.

Authors' Awards

THE annual award of premiums to authors of papers published during the year in its *Journal* is announced by the British Institution of Radio Engineers.

The Institution's premier award, the Clerk Maxwell premium (value 20 gns) is to be presented at the annual general meeting on October 26th to F. N. H. Robinson, a research fellow at the Clarendon Laboratory, Oxford, for his paper "Microwave shot noise in electron beams and the minimum noise factor of travelling wave tubes and klystrons."

Dr. T. B. Tomlinson, formerly at the University of Southampton and now at the G.E.C., receives the Heinrich Hertz premium (20 gns) for "Partition components of flicker noise." The premium is awarded for the most outstanding paper dealing with the mathematical or physical aspects of radio.

For his paper "Problems of television cameras and camera tubes" L. H. Bedford (Marconi's) receives the 15-gn Louis Sterling premium awarded for the most outstanding paper on television technique.

The 15-gn Brabazon premium (awarded for a contribution on electronic or radio aids to aircraft safety) is shared by J. W. Jenkins, J. H. Evans, G. A. G. Wallace and D. Chambers, of Cossor, for "A high-definition general-purpose radar."

For his paper "Some factors in the engineering design of v.h.f. multi-channel telephone equipment" W. T. Brown, of British Telecommunications Research, receives the 10-gn Marconi premium (an engineering award); Dr. G. N. Patchett, of Bradford Technical College, receives the 10-gn Leslie McMichael premium (awarded for a paper on improvements in the technique of broadcast or television reception) for his contribution "A critical review of synchronizing separators with particular reference to correct interlacing"; and R. W. Walker, King's College, Newcastle-upon-Tyne, the 10-gn Students' premium for his paper "An electronic random selector."

The second award of the Sir J. C. Bose premium for a contribution by an Indian goes to S. Deb (Institute of Radio Physics and Electronics, Calcutta University) for "Decay of emission from an oxide-coated cathode due to adsorption of matter liberated from the anode."

The Institute has also awarded 20-guinea premiums for five papers read at the Industrial Electronics Convention held in Oxford in July last year.

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PERSONALITIES

Sir Robert Watson-Watt, F.R.S., has been appointed president and chairman of the board of Logistics Research, of Redondo Beach, Cal., U.S.A., manufacturers of electronic computors. Sir Robert has been in North America for some time and was appointed adviser on radar and electronics to the Canadian Defence Research Board in 1952.

Sir Leslie Nicholls, K.C.M.G., M.I.E.E., is relinquishing, at his own request, the chairmanship of Cable & Wireless, Limited, in January next; he is 60. A regular soldier from the age of 17½, Sir Leslie retired with the rank of Major-General shortly before his appointment to the board of Cable & Wireless in 1947. During the last war he served as chief signal officer in various theatres of war and after the invasion of Europe became deputy chief signal officer to General Eisenhower at S.H.A.E.F.

Captain Geoffrey C. F. Whitaker, R.N., has relinquished his appointment as assistant captain-superintendent of the Admiralty Signal and Radar Establishment, which he has held since 1952, and has become fleet electrical officer on the staff of the Flag Officer Commanding Reserve Fleet. Captain Whitaker, who had previously been at A.S.R.E. for two years, has served exclusively in the research and development field in his shore appointments since the war. He has been Admiralty representative on the I.E.E. Radio Section Committee since 1952, on which he is continuing to serve. As announced last month, he is succeeded at A.S.R.E. by Captain G. C. Turner.

Dr. David G. Tucker, since 1950 in the Royal Naval Scientific Service at H.M. Underwater Detection Establishment, Portland, has been appointed to the chair of electrical engineering at the University of Birmingham. Professor Tucker, who is 41, joined the Post Office research station, Dollis Hill, in 1934 where, in 1946, he was appointed head of the transmission measurements research group. He received his doctorate of science in 1948 from London University, where he obtained his Ph.D. and B.Sc. degrees. Twelve of his many contributions to the technical press have appeared in our sister journal *Wireless Engineer.*

Colonel A. H. Read, at present telecommunications attaché at the British Embassy in Washington, has been awarded the Marconi Memorial Medal of Service by the American Veteran Wireless Operators' Association. He was for 32 years in the Post Office and was at one time inspector of wireless telegraphy. At the time of his retirement from the Post Office last year he was director of overseas telecommunications.

J. D. Craggs, M.Sc., Ph.D., F.Inst.P., has been appointed to the Robert Rankin Chair of Electronic Engineering in the University of Liverpool, where he was formerly reader of electronic engineering.

During a tour of the United States, which he is beginning early in October, **P. D. Collings-Wells,** B.Sc. (Eng.), of Goodmans Industries, Ltd., will deliver a lecture on "Standards of acceptance for high-fidelity loudspeakers" at the New York Convention of the Audio Engineering Society. He will also lecture to branches of the Society. One of the objects of the tour is to promote discussions which it is hoped will ultimately lead to the formation of a set of standards governing minimum performance requirements for high-quality loudspeakers.

Appointments to fill the post of engineer-in-charge at two of the new B.B.C. television stations are announced. **J. J. Allen** goes to the Channel Islands station at Les Platons, Jersey, which is now nearing completion, and **W. Balfour** is appointed to Meldrum, Aberdeenshire. Mr. Allen joined the engineering equipment department of the B.B.C. in 1939 and since 1953 has been in the planning and installation department. Mr. Balfour has been with the Corporation since 1934, when he joined the staff at the Washford, Somerset, station as assistant maintenance engineer. He was previously at the G.P.O. station at Portishead. Since 1950 he has been engineer-in-charge at the studio centre and transmitter in Aberdeen, for which he will continue to be responsible. The B.B.C. also announces the appointment of **H. F. Bowden** as engineer-in-charge of the short-wave transmitter at Skelton, Cumberland, in succession to **S. A. Williams,** who has retired. Mr. Bowden, who joined the London staff in 1926, has been assistant engineer-in-charge at Skelton since 1945, having previously held the same position at the Rampisham, Dorset, short-wave station.

W. T. White, who has been with the Ferguson organization for more than 25 years and is now general works manager of the electronics division, and **C. E. Payne,** chief engineer of the division since 1945, have been appointed to the Board of the Ferguson Radio Corporation. **S. T. Holmes,** publicity manager of the Thorn group (which includes Ferguson), has also been made a director of the Corporation.

Christopher E. G. Bailey, M.A., M.I.E.E., has been appointed technical director of Solartron Electronic Business Machines, Ltd., and will act in a general advisory capacity on research and development work to the Solartron Electronic Group, of Thames Ditton, Surrey. He has been a consultant to the Group for some time and was largely responsible for the design and development of the Solartron radar simulator. He read physics at Balliol College, Oxford, where he was an exhibitioner, after which he joined the Gramophone Co. in 1928 for three years. He has since then been on the staffs of a number of radio companies, including Philips in Holland. He is 49.

A. T. Bardens, A.M.I.E.E., M.Brit.I.R.E., until recently engineer-in-charge, Radio Hong Kong, has joined Overseas Rediffusion, Ltd., as a senior engineer for appointment abroad. He was previously with Cable & Wireless and held various technical posts during 28 years' overseas service. Radio Hong Kong operates one short-wave and two medium-wave stations.

OBITUARY

Harold L. Kirke, who retired from the position of assistant chief engineer of the B.B.C. in 1952 owing to ill health, died on August 25th at the age of 60. He joined Marconi's in 1920 and was closely associated with the setting up of the Writtle experimental broadcasting station in 1922. He went to the B.B.C. in 1924 and in the following year was appointed head of the development department which later became the research department. Mr. Kirke was assistant chief engineer for two years before his enforced retirement. He was appointed C.B.E. in 1947.

OUR AUTHORS

R. E. Wyke, contributor of the article in this issue on small power valves, has been with the M.O. Valve Co., where he is now in charge of design and development, for just over 20 years. Since the war he has been mainly concerned with government work on improving valve reliability.

Herbert J. Fraser, who in this issue describes a simple circuit for reducing hum in receivers, has been on the engineering staff of Amalgamated Wireless Valve Co. Pty., Ltd., Australia, since 1944. He has of late been concerned with production engineering of transmitting

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and special valves and on the development of electronic equipment for valve production and testing. He received a diploma in radio engineering from the Marconi School of Wireless, Sydney, in 1944. He is 32.

WHAT THEY SAY

Subscription Television.—" It may not be generally known that the wired television systems we have developed have been designed so as to enable subscribers to receive additional programmes for an extra payment —through a coin box or otherwise. This method of subscription television, if introduced, will have the great advantage over any radio method of subscription television in that it will not be necessary to employ radio channels wastefully for the benefit of a limited part of the population."—J. S. Wills, chairman and managing director of Broadcast Relay Service, Limited.

Bonanza.—" If we made no profits whatever from selling [domestic] radio and television sets, we would still make sufficient profits in the other parts of our business to maintain our present dividends."—Pye Limited, report for 1954/55.

NEWS IN BRIEF

During July **Receiving Licences** for television increased by 49,161 and licences for car sets by 4,893 but " sound only " licences decreased by 22,227. Licences current in the U.K. at the end of the month were " sound " 9,061,008, television 4,725,583 and car radio 280,803.

The spring meeting of the Physical Society will be devoted to the subject of **Semi-conductors.** It is being organized by the B.T-H. Company and will be held at Ashorne Hill, near Leamington, from April 10th to 12th. The meeting is open to non-members on payment of a fee of 10s, but accommodation is limited to 150. Application forms are obtainable from the Physical Society, 1, Lowther Gardens, Prince Consort Road, London, S.W.7.

Elsewhere in this issue is a contribution from a Swedish correspondent on **Long-Distance TV Reception.** We have also heard from Invicta Radio, Limited, that a correspondent in Portugal who has been experimenting with a 1948 Invicta set has received B.B.C. transmissions on a number of occasions recently.

" Free Grid's " reference last month to the need for **Communal Television Aerials** to avoid the unsightly forests springing up in populous areas finds an echo in an announcement from Burntisland, in Fife, where each block of 39 houses is to have a communal aerial.

Is it the First? The Post Office has granted the Port of London Authority permission to install a point-to-point radio-telephone link between its Police Headquarters on the north bank of the Thames and its main transmitting station at Shooter's Hill, south of the Thames, previously linked by cable. Normally the Post Office stipulates one end of a private radio-telephone link must be mobile.

Science Museum Amateur Station.—An amateur radio station is to be set up in one of the demonstration rooms adjacent to the Communications Galleries at the Science Museum, South Kensington, London, S.W.7. The station is being designed by the Radio Society of Great Britain in collaboration with Gerald Garratt (G5CS) who is deputy keeper in charge of the Communications Department at the Museum. The station will be operated daily by transmitting members of the staff headed by G. Voller (G3JUL) who is assistant in the Communications Department.

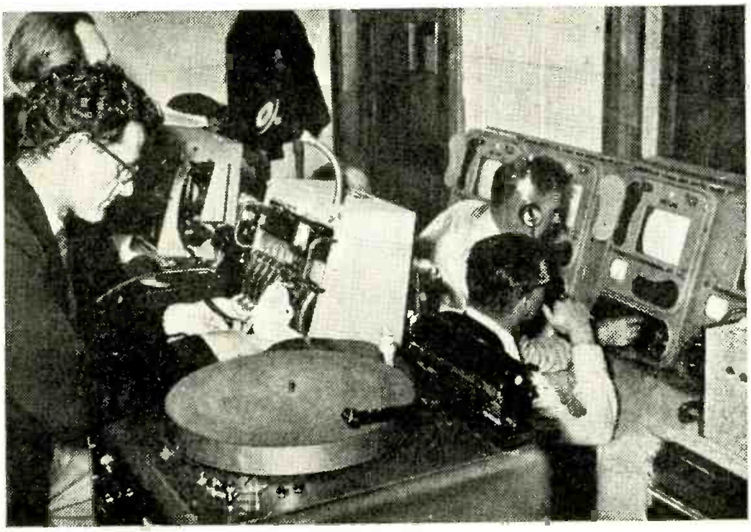
Films on Loan.—Club secretaries may like to know that there are a number of electronics and electrical films which can be borrowed free of charge from the Central Film Library of the Central Office of Information, Government Building, Bromyard Avenue, Acton, London, W.3. Among those recently added to the list are " The Electron Microscope " (18 minutes) and " Electric Induction Heating " (23 minutes). Both were sponsored by Metropolitan-Vickers. Also available under the same scheme are three films on capacitors, inductors and ammeters and voltmeters, sponsored by the Electrical Development Association.

At the commencement of his European tour, William Stern, manager of the international division of Brush Electronics Corporation, of Cleveland, Ohio, visited B. & K. Laboratories, in London. Mr. Stern announced that Brush are now growing **Quartz Crystals.** Although the manufacturing cost is about three times that of natural quartz, the resultant crystal is substantially pure whereas only 10 per cent of the natural mineral is usable.

Tickets for the exhibition " **Silicones for Industry,**" which is being held in Leeds (September 26th to 30th), can be obtained from Midland Silicones Limited, 19, Upper Brook Street, London, W.1. The exhibition, which covers the history, production and application of silicones, is being held at the Leeds Church Institute, 5, Albion Place, from 10.0 to 6.0.

Cable and Wireless, Limited, have acquired a new headquarters building at 110-124, Theobalds Road, London, W.C.1, which will be known as **Mercury House.** It will be opened towards the end of the year. The need for the company to find new offices arises from the continued growth of the Post Office's London Telegraph Station in Electra House, Victoria Embankment.

For some time **British Road Services** have been operating experimental radio-telephone services for the parcels collecting vans working in the Bristol, Birmingham, Leicester and Liverpool areas. A similar service (using equipment supplied by Pye Telecommunications) is now being operated in the London area. The fixed station (working on 85.925 Mc/s) is at the B.R.S. depot at Waterden Road, Stratford, E.15. The mobile sets operate on 72.425 Mc/s.



COMMERCIAL TELEVISION'S first studio—the Granville Theatre, Walham Green, South London—was converted for Associated-Rediffusion (the London Monday to Friday programme contractors) by Central Rediffusion Services Ltd. This control room, equipped with Marconi gear, is installed beneath the stalls.

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U.S.S.R. Television.—Another television station has been brought into service by the U.S.S.R. The new transmitter at Tallinn, Estonia, which has an e.r.p. of 100 kW, radiates on 59.25 Mc/s (vision) and 65.75 Mc/s (sound). This is the fourth major station in the Union, the others being at Moscow, Leningrad and Kiev. There are also a number of low-power stations in operation.

Amateur Courses.—In addition to those centres mentioned last month (page 443) as providing courses in preparation for the radio amateur examination, we have also been notified of the following:— Swarthmore Adult Education Centre, Woodhouse, Square, Leeds (Fridays), organized by the Leeds Amateur Radio Society, and the Central Evening Institute of Further Education at St. Thomas's Schools, Granville Street, Birmingham (Mondays). The Leeds course, which covers two years, started on September 23rd and that in Birmingham on September 12th. The fee for each is 15s.

A new electronics laboratory has been opened at the **North Gloucestershire Technical College,** Cheltenham, where, in addition to the higher and ordinary National Certificate courses, they are running an introductory and an advanced electronic engineering course.

Geoffrey Parr, the well-known secretary of the Television Society, is giving a course of six lectures on **Writing Technical Reports** at the Borough Polytechnic, Borough Road, London, S.E.1, on Thursdays at 6.30, commencing on October 20th. The fee is 10s.

The production of **Films for Television** will be covered in a course of seven lectures arranged by the British Kinematograph Society. Commencing on October 14th at 7.45 at 2, Savoy Hill, London, W.C.2, the course, for which the fee for non-members is 2gns, covers basic principles of television and cinematography, lighting, sound recording and film scanning. Full particulars are available from the B.K.S., 164, Shaftesbury Avenue, London, W.C.2.

Reference is made in the annual report of the Ministry of Labour and National Service to the **Technical and Scientific Register,** which is kept by the Appointments Service of the Ministry. During 1954 a total of 1,800 vacancies were filled from the register. At the end of the year there were nearly 4,000 names on the register.

I.E.E. Students.—The new officers of the London Students' Section of the I.E.E. are: chairman, M. H. F. Collins (B.T-H.); vice-chairman, K. W. E. Gravett (Post Office Research Station); hon. secretary, E. L. Jones (Edison Swan).

BUSINESS NOTES

Sylvania-Thorn C.R.T. Project.—Sylvania Electric Products, of the U.S.A., and Thorn Electrical Industries, who have already made arrangements for the joint development of colour tubes in this country, have now negotiated for the setting up of a joint concern for the large-scale manufacture of monochrome tubes in the U.K. Production is unlikely to start before the end of next year. It is stated that it is improbable that the firm will be members of the British Radio Valve Manufacturers' Association.

Sapphire Bearings, Limited, has recently taken possession of a new factory at Bletchley, Bucks, which, with its 15 automatic sapphire-point grinding machines, is claimed to be the largest sapphire engineering factory in the world. The company, which produces the Windsor "flame-fashioned" sapphire-tipped gramophone stylus, began business with one machine in East London in 1952.

International Aeradio, Limited, have been appointed consultants on communications to the Antarctic Aerial Survey Expedition to the Grahamland Peninsular which is being undertaken by Hunting Aerosurveys, Limited, for the Falkland Islands Dependencies. Besides advising on the equipment required for the Expedition I.A.L. are providing the staff to install and maintain it.

Ultra Electric, Limited, is to build a new factory covering about 120,000 square feet at Gosport, Hants, for the production of television receivers. The company, which began 35 years ago in one room in East-Central London, already has manufacturing floor space of some 175,000 square feet. A considerable area of the present factory space is devoted to the production of electronic equipment including the homing device, Sarah.

Ekco search radar for the detection of dangerous storm clouds is being used by the British Overseas Airways Corporation for the route-proving flights of the Bristol Britannia aircraft. This 3-cm equipment, with which clouds are detectable at a distance of up to 120 miles, will also be installed on the fleet of Britannias which the B.O.A.C. will operate.

A second Britannia flight simulator, which provides facilities for the entire flight crew to be trained on the ground, has been ordered from **Redifon, Limited,** by the British Overseas Airways Corporation.

Granada TV Network, Limited, programme contractors for the Monday-to-Friday service from the Lancashire station of I.T.A., are setting up the Granada Television Centre in Manchester. **Marconi's** are supplying five television cameras, teleciné equipment and control room gear for the centre.

Decca Radar, Limited, is to supply new radar equipment "incorporating special features to meet the operational requirements of naval vessels" for ships of the Royal Navy.

R.C.A. Photophone, Ltd., has moved its offices and works from Shepherds Bush to Lincoln Way, Windmill Road, Sunbury-on-Thames, Middx. (Tel.: Sunbury-on-Thames 3101.)

Simplex-Ampro, Ltd., manufacturers of ciné sound and vision equipment, have recently opened a service department at their offices at 167-169, Wardour Street, London, W.1.

OVERSEAS TRADE

Venezuela is to equip four of her main civil and military airfields with Decca Type 424 airfield control radar. Two Decca Type 41 storm warning radars have also been purchased to assist in the preparation of aviation weather forecasts.

Two examples of equipment for the control of guided missiles will be shown by the General Electric Company on their stand at the British Trade Fair, **Copenhagen,** (September 29th-October 16th) where they will also be exhibiting communications equipment and accessories.

Three vessels being built in Lübeck, Germany, for the Scindia Steam Navigation Company, of **India,** are to be equipped with Marconi radio communication and navigational equipment.

Radio equipment selected by the Council of Industrial Design for showing at the German Industries Exhibition, **Berlin** (September 24th-October 9th), includes Decca's Deccalian record reproducer, Ekco's "Stroller" mains/battery portable, a Ferranti 17-in console television receiver and Imhof's "Trolleygram" incorporating a Pye amplifier and Collaro transcription unit.

Forty-six air navigation beacons and communications transmitters have been ordered from Redifon, Ltd., by **India**'s civil aviation department. Thirty similar radio installations have already been supplied by Redifon for use at Indian airfields.

A contract awarded to Marconi's by the **Iranian** Ministry of Posts, Telegraphs and Telephones calls for the supply and installation of dual diversity receiving equipment for the country's external radio-telephony and telegraphy service.

Jorge J. Larach y Cia., San Pedro Sula, **Republic of Honduras,** have informed the British Legation at Tegucigalpa that they are interested in importing British broadcast receivers.

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Radio Show Review

THIS YEAR'S TRENDS IN VISION AND SOUND BROADCAST RECEIVERS—AND SOME HIGHLIGHTS

In the following pages the technical staff of "Wireless World" reports on tendencies in design in those branches of radio most fully represented at the National Radio Exhibition. At this year's show, interest centred on receivers for television and V.H.F. sound broadcasting. A survey of aviation radio equipment shown at the Farnborough Exhibition appears after this review.

HOWEVER much television sets may differ from one another in detail they are rapidly becoming standardized in their basic form. Nearly all sets now have a multi-channel tuner for Bands I and III which includes a cascode r.f. stage and a triode-pentode frequency-changer. There are usually two, but sometimes three, i.f. stages in the vision channel and one or two in the sound, the intermediate frequencies being 34.65 Mc/s and 38.15 Mc/s, the new standards, or very close to them. There are diodes for detection and interference-limiting, one or two video stages and one or two audio stages. For the rest, there is a main sync separator and usually a line and frame pulse separator, the timebases and the power supply.

Timebase circuitry is more nearly standardized than anything else. The use of flyback e.h.t. and h.t. boost is universal and it is remarkable how detailed improvements in design have enabled the output to be increased. Tube sizes and operating voltages are steadily increasing and yet can still be scanned and the voltages obtained from what is basically the same circuit.

The improved performance comes about through a gradual reduction of losses. It is fundamental that in essence scanning does not require power, but it does need energy. The whole point of modern circuits is that the energy supplied to the deflector coil can be largely recovered. The only power needed is to supply the unavoidable losses in the copper of coils, the iron of cores, the anode dissipation of valves and, of course, the e.h.t. Improvements in the detailed design of deflector coils, transformers and valves have reduced the losses and enabled a considerable improvement in performance to be secured.

The use of ferrite cores for transformers and deflector coils is now quite general and the auto-transformer is preferred to the double-wound transformer. Several firms, however, adopt the so-called direct-drive circuit in which the transformer as a coupling element to the deflector coils is eliminated. A transformer for e.h.t. is still needed, however, and its primary serves as an energy store to permit h.t. boost to be obtained.

A typical circuit of this nature is shown in Fig. 1. The two parts of the line deflector coil are L_1 and L_2 with the linearity control L_3 connected between them. This operates in the now usual manner by controlling the degree of saturation of a ferrite-cored coil by a permanent magnet. The width control operates by introducing loss in the circuit to reduce the width below the maximum possible. With an h.t. line of 215 V full scan of a 17-in tube at 11.75 kV

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is obtained. The supply voltage for the output valve is 390 V, so that the boost obtained from the energy-recovery circuit amounts to 175 V.

A supply for the first anode of the tetrode tube is obtained from a tapping on the deflector coil *via* a non-linear resistance R.

As a contrast, the auto-transformer type of circuit is shown in Fig. 2. With an h.t. line of 200 V a 17-in tube operating at 14 kV can be scanned, the mean anode current of the driving valve being 100 mA, so that the power input is only 20 W. A boost of 250 V is obtained. The deflector coils are L_1 and L_2 and linearity is controlled by the saturation of L_3. The width control is L_4.

The drive for the output valve is a saw tooth form and in the case of both Figs. 1 and 2 is obtained with one extra valve which forms with the output valve a multivibrator. This is, however, hardly a general practice and a separate saw tooth generator is more usual. Ekco use a blocking oscillator, while McMichael adopt a multivibrator for which a triode-pentode is used.

On the frame side, energy recovery is not practicable and the power needed is much less because of the relatively slow repetition rate. The output valve is a pentode with some form of negative feedback for linearizing the circuit. The saw tooth generator is generally a multivibrator, although sometimes a blocking oscillator is used and occasionally a thyratron.

The increased use of the double-triode or triode-pentode as a multivibrator both in line and frame sawtooth generators is quite marked this year.

Synchronizing methods remain much the same. The line timebase is usually locked by a pulse from the main sync separator and there is some form of frame pulse separator in the feed to this timebase. A slight increase in the use of flywheel sync is evident. Bush, for example, now include it in all the new models. A well-known form is used with a phase-discriminator comprising a pair of diodes fed in push-pull with differentiated sync pulses and in parallel with a saw tooth from the line output circuit. The integrated output is applied as bias to the grid of one valve of the multivibrator line-sawtooth generator.

Kolster-Brandes use quite a different arrangement in which a sawtooth from the blocking oscillator is mixed with the sync pulses and applied to a cathode-follower type detector.

On the frame side there is very little uniformity

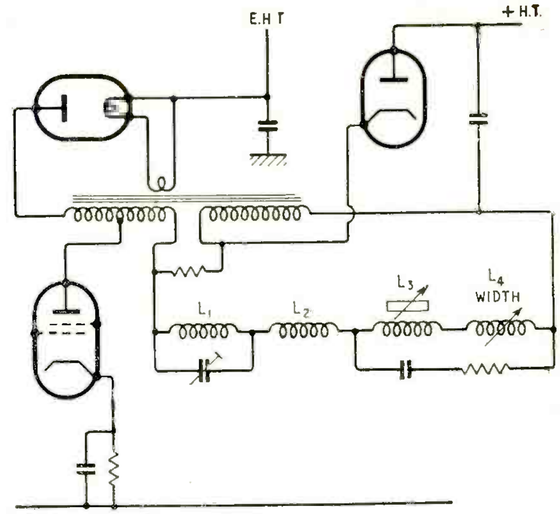


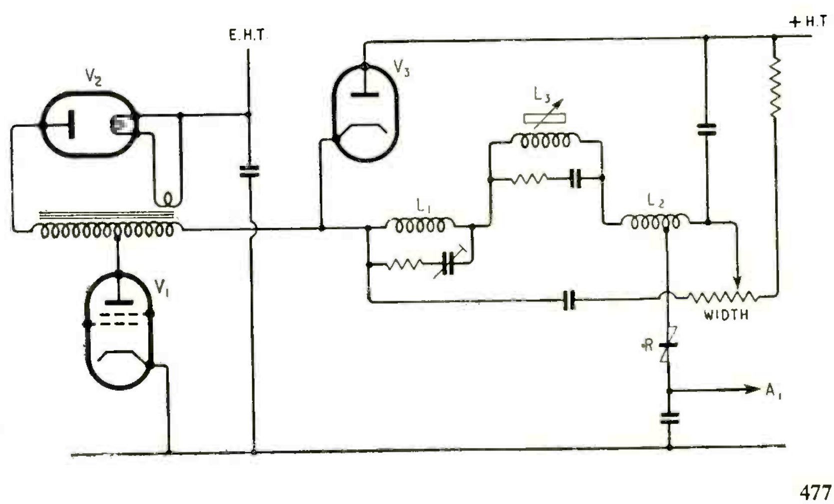
Fig. 2. Line output circuit of Ultra VT9-17.

in the methods adopted for separating the frame and line pulses. The integrator, usually combined in some way with diodes, is still a favourite, mainly because it tends to make the frame synchronizing less likely to be affected by noise and interference than some other methods. Bush adopt a simple arrangement which is virtually a double integrator with a biased diode for the resistance element of the second section. This gives this section a short charging time constant and a slow discharge time constant.

The short time-constant integrator fed through a diode and with a second limiting diode is still quite often used, but G.E.C. adopt a differentiator with diode limiter. One thing is quite certain: designers are by no means agreed on the best way of achieving frame synchronization.

Video stages are, in the main, unaltered. Most sets have one pentode. However, there is a slight tendency evident to follow the video amplifier by a cathode-follower. When this is done the two valves are combined in one envelope as a triode-pentode. There are two reasons for this. It enables a lower output impedance to be obtained which is useful in certain a.g.c. circuits. It will be remembered that Pye adopted a cathode-follower output stage some years ago for this reason. However, it also increases the video gain. This is rather unexpected for the

Fig. 1. Basic circuit of line output stage of Murphy V240 and V250.



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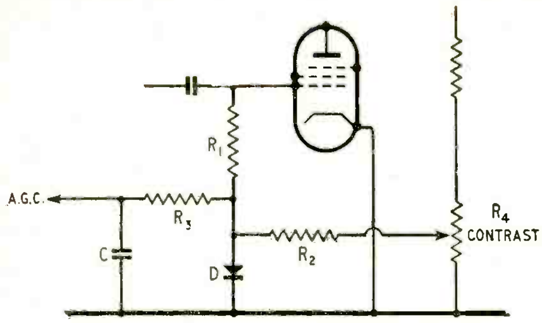


Fig. 3. A.G.C. circuit of G.E.C. set.

cathode-follower is noted for giving under unity gain The point is that by removing the tube capacitance from the video coupling the video stage gain can be so increased that it more than offsets the cathode-follower loss.

One change this year is an increase in the number of sets fitted with a.g.c. This is one result of the advent of alternative programmes but is also desirable to minimize fading and it can help to reduce aircraft flutter. It is, of course, doubtful whether a.g.c. will be effective enough to prevent some adjustment of contrast being desirable when a change from one station to another is made, but at least it does reduce the amount of adjustment needed.

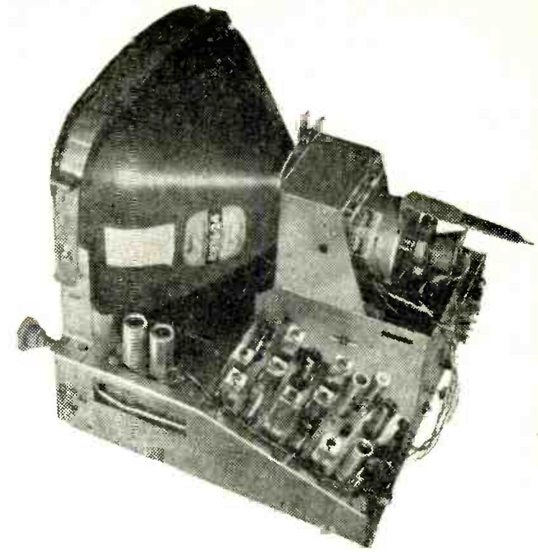
True gated a.g.c. systems, which do not affect the black level, are still in the minority. Most operate by utilizing the mean bias voltage developed on the grid of the sync separator. This results in a tendency for the system to keep the mean brightness of the picture constant, which is equivalent, apart from the gain-control action, to reducing the d.c. component of the signal.

It is, however, very rare for the d.c. component to be fully retained and most designers consider it desirable to remove a considerable part of it. This is a very debatable matter on which strong views are held on both sides and one in which, if one may judge by the trend of practice, the supporters of the d.c. component are losing ground.

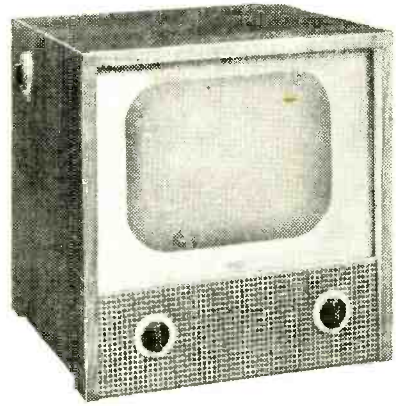
Kolster-Brandes use a constant mean-level system, but employ a separate diode to develop the control voltage. It is applied to two of the three i.f. valves and, delayed, to the r.f. stage. The amount of i.f. stage bias is limited. As a result, on weak signals the control operates chiefly on the i.f. stages to keep the signal-to-noise ratio at a maximum. On moderate signals it functions on both i.f. and r.f. stages, while on strong signals, the i.f. gain is reduced to a fixed minimum and further control is effective only on the r.f. stage to avoid overloading.

A further refinement is the interconnection of the vision and sound channel a.g.c. systems so that if the vision transmitter ceases to operate the sound signal takes charge and prevents the vision-channel gain from rising unduly.

G.E.C., on the other hand, use a very simple arrangement in the BT2889. This is sketched in Fig. 3. The sync-separator grid leak is split into two parts R_1 and R_2. The a.g.c. voltage is taken from the junction. The diode is biased through R_2 from the potentiometer R_4 forming the contrast control. Until the signal is strong enough for the sync separator grid current to exceed the current through R_2, determined by the setting of R_4, the diode D conducts and short-circuits the a.g.c. voltage. When the signal exceeds this the diode becomes non-conductive and an a.g.c. voltage dependent on the mean sync separator current through R_2 becomes available. This is filtered by RC and applied to the r.f. grid. A manual i.f. gain control is provided.



Decca television receiver chassis.



Peto-Scott TV1416 14-in. table model.

Bush use a similar arrangement in which a fraction of the sync-separator voltage is applied *via* a contrast-control potentiometer to the r.f. stage and one i.f. stage.

By no means all designers are convinced of the need for a.g.c. and quite a lot of sets do not have it. Any need for contrast re-adjustment when switching from one station to another can be avoided by switching pre-set manual gain controls. Murphy do this. The r.f. stage has two cathode-bias resistances, labelled sensitivity, one of which is switched into circuit for Band I and the other for Band III, and adjusted to equalize the signals on the two bands.

Gated a.g.c. systems, with which the black level can be fully retained, are less often used. Ultra still employ the frame-gated system described in last year's report and in their fringe-area models G.E.C. use a line-gated system. Ekco have adopted a line-gating circuit the essentials of which are shown in

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Fig. 4. Positive-going pulses from a tapping on the line timebase output transformer are applied to D_1 through the differentiating circuit C_1R_1, the resistance also providing a bias for D_1 and acting as a contrast control. The pulses are also applied through R_2C_2 to the anode of the video stage to black out the line flyback.

Because of the differentiation in C_1R_1 each pulse after C_1 is followed by a negative-going pulse coinciding with the back porch of the video signal, which is at black level. This negative pulse makes D_1 conduct, and being coupled to D_2 through C_3 it pulls down the cathode of D_2 and makes this diode conduct also. In effect, therefore, C_3 becomes connected *via* both diodes between the video anode and the input capacitance C_4 of the a.g.c. filter, so that C_4 is charged to the potential of the video anode, which is dependent on the prevailing black level, less the voltage to which C_3 is charged. This last voltage is dependent on the settings of R_1 and R_3 which govern the precise conduction conditions of D_1 and D_2.

On sound, a.g.c. is almost invariably used and differs in no way from the conventional methods of purely sound sets.

One result of the adoption, already noted, of the standard intermediate frequency of 34.65 Mc/s for the vision channel is an increase in the number of sound rejection circuits. This is probably the only objection to this frequency which otherwise has many advantages. In some sets every i.f. coupling now has at least one trap, for the sound signal of the adjacent channel must be considered as well as that belonging to the picture.

As an example, the McMichael sets have two traps in the second i.f.-detector coupling, which is basically a coupled pair. The traps are tapped coils capacitively coupled to the filter coils. The secondary trap is for own sound and the primary trap for adjacent sound rejection. Between the two i.f. valves there is another coupled pair each with traps tuned to own sound rejection, the primary trap acting also as a sound channel pick-out circuit.

There are two i.f. stages with three coupled pairs, three traps tuned for own and one for adjacent channel sound rejection. One i.f. stage is common to both sound and vision channels. A 6-dB bandwidth of about 2.7 Mc/s is claimed with 40-dB sound-channel rejection.

The precise forms of the intervalve couplings and traps vary very much. There is undoubtedly a marked tendency to use coupled pairs of circuits as intervalve couplings instead of stagger-tuned single circuits. Designers' preferences in the matter of traps fall into two main groups as illustrated in Fig. 5. The shunt trap at (a) usually has a 3-pF coupling capacitor with which the inductive reactance of LC resonates to form a "short-circuit" across L_2. In (b) the trap is in series with L_2 and the input capacitance of the valve; rejection occurs at parallel resonance when LC has a high impedance and tends to isolate L_2 from the valve.

Other methods are used. The trap may be coupled to the main coils or it may be used as a top-end coupling element between the primary and secondary of the intervalve coupling.

As said earlier, the basic arrangement of the tuner is virtually a standardized one and is very much the same as in last year's two-band sets. Nearly all sets are now two-band, of course, but in spite of the standardization of the basic circuit there is great variation in detail, especially in the method of station selection.

The basic circuit is that of a double triode as a cascode r.f. stage with a triode-pentode as frequency

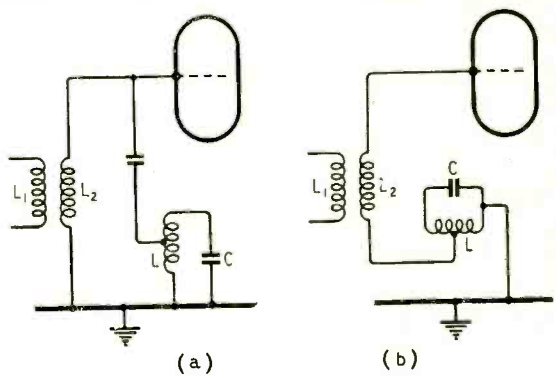
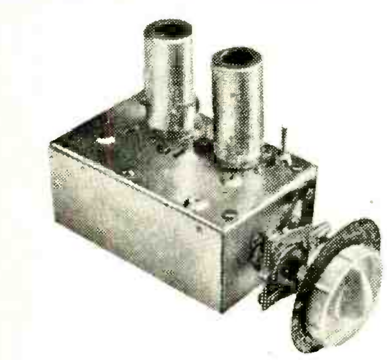


Fig. 5. Typical forms of sound-channel rejectors.



Valradio turret tuner which is available for conversions.

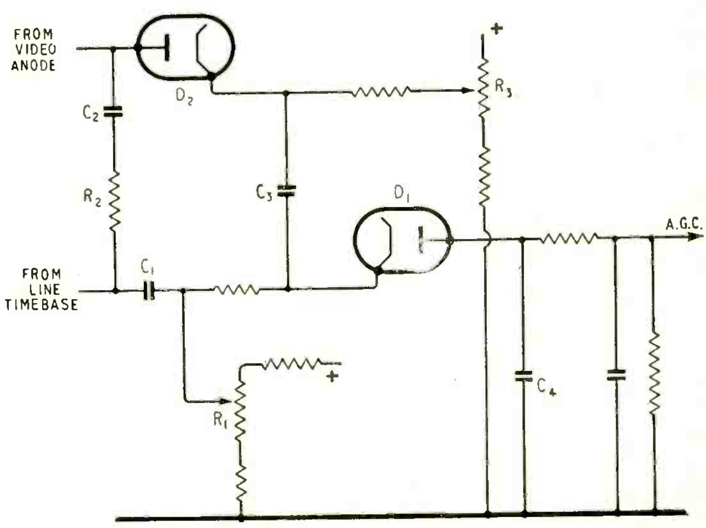


Fig. 4. Ekco line-frequency gated a.g.c. circuit.

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changer. In the cascode stage the first operates as an earthed-cathode stage and the second as an earthed grid. Invariably the anode of the first is connected to the cathode of the second through a small coil tuning with the valve capacitances to the upper end of Band III. This is to increase the gain at the highest frequencies where it would otherwise fall off.

The input is a single tuned circuit and there is often an i.f. trap in the feeder connections. The first triode is often, but not always, neutralized by a capacitance bridge circuit. The second triode is nearly always coupled to the pentode through a coupled pair of tuned circuits.

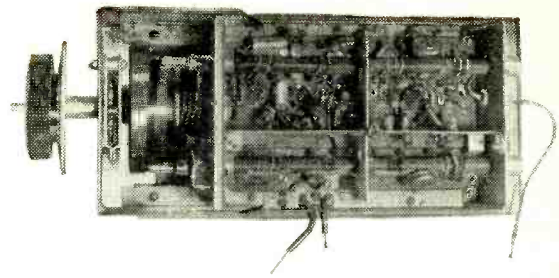
The oscillator is invariably a Colpitts. The coupling to the mixer grid varies somewhat. Often the oscillator coil is wound on the same former as the two intervalve coils so that the coupling is by mutual inductance. However, capacitance coupling is used nearly as often.

The main differences between tuners are in the arrangements for station selection. The turret tuner is probably the favourite but some other systems run it close. In the turret completely separate coils are provided for each channel and mounted in a revolving framework or turret. Each set of coils has its contact studs which press against contact springs when the turret is rotated.

A clicker mechanism stops the turret and holds it in the proper position and usually 12 positions are fitted so that 12 channels can be provided for. Usually, the coils for all these channels are not fitted and the set is supplied with coils for two or three channels only, appropriate to the area in which the set will be used. It is not envisaged that in the near future any receiver will be able to receive more than three channels. Additional coils are readily fitted, however, for they clip into the turret without soldering.

As will appear later this policy has the advantage of enabling a television set to be readily combined with f.m. sound reception, since some of the vacant turret positions can be used for Band II.

The second major method of station selection is by the so-called incremental-inductance tuner. In this, wafer switches are used, usually with 12 positions, and the coils are connected in series around the switch



Bush Telepic two-band tuner.

plate which short-circuits the unwanted ones. There is a small coil tuning to the highest frequency channel at one end of the chain; each switch step then adds a minute amount of inductance to change the tuning one channel at a time. Then a relatively big step is added to bring the tuning to Channel 5 and further smallish steps follow until Channel 1 is reached.

With this method all coils must be provided and alignment must always start with the highest-frequency channel and proceed in turn to the lowest.

A third system is to provide one set of Band I coils and another for Band III with a switch changing over from one to the other. Each set of coils is arranged to cover the whole of each of its bands, sometimes with composite metal and dust-iron cores. Some makers, G.E.C. for example, provide two such sets of coils for Band III and a three-way switch. The coils are then preset for any one Band I and any two Band III stations and the user has switch selection among three channels.

Others gang the cores and make them a user control. Bush do this, but provide the panel control with a clicker mechanism so that it moves the cores in preset jumps. At the appropriate place the band change-over switch is operated automatically. So far as the user is concerned the control is like that of a turret, but the internal mechanism is quite different.

In addition to the stepped movement for station selection the cores can be moved continuously over a small range by another panel control. This is for fine tuning and is provided mainly to permit the correction of any oscillator drift. Such a control is provided on all sets but with the other kinds of tuner it is usually in the form of a very small variable capacitance between the oscillator grid and earth.

A fair number of television sets this year permit reception of the f.m. sound transmissions on Band II. All the English Electric models, for instance, can be obtained with or without Band II. The television set rather lends itself to this, for its "front end" is already of a v.h.f. type and if it has a turret tuner it needs only Band II coils in the "blank" positions.

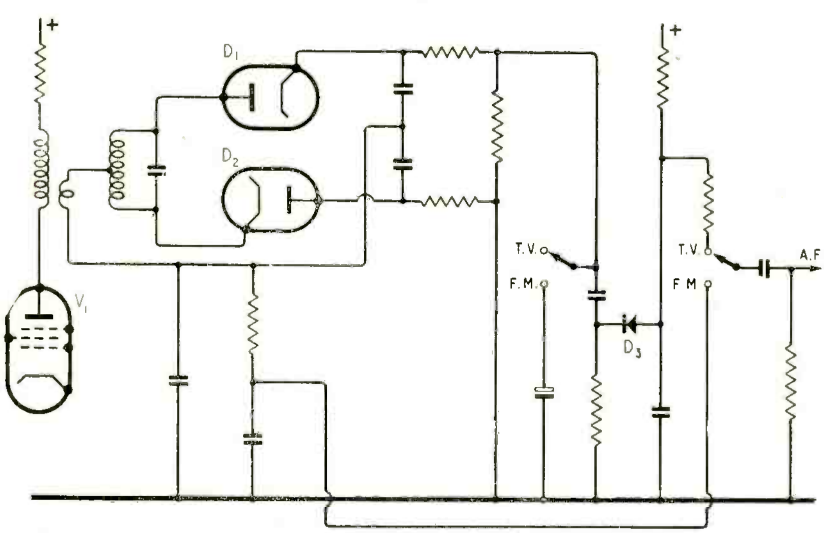


Fig. 6. Ekco sound detector circuits in the television and f.m. models.

(*Continued on page 481*)

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The sound i.f. amplifier is of ample bandwidth and the main addition is an f.m. discriminator.

The arrangement used by Ekco is shown in Fig. 6. V_1 is the second sound i.f. stage and feeds a discriminator with a double-diode D_1, D_2 ratio detector. For a.m. sound the two switches are changed over, disconnecting the ratio detector reservoir capacitance and altering the a.f. output point. The usual a.m. noise limiter D_3 is also brought into circuit.

Other linked switches alter the connections of the a.g.c. circuit and disconnect certain valve heaters on f.m., but the switching is all basically simple.

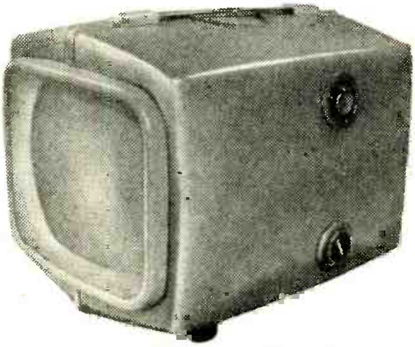
During the last year the 14-in tube has been the most popular size. Such sets are still widespread, but are somewhat outnumbered by the 17-in, and there are now quite a lot of sets with 21-in tubes. The 12-in appears to be on the way out, for only two or three models of the normal kind were on view. Murphy, however, showed a new 12-in design which might be called a transportable. It is extremely compact and has a carrying handle; it is intended for easy moving from room to room.

Ekco showed a mains/battery portable television set with a telescopic aerial and a 9-in tube. It weighs 30 lb and measures $10\frac{1}{2}$ in by 13 in by 15 in. It covers Bands I, II and III, and operates from a 12-V car battery.

One aspect of Band III which has not so far been mentioned is how owners of Band I sets are catered for. There are very many such sets, and most set makers have a range of convertors for their own earlier models. A range is needed because of the varying requirements of different sets.

Some convertors are merely attachments which feed into the aerial socket on the receiver and leave it quite unaltered; others are similar, but draw their power from the receiver and so require internal alterations to be made. Still others are virtually new front ends. The H.M.V., for instance, has a complete Band I and Band III tuner; the r.f. and frequency-changer valves are removed from the receiver and plugs fitted in place of them, so providing the power for the convertor and feeding into the i.f. amplifier.

Except for some very old models, it may be taken that conversion is possible and a suitable convertor is usually available from the makers of the set. There are, however, a number of general-purpose convertors. The Pam has preset tuning and operates to convert a Band III signal to the local Band I frequency. It has its own power supply, and it is noteworthy that a four-section filter is included in the i.f. output in an endeavour to separate the frequencies generated by the two oscillators, the one in the convertor and the one in the set.



Murphy V230 12-in table model.

Channel Electronics also have a range of convertors and pre-amplifiers, the latter being intended for fringe areas. There is a Band III model comprising a cascode r.f. stage and power unit. Spencer-West is another firm in this field, and, in addition to convertors and pre-amplifiers, has a range of mast-head amplifiers and distribution amplifiers for Bands I, II and III.

TELEVISION AERIALS

DURING the past twelve months the Band I—Band III aerial situation seems to have crystallized into a definite shape. The pilot transmitter installed and operated by Belling-Lee in South London no doubt had something to do with that, as it provided a genuine signal for testing drawing-board designs. So far as the main body of television aerials is concerned they seem to fall into three main classes; add-on elements for adapting an existing aerial for Band III reception; dual-band aerials designed for optimum performance on both bands and separate Band III aerials which are either used independently, or, with small modifications, assembled with a Band I aerial and sharing the same pole and feeder.

The Band III aerial adaptors take various forms, but the most common is a short quarter-wavelength rod with a clamp or snap-on connector for fixing to each half-dipole rod of the Band I aerial. The usual place of fitting is one each side of the insulator with the open ends pointing outwards and either lying parallel to the parent dipole or set at an angle. Some makers use twin rods for each add-on unit and either fit them like a "V" (Telerection) or parallel like prongs of a fork (Labgear).

An unusual adaptor kit has been evolved by Belling-Lee; it consists of two rods insulated from the Band I dipole and straddling the centre insulator and extending some distance along and parallel to the parent dipole. These have the effect of electrically breaking up the Band I dipole into two $\frac{3}{4}$-wavelength long sections—the exposed ends of the rod—separated by a form of transmission line. The two phantom $\frac{3}{4}$-wavelength aerials are in effect both connected to the feeder *via* a phasing and matching transformer section and the signals received are additive and improve reception on Band III to the extent of 2 dB. Another Belling-Lee adaptor kit, intended for use with an existing Band I dipole, takes the form of an extension arm carrying a Band III folded dipole and a director with phasing bars leading back to the Band I dipole's insulator for connection to the feeder. The Band I dipole behaves as a reflector on Band III and as a single dipole aerial on Band I. It is similar to the Band III section of one of their dual-band aerials.

In most cases the Band I aerial has no detrimental effect on the performance on Band III; on the contrary, in some designs it enhances the performance. Under certain conditions, however, one case being when the Band I dipole happens to be an exact odd number of half-wavelengths long at the alternative Band III frequencies, fitting adaptor units to the centre of such a dipole will not give a satisfactory performance on Band III. The Band I dipole (and Channel 4 with Channels 8 and 9 as the alternative is a case in point) being exactly $1\frac{1}{2}$ wavelengths long on the high band itself functions as an harmonic aerial reasonably well matched to the low-impedance feeder, but its polar diagram, or response pattern, is unsuitable for television purposes; its response is largely from high angle directions and greatly influenced by the position in which it may be fitted and on height above ground.

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In order to overcome this the Band III rods are usually fitted about a half-wavelength (Band III channel) away from the centre insulator on each side with their open ends pointing inwards. The exposed centre section of the Band I rod is then half a wavelength long overall, as the adaptors are generally each a quarter wavelength long. The adaptor rods, in conjunction with the portions of the parent dipole adjacent to them, behave as quarter-wavelength sections of transmission line, which, being shorted at the outer ends, presents an infinitely high impedance at the inner ends. The original Band I dipole now looks like a shorter half-wave dipole supported at its end by two high-impedance sections of transmission line, or by insulators. It thus functions as a plain dipole.

The same principle can be applied to convert a Band I dipole into a form of director and is indeed so done by Antiference when adapting their Antex "X" for Band III use. The dipole element of the Antex has adaptor units fitted close in to the centre and pointing outwards; the director element has them fitted near the ends of the rods and pointing inwards.

The 1½-wavelength harmonic relationship of a Channel 4 Band I aerial to Channels 8 and 9 in Band III is actually utilized advantageously by Belling-Lee in the design of two dual-band aerials for use in the Midlands. Its simplest form is an angle rod, rather like a wide "V" turned on its side, with arms vertical and the open end pointing towards the transmitting station. Being 1½ wavelengths long on Band III it is a satisfactory match to a 70-ohm feeder and the forward inclination of the rods apparently so modifies the forward response pattern that only one lobe is evident, resembling that of an "H" aerial system but with a little more back response. Being a uni-directional aerial it shows a gain of about 3 dB on Band III compared with a plain dipole. On Band I the performance is apparently unaffected by the shape. There is a companion model consisting of two similar angle rods mounted on a cross arm and both connected to the feeder to produce in-phase operation. The gain is 3 dB on Band I and 7 dB on Band III.

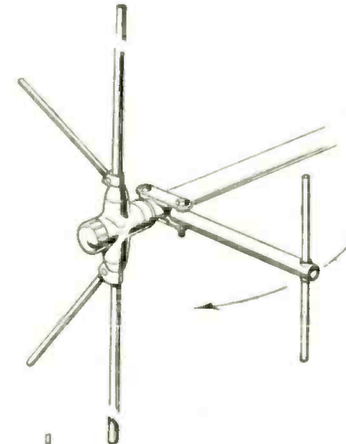
Another dual-band aerial operating as an harmonic system on Band III is the Aerialite "Duband" consisting of a Channel 4 Unex (X-type) with the addition of two "V"-shaped directors turned horizontal with the open ends pointing towards the transmitting station. The forward inclination of the aerial portion of the Unex presumably suppresses any spurious high-angle responses, leaving one forward lobe only in the polar diagram.

Band I aerials intended for use also on Band III, and which are not an exact number of odd half wavelengths long at the high band, have, as a rule, separate Band III elements incorporated in the construction. A striking example is the Wolsey Band I/Band III series of in-line aerials. Various models were shown, but taking a plain Band I dipole as the basic pattern the Band III part of the aerial consists of a backward inclined folded dipole sprouting from the Band I dipole's insulator and having similarly inclined directors and a reflector. A 30° angle between folded dipole and Band I dipole is said to give the best all-round results. Companion models based on "H" Band I aerials are also included.

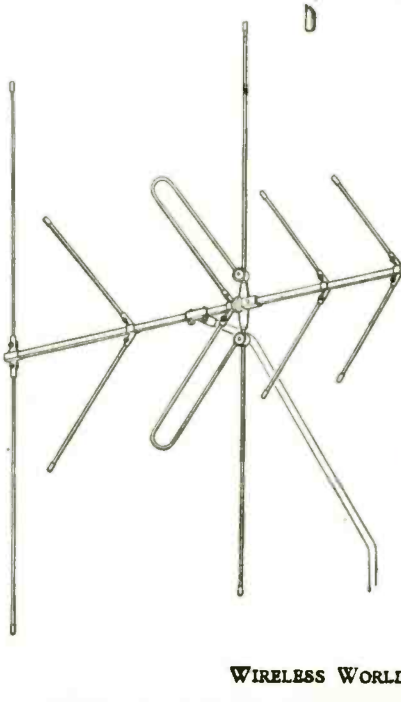
A most unusual form of dual-band aerial has been evolved by Antiference. Basically it consists of a Band I dipole with the feeder connected in the usual way at its centre. Placed close to it, but in no way electrically connected, is a plain Band III dipole. With a certain critical spacing between the two rods and also critical adjustment of length of the shorter element, Band III signals can be received just as satisfactorily on the Band I dipole of the combination as on a separate Band III dipole. Antiference call it "electronic coupling" and in practical form it consists of either a plain low-band dipole, or "H" aerial, with a forward extension boom carrying a close-spaced Band III plain dipole with various numbers of directors in front according to the Band III performance required.

When none of the elements in a dual-band aerial serves any function on both bands it might be more in keeping with rational classification to call them compound aerials; composite or combined would serve just as well. Numerous examples of this pattern were shown at the exhibition and their main feature of interest lies in the methods employed to connect them up to a single feeder cable. As separate aerial systems they have little individual interest as the majority follow a common form with folded dipole, one reflector and any number of directors up to about 12.

They can, however, develop into quite elaborate affairs, the Belling-Lee Type L916/L being an outstanding example. This has an "H" for Band I, and,



Aerialite Model 602 adaptor kit on "H" aerial. Independent orientation of each system is possible.



Wolsey "H" aerial with 4-element folded-dipole Band III section embodied.

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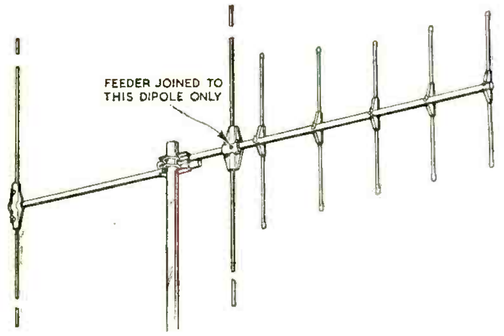
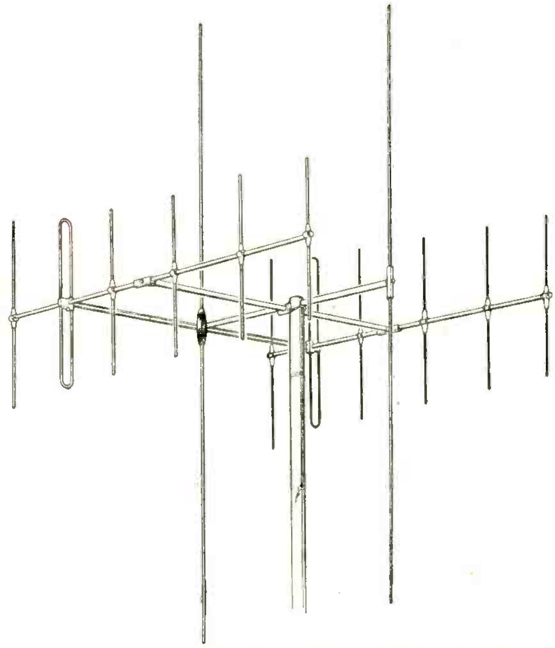


Dual-band aerial developed by Antiference embodying "electronic coupling" feature.



Belling-Lee L916/L with Band I "H" and two Band III six-element aerials embodied in one assembly.

disposed on either side, a six-element Band III system (see sketch). The two Band III aerials are spaced laterally for best broadside working and minimum mutual interaction and the feeder points of all three aerials are directly connected (that is to say, there is no combining unit) by sections of transmission line functioning as impedance matching and phasing transformers. The gain on Band III is 9 dB.

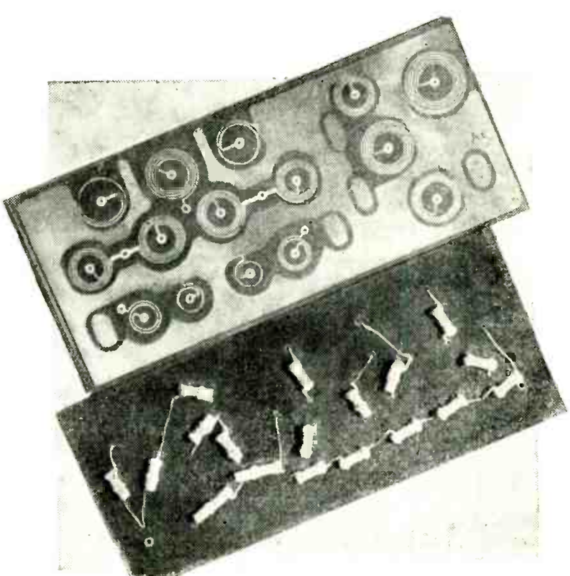
Sometimes provision is made in the design of the compound aerial independently to orientate the two aerial systems as the B.B.C. and I.T.A. transmitters are not likely to be always co-sited. Another very good reason for allowing independent setting of the two aerials, even where the two transmitters are in a straight line from the receiver, is that it might be necessary to offset one or the other in order to suppress a troublesome reflection.

One method of achieving this is to mount the high-band system on a short arm projecting sideways from the cross arm of the Band I aerial, a favoured form of assembly in the Aerialite 804 to 807 series of composite aerials. Another is to fix the Band III section to the pole a little below the Band I aerial, the fitting being such that the two systems can have different directivities.

The combining filters, cross-over networks or diplexer units, as they are variously called, which are fitted to most of the combined aerial assemblies, consist of a high- and a low-pass filter fitted in a small weatherproof box and placed so that each system can be connected to it by short lengths of coaxial cable. Its function is to enable the feeder to "see" its own characteristic impedance at the aerial termination whichever band is being employed so that correct matching is obtained under all conditions. Printed circuit elements are coming into favour for this type of filter as some of the inductors are so small that this form of construction is ideal for exact reproduction. Capacitors are printed where it is practical to do so. Several specimens of printed circuit plates for this purpose were shown on the T.C.C. stand.

Units for keeping unwanted signals in the aerial from reaching the receiver have been developed by Labgear. They are housed in neat boxes and are interposed between the receiver and the coaxial cable. They take the form of high- and low-pass filters according to the type of rejection required. For example, the Type E5028 suppresses all signals below about 38 Mc/s; the E5031 cuts off at 70 Mc/s and suppresses all signals of higher frequency. One of each kind connected in series provides a band-pass filter allowing all Band I signals to pass freely to the set but suppresses everything below 38 Mc/s and above 70 Mc/s.

There is an i.f. rejector effective between 30 and 40 Mc/s and another which is believed to be quite unique in its operation. It has been designed for dual-band aerials (and receivers) and consists of two high-pass filters and one low-pass arranged to give complete rejection of all signals outside the two television bands. It has 18 capacitors, 15 inductors, some of which are only a fraction of a microhenry, and employs a printed circuit inductor element. This



Printed circuit element of Labgear Type E5038 comprehensive aerial filter. Capacitors are fitted on back of the plate.

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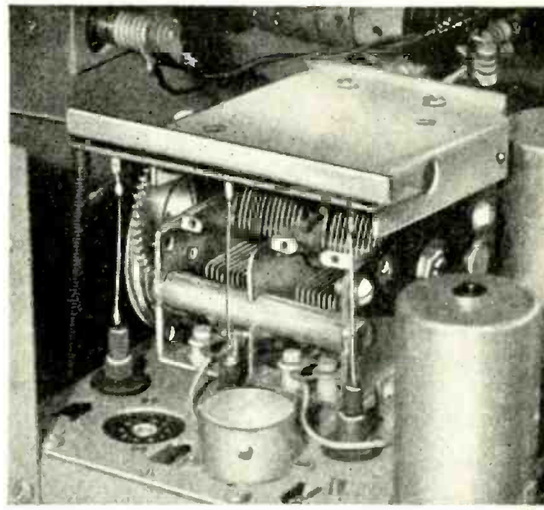
composite filter cuts off below 40 Mc/s, passes 40 to 70 Mc/s, cuts off from 70 to 150 Mc/s and again lets through at 150 Mc/s and over. This gives protection to i.f. interference around 38 Mc/s, to break-through of police, business radio, amateur transmissions and f.m. The attenuation is 40 dB or better over the rejection regions with very low insertion loss over the working bands. It is known as the Type E5038.

The number of separate Band III aerials now available is legion; they are all of fairly uniform design with folded dipoles and anything up to 12 or more parasitic elements all of which, with the exception of one reflector, are directors. Aerial gains range from about 5 dB to about 14 dB as broadside arrays figure among them.

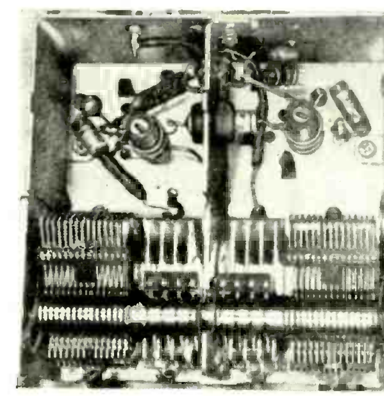
One that is different to the majority has been evolved by J-Beam Aerials; it consists of a skeleton slot mounted horizontally and flanked on each side by a multi-element yagi so arranged that the short ends of the slot serve as the aerial element of each yagi. The coaxial feeder is joined into the centre of the skeleton slot via a "delta" type matching transformer and it is claimed that this form of construction ensures accurate matching and imparts wide-band characteristics to the system.

SOUND RECEIVERS AND REPRODUCERS

THE establishment by the B.B.C. of a full three-programme service from the v.h.f. station at Wrotham has had a profound effect on the structure of the sound receiver market. After a slow and what appeared to be in some quarters a reluctant start, the industry has now responded handsomely to the demand created by the increasing number of listeners in S.E. England who have made it their business to investigate the combined advantages of v.h.f. and frequency modulation. Most new sound broadcast receivers are being fitted with a v.h.f. range and there are so many of these new models that they already equal in number the older short-, medium- and long-wave sets still retained in the manufacturers' catalogues. Until v.h.f. spreads into the Regions we cannot expect to see the phenomenon of the tail wagging the dog: only three or four receivers for v.h.f. only were on show and about as many adaptors for feeding into the pickup terminals of existing sets. The combined "T.V./F.M." receiver discussed in the preceding section is another development which, so far as numbers go, can only be said to have a promising future.



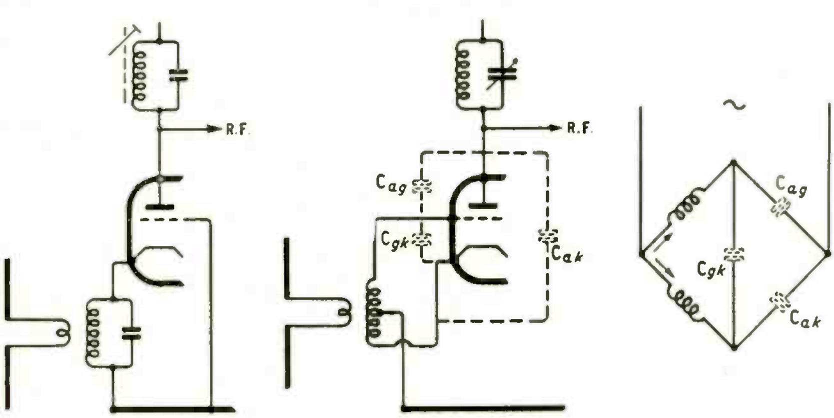
Above: In the Pye HFT111 tuner ganged permeability tuning is employed for v.h.f. and capacitance for other wavebands.



Left: Capacitance tuning for all wavebands is favoured in the Murphy A242.

Examination of the circuits of a representative selection of this year's sound receivers shows a preference for a double triode as the "front end" of the v.h.f./f.m. section. The first half functions as an earthed-grid r.f. amplifier, the input being injected into the cathode circuit (Fig. 7(a)), while the second half is a mixer-oscillator.

In most sets the input transformer is designed to match a 300-ohm loaded dipole fixed to the inside of the cabinet and there is usually a primary tap for a 75 to 80-ohm coaxial cable in case an outdoor aerial system is necessary at the fringe of the service area. It is common practice to include a wave trap in the cathode circuit (Fig. 8(a)) to reject interference at intermediate frequency which may be picked up by the aerial.



(a) (b) (c)

Fig. 7. (a) Simple earthed-grid r.f. amplifier (b) Compromise earthed-grid/earthed-cathode circuit arranged as a bridge (c) to reduce radiation.

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One of the chief anxieties of the v.h.f. set designer is, or should be, to prevent oscillator radiation from the aerial. The first line of defence is in the coupling between the oscillator and the preceding r.f. stage, but this does not always prove to be sufficient, and many of the triode r.f. circuits make use of a combination of the earthed-grid and earthed-cathode connection. At first sight this appears to throw away the advantage of the screening effect of the earthed grid, but as this is never complete there may be more to be gained by a compromise. By connecting the aerial secondary coil between grid and cathode and returning a tapping point to earth a bridge is formed with the valve anode-grid and anode-cathode capacitances which can be balanced to the extent of providing a higher barrier to oscillator r.f. than the fully earthed grid alone (Fig. 7(b) and (c)). Incidental advantages of the modified earthed-grid circuit are less negative feedback with more gain and a higher output impedance.

The balanced inter-stage coupling between the r.f. and oscillator/mixer valves (Fig. 8(a)), is by now well known. Again, a bridge network is formed which includes the grid-cathode capacitance of the oscillator valve and the r.f. is injected between earth and a null point in the oscillator grid circuit (Fig. 8(b)). This may be a tapping on the coil or the junction of a split tuning capacitance.

About half the set makers favour ganged permeability tuning for the r.f. and oscillator circuits and half employ special condenser gangs with low-capacitance sections for the v.h.f. range.

When the primary of the first i.f. transformer in the anode circuit of the triode mixer is tuned to resonance the feedback through the anode-grid capacitance of the valve is negative at the intermediate frequency. This reduces the output impedance of the valve and throws heavy damping on the i.f. transformer. Positive feedback is necessary to offset this effect, and the means of applying it are many and various. The simplest and most popular method (Fig. 9(a)) is to feed both r.f. and mixer stages from a common "decoupling" resistor and to permit some feedback by using a bypass capacitor of lower than normal value. The feedback path to the mixer grid is *via* the r.f. anode circuit and interstage coupling, which will be capacitive at intermediate frequency. If all goes well the feedback will be positive and can be controlled by the value of the bypass capacitor. The McMichael FM55 and Murphy A242 receivers both make use of elaborations of this basic feedback method designed to give greater stability of performance. Cossor in the Model 523 apply inductive feedback directly from the cathode of the mixer to a tertiary winding on the first i.f. transformer (Fig. 9(b)).

If a pentode mixer is used no feedback is required as the output impedance is inherently high and the anode-grid capacitance small. Bush (VHF54), G.E.C. (BC5842) and Pye (Fenman II) are using pentodes not only as mixer-oscillators but in the r.f. stage too. It can be claimed that suppression of the oscillator radiation at least comparable to the balanced triode can be achieved with less circuit elaboration, and that higher gains are possible. The pentode costs more and is fundamentally a noisier valve than a triode, but in practice it is doubtful if the difference would be noticeable within the station service area. Whatever the final outcome, the ancient pentode-triode controversy seems to have shifted its battle-ground from the output to the input stages of the receiver.

In receivers covering all broadcast wavelengths the heptode section of the frequency changer used on

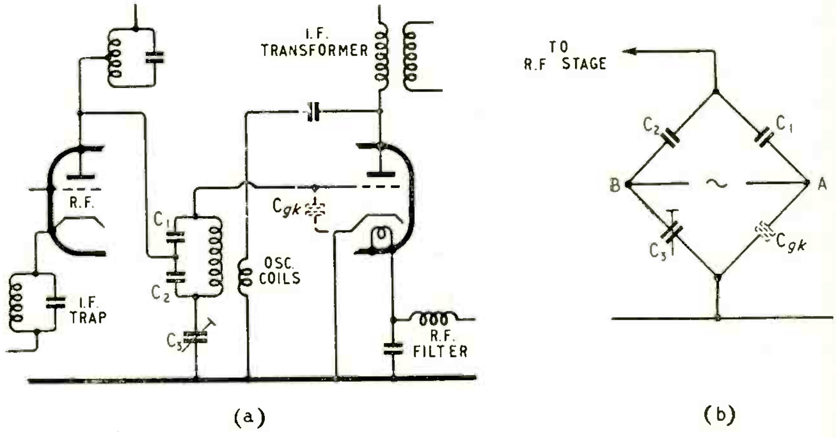

Fig. 8. (a) Inter-stage r.f./mixer coupling is virtually a bridge network (b).

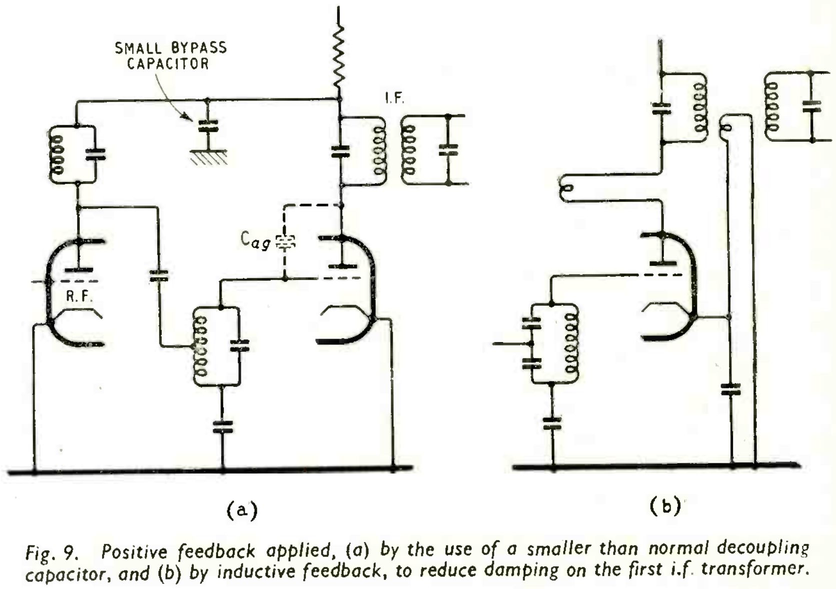

Fig. 9. Positive feedback applied, (a) by the use of a smaller than normal decoupling capacitor, and (b) by inductive feedback, to reduce damping on the first i.f. transformer.

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longer wavelengths is employed as the first i.f. amplifier when the set is switched to v.h.f. This and subsequent i.f. stages have the primaries of 10.7 Mc/s and 465 kc/s transformers connected in series in their anode circuits. Some makers switch at least the first primary windings when changing from "f.m." to "a.m." but many designers are content to accept the small series reactance of the 10.7 Mc/s circuits at 465 kc/s and dispense with switching altogether.

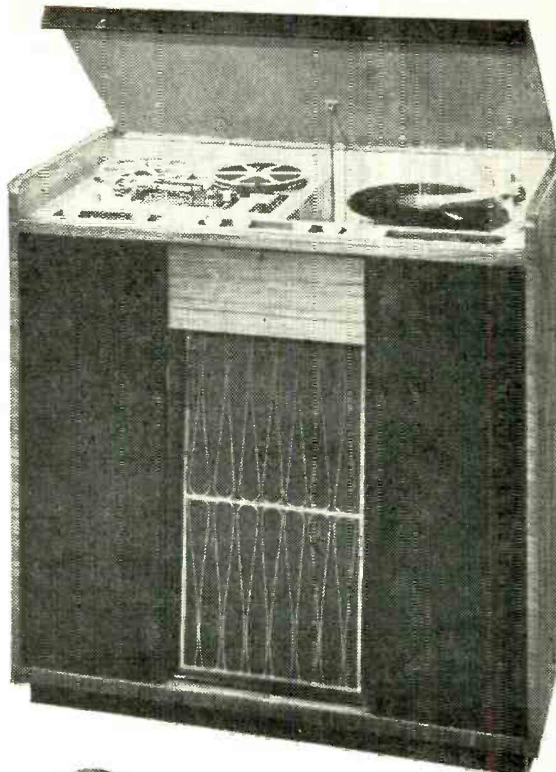
Much of the sound reproducing equipment described in a recent review (July issue, pp. 312-316) was shown to the general public for the first time at Earls Court. Individual new items not previously recorded include the Goodmans Axiom 80 loudspeaker with cantilever-suspended, free-edged cone and a new range of Goodmans cabinets of comparatively small volume, made possible by the use of acoustically damped vents.

The growing interest in tape recording is reflected in a number of new recorders and reproducers, one of the most interesting technically being the "Reflectograph" with transistors in the early stages of the amplifier. At the low levels available from the magnetic tape at low frequencies, mains hum is a serious problem and the absence of heater current in the preamplifier is a distinct advantage.

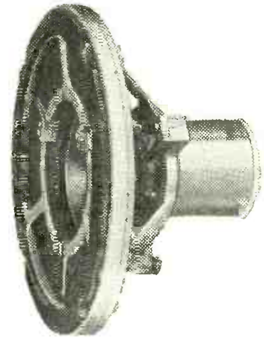
Another firm (Specto) is in production with a twin-track reproducer for H.M.V. "Stereosonic" tape records. It is equalized to C.C.I.R. standards and is designed to work with two Tannoy Dual Concentric loudspeakers.

In the Portogram TR/100 console tape recorder, space is provided for a v.h.f. tuner and a gramophone turntable, as well as storage of disc and tape records.

The public interest in good quality of sound reproduction continues to expand and all demonstration rooms were packed. Many set manufacturers are following the German vogue for what is termed "3D" reproduction. This usually involves the use of more than one loudspeaker inside the cabinet and various

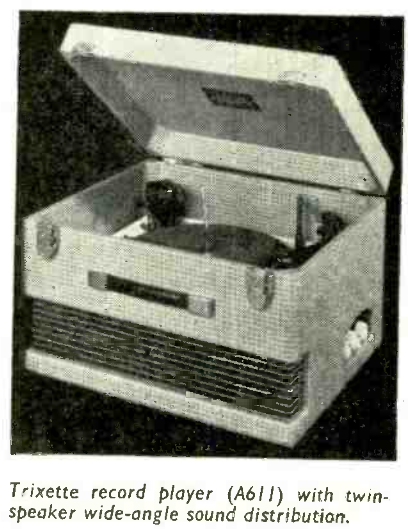


Above: Portogram TR/100 console tape recorder, with space for v.h.f. tuner and record player.



Left: Goodmans "Axiom 80" loudspeaker.

"Spectone" reproducer for "Stereosonic" tape records.



Trixette record player (A611) with twin-speaker wide-angle sound distribution.

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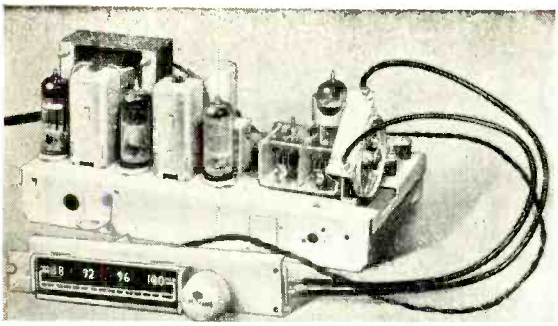


H.M.V. Model 1252 v.h.f. tuner for addition to existing radio-gramophones.

apertures in the sides and back to disperse the sound output. Many people find the result more pleasing than the relatively narrow beam radiated at middle and high frequencies from the conventional single-cone loudspeaker.

"High-fidelity," which means wide-range frequency response with the minimum distortion, is no longer the hobby of the few, whose needs were supplied by a handful of small firms. The big companies now find that there is sufficient business to justify a serious attack on this market. Development teams have been allocated to the production of new amplifiers, radio feeder units and loudspeakers, and these have been demonstrated to keen audiences with the skilled showmanship which is the dominant feature of the Radio Show.

VALVES AND CATHODE-RAY TUBES

FOLLOWING the general acceptance of 21-inch cathode-ray tubes in television receivers, the latest trend in design has been to shorten the length of the tube by increasing the normal 70° scanning angle to something like 90°. The examples of this reported last year have now been joined by two more 21-in tubes, from G.E.C. and Mullard respectively. Both operate with about 16kV on the anode, for which the grid cut-off voltage is between -40V and -80V, and they have 6.3V, 0.3A heaters and external conducting coatings. The G.E.C. tube, however, has a triode gun while the Mullard is a tetrode.

Of course, this increase in scanning angle brings with it considerable problems in design. In the first place, the small change from 70° to 90° demands a somewhat disproportionate increase in scanning power of about 50 per cent. Within the tube itself the electron beam is liable to be interrupted by the glass wall at maximum deflection, producing corner cutting of the picture. In addition, with the approximately flat faces now being used, the beam strikes the screen at increasingly acute angles towards the edges and so has a tendency to be defocused there.

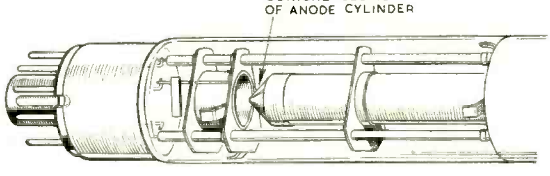
These troubles have to be overcome partly by the design of the external deflection system and partly by the electrostatics of the internal electrode structure. In the Mullard tetrode gun, for example, an extra electrode at about cathode potential is used to obtain optimum uniformity of focus over the whole screen, and it appears that this uniformity is achieved at the expense of "spot smallness" in the centre. The desired condition is produced when the extra electrode is zero or slightly negative with respect to the cathode. If the voltage on it is increased the spot size in the centre of the screen is certainly reduced, but inferior focusing is obtained at the edges. However, the necessary sacrifice in "spot smallness" at the centre is largely offset by the reduction obtained in the length of the tube: this causes the magnification of the focusing "lens" to be less than with a normal-length tube, so that the image formed on the screen (i.e. the spot) of the electron cross-over point in the gun is smaller than usual.

In the triode gun of the G.E.C. tube the improvement in uniformity of focusing is obtained by a conical section at the cathode end of the long anode cylinder (see illustration). This works by eliminating the bulging equipotential lines of electrostatic field which in normal anode structures have a divergent effect on the electron rays of the beam. The criterion in all such systems, however, is that the beam diameter should be as small as possible within the deflector coils.

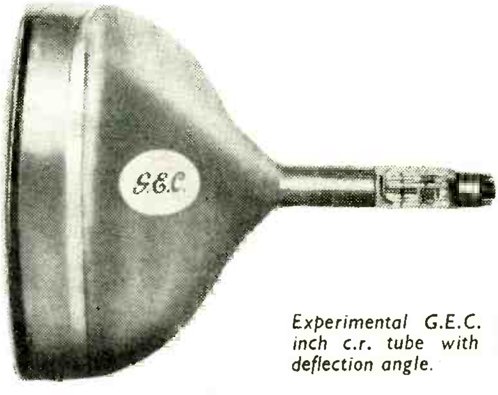
Generally speaking the reduction in length achieved by the increase from 70° to 90° scanning angles is about 3 inches and this is quite a help in the mechanical design of the big 21-in sets. It seems, however, that there is still scope for the same method of reducing length on the popular 17-in tube, and G.E.C. have been trying it out on an experimental basis. It will be remembered that their first introduction of the 90° scanning angle was in a tube as small as 12 inches. The experimental 17-in tube is similar to their existing type 7401A except that it has the 90° angle instead of 70°.

Small tubes are, of course, in the minority nowadays, but a new 12-in type was shown by Ediswan, the CRM124. This incorporated the improved type of ion-trap developed by Ediswan which traps positive ions as well as the negative ones by means of a slanting electrostatic lens formed between the first and final anodes. Ediswan also have a new 14-in rectangular tube, the CRM143, which has similar characteristics to the CRM124.

Aluminizing now seems to be a common feature of



Conical part of anode in G.E.C. 21-inch 90° c.r. tube for obtaining uniformity of beam focus.



Experimental G.E.C. 17-inch c.r. tube with 90° deflection angle.

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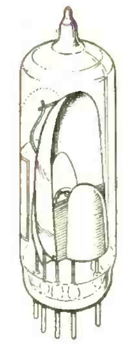
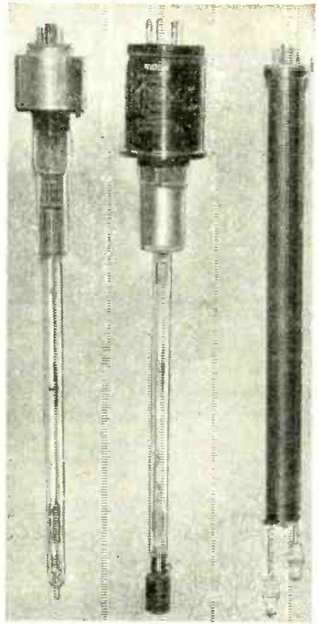
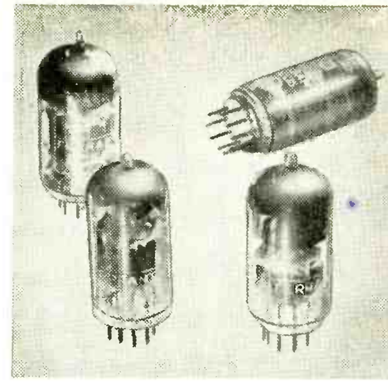


Brimar EM85 side-display tuning indicator.

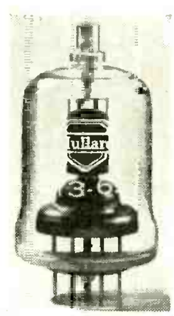


English Electric travelling-wave tubes N1013, N1004 and N1012.

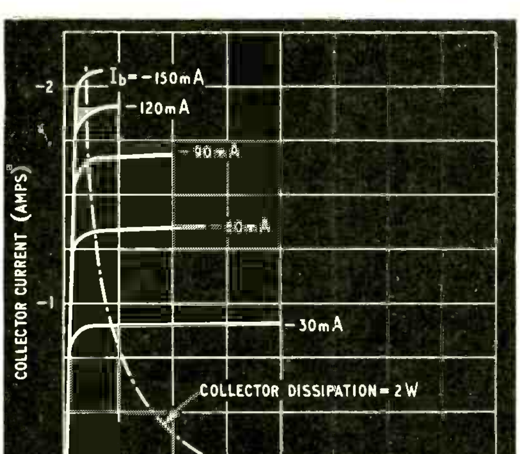


Ferranti valves for Band-III television reception.

Ediswan ES1001 industrial power triode.



Right: Mullard QY3-65 transmitting tetrode.



Provisional collector characteristics of Mullard OC15 power transistor (development model) for earthed-emitter operation.

almost all cathode-ray tubes. The main reasons for it are well known, but it has other advantages which are perhaps not so familiar. In manufacture, for example, it has been found that the variations in screen brightness from tube to tube do not have such a wide range, or "spread," when aluminizing is used, so that fewer of the aluminized tubes are likely to be rejected as being outside the required limits than the non-aluminized types. In addition, aluminizing overcomes the effect known as "mottling" on the non-aluminized screens.

No significant developments in receiving valve design have taken place since our review in June this year (page 277), except that Ediswan and Ferranti were showing their versions of the Band-III "front end" types which have now become so familiar. A new "magic eye" tuning indicator, the Brimar EM85, however, was notable, for having a screen which is viewed through the side of the bulb. It is suitable for f.m. receivers and can be mounted on a travelling cursor on the tuning system. Incidentally, Brimar have recently produced a new Brimistor current-limiting element, the CZ10, for use as a protective device in the filament circuits of mains/battery receivers using the latest 25 mA valves.

In transmitting valves, English Electric have extended their range of travelling-wave tubes to include 13 different types, N1001 to N1013. These valves are notable for their ability to amplify over bandwidths up to 1,000 Mc/s. Ediswan had a new radiation-cooled triode, the ES1001, designed for use in industrial heating equipment. Its maximum anode dissipation is 1 kW at 40 Mc/s. This firm were also showing their "Vapotron" industrial valve (characterized by a water-vapour cooling system) which is now known as the ESV892. A new "packaged" magnetron for the 3-cm band made by Mullard operates in the frequency range 9345-9405 Mc/s and has a peak output power of 250 kW. Maximum anode voltage and current are 23 kW and 27.5 A respectively. Mullard also had a new transmitting tetrode of all-glass construction, the QY3-65, with a maximum operating frequency of 250 Mc/s and an anode dissipation rated at 65 watts. It can be used as an r.f. driver, power amplifier, power oscillator or as an a.f. power amplifier.

Amongst transistors the most interesting exhibit was a development-model power transistor made by Mullard, the OC15. Two of these in a Class B type

(*Continued on page 489*)

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of audio output stage will give an output of 10 watts, working from a 12-volt accumulator, the peak collector current per transistor being about 2 A. The OC15 is a *p-n-p* junction type in a hermetically sealed can which has to be bolted to the metal chassis to conduct the heat away. Its equivalent-circuit resistances are: emitter, 0.25Ω; base, 5Ω; collector 20 kΩ. With earth-emitter operation the emitter cut-off current at a collector voltage of 6 V is −2.5 mA, while the current gain is about 25. The illustration gives some idea of the power capabilities of the device.

For high-frequency operation, and particularly in pulse circuits, G.E.C. were showing the EW51 point transistor. Used as a pulse amplifier, its speed of response is such that if the rise time of the input waveform is 0.05 μsec the rise time of the output waveform is less than 0.15 μsec. In a typical application the current gain (alpha) falls to 0.7 of its l.f. value at 4 Mc/s. To achieve this performance the spacing between the metal whiskers on the germanium surface has to be extremely small and is, in fact, about 0.001in.

Since transistors are somewhat unrewarding in their external appearance, it was interesting to learn from G.E.C. something about the internal construction of their latest junction types, EW53, EW58 and EW59. The small germanium wafer is actually mounted on a frame made of nickel. The base lead is connected directly to the wafer while the collector and emitter leads are joined to small indium beads on opposite faces of it. The three leads are taken through a glass bead which is set in a copper thimble, and the whole device is hermetically sealed inside a small gold-plated copper can.

Germanium has already proved its worth in power rectification, and an example of this at the Show was a new germanium power rectifier shown by S.T.C., the R60A. Four of these extremely small units arranged in a bridge circuit with a 250-V a.c. input will give a d.c. output current of 500 mA. With half-wave rectification into a resistive load, a 250-V input will produce 250 mA of d.c. Westinghouse have extended the range of their contact-cooled metal rectifiers, which are also notable for their small size, and the smallest, which gives an output of 280 V, 20 mA, measures only about 1in × ¾in.

Left: Ediswan coin-operated time switch for "coin-in-the-slot" television.

Below: Pye telephone answering machine. The "announcement" tape is in the circular window at the bottom.

EXHIBITION SIDELIGHTS

THE telephone answering machine, shown by Pye Telecommunications, is intended for use in the absence of the subscriber and permits the caller to record a message. The device is started by "ringing" signals from the Post Office line, which are rectified and then used to operate a relay switching system. This actuates a delay circuit, which, after 10 seconds, causes an announcement on a continuous length of magnetic tape to be played back to the caller, inviting him to record his message. At the end of the announcement a hole in the tape is used to start the main tape recording unit. While this is running the input from the telephone line is monitored and when the caller has finished speaking the machine "listens" for a final six seconds then switches off and clears the line. The monitoring circuit is designed to recognize the receipt of dialling tone, which can occur when a call from an automatic exchange is terminated. A total of one hour of recorded messages can be accommodated on the main tape, and the machine will handle input levels from +6dB to +35dB relative to a milliwatt.

The general idea of "coin-in-the-slot" television as a way of collecting rental or hire-purchase payments on receivers, has become quite well known by now, but at this Radio Show an actual machine for the purpose was exhibited by Ediswan. It is, in fact, a coin-operated time switch designed to interrupt an electric circuit at the end of a pre-paid length of time, which may be hours or weeks. The insertion of a coin sets a register to show the amount of viewing time which has been paid for, and connects the electricity supply to the set. A self-starting synchronous motor driving a cam through a train of gears provides the timing mechanism and this switches off the supply at the end of the pre-paid time. As in electricity slot meters, the machine can be "stoked up" with several coins for a long continuous run.

Another exhibit of some interest shown by Ediswan was a prototype transistor amplifier for electro-physiological work which is capable of driving a recording pen directly. It has sufficient amplification to give a pen deflection of 1cm, peak-to-peak, with an input of 100μV, while the maximum possible deflection is 1.5-2 cm peak-to-peak. The frequency response is substantially flat from zero to 15 kc/s. Small dry cells provide the sole power supply, so that the amplifier has the great advantage of portability, as well as small size, compared with conventional valve equipments used for this type of work. A complete miniature portable recording unit, incorporating the amplifier, is under development.

Transistor circuits were also a feature of the Mullard display, and in addition to several audio amplifiers and output stages (one of which is mentioned under

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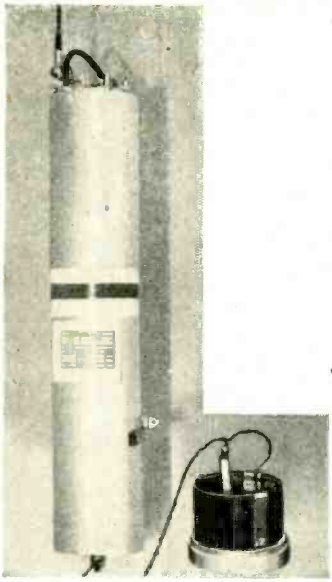
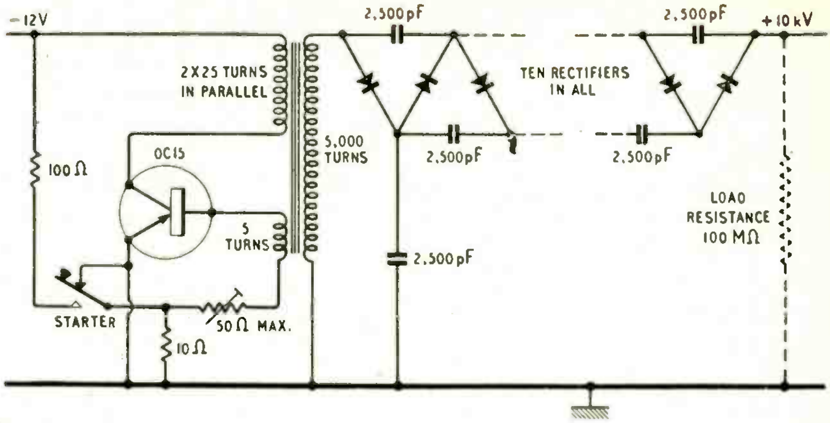




Circuit of Mullard transistor d.c. converter giving 10 kV e.h.t. from a 12-V battery.

Left: R.A.F. "Sonobuoy" with the hydrophone to the right.

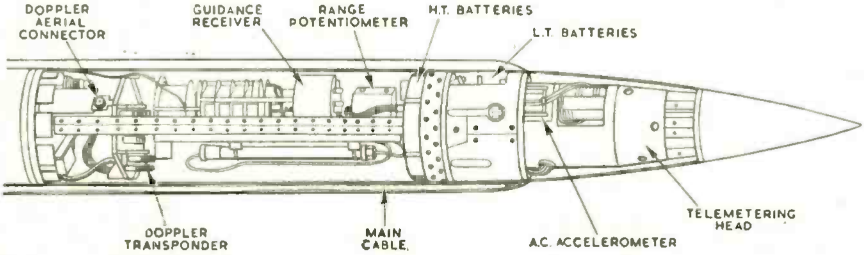
"Valves and C.R. Tubes") there were demonstrations of transistor d.c. converters for producing h.t. and e.h.t. voltages from l.t. supplies. These made use of the fact that the junction transistor in a suitable circuit has characteristics very close to those of an ideal switch. The transistor is used in a simple relaxation oscillator circuit, interrupting the input from an l.t. battery. Energy is stored in the inductance of a coupling transformer (see diagram) during the "on" period, while in the "off" period it is delivered at an increased voltage to the output circuit. Simple rectifiers or more complex voltage multipliers are used in the output circuit, depending on the voltage required.

Very good conversion efficiency is obtainable at power levels ranging from a few milliwatts to several watts. The operating conditions are such that the transistor is "bottomed" when it is "on," and as a result the efficiency is quite high, the figures for the six converters on view ranging from 55% to 80%. The voltage outputs of the six circuits ranged from 30 V (using a 1.2-1.5-V battery) to 10 kV (using a 12-V battery).

A rather unusual piece of radio apparatus on the Royal Air Force stand was the "Sonobuoy" used by aircraft for locating ships and submarines. It is a miniature automatic transmitter in a canister which is dropped into the sea by parachute. A hydrophone dangling below the sea surface at the end of a 30-ft wire picks up any engine sounds, which are relayed by the transmitter back to the aircraft. The transmitter, which is powered by Kalium dry batteries and a 2-V accumulator, consists of an electron-coupled oscillator with three doublers and an output stage, producing an r.f. output of about 300 mW in the lower v.h.f. region. The oscillator is frequency-modulated by a reactance valve, which is driven through two a.f. stages from the hydrophone; this is a magnetostriction device and has an underwater range of about 3 miles. The transmitter signals can be picked up at a distance of about 10 miles. Also on the R.A.F. stand was a sectioned rocket, containing radio equipment for guidance and telemetering, as used in guided missile design.

Teledictor automatic coin-sorting machine.

Radio apparatus in an R.A.F. test rocket for guided missile design.



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Ediswan P.T.F.E. valveholders.

To demonstrate that all the channels of their 13-channel television receivers really do work, Pye had an elaborate closed-circuit picture generating system with 13 cameras and 13 transmitters, all operating on different frequencies, feeding into a group of 13 receivers, each of which displayed a different picture. The cameras were the small Pye industrial models using 1-in diameter photo-conductive pick-up tubes, and each had its own waveform generating unit. The transmitters (13 for sound and 13 for vision) were simple crystal-controlled oscillators with frequency multipliers to produce the required channel frequencies in Bands I and III. A control room was equipped with a push-button monitoring system and enabled any video camera output to be fed to any transmitter; sound was also added at this point.

An electronic machine for sorting coins of two different alloys, originally developed for the Royal Mint, was shown by Teledictor in the "Electronics and Careers" section. The mixed coins are loaded into a rotary hopper which feeds them one by one through a gap in an iron-cored inductor, and the effect they have on the magnetic flux is used in the electronic circuit as an indication of their composition. If the flux variation is indicative of cupro-nickel the coin is allowed to fall straight into an appropriate box. A silver alloy, however, causes a signal to be fed to an electromagnetic actuator, which deflects the falling coin into another box. The sight of the machine rattling through half-crowns at the rate of 8 per second is quite impressive.

BRITISH AIRCRAFT RADIO

Highlights of the Equipment Seen at this Year's Air Show

MODERN commercial and military aircraft now carry such a vast amount of radio and radar equipment that size and weight have become vitally important. Miniaturization has ceased to be an adequate description and sub-miniaturization is taking its place. This, at least, was one of the impressions gained from the air show held recently at Farnborough by the Society of British Aircraft Constructors.

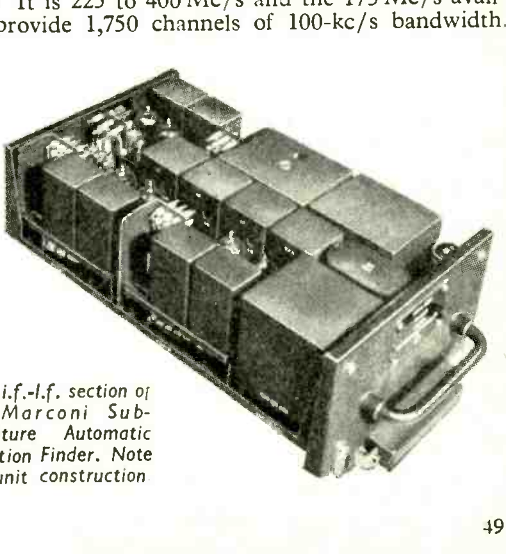
One example of this trend was the new Marconi sub-miniature direction finder (Model AD722) covering 200 to 1,750 kc/s. A significant factor in the reduction in size and weight of this equipment is the dispensing with a power supply unit, the set being operated (included h.t.) entirely from the aircraft's 28-volt d.c. system.

The direction finder is a modern version of the Bellini-Tosi system with two fixed crossed loop aerials, the modern flavour being given by the use of dust-iron cores and by encasing the loops in a sealed unit only ½in thick so that it can be mounted on the outside of the aircraft without affecting the "drag." The loops connect to a goniometer embodied in a direct-reading panel-mounting indicator giving continuous bearing information.

Another aid to navigation in the air is VOR (very high frequency omni-range) and Marconi's have this year introduced a new receiver embodying both VOR and ILS facilities, or at least for part of the ILS. It is the model AD704 and represents another example of weight reduction by streamlining several facilities in one set; the AD704 also serves as a communications receiver over the range 108 to 136 Mc/s. The set is used for receiving the localizer signals of ILS but to complete the ILS equipment two other units, the AD706 and A708, are required, these being the glide path and marker receivers.

Standard Telephones were showing also a new complete airborne VOR/ILS receiver, the SR32/33, capable of receiving any one of 100 pre-set frequencies in the 108- to 118-Mc/s band and any one of 20 spot frequencies in the 300- to 325-Mc/s band and also one spot frequency on 75 Mc/s. These together cover localizer, glide path and marker facilities.

Indications are that a new u.h.f. radio-telephone band is coming into use for ground-to-air communications. It is 225 to 400 Mc/s and the 175 Mc/s available provide 1,750 channels of 100-kc/s bandwidth.



Main i.f.-l.f. section of the Marconi Sub-miniature Automatic Direction Finder. Note the unit construction

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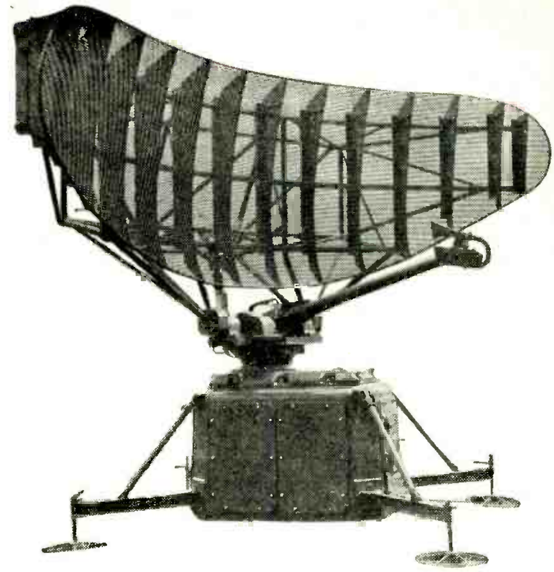
Plessey were showing the ground equipment in rack form and of quite massive construction. The fact that it is entirely weatherproof with all units sealed no doubt gives this impression. Two transmitters are available, one a single-channel set, crystal controlled and allowing full remote control, and the other a multi-channel set which, while making available the whole 1,750 channels by mixing the harmonic outputs of some 32 crystals, provides on immediate call and by remote control 12 pre-selected channels. Normal r.f. power output is 10 watts but the addition of an r.f. amplifier and its power supply unit raises the available r.f. power to 150 watts.

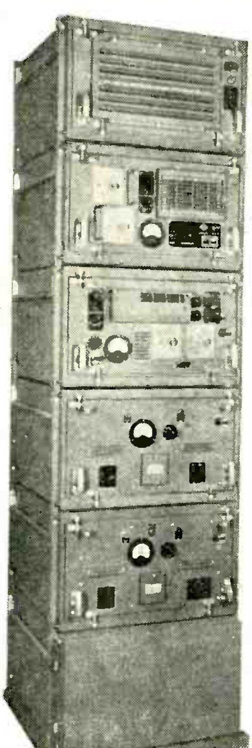
A small airborne set for use in the new u.h.f. band is the Burndept BE234 working on a single spot frequency between 238 and 248 Mc/s with facilities for emergency working on the international distress frequency of 243 Mc/s. The use of an overtone crystal enables the working frequency to be reached by a frequency multiplication of 12. The output of the transmitter is 2.5 watts and amplitude modulation is employed. The self-contained receiver is a double superhet with a first i.f. on about 20 Mc/s and the second on 2 Mc/s.



Aerial unit of the 3-cm medium-range Decca Type MR75 surveillance radar.

A further example of equipment for this new band was an automatic ground direction finder shown by Standard Telephones. It is the Type FGR1X-1340 and provides remote selection of 10 spot frequencies in the band 225 to 400 Mc/s. Bearings are displayed on a cathode-ray indicator. It employs a fixed vertical aerial mounted in the centre of a rotating fibreglass cylinder carrying a reflector. This imparts a rotating cardioid response to the system which in effect is tantamount to modulating any received signal by a sinewave of a frequency equivalent to the speed of rotation, in this case 40 c/s. Bearing information is obtained by comparing the instantaneous phase of the 40-c/s modulation of the signal with a 40-c/s sinewave generated by an alternator embodied in the base of the spinning cylinder.

Plessey 225- to 400-Mc/s radio-telephone ground equipment and (right) Rotating aerial system of the Standard Telephones u.h.f. direction finder, FGR1X-1340.



The c.r. indicator includes a switch which displays instantly when required the reciprocal of the bearing with magnetic correction (the QDM) for passing back by R/T to the aircraft.

Another system of direction finding demonstrated on the airfield by Standard Telephones was one to which has been given the title Commutated Antenna Direction Finding (CADF) because it operates by sampling in sequence the signals picked up on a ring of vertical aerials by one receiver, mixing them with the same signal picked up by a nearby single aerial and on comparison in a suitable discriminator a sinewave output at the frequency of the aerial commutating cycle is obtained. The phase of this signal varies with bearing and the actual bearing is obtained by comparison with a reference signal derived from the commutating system. Although demonstrated on v.h.f. signals it is equally applicable to u.h.f. and to h.f.

Heavy storm clouds are a potential source of danger to aircraft and generally avoided wherever possible, or when sufficient warning of their presence is available under conditions of poor visibility. Ekco airborne search radar was developed especially to give this early warning and this year a new version was shown having a longer range, 120 miles as compared with 40 to 50 miles of the early set. It also embodies a discriminating feature in that cores within the clouds of heavy air turbulence are emphasized on the P.P.I. display.

Pye were showing the ground equipment of a new ILS (instrument landing system). Its special features are long-range localizer transmitter, high accuracy and automatic monitoring of the whole equipment from a centrally disposed control console. Two localizer transmitters are used; they operate in the 108- to 112-Mc/s band, each gives 50 watts out-

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put and each feeds dipoles in the localizer aerial system. They are separately modulated and the approach path is determined in the air by comparing the amplitudes of the two modulating signals, the resultant information being passed to a combined approach and glide path indicator. The localizer aerial is directional, giving a beam width of $\pm 70^{\circ}$ centred on the approach to the runway.

Glide path transmitters are of 20 watts output, operate in the 328- to 355-Mc/s band and feed into vertically stacked aerials. Different modulating tones are used and again comparison of their amplitudes gives the glide angle. There are three marker beacons in the system on 75 Mc/s.

Other ground navaids shown this year comprised a new ground beacon and airborne apparatus by means of which aircraft can fix their own position. It is known as "Tacan," operates between 962 and 1214 Mc/s and was shown by Standard Telephones. It is an interrogator-responder system and has a range of 200 miles.

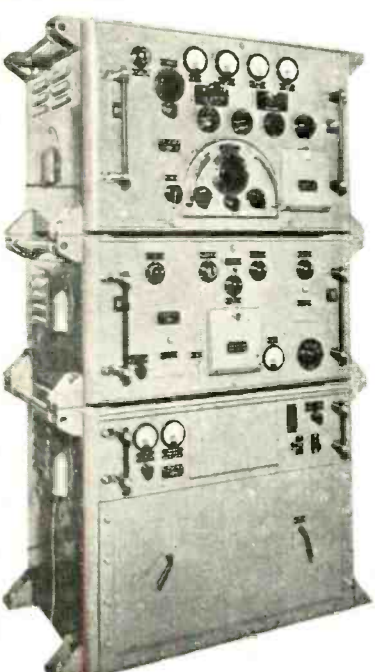
Decca had a new medium-range surveillance radar, the Type MR75, working on 3.2 cm and having an operational range of 75 miles on large, and 45 miles on small, aircraft. It is said to fill the gap between the more elaborate long-range surveillance radars and short-range approach control radars. The aerial is a 14-ft horizontal mesh-covered system fed by a horn and rotating at 10 r.p.m. All the equipment, except the display unit, is housed in a single cabinet 2ft 6in square at the base and 5ft 6in high. Several display units, located up to 2,000 yards away, can be used with one equipment and aerial system.

For long-distance point-to-point ground communications relating to routine movements of aircraft and operational instructions, radio telegraphy, or its modern counterpart the teleprinter, has no rivals yet. Frequency-shift signalling is the well-established system for rapid and accurate handling of large volumes of radio traffic and equipment for this purpose was well in evidence.

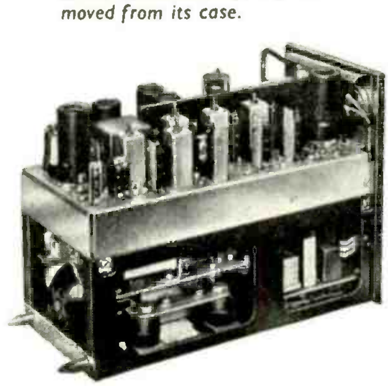
Redifon had a frequency-shift receiving adaptor (Type AFS10) designed especially for simplified operation. One of its principal features is the ability to accept signals whose carrier frequency may drift as much as 2.75 kc/s above or below the nominal frequency. It is intended for use with the Redifon R50M communications receiver, but will function with any other good set of this type covering frequencies between 445 and 470 kc/s. Another feature is that it provides the 80-0-80 volts required for operating the teleprinters (two) and radio telephony can be employed as an alternative service. Plessey were showing frequency-shift adaptors for use with suitable existing communications receivers, also complete dual-channel f.s.k. receiving terminals and for the radio link 100-watt and 1-kw h.f. transmitters.

Medium-frequency ground beacons still play an important part in air navigation in all parts of the world, but perhaps their importance is realized less in Europe where v.h.f. is so prominent than in the more remote parts. For use under the most arduous conditions, Redifon have a robust m.f. ground beacon transmitter (Type T1918) giving 300 watts output over the range 110 kc/s to 1500 kc/s in four tuning bands. It is made up of three separate units designed for easy separation and transportation by air, or other means. They can be stacked for operation either vertically or used side by side, as in a vehicle. Units are sealed and the transmitter will work in 18in of water. A special feature is the provision for use of radio telegraphy and telephony, should the need arise.

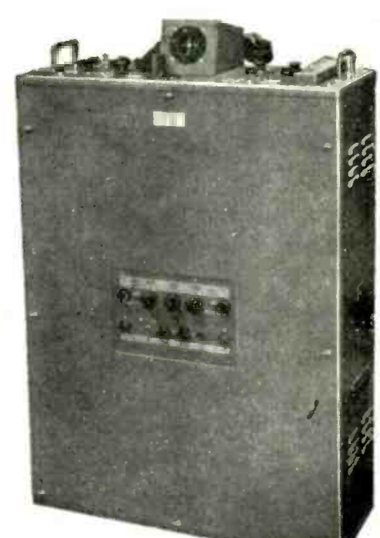
A most interesting development was seen on the Ultra stand. It is described as a "sea cell" and is intended for operating the "Sarah" rescue beacon equipment in emergency inflatable dinghies. The cell is normally dry, or inert, but on immersion in sea water becomes active and will operate "Sarah" for 100 hours continuously, or for about 4 days. The output is 1.3 volts and the h.t. supply for the equipment is provided by a small vibrator unit. The overall size is $3\frac{1}{8} \times 4\frac{1}{8} \times 4\frac{1}{8}$in. Another Ultra exhibit was an aircraft "station" intercommunication box (UA118/A) operated entirely by transistors. This new box is about half the size and three-quarters the weight of the equivalent valve-operated model.



Left: Redifon Type T1918 m.f. beacon transmitter.



Below: Burndept u.h.f. airborne transmitter-receiver removed from its case.



Right: The control console of the Pye Instrument Landing System.

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Radio Equipment Firms at the Farnborough Show

Amalgamated Wireless (Australasia) Ltd., 99 Aldwych, London, W.C.2.

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

British Insulated Callender's Cables Ltd., 21 Bloomsbury Street, London, W.C.1.

S. G. Brown Ltd., Shakespeare Street, Watford, Herts.

Burndept Ltd., West Street, Erith, Kent.

Canadian Marconi Company, 2442 Trenton Avenue, Montreal 16, Canada. (Agents: Marconi's Wireless Telegraph Co. Ltd., Chelmsford.)

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

A. C. Cossor Ltd., Highbury Grove, London, N.5.

The Decca Navigator Co. Ltd., 247 Burlington Road, New Malden, Surrey.

Decca Radar Ltd., 1-3 Brixton Road, London, S.W.9.

Electric and Musical Industries Ltd., Hayes, Middlesex.

Ferranti Ltd., Ferry Road, Crewe Toll, Edinburgh, 5.

General Electric Co. Ltd., Kingsway, London, W.C.2.

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

W. T. Henley's Telegraph Works Co. Ltd., 51-53 Hatton Gardens, London, E.C.1.

McMichael Radio Ltd., Wexham Road, Slough.

Marconi Instruments Ltd., Longacres, St. Albans, Herts.

Marconi's Wireless Telegraph Co. Ltd., Chelmsford, Essex.

Mullard Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

Murphy Radio Ltd., Welwyn Garden City, Herts.

Plessey Co. Ltd., Ilford, Essex.

Pye Telecommunications Ltd., Newmarket Road, Cambridge.

Redifon Ltd., Broomhill Road, Wandsworth, London, S.W.18.

Salford Electrical Instruments Ltd., Silk Street, Salford 3, Lancs.

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

Telegraph Construction and Maintenance Co. Ltd., Greenwich, London, S.E.10.

Thermionic Products Ltd., Shore Road, Hythe, Southampton.

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

Venner Accumulators Ltd., Kingston By-Pass, New Malden, Surrey.

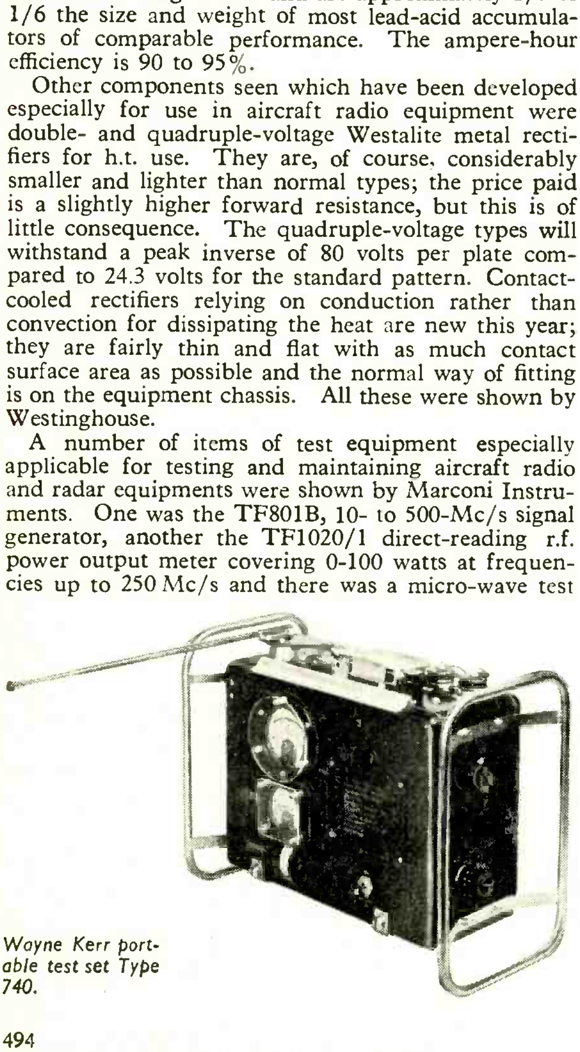
Wayne Kerr Laboratories Ltd., 3 Sycamore Grove, New Malden, Surrey.

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

While on the subject of power supplies there were some interesting, but not entirely new, lightweight secondary cells, shown by Venner Accumulators. They are silver-zinc accumulators and the smallest shown, while weighing only $\frac{3}{4}$ oz and measuring $\frac{9}{16} \times 1\frac{1}{8} \times 1\frac{1}{2}$in is capable of giving a 10-A continuous discharge. Its rating is 0.75 amp hr. Silver-zinc accumulators give a nominal voltage of 1.5 and are approximately 1/5 to 1/6 the size and weight of most lead-acid accumulators of comparable performance. The ampere-hour efficiency is 90 to 95%.

Other components seen which have been developed especially for use in aircraft radio equipment were double- and quadruple-voltage Westalite metal rectifiers for h.t. use. They are, of course, considerably smaller and lighter than normal types; the price paid is a slightly higher forward resistance, but this is of little consequence. The quadruple-voltage types will withstand a peak inverse of 80 volts per plate compared to 24.3 volts for the standard pattern. Contact-cooled rectifiers relying on conduction rather than convection for dissipating the heat are new this year; they are fairly thin and flat with as much contact surface area as possible and the normal way of fitting is on the equipment chassis. All these were shown by Westinghouse.

A number of items of test equipment especially applicable for testing and maintaining aircraft radio and radar equipments were shown by Marconi Instruments. One was the TF801B, 10- to 500-Mc/s signal generator, another the TF1020/1 direct-reading r.f. power output meter covering 0-100 watts at frequencies up to 250 Mc/s and there was a micro-wave test set, TF890A, for checking characteristics of transmitters, receivers and aerial systems in the 3-cm band. It embodies a cavity wave meter covering 9000 to 9680 Mc/s.



Wayne Kerr portable test set Type 740.

Wayne Kerr had a test set, the Type 740, which is designed especially for functional tests of airborne v.h.f. transmitters, receivers and intercom units in an aircraft. It can be used by semi-skilled persons and by rotation of a switch and observation of a meter scaled "pass" or "reject" most of the equipment can be quickly checked over. Detailed investigation of "reject" equipment can then be undertaken by the skilled staff. The gear is reasonably small and light and quite easily operated in confined spaces.

TELEVISION IN AUSTRALIA

PROVISION has been made for both commercial and Government-operated stations in Australia and licences have already been granted for four commercial stations —two in Sydney and two in Melbourne. British equipment worth £0.25M has now been ordered for the first two Government-operated stations. They are due to come into service towards the end of next year.

Some months ago, the Australian Broadcasting Control Board issued a report on the standards to be adopted for television in the Commonwealth. The system agreed upon is 625 lines, with frequency-modulated sound. Ten 7-Mc/s channels between 49 and 216 Mc/s are being made available for the operation of the service and the Board, with the concurrence of manufacturers, suggests that from the outset receivers should be tunable to all ten channels. It is also suggested that receivers should be capable of economic adaptation to provide for the u.h.f. bands (500 to 855 Mc/s) which will eventually be used.

Standardized intermediate frequencies are to be employed for all receivers used in the Commonwealth; they are: sound 30.5 Mc/s and vision 36 Mc/s. These frequencies must be adhered to to within ± 0.25 Mc/s and the oscillator frequency must be above the channel frequency. Beat oscillator radiation must be kept to less than 50 μV/m at 100 feet in the lowest three channels, 100 μV/m in channels 4 and 5 and 150 μV/m in the top five channels.

The transmitters for the Government-operated stations, which are to be erected in Sydney and Melbourne, are to be provided by Marconi's, through their associates Amalgamated Wireless (Australasia), Limited. The installation at each station will consist of an 18-kW vision and 4-kW sound transmitter, 5-kW and 1-kW standby transmitters, ancillary equipment and an 8-stack aerial array. A sound and vision radio link is also being provided between the two stations.

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Simple Hum-Reducing Circuit for Radio Receivers

By HERBERT J. FRASER, A.M.I.E.E.*

THE economic design of a.c. operated radio receivers requires low hum output from the loudspeaker for low values of filter capacitance in the power supply. If the receiver has two a.f. stages and the grid bias for the second stage is obtained from a resistor in the common negative h.t. supply line, the use of hum cancellation at the grid of the second amplifier is commonly used to lower the cost of the filter components for a given level of hum output. It can be shown that if the resistor R_x is added to the otherwise conventional circuit of Fig. 1, a further reduction in hum output or in filter cost is obtained.

The equivalent circuit for hum potentials at the grid of V_2 (Fig. 1) is shown in Fig. 2 which can be represented by the equivalent bridge circuit of Fig. 3. Minimum hum at the grid of V_2 will be obtained when this bridge circuit is balanced.

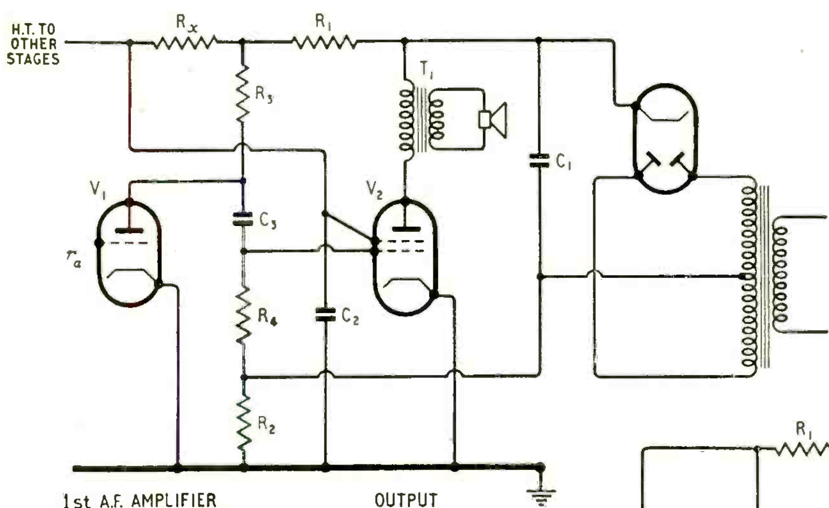

Fig. 1. Audio circuit and power supply of a.c. Receiver.

It can be shown that at balance the following relations hold.

(a) Resistive balance:

$$R_x = \frac{R_2R_3}{R_4} - \frac{R_2}{R_4} \cdot \frac{X_{c2} \cdot X_{c3}}{r_a} \quad .. \quad .. \quad (1)$$

(b) Capacitive balance:

$$C_2 = C_3 \cdot \frac{R_4}{R_2} \cdot \left[\frac{1}{\frac{R_x}{r_a} + \frac{R_3}{r_a} + 1}\right] \quad .. \quad (2)$$

where X_{c2}, X_{c3} = reactance of C_2 and C_3 at the hum frequency considered and r_a = anode resistance of V_1. In a practical circuit it is found that the second term on the right-hand side of Equ. (1) is negligible and $R_x \ll r_a$.

Hence equations (1) and (2) become

$$R_x = R_2 R_3/R_4 \quad .. \quad .. \quad .. \quad .. \quad (3)$$

$$C_2 = C_3 \cdot \frac{R_4}{R_2} \cdot \left(\frac{r_a}{R_3 + r_a}\right) \quad .. \quad .. \quad (4)$$

Because the bridge balance does not depend upon frequency it can be balanced for all hum-frequency components. The resistive balance is independent of capacitive balance and in particular it does not depend upon the value of C_2 which will be the main variable if C_2 is an electrolytic capacitor.

Experimental results were taken on a receiver with the end circuit of Fig. 1 with the following values of components:— r_a = 80 kΩ; R_1 = 2.5 kΩ; R_2 = 220 Ω; R_3 = 270 kΩ; R_4 = 470 kΩ; C_1 = C_2 = 16 μF; C_3 = 0.02 μF; R_x = 100 Ω. (C_3 and R_x were adjusted for minimum hum.)

The hum voltage measured across the secondary of the output transformer T_1 for R_x = 0, was −46 dB (arbitrary reference level) and −63 dB for R_x = 100 Ω. R_x differs from the value (126 Ω) calculated

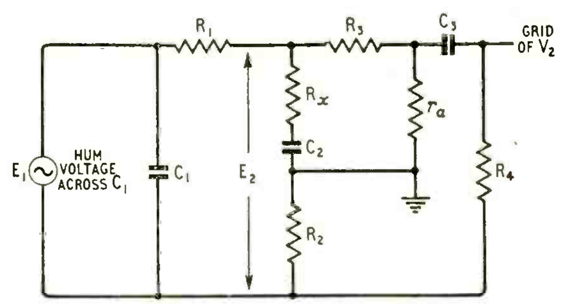

Fig. 2. Equivalent hum circuit of Fig. 1.

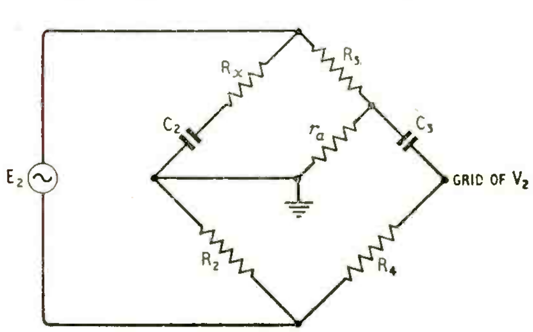

Fig. 3. Equivalent bridge circuit of Fig. 2.

* Amalgamated Wireless Valve Co. Pty. Ltd., Sydney, Australia.

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from Equ. (3) because other sources of hum, such as that due to anode and screen voltages, have not been considered in the simple theory. The value R_x required for circuits including negative feedback from the secondary of T_1 to the grid of V_1 has been found to be much less than that predicted by Equ. (3).

The bridge balance is not particularly critical. Table 1 shows the hum output when the bridge was first adjusted for minimum hum (−63 dB) and each component listed was varied by ±25%.

TABLE 1
Hum output in dB

Component	+25%	−25%
R_2	−51.5	−47
R_3	−51	−57.5
R_x	−55	−59
R_4	−54.5	−55
C_2	−53	−53
C_3	−57.5	−50
r_a	—	−54.5

It is seen that despite these large changes in components the hum is not higher in any case than the minimum hum obtainable for $R_x = 0$. In practice resistive balance can be held to close limits as it depends only upon the three fixed resistors R_2, R_3, R_4, and it represents a distinct advantage in hum reduction even if the bridge is not accurately balanced capacitively.

APPENDIX

To derive the balance conditions for Fig. 3, the three delta arms comprised by R_3, r_a and $R_x - jX_{c2}$ are replaced by their star equivalent obtained by means of the star-delta theorem*; the circuit then takes the form shown in Fig. 4, in which $Z = r_a + R_3 + R_x - jX_{c2}$. Only two of the

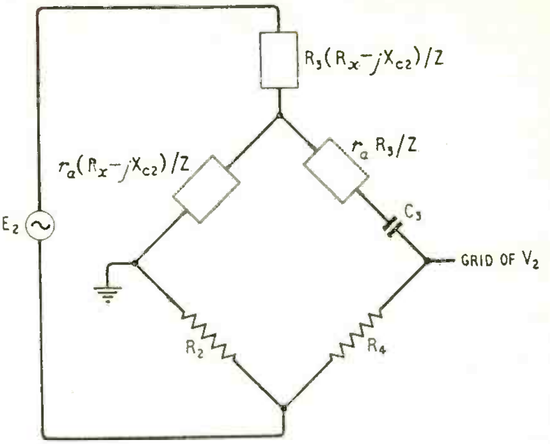


Fig. 4. Equivalent circuit of Fig. 3.

star elements enter into the balance condition which is, by the ordinary bridge relation,

$$\frac{R_2}{R_4} = \frac{r_a(R_x - jX_{c2})/Z}{r_aR_3/Z - jX_{c3}}$$

Expanding, and equating real and imaginary parts separately, we get

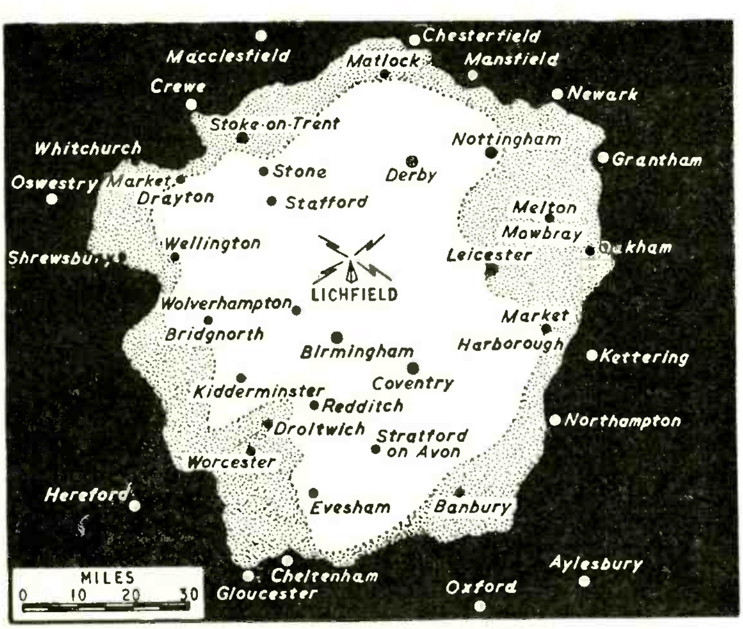
$$R_x = R_3\frac{R_2}{R_4} - \frac{X_{c2}X_{c3}}{r_a} \cdot \frac{R_2}{R_4}$$

$$X_{c2} = X_{c3}\frac{R_2}{R_4}\left(1 + \frac{R_3 + R_x}{r_a}\right)$$

$$\text{whence} \quad C_2 = C_3\frac{R_4}{R_2}\bigg/\left(1 + \frac{R_3 + R_x}{r_a}\right)$$

* "Some Electrical Theorems", by W. Tusting, *Wireless World*, November 1954, p. 550.

I.T.A. MIDLAND STATION: TEST TRANSMISSIONS



SOME idea of the anticipated coverage of the I.T.A. Midland transmitter at Lichfield will be gained from this map on which has been superimposed the authority's estimated 2-mV/m contour (dotted) outside which is the 0.5-mV/m area (shaded).

Work has already begun on the site on which Marconi's will be erecting a 450-ft self-supporting mast and aerial system. The site is 500ft above sea level.

The transmitting equipment for the station, which will operate in Channel 8 (189.75 Mc/s, vision, and 186.25 Mc/s, sound) with an e.r.p. of 144 kW, is being supplied to Pye.

Belling and Lee have been asked to radiate a test signal from a temporary low-power transmitter on the site, as they did from Croydon, and it is hoped that regular transmissions will begin on October 10th. The proposed schedule for transmissions using a similar test card to that radiated from London (with the same call sign, G9AED) is: Monday to Friday 9.30-12.30, 2.0-5.30, and 7.30-8.30; Saturday 10.0-1.0.

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LETTERS TO THE EDITOR

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

Band III Convertors

A NUMBER of advertisers in your September issue offer convertors for the reception of the I.T.A. Band III transmissions on Band I receivers. All assert their units are suitable for *any* type of receiver without internal modification; some say categorically they will work with either "straight" or superheterodyne receivers. These statements are apparently aimed largely at home constructors.

Now the majority of "straight" sets in the London area have been tuned to the upper sideband of the Alexandra Palace transmitter to make sound rejection simple. As the I.T.A. transmitter will be sending out vestigial sideband (lower sideband only) straightforward conversion will not work. Either separate sound and vision convertors will have to be fitted or the existing receiver retuned to the lower sideband. This latter course would be preferable in case the B.B.C. decide to change over to single-sideband when they move to Crystal Palace. In other words, many of those who attempt to fit convertors will be faced with the problem of retuning and adding sound rejectors in order to cut their losses.

Unfortunately, the Belling-Lee experimental Band III transmissions from their Croydon station have contributed, quite inadvertently, to this problem, since both upper and lower sidebands have been radiated. People who have bought and fitted convertors have received the test card satisfactorily and are temporarily happy. I fear some of them are in for a rude awakening when the I.T.A. station starts up in earnest.

Thornton Heath, Surrey. H. BANHAM.

F.M. at Sea

I AM glad you have drawn attention in your September issue to the Parliamentary announcement by the Postmaster General; in view of the sad history of marine v.h.f., it is not surprising that it was "tucked away."

The whole story of marine v.h.f. since its inception after the war, has been a long one of restriction, frustration and contradiction by the Post Office administration and I would like to reconstruct it in the hope that the same mistakes do not occur in future.

At Atlantic City, 1947, an extraordinary resolution was hurriedly passed in the last few days making f.m. compulsory in Region II (America) and strongly recommending it in Regions I and II (the rest of the world). There had been no experience of commercial marine v.h.f. prior to this and the decision ignored the vital factor that a.m. was standard for all aeronautical services. In May, 1949, the G.P.O., pointing out the important advantages of using a.m., decided to reverse the Atlantic City policy and to standardize on a.m. for Commonwealth marine services. The G.P.O. must have realized the far-reaching consequences of this reversal and should have dismissed all considerations of reviewing it once again at some future date. Indeed, once the decision was made it should have been supported actively and effectively in Britain and throughout the world.

After the G.P.O. announcement of a clearly defined policy, my company felt it was safe to enter the market and give full support to the G.P.O. and between 1950 and 1953 great strides were made in Great Britain and throughout the rest of the world in fitting ships and vessels with British equipment.

As these strides were continued, we began to sense opposition and obstruction to our plans to further the G.P.O.'s stated policy. Although continually pressed, the G.P.O. refused to establish further Public Correspondence schemes beyond the initial Thames Radio Service. The G.P.O. would not discuss with us ways and means of opening up additional v.h.f. channels for ship-to-shore communications with liners. Our export salesmen began to hear rumours from abroad that the G.P.O. were thinking about changing back to f.m. Although in 1951 Mr. Ness Edwards, then P.M.G., announced in the House that Great Britain would continue to support a.m. for international standards, we were left in no doubt that the G.P.O. were considering a *volte face* in January, 1953, when the G.P.O. asked the radio industry what its attitude would be to a change to f.m. As Britain's largest suppliers we vigorously opposed this change, as we felt that Britain was being "pressurized" from America to use an inferior marine system and we owed allegiance to our numerous marine customers who, with us, had supported the G.P.O.'s agreed 1949 policy.

The net result of these G.P.O. actions has been the stagnation of marine v.h.f. since 1953, with the consequent damage to our business and complete cessation of exports of marine v.h.f. whilst the shipowner has been deprived of a new and important form of communication for safety and business purposes.

We ask ourselves, therefore, if we should now support the G.P.O.'s changed policy for f.m. Past history tell us "No" but if the new P.M.G. can restore confidence and show sincerity by positive action, we would be the first to support him. The positive action he can take is threefold:—

1. To agree quickly a reasonable international marine v.h.f. specification with sufficient working frequencies and narrower channel spacing.
2. To announce the intention of setting up a number of public marine v.h.f. stations to the new f.m. standards within a specified period.
3. To state that a.m. to present standards can continue to be used on private marine channels.

Pye Marine, Ltd. R. I. T. FALKNER.

Tape Bookmark

R. G. WICKER states in his letter (your September issue) that he uses a 2-c/s signal for "finding the place" on magnetic tapes. A simpler method of imposing a signal is by means of a permanent magnet, which, if applied close to the tape, gives a very strong audible pulse on fast wind-on or rewind, even although not in contact with the head. Also this uses very little tape.

The essence of our tape selector mechanism (*Wireless World*, April) lies in its simplicity and ability to work whether the tape is moving at high speeds or at the playback speed.

We had considered the idea of applying a signal to the tape but the complexity involved outweighs the advantages of this technique although the home constructor with space to spare may prefer this method.

London, S.E.26. J. R. PRICE.
R. A. FREWER.

IN your August editorial, you reviewed ways and means of precise location of individual recordings on a length of magnetic tape. The problem is undoubtedly an irritating one for which no simple and elegant solution has yet been found.

The conventional type of indicator usually provided on a tape recorder is far too crude to give anything like precise location. If a device of this general character is to be used, then the revolution counter is definitely superior, yet its accuracy is inevitably prejudiced by changes in tape length due to humidity and temperature and to changes in winding tension.

The idea of recording a sub-audible note on the tape for registering purposes fails, as you rightly point out, because the playback head is normally inoperative during

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fast wind and rewind. If a procedure of this kind were seriously contemplated, it might be as easy to obtain the necessary signals at the start and finish of a recording by interruptions, possibly coded, of the h.f. bias current. Any frequency transformation or the like which might be found necessary would probably prove no more expensive than the provision of the v.l.f. source.

The technique proposed by J. E. Price and R. A. Frewer (April issue) certainly has the merit of simplicity and should be quite precise in operation (I have not had the opportunity of trying it) but it does undoubtedly involve the provision of a few "bits and pieces." Furthermore, affixing four layers of adhesive tape neatly along the recorded tape would prove a real trial to the ham-handed.

Quick-drying paint along an inch or two of the tape should be discernible to the eye with the fastest rewind speed and might prove a satisfactory solution to some users. Probably such markings, used in conjunction with a photocell and the other usual ancillaries, would enable automatic braking to be achieved but the arrangement would be as complicated as anything mentioned so far. As an alternative, quick-drying conducting paint and a free-running roller which embodied a pair of slip-rings to be short-circuited by the paint might prove reasonably simple and reliable.

For a number of diverse reasons, magnetic tape manufacturers in this country are pressed from time to time to print some form of distinguishing coding on the back of the tape. For an equal number of reasons this pressure has so far been successfully resisted. Such printing, it might be thought, could serve as bookmarks for recording but it would require counter circuits introduced into the recorder to make it operative.

Crude though it may be, there is probably nothing to touch the bits-of-paper technique. This is all very deplorable but the truth is that no one will be attracted to any device, elaborate or simple, which involves anything in the nature of delicate operations on the tape.

Slough, Bucks. H. G. M. SPRATT.

F.M. Receiver Design

S. W. AMOS' and G. G. Johnstone's reply (August issue) to their critic J. K. Carter demands further comment, as it may seem over-facile.

Even if a single conventional moving-coil speaker were the form of transducer in general use in the sort of high-quality equipment to which an f.m. feeder is likely to be added, it would remain a fact that distortions in successive parts of a chain add up, to the detriment of the overall quality. That frequency-divided multiple units may reduce the audible effects of speaker distortion to a very low level is well enough known to need no elaboration. The designer of one unconventional moving-coil speaker used as a single unit has claimed* that by its use an increment of distortion from 0.1% to 0.4% in the amplifier can be heard; and certainly this speaker does not itself introduce audibly significant intermodulation. So the loudspeaker is not a universal offender.

However, Mr. Carter's enquiry really begs the question "What sort of distortion?" As "Cathode Ray" has been ably pointing out in your pages, an unqualified percentage figure is not a true measure of distortion once we start considering *sound* rather than an abstract waveform.

Despite the alleged 3% distortion, f.m. reception *via* a ratio detector shows, under favourable conditions, less audible distortion than any other source readily available (I have not yet heard a unit using the Foster-Seeley circuit; and the ratio detector certainly is simplicity itself to align), yet the distortion introduced by the S.B. line when the programme source is anywhere but London produces a marked deterioration although the stated limits of distortion for a single link are only 0.6% at 1,000 c/s and 5% at 100 c/s (I say "only," but one shudders to think of the possibilities—at the actuality, often enough—when a programme comes from a distant region *via* perhaps four or five links!) Whatever may appear on paper, distortion in the ratio detector does not appear to be significant in practice.

Similarly, one gets excellent results from commercial gramophone records although the distortion of the whole channel measured from the input of the cutter amplifier to the output of the pickup can scarcely be less than several per cent at maximum modulation—it is significant that one never sees measured results published. And it is customary to adjust tape recorders for from 2½% to 5% distortion at maximum level, yet we happily use these machines to record f.m. transmissions and replay them through amplifiers of the "point one" class (*vide* Richard Arbib in your August issue, for instance).

I would suggest that distortion data might yield some meaning if we were invariably given not a single figure but—as a minimum—graphs of 2nd, 3rd and total harmonic distortion plotted against signal level from zero to maximum for a stated frequency near the middle of the spectrum, and of d_2, d_3 and d_{tot} plotted against frequency at maximum level throughout the useful range of the equipment. Unfortunately the only equipment for which even reasonably comprehensive test figures are customarily published is amplifiers of the highest class, which for practical purposes can invariably be simply assumed to be above reproach in any case!

London, N.10. IAN LESLIE.

* F. H. Brittain, "Metal Cone Loudspeaker," *W.W.* Jan. '53.

Radio in Schools

YOUR readers may be interested to know that we are including amateur radio as one of the subjects a child may opt to do in this school.

Our reasons are as follows. Once the basic subjects have been adequately covered, we believe that a child may best be helped to grow into a mature and responsible adult by using his real interests as a means through which to educate him. We find that a number of our boys are very keen indeed on amateur radio and we have planned a scheme of work around this topic which will strengthen the English, mathematics, science, geography, etc., of the pupils following it, as well as giving them a basic knowledge of radio itself. It will be clear, then, that our aim is in no way vocational, but is directed to improving the pupil's general education.

Our difficulty is equipment. As most people know, educational funds for such a purpose are very limited indeed. If any of your readers have components, valves and accessories, meters and test gear, old receivers, materials, etc., lying idle, we should be most grateful for them. They may rest assured that such gifts, however small, would be most gratefully received and put to the fullest possible use.

Headmaster, A. W. ROWE.
Holmer Green County School,
High Wycombe, Bucks.

Transistor Letter Symbol

SHORTLY after you published my letter in the July issue I was sternly informed that "The Americans use V for valves as we do." Checking what American literature I have in hand, I find that *Audio Engineering* uses V, Terman uses T, and Begun uses VT.

Of course, "tube" has the virtue of being more general than "valve," covering things like c.r.ts and photocells and thereby giving a logical reason for using T for both valves and transistors. My correspondent demands that T should be kept for transformers but it seems perfectly satisfactory to put mutual inductances in the list of inductors, as is already done with r.f. transformers.

Prestwich, Manchester. V. MAYES.

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Transistor Equivalent Circuits

4.—*Conclusion*

By W. T. COCKING, M.I.E.E.

SUMMARY: In this concluding article of the series, some elementary aspects of transistor amplifiers are considered. The question of frequency response is touched upon and the applicability of the d.c.equivalent circuit to the designing of circuits for stabilizing the operating point is pointed out.

WE have now derived several basic equivalent circuits for the transistor and it might be thought that the subject is exhausted. This is not so, however, for there is one important effect that we have so far ignored and another that we have stressed so little that it may well be overlooked, although we have actually taken account of it.

Before discussing these matters, however, we propose to digress a little from our main theme of equivalent circuits to consider some of their applications. The valve, as is well known, has a moderate to high output impedance and an input impedance so high that it can often be ignored. The lowest output impedance normally found is about 500 Ω, for a large power triode; the highest is several megohms, for an r.f. pentode. Unless positive grid drive is used, the input resistance is tens of megohms or more, except at very high radio frequencies.

With a junction transistor, on the other hand, the output resistance is high, being around 1–2 MΩ, but the input resistance is low, perhaps 50 Ω to 2 kΩ. This has a big influence on circuit design. Figures for voltage or current amplification can have little meaning unless the impedances are also stated, and it is often better to express amplification in terms of power.

In order to obtain maximum power gain, it is essential to match the output resistance of one stage to the input resistance of the next by means of a step-down transformer. Now the input resistance of a stage depends upon the load resistance of that stage and the output resistance depends upon the internal resistance of the stage or other device which drives it. The general solution for the optimum conditions in a multi-stage transistor amplifier can thus be quite complicated.

Except in the early stages, where the signal levels are very small, this condition of matched impedances is not very satisfactory, however, because too much non-linearity distortion occurs. Hitherto, we have treated the transistor on the basis of a linear approximation to its characteristics. Just as in the case of the valve, this becomes rather inaccurate at high signal levels and it becomes necessary to determine the proper conditions by a graphical construction.

We need not go into this in detail here, for the procedure is identical with that for the valve. Basically, one takes a set of collector voltage–current curves for the transistor and by trial and error determines the optimum load for it for maximum power output and minimum distortion, taking care not to exceed the maximum ratings for peak voltage, peak current and mean power. One then obtains a figure for the peak current input at base or emitter, according to the form of connection being employed.

For the output stage, it oftens pays to use the earthed-base connection, for the collector characteristic curves are straighter and more evenly spaced than in the earthed-emitter connection.

The procedure so far is exactly like that for a valve, save that the input is expressed as a peak current instead of a peak voltage. There is now, however, a difference, for the input characteristics are not linear and must be taken into account. Strictly, one must have a set of input voltage-current curves and draw a load line upon them to represent the resistance of the input circuit and determine its proper value for minimum distortion. Very commonly, the input distortion may be much greater than the output and may preclude the possibility of impedance matching.

In order to make the distortion negligible, it is often necessary to feed a transistor from a source having a resistance high compared with the input resistance. This means operating in a mismatched condition with a consequent loss of amplification. Resistance-capacitance coupling may then entail relatively little further loss of amplification and may well make for a lighter and more compact amplifier even if it does entail the use of more transistors.

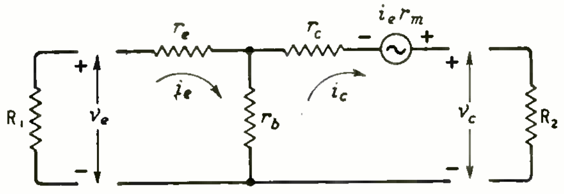

Fig. 1. Transistor equivalent circuit with source and load resistances.

Whatever form of coupling is used, it is essential to know the input resistance and some other characteristics. In Fig. 1 is shown the T form of equivalent circuit for an earthed-base transistor; R_1 and R_2 are the resistances of the input and output circuits respectively.

First of all, ignore R_1 and let v_e be a signal voltage applied between emitter and base; R_2 is connected and v_c is the output voltage developed across R_2 by i_c flowing in it. The equations are:—

$$v_e = i_e(r_e + r_b) - i_c r_b \quad \ldots \quad (1)$$

$$i_e r_m = i_c(r_b + r_c + R_2) - i_e r_b \quad \ldots \quad (2)$$

From (2) we get straightaway

$$i_c = i_e \frac{r_b + r_m}{r_b + r_c + R_2} = i_e A_c \quad \ldots \quad (3)$$

where A_c is the current amplification.

Inserting this result in (1),

$$v_e = i_e(r_e + r_b - A_c r_b)$$

The input resistance is defined as

$$r_{in} = \frac{v_e}{i_e} = r_e + r_b(1 - A_c) \quad \ldots \quad (4)$$

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The voltage amplification is

$$A_v = \frac{v_c}{v_e} = \frac{i_c R_2}{i_e r_{in}} = A_c \frac{R_2}{r_{in}} \quad \ldots \quad (5)$$

To determine the output impedance, we imagine R_2 of Fig. 1 to be disconnected and R_1 connected while v_c becomes an externally-applied driving voltage. If v_c is of opposite polarity to that shown, the directions of the currents and the polarity of $i_e r_m$ are all unaltered. The equations then become:—

$$v_c = i_c(r_c + r_b) - i_e(r_b + r_m) \quad \ldots \quad (6)$$

$$0 = i_e(r_b + r_e + R_1) - i_c r_b \quad \ldots \quad (7)$$

whence

$$r_{out} = \frac{v_c}{i_c} = r_c + r_b - r_b \frac{r_b + r_m}{r_b + r_e + r_m} \quad \ldots \quad (8)$$

By a similar procedure, using the two-generator equivalent circuit, the relations can be obtained in terms of r_{11}, r_{22}, α and β. They are all listed in Table 1 with the formulae for the earthed-emitter connection also.

At this stage, it is desirable to quote some practical values so that we may be familiar with the orders of magnitude of the quantities involved. In Part 3, we quoted the following figures for a junction transistor:— $r_{11} = 785\,\Omega$, $r_{22} = 1.5\ M\Omega$, $\alpha = 0.97$, $\beta = 0.956$ for the earthed-base connection. These became $\rho_{11} = 785\ \Omega$, $\rho_{22} = 30\,k\Omega$, $a = 48.5$, $b = 0.0446$ for the earthed-emitter connection. Suppose that the load resistance R_2 is $100\,k\Omega$. Applying the relations of Table 1, first for earthed-base connection, we get:—

$$A_c = 0.97 \frac{1.5}{1.6} = 0.91$$

$$r_{in} = 785(1 - 0.91 \times 0.956) = 102\,\Omega$$

For the earthed-emitter connection, we have:—

$$A_c = 48.5 \frac{30}{130} = 11.2$$

$$r_{in} = 785(1 + 11.2 \times 0.0446) = 1{,}175\,\Omega$$

If the source resistance R_1 is also $100\,k\Omega$ the output resistances in the two cases are:—

$$r_{out} = 1.5\left(1 - 0.97 \times 0.956 \quad \frac{0.785}{100.785}\right)$$

$$\approx 1.5\,M\Omega \text{ (earthed-base)}$$

$$r_{out} = 30\left(1 + 48.5 \times 0.0446 \frac{0.785}{100.785}\right)$$

$$= 30.3\,k\Omega \text{ (earthed emitter)}$$

TABLE I

Earthed-Base Transistor

Current amplification

$$= \frac{i_c}{i_e} = A_c = \frac{\alpha r_{22}}{r_{22} + R_2} \qquad = \frac{r_b + r_m}{r_b + r_c + R_2}$$

Voltage amplification

$$= \frac{v_c}{v_e} = A_v = A_c \frac{R_2}{r_{in}}$$

Input resistance

$$= \frac{v_e}{i_e} = r_{in} = r_{11}(1 - \beta A_c) = r_e + r_e(1 - A_c)$$

Output resistance

$$= \frac{v_c}{i_c} = r_{out} = r_{22}\left(1 - \frac{\alpha\beta r_{11}}{r_{11} + R_1}\right)$$

$$= r_c + r_b\left(1 - \frac{r_b + r_m}{r_b + r_e + R_1}\right)$$

where R_1 and R_2 are the external emitter and collector circuit resistances respectively.

Earthed-Emitter Transistor

Current amplification

$$= \frac{i_c}{i_b} = A_c = \frac{a\rho_{22}}{\rho_{22} + R_2} \qquad = \frac{\rho_m - \rho_e}{\rho_c + \rho_e + R_2}$$

Voltage amplification

$$= \frac{v_c}{v_b} = A_v = -A_c \frac{R_2}{\rho_{in}}$$

Input resistance

$$= \frac{v_b}{i_b} = \rho_{in} = \rho_{11}(1 + bA_c) = \rho_b + \rho_e(1 + A_c)$$

Output resistance

$$= \frac{v_c}{i_c} = \rho_{out} = \rho_{22}\left(1 + \frac{ab\rho_{11}}{\rho_{11} + R_1}\right)$$

$$= \rho_c + \rho_e\left(1 + \frac{\rho_m - \rho_e}{\rho_b + \rho_e + R_1}\right)$$

where R_1 and R_2 are the external base and collector circuit resistances respectively.

Two-stage Amplifier

Consider now a two-stage amplifier, such as that sketched in Fig. 2(a). The complete equivalent circuit has the form (b) and seems quite complex. However, it can be further reduced to the form (c) for which the only assumption is that the reactance of the coupling capacitor C is negligibly small at the frequencies under consideration. Apart from this, the only changes are the substitution of the input resistance of each stage for the feedback generator ($bi_{e1}\rho_{11}$ or $\beta i_{e2} r_{11}$) and slope resistance (ρ_{11} or r_{11}).

Consider the inter-transistor coupling. The load on V_1 comprises R_{c1}, R' and r_{in} all in parallel. We have seen that for an earthed-base transistor r_{in} is of the order of $100\,\Omega$ only and, for an earthed-emitter transistor, ρ_{22} is about $30\,k\Omega$. Even if R_{c1} and R' in parallel have a value of no more than $1\,k\Omega$, the combined value in shunt with r_{in} will only be about 10% less than r_{in} by itself. Approximately, therefore, the load on V_1 is merely r_{in} and the current amplification of V_1 is very little less than the current amplification factor a.

Generally speaking, with junction transistors in RC coupling, the load impedance of one stage is very nearly the input resistance of the next and this is low compared with the resistance ρ_{22} or r_{22} so that the current amplification A_c is very nearly the current amplification factor a or α, as the case may be. In working out a preliminary design, therefore, only three simple steps are necessary:—

1. Choose the output load R_{c2} for the required power output and determine the input current i_{e2} for this output stage. Usually this must be done graphically from the characteristic curves, since distortion is important here.
2. The preceding stages will each have a current gain of nearly the current amplification factor. So the input current to the first stage is nearly i_{e2} divided by the product of the individual current amplification factors. In earthed-base connection α is less than unity and this arrangement is consequently useless for current amplification with RC-coupled junction transistors. The earthed-emitter connection must be used.
3. Compute the input resistance of the first stage. Under these conditions it is very nearly $\rho_{11}(1 + ab)$.

The input circuit must then be designed so that the signal source can feed into this impedance efficiently. This will often entail the use of a transformer.

Conditions with the point-contact transistor are very

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different from those with the junction type. Krugman quotes $r_{11} = 250\,\Omega$, $r_{12} = 100\,\Omega$, $r_{21} = 24\,\text{k}\Omega$, $r_{22} = 12\,\text{k}\Omega$. From Table 2 of Part 3, $r_{12} = r_b$ and $r_{21} = r_m + r_{12} = r_m + r_b$, $r_{22} = r_c + r_b$, $r_{11} = r_b + r_e$. Therefore, from Table 1 of Part 3, $\alpha = r_{21}/r_{22} = 24/12 = 2$ and $\beta = r_{12}/r_{11} = 100/250 = 0.4$.

In the earthed-base connection, with a load R_2 of 24 kΩ, we have

$$A_e = 2\,\frac{12}{12 + 24} = 0.66$$

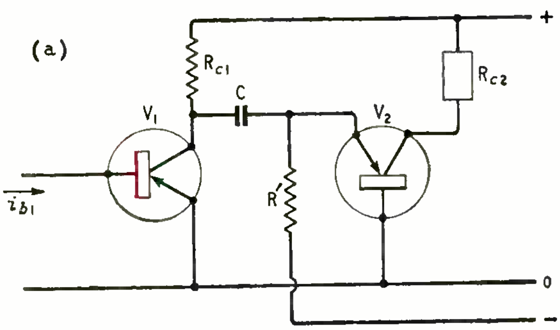
$$r_{in} = 250(1 - 0.66 \times 0.4) = 183.3\ \Omega$$

This is a condition which might appertain to an output stage. For a previous stage the load cannot exceed $r_{in} = 183.3\,\Omega$ unless a transformer is used. This is small compared with r_{22} and the current amplification is nearly 2; it is $2 \times 12/12.183 = 1.98$. Unlike the junction transistor, therefore, a point-contact transistor will give a small current gain in the earthed-base connection.

The output resistance depends on the value of the source resistance. If this is very small, r_{out} tends to $r_{22}(1 - \alpha\beta) = 24(1 - 0.8) = 4.8\,\text{k}\Omega$ in the example considered. If it is very large, r_{out} tends to $r_{22} = 24\,\text{k}\Omega$. In this case, therefore, the output resistance must lie within the limits of 4.8 kΩ and 24 kΩ and, with practical values of source resistance, it is likely to be in the range 6–10 kΩ. Whatever the values of R_1 and R_2 the input and output resistances are always positive.

Let us now consider the point-contact transistor in

Fig. 2. Two-stage transistor amplifier (a) and its equivalent circuit (b). A simplified equivalent circuit is shown at (c).



the earthed-emitter connection. From Table 1, Part 3, $\rho_{11} = r_{11} = 250\ \Omega$, $\rho_{22} = -11.85\,\text{k}\Omega$, $a = -2$, $b = 0.6$ and so, taking $R_1 = R_2 = 20\,\text{k}\Omega$, we get

$$A_e = \frac{-2 \times -11.85}{8.15} = 2.9$$

$$r_{in} = 250\,(1 + 0.6 \times 2.9) = 685\,\Omega$$

$$r_{out} = -11.85\left(1 - 2 \times 0.6 \times \frac{250}{20{,}250}\right) \approx -12\text{k}\Omega$$

The input resistance is positive but very small, while the output resistance is negative.

Point-Contact Characteristics

From Table 1, for the extreme limits of zero and infinity for R_2, the current amplification varies from a to zero. With zero load, it equals the current amplification factor of the transistor and is negative. Since ρ_{22} is negative as R_2 is increased A_e remains negative but increases rapidly to infinity when $R_2 = \rho_{22}$. For any higher value of R_2 the amplification falls and becomes positive, which means that the output current reverses in phase as R_2 passes through the value ρ_{22}.

The input resistance is $\rho_{11}(1 + bA_e)$. With $R_2 = 0$, $A_e = a$ and is negative. If, as is normally the case, ab is numerically greater than unity, the input resistance is negative. It becomes infinite when A_e becomes infinite and for higher values of R_2 it is positive and reaches the value ρ_{11} when the load is infinite. This critical condition of infinite input resistance occurs when

$$R_{22} = -\rho_{22}$$

The output resistance when R_1 is infinite is $\rho_{22}(1 + ab)$ and is positive and low in value. As R_1 is increased, ρ_{out} falls and passes through zero when

$$-1 = \frac{ab\rho_{11}}{\rho_{11} + R_1}$$

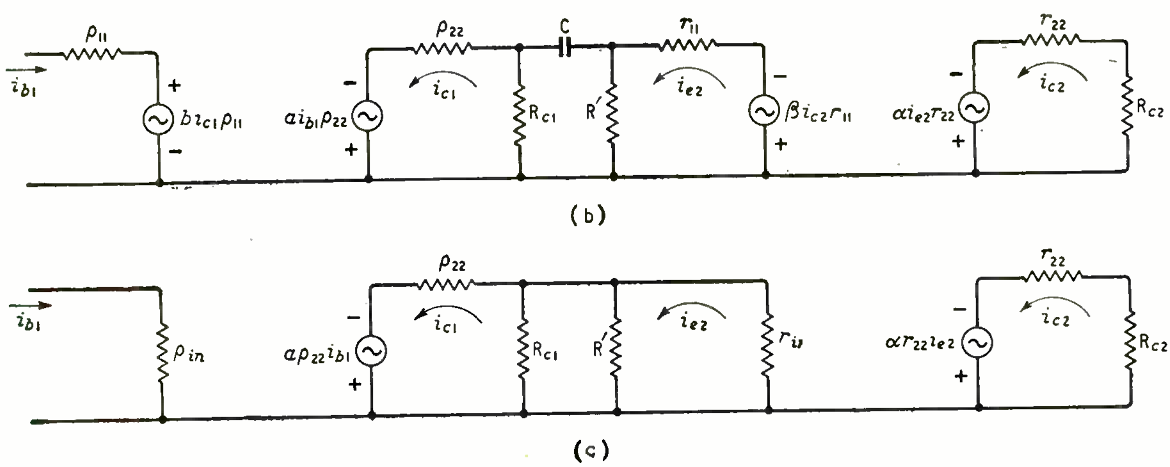
or $R_1 = -\rho_{11}(1 + ab)$

For the transistor we have considered, this value is

$$R_1 = -250(1 - 2 \times 0.6)$$
$$= -250 \times -0.2$$
$$= 50\,\Omega$$

For higher values of R_1 the output resistance increases in value and becomes negative.

If the input and output resistances of a point-contact transistor are both to be positive, it must be operated



with a source resistance R_1 of less than $-\rho_{11}(1+ab)$ and a load resistance R_2 of greater than $-\rho_{22}$. It is not usually convenient to observe these limits and this is a major reason why the point-contact transistor is not much used in the earthed-emitter condition.

This is not the place to go into the reasons why the point-contact transistor can have negative input and output resistances in the earthed-emitter connection. We merely note the fact, which is one that makes it necessary to be very careful how one uses this kind of transistor in this circuit. The fact, however, can be put to good use for as a consequence of it the point-contact transistor is well suited for use as an oscillator and in switching circuits.

High Frequencies

Returning now to transistor amplifiers generally, there is one matter which we have, so far, ignored completely. We have treated the transistor constants as being pure resistances. In practice, they have reactive elements; in other words, the voltages and currents are not precisely in phase.

The main effect at low and moderate frequencies is to the current amplification. As the frequency is raised, the magnitude of α falls and there is a phase angle between i_e and i_c. It is not uncommon, although very approximate, to allow for the effect by writing:

$$\alpha = \frac{\alpha_0}{1 - jf/f_\infty}$$

where α_0 is the low-frequency current amplification factor as previously defined and previously designated by α. The frequency under consideration is represented by f while f_∞ is the frequency for which the magnitude of α is $1/\sqrt{2}$ of its low-frequency value. For some of the older transistors, the value of f_∞ was only a few kilocycles but, in the newer junction types, it is often 1 Mc/s or so. With these, the change of α through the a.f. range is negligible.

This may not be so in the earthed-emitter circuit, however. To a good approximation:

$$a = \frac{\alpha}{1-\alpha} = \frac{\alpha_0}{1-\alpha_0-jf/f_\infty} = \frac{\alpha_0}{1-\alpha_0} \cdot \frac{1}{1-jf/f_\infty(1-\alpha_0)}$$

The cut-off frequency is $1-\alpha_0$ times that for earthed-base operation. As α_0 is around 0.95 for a junction transistor, $1-\alpha_0$ is around 0.05 and the cut-off frequency is only about one-twentieth. In earthed-emitter operation, therefore, the change of amplification factor with frequency is much more important and may have to be considered even at a.f.

The effect of frequency upon the operation of a transistor is sometimes taken into account by elaborating the equivalent circuit by the addition of capacitances. So far, all attempts to do this seem approximate. We feel that a representation has not yet been devised which is both sufficiently accurate and sufficiently simple to be of much practical use.

For audio frequencies, and with modern transistors, frequency effects are usually small and can be ignored. At high frequencies, some guidance is obtainable from the value of f_∞ but, apart from this, the approach must be largely experimental.

Turning now to another matter, we said at the beginning that there was one thing which we have stressed so little that it may well have been overlooked, although we have actually taken account of it. This is the collector current with zero emitter current, normally designated by I_{c0}. If we refer to the d.c. equivalent circuit for the earthed-base transistor Fig. 2, Part 3, and to the characteristics of Fig. 3, Part 3, we see that we have designated as I'_c the collector current for zero emitter current and in Fig. 2(f) we took account of this by the battery E'_c.

The current flowing with $I_e = 0$ is E'_c/r_{22} when $V_e = 0$ and this equals I'_c of Fig. 3 and the I_{c0} of conventional nomenclature. From now on, we adopt this convention and so $E'_c = I_{c0}\, r_{22}$ and the d.c. equivalent circuit of Fig. 2(f), Part 3, is applicable.

The practical importance of I_{c0} is that it varies a great deal with temperature and, in transistor circuit design, it is necessary to arrange the circuit so that its variation has a minimum effect upon the operating conditions. To this end, d.c. feedback is quite often employed. The use of the d.c. equivalent circuit in one or other of its many possible forms facilitates the design of such circuits. The aim is to devise a circuit in which I_e, V_e (or I_b, V_b) and I_c, V_c are substantially independent of the value of I_{c0}.

It may be objected that the d.c. equivalent circuit is not of much use for this purpose because it depends upon a linear approximation to the transistor characteristic and so can be reasonably accurate only over a small range. The whole purpose of a stability circuit, however, is to keep the operating point substantially constant and therefore within the range of validity of the linear approximation. We cannot safely use the d.c. equivalent circuit to calculate the performance of a poorly stabilized circuit, but we can do for a well-stabilized one. We can, therefore, use it as an aid in devising such a circuit. It will only be invalid if we do not succeed in finding one, and that is not of much importance.

In this series of articles, we have but touched upon the fringe of transistor circuitry, but it is hoped that they have served their purpose which is, by the analogy with the valve, to give the newcomer to the transistor some familiarity with the equivalent circuits and to endow them with some meaning.

We have not, for instance, dealt at all with the earthed-collector circuit. This bears the same relation to the earthed-emitter circuit as the cathode-follower bears to the ordinary valve amplifier. It is, in fact, a transistor "cathode" follower. It can, therefore, be treated in an analogous manner.

Violation of Amateur Bands

THE continued presence in exclusive amateur bands of commercial and broadcast stations is criticized in the July issue of the *R.S.G.B. Bulletin*, in which the present position in each of the bands is briefly surveyed. The hope is expressed that with the lessening of world tension there will be a reduction in the number of propaganda broadcasts which have been cluttering up the 7-Mc/s band for the past ten years —"broadcasts which we suspect have no listening public other than the diplomatic mission across the road." The "noisome pestilences" in the 14-Mc/s band, allocated exclusively to amateurs throughout the world, are the jamming stations which "appear to idle for hours on odd frequencies in the band ready to pounce on victims which come up outside the band."

The writer castigates the British Government, which, although a signatory to the Atlantic City and Buenos Aires conventions, is "just as much to blame for breaking international agreements as are countries behind the Iron Curtain."

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Dry-Cell Reactivator

Recharging with Partially Rectified Alternating Current

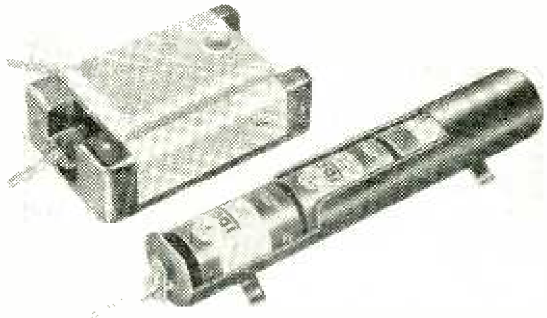
By R. W. HALLOWS, M.A.(Cantab.), M.I.E.E.

AN article of mine on the possible means of reactivating dry cells published some time ago in *Wireless World** has since brought me a great deal of interesting correspondence from many parts of the world. Research work on this fascinating and rather important problem has already led to several solutions, each satisfactory up to a point, of which practical use is being made commercially. In some United States towns, for example, meter-readers hand in at the end of the day's work the flashlamps with which they are provided. The batteries are placed overnight in the racks of large reactivators and next morning each man draws a flashlamp containing a "rejuvenated" battery, which can be relied upon to give him all the light that he needs throughout the day.

It is, in fact, recognized that cells can readily be reactivated, provided that certain conditions are complied with. Nothing can be done with a cell whose can is punctured, or with one which has suffered a slow decline in e.m.f. through long use, through evaporation of the water in the electrolyte, or through standing idle on the shelf. It is widely accepted that the e.m.f. of a "run-down" cell, otherwise in good condition, can be restored by passing a suitable reverse current through it, if (a) the period of service has been short—say, not more than one or two days; (b) the e.m.f. has not fallen below about 0.9 V; and (c) the reactivating current is applied without delay.

If such conditions are fulfilled, apparatus as simple as an ordinary trickle-charger will enable a cell of good quality to be given from eight to fifteen or more new leases of life. There are, though, certain serious "snags." The first is that unless the reverse current is limited to something quite small and the reactivating process made a long, slow one, the cell is apt to become very hot. It may even burst, with rather devastating results! The second drawback is that after reactivation the open-circuit e.m.f. may be 2.4 V, or even rather more. Though the e.m.f. falls quickly under load to a normal value, it is to begin with undesirably high for, say, the filaments of the sub-miniature valves used in hearing aids.

A successful method of dry-cell reactivation has been developed in Holland by Mynheer Beer, who was kind enough to send me some time ago some of his apparatus for test purposes. This reactivator, the Elektrophoor, has been produced commercially in a considerable number of forms: special patterns are available for reactivating the combined h.t. and l.t. batteries of hearing aids and "all-dry" wireless sets, cycle-lamp batteries and a variety of flashlamp batteries. As I make a good deal of use of a flashlamp using three "U2"-sized cells, the Type E4 Elektrophoor, specially designed to deal with batteries of this kind, appealed particularly to me. Laboratory tests apart, the Elektrophoor has proved its worth by having kept the three-cell battery now still in use up to the mark for over 15 months.



The reactivator unit, with holder for three series-connected cells.

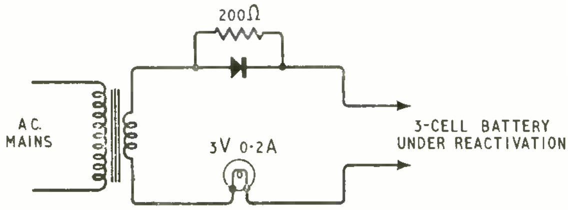


Fig. 1. Circuit of the Elektrophoor reactivator.

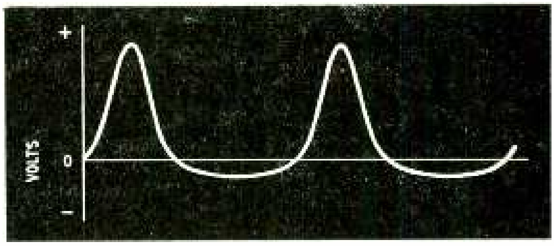


Fig. 2. Output of the reactivator, as shown by an oscilloscope, when applied to a partly run-down 3-cell battery.

The circuit arrangement is shown in Fig. 1. It consists of a step-down transformer, whose 6-volt secondary feeds a metal rectifier, shunted by a resistor with a nominal value of 200 Ω. The measured value of that in the apparatus tested was actually 240 Ω. In the other "leg" of the secondary's output is a 3-V, 0.2-A flashlamp bulb.

It will be appreciated that with ordinary good-quality a.c. and d.c. meters it is not possible to measure exactly in such an arrangement the applied reverse e.m.f. or the current that flows; nor can one determine the respective values of the a.c. and d.c. components. It is stated in the handbook that the charging current is mainly a.c., with some pulsating d.c.

It is difficult to see how a run-down dry cell could be reactivated, in a few hours at any rate, by applying a current that was mainly alternating. The story told by the oscilloscope is illustrated in Fig. 2. It will be

* "Reactivating the Dry Cell." R. W. Hallows, *Wireless World*, August, 1953; p. 344.

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seen that when the Elektrophoor is dealing with a partly run-down cell its output is what may be described as "very dirty d.c." The net direct e.m.f. works out at approximately 4.7 V.

The lamp glows when the apparatus is connected up and switched on. A value for the effective current flowing may thus be obtained by using a similar lamp in a circuit containing a battery, a rheostat and a 0-500 milliammeter, the rheostat being adjusted until the brilliance of the two lamps is matched. As a check, the lamps are changed over and another reading is taken. The current is found in this way to vary, according to the condition of the cell under charge, between about 0.135 and 0.16 A.

Laboratory tests gave results very similar to those obtained with a simple trickle-charger, so far as the life of the cells was concerned: discharged through 6 ohms per cell for 3 hours a day and then immediately put into the reactivator they had a useful life from nine to seventeen times as long as that of untreated cells.

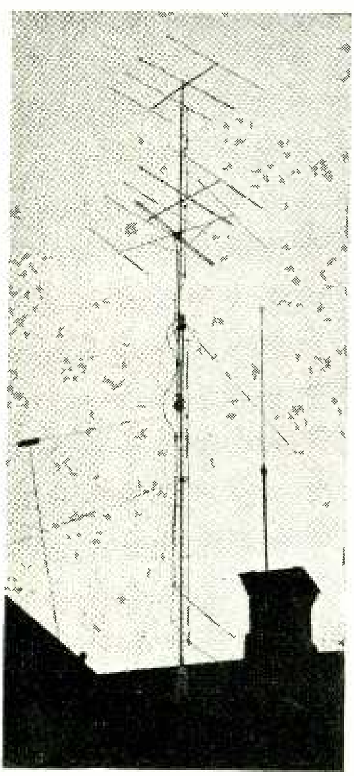
Two important differences were, however, noted. In the first place, the open-circuit e.m.f. of cells immediately after reactivation was never undesirably high, for it averaged 1.55-1.6 V. Secondly, no cell was found to become hot during reactivation.

Further tests showed that it was not essential to put cells on charge as soon as possible after their period under load. Three cells which had been used intermittently for over three months without ever being reactivated were placed in the Elektrophoor and given an all-night charge. Their average e.m.f. was 1.22 V on open circuit. Next morning all showed e.m.fs in the neighbourhood of 1.5 V. They were put into a flashlamp and a night in the reactivator whenever they seemed to need it has kept them at work ever since.

The only differences between the Elektrophoor circuit and that which I used previously with an ordinary trickle charger are the addition of the flashlamp and of the resistor shunting the rectifier. The purpose of the lamp is presumably to limit the charging current. All that the resistor can do is to allow some alternating current to by-pass the rectifier.

I do not pretend to know why this a.c. improves the reactivation. It may give a kind of electro-chemical shake-up to the cell and so assist the processes of depolarization and of re-deposition of zinc on the inner surface of the can. Be that as it may, one certainly finds on breaking open a cell which has been reactivated in this way that the zinc is more evenly and smoothly re-deposited and is in a less pasty and lumpy state than when reactivation has been done without the shunt resistor across the rectifier.

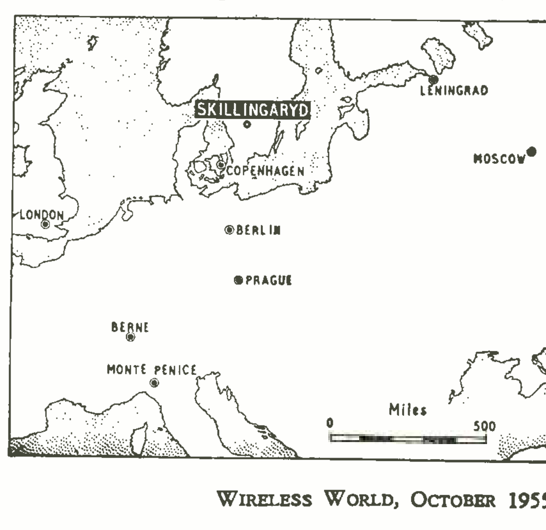
Long-range Television Reception



AT ONE time the reception of television pictures over distances of several hundred miles was considered just a freak, but now, to judge from various reports, it is becoming a consistent freak. One gets the impression that if one cannot view opera from Milan or ballet from Moscow as a matter of course every evening it is only for the lack of a few hundred lines on the screen and a few extra elements on the aerial—not through any fault of the waves themselves!

However, the Continental viewers with their common standards are in a much better position for this international eavesdropping than we are. Some of the most remarkable results in recent months have been obtained by a couple of Swedes, B. Pettersson and I. Sandblom, from the town of Skillingaryd in southern Sweden. Using a 17-inch 625-line German receiver by Nord-Mende of Bremen and an ordinary dipole aerial, they received their first long-distance picture on 1st June, 1954—from Russia. Since then, with a more elaborate aerial array, they have been picking up programmes from Italy, Switzerland, Russia, Czechoslovakia, Germany, Denmark and Holland, not to mention the Swedish experimental transmitter and some unidentified stations. The screen pictures on the opposite page have all been obtained this year.

On the European channels 2 and 3 (48 and 55 Mc/s vision) good reception has been obtained with a



The aerial system used for reception. Right: Sketch map giving some idea of the distances between Skillingaryd and the countries from which the transmissions have been received.

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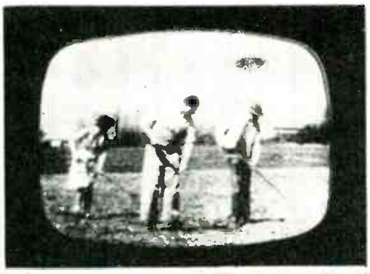
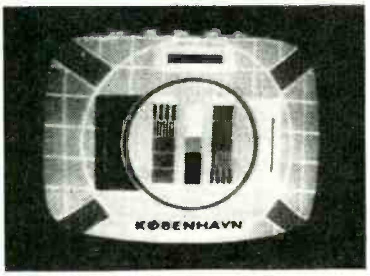
ITALY

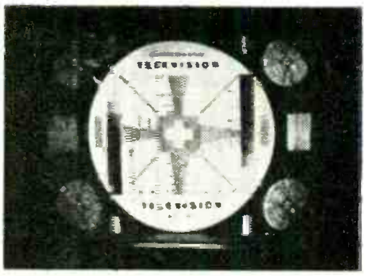
single aerial array, while for channel 4 (62Mc/s vision) an 8-element stacked array is used. A telescopic mast raises the assembly about 40ft above the roof of the house, giving a height above ground of about 65ft, and there is a mechanical system for rotating the aerial to point it in any desired direction.

Experience has shown, apparently, that receiving conditions are poor during warm periods and best at changes between high and low barometric pressures. During 1955 reception has been somewhat inferior to that in 1954. Of all the stations they have picked up, Pettersson and Sandblom regard the Italian and Russian ones as the most reliable, while others prove more or less capricious. An outstanding day was 22nd May, 1955, when Italy came in "just like a local programme." Later on in June, with two receivers operating, they saw test-cards from Switzerland and Italy simultaneously. British transmissions have sometimes broken through the Italian and Russian programmes, but, of course, being on 405 lines, they could not be displayed on the screen.

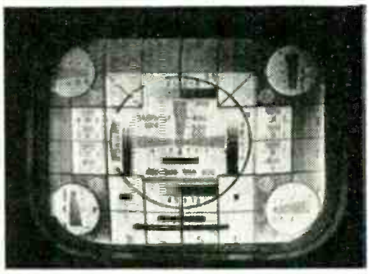
DENMARK

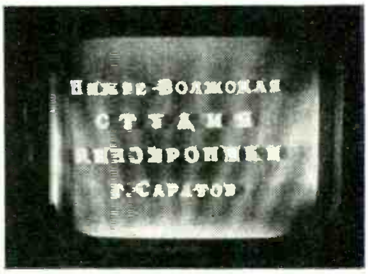






RUSSIA





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MORE ABOUT FOURIER

Analysing Waveforms into their Various Harmonics

By "CATHODE RAY"

ONE can hardly take an intelligent interest in any of the technicalities embraced by *Wireless World* without some acquaintance with Fourier's theorem—the one that says all kinds of waveforms can be analysed into or built up from pure sine waves having frequencies that are whole-number multiples of the fundamental frequency of the wave. Last month we took almost nothing for granted and set about an inquiry as to why sine waves have such a unique status among waveforms. Though we didn't succeed in establishing that they are absolutely compulsory, we found that there are very good reasons for their privileged position in the scheme of things. For instance, while there might conceivably be other ways of reckoning frequency, such ways would stand no chance at all against the accepted practice of reckoning the frequencies of waves as the frequencies of their Fourier fundamental sine waves.

It is easy enough to demonstrate on paper that adding together a fundamental and one or two harmonic sine waves produces waves of other shapes, and then to say that all waves of those shapes can be analysed into sine waves. But what about sundry waveforms that are produced, say, by a valve oscillator? The oscillator doesn't know that it is generating a lot of harmonic sine waves; it is only one oscillator, after all—not a legion of them. Then do those harmonic sine waves predicted by Fourier exist really, or only in the mathematician's imagination? It is particularly difficult to believe that waveforms like those in Fig. 1(a) can be made up entirely from smooth sine waves (b). Doubts like this must have been in the mind of a radar trainee during the war, who had been taught that when a square wave is applied across a CR circuit having a short time-constant, the waveform across R consists of sharp peaks (Fig. 2). The explanation of this phenomenon was of course given him in terms of exponential charging of C—without a hint of Fourier. But having on another occasion heard about the Fourier principle, he put the two things together and inquired whether, if the square wave really consisted of sine waves, as was said, these sine waves when applied to the CR circuit would come out in such a way as to make the peaky wave.

I don't know what was going on in the fellow's mind, but it may have been something like this: "The shape of the pointed waveform comes from the charging of the condenser—I can see that all right—and sine waves don't come into it at all. Even if it is true, as they say, that the square wave is made up of sine waves (it doesn't look like it) and the peaky wave too (looks even less like it), the change from one to the other has nothing to do with sine waves that I can see. This just shows that the Fourier idea doesn't stand up to things like this, which work on other principles. It'll be fun to catch out old——with it!"

But I would rather give him credit for quite exceptional intelligence, first for putting together two different lines of instruction—instead of just taking them as given—and secondly for devising a "critical test" of the Fourier principle. Anyway, the instructor was so impressed that he retired to his room for a few hours to perform the tedious job of drawing the fundamental and harmonics up to the 15th, to represent the infinite series needed to make a perfect square wave, then redrawing them all with the attenuation and phase shift that each individually would suffer in the CR circuit, and lastly putting these all together. The result bore an unmistakable likeness* to the peaky waveform arrived at by the entirely different route of charging-capacitor theory, and effectively dispelled any feeling there may have been that the Fourier idea only works within limits and can't be relied upon in cases like this, which old Fourier himself perhaps never envisaged even in bad dreams.

And although last month I may have shaken confidence a bit by suggesting that even the reception of a distorted r.f. transmission on harmonic frequencies cannot be taken as complete proof that it actually has these frequencies (it all depends on how you define "frequency"!), the universe is so made that obvious frequency-selectors like tuned circuits fit in perfectly with the Fourier idea of frequency. So we are not really going to forsake the normal practice of relating frequency to sine waves. That being granted, the reality of the Fourier harmonics can hardly be doubted. They can be tuned in, one by one. And think of multivibrators!

Fourier Analysis

So for the rest of the time let us accept Fourier unreservedly and consider the relationship between some of the more important waveforms and the sine waves into which they can be analysed. I nearly said "sine waves of which they are made," but thought that might tend to confuse. One has only to think of the devices actually used to generate (for example) square waves to realize that they do not do so by generating innumerable sine waves and then putting them together, even though square waves could be produced that way if one had an infinite number of sine-wave generators. So it would be more correct to say "sine waves of which they *could* be made." A square table top *could* be made entirely of pieces shaped like Fig. 3(a), by putting them together as at (b). But it would not usually be made that way. Whether it was or not, however, it could always be divided into such pieces.

Now although it is easy enough to put together any desired number of harmonic sine waves, having any desired amplitudes and phases, and so construct an infinite variety of waveform, it is not so obvious how one sets about analysing any given waveform into its harmonics. If the waveform exists physically as a voltage or current, there are such instruments as wave analysers for measuring the harmonics. These instruments read the amplitudes of the various harmonics, but not usually their phases—which are necessary in order to tell anyone how to reconstitute

* To be seen in *Wireless World* Dec. 1945, p. 360.

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the original waveform from its ingredients. Then there are various ways of analysing a waveform drawn on paper. Neither of these procedures gives perfectly accurate specifications for perfect square waves, pulses, triangles, etc. But these specifications can be calculated mathematically.

The starting point is the complete general Fourier series consisting of all harmonics from 1 (the fundamental) up to infinity. Of course, we don't write them *all* out, or there would be no time for anything else! The first few will do, just to indicate what symbols one is intending to use. At this stage the only thing that is known is the ratio of each frequency to the fundamental. Taking the fundamental as 1, the frequencies continue as 2, 3, 4, 5, 6 etc., as we all know.

The first step is to find the actual frequency of the fundamental. That is done by noting the "period"—the shortest time that includes the whole waveform. Every equal interval of time that follows will then (if, as it must be in order to come within the scope of Fourier, the thing is truly periodic) consist of an identical repetition of the same waveform. Call the period T seconds. Then the fundamental frequency is 1/T c/s, usually denoted by f. When, by examining the waveform, we have found what T is, the value of f follows.

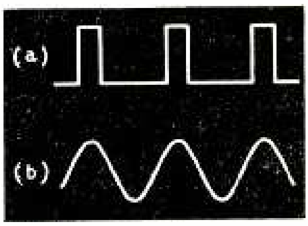

Fig. 1. Is waveform (a) really composed of (b) plus others of the same smooth shape?

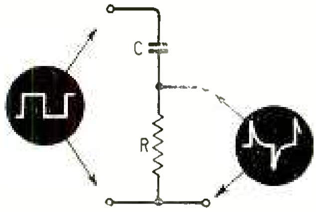

Fig. 2. The transformation of the input square wave into the output peaky wave is usually explained in terms of the exponential charging of C through R. Can it alternatively be explained by Fourier?

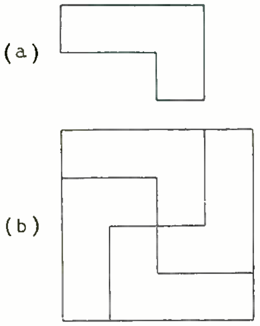

Fig. 3. Although the square table top (b) doesn't have to be made of pieces shaped like (a), it can be so made, and it can be divided up into such pieces.

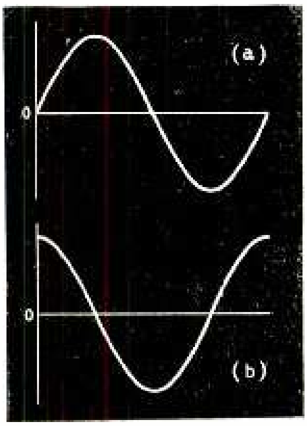

Fig. 4. One cycle of a sine wave (a) and of a cosine wave (b).

Specifying Phases

So now we definitely know all the frequencies, but neither the amplitudes nor the phases. For the meanwhile we shall just have to write a letter, such as A_1, to denote the peak value of the fundamental. Remembering last month's findings, we now have the mathematical formula for the fundamental sine wave: $A_1 \sin 2\pi ft$, usually abbreviated to $A_1 \sin \omega t$.

But what about phase? Right up till now I have been rather loosely talking about "sine waves" without regard to phase, so cosine waves (which are just the same thing beginning quarter of a cycle ahead) have equally been included. But now we must be more strict and remember that a sine wave is one that starts from zero as in Fig. 4(a), whereas a cosine wave starts from maximum as at (b). But of course a wave might start at *any* stage in its cycle; i.e., in any phase. There are two ways of specifying the phase. One is to work throughout in sines (*or* in cosines) and specify the starting handicap or phase difference as an angle. For example, a cosine wave $\cos \omega t$ can be written as $\sin (\omega t + 90°)$, or more usually $\sin (\omega t + \pi/2)$, $\pi/2$ being a right angle in radians, the mathematical units of angle. The general expression, covering any phase difference, ϕ, is $\sin (\omega t + \phi)$.

The other method is to analyse $A \sin (\omega t + \phi)$ into, say, $a \sin \omega t + b \cos \omega t$. As we saw last month, adding together any two waves of sine shape but different phase gives a wave of sine shape and (in general) a phase different from that of either of the component parts. We can, in fact, by mixing sine and cos waves in the right proportions, get a wave of any desired phase and amplitude. It is pretty obvious, for example, that if the sine and cos have equal amplitudes ($a = b$) the result has its peak half-way between those in Fig. 4; namely, 45° from the start. And in case it looks as if this method only avails for angles from 0° to 90°, let us remember that either a or b or both can be negative, so all four quadrants are covered.

The full expression for the fundamental term now appears as either $A_1 \sin (\omega t + \phi_1)$ or as $a_1 \sin \omega t + b_1 \cos \omega t$. The frequency of the next, the second harmonic, we know to be exactly twice as great, so we can write its specification as $A_2 \sin (2\omega t + \phi_2)$ or as $a_2 \sin 2\omega t + b_2 \cos 2\omega t$. And so on. After the third, the scheme of symbols is clear enough for anyone to grasp, so it is sufficient to indicate the whole series as $a_1 \sin \omega t + b_1 \cos \omega t + a_2 \sin 2\omega t + b_2 \cos 2\omega t + a_3 \sin 3\omega t + b_3 \cos 3\omega t + \ldots$ or of course the alternative in $(\omega t + \phi)$ style.

Obviously the phases of all the component harmonics will depend on where the whole waveform is reckoned to start. Usually we are free to start anywhere we like, and those who know the ropes take care to fix the start where it will ease the subsequent calculations —preferably where it will make either the sin or the cos lot drop out completely, all the a's (or all the b's) being zero. This is not always possible, but those for

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which it is include most of the important "ideal" waveforms.

Anybody who already knows all about Fourier and is reading this merely to see what kind of a mess I'll make of it will no doubt be aching to point out that I've omitted something. There should really be a zero-frequency term, A_0. I have been assuming that what we are to analyse is a purely "a.c." waveform; but to cover all contingencies we had better include the A_0 (which, because it doesn't alternate, requires no sin to be attached).

Wave Multiplication

So far, the only thing we have done on our particular waveform to be analysed—as distinct from finding suitable expression for the general Fourier series, which covers *every* possible waveform—is to find its frequency, which is dead easy once we know how long each cycle takes to occur. Before we can progress with the more difficult job of finding the values of a_1, a_2, a_3, etc., and of the ϕs or bs, we must get hold of the idea of multiplying one sine (or cos) by another. (To keep our feet on the ground, we should remember that this is what is actually done in a hexode or other "multiplicative" frequency changer; the output is proportional to the signal input voltage multiplied by the mutual conductance (g_m); and since the oscillator, which generates a sine wave, varies g_m, the valve in effect multiplies one sine wave by another.) If we multiply $\sin\theta$ by $\sin\theta$, to give what is written as $\sin^2\theta$, we find it comes entirely on the positive side of the line. At the positive peak, $1 \times 1 = 1$. At the negative peak -1×-1 also $= 1$. Plotting the whole curve, as in Fig 5 (where the dotted line is the original sine wave), we see that it is like a half-size sine wave stood up on the base line. Its average value over a whole cycle, as can easily be proved if the graph doesn't show it clearly enough, is $\frac{1}{2}$. The same applies to $\cos\theta$. If now we try multiplying a sin or cos by a sin or cos of a *different* frequency, we find that the average over a complete cycle of both always comes to nought. By "a complete cycle of both," I mean the interval between two successive occasions when they have the same phase relationship. For instance, if one of them has one third the frequency of the other, Fig. 6 shows one complete cycle. The important thing to notice is that the second half, from b to c, is exactly the same as the first half, a to b, except that it is upside down. So even if the average from a to b comes to something, it will be exactly cancelled out by the average from b to c. And obviously what holds for one complete cycle holds for a continous train of complete cycles.

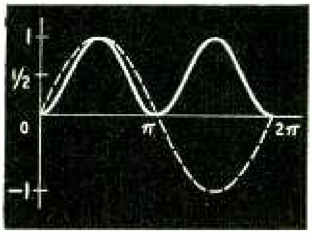

Fig. 5. The full line is a sine-squared curve, resulting from multiplying the values represented by the dotted sine wave by the same.

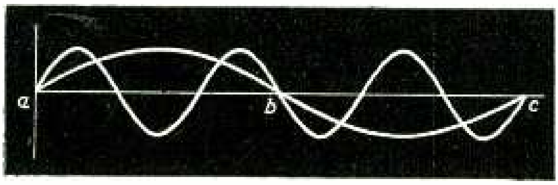

Fig. 6. One complete cycle of a combination consisting of two waves, one of them three times the frequency of the other. The average value of the two multiplied together is nil.

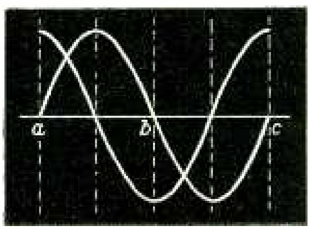

Fig. 7. The average value of sin × cos is also nil, as can be seen by comparing the two halves of the cycle, a—b and b—c.

Whatever the ratio of one frequency to the other, there is always some kind of symmetry with respect to the base line, causing the average to be zero. The only exception is, as we have seen, the ratio 1 : 1. And even then an average value only exists when sin is multiplied by sin or cos by cos, but *not* when sin is multiplied by cos. In Fig. 7, where a single cycle of each is plotted, the half from b to c is an inversion of a mirror image of a to b, so again the product cancels out.

The significance of all this may begin to appear if we consider what happens when we multiply the whole general Fourier series by the sine of any of the frequencies involved, and average the result over one cycle of the fundamental frequency. The average for all the cos terms is zero, for a start. So is the average for all the sin terms except the one having the same frequency as the multiplier. Suppose, for instance, we had multiplied by $\sin\omega t$. Then the only Fourier term that would give any average would be $a\sin\omega t$, and since the average of $\sin^2\omega t$ over a cycle is $\frac{1}{2}$, the average of $a_1\sin^2\omega t$ would be $a_1/2$.

The procedure, then, for analysing a waveform is first to express it as a mathematical formula. Fourier tells us that this formula is equal to his general series, so what we have to do is find the values of a_1, b_1, etc., in the series. First multiply the formula by $\sin\omega t$, where ω is 2π times the fundamental frequency of the waveform, and take the average over one fundamental cycle. This average being $a_1/2$, a_1 must be double the average. Then repeat the process for a_2 by multiplying the formula by $\sin 2\omega t$; and so on. Having finished all the sin terms one does the cos terms. The result is the *particular* Fourier series equal to the particular waveform analysed.

An Example

People who are new to this will no doubt be seeing some difficulties. How does one express a waveform as a mathematical formula? And how does one calculate the average? The short answer, of course, is: learn the appropriate mathematics.

But rather than dismiss the class in such an unsatisfied state, I will finish with an example. None other than the good old square wave, Fig. 8(a). How does one express it mathematically? The first half-cycle is easy; it is v (the instantaneous value) $=$ V (the peak value). But we have to average over a whole cycle, and the second half-cycle follows a different formula, $v = -$V.

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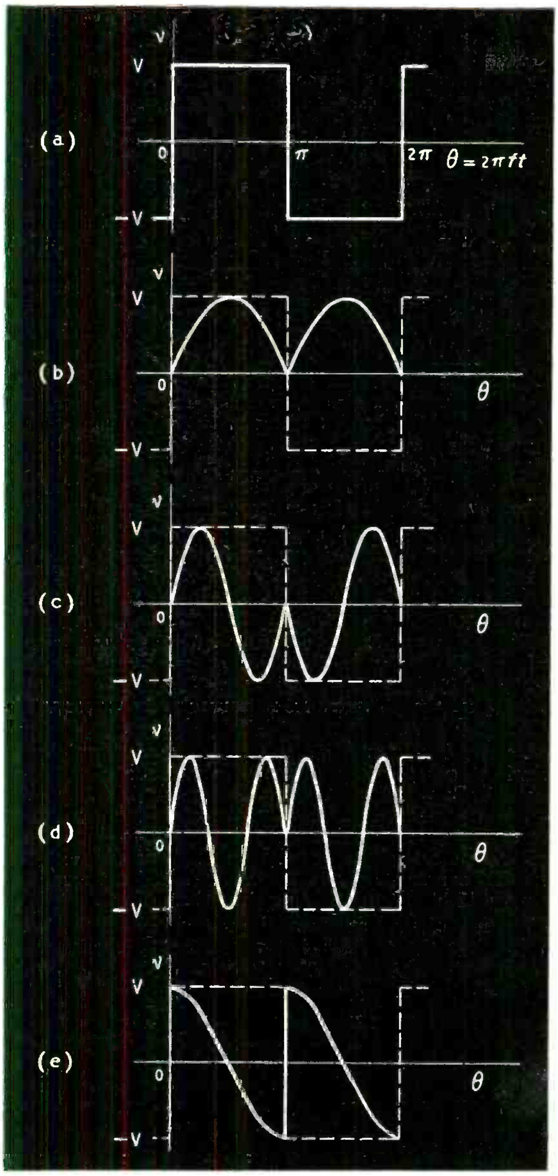
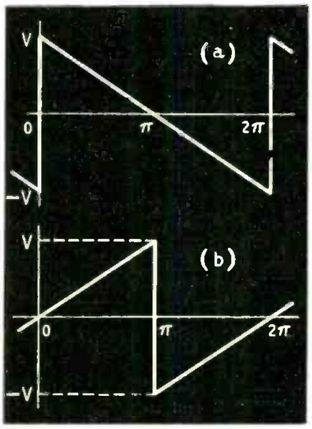


Left: Fig. 8. Results of multiplying a square wave (a) by (b) a sine wave of its own fundamental frequency, (c) a second harmonic (d) a third harmonic, and (e) a fundamental cosine wave.



Right: Fig. 9. The square wave, Fig. 8(a), can be made by adding together these two sawtooth waves.

There are various ways of getting over this. An ingenious one is to tackle a saw-tooth, Fig. 9(a), in which v falls at a steady rate of $V\theta/\pi$ throughout the cycle, and then add it to the result obtained for a different saw-tooth (b), which when added to the first makes up the required square wave. Perhaps you would like to have a go at this afterwards; and in case the second saw-tooth seems to offer the same difficulty as the square wave I would point out that the averaging should be done over the whole cycle from $-\pi$ to $+\pi$.

Another and simpler method is to average over the two half-cycles of Fig. 8(a) separately and add them together. First of all we note that the combined average of the wave as it stands, which is the " d.c." term, A_0, is nil, since it has equal positive and negatives halves. Next, to get the value of a_1, in the fundamental sine term $a_1 \sin \omega t$, we multiply the waveform by $\sin \omega t$, or $\sin\theta$ as it appears on the graph. The result is shown, against a dotted framework of the original square wave, in Fig. 8(b). In the second half, the negative values of $\sin\theta$ are multiplied by $-V$, so are positive, exactly as in the first. The effect of multiplying the sine wave by the square wave is, as it were, to rectify it. Now we know (or jolly well ought to) that the average value of a rectified sine wave of peak value V is $2V/\pi$, or 0.637V. The value of a_1 is, as we saw, twice the average, so in this case is $4V/\pi$.

To get a_2, we must multiply the square wave by $\sin 2\omega t$ or $\sin 2\theta$. The result is shown at (c). Obviously the positive and negative half-cycles cancel out and the average is nil, so $a_2 = 0$. The same goes for all the even terms, so we can concentrate on the odd ones. In (d), out of the six half-cycles, four cancel one another out; the remaining two make up an average which is one third what it was in (b), and consequently $a_3 = 4V/3\pi$. Continuing on the same principle shows $a_5 = 4V/5\pi$, $a_7 = 4V/7\pi$, and so on.

The Full Recipe

Lastly we come to the cos terms. They can quickly be disposed of, for (e) shows that the average of the fundamental is nil; and one can easily see that the same applies to all the harmonics. So only the sin terms survive, and their values are $4/\pi$ times the amplitude of the square wave, divided by the number of the harmonic. The Fourier recipe for a square wave having amplitude V is therefore

$$\frac{4V}{\pi}\left(\sin \omega t + \frac{\sin 3\,\omega t}{3} + \frac{\sin 5\,\omega t}{5} + \frac{\sin 7\,\omega t}{7} + \ldots\right)$$

The process of multiplying a sine wave by a square wave and taking the average is just what is done physically in the wave analyser described by M. G. Scroggie in the August issue; even when the beat oscillator gives a sine wave it has nearly the same effect on the rectifiers in the modulator as a square wave, and this is why that type of analyser responds not only to the fundamental frequency of the beat oscillator, but also (to one-third the extent) to three times that frequency, and so on. This Fourier business is a fascinating and useful pursuit, and one I can recommend for further attention.

I'm not going to spin out the space with recipes for all the other stock wave shapes, because they are given in many reference books, including *Radio Designer's Handbook* (4th edition), Chapter 6, Sec-

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tion 8. But to anticipate indignant shouts to the effect that in choosing the square wave I was cheating, because I was able to use a well-known result in evaluating the average, whereas the average of a sine wave multiplied by (for example) a truncated pyramid wave is emphatically not something one is expected to be able to pull out of the mental store on demand, I must point out that the well-known result, and the less well known, and the totally unknown, are all obtained by means of the integral calculus. As I said before, the short—and in fact only complete—answer is to learn the appropriate mathematics.

Books on Servicing

HAVING dealt with the time-bases and their associated circuits in the first volume of "Television Receiver Servicing," in his second volume E. A. W. Spreadbury covers the remaining sections of a receiver—video stage, tuning circuits, power supplies and aerials. In writing the volumes the author, who is technical editor of *Wireless and Electrical Trader* and an examiner for the practical tests for the R.T.E.B. Television Servicing Certificate, had in mind the service technician who already has a reasonably good grasp of the principles of "sound" receiver servicing.

This 308-page volume, with 176 diagrams and illustrations, is published by the Trader Publishing Company, Dorset House, Stamford Street, London, S.E.1, price 21s (postage 8d)

The latest in the series of booklets published by the Central Youth Employment Executive on the choice of careers covers radio and television servicing.* Within its 36 pages are briefly outlined the training required by and the opportunities open to those who take up servicing as a career. It covers not only the type of servicing undertaken in retail shops but also the opportunities for service technicians in industry.

To whet the appetite of the keen youngster a typical circuit diagram of a superhet is given with a key to the components used. It is a pity however, that some of the symbols in the key are so archaic and bear little likeness to the modern, *W.W.*-style symbols used in the circuit.

* "Radio and Television Servicing" H.M.S.O. 1s. 6d.

Education and Training

WITH the opening of the scholastic year, we have been notified of a large number of colleges at which courses in radio and allied subjects are being provided. A bulletin of part-time courses in higher technology being held in London and the Home Counties is obtainable from the Regional Advisory Council for Higher Technological Education, Tavistock Square, London, W.C.1, price 1s 6d. Among the subjects covered are colour television, f.m., digital computors, microwave theory, pulse techniques, semi-conductors and servo-mechanisms.

New full-time servicing courses are being provided by the Northern Polytechnic, Holloway, London, N.7, where in addition to the standard courses in telecommunications there are also evening classes in v.h.f. sound and vision techniques and electronic computors. The prospectuses from the South-East London Technical College, Lewisham Way, S.E.4, and the Norwood Technical College, London, S.E.27, also include special lectures in addition to established courses. At the South-East London T.C. a course of five lectures on the principles and practice of frequency modulation is to be given on Tuesday evenings from November 22nd.

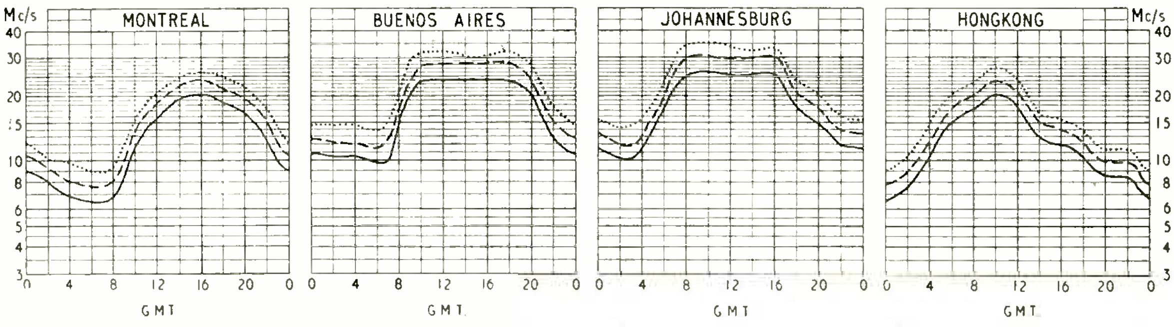
A one-year evening course on linear servo-mechanisms is among a number of specialized courses available at the Battersea Polytechnic, London, S.W.11. It will be held on Monday evenings from October 3rd (fee £2).

Thirty lectures on the theory of microwave circuits (suitable for graduates in physics, mathematics or electrical engineering) will be given on Wednesday evenings at the Battersea Polytechnic, commencing on October 12th (fee 4 gns).

A series of 22 lectures (fee £2 10s) on the fundamental principles of pulse techniques will again be given at the Borough Polytechnic, London, S.E.1, on Monday evenings from October 3rd. The Borough's evening course on transistors is this year being divided into two—basic principles (8 lectures) and special applications (10 lectures). The first course starts on October 18th and the second on January 12th. The fee for each is 25s.

A course of six lectures in linear network synthesis will be given at the College of Technology, Manchester, on Tuesday and Wednesday evenings, beginning November 1st (fee 25s).

SHORT-WAVE CONDITIONS *Predictions for October*



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

PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

THE full-line curves 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.

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EUROPEAN COLOUR TELEVISION

The Problem of Channel Allocation

FROM A CORRESPONDENT

IT seems to be common ground that all broadcasting authorities favour colour television systems which, like the American N.T.S.C. system, provide for the transmission of the colour information by means of sub-carriers. These sub-carriers may be one or two in number and may be modulated in various manners, either by the primary colour signals themselves or by various derived signals. In some systems they are situated within the vision-carrier band used by the corresponding monochrome system, whereas in other systems they are outside these bands. However, they all have in common the feature of giving rise to additional r.f. signals which are *a priori* capable of causing interference to other stations, whether monochrome or colour, in the same or adjacent channels, or of being interfered with by those stations.

This is a particularly significant consideration and it is one which may indeed preclude the broadcasting of colour television in Bands I and III within the framework of the Stockholm Plans. In other words, if the stations provided for at Stockholm in 1952 should simply begin to radiate programmes in colour it is probable that the interference protection afforded by the Plans will not be maintained and they will no longer be respected. The matter was raised recently at a study group meeting of the International Radio Consultative Committee at Brussels and was the subject of much discussion by the delegates. It became evident, however, that a decision would have to await the results of practical experiments.

Protection Between Stations

In considering the Stockholm Plans for Bands I and III one sees that they do not consist of a regular pattern of evenly-spaced channels of equal width. Because the Plans have to accommodate stations using no fewer than six different transmission standards it was *a priori* impossible to arrange their sound and vision carrier frequencies in any way which would ensure that there were standard frequency differences between the carriers of stations sharing a channel or between those of stations in adjacent channels. Consequently, the frequency difference between, for instance, a particular vision carrier and a carrier of another station may have almost any random value. The protection considered necessary, and this is of course one of the fundamentals of the Plans, had therefore to be verified for every pair of stations individually. By protection is meant in this context the ratio of the field-strength of the carrier of the station being considered to that of an unwanted carrier, measured at the least favourable point on the contour of the "field-strength to be protected" of the station being considered. The numerical values of the "protection ratio" and the "field-strength to be protected" are basic characteristics of the Plans.

In view of the difficulty, then, which was experienced at Stockholm in working out the Plans for the relatively less complex case of monochrome stations, it seems extremely improbable, in the light of the data at present available, that the Plans for Bands I and III can remain workable for colour television.

There seem to be two alternatives facing the authorities. The first is to convene in the fairly near future another conference with the task of working out a new series of plans which would supersede the Stockholm Plans and might cover also Bands IV and V (to which the Stockholm Plans do not refer at all). The second is to retain and put into effect the Stockholm Plans as they stand for monochrome television, and to convene, when the necessary technical data has been accumulated, an international conference to assign channels in Bands IV and V for colour-television stations. The second solution has many supporters because, in the European context, it could virtually dispose of the compatibility problem. The basis of that problem is the reluctance to render obsolete the receivers already in the hands of the public. It would seem to be practicable, when colour transmissions begin in Bands IV and V, for the luminance signal only to be radiated by the corresponding Band-I and Band-III stations.

Need for a Common Standard

One of the major difficulties encountered in working out the Stockholm Plans was, as already mentioned, that arising from the adoption of different transmission standards by the various countries. It is rather doubtful whether European plans for Bands IV and V for colour television could gain international agreement as long as the differences persist. The rational solution therefore appears to consist in securing, first of all, agreement on common transmission standards for colour television in the European area. This possibility was often postulated at the Brussels meeting, mainly as being necessary to permit the effective relaying of colour programmes from country to country. It is generally recognised that the higher production costs of colour television will make the "Eurovision" idea even more necessary than it is at present for monochrome television, and it is doubtful whether it would be possible to "convert" colour transmissions from one standard to another by any system analogous to that used at present for monochrome. It would seem, however, that quite apart from this programme-exchange consideration, the adoption of a common standard, at any rate for certain parameters, is necessary before the channel-allocation plans can be established.

Suppose, then, that a single system for colour television has been adopted by the European countries and that it has been decided to plan for colour transmission in Bands IV and V—how is the compatibility question affected? The point is that as there is at present no regular programme transmission in Bands IV and V in Europe (with the exception of one low-power experimental station in the German Federal Republic) there are no receivers in the hands of the public. Transmissions in these bands can therefore be of programmes different from those being radiated in Bands I and III, or the same, whichever best suits the situation in the individual countries. There is, of

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course, no reason why the programmes should be in colour, at any rate at the start, provided that they conform with the colour standards. Where the same programme is radiated by the Band I and Band-III stations, however, it would be necessary to convert the luminance signal to the appropriate standard, as the "European" colour standard would probably not be compatible with any of the existing standards. This conversion process, however, should be possible by the system used at present.

Now the Brussels study group meeting did not come to any decision on these points; indeed, it stated that no decision could be taken until more information had been collected; but it did do two things which should make the decisions easier and surer in due course. One was to write to all the governments concerned, asking them to consider the matter very carefully and very urgently, and above all not to make any decision on the national scale which would preclude the future establishment of a common European standard for colour television. The other was to set up a committee of experts with the task of reporting on the different systems and standards of colour television that are in existence and under consideration. The intention is that a complete study of the problem shall have been made in time to submit fully documented proposals to the next plenary meeting of the C.C.I.R., which is planned to be held in Warsaw next summer.

At the same time, the European Broadcasting Union, of which all the television services at present forming the European network (or expected to join it in the near future) are members, has appointed a small working party to report upon the situation at its next General Assembly (which will take place in Rome in October) so that the necessary action may be taken to find a solution acceptable to the members as an entity. Perhaps these broadcasting authorities are more interested in the attainment of a unique standard for European colour television for its programme-exchange implications than its influence upon the possibility of establishing a channel-allocation plan. But although the causes may differ the desired objective is the same, and the E.B.U. undoubtedly intends to bring the common viewpoint of the European television authorities to the attention of the C.C.I.R. at the Warsaw conference. It is interesting to note, by the way, that the E.B.U. recognises the influence of the manufacturers in the establishment of national transmission standards and fears that, unless suitable action is taken on the international plane, each country will tend to adopt colour-television standards compatible with its existing monochrome system. This, it contends, is neither necessary nor, in the wider view, desirable.

BOOKS RECEIVED

Transistors and Other Crystal Valves by T. R. Scott, B.Sc., M.I.E.E. An account, by the Director of Research, Standard Telecommunications Labs., of the development of semi-conductor devices to the present state of the art, with chapters on compound semi-conductor materials and speculations on future trends. The part played by crystal imperfections in determining performance characteristics is taken as the central theme of the book. Pp. 254+XVI: Figs. 65. Price 45s. Macdonald and Evans Ltd., 8 John Street, Bedford Row, London, W.C.1.

The Suppressed Frame System of Telerecording by C. B. B. Wood, E. R. Rout, A. V. Lord, B.Sc. (Tech.), A.M.I.E.E., and R. F. Vigurs. First of a series of monographs published by the Engineering Division of the B.B.C. Describes the camera, picture display unit and video control equipment used for recording the Coronation. Pp. 10+V; Figs. 9. Price 5s. B.B.C. Publications Dept., 35, Marylebone High Street, London, W.1.

An Automatic Counter for the Measurement of Impulsive Interference by J. Miedzincki, B.Sc. Details of a device for counting the number of switching operations in an electrical appliance and the number of occasions on which the radio inference exceeds a prescribed value. E.R.A. Technical Report M/T114. Pp. 24; Figs. 8. The Electrical Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey.

Electrical Measurements and Measuring Instruments by E. W. Golding, M.Sc.(Tech.), M.I.E.E. Fourth edition of a comprehensive treatise covering the syllabuses of the B.Sc.(Eng.), City and Guilds (Final) and I.E.E. examinations on this subject. Pp. 913; Figs. 550. Price 40s. Sir Isaac Pitman & Sons, Ltd., Parker Street, London, W.C.2.

Ultrasonic Engineering by Alan E. Crawford. Review of mechanical and electrical methods of generating high-energy vibrations and their application in engineering, chemistry, metallurgy and biology. Pp. 344+X; Figs. 222. Price 45s. Butterworths Scientific Publications, 88, Kingsway, London, W.C.2.

High Quality Sound Reproduction. Booklet based on *Wireless World* articles describing a 20-watt power amplifier, a pre-amplifier and a v.h.f. tuning unit, with additional point-to-point wiring diagrams, dimensioned chassis drilling plans, etc. Includes further notes on the Mullard 5-valve, 10-watt amplifier and two pre-amplifier designs to go with this amplifier. Pp. 48, profusely illustrated. Price 3s. 6d. Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

F.M. Explained by E. A. W. Spreadbury, M.Brit.I.R.E. Reprint of a series of articles from *Wireless and Electrical Trader* describing the salient features of v.h.f. receivers and methods of alignment and servicing. Pp. 37; Figs. 25. Price 2s. 6d. Trader Publishing Co., Ltd., Dorset House, Stamford Street, London, S.E.1.

A.R.R.L. Antenna Handbook. Seventh edition 1955, by the headquarters staff of the American Radio Relay League. Principles and construction of receiving and transmitting aerials for amateur frequencies. Pp. 311; over 400 illustrations, charts and tables. Obtainable in U.K. from The Modern Book Co., 19-23, Praed Street, London, W.2, price 18s. (19s. by post).

Radio Amateur Operator's Handbook. Ready reference and general information on operating an amateur radio station. Pp. 48. Price 3s. Data Publications, Ltd., 57, Maida Vale, London, W.9.

Proceedings of the Fourth Meeting of the Mixed Commission on the Ionosphere (Brussels, 16th-18th August, 1954). Pp. 238; Figs. 78. Price 43s. General Secretariat U.R.S.I. 42 rue des Minimes, Brussels, Belgium.

Proceedings of the XIth General Assembly of the Union Radio-Scientifique International (The Hague, 23rd August-2nd September, 1954).

Part 4—Radio Noise of Terrestrial Origin. Pp. 60. Price 8s. 8d.

Part 8—Administrative Proceedings. Pp. 125. Price 14s. 6d. General Secretariat U.R.S.I., 42 rue des Minimes, Brussels, Belgium.

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Small Power Valves

Design of Electrode Systems for Particular Applications

By R. E. WYKE*

AT one time a few basic pentodes or beam tetrodes were used as general-purpose power valves, but of recent years a number of different types have been designed and manufactured for such uses as scanning cathode-ray tubes, current and voltage stabilizing, pulse modulation and so on. At the same time considerable improvements have been made in the more conventional types of low frequency amplifier valves. These improvements have been, in general, a reflection of the reduction in size which has taken place in almost all valve designs during the past ten years and, so far as the larger types are concerned, the reduction in cathode heating power made possible by increased use of the oxide-coated cathode.

The size of the lower-powered valves has been reduced by the use of the familiar pressed-glass base technique, and in both these and in valves of larger powers the introduction of new electrode materials and processing methods has permitted an increase in electrode loading. For example, except in the case of series stabilizers, all power valves require for efficient operation that at some time during the duty cycle the anode current shall be almost or completely cut off by the application of a negative voltage to the control grid. Should this grid itself emit, electrons will reach the anode to form a part of the anode current, which will be practically independent of the grid voltage. This effect, known as grid emission, occurs whenever the grid itself becomes excessively hot. To prevent this, the grids of power valves are often cooled by the use of large cross-section supports and by welding radiating fins to the ends of these support wires. If, however, the electron work function of the grid material is increased, its maximum safe operating temperature can be raised and the grid itself reduced in size. One of the modern methods of doing this is by gold-plating the grid wires. Emitting material from the cathode, deposited during processing on to such a surface, has a high work function and in consequence the safe operating temperatures of the grid can be increased by as much as 50%.

* M. O. Valve Company

TABLE 1

Type	Application	I_a (mA)	$I_{a(pk)}$ (mA)	V_a (d.c.)	V_a
A2293	series stabil.	120	—	300	—
E2637	shunt stabil.	1	—	30,000	—
CV2231	pulse mod.	2	2,000	7,000	8,500
N339	line output	80	240	300	7,500
N709	class A audio	48	120	250	500
DA42	class B audio	50	280	1,000	1,900

Although at first sight the desired characteristics for all types of power valves of comparable wattage rating are similar, they do in fact differ considerably, so that, apart from the control-grid characteristic mentioned above and the need for a high anode loading, they have little in common. Fig. 1 and Table 1 show typical operating conditions for various types of power valves using a similar cathode.

Stabilizers.—There are two classes of valves here, one suitable for use as series stabilizers and the other for use as shunt stabilizers. The former are used in series with the load and must themselves absorb as little power as possible. They must be essentially low-impedance devices, and, for this reason, pentodes, either used as such or triode-connected, are frequently adopted. However, of recent years several low-impedance triodes specially designed for series stabilizer use have become available. The low-impedance requirement entails the use of close electrode spacing, and since a good grid control characteristic is of no great importance the grid wire spacing is made as wide as mechanical rigidity will allow, so that such valves have very low amplification factors, usually between 2 and 5. Working as it does under

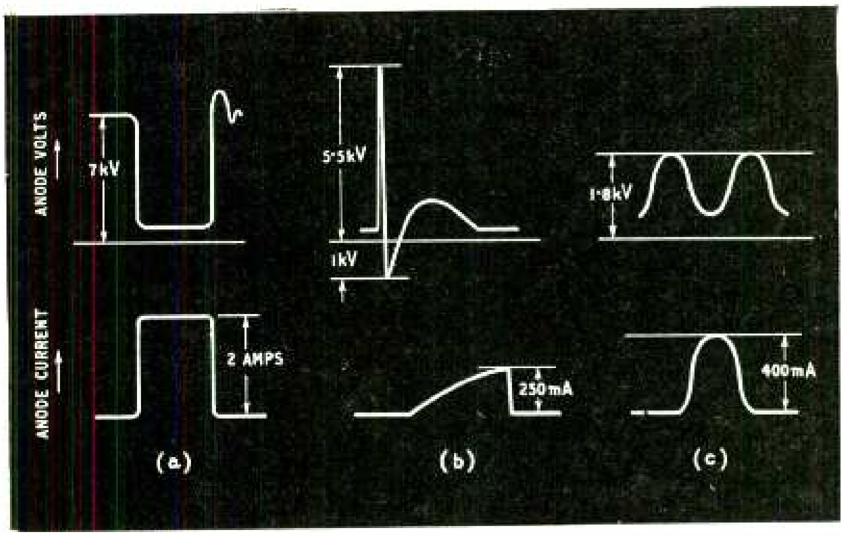

Fig. 1. Typical operating conditions of voltage (above) and current (below) for various types of power valves: (a) pulse modulator, (b) line output valve, and (c) class B amplifier. Volts and current are not to scale.

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d.c. conditions the anode current of the series stabilizer is almost constant throughout operation. It is therefore unique among power valves in that its cathode need not supply a peak current greatly in excess of the mean current, and the cathode temperature of this class is often lower than that of other valves of a similar size and mean cathode current rating. In fact, the efficiency of the modern coated cathode is such that the ultimate loading of the series stabilizer is usually determined by the temperature of the anode or valve envelope rather than by the available emission.

Since ease of valve production is largely set by the mechanical strength of the electrode structure, there is a lower limit of anode impedance below which it is hardly economic to go, and the valve designer has to accept the limitations imposed by small-clearance electrodes. This has led to the efficient series stabilizer usually having a cathode current rating of about 150mA, and although valves are made to handle much larger currents they usually consist of a multiplicity of these small units arranged in parallel within a common envelope. It is unlikely that a valve capable of handling high currents with a single electrode system will become available for some time to come, and it is probable that the most efficient and economic way of stabilizing such currents will be by the use of a number of small mass-produced valves in parallel. A basic circuit of a typical series stabilizer unit is shown in Fig. 2.

Up to now shunt stabilizers have not been widely used in this country, but the increasingly high voltages needed for television and equipment such as radiation monitors will lead to their greater application in the future. The shunt stabilizer is essentially a high-impedance device, usually operating at a high anode voltage. Triodes are generally used and valves specially designed for this purpose often have cathode and grid structures similar to those in cathode-ray tubes. Single valves are invariably used.

Pulse Modulators.—A pulse modulator is required to amplify voltage pulses from an earlier stage and to feed them into the drive circuit of a larger output valve. The load will be a coupling transformer and will be highly inductive. The operating voltage of the output valve may be quite high, often some thousands of volts, and this high d.c. voltage will have to be held off by the modulator during the quiescent part of the duty cycle. When the drive is applied the grid of the modulator is taken up to a high positive value and the peak anode current is very large. At the same time the voltage dropped across the load causes the anode voltage to fall to quite a low value. As soon as the drive is removed the anode current and voltage return to their original value, the inductive load often causing the voltage to "overshoot" by a large amount unless an inverse diode is fitted. The electrical requirements of a pulse modulator are, then, that it shall operate at a high anode voltage, have a low impedence (otherwise the power loss when driven would be excessive), and be capable of a high cathode emission. Since the anode current must be zero during the quiescent period (when the anode voltage is very high), the valve must have a good grid control.

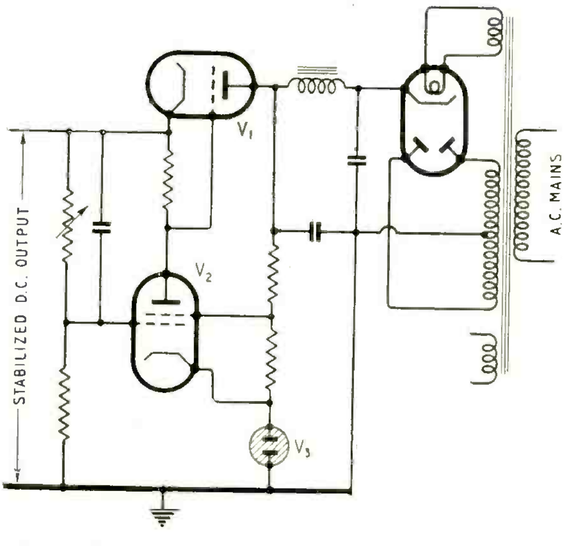

Fig. 2. Typical series stabilizer circuit. V_1 is the series stabilizer valve, V_2 the control amplifier valve and V_3 the voltage reference tube.

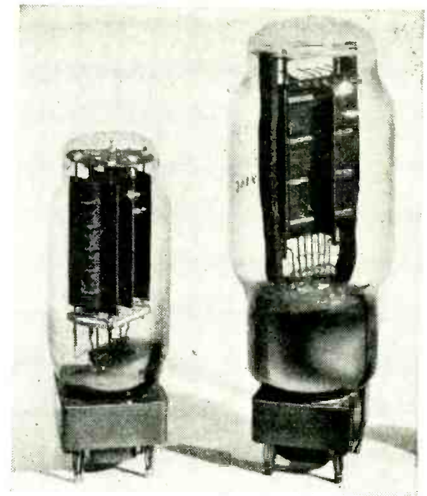

Fig. 3. Illustrating the redesign of a 100-watt anode dissipation audio output triode. The modern version is on the left.

Obviously these conditions can only be met by the use of a tetrode or pentode. The cathode current density during operation is high, so that suppression of secondary electrons from the anode readily occurs and conventional forms of suppression by a third grid or beam plates are often unnecessary. The high cathode emission required is usually obtained by operating the cathode at an increased temperature. This, coupled with the fact that during the bulk of its duty cycle the pulse modulator is non-conducting, causes a fairly rapid increase in cathode interface resistance, so that the life of such valves is usually appreciably shorter than that of other valve types of a comparable mean power rating.

When the length of pulse handled is extremely short, less than a microsecond, the rate of rise and fall of anode current is so high that the valve is effectively handling a high frequency signal. Under these circumstances the valve inter-electrode capacitances must be kept low if distortions of pulse shape during amplification are to be avoided.

Line Output Valves.—To a very limited extent the characteristic requirements of the line output valve are

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similar to those of the pulse modulator. Both valves require a low impedance while passing current and a very high impedance during the non-conducting portion of the duty cycle. Here the similarity ends. The line output valve works at a fairly high mean anode current with a peak/mean current ratio of about 3:1 only; the anode voltage rises to a high value for only an extremely short time during each cycle of operation and may then overshoot negative with respect to the cathode. The drive is such that the grid voltage does not reach a high positive value with respect to the cathode, so that the suppression of grid emission does not present too difficult a problem as the grid dissipation is small. On the other hand, the screen dissipation tends to be quite high, often approaching that of the anode itself, and careful attention has to be given to the prevention of screen emission. As in any output valve, currents to the anode which are not modulated by the control grid will cause loss of output. In the case of the line output valve, emission from either control or screen grid, being thermal in character, will cause a gradual loss of scanning width as the valve warms up.

The fact that variations in output are being constantly monitored visually by the user make it advisable for line output valves to be rated far more conservatively than, say, audio output valves, where output is usually readily adjusted by means of a volume control and has the added grace that the ear is far more tolerant of distortion than is the eye.

Low Frequency Amplifier Valves.—These form the largest class of small power valves. They are used for the output stages of domestic receivers, public-address and high-quality sound reproduction equipment, speech reinforcement systems, servo motor control systems and countless other applications. Valves used in domestic radio sets invariably follow the fashionable design pattern of the day so as to suit mass-production requirements in both the valve and the receiver factories. For example, if a new base or bulb shape is introduced, within a very short time a complete new range of valves, often having a similar performance to previous ranges, will become available in the "new look." This means that many valves are used in equipment before they have had time to establish themselves as sound commercial products and before their users have had time to understand their particular peculiarities. The resulting unreliability, which is by no means peculiar to radio valves, is all too familiar to both radio dealers and the general public alike.

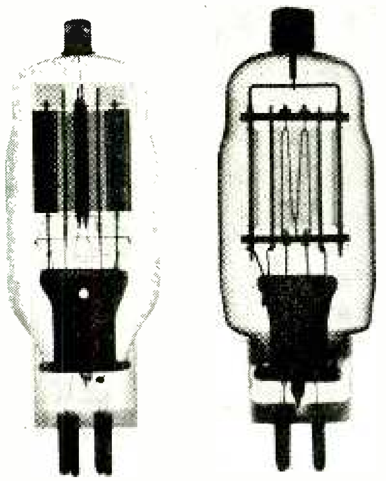

Fig. 4. Radiograph of two triodes having anode dissipations of 2-40 watts. The valve on the right (DA 41) is the older filament type, while the one on the left (DA 42) has an oxide-coated cathode and is suitable for mass production.

When the equipment has to give a public service, as with public-address or radio relay systems, reliability of operation is of extreme importance. The service must not have repeated breakdowns or its popularity will suffer. A valve type which has a consistently good life will give a service in which replacements can be made on a routine basis and not as a result of failure during operation. Economy is of importance, but more in consideration of replacement and servicing costs than in initial outlay. Consequently makers of such equipment have used known and trusted valve types of proved reliability for years on end and have been understandingly reluctant to risk their reputations by introducing valves of a more modern design. The designs of many of the valves used in public-address equipment to-day are approaching twenty years old; a long time indeed in the electronics industry!

Recent Trends.—During the post-war years valve manufacturers have been cautiously trying to improve established types and incorporating improvements only after very extensive life testing covering many thousands of hours under operating conditions. These improvements have taken two main forms.

In the first case valves have been wholly or partially redesigned to make them easier to produce or to avoid the continued use of obsolete components which may, during the course of several years, have become peculiar to one particular valve type. An example of such redesigning is shown in Fig. 3. In this case a well-known valve, first made some twenty years ago, has been completely redesigned. A more robust filament system, having fewer loops of heavier material, is used. New grid-treatment processes allow the grid to operate safely at a higher temperature than hitherto so that its size can be decreased and the anode loading, which greatly influences grid temperature, can be increased. The consequent use of a lighter anode structure has allowed the designer to dispense with the rather clumsy system of anode supports previously used, and the whole valve is more suitable for modern manufacturing technique with its emphasis on economy in the use of materials and man power. A slight reduction in overall size has followed, but this was not a prime intention in the redesign.

In this case the new valve is a direct replacement for the old and retains the same type number. In the second case an entirely new valve may be introduced which is not essentially a plug-in replacement for the original type but which will, it is hoped, be used when new equipment is designed; or with minor circuit modifications will replace it in existing equipment. This has been done when the existing valve has features which make it unsuitable for modern usage. For example, a certain small class-B output triode has a thoriated tungsten filament. The inherent fragility of this type of filament and its extreme sensitivity to operating voltage make it unsuitable for use in mobile equipments or industrial applications where there may be some vibration present or where the mains voltage may fluctuate wildly. Consequently, a new valve has been developed which, while having the same operating characteristics as the original, is more suitable for

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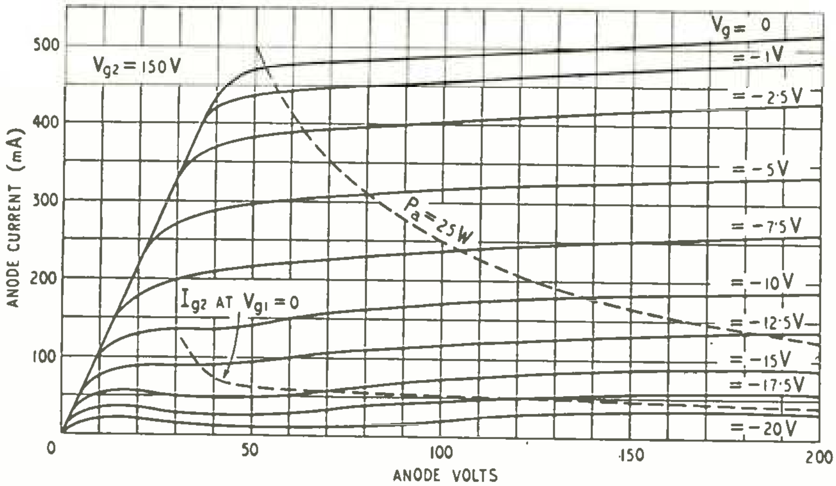

Fig. 5. Characteristics of a typical low-impedance output tetrode (KT55) suitable for use in high-quality amplifiers.

modern requirements. The thoriated tungsten filament system has been replaced by an indirectly heated oxide-coated cathode, with consequent saving in cathode heating power. Since the grid of a valve having such a cathode has to work at a lower temperature than that of one having a thoriated tungsten filament, the grid of the new valve has larger diameter support wires, welded-on radiators, and is specially processed to avoid grid emission. The original anode, which was machined out of solid carbon, has been replaced by a fabricated metal structure and mica insulators are used instead of the ceramic ones. The temperature of the glass foot tube has been reduced by fitting a polished metal reflector between it and the electrode system. Fig. 4 is a radiograph showing the essential constructional differences of the two valves, while Table 2 gives a list of the materials used for their electrodes.

Economy in operation is influencing valve design to an increasing degree. The use of high-impedance valves in push-pull class-B operation is becoming more popular when power outputs of 30 watts or over are required. Such valves operate when quiescent at zero grid voltage and require no bias supplies, although, of course, a low-impedance driving stage is needed. High peak anode currents are obtained by driving the grid well positive with respect to the cathode so that a high power output can be achieved without the use of excessively high anode voltage. The efficiency of circuit arrangements of this type can be as high as 66% and a pair of valves of the type shown in Fig. 4 can give an output of 175 watts at about 5% distortion for a total input of 275 watts. Since this type of circuit calls essentially for high-impedance valves, triodes are usually used and their relatively large electrode spacing and close pitched grids ensure very little characteristic variation from valve to valve.

For low power needs—high-quality audio amplifiers for example—a reduction in equipment costs may be realized by the use of the specially low impedance pentodes and beam tetrodes which are now available. The characteristics of a typical valve of this type are shown in Fig. 5. It will operate directly from the mains via a metal or valve rectifier to give an output of 25 watts from a pair of valves operating in push-pull, with a line voltage of 220 volts. The heaters are connected for series operation. It can also be used as an inverter to provide a source of a.c. to operate, for example, gramophone motors from d.c. mains, and is quite a useful series stabilizer. Constructionally it consists of two separate cathode, control-grid and screen-grid systems mounted inside a common suppressor and anode system. Separate electrode systems are used to avoid the loss in mechanical strength and lack of characteristic uniformity which usually occurs with close electrode spacings in a large valve.

Trends of this sort must continue, and there will undoubtedly be a more extensive use of the pressed-glass base, which, since it is farther away from the electrode system, runs cooler and is less liable to failure than is the older glass-pinch type of foot tube.

TABLE 2

	DA41	DA42
anode	carbon	carbon-coated nickel
grid winding wire	molybdenum	gold-plated molybdenum
grid support rods	molybdenum	copper
cathode	thoriated tung. wire	oxide-coated nickel
heater	—	alumina-coated tungsten
insulators	ceramic	mica

Commercial Literature

Dual-channel Oscilloscopes; three models covering respectively d.c. to 10 Mc/s (with 6-in tube having separate gun systems), d.c. to 100 kc/s, and d.c. to 250 kc/s. Time bases are calibrated for time measurement. Specifications on leaflets from Nagard, 18, Avenue Road, Belmont, Surrey.

Hearing Aids using glass-sealed transistors and powered by single "Penlight" battery giving approx. 150 hours' service. Dimensions are $2\frac{7}{8}$in × $2\frac{1}{8}$in × $\frac{1}{2}$in and weight is $2\frac{1}{8}$oz. One type has volume control and top-cut switch, and another the addition of optional automatic volume compression. A choice of three frequency responses is offered. Leaflet from Amplivox, 2, Bentinck Street, London, W.1.

Wire-twisting Tool, in the form of pliers with a simple spinning mechanism, for joining pairs of wires. Any length can be twisted in two or three seconds and the ends cut off by the side-cutters incorporated. Descriptive leaflet from Douglas Kane Associates, 55, Pall Mall, London, S.W.1.

Q Meter for measuring circuit magnification, inductance, capacitance and power factor over the frequency range 100 kc/s-100 Mc/s. Q values from 10 to 400 can be handled. Specification and description from Advance Components, Marlowe Road, Walthamstow, London, E.17.

Measuring Instruments and accessories for r.f. and a.f. by Rohde and Schwarz of Munich. A comprehensive catalogue in English from the agents, Aveley Electric, Ayron Road, Aveley Industrial Estate, South Ockendon, Essex.

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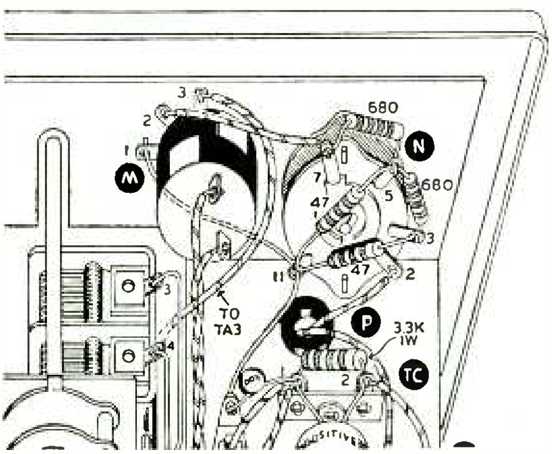
Instrument Kits

A Critical Assessment of Test Gear for Home Assembly

By CHARLES B. BOVILL,
A.M.I.E.E., M.Brit.I.R.E.

THE rapid development of radio techniques during the past few years has made it almost impossible for the amateur to carry out any experimental or constructional work without a certain amount of measuring equipment. Recognizing this, the American Heath Company has introduced a range of some forty different kits of parts from which test gear can be constructed.* These include complete sets of components for signal generators, impedance bridges, valve voltmeters, Q meters, and so on, together with the appropriate instruction booklets.

Apart from the interest of the kits to amateur experimenters, they seem to fulfil a need that has long been felt in technical schools, where many instructors find themselves at a loss to impart the practical knowledge of layout of components to students. If one of these kits is made up by a class and the various components are examined, and if necessary criticized, and the reasons for details of layouts are discussed, the students can be given a valuable insight into the practical design of modern electronic apparatus.



( ) Connect a bare wire to M1 (S). Run the wire through N11 (NS) to the solder lug adjacent to the large panel cutout (S).

( ) Connect a 47 Ω resistor from N11 (NS) to N5 (NS).

( ) Connect a 47 Ω resistor from N11 (S) to N3 (NS).

( ) Connect a 680 Ω resistor from N3 (S) to N5 (NS).

( ) Connect a 680 Ω resistor from N5 (S) to N7 (NS).

( ) Connect a bare wire to N7 (S). Cover with a 1 1/2" length of spaghetti and connect to M2 (S).

( ) Connect the free end of the wire coming from TA3 (see Pictorial 2) to M3 (S). Run wire as shown in Pictorial 3.

( ) Connect a bare wire to N2 (S). Cover wire with a 2 1/2" length of spaghetti. Run wire through grommet P and connect to the center terminal of the RF OUT connection (S). See Pictorial 4.

Example of the wire-by-wire type of instructions and diagrams as they appear in the signal generator booklet.

In order to assess the value of these kits for instructional purposes, two were obtained and tested under the conditions which would be expected to be found in a normally equipped technical school. The ones selected were a signal generator (Type SG8) and a Q meter (Type QM1). It would appear after perusal of the instruction booklets that they are each intended for a different kind of constructor. The signal generator instructions are of the wire-by-wire type and enter into the greatest detail and evidently assume very little previous experience on the part of the constructor, whereas the instructions for building the Q meter are general, although they include comprehensive wiring diagrams, and it is supposed that the constructor of this equipment must have some previous technical knowledge.

In view of the different nature of the two kits, their construction was carried out in an appropriate manner in each case. The signal generator was made step-by-step, following the instruction booklet in the closest detail and without any reference to the theoretical circuit diagram. This enabled the instruction booklet and the general idea of the kits to be checked. In the case of the Q meter, the circuit diagram and the wiring diagrams were used in order to build up the three main units, but no rigid plan for their construction was followed.

Upon completion, each instrument worked at once when switched on and without any fault—evidence of the soundness of the design and of the efficacy of the instructional booklets.

The signal generator's mechanical design consists of an oscillator sub-chassis which is first assembled and wired as a complete unit. This is then fitted to the main chassis and connected to the modulator, power supply and to the various switches, output and input sockets, and so on. The final operations are attaching the panel knobs and making up the output lead.

The critical wiring, from the point of view of the r.f. circuits, is so arranged that the constructor is obliged to follow the instructions carefully, and in this way the manufacturer of the kit evidently sustains the claims for accurate calibration. All of the components are of good quality and the only criticisms which can be made are in connection with the knobs supplied and the cursor of the tuning capacitor. The knobs are supplied with tapped holes for the grub screws which hold them to the spindles, but the grub screws are a separate item. In practice it was found that the threaded holes were badly tapped and it was necessary to retap them before the grub screws could be fitted satisfactorily. The Perspex cursor was badly warped on delivery and when fitted to the capacitor drive spindle scraped the front panel until it was rewarped back to a position at right angles to the spindle.

Following the instruction booklet, the SG8 was completed in 5 hours 35 minutes, and it was estimated that a total of two hours was taken in checking the calibration.

The Q meter was found to be no more complicated than the signal generator to construct and took about

* Imported by Rocke International, 59 Union Street, London, S.E.1. An importation licence is required.

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the same time to complete. The instrument consists of three separate units, the main chassis and power supply, the oscillator generator unit and the valve voltmeter unit, with its associated calibrated variable capacitors. The units are assembled as complete equipments, then the oscillator and valve voltmeter chassis are attached to the main chassis and interconnected, after which the front panel is fixed to the main chassis. This attachment depends entirely upon the spindles of the various controls, and some care is needed in aligning the chassis and the front panel. In practice it appears to give adequate rigidity to the instrument.

Great care has been taken to ensure that the constructor makes up the instrument correctly; for example, a jig is supplied for the alignment of the four test terminals on the top of the case and a generous surplus of nuts, bolts, screws, washers and so on is included in the kit. Even the vernier capacitor string drive assembly is designed to be practically foolproof. The 50-microamp meter, which serves as the indicator of the instrument, is supplied very carefully packed and with a shorting wire across its terminals. The only faults noted with the QM1 equipment were the same as experienced with the SG8 and in the quality of the wire supplied with the kit, which was discarded in favour of plastic sleeved type.

The Signal Generator.—This is what would be considered in this country as a calibrated servicing oscillator. It is of good electrical and mechanical design and of attractive appearance, both internally and externally, when completed. The whole chassis is copper plated and the front panel is finished in a medium grey colour with calibrations, dial titles and so on in white. The characteristics of the instrument are as follows:

Frequency ranges:	160–500 kc/s 500–1,650 kc/s 1.65–6.5 Mc/s 6.5–25 Mc/s 25–110 Mc/s 110–220 Mc/s (harmonic range)
R.F. output:	in excess of 100,000 microvolts
A.F. output:	2–3 volts
A.F. input:	5 volts across 1MΩ
Power supply:	110/125/210/240 volts a.c. (export models)
Dimensions:	$9\frac{1}{2}$in × $6\frac{1}{2}$in × 5in

The circuit comprises a Colpitts type oscillator, a cathode-follower output stage and a triode modulator. The power supply from the mains is through a transformer and the a.c. is converted to a 200-volt h.t. supply by a selenium rectifier.

The coupling between the oscillator and the output stage is by a small capacitor connected between the anode of the oscillator and the grid of the output valve. The modulation is applied to the grid of the output valve and is derived from an a.f. Colpitts oscillator working at about 400 c/s. The r.f. output is developed across a 2,000-Ω resistor in the cathode of one half of a 12AU7 double triode, the other half being used as the r.f. oscillator. A part of the cathode load consists of a potentiometer which feeds into a three-step attenuator and thence to the output socket. There is a d.c. connection between the cathode and the output socket, a point that is considered to be a weakness, and it would appear to have been better

Appearance of the completed signal generator.

TABLE 1

Band A, long waves.	200 kc/s	5 kc/s low	$2\frac{1}{2}$% error
	233 kc/s	5 kc/s low	$2\frac{1}{2}$% error
Band B, medium waves	647 kc/s	no error	no error
	908 kc/s	8 kc/s low	$2\frac{1}{4}$% error
	1430 kc/s	20 kc/s low	$1\frac{1}{2}$% error
Band C, short waves	3000 kc/s	10 kc/s high	0.3% error
	4000 kc/s	50 kc/s high	1.25% error
	6150 kc/s	150 kc/s low	2.3% error
Band D, short waves	7100 kc/s	150 kc/s low	2% error
	11910 kc/s	410 kc/s low	$3\frac{1}{2}$% error
	20000 kc/s	500 kc/s low	$2\frac{1}{2}$% error
Band E v.h.f.	41.50 kc/s	400 kc/s low	1% error
Band F u.h.f.	194 Mc/s	8 Mc/s low	4% error

to have included a capacitive coupling between the attenuator and the output socket. The modulator stage can be modulated externally if necessary and switching is included to permit of the stage being used as a fixed-frequency a.f. source with a variable output if required. The variable a.f. control serves the dual purposes of an input control to the modulator and an output control when the valve is used as an a.f. source.

The modulation being applied to the output-valve grid has undoubted advantages and it was found that the modulation percentage varied very little over the whole frequency range of the instrument. The advantages of the output stage are apparent also when the attenuator controls are varied, it being found that their variation has very little effect on the oscillator frequency, even on the highest frequency range.

One of the weaknesses of oscillators of the servicing type lies in their rather large leakage of r.f., and a test was made with the SG8 to determine its performance in this respect. The test was made with a communications receiver having a sensitivity of better than 5 microvolts on all ranges which was connected to a vertical aerial $4\frac{1}{2}$ft high. The SG8 was used with its output lead disconnected and with the attenuator at maximum output. The following results were obtained:

Long waves, 300 kc/s: signals became undetectable at 3ft.

Medium waves, 1,000 kc/s: signals became undetectable at 5ft.

H.F., 10 Mc/s: signals became undetectable at 15ft.

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V.H.F., 41.5 Mc/s: signals became undetectable at 15ft.*

U.H.F., 190.0 Mc/s: signals became undetectable at 15ft.*

One of the claims made by the suppliers of the kit is that the adjustment of the coils in the factory before delivery makes it possible to expect the calibration of the finished article to fall within 2–3%. It is suggested in the instruction booklet that the U.S. Bureau of Standards station WWV should be used as a check (2.5–5.0–10.0 Mc/s) and that main broadcasting stations can also be used for this purpose. It must be understood, however, that there is no provision for individual adjustment of calibration on different ranges and that the only variable provided is the position of the cursor on the tuning capacitor spindle. It is recommended that this should be set initially to cover the whole tuning scale. This was carried out, with the results in Table I.

The stability of the oscillator was found to be good over a series of checks lasting 90 minutes each. These checks were made by heterodyning the SG8 against stable transmissions on m.f. and h.f. At 200 kc/s the drift was sufficiently small to be considered as being negligible and on 17,100 kc/s the maximum drift over the 90-minute period was less than 2 kc/s.

In view of the type of attenuator and the absence of an oscillator output indicator in the design of the instrument, the output of the generator varies with the frequency and with the setting of the tuning control on each range. No attempt was made, therefore, to measure the output of the SG8, beyond verifying that the claimed output of 100,000 millivolts was obtainable with the controls at maximum on each range.

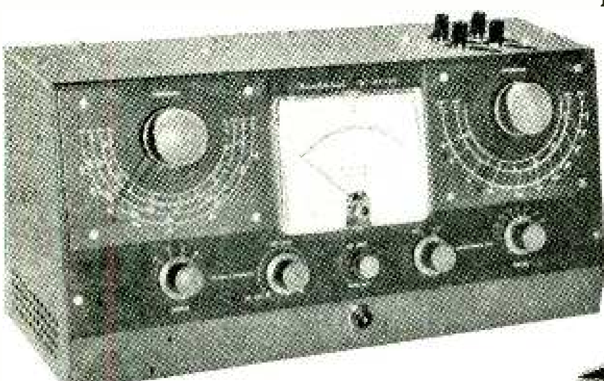
The Q Meter—The principle of this type of instrument is doubtless well known to readers of *Wireless World* and the subject was very fully dealt with by "Cathode Ray" in the July 1949 issue. It should therefore suffice to recall that in the usual design of Q meter a small voltage *e* is introduced in series with the coil under test and when this is tuned to resonance, a voltage E appears across it which is usually observed on a valve voltmeter. The Q is then equal to E/*e*. If the inserted voltage *e* is adjusted to a predetermined level, the valve voltmeter can be calibrated to read Q directly. This is the method used in the Heath instrument.

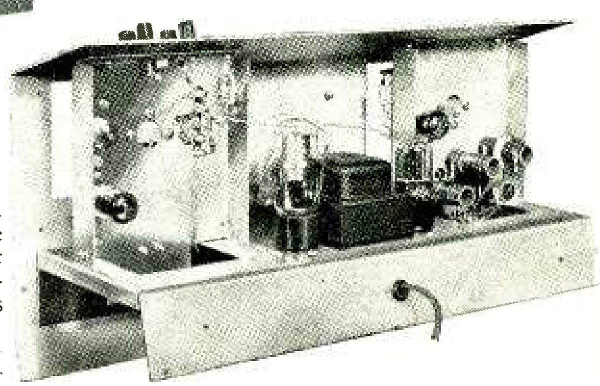
The Q meter when assembled and set up has the following characteristics:

Frequency range:	150 kc/s to 18 Mc/s.
Inductance range, measured at 250 kc/s, 790 kc/s, 2.5 Mc/s and 7.9 Mc/s:	1 microhenry to 10 millihenries.
Capacitance measurement range:	40 pF to 400 pF
Vernier capacitance range:	3 pF
Q measurement ranges:	0–250 and 250–500
Power supplies:	110–250 volts a.c. (export models).

In the circuit the r.f. generator is a cathode-coupled type, with four switched ranges. Its output is fed to the grid of a valve arranged as a cathode follower which serves to isolate the tuned circuits from the test circuit. The generator and output valves are the two halves of a twin triode, type 12AT7. A variable resistor in the anode circuit of the oscillator valve enables its output level to be adjusted. The voltage developed across the cathode of the isolator stage is fed through a small capacitor of preset type to the test-circuit insertion element. This is formed by a 5000-pF fixed capacitor of low loss and minimum inductance which is connected in series with the coil test terminals. These terminals and the insertion capacitor are shunted by a resonance capacitor of 450 pF which is, in turn, shunted by the valve voltmeter diode. A 3-0-3 pF capacitor is connected across the resonance capacitor to enable fine adjustments to be made. The valve voltmeter is of conventional type with its indicator between the cathodes of a twin triode valve. A second diode is placed across the grid circuit of one of the triode valves to neutralize variations in the standing output of the detector diode. Further to stabilize the diodes, they have their heaters slightly under run.

A 0–50 microammeter is used as an indicator both for direct Q measurement and for the setting up of the output level of the r.f. generator, these functions being selected by a switch. In the position for Q indication, the meter is connected between the cathodes of the triode valves, whilst in the other position the meter is connected to a germanium diode and thence to the output of the isolator stage. A variable resistor between the cathodes of the valve voltmeter triodes, with its moving arm connected to h.t. negative, balances the valves and sets the zero of the indicator for initial calibration. An 0D3 valve stabilizes the h.t. supply to the generator and valve voltmeter stages.





The Q Meter as it appears when made up, with a rear view of the chassis on the right.

* Tested with a television receiver connected to appropriate aerials.

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To set up the instrument, the r.f. generator frequency scale must be calibrated. This is an engraved scale and the correct procedure is to set the cursor to the position where the scale and capacitor minima coincide and then to set the capacitor to the calibration corresponding to some known and accurate frequency, such as a broadcasting station. A trimmer across the capacitor in the oscillator stage is then adjusted until the frequencies are identical, this usually being done by zero beating and with the aid of a receiver. This adjustment will determine the accuracy of the scale on all ranges as there is no individual trimming on each range.

As shown in Table 2, the results using this method are reasonably good, evidently due to careful trimming of the coils, and by the inclusion of a close-tolerance capacitor for tuning.

When the oscillator is calibrated, the resonance capacitor has to be set up. To facilitate this adjustment a standard coil is provided with the kit; in the one supplied the coil had an inductance of 250 μH and the required tuning capacitance marked upon it was 96 pF, at a frequency of 1 Mc/s. This capacitance is slightly less than the normal value required to tune a typical coil of this inductance to 1 Mc/s and the value is given so as to take into account the stray capacitance in the valve voltmeter and measuring stages, which is evidently about 10 pF.

The setting up of the resonance capacitor is purely a mechanical procedure. The capacitor is adjusted to tune the coil and the cursor is set to 96 pF. The scale associated with the resonance capacitor is also graduated in microhenries and millihenries for spot checking on frequencies of 250, 790, 2500 and 7900 kc/s, and its accuracy depends upon the setting up to exactly 96 pF at 1 Mc/s.

The final adjustment is for the Q meter proper. The inductance test terminals are short circuited and the valve voltmeter indicator is adjusted to zero with the balancing control. The generator level is then set to a mark on the microammeter, which for this test is switched to read the output from the isolator stage. Next, the standard coil is placed in the inductance test terminals and the microammeter is switched to read Q in the valve voltmeter circuit. The Q reading with the coil tuned to resonance is noted and, with the aid of the preset capacitor between the isolator cathode and the test circuit, it is adjusted so that the Q meter reads the figure indicated on the standard coil, which was, in the example tested, 110. This setting theoretically holds good over the whole range of the instrument.

The performance of the Q meter was measured against Marconi Instruments laboratory standards types TF329G and TF886A, and the results obtained are shown in Table 3. It will be noted from this table that errors are negligible up to a frequency of about 6 Mc/s, after which they become appreciable, evidently on account of the losses in the resonance capacitor, which is only of normal commercial quality, and because of losses in the valve voltmeter circuit.

In the view of the simplicity of the oscillator, its stability is reasonably good and after an initial warming-up period of 15 minutes it was run for one hour at 2.5 Mc/s, during which time its drift was less than 500 c/s. The harmonic output is low and has to be carefully searched for to be detected. The buffer cathode follower stage is effective and variation of the carrier level control even on 15 Mc/s does not perceptibly alter the carrier frequency.

TABLE 2

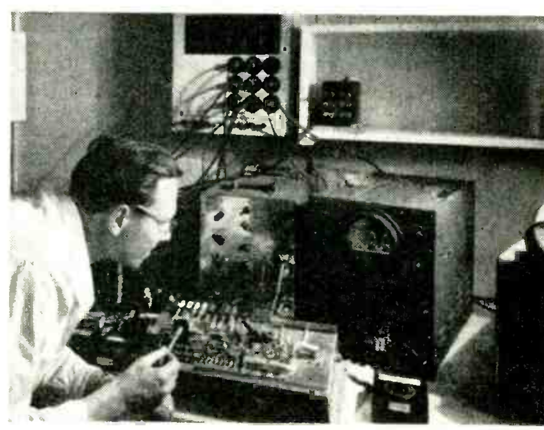
R.F. Frequency Calibration
(trimmer adjusted 908 kc/s)

Range	Frequency (kc/s)	Kit reading (kc/s)	Error (kc/s)	Percentage
A	164	164	0	0
A	200	199	−1	0.5
A	233	232	−1	0.5
B	692	693	+1	0.15
B	881	881	0	0
B	1403	1403	0	0
C	1448	1445	−3	0.2
C	2500	2501	+1	0.04
C	5000	5010	+10	0.5
D	6025	5950	−75	1.2
D	7105	7010	−95	1.4
D	11730	11700	−30	0.2
D	15120	15100	−20	0.1

TABLE 3

Q Meter Instrument Accuracy Check

Kit			Laboratory Instrument		
Frequency (kc/s)	Q reading	Capacitance to tune (pF)	Q reading	Capacitance to tune (pF)	Error
250	70	290	70	305	0
1000	110	96	110	96	0
2500	67	217	67	216	0
6700	133	400	160	400	−20%
7900	132	122	150	126	−13%
7900	40	165	46	166	−15%
10000	114	80	170	77	−40%
12000	114	50	184	53½	−41%
15000	186	78	266	82	−42%



Transistor research work for British firms is being done in Switzerland by an independent non-profit-making organization, the Battelle Memorial Institute, which undertakes research contracts in a wide variety of scientific subjects. Founded by an American industrialist, it has its main laboratories at Columbus, Ohio, and European establishments at Frankfurt and Geneva. This picture shows work in progress in the well-equipped electronics laboratory at Geneva.

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OCTOBER MEETINGS

Institution of Electrical Engineers

Radio and Telecommunication Section.—October 19th. Address by H. Stanesby (chairman) at 5.30.

October 31st. "The technique of ionospheric investigation using ground back scatter" and "A study of ionospheric propagation by means of ground back scatter" by E. D. R. Shearman; "An experiment to test the reciprocal radio transmission conditions over an ionospheric path of 740 km" by R. W. Meadows; and "An experimental test of reciprocal transmission over two long-distance high-frequency radio circuits" by F. J. M. Laver and H. Stanesby at 2.30; "V.H.F. propagation by ionospheric scattering and its application to long-distance communication" by W. J. Bray, Dr. J. A. Saxton, R. W. White and G. W. Luscombe at 5.30.

Both meetings will be held at Savoy Place, London, W.C.2.

Cambridge Radio Group.—October 11th. Address by Brig. E. J. H. Moppett (group chairman) at 6.0 at the Cambridge Technical College, Collier Road, Cambridge.

North-Eastern Radio and Measurements Group.—October 17th. Address by C. H. W. Lackey (group chairman) at 6.15 at King's College, Newcastle-upon-Tyne.

Physical Society

London.—October 18th. "Travelling wave tubes" by Dr. R. Kompfner at 5.0 in the Lecture Theatre, Science Museum, Exhibition Road, S.W.7.

British Sound Recording Association

London.—October 21st. "Audio amplifiers" by R. Chapman at 7.0 at Royal Society of Arts, John Adam Street, Adelphi, W.C.2.

Radar Association

London.—October 12th. "Deep sea diving by radar and underwater camera" by J. Gilbert at 7.30 in the Anatomy Theatre, University College, Gower Street, W.C.1.

Radio Society of Great Britain

London.—October 28th. "Amateur radio in the Antarctic" by Roth Jones (VK3BG)—read by Arthur O. Milne—at 6.30 at the I.E.E., Savoy Place, W.C.2.

British Institution of Radio Engineers

London Section.—October 26th. Annual meeting at 6.0 followed at 7.0 by "Recent advances in microwave tubes" by Dr. R. Kompfner at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

Merseyside Section.—October 5th. "Stereophonic sound" by R. A. Bull at 7.0 at the Chamber of Commerce, Old Hall Street, Liverpool, 3.

North-Western Section.—October 6th. "Colour television" by Dr. G. N. Patchett at 6.30 at the College of Technology, Sackville Street, Manchester. This will be followed by the annual general meeting.

West Midlands Section. — October 12th. "Frequency modulation broadcasting and reception" by H. E. Farrow at 7.15 at Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.

Television Society

London.—October 7th. "Progress in American colour television" by D. C. Birkinshaw at 7.0 at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, W.C.2.

October 27th. "V.H.F. aerial problems" by G. J. Lomer at 7.0 at 164, Shaftesbury Avenue, W.C.2.

British Kinematograph Society

London.—October 19th. "Magnetic recording in film production" by H. V. King and A. W. Lumkin.

October 26th. "Special effects for television and electronic films" by Dr. A. M. Spooner.

Both meetings will be held at 7.15 at the Gaumont-British Theatre, Film House, Wardour Street, W.1.

Institution of Production Engineers

Midlands Section.—October 19th. "The application of electronics to industry" by J. B. C. Robinson at 7.0 at The James Watt Memorial Institute, Great Charles Street, Birmingham.

Tees-side Section. — October 11th. "The practical uses of electronics in industry" by K. A. Zandstra at 7.0 at the Technical College, Darlington.

Luton Section.—October 25th. "Principles of colour television" by P. F. Carnt at 7.30 at Skefko Ball Bearing Co., Ltd., Luton.

CLUB NEWS

Cleckheaton.—The civil defence officer to the West Riding County Council will speak on emergency communications at the meeting of the Spen Valley and District Radio and Television Society at 7.30 on October 5th at the Temperance Hall, Cleckheaton. Sec.: N. Pride, 100, Raikes Lane, Birstall, near Leeds.

Coventry.—At the meeting of the Coventry Amateur Radio Society on October 10th, members will describe their stations. Meetings are held on alternate Mondays at 7.30 at 9, Queens Road, Coventry. Sec.: J. H. Whitby (G3HDB), 24, Thornby Avenue, Kenilworth, Warwicks.

Edinburgh.—The subject of the suppression of amateur transmitter interference with television will be discussed at the meeting on October 20th of the Lothians Radio Society. The club meets at 7.30 on alternate Thursdays at 25, Charlotte Square, Edinburgh, 2. Sec. J. Good (GM3EWL), 24, Mansionhouse Road, Edinburgh, 9.

Ilkeston.—Meetings of the Ilkeston and District Amateur Radio Society (G3JSZ) are held at the Ilkeston College of Further Education, Field Road, Ilkeston, every Thursday at 7.0. The programme for the present session, which began on September 15th with a lecture on wire broadcasting, includes a series of talks on receiver design and construction. On October 9th, members will visit the Post Office station at Rugby. Sec.: J. Eaton, 74a, Station Road, Langley Mill, Nottingham.

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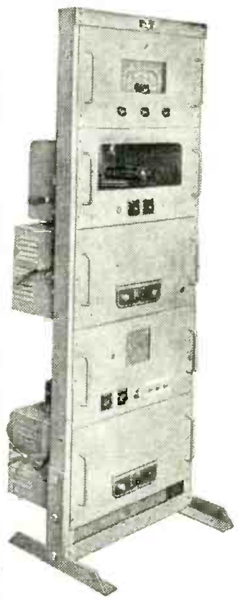

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RANDOM RADIATIONS

By "DIALLIST"

Yet Again!

THE poor old Radio Show! In three out of the last five years its fate has suddenly gone into the balance only a few days before the announced opening date. With the rights or wrongs of the matters in dispute I'm not concerned. What's worrying me is that this almost annual uncertainty about the opening date (or, indeed, whether it would be open at all!) is doing no good to our internal and external trade in broadcast receivers and sound-reproducing gear. One of the most important days from the business point of view is the pre-view, for normally it is marked by the visits of buyers from abroad. As there's then nothing like the crowd that comes on the other days, visitors to the pre-view have every chance of talking unhurriedly to the representatives on the stands. Cancellation of the pre-view must be a big blow to the industry, for it's their biggest and best shop-window display to those ready to place large orders.

Interval for Indignation

I write with some feeling. Though I'm not a buyer in the big business sense of the word, I'd been invited to the pre-view and had made my arrangements accordingly. I'm living at present too far from London to make it possible to get home the same day after a visit to the Show. It isn't funny to have to cancel hotel accommodation when the opening is postponed and then to find that it isn't to be had at a later date. It must have been still less funny for those coming from farther afield who had reserved seats or berths in trains, ships or 'planes. Our prestige is lowered by this sort of thing and we shall certainly have to do something about it. *What* we're to do, I don't know. But I'm not sure that it wouldn't be better to have no Radio Show at all than one with an uncertain opening date and the possibility that it may never open at all.

"Hi-Fi"

ONE wonders how far the B.B.C. (or should it be the G.P.O.?) intends to go in giving us real "high fidelity" from the v.h.f. service. The bandwidth is, I believe, somewhat greater than that used in medium-wave and long-wave transmitting gear; but so far it's a lot short of what one would have liked—and hopes eventually to have. It seems rather a missed opportunity. "Hi-Fi" is already having something like a boom among recording enthusiasts, who are ready to spend freely on first-rate equipment. Don't you think that "high-fidelity" v.h.f. programmes would lead to similar enthusiasm among listeners. I'm quite sure that it would and that it would mean excellent business for both receiver and component manufacturers.

F.M. Only

As soon as the three programmes become available on v.h.f. in my locality I shall be looking for a new set. I shan't want to make any further use of the medium-wave or the long-wave bands for broadcast reception, for nearly all the home and Continental stations are affected most of the time by interference of one sort or another. Therefore, I don't want an a.m./f.m. receiver. Still less do I want one with two or three short-wave bands as well, for I prefer to use a special short-wave receiver for the reception of distant stations. I'd like my money to go into really good v.h.f., i.f. and a.f. circuitry and components and not into a whole lot of things that I'd never use. I believe there is a future for Band II only receivers and I am glad to see that two or three manufacturers were featuring them at Earls Court.

In Western Germany

Writing of f.m. reminds me to thank a kind reader, who was recently serving in Western Germany with the R.A.F., for sending me a list of the Band II f.m. broadcasting stations operating in that country. It contains no fewer than 109; but as it is dated September, 1953, there are probably a tidy few more in action by now.* Of 40 channels between No. 2 (87.6 Mc/s) and No. 41 (99.3 Mc/s) 35 were then in use by West German stations. From the look of the map which accompanies the list I'd say that there must be few places in that country—except, possibly in the more mountainous districts—that aren't within the service area of a v.h.f. station. What's more, I'm told that the modulation bandwidth is 10-12 kc/s. The figure isn't official;

* The latest edition of our "Guide to Broadcasting Stations" includes nearly 150.—ED.

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but my correspondent says that the quality is so good that he can't think that it's any less than that.

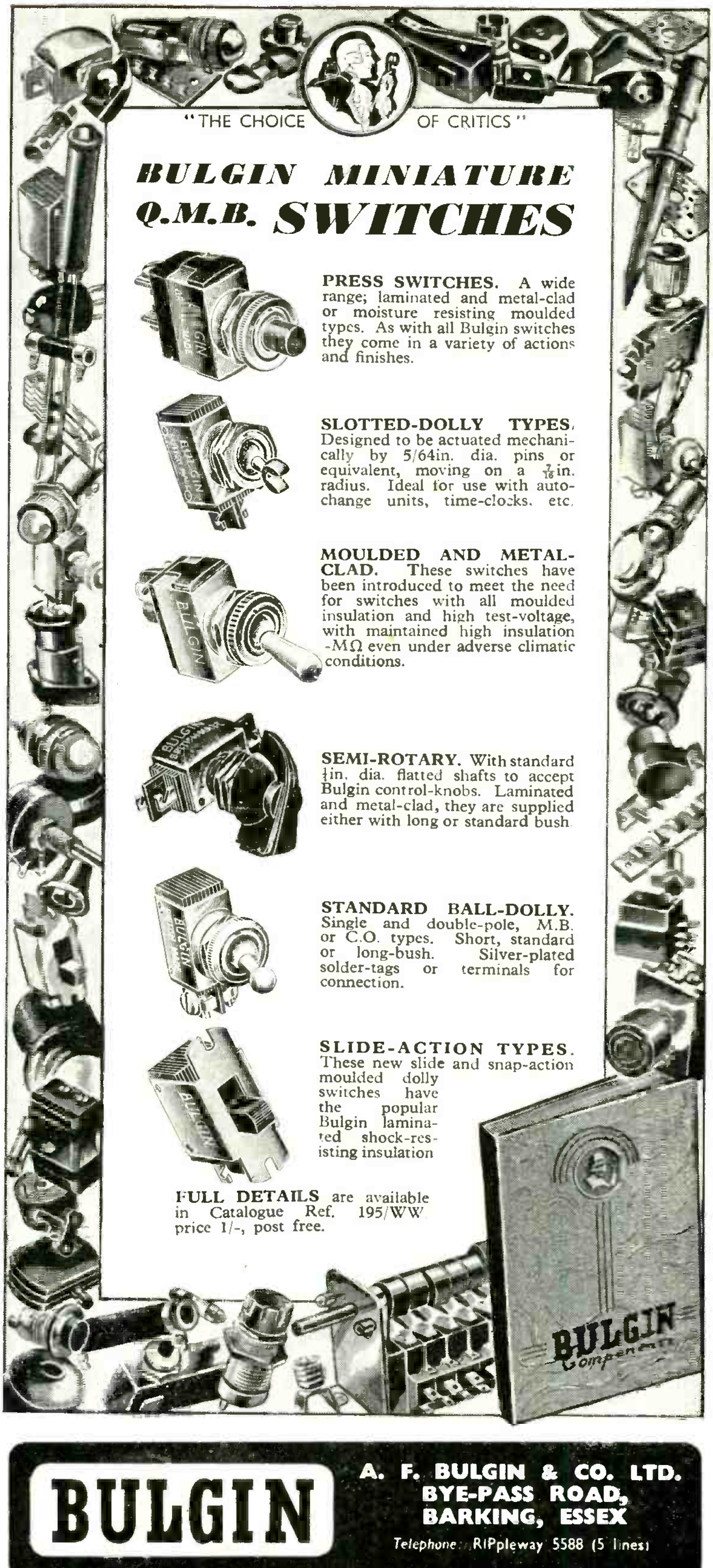
When Pictures Won't Stay Put

MOST of us with television receivers must have had bother at one time or another with the line-hold or the frame-hold of our television receivers. The component actually used for each of these controls in most, if not all, sets is a potentiometer, in series with which is one, or maybe two, fixed resistors. If the picture won't stay put in one sense or the other, the oscillator concerned is clearly not being properly held by the sync. It's not uncommon to find that just when you think you're going to get the picture steady by turning the knob in one direction you have come to the end of its travel and just can't make the tiny further movement that seems to be needed. The very first thing to suspect in such cases is the resistor(s) in series with the pot, for it's more than likely that one has gone high. If not, the valve is probably to blame. A very annoying form of slipping or rolling is that which develops when the set has been in use for a time, for you have to keep jumping up to try and steady things down by knob-twiddling. If you have that experience it's long odds on its being due to a resistor going high or the valves becoming defective as the set warms up.

LAB. LIFE

Holidays over!—A sad refrain!
The boys are back in the lab. again:
Back to the grind, the snags, the moans—
More horrible sounds come out of the 'phones.
Noise and distortion, percentage mod.—
Who designed this? The silly old bod.!
Are you ambitious? A glutton for work?
Study each evening and plough through the murk?
You're climbing the ladder, press on non-stop,
Earn nearly as much as the Model Shop.
How they all laughed when it went off BANG!
You're holding the baby for somebody's clang.
Let's check all the drawings, they're bound to be wrong,
The draughtsman's resigned, and you won't be long.
During these days of trouble and strife
Peculiar to laboratory life,
There's only one thing that's worth a small fee,
Somebody tell me how soon we'll have tea.

E. E. Rowe.



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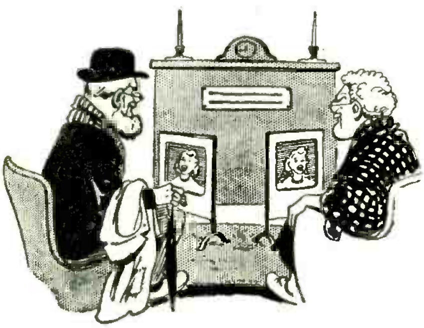
UNBIASED | By FREE GRID

"*Transistor TV*"

THE architects of our post-war houses seem singularly lacking in imagination. I have yet to come across a new house equipped with a coaxial TV socket in each room on the ground floor so that the trolley-borne television receiver can be taken from room to room. Surely it is high time that architects and builders installed coaxial cables at the same time as ordinary electric wiring. The TV aerial mast, too, should be architect-designed as an integral part of the house.

Even this doesn't really go far enough for the day is coming when each room will be fitted with a built-in TV screen fed from a master receiver in the roof. I am not forgetting the necessity of high voltage supply to each tube and other complications. There would, I admit, be very great complications and the ultimate solution to these will, I think, be the development of what I will call "transistor TV."

To explain my meaning I would remind you that only yesteryear we appeared unable to get away from



In 1984.

thermionic valve technique with its demand for lots of volts and amps. Almost overnight transistor technique has shown us the way out; in the same manner something will be developed which will relegate present-day television techniques to the Science Museum. The thermionic valve is on its way out and a decade hence the c.r. tube will be following it.

Radio Golf Balls

FROM an item of news in *Tele-Tech* (August 1955) I learn that the Great White Chief of a big American radio concern has had a radio transmitter built inside a plastic golf ball. I need hardly say that use of a transistor has made this possible. The main idea behind the construction of this radio golf ball is the boosting of transistor technique for not only does it show the compactness of transistors but also their ruggedness. Knocking the ball about does not put the transmitter out of action.

One useful feature is that the radiated signals are sufficiently strong to be picked up on a personal portable so that it is very easy to locate a lost ball by ordinary d.f. methods. If such unlosable golf balls could be produced cheaply they would find a ready market among Scotsmen.

The idea is not so simple as one I dealt with in these columns some years ago. I suggested that golf-ball manufacturers should incorporate a small piece of radio-active material in the core so that a lost ball could easily be found by rooting around the long grass with a Geiger counter.

Transmondial Television

ONE idea which I have always wanted to see tried out is the interchange of television programmes between this country and the U.S.A. and now at last there seems to be nothing to hinder the installation of a link similar to that being set up between England and France.

As the result of the experience we have gained with the experimental European link I think we can dispense with any temporary American link and get to work immediately on a permanent one. The sea—three thousand miles of it—has always been the impassable barrier to the men of little imagination in the ranks of radio engineers. I asked one of these professional obstructionists why it was impossible to send TV signals to America across the shortest sea route.

As I expected, he fell into my trap and pointed out with a great wealth of sarcasm that the gap of 1,800-odd miles between Newfoundland and Ireland would prove a far more formidable task for television engineers than Brown and Alcock found it for the first transatlantic plane crossing in 1919. He was quite incredulous when I retorted that there was only sixty miles of sea separating London from New York and that even this was broken up by the presence of an island into two stretches of 22 and 38 miles.

It will be quite obvious to readers of *Wireless World*, of course, that the two stretches of sea are the Straits of Dover and the Bering Strait, the island being the continents of Europe

A professional obstructionist.

and Asia which together form the world's largest island as they fulfil the definition of a piece of land surrounded by water. There is no longer any political reason why a chain of relay stations should not be built between Calais and the Asian shore of the Bering Strait from which it is a mere 38 miles across to the U.S. territory of Alaska.

Back to Methuselah

IN the announcement in the September issue of the publication of "Second Thoughts on Radio Theory" mention is made that "Cathode Ray" has been writing for *Wireless World* for over twenty years. This set me wondering who is the "oldest inhabitant" among *Wireless World's* regular contributors. After much turning up of old issues I found that the palm must be awarded to the Editor himself, whose name first appeared as a contributor over thirty years ago. I myself take second place with just over a quarter of a century while "Diallist" and "Cathode Ray" both have over twenty years to their credit.

I was interested in "Diallist's" reference to myself in one of his recent radiations in which he told us that he began writing his feature for *W.W.* on January 18th, 1935, and has never missed an issue. "Unbiased" commenced on September 17th, 1930, and so I have $4\frac{1}{4}$ years seniority. I must confess, however, that "Unbiased" has not appeared in every issue since it started.

There are also one or two "irregular" contributors like M. G. Scroggie (28 years) and W. T. Cocking (26 years) who are also entitled to claim admission to the Methuselah Club. I am, however, more interested in readers than in writers and I have often wondered how many genuine readers-since-the-first-number (April 1911) are still on this side of Jordan.

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