Wireless World

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Copyright Bill

IT is generally believed that the home recordist, under the law as it stands at present, is free to make records of broadcast transmissions and to play them back, in his own home, to an audience limited to his own family or intimate circle of friends, without risk of proceedings under the Copyright Act. But play-back of the records in circumstances that introduce the slightest element of "public performance" may lead the home recordist into trouble.

However, until these views have been tested by a decision in the Courts, there remains in some minds a slight scintilla of doubt as to the true legal position of the home recordist. Any uncertainties that may exist should be removed if the relevant provisions of the recently introduced Copyright Bill are given force of law.

After proposing that copyright shall subsist in every sound and vision broadcast made by the B.B.C. and I.T.A., the Bill goes on to specify the acts which would constitute infringement. So far as recording is concerned, these are the making of records of sound transmissions "for the purpose of selling or letting for hire records embodying that recording, or for the purpose of broadcasting the recording or of causing it to be heard in public or, where such a recording has been so made, making a record embodying that recording." The making of records of vision transmissions by means of cinematograph film or similar methods is restricted in exactly the same way, though the publication of single-shot "stills" of television broadcasts would seem not to constitute an infringement.

So far as the genuine home recordist is concerned, the proposed legislation would seem to remove nearly all uncertainty. But one of the provisions might cause some embarrassment to those in the habit of "dubbing" part of a record on to another. The veto on making copies of "off the air" recordings, contained in the last sentence of the passage from the Bill quoted in the preceding paragraph, would appear to rule out this practice. We imagine, however, that the clause is not really directed against the home recordist, but was added in order to put an additional obstacle in the way of the potential infringer of copyright.

The Bill follows broadly the recommendations of the Copyright Committee, published in 1952.

Too Many Exhibitions?

MORE than once we have suggested that the number of exhibitions catering for our art and its offshoots tends to become excessive. Now comes news of still another addition. The organizers of the British Industries Fair for 1956 are inviting the industry to participate in a separate "electronics display," which will be part of the electrical section at Olympia. It would be foolish and short-sighted to complain of too much limelight, but there can be no doubt that the present proliferation of exhibitions is wasteful. And the waste is not confined to the exhibitors; several of the exhibitions tend to overlap in their scope, and so the visitor—even the visitor with highly specialized interests—may be forced to visit several exhibitions in order to see all that is being shown within his own particular sphere.

The whole field of radio and electronics is now so vast that it would be ridiculous to suggest that all its diverse aspects should be (or could profitably be) covered by a single exhibition. But we see no reason to change our opinion that adequate coverage could be given by two main exhibitions, one domestic and the other professional. The first would be very much on the lines of the present National Radio Show, with sound and vision broadcast receiving equipment in the middle of the picture. The professional exhibition, on the other hand, would present accessories and components for the designer and manufacturer, communication equipment and, of course, as many as may be of the huge number of electronic devices now being offered to industry. Admittedly, the scope of such an exhibition would be wide, but it should be possible to organize it on a sectional basis, planned to make things easy for the specialist visitor.

RADIO NAVAIDS

Two Systems Compared

By "RADIOPHARE"

THE Ministry of Transport and Civil Aviation has recently re-stated the United Kingdom policy on short-range radio-navigation aids. In short, it is that "of all existing systems Decca best meets the air traffic control requirements for navigation on the U.K. national airways." In view of the considerable publicity which has been given to TACAN, recently proposed for adoption as a common system in the U.S.A. in preference to the previously accepted VOR/DME system, we have asked a user of radio nav-aids to draw some comparisons between the two basic types of system—hyperbolic and rho-theta.

IT is extremely difficult, in a case of this nature, to avoid comparing apples with oranges. So let it be said at once that the Decca Navigator system is already fairly widely installed, and has proven its solid worth in many applications. TACAN*, on the other hand, has yet to be subjected to the searching test of everyday operation; true, it has been demonstrated and has been shown to be capable of highly accurate performance. But no one would claim that it is yet a fully developed system. There is thus little point in drawing comparisons between the two systems, since the essential basis for a valid comparison is lacking.

What can be done to some effect, however, is to compare the philosophical bases of the two families of systems to which Decca and TACAN belong; i.e., the hyperbolic and the rho-theta (range and angle). Each has its pros and cons which must be weighted by reference to the particular operational requirement; this at least partially explains the fact that whilst Decca is now firmly established in marine navigation, its application to aviation is still somewhat limited.

It is a major characteristic of rho-theta systems that they consist of point-source elements, each of which is self-sufficient and provides all the information required to navigate within its area of cover. The information consists, in effect, of an infinite number of radials and concentric rings, both having the point-source as their origin. Thus it is possible to provide a continuous display of bearing and distance to or from the particular point-source. Since the information also provides the particular identity of the point-source, absolute geographical position is established with complete freedom from ambiguity. Generally speaking, the angular accuracy tends to be constant throughout the service area, whilst the range accuracy tends to vary directly with distance from the source; thus the *spatial* accuracy of both rho and theta is a function of distance. Putting it another way, it can be said that accuracy improves as the beacon is approached; and since in practice the beacons must, for other reasons, be sited just where the greatest accuracy is required, this works out very well.

* TACtical Air Navigation.

The complementary characteristic of hyperbolic systems is that they deliberately conceal the fact that point-sources are employed; not less than two such point-sources are required to provide "position-line," or three to provide a positive "fix." In the vernacular, two point-sources comprise a "pair," three or more working co-operatively, a "chain." In c.w. hyperbolic systems, such as Decca, the stations of a chain operate on frequencies which are integral multiples of a common parent frequency, and are phase-locked; consequently, the phase-difference of the signals from a "pair" as received at any remote point is a function of the distance and bearing of that point with respect to the "base-line" joining the pair. The locus of points of constant phase-difference forms a hyperbola, and if such curves be plotted in constant increments of phase-difference, then a family of hyperbolæ is obtained. Such a family, over-printed on a chart, furnishes "position-line" information, i.e., position can be established as being on a particular line, but whereabouts on the line cannot be determined.

However, by adding a third station a second "pair" is established; a second family of hyperbolæ may be added to the chart, and (with certain reservations) a "fix" can be established.

Finally, the information derived may be processed by automatic means, as in the Decca system, so that a ship's or aircraft's position can be continuously displayed on a chart in the craft itself. It is fair to say, however, that the display is really a "change of position" indicator; i.e., there is no way in which it can, unaided, derive absolute position information; it must, when first coming into the coverage of the system, be manually set to the correct position. Thereafter it will faithfully continue to display position so long as the essentials for correct operation are satisfied.

Comparative Virtues

The foregoing description leads into two of the principal sources of debate when the comparative virtues of the systems are discussed. Rho-theta systems, whilst generally somewhat less accurate, do provide positive fix information, completely free from ambiguity. Hyperbolic systems, on the other hand, whilst capable of extremely high accuracy, are subject to varying degrees of ambiguity and are not capable, as a class, of providing absolute fix information. Secondly, the hyperbolic systems are held to require a more specialized approach in operation, whereas the rho-theta systems present their information in terms which anyone can understand. Thus, in general, those who are interested in obtaining the highest possible accuracy in navigation, to use the word in its popular connotation, will choose a hyperbolic system, whilst those who wish to "drive" will go for rho-theta.

In this context, it is widely held that the aircraft pilot is a "driver," which is to say that he is rarely interested in his absolute geographical position; his principal preoccupation is with progress along and departure from the planned flight path. He requires to be continuously informed by the most direct and simple means, which heading to hold and how far he must go in order to reach his destination or some selected intermediate point. Among other things, this information is essential to efficient cruise control; if his basic navigational information is of the nature of a geographical fix, he must frequently convert it to "which way and how far" for cruise control purposes. If, on the other hand, the information is directly presented in the "which way and how far" (i.e., rho-theta) form, he will normally have all he requires, and on those few occasions when absolute geographical position is required, it may be extracted with great ease. Thus, provided that the ground elements of the system could be deployed in sufficient numbers and in the right places there is no doubt that a combination of good rho-theta systems would do a very good job; I say "systems" because no one existing system is adequate for world-wide cover.

Here again we reveal another point of difference; but it becomes necessary to particularize. The only rho-theta system which has so far enjoyed wide demonstration is VOR/DME (v.h.f. omni-directional range/distance-measuring equipment), of which only the VOR component is deployed on a major scale. Being a v.h.f. system, VOR enjoys almost complete freedom from interference by atmospherics in its various forms; but its effective range is essentially "line of sight": in other words, anything from 50 to 200 miles, dependent upon aircraft altitude. Decca, on the other hand, operates in the region of 100 kc/s. For this reason it does have to contend with atmospherics, but its effective range is constant at about 250 miles, irrespective of aircraft altitude; furthermore, this range is not the maximum range at which usable signals may be received, but is that at which sky-wave interference compromises the very high accuracy of the system. Consequently, future development may well produce methods by which the effective range can be appreciably increased; and, in fact, a derivative of the Decca system, now under development, promises to be effective at well over 1,000 miles.

TACAN operates in the band between 960 and 1200 Mc/s, and its radiation characteristics and performance through atmospherics may therefore be expected to be similar to VOR, except that the higher frequency permits the use of more elegant arrays for the ground component; this makes it possible to eliminate or reduce certain siting problems which have often proved to be troublesome in VOR.

Another interesting difference between hyperbolic and rho-theta systems is highlighted by TACAN. Generally speaking, as has already been said, ambiguity is an inherent feature of hyperbolic systems; furthermore, in a given hyperbolic system, increased resolution usually means an increased number of ambiguities, and whilst it is possible to do much to resolve these ambiguities, it is never possible to remove them completely.

In a rho-theta system, on the other hand, it is possible to introduce ambiguities in the interests of increased resolution, and then to remove them completely in the final answer. Thus, although increased accuracy has been obtained, the system retains unimpaired its ability to provide absolute geographical fix information, and this is just what TACAN does.

It would be possible to continue drawing parallels and stating contrasts between the two groups of systems, but perhaps sufficient has already been said to demonstrate that it is impossible to generalize in this matter, and that there is no "best" system. Each has its merits and demerits, and these must be weighed against a particular operational requirement to determine which will provide the better answer in that case. Standardization is a worthy aim, but it is full of pitfalls; in particular, it is always dangerous to standardize until all the relevant facts are known and understood, and we probably have yet some way to go before this degree of understanding is achieved in the field of radio aids to navigation.

I.T.A. Lichfield Transmitter

PRELIMINARY details have now been given of the new Band-III television transmitter which is being built at Lichfield to cover the Midlands area for the I.T.A. The vision transmitter will give a peak-white power output of 20 kW and the associated sound transmitter an output of 5 kW. To simplify construction and maintenance the r.f. portions of both transmitters have been made similar to each other wherever possible. The same sort of crystal drive units have been used, and these both give outputs at about 16 Mc/s, which are subsequently multiplied to carrier frequency (189.75 Mc/s vision, 186.25 Mc/s sound) and increased in power to 30 W. Low-power air-cooled amplifiers then raise this to 300 W, and these are followed by medium-power amplifiers, each consisting of two grid-modulated air-cooled valves.

These medium-power amplifiers can actually be used as the output stages of the transmitters, being nominally rated at 4 kW vision (peak white) and 1 kW sound. Normally, however, they operate as driving stages for the final power amplifiers. In the vision transmitter the final power amplifier comprises two water-cooled valves working Class-B in a twin cavity circuit, while in the sound transmitter it has a single water-cooled valve, also in a cavity circuit. The outputs of the power amplifiers pass through coaxial feeders to a combining unit, and this also contains elements to give the transmitted signal the necessary vestigial-sideband frequency characteristic.

Programmes are fed to the station by microwave links (for vision) and landlines (for sound), and both channels are duplicated to guard against breakdowns. Also duplicated are the vision and sound input equipments in the control room. To provide a local source of programme material a new type of film scanning equipment using a Staticon (photo-conductive) pick-up tube is being installed.

As already reported, the transmitting equipment is being supplied by Pye. Later on they will be installing a further set of similar transmitters which are intended to operate in parallel with the first set to provide a service with complete standby facilities.

The aerial, which is being supplied by Marconi's, is a 16-stack high-gain array; ultimately it will be used as a split 8-stack array, each half being fed by one vision and one sound transmitter. Marconi's are also constructing the 450-ft tower on which it will be mounted.

WORLD OF WIRELESS

Co-siting of London B.B.C. and I.T.A. Stations

London Television Stations

THE Television Advisory Committee has at last recommended that the best technical solution of the problem of siting television stations in London is for a single tower to carry both the B.B.C. and I.T.A. aerials. The mast being erected at the Crystal Palace is therefore to be modified. It was originally designed to carry one Band I and one Band III aerial in anticipation of the B.B.C.'s second programme. The addition of the I.T.A. aerial will involve halving the size of the B.B.C.'s Band I array.

The top 250 feet of the 640-ft mast is to be redesigned and this will delay its completion until the middle of 1957. In order, therefore, to bring into use as soon as possible the new B.B.C. transmitter, which is being installed at Crystal Palace, a temporary 250-foot mast is to be erected. The radiated power from the temporary array will be 60 kW instead of the proposed 200 kW. This will be raised to 125 kW when the redesigned mast is brought into service about May, 1957. It is planned ultimately to increase the power to the maximum permitted under the Stockholm Plan—500 kW.

The temporary mast, formerly used for the provisional Northern Ireland transmitter, and the arrays at Crystal Palace are being supplied by Marconi's. The I.T.A. is to build its permanent transmitter (the Croydon station is temporary) on a site adjoining that of the B.B.C.

U.K. Radio Backbone

A CHAIN of radio relay stations extending through the centre of the country from north to south is to be built by the Post Office for the internal telephone service and for feeding television transmitters. This was one of the many references to the use of radio and electronics by the Post Office made by the Postmaster-General at the dinner of the Telecommunication Engineering and Manufacturing Association, at which he was the principal guest. When brought into service in about four years' time, the chain will provide 1,200 telephone circuits and two television channels, but its ultimate capacity will be several thousand telephone circuits and an increased number of television channels.

Purchase Tax

DESPITE the increased purchase tax (from 50 per cent to 60 per cent) on domestic sound and television receivers, the retail price of many of them is unchanged. A number of manufacturers have reduced the list prices and thus, in effect, are paying the extra tax themselves. Where the tax has not been absorbed the increase means an extra 15s on a £16 receiver, 25s on a £27 10s set and 7gns on a 138-guinea television receiver.

The purchase tax on replacement valves and tubes is also increased. On a 15-in tube, the retail price of which is £15, the tax is £7 0s 5d and on a 21-in tube (£21 15s) it is £10 3s 7d.

Brit.I.R.E. Report

ALTERATIONS in its graduateship examination scheme are announced in the annual report of the British Institution of Radio Engineers. As from November next year candidates will be required to complete two three-hour physics papers instead of one, and two new optional subjects (applied electronics, and radar engineering and microwave techniques) have been introduced.

Discussing the question of efforts which have been made to secure "professional unity among engineers" the report draws attention to the representation of radio and electronics engineers on the Ministry of Labour committees concerned with the Technical and Scientific Register. It is pointed out that whereas the civil and mechanical engineers are represented by a number of bodies "the interests of the radio and electronics engineer are the concern of an Advisory Committee comprising representatives of only *one* Institution."

Amateur Show

WHEN Vice-Admiral Dorling opens the ninth Amateur Radio Show (organized by the R.S.G.B.) at noon on November 23rd, he will present an engraved silver plaque for the most outstanding piece of amateur-constructed equipment exhibited.

In addition to the home-constructed equipment shown by members, 18 manufacturers and organizations will be exhibiting. They are Avo, Cleminson's E.M.I., G.E.C., Harwin Engineering, J-Beam Aerials, Labgear, Measuring Instruments, Minimitter, Multicore, P.C.A. Radio, Panda Radio, Philpott's, R.A.F., S.T.C., *Short-wave Magazine*, Television Society and *Wireless World*.

The Exhibition will be open daily from 11.0 to 9.0 until November 26th, at the Royal Hotel, Woburn Place, London, W.1. Admission 1s.

Mr. Briggs in the New World

THE lecture-demonstration of high-quality sound reproduction given recently by G. A. Briggs in the Carnegie Hall, New York, followed broadly the lines of the Royal Festival Hall events, but with distinguished American musicians collaborating for the direct comparisons of live and recorded sound.

The American audience found Mr. Briggs' unique brand of informed wit as much to its taste as did those of Bradford and London. The applause was uninhibited after the playing of the record of "Tugboat Noises" which can now surely qualify also as an "ice-breaker" in any demonstration of this kind.

One significant reaction was a widespread disbelief in the indication of the neon instantaneous power level meters. With amplifiers rated at 50 watts and upwards being widely advertised for use in the American home, it seemed incredible that Carnegie Hall could be filled with *realistic* sound on some items with peak powers of 5 watts or less.

We can sympathize with our friends "from

Missouri" but we can also reassure them that indeed they "were shown"—as we were in the slightly larger Royal Festival Hall.

Writing Premiums

SINCE 1951 the Radio Industry Council has been awarding annually up to six 25-guinea premiums for technical writing to encourage a far greater flow of articles from within industry to the technical press. The criteria taken into consideration when making the awards are the value of the article in making known British achievement in radio and electronics, originality of subject, technical interest, presentation and clarity.

Details of the scheme are given in a leaflet issued by the R.I.C. in which authors are reminded that articles published during 1955 must be submitted to the Council (59 Russell Square, London, W.C.1) before the end of the year.

PERSONALITIES

Sir Gordon Radley, C.B.E., Ph.D.(Eng.), M.I.E.E., who is the first engineer to become director general of the Post Office, and **Dr. Mervin Kelly,** of Bell Telephone Laboratories, have been awarded the Christopher Columbus communications prize. The award, which is made annually by the city of Genoa, is given for their part in leading the two teams—British and American—in the transatlantic telephone cable project. It carries a monetary prize as well as a medal.

Colonel J. Reading, M.B.E., B.Sc.(Eng.), M.I.E.E., has left the Post Office, where he has been an assistant engineer-in-chief since 1951, to join Ericsson Telephones as export director. He graduated from the Northampton Engineering College, London, in 1924 and after a brief period in industry joined the Post Office as a probationary assistant engineer in 1925. Throughout the last war he served in Royal Signals and from 1945 until 1946, when he rejoined the Post Office, was chief signal officer, War Office Signals. Col. Reading left for a tour of Australasia and Canada on November 19th.

A. E. Jennings, B.Sc., formerly with E.M.I. Research Laboratories for 10 years, has joined 20th Century Electronics as head of their photo-electric laboratory. At E.M.I. he was primarily concerned with pick-up tubes and was a leading member of the team which developed the c.p.s. Emitron.

H. J. C. Gower, A.M.I.E.E., who has joined Granada TV Network as head of outside broadcasts, had been with the B.B.C. from 1938 with the exception of the war years when he served with the R.A.O.C. and R.E.M.E. supervising radio and radar maintenance. When he rejoined the B.B.C. in 1946 he returned to Alexandra Palace but later went to the engineering planning and installation department where in 1950 he took charge of the department's television outside broadcast unit. Before joining the B.B.C. he was for three years in the E.M.I. Research Laboratories.

Granada TV Network also announces the appointment of **W. Nugent** as technical supervisor, **Donald W. Pickering** and **Owen D. Howells** as assistant television recording engineers. Mr. Nugent was with the B.B.C. on operations and maintenance from 1943, spending five years on sound broadcasting and five years on television. Both Mr. Pickering and Mr. Howells have been with the B.B.C. for a short while.

E. C. Presland, A.M.I.E.E., who joined Willesden Transformer Company two years ago, has been appointed works manager. He was previously with the English Electric Company.

L. H. Light, who contributes an article on transistor power supplies in this issue, is at present in charge of a group at Mullards doing research on the applications of valves, transistors and cold-cathode tubes in industrial, switching and computing fields. He has been in the valve measurements and applications laboratory of the Mullard Radio Valve Company since graduating with honours in Natural Philosophy from Glasgow in 1948.

OBITUARY

H. A. Watts, M.B.E., at one time an assistant director in the Directorate of Radio Production at the Ministry of Aircraft Production, died at his home in Farnborough, Hants, in October at the age of 71. He entered Government service in the old Air Ministry Instrument Design Establishment at Biggin Hill in 1920, was transferred to the radio department of R.A.E., Farnborough, and in 1938 came to the M.A.P. headquarters in London. He was chairman of a joint service committee which produced what proved to be the most widely used specification for the general engineering requirements for radio equipment for the Services.

Hubert Wood, B.A.(Oxon), M.I.E.E., who for the past six years had been manager of Ferranti's radio and television department, Moston, Manchester, has died at the age of 40 after a short illness. After reading physics at Corpus Christi College, Oxford, where he took his degree with first-class honours, he joined the staff of Ferranti's radio laboratory in 1936 and during the war was engaged on radar development.

We learn from the *Proceedings of the I.R.E. (Australia)* of the death earlier this year of **A. S. McDonald** at the age of 64. As chief engineer and assistant general manager of Amalgamated Wireless (Australasia), he was responsible for experiments carried out jointly by A.W.A. and Marconi's in short-wave transmissions which resulted in the opening in April, 1927, of the beam wireless service between Australia and the United Kingdom. He was also concerned with the introduction in 1930 of the first overseas commercial two-way radio-telephone service from Australia.

IN BRIEF

Broadcast Receiving Licences current in the United Kingdom at the end of September totalled 14,154,439. The month's increase in television licences was 97,434, bringing the total to 4,883,849. The number of car radio licences was 284,549.

1956 Shows.—Dates have now been announced for next year's National Radio Show and the Components Exhibition. The Radio Industry Council will again hold the annual Radio Show at Earls Court, London, from August 22nd to September 1st, with a pre-view for invited guests on August 21st. The Components Show, organized by the Radio and Electronic Component Manufacturers' Federation, will be held from April 10th to 12th at Grosvenor House, London, W.1. Although this is a private show it is proposed to have a pre-view on April 9th.

Pontop Pike.—The permanent television station on Pontop Pike, near Newcastle-upon-Tyne, was brought into service by the B.B.C. on November 15th. It has an effective radiated power of 12 kW and replaces the low-power temporary station which has been in use since May, 1953

A New Coast Station at Ilfracombe, Devon, was brought into service by the Post Office on November 1st. The radiotelephone services operated by the Burnham-on-Sea, Somerset, station have been taken over by the new station, which operates on 1855 and 2670 kc/s and, of course, uses the calling and distress frequency 2182 kc/s. Burnham will continue to operate the radiotelegraph services in the 500-kc/s band.

Electronics at B.I.F.—With the introduction of an electrical section at the British Industries Fair at Olympia (April 23rd to May 4th), it is planned to bring purely electronics exhibits together within this section.

An **Industrial Electronics Exhibition** is being planned by the South of Scotland Electricity Board, which will have the co-operation of the D.S.I.R., technical colleges and some fifty firms. It will be held in Glasgow (Kelvin Hall) from February 2nd to 9th, and in Edinburgh from February 13th to 16th.

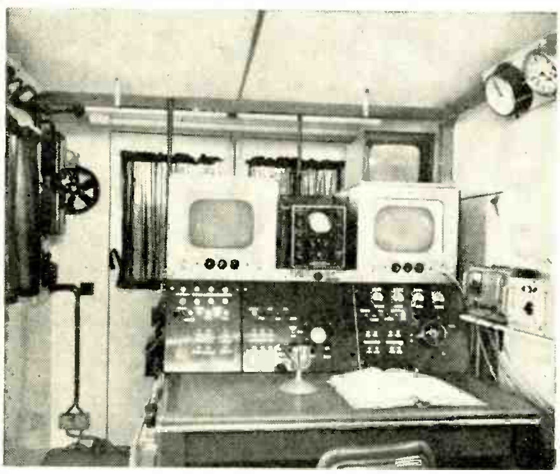
R.S.G.B.—Although John Clarricoats, the well-known general secretary of the Radio Society of Great Britain, is not due to retire for some years, the Council is inviting applications for the post of deputy general secretary. Applicants should be between 28 and 38, and experience of amateur or experimental radio work will be an advantage. Commencing salary will be not less than £900 p.a. Applications must reach the Society at New Ruskin House, 28/30 Little Russell Street, London, W.C.1, by December 31st.

Although for obvious reasons details of beneficiaries of the **Electrical Industries Benevolent Association** are not published, we understand that a goodly number of them are in the radio industry from which the Association receives a considerable part of its income. Among the donors listed in the 1955 report are the Radio Industries Clubs of London and Glasgow, who together gave over £500. This year's president, too, is very much in radio—Sir Harold Bishop.

The latest edition of the **B.E.A.M.A. Catalogue,** published for the British Electrical and Allied Manufacturers' Association by our publishers, includes in its 1,034 pages detailed descriptions of the products of the electrical industry, a trade directory and classified buyers' guide. It also includes a glossary in five languages. Of the 16,000 printed, 15,000 have been despatched overseas.

The London office of the **International Maritime Radio Committee** (C.I.R.M.), which has its headquarters in Brussels, is now in Ingersoll House, 9 Kingsway, W.C.2. The president of the committee is H. C. Van de Velde, and the secretary-general J. D. Parker.

Also in Ingersoll House is the office of the **Radio Marine Associated Companies** which is the co-ordinating body for twenty-four radio marine companies in nineteen countries. H. C. Van de Velde is chairman of R.A.M.A.C., and the secretary-general is E. Fost.



CONTROL CONSOLE in the trailer housing the Belling-Lee transmitter (G9AED) which is radiating test transmissions on 189.75 Mc/s vision and 186.25 Mc/s sound from the I.T.A. station site at Lichfield, Staffs. The transmission times are now Monday to Friday, 9.30 a.m.—12.30, 2.0—5.30, 7.30—8.30 p.m. and Saturdays 10 a.m.—1 p.m.

In the ten-man advance party of the Royal Society's **Antarctic Expedition,** which will be participating in the International Geophysical Year (1957/8), are Major G. E. Watson, R.E.M.E., an electronics engineer loaned by the War Office, and Dr. Stanley Evans, a radio-astronomer from the Jodrell Bank Experimental Station. The party sails in the 540-ton M.V. *Tottan* on November 22nd, and will erect the research station in preparation for the main party due to leave England in a year's time. The pilot scientific programme includes ionospheric soundings.

Wired Television.—Although the Hull Corporation has decided not to seek immediately Government permission to pipe television to inhabitants served by the Hull Telephones Department, it was agreed that the subject should be reconsidered later. Whilst some of the telephone distribution equipment would be usable in such a scheme, capital outlay of some £100,000 would be required to start a service.

A new circular has been issued by the Union Observatory in Johannesburg giving details of the time signal and **standard frequency transmissions** which it now radiates continuously except for the period 0630 to 0700 G.M.T. The transmitter, which uses the call ZUO, operates on 5 Mc/s with a power of 100 watts.

In the past Brimar have delayed the publication of **Valve Application Reports** until production valves were available for measurement. To enable engineers and designers to consider possible applications before the valves are under full production, interim reports giving measurements on pilot types will in future be issued. These will be followed by the normal application reports.

Television in Egypt.—The Egyptian government has called for tenders for the supply and erection of equipment for the first part of the country's "general project for television." The specification calls for a 625-line vestigial sideband transmitter operating in Band III with f.m. sound.

Middle East Communications.—Cable and Wireless have opened a direct radiotelephone service between Cyprus and Amman, in Jordan. They have also introduced a wireless telegraph service between Aden and Meifaah, in the Eastern Aden Protectorate.

Brit.I.R.E. Council.—Rear-Admiral Sir Philip Clarke was re-elected president of the British Institution of Radio Engineers at the annual general meeting on October 26th. This is his second term of office. The ordinary members of the council elected at the meeting are Air Vice-Marshal C. P. Brown, J. W. Ridgeway, Professor E. Williams, R. N. Lord and A. H. Whiteley.

At its inaugural meeting on October 19th, the Cardiff Centre of the **British Sound Recording Association** elected J. H. Robinson, of Castle Studios, Cardiff, as chairman. The secretary is J. G. Pearce, 2 Canada Road, Gabalfa, Cardiff.

A post-graduate evening course in **Pulse Techniques** will start at the Kingston Technical College on January 17th at 7.0. A lecture programme is obtainable from the head of the engineering department, Fassett Road, Kingston-upon-Thames.

A series of six free lectures on **Automation** begins at the Woolwich Polytechnic, London, S.E.18, at 7.0 on November 23rd and will continue on December 1st and 14th, January 19th and 24th, and February 1st. The two January lecturers are to be men in the electronics industry: R. A. Gail (E.M.I.), who will deal with automatic control of machine tools, and J. A. Sargrove (Sargrove Electronics), whose subject is "Automatic machine and process control." Seats can be reserved for individual lectures or the series on application to the Polytechnic.

A technical talk on **Band III Aerials** will be given by Belling & Lee in Birmingham Town Hall on November 30th, at 3.30. Applications for tickets must be sent to Belling & Lee, Great Cambridge Road, Enfield, Middlesex.

A course of eight lectures on **Colour Television** will be given at 7.0 on Wednesdays, commencing on February 1st, at the College of Technology, Manchester (fee 30s). Intending students should have reached a standard at least equivalent to that of the Higher National Certificate.

Outward Form.—D. H. C. Scholes, of Plessey, and G. Birkbeck, of Mullard, were on the ten-man committee set up by the London Regional Advisory Council for Higher Technological Education to consider "ways of achieving, through modifications in existing arrangements for education and training, a closer attention to æsthetic considerations in the manufacture of light engineering products." The committee's report is published by the Regional Advisory Council.

B.S.I. in Birmingham.—The British Standards Institution has now opened a sales office in the headquarters of the Birmingham Chamber of Commerce at 95 New Street, Birmingham, 2.

BUSINESS NOTES

A trading agreement has been concluded between the **Automatic Coil Winder and Electrical Equipment Co.**, and Blume and Redecker, of Hanover. It provides for the Automatic Coil Winder Company to take over the sales of the German company's laminating, wire-stripping and coil-winding equipment in the United Kingdom, Commonwealth countries and other overseas countries, including the U.S.S.R. The English company will continue to produce its own Douglas and Macadie coil winders.

Webcor (Great Britain), Limited, the British subsidiary of the American Webster-Chicago Corporation, is now established in Ingersoll House, Kingsway, London, W.C.2 (Tel.: Covent Garden 0283). It will market in this country and abroad record players, which will be known by the American term "fonografs," and tape recorders, some of which will incorporate broadcast receivers. The general sales manager is H. E. G. Harvey and R. E. Singleton, formerly with Decca and Cossor, is technical representative.

Westrex, Limited, of Liberty House, Regent Street, London, W.1 (previously known as the Western Electric Company, Limited), a subsidiary of the Westrex Corporation, of New York, recently demonstrated the new Monatel f.s.k. receiver. This equipment, which can be used for single diversity or dual diversity (Divatel) reception, is imported from the U.S.A. It provides for the reception of radio-teletype, facsimile, R/T or W/T.

Combined a.m.-f.m. radio-telephone equipment is being fitted by **Redifon, Limited,** in 14 vessels of the Shell tanker fleet. Known as type GRT174, this equipment enables vessels to use the marine v.h.f. radio-telephone service in any part of the world irrespective of the type of modulation employed.

A new company—**Continental Radio and Electronics Limited**—has been formed to market in this country equipment manufactured by Continental-Rundfunk G.m.b.H., of Osterode, Harz, Germany. The new company, which is temporarily at Blenheim House, 1 Blenheim Grove, Peckham, London, S.E.15, will handle the Diktat tape recorder and the Imperial range of broadcast receivers and radiograms which it is hoped eventually to manufacture in this country.

An **Ediswan** cathode-ray tube service depot has been opened in the premises of J. J. Eastick and Company, Limited, Library Place, St. Helier, Jersey. It is pointed out that Ediswan Mazda valves must still be returned to the Valve Service Depot, Brimsdown, Middlesex, for examination.

The telephone number of **Pye Telecommunications, Limited,** of Cambridge, is now Teversham 3131.

A "loud-to-loud" telephone instrument designed to operate on public telephone networks as well as internal office systems has been developed by **Winston Electronics.** Acoustic feedback between microphone and loudspeaker is avoided by a voice-operated electronic switch with a time constant of 3 milliseconds. F. Winston Reynolds has returned recently from a tour of Europe, during which the "Tellaloud" was demonstrated successfully on a number of trunk systems with varying characteristics.

Sole manufacturing and marketing rights in the "Electrophoor" dry-battery reactivator for the U.K., the Commonwealth and other countries are held by **Cass and Phillip, Ltd.,** of Canning Road, Wealdstone, Middx. The reactivator was described in our October issue.

John Lionnet and Company, of 62-63 Queen Street, London, E.C.4, who have been sole export representatives for **Bakers Selhurst** loudspeakers for the past three years, have now taken over their distribution in the United Kingdom.

S.A.I.T.—Société Anonyme Internationale de Télégraphie Sans Fil, the Belgian associates of Marconi's, who have had an office in London for many years, have moved to Ingersoll House, 9 Kingsway, London, W.C.2.

OVERSEAS TRADE

Chile.—A contract worth more than £250,000 has been awarded to Marconi's Wireless Telegraph Company for the complete radar and communications equipment for two destroyers now under construction in this country for the Chilean Government.

Australasia.—Two 20-kW induction heaters for the brazing of car parts have been ordered from Redifon, Limited, for installation in Adelaide. The Company is also providing a dielectric generator and large welding press for use in motor car manufacture in Wellington.

Pye, Limited, are forming a **French subsidiary** to be known as Pye (France) S.A. It will be primarily concerned with the introduction of the Company's telecommunication equipment into France.

Norway.—Passenger radio-telephone equipment for the 6,500-ton liner *Bergensfiord* under construction at Wallsend-on-Tyne for the Norwegian American Line is being supplied by Redifon. The h.f. transmitter and associated receivers operate on any one of twenty crystal frequencies.

H.R.H. the Duke of Edinburgh inspected the Marconi research and demonstration vessel "Elettra II" during his visit to Copenhagen for the British Trade Fair. D. P. Furneaux, a management executive of the Marconi International Marine Communication Company, is seen describing the Salvita portable lifeboat transmitter receiver.

Transistor Power Supplies

Circuits for Obtaining H.T. and E.H.T. from Low-Voltage Sources

By L. H. LIGHT,*
B.Sc., A. Inst.P.

OF the many conventional methods of converting d.c. power from one voltage to another (vibrators, rotary convertors, cold-cathode tube and thyratron inverters) none is efficient at very low levels. This is because all these devices consume an appreciable amount of power in order to keep going. A rotary convertor, for instance, uses power to overcome its frictional, iron and copper losses; a vibrator coil consumes power, and so on. In every case the amount of power used by the convertor itself does not vary appreciably as the load is reduced. Thus, at low levels (below about 1 watt) these convertors are very inefficient. It is uneconomic, for instance, to operate any of them from dry batteries. Yet the need for high voltages in battery operated equipment (such as portable radiation counters) is growing.

Soon after the introduction of transistors it was appreciated that they could be used in efficient low-level convertors. Most of the devices mentioned above operate by interrupting a direct current flowing through a transformer primary, thereby enabling a different d.c. voltage to be obtained (after rectification) from the secondary. Alternatively, the interrupted direct current can be fed through an inductor, and use be made of the ringing-choke principle to obtain an increased voltage. To obtain zero operating losses, the interrupting device should obviously have an infinite resistance in the "off" condition and zero resistance in the "on" condition.

A junction transistor can be made to operate as an interruptor with nearly perfect characteristics. "Off" corresponds to collector-current cut-off, when the resistance may run into hundreds of kilohms. In the "on" condition the transistor is "bottomed," that is, it operates somewhere below the knee of the collector-current/collector-voltage characteristic; in this region its effective resistance may amount to a fraction of an ohm.

The problem of making an efficient d.c. convertor therefore resolves itself into one of designing a circuit in which the transistor spends as much time as possible in those conditions alternately, the transitions through the lossy intermediate regions being kept as short as possible. This clearly implies non-sinusoidal waveforms and therefore some kind of relaxation oscillator.

A suitable circuit, due to P. H. Janssen and C. van der Vijver, is shown in Fig. 1. In this, energy is stored in the inductance of the transformer in the "on" period (the input stroke) and delivered to the output circuit at a higher voltage during the "off" period (the output stroke). It works on the ringing-choke principle, although the ringing is arrested long before the peak voltage possible is reached.

The operation of the circuit† is as follows. Imagine that the output capacitor C_0 is charged to some voltage V_0, and that the operating point of the transistor is point 0 of Fig 2 (i.e., it is fully "bottomed"). The resistance of the transistor is very small, so small that it has little effect on the circuit, which behaves virtually as Fig. 3(a) with SW closed. The current through the primary inductance rises linearly (Fig. 4(a)). The resulting linear rate of change of flux induces a constant voltage in the transformer winding in the base circuit, and, since the base input resistance is approximately constant, a nearly constant base bias current is applied. The operating point therefore moves upward until some point is reached where it begins to move round the "knee" (point P of Fig. 2). The transistor now has an appreciable resistance and Fig. 3(a) no longer applies, Fig. 3(b) being a more accurate representation of the circuit. Because of the increasing transistor resistance R, the rate of change of current in the transformer primary decreases.

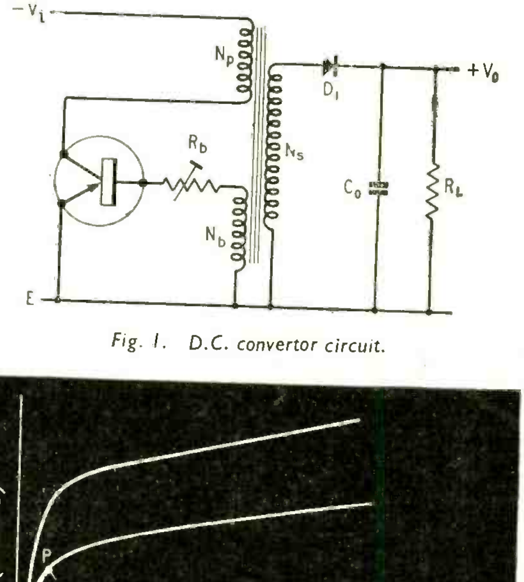


Fig. 1. D.C. convertor circuit.

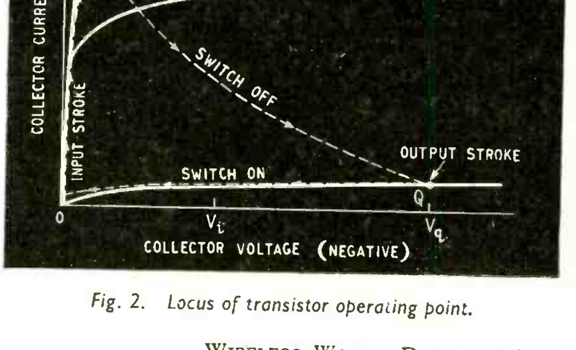


Fig. 2. Locus of transistor operating point.

* Mullard Ltd.
† Light, L.H. and Hooker, P.M., "Transistor D.C. Convertors," *Proc.I.F.E.* Pt. B. 1955.

The base voltage therefore decreases. The resulting reduction in bias causes a reduction in collector current. This causes a further reduction in base voltage, and so on, so that by a cumulative action the collector current is cut off. The operating point moves rapidly to Q of Fig. 2.

During the whole of this time (the " on " period), the rectifier D_1 (Fig. 1) remains non-conductive. On the cessation of current through the primary, the flux collapses and the polarity of the secondary voltage reverses. When it becomes equal to V_0, it is " caught " there, D_1 conducts and transfers the energy stored in the inductance to the capacitor C_0 (and so to the load R_L). The secondary voltage then decreases below the voltage across C_0, and D_1 ceases to conduct. The transistor operating point then returns to 0.

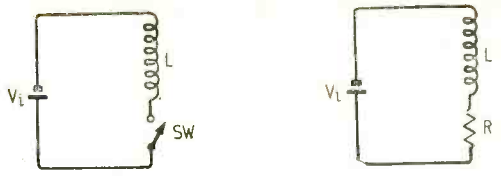
If the circuit were exactly like Fig. 1, the operating point would remain at 0. In order to initiate another forward stroke it is necessary to apply some negative bias to the base. Once this happens, collector current begins to flow, bias voltage is developed across the base winding, more collector current flows, and the transistor rapidly switches on again.

In practice, it is not always necessary to make special arrangements to apply a switching-on bias, because, after the output stroke, stray capacitances discharge through the transformer windings, causing ringing which carries the base negative after a short time. Similarly, when a convertor battery is initially switched on, the resulting current surge will often start oscillation. If, however, a long positive pulse is applied to the base, oscillation ceases.

The efficiency of transistor convertors can be very high. In practical arrangements values of 65%–85% are usual. The transistor dissipation is normally only a small fraction of the total power handled. The main losses are in winding resistances, the " on " resistance of the transistor, rectifier losses and transient losses in the transistor. These last require some explanation: we find that every time the transistor is switched off the collector current takes a few microseconds to decay even though the cutting-off voltage applied to the base was sharp. While this current, which is due to hole-storage effects in the transistor, flows, a high voltage already exists on the collector due to the inductance, and the collector dissipation is momentarily high.

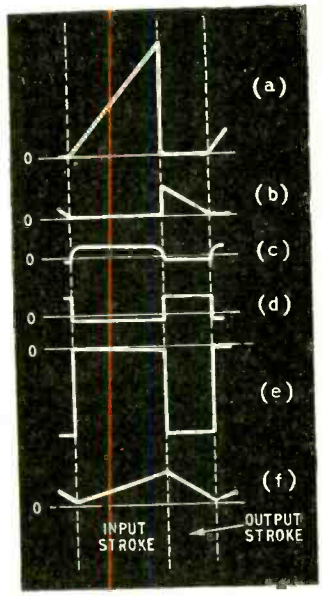
Operating Frequency

Although the energy lost thus per cycle is small, the loss due to these transients can be comparable with other losses or even predominant, depending on the operating frequency chosen. It is therefore desirable to keep the operating frequency low to minimise the transient losses. On the other hand high transformer inductance values are required to attain a low frequency, which in any given transformer volume lead to higher winding resistances and increased losses due to this cause. The operating frequency normally chosen is a compromise giving minimum overall losses, though it can be varied from this optimum to take account of other requirements, e.g., upwards to give minimum size of smoothing components or downwards to give reduced transistor dissipation, when, say, this allows a transistor with a lower rating to be used. The optimum frequency is normally in the range 500c/s–5kc/s, so that transformers with Ferroxcube cores are commonly used to keep eddy current losses negligible. Note that the transient loss per cycle can be reduced by increasing the positive voltage existing on the base and decreasing the impedance of the base circuit during the period that hole-storage currents flow. A capacitor shunted across R_b fulfils both these functions.



(a) (b)

Above: Fig. 3. Representation of the Fig. 1 circuit when (a) operating point is at 0 (Fig. 2) and (b) operating point is at P.



Right: Fig. 4. Waveforms in Fig. 1 circuit: (a) current in primary, (b) current in secondary, (c) base current (negative), (d) base voltage, (e) collector voltage, (f) flux in transformer core.

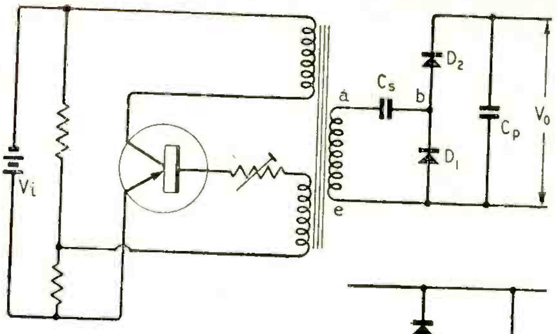
What determines the transformer design? This subject has already been discussed fully† so we will give a mere outline here. The primary inductance determines the operating frequency and is thus chosen to give the optimum or any other desired value. In the calculation of primary turns required, allowance must be made for an airgap in the magnetic path which is usually necessary because of the d.c. magnetisation of the core.

The primary/secondary turns ratio is given by the requirement that the peak collector voltage rating of the transistor is not exceeded. (This ratio does not affect the output voltage because the circuit operates on the ringing and catching principle. We have already seen that the output voltage is determined solely by the power level setting and the load.)

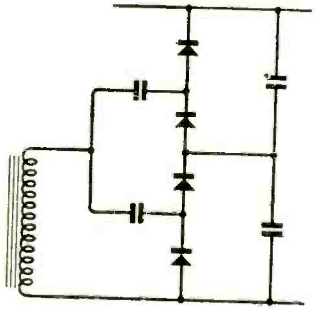
During the output stroke, the collector voltage is the input voltage plus the voltage induced in the primary of the transformer when its secondary is delivering the output voltage, i.e., $V_c = V_i + (N_p/N_s)\,V_o$. At the same time a voltage $(N_b/N_s)\,V_o$ in the opposite sense is induced in the base winding, so that the condition

$$V_i + \frac{N_p}{N_s}\left(1 + \frac{N_b}{N_p}\right) V_o < V_{cb\,max}$$

must be met, where $V_{cb\,max}$ is the maximum collector voltage rating.



Above: *Fig. 5. Convertor with "diode pump" voltage doubler.*



Right: *Fig. 6. Convertor with voltage quadrupler.*

The primary/base winding ratio is determined simply by the need to provide sufficient drive for the transistor. The spread between transistors must be borne in mind here.

Push-pull versions of the circuit can be made when the power output required is beyond the handling capabilities of a single transistor. As push-pull arrangements have the advantage that a smaller transformer can be used, they are useful also when utmost miniaturization is aimed at.

Voltage Multiplier Rectification

When very high voltage-step-up ratios are required, transformer winding difficulties, stray capacitances and leakage inductance all increase. The last two slow down the switch-on and switch-off processes, giving increased losses, while large stray capacitances also cause an appreciable part of the high-voltage energy to be held in the windings, from which it is only partially recovered. It is thus usually better to obtain high voltage ratios by a convertor giving a moderate degree of voltage increase followed by a voltage multiplier rectifier system. As the "diode pump" voltage doubler circuit is the basis of all multiplier systems, we shall make a few observations on the operation of the above convertor circuit with "diode pump" output (see Fig. 5). We shall assume that C_s and C_p here are large.

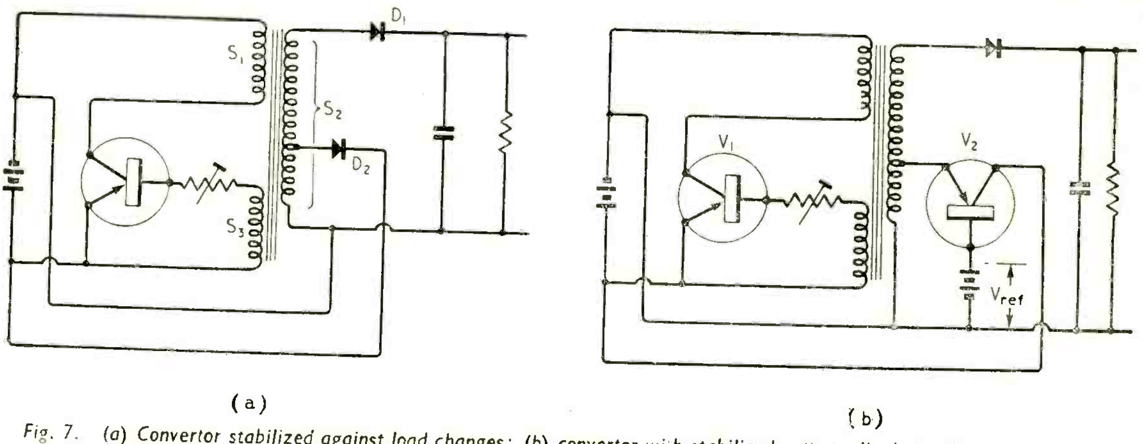
In contrast to the simple circuit, current can now flow in the secondary during the input stroke. By ordinary transformer action point *a* then is at $-(N_s/N_p)V_i$ volts, and current flows through diode D_1 to charge capacitor C_s to this voltage.

We thus have $V_{ab} = (N_s/N_p)V_i = V_t$, say. As before, the transistor switches off at the end of the input stroke, point *a* goes positive and its voltage rises until it is arrested by diode D_2 opening. This happens when $V_{ea} + V_{ab} = V_o$. Current then flows through C_s and D_2 to transfer energy stored in the inductance of the transformer into C_p. The secondary voltage remains substantially constant at its value of $(V_o - V_t)$ for the whole of the output stroke provided that C_s is so large that the flow of charge through it does not change the voltage across it by much. Compared with the simple circuit, the secondary voltage during the output stroke is therefore reduced from V_o to $(V_o - V_t)$. The number of secondary turns can be reduced in the same ratio while maintaining the transistor collector voltage the same. The use of a voltage quadrupler circuit, one form of which is shown in Fig. 6, allows a further twofold reduction in secondary turns.

The value of the output voltage V_o is still a function of the load and of the power-level setting of the convertor. The output resistance of the voltage doubler circuit is, however, somewhat lower than that of the simple one, because the part V_t of the output voltage derived by simple transformer action is independent of the load. The part of the output voltage $(V_o - V_t)$ derived from stored energy is load-dependent as before.

Negative base bias is usually necessary to start oscillations in voltage multiplier circuits, and this is incorporated in Fig. 5. The bias is required only until oscillations are firmly established, and it is possible to arrange switching so that it is only transiently applied.

While the regulation of the convertor can be improved and the output voltage stabilized by conventional means, these all waste much power. It is better to use some internal stabilizing circuit which either returns excess power to the battery or adjusts the power drawn from it to the load requirements.



(a) (b)

Fig. 7. (a) Convertor stabilized against load changes; (b) convertor with stabilized output; (both "spill-over" systems).

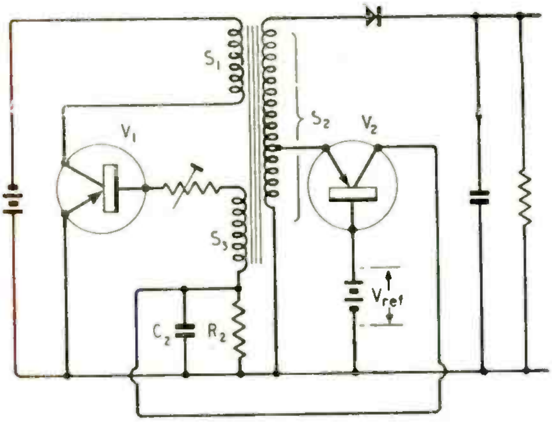


Fig. 8. Convertor with feedback stabilizing circuit.

Examples of both methods are shown. The circuits of Fig. 7 return excess energy to the battery; that of Fig. 7(a) reduces the output voltage changes due to load changes, while that of Fig. 7(b) also stabilizes against battery voltage changes.

Consider Fig. 7(a). The tap on winding S_2 is positioned such that when the wanted output voltage appears across S_2 the tap voltage equals the battery voltage. If the load decreases and S_2 therefore generates too great a voltage on the output stroke, current flows (" spills over ") through diode D_2, recharging the battery. This energy drain on the transformer reduces the rise in output voltage. As the battery is used as a reference, no stabilization against changes in the input voltage is possible.

In the circuit of Fig. 7(b) a transistor replaces the diode and a separate reference battery is used. The transistor acts as a gate which opens when the voltage on the tap exceeds the reference voltage. $\alpha'/(1+\alpha')$ times the spill-over current then flows via the collector into the supply battery, while the fraction $1/\alpha'$ flows into the reference battery*. This circuit thus stabilizes against battery voltage changes and still returns much of the excess energy to the supply battery. V_{ref} must exceed the maximum input voltage encountered by a fraction of a volt.

True feedback regulating circuits have been devised in which control is applied to the base of the switching transistor to vary the power drawn from the battery, one of them again stabilizing against load variations, while the other, shown in Fig. 8, stabilizes against changes due to all causes. As before, if the output voltage exceeds its nominal value, current flows through transistor V_2 but it now develops a positive voltage across C_2R_2. This bias reduces the base current of V_1 during the input stroke and thus causes the transistor to switch off at a lower value of the peak input current in the primary. The average input power is thereby reduced. This type of circuit is more efficient that the previous one when there are large variations in load or input voltage.

Transistor power supplies can be made up in a wide range of specifications and their field of application is therefore equally wide. A few examples will illustrate the variety of designs that can be made.

Fig. 9 shows (in front) a very-low-level convertor using the OC70 transistor and miniature selenium rectifiers. Operating from a 1.2-volt cell, it is capable of delivering an output of 30V, 100μA which is sufficient to supply two hearing-aid type preamplifier valves or a semi-electrometer valve with h.t. It thus eliminates the relatively expensive miniature h.t. battery commonly used in hearing aids.

Another convertor has been designed to give 50V, 3mA, with a 6-V input. It uses the OC72 transistor and its efficiency is about 80%. This type of convertor is finding application in " hybrid " radio sets, i.e. sets with valve frequency changer and i.f. amplifier but transistors in the audio side. It supplies sufficient h.t for the two valves.

A unit capable of some 4W output is also shown in Fig. 9. This uses an OC15 power transistor and germanium junction rectifiers to provide an output of 150V, 30mA, at 75% efficiency. One of its many possible applications is as an h.t. supply for small portable transmitters and receivers. Its 12-V input may be derived from the accumulator which supplies the valve heaters. This convertor, in common with the others mentioned so far, uses the simple circuit of Fig. 1.

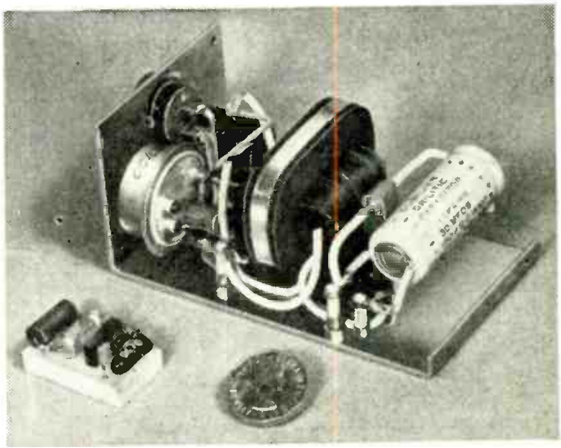


Fig. 9. In front is a low-level h.t. supply unit suitable for hearing-aid type valves, while behind is an h.t. supply which can be used for portable transmitters and receivers. A three-penny bit gives an idea of the sizes.

A power source suitable for many types of radiation detector is operated from four 1.2-V mercury cells and can give up to 60μA at 400V or up to 35μA at 700V. It uses the OC72 transistor and selenium rectifiers in the quadrupler circuit of Fig. 6, incorporates stabilization against load changes and has an efficiency of 70% at maximum output.

Oscilloscope Supplies

Fig. 10 shows a demonstration battery-operated oscilloscope system in which both the 2-kV e.h.t. for the 5-in cathode-ray tube and 150-V line for the simple valve amplifier are derived from the convertor mounted on the white panel. The 2-kV, 0.8-mA output is obtained from a voltage quadrupler circuit, while the 150-V, 3-mA line is fed from a tap on the transformer secondary via a single rectifier. The overall efficiency with a 12-V input is 70%.

A convertor giving 10kV at 100mA from a 12-V input with 55% efficiency has also been made. A Cockroft-Walton voltage multiplier with 5 doubler stages was used to generate the output. Both e.h.t.

* Here α' is the base-collector current gain of the transistor.

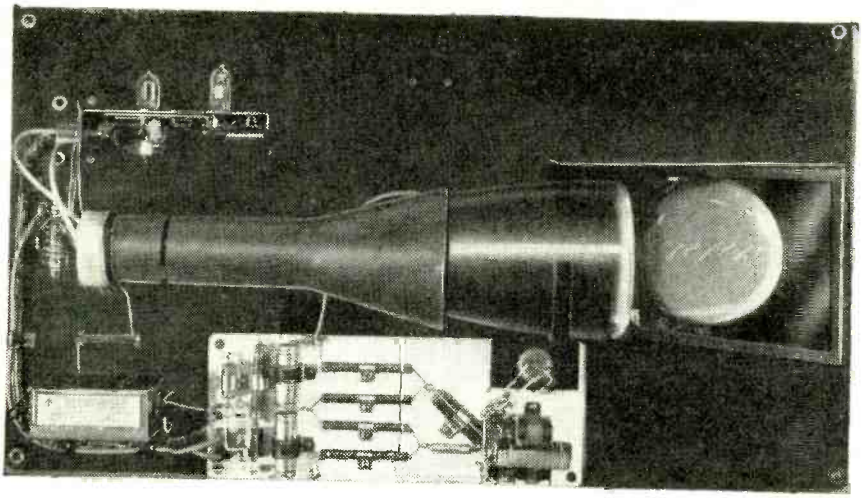


Fig. 10. Battery-operated oscilloscope system giving both h.t. and e.h.t.

units use the OC15 power transistor and selenium rectifiers. They have applications in portable insulation testers, photo-flash equipment, flashing beacons and as power supplies for photo-multipliers, image convertors and cathode-ray tubes.

While all the convertors described above have been designed around the basic circuit of Fig. 1, it must not be thought that this is the only possible one. It has the great advantages of simplicity, good efficiency and non-critical design, but also the shortcomings that by itself it has a high output impedance and that the output depends on the current gain and base resistance of the particular transistor in use, so that the external base resistance must be adjusted to obtain a given output. There will thus be many cases where different circuits are preferable and references to some of these circuits are given below [1, 2, 3].

It will be seen from the photographs that the size and weight of transistor power supplies are very moderate. This, coupled with their high efficiency, should make their adoption advantageous in many applications where h.t. batteries are required at present. For example, a great saving in weight, volume and running cost is obtained when the e.h.t. supply for a Geiger-Muller tube or photo-multiplier is obtained from a few small l.t. cells and a transistor convertor, or if a convertor allows the h.t. requirements of a small portable transmitter to be drawn from the accumulator which normally supplies the heater power only.

As transistor convertors are already capable of giving an output of several watts (which will no doubt be increased in the future) they cover part of the field over which vibrators are used. The question arises: how do these two devices compare‡ ?

We have seen already that transistor convertors are smaller and lighter. In addition, they are more efficient over quite a range of output power, cause less interference, and offer promise of much longer life and greater reliability than the vibrator. The vibrator, on the other hand, scores in that its performance is unaffected by temperature, whereas the transistor convertor has a definite upper temperature limit and its efficiency falls a little with temperature below this. At present, also, the initial cost of the transistor convertor is higher than that of the vibrator unit, although it is expected to become competitive as mass production of power transistors is streamlined.

We see, therefore, that transistor d.c. convertors not only provide a way of stepping up voltages from battery supplies at those low power levels for which no efficient and convenient method has been known so far, but that they also show substantial advantages over competitive devices at intermediate power levels of some watts. This, together with the flexibility in design which makes it possible to obtain an output of tens, hundreds or thousands of volts at power levels from an odd milliwatt upwards, make them important new tools in the electronic engineer's kit-bag. The designer of miniature and portable equipment, in particular, will find them of the greatest help.

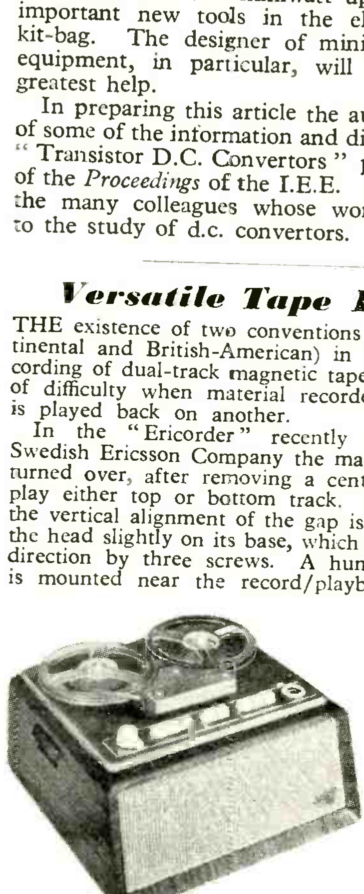
In preparing this article the author has made use of some of the information and diagrams in his paper "Transistor D.C. Convertors" published in Part B of the *Proceedings* of the I.E.E. He wishes to thank the many colleagues whose work has contributed to the study of d.c. convertors.

[1] Uchrin, G. C., and W. O. Taylor. "A new self-excited square-wave transistor power oscillator," *Proc. I.R.E.*, January, 1955, p. 99.
[2] Pearlman, A. R. "Transistor Power Supply for Geiger Counters," *Electronics*, August, 1954, p. 144.
[3] Johnston, D. L. "Transistor H.T. Generator," *Wireless World*, October, 1954, p. 518.
‡ Grimsdell, G. "The Economics of the Transistor D.C. Transformer," *Electronic Engineering*, June, 1955, p. 268.

Versatile Tape Recorder

THE existence of two conventions (the so-called Continental and British-American) in the direction of recording of dual-track magnetic tapes is often the cause of difficulty when material recorded on one machine is played back on another.

In the "Ericorder" recently developed by the Swedish Ericsson Company the magnetic heads can be turned over, after removing a central fixing screw, to play either top or bottom track. Fine adjustment of the vertical alignment of the gap is effected by turning the head slightly on its base, which can be tilted in any direction by three screws. A hum-compensating coil is mounted near the record/playback head and this must be reversed whenever the head is turned over.



"Ericorder" Type KTB202.

The machine gives tape speeds of $3\frac{3}{4}$ and $7\frac{1}{2}$ in/sec and will take spools up to 7in in diameter. Control is by push buttons, and there is provision for the usual accessories.

Colour Television Tests

Investigating Possible Defects of the British N.T.S.C. System

THE main purpose of the first group of experimental colour transmissions which the B.B.C. have been putting out from Alexandra Palace has been to test the compatibility of the British N.T.S.C. system*—that is, to assess how much the presence of colour information in the signal affects the quality of the pictures and sound on existing black-and-white television receivers. Colour pictures, mainly from slides and films, have been radiated by the low-power transmitters at Alexandra Palace and observations have been made on some thousands of ordinary monochrome receivers. Experimental colour receivers have also been in use, but as so few are available at present no large-scale observations have been made on the quality of the colour pictures.

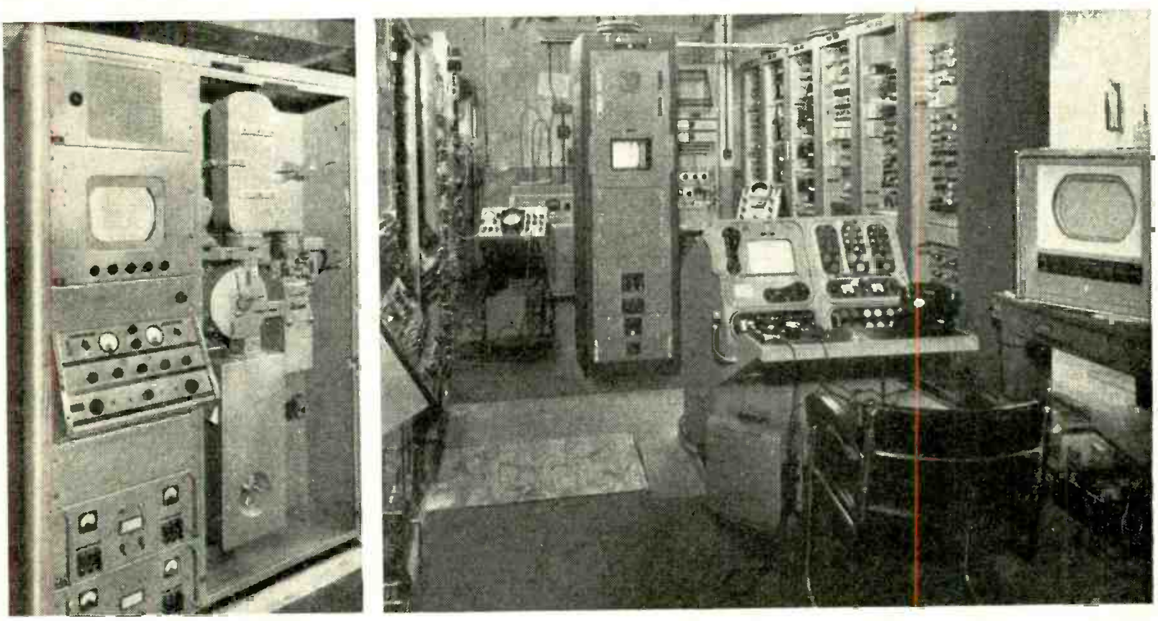
One of the main points under investigation has been the visibility of the dot structure produced by the colour sub-carrier on existing black-and-white sets. To test for this, and most of the other possible defects, the colour information in the transmitted signal has been switched on and off at 15-second intervals during each slide or film, so that the observers could compare the compatible black-and-white transmission with what is, in effect, a plain black-and-white transmission. The procedure would also show up, for example, whether the presence of the colour information introduces any degree of "buzz" into the sound channels of the receivers.

Another subject for study has been the tonal gradation of the compatible pictures. The matter has arisen because gamma correction in the N.T.S.C. transmission system is applied to the red, green and blue colour-component signals before they are combined to produce the luminance (brightness) signal. This is not the same thing as applying the gamma correction to the luminance signal itself; consequently when the luminance information is displayed on a black-and-white receiver the overall contrast is not correct. However, the presence of the colour sub-carrier acts to rectify this defect to some extent. The whole question is quite important as it may influence a decision on whether the colour information should be transmitted inside or outside of the normal band.

*The general principles of this system have already been described in "Transmitting Colour Information," *Wireless World*, August, 1955. Details of the actual colour signal radiated from Alexandra Palace were given in the same issue under the title "Colour Television Standards."

Asynchronous Operation

The effect of running the transmitting equipment unlocked to the mains has also been under observation. Here it has been necessary to see whether the picture has been marred by any visible beat effect between the asynchronous 50-c/s frequency and the 50-c/s mains hum in the receiver. There is a danger, too, of a beat pattern being caused by interaction between the colour sub-carrier and the sound carrier. A slide having large areas of colour information has



Right: General view of the colour equipment. In the centre foreground is the camera control desk, while the racks to the right of it contain waveform generators, encoding circuits and power supplies. The tall cubicle in the rear centre is a colour monitor using optical superimposition of images from three c.r. tubes, while on the extreme right is another monitor using a 15-in RCA tri-colour tube. On the extreme left is the slide- and film-scanner, of which a front view is shown separately in the left-hand picture.

been used with the intention of showing this up, and the sound carrier has been switched on and off at intervals so that any pattern of this type can be easily identified.

The colour sync signal is yet another possible source of interference. It consists of a short burst of sub-carrier frequency and occurs during the fly-back time of the line time-base; in some black-and-white receivers it might appear as a series of vertical white lines. Here, a caption slide with white letters on a black background has been used as the most likely sort of picture to reveal the effect.

There is also the possibility that the synchronizing of the black-and-white receiver itself may be affected by large amplitudes of colour sub-carrier occurring just before the line sync pulses. Because of the narrow bandwidth of the chrominance signal this colour information could continue after the cessation of the associated luminance information and extend into the sync period, or at least the "front porch" period, perhaps causing line sync pulling. To test for this defect a special slide has been used with a highly saturated colour occupying a few lines at the extreme right-hand edge of the picture.

Further tests are being done to observe the effect of putting a filter in the luminance channel to remove the components of the luminance signal which fall in the chrominance band. This filter improves the colour picture but it may also cause a deterioration of the compatible black-and-white picture. Another network is inserted at the input of the vision transmitter for phasing purposes, to correct the response of colour receivers, and again it is necessary to see whether this affects the quality of the black-and-white pictures.

Colour Transmission Equipment

The experimental equipment for generating the colour pictures at Alexandra Palace is shown in the photograph. There is a colour slide- and film-scanner designed by the B.B.C. Research Department, and signal coding equipment and colour picture monitors produced by Marconi's. A three-tube colour camera and colour test equipment have also been supplied by this firm.

The B.B.C. scanner works on the flying-spot principle, using a cathode-ray tube with a phosphor which emits light as evenly as possible over the whole of the visible spectrum. The light from the raster is passed through either the slide or the film as desired and the coloured image so produced is split into three separate parts, which contain respectively the red, green and blue information in the picture. This colour analysis is performed by a combination of dichroic mirrors, coloured filters, plane mirrors and lenses. The three colour-separation pictures, which emerge from the analyser as three physically separate rays of light, are then focused on to three photo-multiplier tubes which convert the varying intensities of light into corresponding voltages. The three voltages are then passed through three separate and identical chains of electronic equipment which supply gamma correction, correction for the distortion introduced by the finite decay time of the light from the scanning tube phosphor, and equalization for aperture loss—exactly as in a monochrome flying-spot scanner.

The film transport mechanism is a standard 16-mm projector with a "pull-down" time of about 4 milliseconds. Since the time available for "pull-down" is only 1.4 milliseconds if all the lines of the television picture are to contain information, some picture information is inevitably lost. This loss occurs at the top and bottom of the picture, where about 15 lines come out black. In order to preserve the usual aspect ratio of 4:3 an equivalent area at the sides of the picture is also made black. Synchronism between the film motion and the television picture repetition rate is achieved in a simple way by amplifying the 50-c/s component of the frame pulses and using it to supply power to the synchronous motor of the film transport mechanism.

The signal coding equipment includes special colour waveform generators and circuits in which the luminance and chrominance signals are derived from the incoming three-colour information. The "master" frequency, from which all the other scanning and pulse waveforms are derived, is obtained from a temperature-controlled crystal oscillator working at 2.6578125 Mc/s ±8 c/s (the sub-carrier frequency). This is multiplied and divided to produce the double line frequency of 20,250 c/s (i.e. 4/525 times sub-carrier) from which the standard 405-line interlaced waveform is generated. Multiple outputs of line and frame trigger pulses, mixed synchronizing pulses and mixed suppression pulses are available.

The input to the encoder consists of the three gamma-corrected colour-separation signals (red, green and blue) produced by the slide- and film-scanner. The encoder may be considered as performing a single linear transformation of the three incoming signals, red, green and blue, to the other three quantities, E_Y, E_I, and E_Q, of which E_Y is the luminance signal.† The colour sub-carrier is then modulated by the E_I and E_Q signals in such a way that the amplitude of the resultant signal conveys the saturation information and the phase conveys the hue. In the absence of colour information the sub-carrier is suppressed. The complete chrominance signal is added to the luminance which is, of course, in video form. Finally, the synchronizing waveform, including the colour sync burst, is added to produce the complete signal, which is then passed to the transmitter and radiated in the normal way.

Occasionally, readers may have seen on their receivers a pattern of seven vertical bars of different tone values. These are actually colour bars, generated electronically for test purposes, representing known values of amplitude and phase of the sub-carrier.

A few observations on the test transmissions made by *Wireless World* suggest that the sub-carrier dot pattern, although clearly discernible when the picture is examined closely on a good receiver, is not at all objectionable at normal viewing distances. On many receivers, it cannot be seen at all. The "buzz" on sound is negligible and there appear to be no synchronizing difficulties. Tonal gradation seems quite satisfactory. Slow beats resulting from synchronous working have been observed, however, and also diagonal-line beat patterns on areas of high colour saturation. However, it remains for the statistical results to be assessed before a complete verdict can be given.

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†See "Transmitting Colour Information," *Wireless World*, August 1955, for full explanation.

LIVING with "HI-FI"

Equipment Should be Heard and Not Seen

By A. DINSDALE

"High-Fidelity Home," in the August issue, described one solution to the problem. Here is another, from an American correspondent, who seized the opportunity for re-modelling the house.

A LOUDSPEAKER cabinet may or may not be a thing of beauty but, if efficient, it is certainly bulky. It poses a problem for the lady of the house when arranging furniture, and more particularly when she wants to *re*arrange it! Similarly with the other bits and pieces that go to make up a high-fidelity audio system. "Can't you stow them somewhere out of sight, or at least make them less conspicuous?"

So much for the viewpoint of the lady of the house. The man of the house wants his gear where he can get at it—preferably without getting up out of his favourite chair to tune the radio or change a record. And he'd like to get that loudspeaker out of its cabinet and built into the structure of the house somewhere. The question is where—and how? The landlord of a rented apartment is apt to object if the tenant gaily tears out a wall to accommodate the speaker, and not all houses lend themselves conveniently to the purpose in hand. Then there is a little matter of expense, especially if the owner is not gifted with the ability to do the job himself.

The basic equipment involved in this case is a Jensen 15-inch "co-ax" speaker, which used to be housed in a bass reflex cabinet, a Hallicrafters Model SX-42 communications receiver, and a turntable for l.p. records. The loudspeaker curve is supposed to be essentially flat to about 15,000 c/s, while there is a switch position on the SX-42 giving an audio output which is essentially flat to 16,000 c/s. The tuning range of the receiver is continuous from 550 kc/s to 110 Mc/s, with f.m. available on the two top ranges.

In an apartment, the bass reflex cabinet stood in a corner, with the receiver resting on top of the cabinet. The turntable reposed on an end table beside the speaker cabinet. The distaff side enjoyed the music, but looked with distaste on the unimportant matter of appearance.

A Fresh Start

When a house was purchased, it was mutually agreed that something must be done about the "hi-fi" equipment—mutually agreed, but for different reasons.

Let's start with the house. It's a very old house, by American standards; that is, it is over 100 years old. It had been neglected for many years. Several windows were broken. Acres of plaster had mysteriously evaporated from the walls. The house lacked many other things which are not germane to the purpose of this article. Sufficient has been written to indicate that a complete re-modelling job was in order.

The ground-floor layout included a largish (by modern standards) living room, off which was a spacious front parlour separated from the living room by French doors. The general appearance was not encouraging, as a glance at Fig. 1 will indicate. The front door of the house opens into the living room, but for some unknown reason a second front door opened into the front parlour, as

Fig. 1. Living room (foreground) and parlour before re-modelling operations started. Note the unwanted front door in parlour.

Fig. 2. Outside view of house. Entrance door to living room is at right rear of porch. Second unwanted door is behind glass-panelled storm door at front.

Fig. 3. Radio/audio control centre. Hallicrafters SX-42 communications receiver on shelf behind and above end table. Turntable on shelf below receiver. L.P. records filed on fourth shelf from top, at extreme left. Plenty of room for additional equipment.

indicated in Fig. 1. Externally, the arrangement is illustrated in Fig. 2. That second front door was exposed to the prevailing winter gales. It had to go.

Opposite the offending door, 28 feet away, was a living room wall, completely blank except for an opening into the dining room—a wall difficult to do anything with from the viewpoint of the lady of the house. Swiftly and surely an idea dawned. Why not cover the wall completely with bookshelves, with special provision for radio and audio gear at a strategic spot for the master's chair? Take off the French doors to the parlour. Build in the speaker where the door is, which would dead-centre it on the master's chair, a clean sweep through the parlour opening. Motion seconded and approved.

Up went the bookshelves. In went the SX-42 and the turntable. Fig. 3 shows what it looks like today. For tomorrow there is ample and inconspicuous room for such additions as a Williamson amplifier with pre-amp., more modern turntable and pickup, a.m.-f.m. tuner, or what-have-you that the bank account will stand for. In setting up a camera to take the Fig. 3 photograph, consideration was given to moving out the end table and lamp to expose the equipment to better view, but it's supposed to be inconspicuous, so it was photographed as inconspicuously as possible.

Building in the Loudspeaker

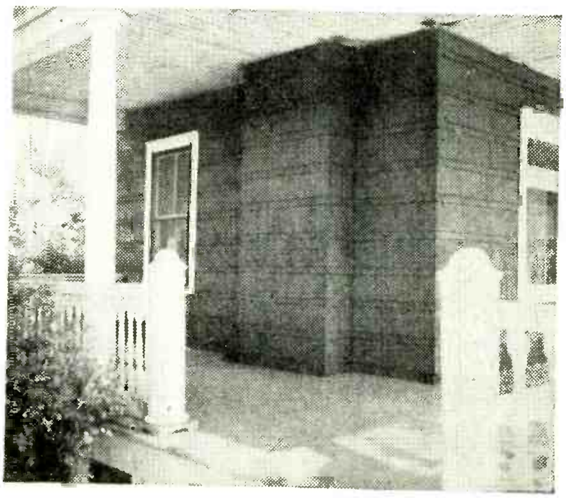
Of course, the day selected to do the job turned out to be cold, but the door came out anyway, despite loud protests about draughts. The wall (of wood construction) was not thick enough to accommodate the loudspeaker, so a jut was built out on to the porch to the extent of 12 inches. This was framed in, sheathed with 1-inch boards and covered on the outside with wood shingles to match the rest of the house, as shown in Fig. 4. Passing neighbours inquired if a fireplace was being installed. Admittedly, the jut doesn't look too elegant on the outside, but the responsible parties have to live *in*side the house—not on the porch.

On the inside, a shelf was installed across the bottom of the loudspeaker space to complete the enclosure, which is 16 inches deep. Stubs, 2in×4in, were installed to brace and reinforce the central section of the loudspeaker panel. The inner sides and back of the enclosure were acoustically treated with a liberal covering of loose spun glass (glass wool), secured by means of a staple gun. The result is a loudspeaker enclosure amounting to about 18 cubic feet. Total cost of materials, about $10.

The speaker itself was installed on a $\frac{3}{4}$-inch plywood panel measuring 3ft 6in wide by 4ft high. Because of the cubic footage of the enclosure, a bass reflex port was not cut in the panel. The panel was securely screwed to the 2in×4in wall studs on each side of the old door opening, to the old header above the door opening, and to the 2in×4in bracing stubs and the edge of the shelf at the bottom. Wiring from the speaker to the control centre was run under the floor.

The remaining space below the speaker enclosure was arranged temporarily as shelved cupboard space for odds-and-ends storage; it could be used for a built-in television set. And tomorrow, when one of the new electrostatic speakers becomes available on this side of the pond, the 15-inch Jensen can easily be replaced. For the time being, the finished job is as illustrated in Fig. 5, with the loudspeaker hidden behind the tapestry over the sofa. Again, it was debated whether to photograph the bare bones of

Fig. 4. Compare with Fig. 2. Unwanted door has been removed and loudspeaker enclosure, 16in deep, built out on to porch. This is the rear view of 18-cu ft enclosure.



the set-up but, as we said before, it's supposed to be inconspicuous.

The centre of the loudspeaker is up 5ft 6in from the floor, in the area of the heads of the two figures on the tapestry. Incidentally, it's surprising how much extra brilliance can be obtained by just raising the speaker up from the floor.

So now the master of the house can relax in his favourite chair, reach all controls without getting up, and have his favourite l.p. or f.m. music beamed straight at him across 28 feet of space. The dispersion over the rest of the living room is good. At this distance, the perspective is considerably improved, and the "noise" does not intrude if only low background music is wanted for reading or conversation in the living room.

Oh, yes! That "tapestry" over the speaker. Actually, it consists of a piece of hand-painted burlap (sacking) suspended from an old broom handle the ends of which are decorated with a couple of wooden door-stops! It does not impede sound, and it's decorative. It fools strangers, who can't figure out where the sound is coming from, or who switched it on from where. Inconspicuousness has been achieved—and so has technical excellence of performance and convenience of handling. Both bosses of the household are satisfied.

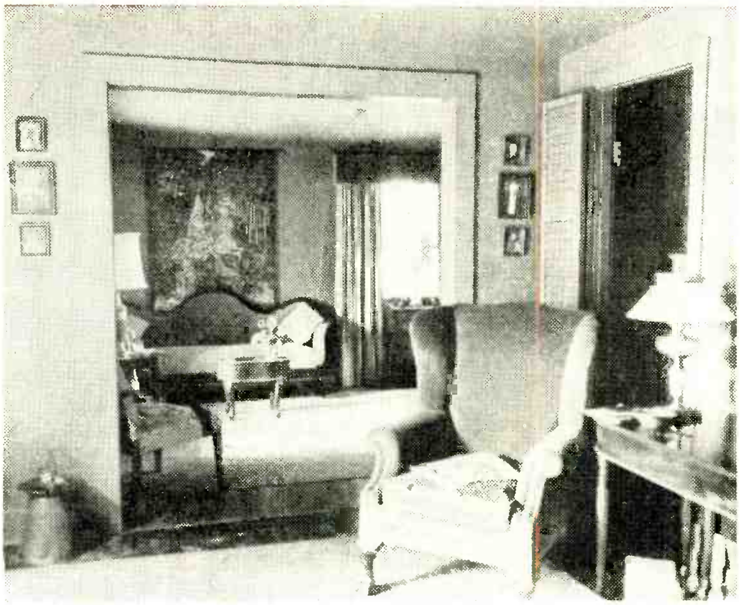


Fig. 5. Compare with Fig. 1. Unwanted door now replaced with loudspeaker hidden behind tapestry over sofa. Speaker beams directly at control centre (Fig. 3) over a distance of 28 feet.

BOOKS RECEIVED

Absolute Measurements in Magnetic Recording, by E. D. Daniel, M.A., A.M.I.E.E., and P. E. Axon, M.Sc., Ph.D., A.M.I.E.E. B.B.C. Engineering Monograph No. 2 giving details of non-magnetic conductor methods of measuring induction normal to the surface of magnetic tape, and of the application of this quantity in deriving specifications of head and tape sensitivity. Pp. 10; Figs. 2. Price 5s. B.B.C. Publications, 35, Marylebone High Street, London, W.1.

Die Empfangstechnik Frequenzmodulierter Sendungen, by A. Nowak and F. Schilling. Stage-by-stage analysis of current practice in v.h.f. receivers for frequency-modulated transmissions. Discusses alternative circuits and methods for mixers, limiters, discriminators, etc. Pp. 290; Figs. 131. Price DM 16.50. Fachbuchverlag Siegfried Schütz, Emdenstrasse 5, Hanover, Germany.

Introduction of TV Servicing, by H. L. Swaluw and J. van der Woerd. Assumes a basic knowledge of radio circuit fundamentals and shows how this can be applied to the isolation and correction of faults, particularly in receivers for 525- and 625-line transmissions. Includes many photographs of picture abnormalities. Pp. 276; Figs. 326. Price 40s. Cleaver Hume Press, Ltd., 31, Wrights Lane, London, W.8.

Vacuum Valves in Pulse Technique, by P. A. Neeteson. Deals primarily with the theory of switching circuits and in detail with variations of the multivibrator circuit for this purpose. Pp. 180; Figs. 147. Price 27s. Cleaver Hume Press, Ltd., 31, Wrights Lane, London, W.8.

Ultrasonic Engineering, by Alan E. Crawford. Methods of generating high-energy vibrations and their application in dust precipitation, emulsification of liquids, drilling, soldering and many other operations. Pp. 344+X; Figs. 222. Price 45s. Butterworth Scientific Publications, 88, Kingsway, London, W.C.2.

Mullard "Ferroxcube." Reference book for designers, giving characteristics of a range of magnetic ferrite materials and cores, with design data for their use in communication coils and transformers, television line output transformers and deflection coil yokes, rod aerials and for information storage elements in computers. Pp. 130; Figs. 89. Price 7s 6d. Mullard, Ltd., Components Division, Century House, Shaftesbury Avenue, London, W.C.2.

A Beginner's Guide to Radio, by F. J. Camm. Practical experiments as an introduction to the theory of simple circuits and the function of components. Pp. 160; Figs. 104. Price 7s 6d. George Newnes, Ltd., Southampton Street, London, W.C.2.

Regulations for the Electrical Equipment of Buildings (Thirteenth Edition—1955). Enunciates requirements for safety, and details the means by which these may be met in practice. Includes revised British Standards for rubber, polythene and p.v.c.-insulated cables. Pp. 182+viii. Price 6s (paper bound) or 8s 6d (cloth bound). The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

PUBLICATION DATE

Owing to the Christmas holiday our printing schedule has been rearranged and the publication of the next issue of *Wireless World* deferred from December 27th until January 3rd

Long Distance

Possibilities of Its Occurrence

INTERFERENCE from Continental v.h.f. stations is occasionally experienced under abnormal propagation conditions during any month of the year, but it is most likely to occur during the summer months on the television and other v.h.f. services in this country. The interference takes the form of a moving pattern of lines (rather like the "water" pattern in a piece of silk) when it occurs on the vision channel, or of a background of "noise" of various kinds when it occurs on sound. Such interference cannot be said to be by any means a major nuisance, being present over a year for only a very small proportion of the total broadcasting time. It is, for example, negligible in comparison with the interference which regularly takes place after dark on the medium frequency broadcasting band, and is usually noticeable only in the outer fringe of a service area. Nevertheless some consideration of the possibilities of its occurence, and of the modes of propagation involved, may be of interest.

The interference with which we are concerned comes from Continental stations legitimately operating on the same or adjacent channels as those occupied by the British stations, or from the harmonics of Continental stations working in the h.f. bands. The v.h.f. bands affected are Band I (41-68 Mc/s) used for television, and Band II (87.5-100 Mc/s) used for v.h.f. sound broadcasting. Not enough experience has been gained on frequencies above 100 Mc/s for us to deal with them here.

Under normal propagation conditions the interference does not occur, because at distances beyond the radio horizon, *i.e.* in the diffraction zone, the field strength of a v.h.f. transmitter decreases very rapidly with distance. Obviously the actual field of such a transmitter at a distance varies with a number of factors, but we may take it that at a distance of about 200 miles the field of a high power v.h.f. transmitter under normal propagation conditions will be of completely negligible importance as a source of interference. It is true that some parts of the Continent are nearer than this, but, under the Stockholm Conference of 1952, the allocations of frequencies among European v.h.f. stations were made so that no channel sharing occurred among stations which were so near to each other that interference would result under normal conditions.

The interference arises, then, only when abnormal propagation conditions occur, that is to say when certain meteorological or ionospheric conditions prevail, and it is therefore with these conditions we have to deal here. The conditions are considered to be abnormal only in the sense that they give rise to out-of-the-ordinary radio propagation; it is not implied, for example, that a meteorologist would consider the atmosphere to be in an abnormal state when they exist.

It is not practicable to list here all the stations

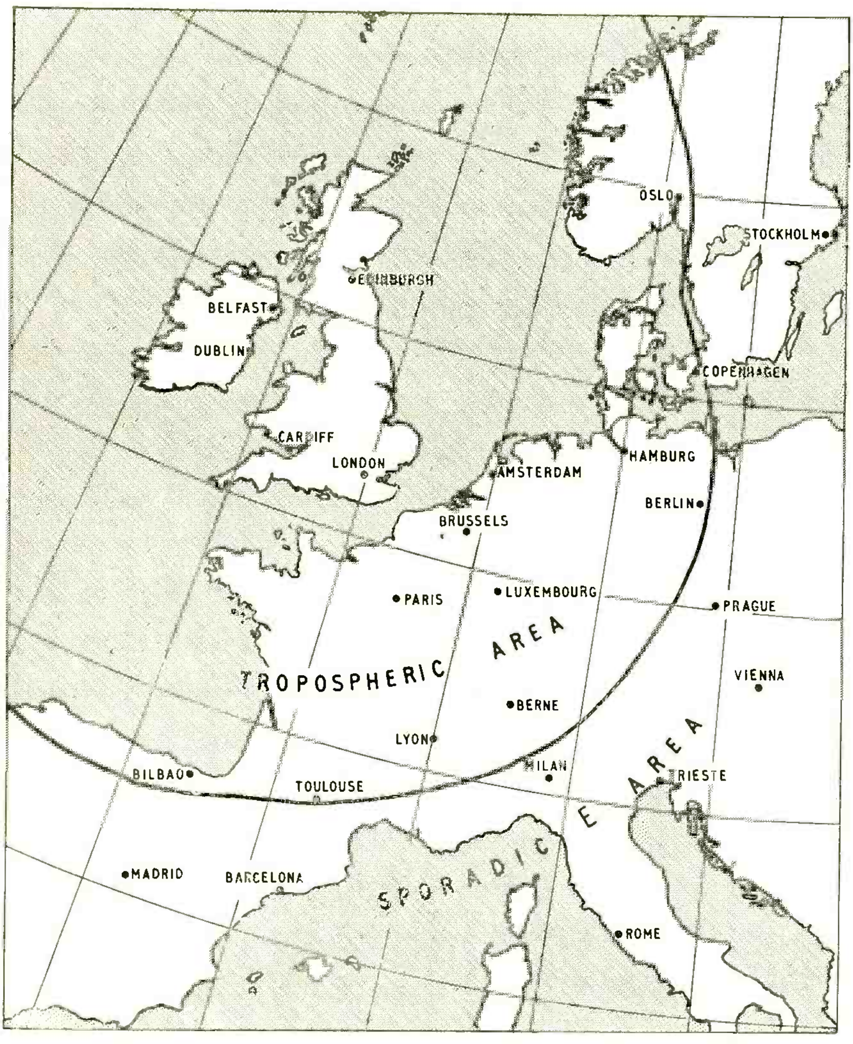


Fig. 1. European areas from which v.h.f. interference may be experienced in U.K. by tropospheric or by sporadic E propagation.

V.H.F. Interference

By T. W. BENNINGTON*

and Modes of Propagation

operating in Bands I and II which might, by modes of propagation which occasionally become operative, cause interference in this country, let alone those that might do so by means of their harmonics, but it is sufficient to say that many such stations exist on the Continent of Europe. Occasional interference may be received, therefore, from stations ranging in distance from about 200 miles to about 1,400 miles from this country, for the small proportion of time when these abnormal propagation conditions prevail. The map of Fig. 1, upon which the curved line indicates a distance of 500 miles from the British coast, may, at this stage, be of interest.

It is appropriate to say at this point that, for a given field strength of the interfering signal, the actual interference caused will be much less serious to the f.m. sound services in Band II than to the television services in Band I. This is because of the "capture effect" in f.m. receivers, whereby the interfering signal is suppressed by the wanted signal unless it exceeds a certain ratio of wanted to unwanted signal. According to Kirke[1] the noise due to the interfering signal is just tolerable when the field strength of the wanted signal is 20 dB above that of the interference, and is completely eliminated when it is 30 dB above it. The comparable figures for the services in Band I are some 20 dB greater than this, and thus they are much more susceptible to the type of interference we are discussing. It would seem, in fact, that the interference in Band II is unlikely to be serious for any appreciable part of the total time.

Propagation of Interference by Sporadic E:— Though signals in the v.h.f. bands are not propagated by the normal ionospheric layers (except for short periods at the sunspot maximum) the ionisation density of the sporadic E, which forms fairly frequently within the normal E layer, does become high enough to sustain their propagation. Sporadic E, then, constitutes a possible medium for the propagation of Continental interference to this country, so let us briefly consider some data indicative of its effects.

Sporadic E is detected and examined during the course of the hourly measurements of ionospheric characteristics made at ionospheric stations all over the world. The principal measurement of interest to us is its critical frequency, *i.e.* the highest frequency it will reflect at vertical incidence. This of course, determines the highest frequency on which it will sustain propagation at oblique incidence, and we may take it that sporadic E with a critical frequency of 7 Mc/s will sustain propagation on about 36 Mc/s in the most oblique case possible, corresponding to transmission over a distance of 1,400 miles. Sporadic E with a critical frequency greater than 7 Mc/s, therefore, is capable of propagating interfering signals on frequencies in the v.h.f. bands such as we have under consideration. We may call this the intense sporadic E.

In order to obtain an estimate of the prevalence

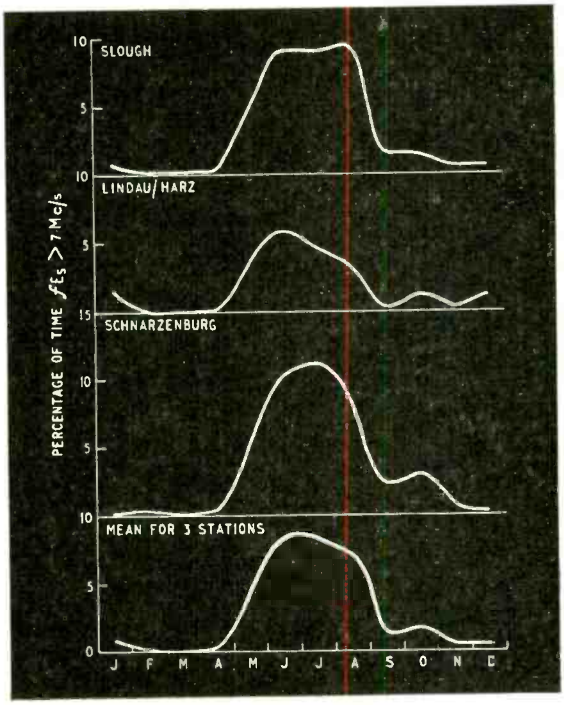


Fig. 2. Monthly variation of intense sporadic E over Europe, mean of monthly values for 1953 and 1954.

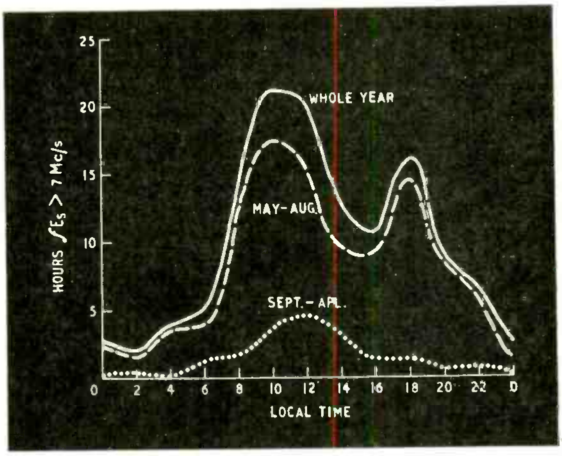


Fig. 3. Diurnal variation of intense sporadic E over Europe; mean hours during each period for three stations for 1953 and 1954.

of such intense sporadic E over Europe the records of three ionospheric stations were examined, namely, those at Slough, England, Lindau/Harz, Germany, and Schwarzenburg, Switzerland. The means of the monthly values for the three stations for 1953 and 1954 were taken, in terms of the percentage of the

* British Broadcasting Corporation

total time during each month when intense sporadic E was present. The results are plotted in Fig. 2 separately for each station, and as a mean for the three stations. The latter curve is, perhaps, the most significant, and it indicates that, for these three stations—which we may consider as being representative of European conditions—the intense sporadic E was present on the average for much over 1 per cent of the time only during May to August.

Fig 3 gives details of the diurnal variations of the intense sporadic E obtained from the records of the same three stations for 1953 and 1954. In this case it is more convenient to express the prevalence in terms of the mean hours, during the periods shown, when it was present at each hour of the day. It is seen that the intense sporadic E is largely a daytime phenomenon, with a main peak around 1000-1200 hrs. local time and a subsidiary peak at 1800 hrs. From Figs. 2 and 3, therefore, we may consider that it is only during the hours 0600 to 2200 (l.t.), and only during the months May to August, that intense sporadic E is likely to be present for a long enough period of the local time for it to be of much importance in the propagation of interfering signals in the v.h.f. bands.

The propagation characteristics of sporadic E as a function of distance are given in Fig. 4, which shows the percentage of the total time during the summer daytime (0600-2200 hrs May-August) when it was present with an intensity sufficient to sustain propagation on the frequencies indicated over various distances. These curves are plotted from the results of a previous examination[2], and are based on the Slough measurements only, for the three years 1948-1950. They may, however, be considered to be representative of European conditions during the average summer daytime. From them it would appear that sporadic E with an intensity great enough to propagate frequencies in the v.h.f. bands over distances less than 500 miles is present so infrequently as to be of negligible importance, that for greater distances the proportion of the total time when it might propagate interfering signals decreases rapidly with increasing frequency, but that, up to the distance of 1,400 miles (maximum possible in one hop) it can propagate frequencies up to somewhat above 55 Mc/s for more than 1% of the time.

We may now summarize the properties of sporadic E as regards the propagation of v.h.f. signals from a distance, as derived from the foregoing brief examination of the data. We should expect it to be effective for an appreciable proportion of the total time (appreciably greater than 1%), only from 0600 to 2200 hrs (l.t.) during the months May to August inclusive (this obviously does not rule out occasional occurrences at other times and during other months). It should not be effective over distances of less than 500 miles, but should be so over those between 500 and 1,400 miles, the occasions when it is effective becoming more numerous as distance is increased towards 1,400 miles. Propagation from beyond this distance should occur extremely rarely, for it involves multi-hop transmission. Finally, the frequency of its occurrence should decrease rapidly with increasing frequency, and, though it may occasionally be capable of sustaining propagation on frequencies up to 100 Mc/s, it is unlikely to do so on frequencies above about 60 Mc/s for more than 1% of the total time at the most favourable times of day and year.

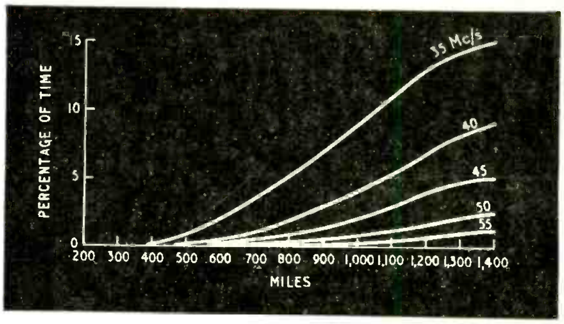


Fig. 4. Percentage of time when sporadic E would sustain propagation over different distances and on different frequencies (based on Slough measurements 1946-1950; 0600-2200 g.m.t.; May-August only).

Propagation of Interference by Inversion Layers in the Troposphere:—Under normal tropospheric conditions there is a steady decrease in the refractive index of the atmosphere with height, *i.e.*, an absence of discontinuity in its lapse rate, and under these conditions a v.h.f. radio wave follows a smoothly curving trajectory to the radio horizon, and, by diffraction, penetrates to a distance beyond it. The range of a v.h.f. station is thus limited and, in fact, "normal" propagation conditions exist.

Under certain meteorological conditions, however, reflection of the radio energy can take place from points in the troposphere up to about 10,000 ft above the surface, and this energy can reach the ground at points far beyond the station's normal range. It is then that abnormal tropospheric conditions (from a radio propagation point of view) are said to exist, and this condition constitutes a second possible medium for Continental interference.

It is not our purpose here to go into the nature of the phenomena which cause this type of propagation, but rather to consider data indicative of the frequency of its occurrence and of its potentialities as a medium for the propagation of interference. However, according to Saxton[3], the propagation is liable to occur when an inversion layer lies in the troposphere, somewhere between the surface and the height mentioned above, (mostly between 1,600 and 6,500 ft) from which refraction of the radio energy occurs. In these regions the refractive index decreases with height at a rate considerably greater than normal, due to the lapse rate of temperature with height being less than normal, or even undergoes an inversion, and there may be also a sudden change in the humidity lapse rate. Such conditions are most likely to be brought about by a subsidence inversion (a condition occurring mainly in anticyclones) or by the passage of a cold front. It should perhaps be mentioned that the above is only one of the tropospheric mechanisms by which v.h.f. radio waves can be propagated over abnormally long distances, but it is, nevertheless, the one which is responsible for most of the abnormal propagation we are discussing.

Since abnormal tropospheric propagation is a meteorological phenomenon it might be thought that the weather records would yield the best information as to its occurrence. But the direct

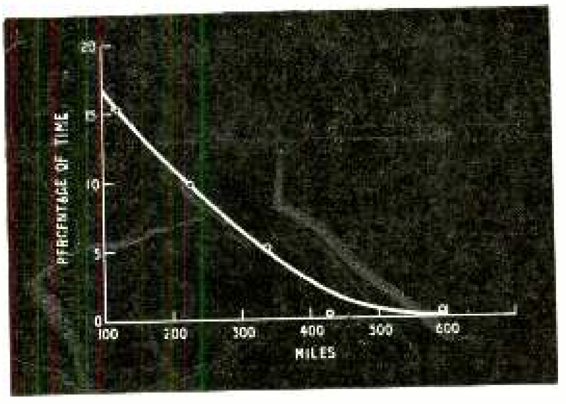


Fig. 5. Percentage of total time when reception by abnormal tropospheric propagation was obtained on 93·45 Mc/s over different distances during Jan.-June 1955.

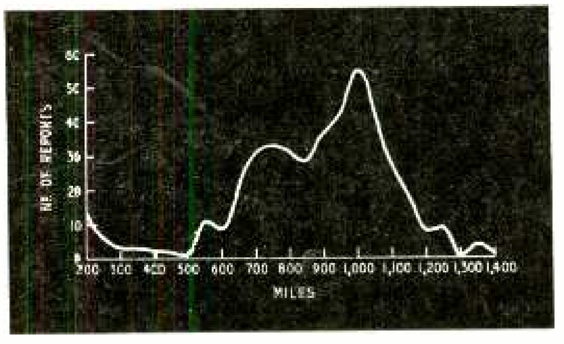


Fig. 6. Relative frequency of reception by abnormal propagation in the band 54-88 Mc/s as indicated by 440 reports of television reception in U.S.A.

application of weather data to radio propagation is difficult. Experience of abnormal tropospheric propagation would seem to indicate that it almost always occurs, in fact, during anticyclonic conditions. But it is difficult to determine the exact extent and intensity of the anticyclonic system that might give rise to such propagation. Again, not all anticyclones (which can occur at all seasons of the year) contain the conditions conducive to abnormal propagation, and an anticyclone which does contain them does not do so throughout its life, but only at certain times. Finally, the calculation of the refractive index from the data obtained from radiosonde ascents, for many different heights and on a long-term basis, is an excessively laborious business, and so we turn to other than weather data for our information.

The best information to be obtained on the occurrence of abnormal tropospheric propagation is, in fact, that resulting from the many experimental results in v.h.f. propagation obtained in this country and abroad, including some published by Saxton[4].

From these we learn that though, in the case of normal propagation through the troposphere, the field strength at a distance beyond the radio horizon decreases with increasing frequency, yet, so far as the field due to reflection from inversion layers in the troposphere is concerned, there is little variation over the frequency range we are considering here (41-100 Mc/s). We may therefore consider the interfering signal strength not to vary with frequency.

As to the seasonal variation in the occurrence of abnormal tropospheric propagation there seems no doubt, from the results of experiments conducted over many months, that though cases of high field strength due to this may occur during any month of the year, there is a period of little activity in the winter (with perhaps a minimum in February) and then an increase towards a period of maximum occurrence in June/July. This is followed by a period of fairly high occurrence, decreasing towards a low occurrence rate in November. This apparent seasonal variation may, however, be merely due to a variation in the relative prevalence of anticyclones and low pressure systems during the various months, the latter not being favourable to abnormal tropospheric propagation. It is of interest to note that the seasonal variation, as outlined above, is very similar to that in the incidence of intense sporadic E.

From the experimental results it seems to be fairly clear that there is no diurnal variation in abnormal tropospheric propagation conditions over the sea, but a definite one over land, a circumstance brought about, no doubt, by the different heating and cooling rates for land and sea, and thus for their convective effects upon the air lying above them. Over the land the high fields due to abnormal propagation have a minimum occurrence between about 1400 and 1600 hrs (l.t.), rising throughout the evening and night to reach a maximum between about 0400 and 0700 hrs and then falling towards the afternoon minimum. It appears that the inversion layers build up during the night, but are removed during the day.

The percentage of the total time during which signals are likely to be propagated by abnormal tropospheric effects is closely related to the distance, and at distances near that at which the field due to normal propagation would have negligible interfering importance it may be in excess of 10 per cent of the total time. Under abnormal propagation conditions the field strength of a station at 220 miles may be equal to that at 90 miles under normal conditions, and in order to provide the same protection against interference which would exist under normal propagation conditions if stations were spaced by about 200 miles, the spacing would have to be increased to the order of 400 miles under conditions of abnormal tropospheric propagation. Fig. 5 may be of some interest in this connection. It shows, for the period Jan.-June, 1955, the percentages of the total recorded time when reception by abnormal tropospheric propagation was obtained at five stations on the east coast, lying at various distances from a 93.45-Mc/s transmitter located in Holland, during the course of an experiment conducted by the B.B.C. Research Department. Although the values shown are for a period of only six months, and although two of the points lie somewhat off the smooth curve, the curve does represent fairly well the average conditions to be expected, and in particular that the distance at which it falls appreciably lower than 1 per cent, namely at about 500 miles, represents the limiting distance in these latitudes for the propagation by abnormal tropospheric propagation of troublesome interference.

We may now summarize the main effects of tropospheric inversion layers on the propagation of v.h.f. signals over abnormal distances, so that we may compare them with those of sporadic E. We should expect them to be effective for an appreciable proportion of the total time mainly during the summer months, the period of maximum occurrence probably being June to September, with occasional occurrences during any month of the year. It should be of less frequent occurrence over the land during the day than during the evening and night, though not over the sea. They should be effective for the greatest proportion of the total time at distances near the normal range of the transmitter, decreasing with distance to become effective during only a negligible proportion of the total time at about 500 miles. They should be almost equally effective over the whole range of frequencies we are considering, *i.e.*, 41-100 Mc/s.

Conclusion:—Referring to the map of Fig. 1 we may conclude that the curved line at 500 miles represents, very roughly, the outer boundary of the Continental area from which we should expect occasional v.h.f. interference in this country by way of inversion layers in the troposphere, and the inner boundary of that by way of sporadic E.

A study made by Smith[5] in the United States is of interest in confirming this view. He examined a number of reports of the reception of television stations over distances greater than 200 miles and the curve of Fig. 6 may be taken as representing his findings for 440 reports of reception of stations in the frequency range 54-88 Mc/s, and which shows their distribution with distance out to 1,400 miles. Smith ascribes the reception reported over distances of 200-500 miles as being due to abnormal tropospheric propagation, and that over distances greater than 500 miles as being propagated by sporadic E. As seen the frequency of reception decreased over the distance 200 to 500 miles, and then, when sporadic E propagation became effective, it increased again. The most frequent reception by sporadic E occurs at 1,000 miles rather than at greater distances, because, according to this author's explanation, the transmitting and receiving aerials radiate or receive little energy at the low angles corresponding to the greater distances for one-hop transmission.

In this country, however, it would appear that reception of v.h.f. signals over abnormally great distances occurs far more frequently by way of tropospheric inversion layers than by way of sporadic E. During the months May-July, 1955 (a period of exceptionally favourable conditions for such propagation) reception of Continental stations in the frequency range we are considering was observed at the B.B.C. Tatsfield receiving station on 46 days. Classifying these days of reception it would appear that the propagation of the signals occurred as follows:—

By abnormal tropospheric propagation alone	69.6%
By sporadic E alone	15.2%
By both mechanisms together	15.2%

This predominance of abnormal tropospheric propagation over that by sporadic E may, however, be due to the fact that many of the receptions were of signals in the 87.5-100-Mc/s band, where the intense sporadic E would, in any case, be unlikely to sustain propagation. It is not implied, either, that all these receptions were of signals of sufficient strength to have been capable of causing interference.

Summing up, we may say that, mainly during the summer months, a certain amount of Continental interference is to be expected on the v.h.f. services in this country, though for a relatively small proportion of the total time, and generally only noticeable in the fringe of the service areas. Some of it is due to propagation by intense sporadic E, and, since the field strength and occurrence rate are greatest at distances near 1,000 miles it would appear impossible to take this into account in the spacing of co-channel stations. To do so would result in a completely wasteful frequency usage situation. It has, however, an occurrence rate which decreases rapidly with increasing frequency and, as shown in Fig. 4, is not likely to approach 10% even on the lower frequencies in Band I. A value near 5% may be reached on these frequencies during summer daytime only which, of course, represents an annoyance factor during this period. So far as tropospheric propagation is concerned the spacing of co-channel stations throughout Europe is already such that, generally speaking and neglecting a few cases of expediency, their signals are protected for 90% of the time, which allows for a certain amount of abnormal propagation. We have discarded the last 1% as being of little importance, so we are, in fact, concerned with the effects of interference occurring between 1% and 10% of the time. This, as we have seen, is concentrated mainly over the months June to September. So far as the v.h.f. sound broadcasting services in Band II are concerned it is, for the reasons given earlier, unlikely to be serious for any important proportion of the time. In Band I, however, it remains an annoyance factor, though the question of what, in this case, constitutes tolerability is a subjective one, and so cannot be decided here. Taking the year through, however, it would seem that one cannot regard the present situation as giving rise to intolerable reception conditions.

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STUDENT EXCHANGE

SINCE its foundation in 1948 the International Association for the Exchange of Students for Technical Experience has made it possible for over 22,000 students from 21 countries to obtain technical experience abroad during the summer vacations. Last summer 5,153 went abroad, an increase of 886 on 1954's figure. By far the largest number of students were sent by Germany (1,184) of whom 362 went to Sweden and 112 came to this country. Of the 644 sent from the U.K. more went to Sweden than to any other country. The countries receiving the largest numbers of students were Germany (1,043), Sweden (1,037) and Great Britain (728).

Although there is no direct reference in the latest report to the number of students who were engaged in electronics and radio, it is obvious from the lists of companies and organizations who participated in the scheme, that light current engineering was well represented.

The work of the I.A.E.S.T.E. is co-ordinated by J. Newby, at Imperial College, South Kensington, London, S.W.7.

NYQUIST'S DIAGRAM

Where and Why it Comes into Negative Feedback

By "CATHODE RAY"

ALTHOUGH the archives show that on quite a number of occasions my theme has been negative feedback, I somehow seem to have got through them all without ever once uttering the magic name "Nyquist." To pukka students of the subject such an omission must seem quite scandalous (typical, in fact, of "Cathode Ray"), but having early examined Nyquist's celebrated treatise* I became possessed of a firm conviction that the less of it was transferred to the pages of *Wireless World* the better. However, even the wisest owl changes colour with the arrival of spring (as Kai Lung might have said), and all this enthusiasm for hi-fi—to say nothing of servo mechanisms—is bound to bring more and more people face to face with Nyquist. Unprepared encounters are apt to prove embarrassing, so I now consider it a good thing to demonstrate to the veriest beginners that despite the esoteric terms of its original presentation the Nyquist idea is a very simple and helpful one.

Fig. 1(a), then, shows an amplifier as a box with input and output terminals; its voltage amplification or gain is customarily denoted by A, which means that for every signal volt applied to the input terminals we get A volts at the output terminals. Now if we take some fraction B of the output voltage and connect it in series with the input terminals, as at (b), the gain of the amplifier itself, reckoned between the same two pairs of terminals as in (a), is still A. But for practical purposes the feedback connection is really part of the amplifier, so the input terminals are now those marked XX. The gain that is effective between them and the output terminals is distinguished as A′. If we try to calculate A′ in terms of A and B by supposing that the signal source delivers 1 volt to the new input terminals, we find it rather awkward. It is much easier to work from the known fact that 1 volt at the *original* input terminals yields A volts at the output. The voltage fed back is then AB volts. If we look again carefully at Fig. 1(b) we will see that from the point of view of the signal source the fed-back voltage is connected upside down, and so to be strictly correct the voltage between the terminals XX (which is the voltage the source has to supply) is 1 − AB.† If, as we are supposing, the voltage fed back is negative, this is expressed by making AB negative, which cancels out the minus sign in 1 − AB and makes 1 − AB greater than 1.

Seeing that it is negative feedback we are talking about, surely it would be less confusing if we were to combine the two minus signs at the start, once for all, and call it 1 + AB? As a matter of fact, when dealing with the thing in the February 1946 issue that is just what I did do. But later (May 1949) we went on to take account of the fact that however deter-

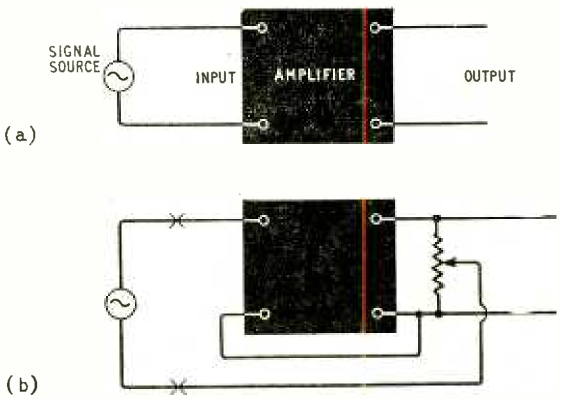


Fig. 1. (a) represents an amplifier without feedback, and (b) the same amplifier with feedback, part of the output voltage having been tapped off and returned to the input. For the feedback to be negative with this particular circuit, the output must be in opposite phase to the input.

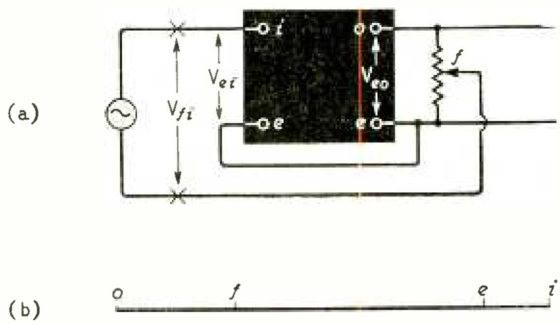


Fig. 2. (a) is a repetition of Fig 1 (b) with terminals labelled and voltages marked correspondingly. (b) is a vector diagram of these voltages, assuming the feedback is perfectly negative.

mined one's intentions to make feedback exclusively negative it nevertheless at some frequencies inevitably becomes positive. This is far from being an academic refinement of thought; it forces itself on the attention of everyone who applies negative feedback to practical multi-stage amplifiers. So in the end it may pay to be strictly correct about our signs and use negative values of AB to denote negative feedback. That being so, the input voltage (for each volt at the original input terminals) must be 1 − AB. The corresponding output voltage being A, we hav

$$A' = \frac{\text{output voltage}}{\text{input voltage}} = \frac{A}{1 - AB}$$

This may well be called the Ohm's law of feedback, in that it must be familiar to anyone who knows anything at all of the subject. But there is at

* "Regeneration Theory," *Bell System Technical Journal*, 1932, p. 126. Incidentally, I wonder how many who glibly refer to the "Nyquist criterion" have ever digested this paper!

† If in point of fact we *don't* see this, it just shows how necessary it will be to invoke the aid of Nyquist.

least the possibility that some of you (a) are completely new to negative feedback, or (b) have been muddled by what I have just said about minuses, or (c) though aware of the formula just quoted lack a really clear picture of what it means. It is precisely to supply such a picture, and to keep one right about signs, that Nyquist's celebrated diagram is a help.

It is based on the familiar practice of representing alternating voltages (or currents) by straight lines at appropriate angles; vectors, in fact. The advantages of this procedure were explained in "Vectors Again" (July, 1954). In Fig. 2 the signal voltage V_{ei} applied between the terminals now labelled *ei* is represented by the length of the line *ei*. The phase of the voltage is represented by the line's angle, and as this is the first voltage to be considered we can make it what we like; the custom is to point the line at "3 o'clock," which is the conventional zero angle.

Vector Directions

The vector representing the output voltage, V_{eo} must obviously be A times as long as *ei*. But what about its direction? Well, with the circuit shown, in order to make the fed-back voltage V_{ef} negative with respect to V_{ei}, V_{eo} must also be negative, which is represented by drawing *eo* in the opposite direction to *ei*.

The fraction of V_{eo} fed back—in other words V_{ef}/V_{eo}—is what we call B. For example, if B were $\frac{2}{3}$, *f* would have to be drawn two-thirds of the way along *eo* from *e*, to represent the fact that the feedback terminal *f* in the circuit is tapped two-thirds the way up the potential divider across the output terminals *eo*. (In practice, A is usually so large that *o* in a vector diagram drawn to scale would be right off the paper; however, for most purposes *o* is not needed, and B is usually a small enough fraction to bring *f* within reasonable bounds).

Because the signal source is connected between terminals *f* and *i*, the voltage it has to supply is V_{fi}, represented on the vector diagram by the line *fi*. This diagram having been drawn with the fed-back voltage vector *ef* in the *opposite* direction to *ei*, to represent *negative* feedback, it shows without the need for any further effort of the mind that the signal input voltage is now greater than it was in Fig. 1(a) for the same output voltage. The distance *eo* represents to scale this constant output voltage; *ei* represents the required input voltage without feedback, so that the gain without feedback (a) is represented by *eo/ei*. Distance *fi* represents the required input voltage with negative feedback, and is clearly equal to the original input voltage augmented by the fed-back voltage. The overall gain now (A′) is represented by *eo/fi*, which is less than A—usually much less.

I need hardly say that reducing the gain of an amplifier is not the main purpose of negative feedback; on the contrary, it is the price that has to be paid for the advantages—reduced distortion, etc.—which have so often been explained. But for design purposes it is most important to know how much the gain is reduced by feedback—the more so because it happens that distortion is usually reduced in the same ratio. The vector diagram enables this important ratio to be visualized. For the gain is inversely proportional to the input required for a given output. So A′/A appears on the diagram as *ei/fi*.

As I said, once the common-sense step has been taken of drawing *ef* in the *opposite* direction to *e* for *negative* feedback, the diagram relieves one of al further thought on the subject of plus or minus signs, and there is no possibility of confusion. But to satisfy outselves that there is indeed a perfectly sound and logical basis for this, let us compare it in detail with the formula we have already arrived at, namely $A' = A/(1-AB)$.

In the voltage notation of Fig. 2 (a), A′ is V_{eo}/V_{fi}. In the same way, $A = V_{eo}/V_{ei}$. So $V_{eo} = AV_{ei}$. Substituting this in the equation for A′, we get $A' = AV_{ei}/V_{fi}$. Now $V_{fi} = V_{fe} + V_{ei}$, and as $V_{fe} = -V_{ef}$ (note that point particularly) $V_{fi} = V_{ei} - V_{ef}$. But V_{ef} is B times V_{eo}, and therefore AB times V_{ei}, so we can put all these things together to give $A' = AV_{ei}/(V_{ei} - ABV_{ei})$; and dividing above and below by V_{ei} (which is the same thing as making $V_{ei} = 1$) we get $A' = A/(1 - AB)$ as before.

The last part of the process is represented in the diagram by choosing the scale so that $ei = 1$. This is very convenient, because to the same scale $eo = A$ and $ef = AB$. Note again that *fe* must therefore be $-AB$, so that $f_i = 1 - AB$. Putting the feedback equation into the form $A'/A = 1/(1 - AB)$, the diagram shows the A′/A—the ratio of gain with feedback to gain without—is represented by *ei/fi*, as we have already seen.

I have now gone through the same chain of argument in at least three different ways, not just to fill up the space, or because I imagine *Wireless World* readers to have a phenomenally low IQ, but because it is worth taking time, even if one thinks one understands negative feedback, making sure that its basic principle is firmly and clearly in the mind, and that any confusion of thought between 1 + AB and 1 − AB has been removed.

With the particular feedback circuit shown in Fig. 2, B is obviously positive, because V_{ef} is just the same as V_{eo} only smaller. So to make AB negative (for negative feedback) A must be negative, which means that the output voltage must be opposite to the input—as shown in the vector diagram. This is automatically achieved by using one ordinary stage of amplification—or any odd number, but three would be the only practical alternative to one. With two stages, A would be positive; so B would have to be made negative by using a phase-reversing transformer or a different input circuit.

Suppose however our Fig. 1 amplifier had two stages, so that A and B were both positive; or a single stage with a reversing transformer, so that A and B were both negative. In either case it would make AB positive, which is represented by drawing *ef* in phase with *ei* as in Fig. 3. Because this feedback

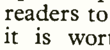


Fig. 3. This vector diagram for Fig. 2 (a) shows perfectly positive feedback.

is positive, we would be wise to apply it with caution, making *ef* at first very small—certainly less than *ei*. The effect, of course, would be to make *fi* smaller; in other words, to reduce the input from the signal source needed to yield a given output. So A′ would be greater than A. The same conclusion results from using the formula, for making AB positive makes $1-AB$ less than 1.

If we gradually increase AB until it is equal to 1, so that *f* on the diagram coincides with *i*, then $1-AB = 0$, and $fi = 0$, and nothing at all is required from the signal source in order to maintain the same

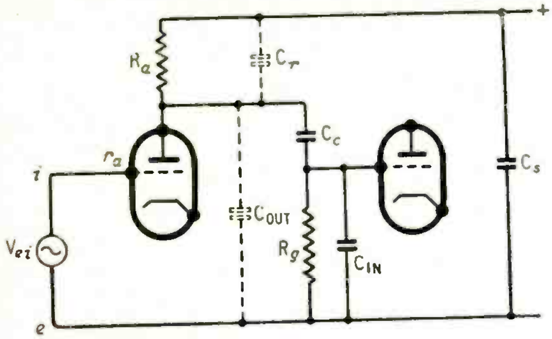


Fig. 4. Circuit diagram of a single resistance-coupled stage of amplification, with stray capacitances shown dotted.

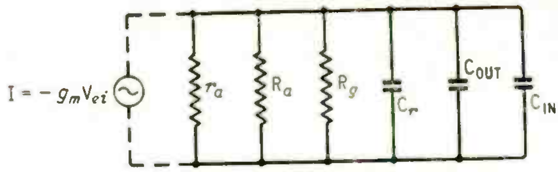


Fig. 5. At frequencies high enough for C_c and C_s in Fig. 4 to offer negligible impedance, all the components are effectively in parallel with one another and with a current generator equivalent to the valve.

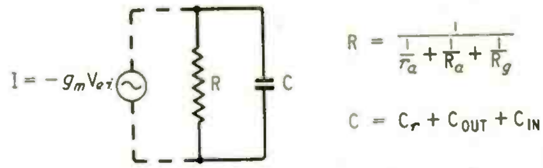


Fig. 6. The separate resistances and capacitances in Fig. 5 can be replaced by R and C as shown here.

output as before. In other words, the amplifier is self-oscillating. That is all right if an oscillator is what we want; but if not, not.

The inevitable curious reader will want to know what happens if he makes AB greater than 1. That is (as he probably meant it to be) rather a tricky question; hence the serious outbreak of mathematics in Nyquist's original paper. But in the circumstances we are considering it would mean that the output voltage would continuously increase, probably at an extremely fast rate. Obviously that could not go on for long; the valves in the amplifier would quickly overload and pull A down until AB was equal to 1; then (apart from special conditions that might cause squegging) the thing would go on oscillating at a higher than original level of output.

Difficult Phase Relationships

Now although to my simple mind the vector diagram would justify itself even if confined to the situations pictured in Figs. 2(b) and 3, because of the help it gives in visualizing the paramount significance of 1–AB, the real high-power brains would describe these contemptuously as "trivial" cases. They would point out quite rightly that all the calculations can be performed by simple arithmetic, using the formula. It is when the phase relationships are other than simple + or – that the diagram really comes into its own. And as in practice these other phase relationships are bound to exist, in spite of all we can do to the contrary, we have, as it were, seen nothing yet.

Take high-quality audio amplifiers, for instance. To rank as high-quality they have to use considerable negative feedback. They are designed to be as independent as possible of frequency, so as to handle all frequencies equally, at least within the audible range. What happens to them outside the audible range might seem to be nobody's business. But not where feedback, intentional or otherwise, occurs, as was soon discovered when negative feedback began to be used in a big way.

There are bound to be stray capacitances across coupling impedances; for example, those denoted in valve-makers' data by "C_{in}" and "C_{out}." These reduce the effective coupling impedances at the higher frequncies, so that A at those frequencies is less. By minimizing stray capacitances and using moderate-valued resistors as coupling impedances—and employing negative feedback—any reasonable amplifier designer can ensure that the amplification remains almost perfectly constant up to the highest audible frequency. But somewhere higher still the stray capacitances inevitably take charge and cause A to plunge.

Again, unless direct coupling is used, there is a similar cut-off below the lowest audible frequency, owing to the series impedance of the coupling capacitors. And the output transformer steepens the cut-off at both low and high frequency ends.

If the only effect of these things on A were to cause it to diminish, there would be nothing to worry about, for the reduced feedback resulting therefrom would release more of the input signal for amplifier duty, and so keep A′ nearly up to standard. But before stray capacitances, etc., have any appreciable effect on the *amount* of A, they have begun to shift its *phase*. To cope with phases other than the 0° and 180° we have had hitherto, one has to interpret A and B in the basic formula as complex quantities‡—things with *j* in them, which cannot just be added or subtracted in a simple straightforward way. While one should certainly acquire the *j* technique, it is often easier to solve problems graphically by means of the vector diagram. If the diagram was a help in visualizing the simple Fig. 2 and 3 cases even when they were actually worked out by arithmetic, much more is it a help in cases worked out by complex algebra.

Fig. 4 shows for example the relevant parts of one resistance-coupled stage, in which stray capacitances are shown dotted. At high frequencies the impedance of C_c is negligible and can be regarded as a short-circuit, bringing C_{out} and r_a (the valve's anode resistance) in parallel with R_g. C_s is the smoothing capacitance, and it, too, is effectively a short-circuit, bringing R_a and Cr in parallel with the others. So in the equivalent circuit (Fig. 5) all the resistances and capacitances are in parallel, and can be lumped together as a simple CR circuit (Fig. 6). To represent the valve in a parallel system, it is more convenient to adopt the equivalent current generator§ than the familiar voltage generator. The amount of current it yields per volt of V_{ei} is what is well-known as the valve's mutual conduc-

‡ "The Complex Number," February 1953, p. 79.
§ "That Other Valve Equivalent," April 1951, p. 152.

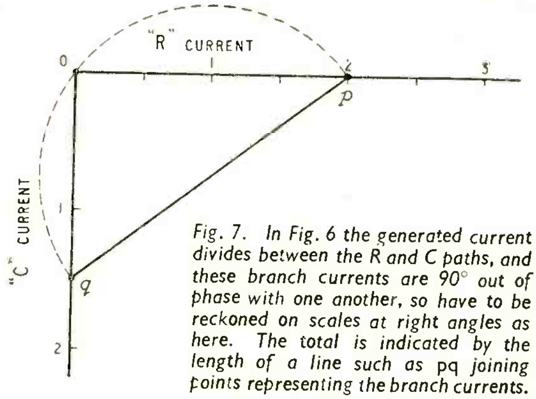


Fig. 7. In Fig. 6 the generated current divides between the R and C paths, and these branch currents are 90° out of phase with one another, so have to be reckoned on scales at right angles as here. The total is indicated by the length of a line such as pq joining points representing the branch currents.

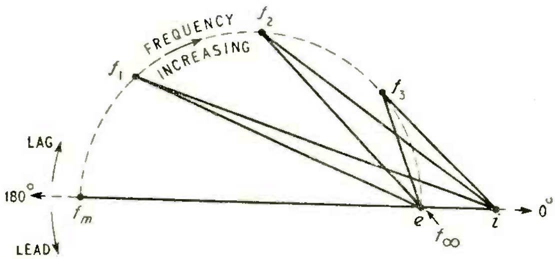


Fig. 8. If the feedback vector diagram for a single-stage amplifier with a single CR combination is plotted for various frequencies, the track traced out by the point f representing the potential of terminal f forms a semicircle as shown here dotted. This semicircle is a simple example of half a Nyquist diagram.

tance, g_m, which we assume to be constant. The output voltage it causes is calculated by multiplying this current by the impedance of R and C in parallel—or alternatively by multiplying the current through R only by R. Over most if not all of the a.f. band, C should be negligible, making the output voltage per volt of V_{ei}, which is A, equal to $-g_m$R. The minus sign indicates that the output is opposite in phase to the input, both being looked at from the same point—say the cathode. So if we draw a vector diagram to represent this situation, with V_{ei} kept constant at 1 unit (whether 1 volt or 1 millivolt or some other unit, we don't have to know) and zero phase angle, we choose the scale so that *ei* is 1 unit long, and then know where to put *o*, because *eo* represents A, which at these frequencies is g_mR units to the left. And if we have decided on how much to feed back, we can plot *f* that fraction (B) of the distance along *eo*. The vector *ef* represents AB, as before.

"C" and "R" Currents

At frequencies high enough for C to pass appreciable current, such current must be deducted from the constant current g_m to show how much is left for R. But because the current through C is quarter of a cycle (90°) ahead of that through R, it cannot be subtracted from g_m in a simple arithmetical manner. Scales of "C" current and "R" current have to be drawn at right angles to one another, as in Fig. 7. For example, if the current through R is 2mA and that through C is 1½mA, the total is indicated by the length of the line joining *p* to *q*. It happens to be 2½mA. The lines from *p* to *o* and from *o* to *q* can be regarded respectively as current vectors, because not only are their lengths proportional to the currents but *oq* is 90° ahead of *po*, according to the standard convention that a.c. vectors rotate anticlockwise.

If we wanted to find all the possible values of currents through C and A, given that the total was constant at 2½mA, we could stick a couple of pins 2½ scale units apart and hold a card bearing the right-angle scales against them, at the same time turning it around. The track—or locus, as it is officially termed—traced out by the corner *o* turns out to be a semicircle, as shown dotted in Fig. 7, where *p* and *q* mark the two pins. This result could have been foreseen if we had remembered the proposition in geometry about the angle between the lines joining any point on a circle to the ends of a diameter being always a right angle. Anyway, it is very useful just now, because the voltage across a resistance is proportional to and in phase with the current through it. So *pq* can be regarded as representing the voltage across R at frequencies at which C can be neglected, and *po* the same voltage at some higher frequency. What goes for the whole voltage A also goes for its constant fraction AB. So *pq* in Fig. 7 can be identified with *ef* in Fig. 2(b). The effect of raising frequency, then, is seen to cause the point *f* to move around in a semicircle, finally ending at *e*, where it represents an infinitely high frequency, at which R is dead-shorted by the zero reactance of C.

This is illustrated in Fig. 8, where f_m marks the original diagram, for medium frequencies, and f_1, f_2 and f_3 represent successively higher frequencies, ending up with f_∞ for infinite frequency. If the position of *f* for very low frequencies were plotted, the effect of C_c in Fig. 4 would make it trace out a lower semicircle from f_m to f_0 coinciding with f_∞, completing a circle. This circle is the Nyquist diagram for this particular amplifier circuit. As we shall see later, a circle is only one of the shapes a Nyquist diagram can take.

In Fig. 8 *ef* represents a constant fraction of the output voltage, so the diagram helps one to visualize how the output changes in magnitude and phase with rising (or falling) frequency. At first, moving from f_m to f_1, the voltage diminishes only slightly, although the phase alters considerably. Beyond about f_2 it is the voltage that falls off rapidly and the phase comparatively slowly. This is how the output would vary, given a constant input voltage (represented by *ei*) *and no feedback*. The input *with* feedback is represented by *fi*, which varies, and we can see that the angle between the output and it is much less than without feedback (*ei*). At least, it is until the amplifier has nearly gone out of business, near f_∞.

Another thing the diagram shows clearly is that the more feedback is used the smaller the phase shift. To go to extremes, if, in comparison with the fed-back voltage *ef*, *ei* were negligibly small, the output and input voltage vectors would almost coincide. Still another thing is that the ratio of output to input (A′), represented by *ef*/B and *fi* respectively, changes far less than that of *ef*/B to *ei*.

A helpful technique is to take particular notice of the frequency at which the reactance of C is equal to the resistance R. Then both C and R pass equal currents, so f is equidistant from f_m and f_∞—f_2 looks about the right spot. The geometry of the diagram shows that without feedback the output voltage is $1/\sqrt{2}$—say 0.707—times what it was at f_m, and its phase is 45° behind. The frequency at which this occurs is often called the turning frequency, so we shall denote it by f_t. How do we find it? Since the reactance of C is $1/2\pi fC$, and at $f = f_t$ we have $1/2\pi f_t C = R$, $f_t = 1/2\pi CR$, and can be calculated if we know the circuit values. It is, let us remember, the frequency at which the output drops by just on 30%, which incidentally is 3dB—just about enough to be noticeable.

The amount that negative feedback reduces relative output loss and phase shift can be calculated by drawing a Nyquist diagram to scale. If you would like an example to work on, assume the valve has a g_m of 6mA/V, an r_a of 10kΩ, and a load resistance of 4kΩ shunted by 0.002μF. The problem is to find the turning frequency for the valve used as an ordinary earthed-cathode stage, and the actual loss and phase shift at that frequency when used as a cathode follower. Answer next month. And until next month, I am afraid, we shall also have to leave the more interesting uses of the Nyquist diagram in connection with multi-stage feedback.

Electronic Digital Computers

2.—*Control Circuits for Automatic Operation*

By A. A. ROBINSON,* M.A., Ph.D., A.M.I.E.E.

THE great speed of calculation attained by electronic computing circuits would be wasted if it were necessary to wait after each elementary step for a human operator to give instructions for the next one. There are two ways of avoiding this difficulty. In the first the sequence of operations is fixed by the circuits and connections. A computer depending on this form of control is a special-purpose computer, and has the disadvantage that it is restricted to solving a limited range of problems for which it was designed. In the second method, used in general-purpose computers, every operation the machine can do is given a code number; and, before starting to solve a problem, the numbers of the requisite operations (known as instructions) are put into the computer to be held in its storage circuits along with the numerical data.

The main purpose of this article is to explain how the stored instructions are selected in the right order and used to produce the necessary control signals, which are sent from the central control circuits to the remainder of the computer. First of all it is necesary to look at the method by which numbers are sent from one part of the computer to another. The signals giving the digits of a number can exist one after another on a single wire or in parallel on several wires. The first, or serial, system will be used principally in this article, and here the digit signals occur units first, then twos, and so on, so that calculations of the kind described last month can proceed from right to left.

Now suppose that ten wires have on them trains of narrow pulses as shown in Fig. 1, the pulses in each train being slightly later than those in the preceding train. Then if the pulses are given the numerical values 1, 2, 4, 8 and so on up to 512, whole numbers up to 1+2+4+8 . . . +512=1023 can be represented as pulse-trains as shown at *x*, which represents 1+4+8=13. In practice the pulses *p*0 to *p*9 are repeated cyclically and a new number can be transmitted during each repetition. Fig. 1 will be referred to throughout this article. The pulse-trains *p*0 to *p*9 will be called *p*-pulses; the time by which each *p*-pulse is delayed on the preceding one the pulse-period; and the time for a complete cycle of *p*-pulses a number-period. In most computers numbers greater than 1023 are used and this calls for a longer series of *p*-pulses. For example, twenty *p*-pulses allow for numbers up to more than a million.

There is one form of calculation, incidentally, not mentioned in last month's article, which follows

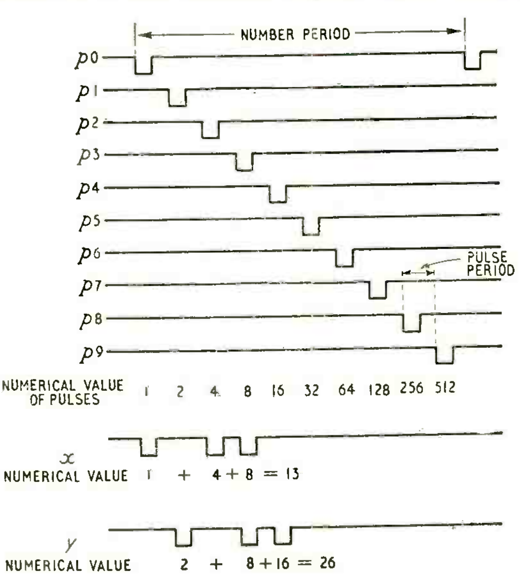


Fig. 1. Representation of numbers on the serial system from pulses occurring at different times. Pulse trains x and y are typical examples.

* Ferranti, Ltd.

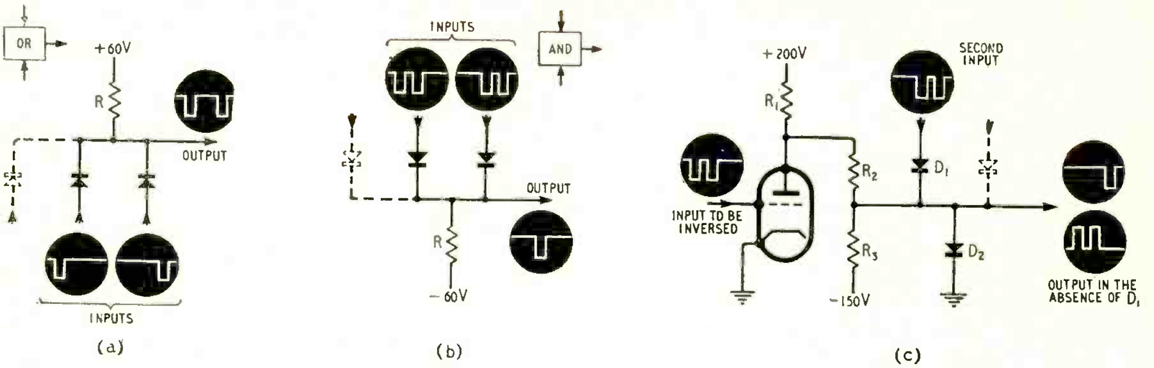


Fig. 2. Gate circuits for manipulating number signals: (a) an OR circuit, (b) an AND circuit, (c) an AND circuit with a phase inverter in one of the inputs. Functional diagrams for the gates are also shown.

immediately from the binary form of the numbers. The numerical value of each pulse in a number-signal is doubled if it is delayed to the next pulse-period. Thus, if a number-signal is passed through a delay-line with a delay of one pulse-period, the number represented is doubled.† This is illustrated by x and y in Fig. 1.

The next items to be considered are three of the simpler circuits used for handling number-signals. First, suppose that two number-signals are to be merged to produce an output with a pulse when either or both of the inputs has a pulse. This can be accomplished for negative pulses by the circuit of Fig. 2(a), consisting of a resistor and two diodes (shown as germanium crystal diodes in this article). Current flows in the diode connected to the input having the lowest potential, so that the output point assumes a potential slightly positive to the more negative of the inputs. (The slight difference of potential is due to the current flowing in the forward resistance of the crystal diode.) This circuit may have additional inputs connected through additional diodes, one of which is shown dotted in Fig. 2(a). In any case there will be an output pulse if there is a pulse at any input, while each input will be substantially unaffected by pulses at the other inputs, provided that the value of the resistor R is sufficiently high. Circuits performing this merging function will be referred to as "OR" circuits, as they give an output if there is a signal at one input *or* the other.

A second form of manipulation is performed by the circuit of Fig. 2(b). This is arranged so that the output point assumes a potential slightly below that of the more positive of the inputs. Here again there may be additional inputs, connected as shown by the dotted lines. There will be a pulse at the output only when a negative signal is present simultaneously at all the inputs. Circuits performing this function are known as gates or "AND" circuits, as they produce an output when there is a signal at one input *and* the other. (Examples were given also in last month's article.) Their uses include selecting pulses which occur simultaneously in two or more inputs, and allowing or preventing the passage of a pulse-train applied at one input under the control of a gating signal sent to the other.

A variation of the AND circuit, used where an output is required only when one of the inputs is negative and the other positive, is shown in Fig. 2(c). One of the inputs has its polarity reversed by a triode. The resistors R_1, R_2 and R_3 are chosen so that in the absence of D_1 the output is negative when the grid of the triode is at earth potential, and at earth potential when a negative signal is applied to the grid. D_2 prevents the output ever having a potential positive to earth. A negative output will be produced only if a negative input is applied to D_1 and not to the grid of the triode. In this circuit there may be spurious outputs at the beginning and end of the true outputs if the input pulses do not exactly coincide in time. These can be removed by applying pulses narrower than either of the input pulses to a third input (shown dotted in the figure).

† In many cases it would be necessary to follow the delay-line by a reshaping circuit to make good the attenuation and distortion. Here and in other places practical details which are not essential to the explanation are omitted in the interests of simplicity.

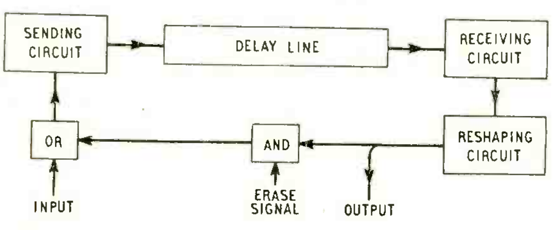


Fig. 3. Delay-line storage system. The AND circuit is a modified gate which closes when an "erase" signal is applied to it.

Storage Systems

The function of storage systems in the arithmetic circuits was explained in last month's article. Such devices are also required in the control circuits, and two types will now be described. First, delay-line storage. Suppose a number-signal of the form shown in Fig. 1 is passed through a delay-line with a delay period of one number-period. Then each pulse in the original signal will appear at the output at the corresponding time in the next number-period; and, if the output of the line is connected back to the input through a pulse reshaping circuit, the number-signal will continue to circulate indefinitely.

The delay-line itself may, for example, take the form of a nickel wire. Current pulses from the sending circuits flow in a coil surrounding one end of the wire. These produce pulses of tension by the magnetostriction effect, which travel at the speed of sound in the wire. A receiving coil near the other

(*Continued on page* 603)

end of the wire has a permanent magnet placed near it. Changes of permeability produced in the wire by pulses of tension change the magnetic flux linking the coil. The resulting induced e.m.fs are amplified and shaped to give the output signals.

Fig. 3 gives the general arrangement of a delay-line store. A modified AND circuit (Fig. 2(c)) prevents the output of the delay-line going back to the input when an "erase" signal is applied. If a new number-signal is then applied to the following OR circuit it will replace the original one in the line. Sometimes an adding circuit is used instead of the OR circuit. This does not affect the normal operation of the store; but, if a number-signal is applied to its input when there is no erase signal applied, the number stored will be added to the new number and the sum recorded in the line.

If it is required to store many numbers separate lines may be employed, or the line may be lengthened, when, say, 100 number-signals will follow one another in the line. In this case each number-signal will appear at the output once in 100 number-periods. In what follows, however, it will be assumed that there is a separate line for each stored number.

Another form of storage, described in last month's article, records digits by the states of bi-stable trigger-circuits. Ten such circuits will register the value of any number that can be shown in the form of Fig. 1. The outputs from the valves will then give the value of the number in a continuous parallel form. The outputs from the left-hand grids have been called direct outputs, and those from the right-hand grids inverted outputs.

In order to record a number-signal in a trigger-circuit store it is sent to the inputs of AND circuits connected through diodes to the left-hand grids of the trigger-circuits (see Fig. 4). Input pulses put each trigger-circuit into the "set" or "1" state only if they coincide with corresponding p-pulses applied to the other inputs of the AND circuits. For example, if there is a pulse in the number-signal at the time of $p1$, then trigger-circuit T_1 of Fig. 4 will be triggered into the "1" condition. To clear a stored number when it is no longer required, the trigger-circuits are "unset" into the "0" condition by a pulse applied through diodes to all the right-hand grids.

Having looked at these individual bits of circuitry, it is now possible to deal with the general organization of the control circuits. It will be assumed that the instructions and numerical data are in the form of ten-digit binary numbers stored singly in thirty-two delay-line stores (referred to collectively as the main store). In an actual computer more than thirty-two numbers and instructions will probably be used. This figure has been chosen as an illustration. Each of the delay-line stores is given a serial number, its "address," which forms part of the instruction whenever it is required to use that store.

Decoding the Instructions

In order to interpret the instructions they will be transferred to a trigger-circuit type store, shown at the right-hand side of Fig. 5. Suppose that five of the trigger-circuits, T_5 to T_9, store the address of the store referred to by the instruction; and five others, T_0 to T_4, store the serial number of the operation that is to be carried out using that store. The outputs of the trigger-circuits are sent through cathode-followers to two "decoding" circuits, one of which is shown in Fig. 6. The "function decoder" takes its input from the trigger-circuits T_0 to T_4, and the "address decoder" from the circuits T_5 to T_9. A decoder consists of thirty-two four-input AND circuits, each of which takes one input from

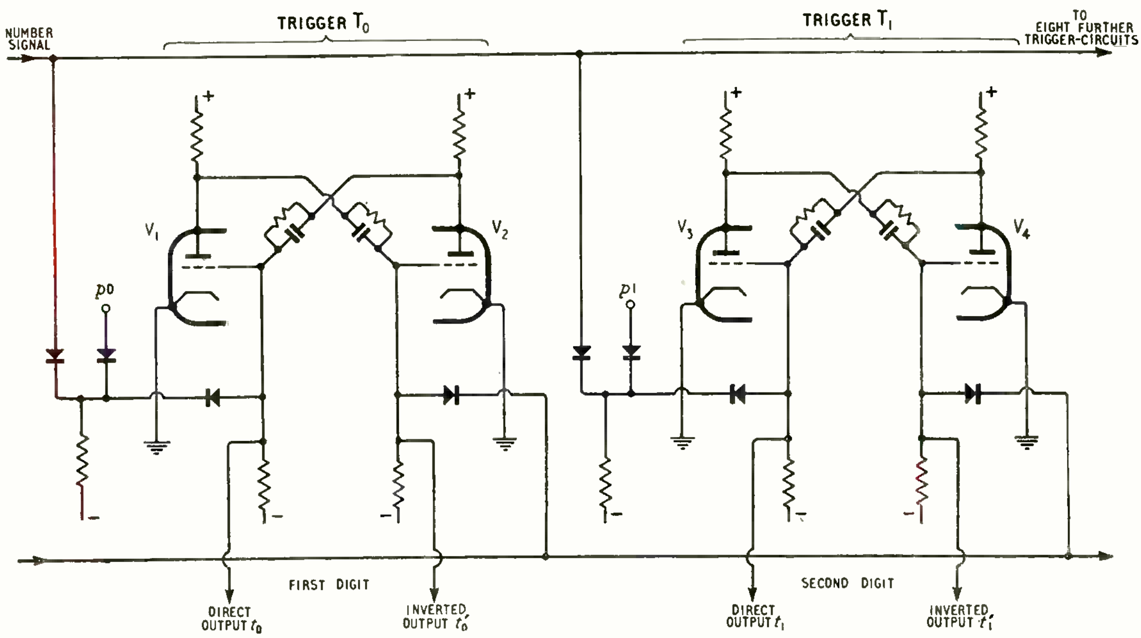


Fig. 4. Trigger-circuit store, showing how p-pulses and gates are used for distributing the pulses of the incoming number signal to the appropriate triggers. When a "1" is stored the "direct output" of a trigger is negative and the "indirect output" is at about earth potential. When a "0" is stored the reverse applies.

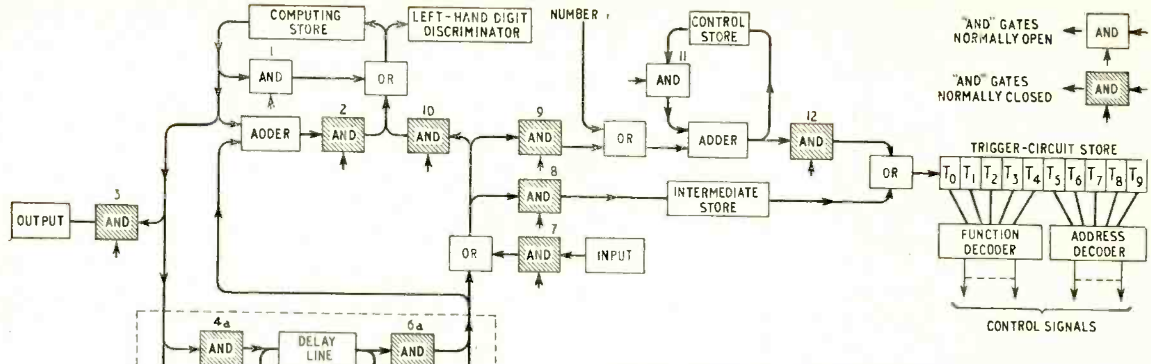
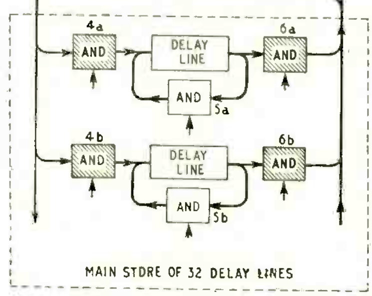



Fig. 5. Schematic of control system of a hypothetical computer, showing how instructions are conveyed from the main store to decoding circuits to produce control signals for switching purposes.

each trigger-circuit (either the direct or the inverted output, see Fig. 4). The AND circuits use between them every one of the thirty-two possible ways of doing this, as indicated in the figure, so that for every possible setting of the trigger-circuits the output of one of the AND circuits will go negative. These outputs are the control signals to the rest of the computer. In the function decoder they indicate the nature of the operation to be done and in the address decoder the store circuit referred to.

It now remains to be seen how the instructions can be taken from the store circuits and fed into the trigger-circuit store. To begin with, the list, or "programme," of instructions is stored in successive addresses of the main store in the order in which it will be required. The special control store shown in Fig. 5 holds the address of the instruction which has just been obeyed. Operations proceed in cycles of four number-periods:—

(1) During the first the number stored in the control store is sent to an adding circuit through gate 11 of Fig. 5. Here 1 is added, forming the address of the next instruction. The new address goes back to the control store ready for use in the next cycle, and also, via gate 12 to the trigger-circuit store.

(2) During the next number-period the output of the "address" half of the trigger-circuit store is decoded by the address decoder, and so allows the instruction stored at the specified address to pass through one of the gates 6 (*a*, *b* . . .etc.) and gate 8. At this stage the contents of the "function" half of the trigger-circuit store are ignored. It is desired to place the new instruction in the trigger-circuit store; but, as this is in use for the selection of the instruction, it is sent to an intermediate store.

(3) During the third number-period of the cycle the instruction goes from the intermediate store to the trigger-circuit store.

(4) During the fourth number-period the operation called for by the instruction takes place under the control of the address and function decoder outputs.

The cycle is then repeated until all the required operations have been performed. Finally a special "stop instruction" is set up on the trigger-circuit store, and this causes the control cycle to be suspended.

In addition to the control system Fig. 5 shows simple computing arrangements. To simplify matters the only calculation allowed for is addition. The "computing store" shown in the figure is a delay-line store which normally circulates its contents

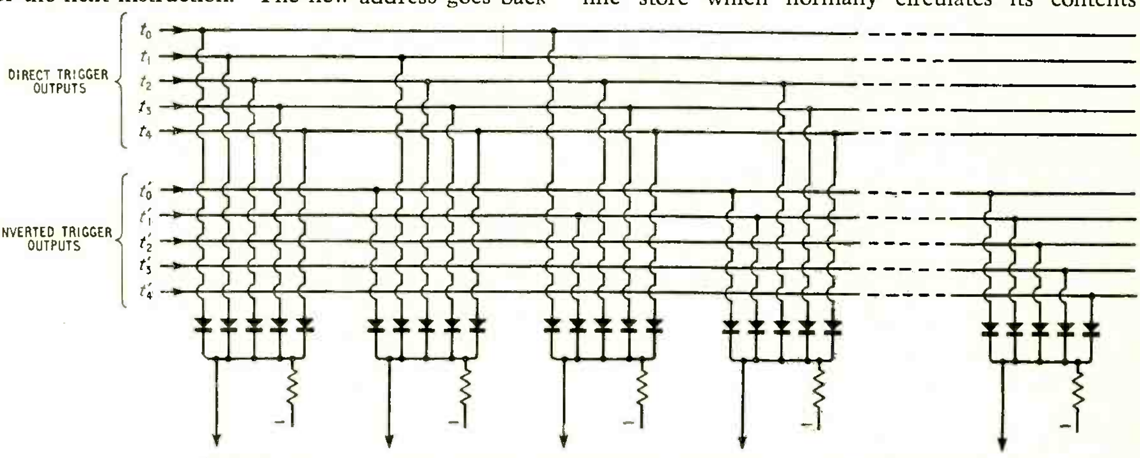


Fig. 6. Decoding circuit giving 32 control signals from different combinations of the outputs of 5 trigger-circuit stores.

through gate 1. During phase (4) of the control cycle the function decoder produces one of the following control signals:

(a) Gate 1 closed, 10 open and one of 6 open (according to the signal sent from the address decoder). The number at the selected main store address is sent to the computing store.

(b) Gate 1 closed, 2 open and one of 6 open. The number in the computing store is added to the number at the selected address and the sum is put into the computing store.

(c) Gate 1 closed, 7 and 10 open. A number from the input mechanism is put into the computing store.

(d) One of gates 4 open and the corresponding gate 5 closed. The number in the computing store is put into the selected address of the main store.

(e) Gate 3 open. The number in the computing store goes to the output mechanism.

(f) Gate 9 open, 11 closed and one of 6 open. The number at the selected address of the main store is sent to the control store, so that the computer skips instructions forwards or backwards in the programme.

(g) This is the same as (f) but the operation takes place only if the left-hand digit of the number in the computing store is 1.

(h) Stop the control cycle.

Operation (g) is used in connection with a modified system of binary numbers where the left-hand digit gives the sign. It enables the sequence of operations to be modified according to results obtained during a computation. This facility, which is invaluable in the construction of programmes, is sometimes referred to as "decision." It should be noted, however, that the decision about the course to be taken if the number is (a) positive or (b) negative is in fact made by the compiler of the programme.

On the question of speed of operation, electronic digital computers differ considerably. Pulse-periods down to one microsecond are fairly common among machines working on the serial principle. In the Ferranti Mk. I computer the pulse-period is ten microseconds, and the standard length of the number is forty binary digits, which are handled in two halves in separate 240-microsecond number-periods. Each of these number-periods consists of twenty ten-microsecond pulse-periods and a forty microsecond gap. The instructions are twenty binary digits long. The time for addition is 1.2 milliseconds, including the time for control operations. Multiplication is performed in 3.36 milliseconds.

As an example of the more complicated type of problem, the machine takes about five hours to solve 80 simultaneous equations. It should be noted that the labour in solving simultaneous equations increases as the cube of the number of equations; several months would be required to solve 80 simultaneous equations by ordinary desk methods.

In this article it has been necessary to ignore many control facilities which would be included in a practical computer, such as the transference of numbers to and from a large "backing-up" store (for example, a magnetic drum) and the handling of numbers of twice the normal length in the computing store. The following books, however, will interest those who wish to pursue the subject further:

A. D. and K. H. V. Booth. "Automatic Digital Computers," Butterworth, London, 1953.

B. V. Bowden (E.). "Faster Than Thought," Pitman, London, 1953.

R. C. Orford. "Progress in Electronic Digital Computers," *Penguin Science News*, 30, pp. 69 to 88.

News from the Clubs

Birmingham.—A lecture on "Wires and cables associated with telecommunication equipment" will be given to members of the Slade Radio Society by R. Blackburn and F. G. Taylor, of B.I. Callender's Cables, on December 9th at 7.45 at the Church House, High Street, Erdington. On the fourth Friday in each month at 8.0 a course of instruction is given for members intending to sit for the Radio Amateurs' Examination. Sec.: C. N. Smart, 110 Woolmore Road, Erdington, Birmingham, 23.

Birmingham.—The success of a meeting recently held in Birmingham has prompted the formation of a group of the British Amateur Television Club in the city. Details of membership and meetings are obtainable from G. Flanner, 194 Aston Brook Street, Birmingham, 6.

Cleckheaton.—Dr. G. N. Patchett will give a lecture on television cameras at the meeting of the Spen Valley and District Radio and Television Society on December 14th at 7.30 at the Bradford Technical College. Sec.: N. Pride, 100 Raikes Lane, Birstall, nr. Leeds.

Edinburgh.—At the meeting of the Lothians Radio Society on December 1st, Dr. A. S. Brown will deal with the radio control of models. On December 15th A. C. Grainger (GM3BQO) will give the second of his series of lectures on building a transmitter. Meetings are held at 7.30 at 25 Charlotte Square, Edinburgh. Sec.: J. Good (GM3EWL), 24 Mansionhouse Road, Edinburgh, 9.

Southend.—A member of the staff of Mullard's will speak on cathode-ray tubes at the meeting of the Southend and District Radio Society on December 8th which will be held at the Palace, Southend-on-Sea. Sec.: P. C. Baldwin, 13 Inverness Avenue, Westcliff-on-Sea.

Swindon.—Mullard valve films and R.S.G.B. films will be shown at the meeting of the Swindon Radio Club on December 9th at 7.30 in the Connaught Café, Swindon. Sec.: G. R. Pearce (G3AYL), 102 Kingshill Road, Swindon.

QRP Society is considering the formation of a group catering for schools which include elementary radio in their curriculum. The secretary, J. Whitehead, 92 Rydens Avenue, Walton-on-Thames, Surrey, would welcome suggestions and comments from interested science masters.

Warrington and District Radio Society (G3CKR) meets on the first and third Thursdays of each month at 7.30 at the King's Head Hotel. Particulars of the winter programme, which includes lectures and films, are obtainable from J. Williams, 22 Ackers Lane, Stockton Heath, Warrington.

Commercial Literature

High Quality Audio Amplifier, 12-watt, and pre-amplifier, designed for use with G.E.C. metal-cone loudspeaker. Frequency response 15 c/s – 20 kc/s ± 1 dB; distortion less than 0.5% (at 12 W). Ultra linear circuit with 15 dB overall feedback. Brochure from the General Electric Company, Magnet House, Kingsway, London, W.C.2.

Government Publications from the D.S.I.R. A list, including some on radio and electronic subjects, from H.M. Stationery Office, York House, Kingsway, London, W.C.2.

F.M. Tuner, 87-100 Mc/s, for connection to pickup terminals, with r.f. stage, mixer, three i.f. stages, ratio detector and triode a.f. stage. Also Band-III convertor; tape recorder and amplifier; and a.m./f.m. radiogram chassis. Leaflets from the Dulci Company, 97-99 Villiers Road, Willesden, London, N.W.2.

"The Electric Tool User," autumn edition, 1955; an illustrated publication showing the various applications of their products from Wolf Electric Tools, Hanger Lane, London, W.5.

Tape Recorder with provision for fitting a radio tuner for recording sound broadcasts; also with optional loudspeaker monitoring when recording, tone controls and mixing facilities. Leaflet on the new model (Mark III) of the Impresario Deluxe tape recorder from Lee Products (International), Elpico Works, Olive Road, Hove 3, Sussex.

Indicating Instruments, miniature panel-mounting type. An illustrated catalogue giving electrical data and full dimensions from Measuring Instruments (Pullin), Electrin Works, Winchester Street, Acton, London, W.3.

Battery Reactivator claimed to increase life of batteries from 5 to 15 times; also process timers; escapement mechanisms; and other electronic timing, counting and control equipment. Leaflets from Cass and Phillip, Caslip Works, Canning Road, Wealdstone, Middlesex.

LETTERS TO THE EDITOR

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

Interference from Band III Convertors

WHILST it is agreed that radiation of an I.T.A.-modulated Band I signal will undoubtedly cause a pattern or a floating picture on adjacent Band I receivers, I do not believe that the phenomenon is appreciably affected by whether the receiver is a straight or a superheterodyne receiver. The article on page 526 of the November issue suggests that the radiation occurs from the output (video) end of the t.r.f. receiver and can be cured by converting it to a superhet using the B.R.E.M.A. recommended i.f.; this is, to my mind, a most dangerous assumption.

There is plenty of evidence to show that interference occurs when the receiver is not a t.r.f. type but a superheterodyne. In this case, the interference must be due t. an I.T.A.-modulated Band I signal existing at the output of the convertor and being radiated by the convertor chassis, connecting leads to the normal receiver, and/or its input circuits. If a Band I aerial feeder is also connected in any way to these points, this aerial will receive a signal and the interference will be exaggerated.

D. N. CORFIELD.

Standard Telephones & Cables, Ltd.
Footscray, Kent.

"*Dry-cell Reactivator*"

THE improved deposition of zinc mentioned by R. W. Hallows in your October issue is probably due to electrolytic polishing.

When a d.c. supply is used for plating the deposit tends to be pasty and lumpy, but if the current flow is periodically reversed metal is removed from any sharp or loosely deposited areas in preference to the main area of metal. Correct choice of forward and reverse currents and times will produce a deposit which is firm and even, the effect noticed by Major Hallows.

No doubt further work will show the correct ratios for the best reactivation.

Great Malvern, Worcs. A. F. STANDING.

IN his article on the above subject in your issue of October, 1955, R. W. Hallows notes certain differences in the nature of the zinc re-deposited when this action is effected by a current source which gives what he describes as a "very dirty d.c." He may be interested to know that this is an effect known in the electro-plating industry and currently being investigated by me in the laboratory.

When an attempt is made to produce thick deposits of electro-plate by normal d.c. methods it is found that the deposits form nodules and other imperfections: in the case of copper this occurs, for example, at about 0.004in of thickness. If, however, the current is reversed periodically it is even possible to reduce the surface roughness and to achieve deposits of some 0.5in without imperfections. This process, which is not new, has been used for some years in the U.S.A. and more recently has been adopted in some British plants. The first patent covering the use of d.c. with superimposed a.c. dates back to 1906, a process involving complete reversal was described in 1925 and the present technique originated in about 1948.

All the effects so accurately noted by Major Hallows can be observed during the operating of Periodic Reverse Current plating, the metal being deposited faster, in a more dense form free from nodules and porosity and at a lower voltage across the electrodes. The voltage can be observed to rise during the forward direction of current (plating cycle); for copper the figures are 1.6 volts rising to 2.5 volts in a typical case. The rise is not uniform, a sharp step in the curve being associated with the onset of gassing at the cathode, a condition usually best avoided either by shortening the cycle or by reducing the current density.

It would appear from the oscillogram that the Electrophoor is merely a device using a very short cycle with a forward/reverse coulombs ratio of the order of 3 or 4 to 1; this ratio has been very successfully used by my firm for electro-forming electronic "plumbing" and similar items, though with much longer cycles, e.g. 15sec forward and 5 reverse. Cycle times vary with the metal being deposited and with the result desired; the literature discloses times from 0.1sec to 40sec. The lower cell voltage and reduced heating would both result from the depolarizing effect of the reverse cycle while the effect on the metal has been mentioned above.

No work has been done in our laboratory on the type of electrolyte used in the Leclanché cell, since the P.R. process works best with cyanide-type electrolytes such as copper, silver and cadmium; however, the mechanism of the process in so far as it is known seems to be such that it could work in the case of cell reactivation and certainly the observed effects are typical. Perhaps Major Hallows will conduct further experiments and publish the results; a suggested first step would be to obtain the oscillogram of current, rather than voltage, against time.

GEORGE E. SMYTHE.

Verichrome Plating Services, Ltd.,
Larkhall, Scotland.

"*Etched Foil Printed Circuits*"

I AM taken to task by your correspondent L. D. Stuart (in the November issue) for liberating hydrogen from the reaction of nitric acid and copper. He is, of course, quite right, as free hydrogen could not exist in the presence of a strong oxydizing agent. I will agree to the substitution of the word "gas."

May I point out an important error in the text? This is in the recipe for the coating solution. It is wrongly given as 111.5 grams of ammonium dichromate whereas it should be 11.5 grams (September issue, page 438, second column, line 5). The solution cannot work with such a concentration.

Malvern, Worcs. H. G. MANFIELD.

Television Sound on Band II Sets

READERS in the Croydon district who possess a Band II f.m. receiver may be interested to know that they can receive I.T.A. sound transmissions even if they lack a television set.

My own receiver has an i.f. of 10.7 Mc/s and the local oscillator operates above the signal frequency. If the dial is set to 90.275 Mc/s the second harmonic of the local oscillator will beat with the I.T.A. sound signal on 191.25 Mc/s which filter through the r.f. stage to produce the i.f. of 10.7 Mc/s. The only other requirements are to detune the f.m. receiver slightly and to have a suitable aerial.

The aerial in use incorporates a vertical quarter-wave section of feeder in a balance-to-unbalance coupling, and as this is approximately a half-wave long at Band III frequencies it seems to operate satisfactorily as a Band III aerial.

Reception in an unmodified Band II f.m. receiver is somewhat noisy but it will be apparent that simple modifications to the r.f. and detector stages should produce a combined band receiver suitable for a.m. or f.m. reception.

Incidentally, must I now get a television licence?

Purley, Surrey. D. H. SNELLING.

Dual-band Television Aerials

2.—"Vee" Dipoles: Separate Aerials with Diplexers

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

IN making the conversions described in the first part of this article the matter of increased windage and consequent stresses at vital points must not be forgotten. While a suitable safety margin is good engineering practice, that margin may disappear if too many additional attachments are made in the process of adaptation: they should therefore be of simple and light construction.

The foregoing methods are mainly suitable for providing dual reception on either Channels 1 and 9 or 2 and 9. There is no point yet in considering Channels 3 and 5 because no one knows what Band III channels will go with them. On the other hand Sutton Coldfield on Channel 4 must be considered in relation to I.T.A. Channel 8.

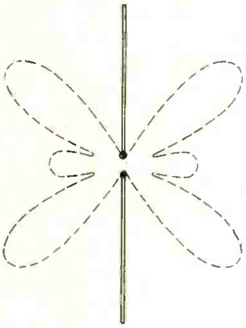


Fig. 9. Vertical directivity of Channel 4 dipole on Channel 8.

The frequency ratio in this case is 189.75/61.75 or approximately three to one. In these circumstances the terminal impedance of a Channel 4 dipole will still be of the order of 80 ohms on Channel 8 and, as can be seen from the curves of Fig. 3, the signal loss is by no means as serious as for Channel 1 and 2 dipoles on Channel 9; it is about 5 dB. The loss is now due, not to gross mismatching, but to loss of gain in the direction at right angles to the axis of the dipole, which is, of course, the normal direction of arrival of the signal.

Fig. 9 shows the vertical directional response of a Channel 4 dipole operating on Channel 8. Since the losses (Fig. 3) are not particularly high, quite a lot can be recovered by tilting the aerial either towards or away from the direction of the transmitter by about 45 degrees so as to make use of the superior lobe normally pointing skywards. This works quite well and practically all the loss can be recovered.

It seems reasonable to expect that quite a number of aerials in "ghost-free" vicinities, not too many miles from the transmitter, could be tilted in this manner if the owner has no objection to the unsightly appearance of the installation, but it would be reasonable to check results at first without recourse to tilting. Aircraft flutter might be objectionable in either case because there will always be a strong upwardly directed vertical lobe. This is one of the prices one must pay for making compromises! The Band I performance may also have to suffer as a consequence of tilting.

At greater distances, or where "ghosts" are troublesome, horizontal directivity and higher gain (which go hand in hand) must be sought. Since we are discussing aerials in which the combined Band I/III signals are fed to the receiver by a single transmission line it might be as well to study Fig. 10(a) which is a "vee" dipole designed to work on Channels 4 and 8 and to possess some useful horizontal directivity on Channel 8 and, indeed, over the whole of Band III. Naturally the plane of the "vee" is disposed vertically.

The gain of this aerial is very nearly the same as a vertical resonant dipole on Channel 4 and is of the order of 3 dB on Channel 8. The horizontal directivity on Channel 4 is almost circular but slightly depressed in the direction of the apex of the "vee." On Channel 8 the horizontal directivity is quite pronounced, see Fig. 10(b), and useful "de-ghosting" can be achieved as a result of this in spite of the small rearward lobe. This aerial is, of course, normally erected with the open ends pointing towards the transmitter. If co-siting of the Band I/III transmitters does not exist and the viewer is placed, to some extent, between the two, it is obviously the better policy to align this aerial in the direction of the Band III transmitter.

Another useful property of this "vee" dipole is the fact that it possesses fairly broad band characteristics and is capable of giving results from Channels

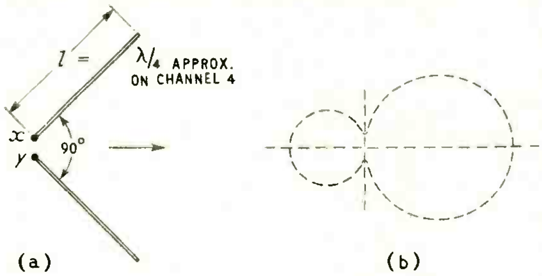


Fig. 10. "Vee" dipole for dual reception on Channels 4 and 8: (a) general arrangement (b) horizontal directivity.

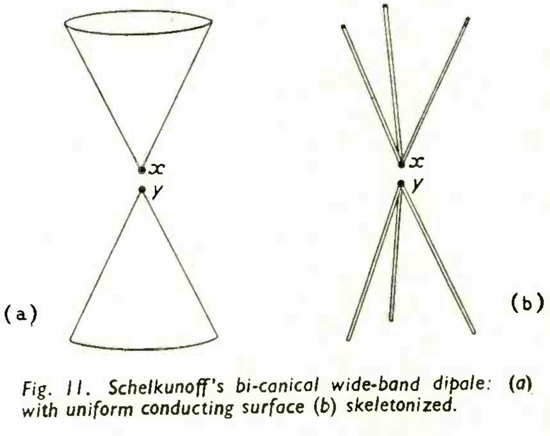


Fig. 11. Schelkunoff's bi-canical wide-band dipole: (a) with uniform conducting surface (b) skeletonized.

* Belling and Lee Ltd.

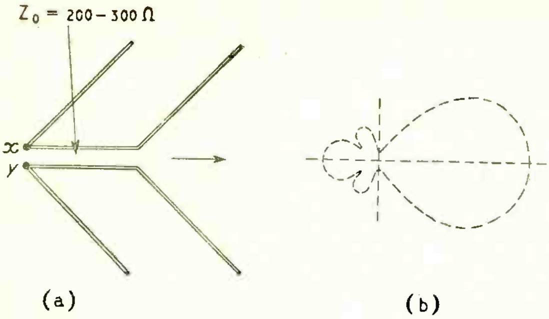


Fig. 12. Co-phased "vee" dipoles: (a) general arrangement, (b) horizontal directivity.

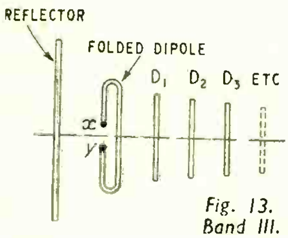


Fig. 13. Typical Yagi array for Band III.

4 to 13 inclusively without serious loss of performance. This requirement does not at present exist, but it must not be forgotten. The wide-band properties of this aerial probably became known as a result of Schelkunoff's mathematical studies[2] of a bi-conical dipole Fig. 11(a) and who chose this form of construction to simplify the mathematics. Its wide-band characteristics then became apparent and it was further ascertained that the structure could be skeletonized, Fig. 11(b), without much loss of bandwidth. From this one can deteriorate, as it were, to the " vee " dipole and still retain a fair measure of wide-band performance.

Higher gain and directivity on both bands may be achieved by using two " vee " dipoles, as in Fig. 12(a), which are connected in parallel with a suitable length of transmission line of fairly high characteristic impedance. An analysis of this arrangement is complicated but relies on the dimensions of the inclined elements and the separation between the apices to provide a maximum in-phase field in the direction of the arrow if energized at the terminals x, y. Having achieved these properties by treating the system as a radiator the principles of reciprocity preserve them for reception.

The resultant gains on Channels 4 and 8, as compared with a half-wave resonant dipole in each case are 3.0 and 7.0 dB respectively. The horizontal directivity on Channel 8 is shown in Fig. 12(b) and the directivity on Channel 4 is similar but less pronounced. This aerial also possesses significant wide-band characteristics. The single and double " vee " arrangements are still the subject of further experiment and measurement, and it is hoped to publish a much fuller account of their properties in the future.

We have dealt with forms of aerials which provide dual reception on at least one channel in each of Bands I and III and convey the signals to the receiver via a single transmission line, or feeder, to use a popular term.

There are many cases where a separate aerial for Band III is desirable. A few which occur to the author may be listed as follows.

(1) Where the Band I installation is inconveniently placed for economic conversion.

(2) Where highly-directional aerials are required on both bands for " de-ghosting," or because of lack of signal.

(3) Where the Band I aerial is inside the building and it is desirable, on technical grounds, to have the Band III aerial mounted on the exterior.

In this case a straightforward series of multi-element Yagi-type arrays, typified in Fig. 13, can be developed and adjusted to exhibit a terminal impedance of the order of 80 ohms over a restricted number of channels on Band III and nominally centred on the only two available channels at the present moment, namely 8 and 9. The number of directors D_1, D_2 etc., progressively improves the gain and horizontal directivity. On the other hand, increasing the number of directors decreases the number of channels over which the aerial may be usefully employed. The graph of Fig. 14 makes this only too clear. The Band III performance relative to an optimized dipole on each channel, is compared for the following aerials all resonated close to Channels 8 and 9 and using a folded dipole.

(1) Folded dipole only.
(2) 3-element array.
(3) Specially designed 3-element array.
(4) 6-element array.
(5) 9-element array.

The specially designed 3-element array was very carefully adjusted in respect of the spacing and length

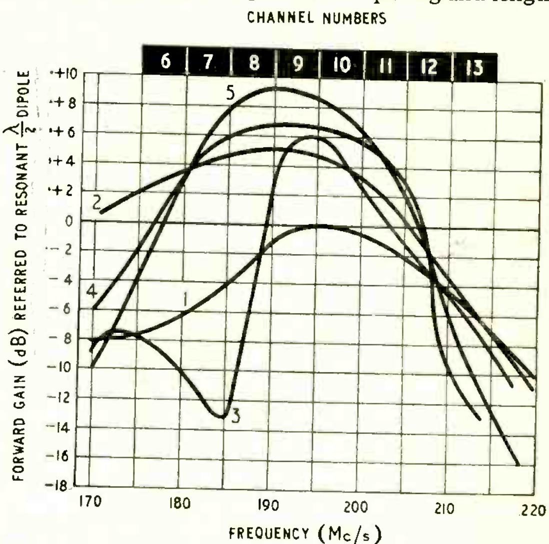
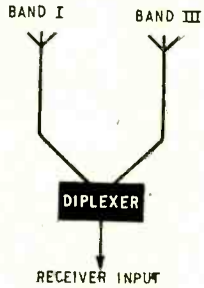


Fig. 14. Forward gain/frequency characteristics of typical Yagi Band III aerials.

Fig. 15. Block circuit of "diplexed" aerials.



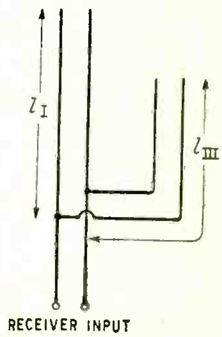


Fig. 16. Two feeders of critical length connected in parallel.

[2] S. A. Schelkunoff and H. T. Friis. "Antennas: Theory and Practice." 1952. John Wiley.

of its reflector and director in order to secure maximum gain on Channel 9. This was only 1 dB better than the 3-element array normally supplied for either Channel 8 or 9 operation. Notice, however, the very rapid falling off in performance over the remaining channels, particularly at about Channel 7 where the horizontal directivity is *reversed.* In all these measurements the aerials remained pointing in the direction of the transmitter so that the curves include the effects of directivity. On the basis of transmitter co-siting this is the only way to express the results in a practical way.

Apart from the special 3-element aerial (curve 3) the remainder show a progressively diminishing band coverage as the number of elements is increased. This is typical for the Yagi arrangement and reminds us strongly that some other approach is needed to meet the future requirements of high gain and directivity coupled with full coverage of Band III. It is possible that the double-" vee " arrangement may help in this respect.

It remains only to erect the separate Band III aerial—and, incidentally, the compact size now enables arrays with 9 or more elements to be installed in a loft—and to connect it to the receiver in addition to the Band I aerial already installed.

Some receivers have been provided with separate aerial input sockets for Bands I and III, but most employ a single input, common to both bands, and this is where we introduce the diplexer. The diplexer is best known to the television transmitter engineer who uses it to combine the outputs from separate sound and vision transmitters through a common feeder into a common aerial, thereby effecting considerable economy. The basic requirements are that, metaphorically, both transmitters can " see " the aerial without seeing each other, for the idea of kilowatts of sound and vision being mixed up in the final stages of both transmitters is quite repugnant! So the diplexer is a sort of dual filter as shown in Fig. 15 but used in the reverse sense since it combines the Bands I and III signals from individual aerials and conveys them to a common input.

Suppose the diplexer had been omitted and the three feeders simply connected in parallel. Due to the high frequencies at which we are working standing waves would be set up on all three feeders, and, dependent upon their respective lengths and the nature of the impedance at each termination could result in almost complete removal of either (or even both) signals from the receiver input terminals. The presence of the impedance of the aerials makes it complicated to give a simple analysis, but if they are neglected we can draw the simple diagram of Fig. 16 and study this to reach some straightforward conclusions.

A low-loss open-circuited line of length l_I will place a short-circuit across x, y when $l_I = \lambda_I \frac{(2n-1)}{4}$

Similarly $l_{III} = \lambda_{III} \frac{(2m-1)}{4}$ where n and m are any integers.

Had the lines been short-circuited at their far ends a short circuit across x, y due to l_I or l_{III} would then occur when

$$l_I = \frac{\lambda_I n}{2}$$

and

$$l_{III} = \frac{\lambda_{III} m}{2}$$

These, of course, would be the worst conditions. If only one of the feeders had been at critical length then the signals from one channel only would be severely attentuated.

In practice the far ends of the feeder are never completely open or short-circuited because of the aerials to which they are connected. So the results are not quite so drastic, but can be serious.

The diplexer, sometimes called a combining, or cross-over unit, connects the aerial feeders to the common feeder by means of filter circuits some examples of which are given in Fig. 17 (a) and (b). They can be described, generally, as a combination of tuned circuits designed in such a manner that the output from two aerials operating on differing frequencies can be connected to a single input with negligible loss of signal from each aerial. A further property is that of negligible mutual interaction between the feeders and constant impedance over the pass band.

The ideal television diplexer would possess the following characteristics.

(a) Zero insertion loss for either Band I or III signals.

(b) Infinite attentuation of Band I signals on Band III and *vice versa.*

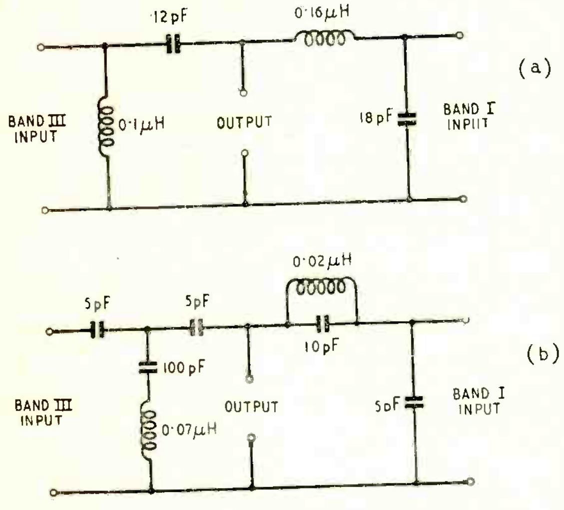


Fig. 17. Typical diplexer circuits.

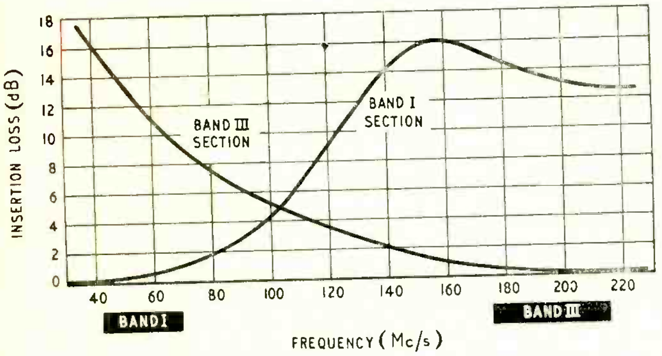


Fig. 18. Characteristics of diplexer circuit of Fig. 17 (a).

All filters have their limitations so that the curves of Fig. 18 show what can be achieved economically. These are for the circuit of Fig. 17 (a).

The need for attenuation of Band I signals when receiving on Band III and *vice versa* may not be fully appreciated. In fact the degree of attenuation which would ultimately seem to be desirable is, at the moment, largely guesswork.

Referring to Fig. 15 it can be appreciated that, when receiving Band I signals, there is a small contribution from the Band III aerial and, of course, the converse applies.

If there is a considerable difference in length between the two feeders a delayed signal may show up as a "ghost." On a 14-inch screen a displaced image of 1/20 inch is just discernible on a receiver of high-class performance, i.e., full vertical and horizontal resolution, good focus, and "non-ringing." This would correspond to a delay of 0.35 microseconds. This corresponds, in air, to increased path of travel for the delayed signal of 115 yards, or, in a solid polythene feeder of $115/\sqrt{\kappa}$ yards where κ is the dielectric constant of polythene. This is about 2.3 so the path of travel would be about 75 yards.

The total increased path would generally be made up of a combination of aerial spacing and extra feeder length, but it is hard to visualise many installations where an extra path of between 75 and 115 yards would exist. In this respect, for all practical purposes, the attenuation due to the diplexer on the undesired band is quite unimportant. It exists because of the need for negligible interaction between the two feeders at the point of connection, since this is equivalent to a degree of mismatching. Measurements suggest that not less than 10 dB is a satisfactory value.

It might be argued that inter-band attenuation would assist in eliminating break through, but this is a design requirement of the receiver, for when truly wide-band aerials have been developed, including Band II (v.h.f. broadcasting) there is not likely to be much inter-band attenuation in these.

Finally, if a combined aerial with single feeder is to be connected to a receiver possessing separate input connections on each band, the diplexer may be mounted on the skirting or back of the receiver and connected in the reverse sense.

Bearing in mind the gradual clearance of private mobile radio from Band III and the rapid development of television in this spectrum a great deal of ingenuity will have to be introduced in matters of aerial design in the not too distant future.

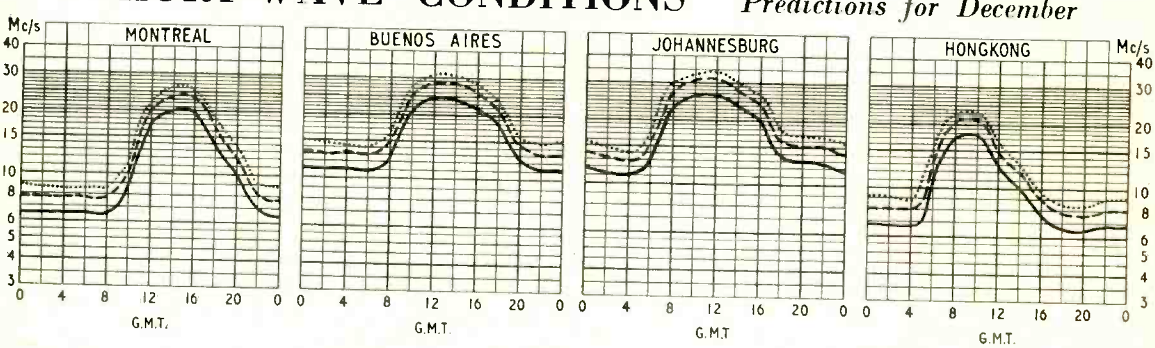
It is sometimes thought that the aerial problem here is not significantly different from that which has been current in the U.S.A. for several years. This false impression should be removed. Apart from the use of 300-ohm ribbon type feeder (which does help in the design of wide band aerials) their frequency allocations are 54–88 Mc/s on Band I and 174–216 Mc/s on Band III. While the Band III spectrum is sensibly the same, their lowest frequency corresponds to a frequency lying between our Channels 3 and 4. Referring to Fig. 3, it is just the channels the U.S.A. do not use, the aerials for which behave so inefficiently over Band III; so they are at a great advantage when designing dual-band aerials. Further, if the curves of Fig. 3 had been based upon a terminating impedance of 300 instead of 80 ohms the losses would have been further decreased.

These factors, apart from the difference in polarization (horizontal in U.S.A.) make the U.K. problem quite different, even in the global sense.

On the other hand, our fundamental reception problem is also different. We need only *one* channel in Band I dependent upon location, because, with rare exceptions, the B.C.C. transmit the same programme on all 5 channels.

Therefore, the dual-band aerial of the future will need to be responsive to one channel in Band I and *all* channels in Band III. The latter is assumed on the basis of the I.T.A.'s statement that the stations so far contemplated will transmit different programmes, and it seems possible, when one considers the ultimate radiated powers to be employed (upwards of 120 kW), that many viewers will be sited favourably for reception of more than one channel. Here the problem of variable directivity rears its ugly head and visions of motorized arrays are seen rising through the mists of the crystal ball!

SHORT-WAVE CONDITIONS *Predictions for December*



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 December.

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

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

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

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

V.H.F. Measurements

By W. TUSTING

Use of Simple Test Apparatus

THE start of Band III television has made many people feel the need for making measurements at frequencies around 200 Mc/s. These are frequencies higher than many have previously met, although low by centimetre-wave standards.

Few of these people, however, have any 200-Mc/s test equipment and they do not always realize how much can be done with quite ordinary apparatus. The writer recently decided to make a Band III tuner and one of the first problems was to measure the frequency of the oscillator.

The only apparatus available was an early model Advance signal generator with a maximum frequency of 60 Mc/s, and the oscillator had to be made to operate at 230 Mc/s, in round figures. It could only be done by making use of harmonics of the 4th and higher orders. This is, of course, a very old way of measuring frequency and is not at all difficult when one knows how. The first time one tries it, however, one may well be baffled by the bewildering sequence of whistles which appears as the frequency of the signal generator is varied. Unless one is careful and knows what one is doing one can get completely lost among them.

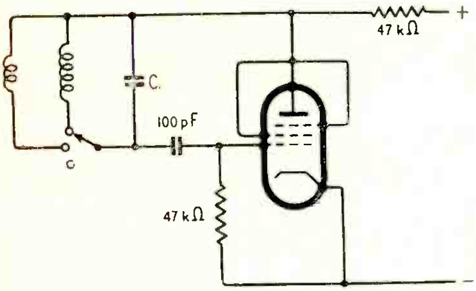


Fig. 1. Basic circuit of oscillator.

The signal generator produces a range of frequencies nf_1 where f_1 is its fundamental and n is an integer. The oscillator under test also produces a range of frequencies mf_0 where f_0 is its fundamental and m is an integer. Thus if f_1 is 20 Mc/s, the range of frequencies produced will be 20, 40, 60, 80, 100, 120, etc., Mc/s and if f_0 is 80 Mc/s, this range will be 80, 160, 240, 320, etc., Mc/s. A whistle will occur whenever any frequencies differ from each other by an audible amount; that is, whenever $nf_1 \approx mf_0$ and zero beat occurs when the two are precisely the same.

As the signal generator (hereinafter abbreviated to s.g.) frequency is varied there is one set of whistles produced as its successive harmonics beat with the fundamental of the oscillator under test. These gradually get weaker as the order of harmonic rises. There is another interleaved set due to higher harmonics of the s.g. beating with the second harmonics of the oscillator under test. These are usually much weaker, for the harmonic order is much higher. There are still others due to the higher harmonics of the oscillator under test and these tend to be still weaker.

The strength of the whistles obtained is thus a guide to the mechanism of production and it is usually the case that the strongest ones are those involving the fundamental of the oscillator under test. This is not an invariable rule, however, especially when high-order harmonics of the s.g. are being used. The harmonics of an oscillator do not always fall off regularly in amplitude. It is possible for particular harmonics to be very weak or even entirely missing, so that a high harmonic can be stronger than a lower one. It is necessary, therefore, to have some definite means of sorting them out and to use their strength only as a rough guide.

Arrangement of Apparatus

In the writer's recent measurements the oscillator had the circuit shown in Fig. 1, one coil being for Band I and the other for Band III. The oscillator frequencies required were 79.5 Mc/s and 229.25 ≈ 230 Mc/s. A 0–1 mA meter was connected in series with the grid leak as an indicator of oscillation, and it also acted to measure the amplitude of oscillation, since the product of the change of current (mA) between the oscillating and non-oscillating conditions with the value of the grid leak (kΩ) is approximately equal to the peak r.f. voltage on the grid.

In order to obtain audible beats it is necessary to mix the output of the oscillator and that of the s.g. and to rectify the mixture. This was done with the circuit of Fig. 2, in which the coil was a couple of turns placed near the oscillator coil of Fig. 1. The full output of the s.g. was used always.

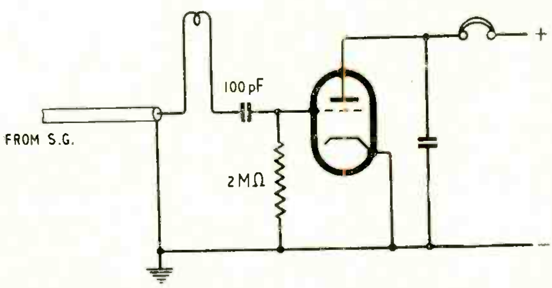


Fig. 2. Connection of signal generator and oscillator to the detector.

With this arrangement the drill is to start at the highest frequency on the s.g. and slowly reduce its frequency, making a note of each frequency at which a whistle is heard as accurately as the s.g. scale can be read. It is useful also to make a rough note of the strength of the whistle, for some will be strong and others weak. The writer classifies them as strong (S), medium (M) and weak (W).

Unless the s.g. control is turned very slowly weak whistles will be missed altogether and strong ones will be noticeable, not as whistles but as slight clicks as they are passed through.

A word of warning here; some whistles may not be due to beats between the oscillator and the s.g., but due to the pick-up of signals. This was found in these tests, for there were whistles at 45 Mc/s and 41.5 Mc/s due to pick-up of Alexandra Palace. They also appeared at 22.5 Mc/s and 20.73 Mc/s on the s.g. due to its second harmonic. Such whistles are easily detected for they do not vary in pitch when the hand is put near the oscillator. This simple test enables them to be weeded out and ignored. They are, however, useful in affording a check on the calibration of the s.g.

TABLE 1

Strength	S.G. (Mc/s)	n	Osc. (Mc/s)
M	52		
S	38.5	2	77
W	35.9		
W	32		
S	26	3	78
W	21		
M	19.4	4	77.6
W	17.8		
W	16.2		
W	15.5	5	77.5

The whistles found on the first test, ignoring those due to Alexandra Palace, are listed in Table 1. This test was made using a Band I coil. The problem is to find the oscillator frequency from these figures.

At first we consider only the strong whistles since these are probably the ones due to the fundamental of the oscillator. In Table 1 there are only two of these, at 38.5 and at 26 Mc/s. We assume that they are due to two adjacent harmonics of the s.g. If they are, we can at once find out the order of harmonics and hence the oscillator frequency.

Let the order of harmonic be n for the higher frequency f_2. The order for the lower frequency f_1 must be $n + 1$ if they are adjacent harmonics, so

$$nf_2 = (n + 1)f_1$$

whence

$$n = \frac{f_1}{f_2 - f_1}$$

Applying this we get $n = 26/(38.5 - 26) = 26/12.5$.

Now n must be a whole number. If we find it is not then the frequencies do not represent adjacent harmonics. However, in this sort of work, we cannot expect n to come out as precisely a whole number, because we cannot read the scale of the s.g. very accurately and also there are errors in calibration. Our figures are only approximate.

In this case n comes out at 2.08. It is sufficiently different from an integer for us not to be quite sure whether or not it should really be 2, but we provisionally take it at that and see where we get. So we enter 2 in the n column against 38.5 Mc/s and 3($= n + 1$) against 26 Mc/s and multiplying out we get column four. One gives 77 Mc/s for the oscillator frequency, the other 78 Mc/s.

Can we now get some confirmation? If we are right so far we ought to have whistles corresponding to higher harmonics, at about 78/4 = 19.5, 78/5 = 15.6 78/6 = 13 and so on. Looking at the Table we see that we had whistles at 19.4 and 15.6 which we classified as M and W. It is reasonable that they should be weaker and so we assume that they do correspond to the 4th and 5th harmonics. We therefore enter 4 and 5 in the n column and multiply out to the oscillator column. All the figures in this column should be the same if we are right in our selection of harmonics. The four sets are, in fact, quite reasonably close and there is very little doubt that the oscillator frequency is about 77.5 Mc/s.

We can, however, get a little bit nearer than this, for some of the s.g. readings are likely to be better than others. Assuming that its calibration is good, frequencies which fall between scale divisions, and so require interpolation, are likely to be less accurate than those which happen to fall precisely on calibration marks. We should, too, give a preference to low-order harmonics, other things being equal. In Table 1, therefore, we tend to prefer the 78-Mc/s figure above the others, since the 26-Mc/s reading of the s.g. from which it is obtained corresponds to a scale marking.

Identifying Other Frequencies

How do the other frequencies arise? They are probably beats of harmonics of the s.g. with second- or third-harmonics of the oscillator. The second is at about 156 Mc/s and if they are beats with this they must be odd-order harmonics of the s.g., for even-order harmonics would only produce beats coinciding with those due to half-the-order with the oscillator fundamental.

The frequencies for which the 3rd, 5th, 7th, etc., harmonics are 156 Mc/s are 52, 31.2, 22.3, 17.3, etc. Mc/s. The first fits precisely and we can say that

TABLE 2

C = 0				C = 5 pF				C = 10 pF			
Strength	S.G. (Mc/s)	n	Osc. (Mc/s)	Strength	S.G. (Mc/s)	n	Osc. (Mc/s)	Strength	S.G. (Mc/s)	n	Osc. (Mc/s)
S	54	2	108	S	44	2	88	S	39.2	2	78.4
W	43.2			S	29.2	3	87.6	S	25.6	3	76.8
S	36	3	108	S	22	4	88	S	19.15	4	76.6
W	33			S	17.5	5	87.5	S	15.35	5	76.75
M	27	4	108	M	14.6	6	87.6	M	12.8	6	76.8
S	21.4	5	107	M	12.55	7	87.85				
S	17.8	6	106.8								
S	15.3	7	107.1								
M	13.4	8	107.2								

the 52-Mc/s whistle is due to the third harmonic of the s.g. beating with the second of the oscillator.

None of the others fits very well. However, we cannot expect to identify all the whistles precisely because our figures are not accurate enough. What with calibration errors in the s.g., errors in reading, changes of frequency in both the s.g. and the oscillator during the measurement due to temperature, mains voltage, etc., one cannot expect precision. What we can do is to identify the order of harmonics in the mains series and that is sufficient.

Some alterations were made to the circuit after these first measurements and the measurements were repeated with three different values for C of Fig. 1, viz., zero, 5 pF and 10 pF, these being the nominal and not measured values of capacitance. The figures obtained are listed in Table 2.

Thus for C = 0 we find 108 Mc/s three times from integral Mc/s readings of the s.g., but all other figures which depend on non-integral readings vary. We thus take 108 Mc/s as the proper value. Again, for C = 5 pF, there are two integral readings which give 88 Mc/s and we take this figure. For C = 10 pF, there is no integral value. Looking down the list we see that 76.8 Mc/s comes twice and that the s.g. readings are nearly half-way between scale marking (on the scale covering 12.8 Mc/s, there are divisions every 0.5 Mc/s). We decide that this is the most probable figure, therefore.

Capacitance Measurement

From the three figures for frequency we can compute the capacitance of the circuit in three different ways. Let the frequency with one value of capacitance C be f_2 and with ΔC added be f_1, then

$$\omega_2^2 LC = \omega_1^2 LC(1 + \Delta C/C) = 1$$

whence

$$C = \Delta C/[(f_2/f_1)^2 - 1]$$

Taking f_2 = 108 Mc/s and f_1 = 88 Mc/s we have

$$C = 5/[(108/88)^2 - 1)] = 5/0.51 = 9.8 \text{ pF}$$

Taking f_2 = 88 Mc/s and f_1 = 76.8 Mc/s we have

$$C + 5 = 5/[(88/76.8)^2 - 1] = 5/0.31 = 16.15 \text{ pF},$$
so C = 11.15 pF.

Taking f_2 = 108 Mc/s, f_1 = 76.8 Mc/s and ΔC = 10 pF we have

$$C = 10/[(108/76.8)^2 - 1] = 10/0.98 = 10.2 \text{ pF}.$$

All three figures should be the same, of course. The first and the last agree well and point to a capacitance of some 10 pF for the circuit. The middle one does not agree quite so well, but is not far out. It is not surprising that the figures do not agree, because the added capacitances are only nominal values. In addition, the 5 pF value was obtained from 2 × 10 pF capacitors in series, so that there was inevitably a small change of inductance because of the different length of circuit.

With the oscillator coil intended for Band III, the figures of Table 3 were obtained. The most likely figures are, for C = 0, 168 Mc/s, C = 5 pF, 148 Mc/s and C = 10 pF, 132.5 Mc/s. To estimate the capacitance we find.

$$C = 5/[(168/148)^2 - 1] = 5/0.29 = 17.25 \text{ pF}.$$

$$C + 5 = 5/[(148/132.5)^2 - 1] = 5/0.25 = 20,$$
so C = 15 pF.

$$C = 10/[(168/132.5)^2 - 1] = 10/0.61 = 16.4 \text{ pF}.$$

TABLE 3

C = 0			C = 5 pF			C = 10 pF		
S.G. (Mc/s)	*n*	Osc. (Mc/s)	S.G. (Mc/s)	*n*	Osc. (Mc/s)	S.G. (Mc/s)	*n*	Osc. (Mc/s)
56.5	3	169.5	49.7	3	149.1	44.3	3	132.9
42	4	168	37	4	148	33.1	4	132.4
33.8	5	169	29.6	5	148	26.5	5	132.5
			24.6	6	147.6	22	6	132
			21	7	147	18.75	7	131.25
			18.4	8	147.2			

The average capacitance is 48.65/3 = 16.22 pF, whereas on Band I it is 31.15/3 = 10.38 pF, a difference of 5.84 pF. One of the capacitors employed was changed between the two sets of measurements; it was a ceramic type and broke. One cannot expect exact agreement, therefore, but this does not account for so big a discrepancy.

The reason for the difference is not known. There was a big difference between the amplitudes of oscillation on the two bands. On Band I the amplitude was about 10 V, whereas on Band III it was only around 4 V and fell to 1.5 V with no added capacitance. This may well have had an appreciable effect upon the effective input capacitance of the valve. Transit-time effects may also have played a part.

The particular arrangement used for the oscillator of Fig. 1 proved unsuitable for Band III, for with a reasonable amplitude of oscillation it proved impossible to obtain a frequency much above 150 Mc/s. The reason was almost certainly the type of valve employed. This was an EF91 strapped as a triode and it was used because it was available. A change was afterwards made to the triode section of a PCF80 with which 230 Mc/s was readily obtained.

A check was made on the amount of inductance added by the switch, which was of the ordinary wafer type. The frequency was measured with the coil connected normally to the switch and found to be 132.5 Mc/s. The coil was then connected without the switch, matters being arranged so that no leads changed in length apart from the internals of the switch. The frequency then rose to 148 Mc/s. By chance the change was precisely the same as the removal of 5 pF from the circuit.

In terms of inductance

$$\omega_2^2 LC = 1 = \omega_1^2 LC(1 + \Delta L/L)$$

so

$$(f_2/f_1)^2 - 1 = \Delta L/L = (148/132.5)^2 - 1 = 0.25$$

The switch thus accounted for 25% of the inductance of the circuit!

It is surprising what a lot of useful information about a circuit one can acquire with very little test equipment. The accuracy may not always be high, but it is certainly good enough to keep one on the right lines, and in the measurement of frequency it is limited only by the accuracy of calibration of the signal generator.

In conclusion, it must be emphasized that around 240 Mc/s the whistles obtained are very weak indeed and with the simple detector of Fig. 2 they can only just be heard. They were, of course, two orders higher than in most of the measurements described. The use of an a.f. amplifier after the detector would remedy this, however, and is really necessary for satisfactory operation.

Vestigial-Sideband Television

EFFECT ON OLD TELEVISION SETS

THE Alexandra Palace transmitter has long been the exception among television transmitters in that it has radiated a double-sideband signal instead of a vestigial-sideband one. This is because of its antiquity. It was the first television transmitter in the world to operate on a service basis and when it opened on a regular service in November 1936, the vestigial-sideband method of operation was no more than a laboratory idea, if it had been thought of at all.

In its 18 years the transmitter has given some 11 years' service, for it was closed down during the war and for about a year afterwards. It is now to be replaced by a new one at Croydon and this is to be of higher power and of the vestigial-sideband type.

This change may affect some viewers, for a receiver designed for the reception of a double-sideband transmission will not necessarily work satisfactorily on a vestigial-sideband transmission. The converse, however, does hold, and a receiver designed for vestigial-sideband operates on double-sideband transmissions.

In double-sideband transmission, the carrier and both sidebands up to some ±3 Mc/s are fully transmitted. In vestigial-sideband transmission the carrier and the lower sidebands, down to −3 Mc/s, are fully transmitted, but the upper sidebands only partially. They are transmitted fully up to +0.75 Mc/s and then rapidly attenuated up to +1.25 Mc/s.

For the reception of such signals, the receiver is tuned so that the carrier falls at −6 dB on the h.f. side of its response curve. There is effectively double-sideband operation for low-modulation frequencies and single-sideband operation for high.

Such a method of reception is perfectly satisfactory for double-sideband reception, for the receiver itself eliminates the upper sidebands of the higher modulation frequencies. All modern receivers are of this kind. One can say, in fact, that almost all receivers marketed since the opening of Sutton Coldfield are of the vestigial-sideband type—and certainly all tunable sets are.

Double-Sideband Receivers

In the case of a set designed solely for Alexandra Palace, however, there were three possibilities open to the designer. It could be a double-sideband receiver, it could be vestigial-sideband using the upper sidebands, or it could be vestigial-sideband using the lower sidebands. Only the last is still right for vestigial-sideband transmissions.

Most early receivers were double-sideband. The question arises as to how they will react to a vestigial-sideband transmission. Theoretically, the only difference will be a slight falling off in definition, since the absence of one sideband will be equivalent to a 6-dB cut in the high-frequency response.

It is probable that most of these older sets do not in any case have the full bandwidth. It is also probable that their performance has deteriorated and, in particular, that they do not focus too well. It is highly probable, therefore, that their users will notice little or no difference when the changeover occurs.

Vestigial-sideband receivers designed for upper-sideband reception, however, are in a different position. They were adopted mainly to facilitate sound-channel rejection and are characterized by having few or no sound-trap circuits. One can, in fact, say that if a receiver has no sound-channel rejectors, gives a good definition and does not suffer from sound-channel interference, it must be of the upper-sideband type.

If such a set is used on a vestigial-sideband transmission one might think that it would give no picture, for its pass-band is on the wrong side of the carrier. However, the transmission is double-sideband for frequencies up to ±0.75 Mc/s, and over this range the receiver will operate normally. Higher modulation frequencies will be severely attenuated, however, and the result will be a loss of definition.

It is difficult to assess just how great this will be, for it must be remembered that all sets of this type are now some six or seven years old at least and are likely to have deteriorated. The change of picture quality with the new transmitter may well be less than one would expect, therefore.

Receiver Modifications

Exactly the same thing happens when I.T.A. is received on one of these sets with a convertor. That is a vestigial-sideband transmission and if it can be received well, there is no reason to expect that the new B.B.C. London transmitter will be any worse.

Very few superheterodynes have been made of the upper-sideband type. Most such sets were t.r.f. It may be asked if anything can be done to convert them to lower-sideband operation. The answer is that it depends very much on one's technical skill. In principle, they can be altered, but it is certainly not a very easy thing to do.

The first thing is to re-trim all the r.f. circuits about 3 Mc/s lower in frequency. If this is done, the pass-band will be roughly correct but, to get it exactly right, some careful experimental alignment with signal generator and output meter will be needed.

This is by no means all, however, for it is quite certain that there will then be severe interference from the sound channel. This requires the addition of sound-channel rejectors.

To obtain adequate rejection without spoiling the pass-band, it is essential to use very-high-Q tuned circuits, to couple them loosely to the intervalve couplings and to use at least two or, better, three traps. It is often quite difficult to find room for the traps, particularly as careful screening is needed. If an attempt is made to cure the sound interference with one trap only, it is probable that it will cut into the pass-band so much that the results will be little better than if the receiver had not been altered at all.

Q MEASUREMENT

With Low Tuning Capacitance

By S. KANNAN,* B.Sc., Assoc.Brit.I.R.E

THE basic functional principle of most Q-meters is illustrated in Fig. 1 to refresh the memory. LC are the "Inductor" terminals, C_m the variable capacitor in the Q-meter and R_i the injection resistor (usually 0.04 ohm.) By reducing the losses in C_m to negligible proportions, the Q-meter is designed to read the ratio E_o/E_i directly as the Q of the inductor connected across LL.

The lowest calibrated value of C_m in most instruments is about 30 pF. Hence a direct Q measurement on a standard Q-meter is not feasible if the inductor under test resonates to a certain frequency (at which its Q is to be determined) with a capacitance of value less than the minimum C_m available in the instrument. One such instance was encountered by the author in the course of designing i.f. transformers with high L/C ratio for an f.m. receiver. It was found necessary to determine the Q (at 10.7 Mc/s) of a coil which resonates to 10.7 Mc/s with total of 15 pF across it.

Only indirect measurements of Q are open to us in such cases. After a detailed consideration of possible methods, the author finally settled on one as most satisfactory for all practical purposes, combining operating ease, minimum calculation and minimum of corrections to be applied, and especially eliminating the need to measure E_i and E_o with the aid of instruments the effect of whose impedance is not easily allowed for, if it can be evaluated at all to any degree of accuracy.

This method uses a standard Q-meter and is based on the fact that a parallel-resonant L/C circuit behaves, at its resonant frequency f ($= \omega/2\pi$) as a pure resistance of value $Q\omega L$, where (with negligible error for $Q > 10$) the Q of the circuit is given by the relation[1]:

$\frac{1}{Q} = \frac{1}{Q_L} + \frac{1}{Q_C}$, Q_L and Q_C being the individual Q values of L and C respectively. When the loss in the capacitor is negligible compared to that in the inductor (as in most practical cases), $Q_C \gg Q_L$, therefore $Q = Q_L$.

If the LC circuit is connected to the "capacitor" terminals of a Q-meter in which a suitable coil has been resonated exactly to the resonant frequency of the LC circuit, then the resonance of the Q-meter should not be affected, as can be checked by means of C_m. But the measured Q of the coil across LL will now be less, and the Q of the coil L can be derived as a function of this drop in measured Q.

The step-by-step procedure and attendant theory then are as follows:—

(1) Set Q-meter at the frequency (f) at which the Q of the coil (L) under test is to be determined.

(2) Connect to the "Inductor" terminals a suitable coil (L_1) of fairly high Q, which will resonate at f with C_m at a convenient value. Resonate the coil L_1 by adjusting C_m, and read off Q' carefully.

(3) Make a parallel combination of the coil L under test and a good quality capacitor C, preferably of the semi-variable variety. Connect this combination across the "Capacitor" terminals as in Fig. 2. Check, by operating C_m, if the resonance is affected. If C_m has to be reduced to restore resonance, disconnect the LC combination, decrease C slightly and reconnect to see if the original resonance of L_1 is affected. On the other hand, if C_m has to be increased to restore resonance, a higher value of C is to be taken and the procedure repeated.

Continue in this fashion until the LC combination leaves the resonance at f unaffected. Read off Q'', the Q of L_1 with LC across the "Capacitor" terminals.

(4) With C alone across the "Capacitor" terminals, resonate L_1 by readjusting C_m and read off Q'''.

(5) Finally, determine the individual inductance values of L_1 and L. If this is done with the aid of the Q-meter itself, the self-capacitance of L_1 may also be determined and noted.

Calculation: If R is the shunt resistance of C (i.e., a parallel resistance representing the effect of all insulation losses in C), then

$$\frac{Q' \omega L_1 R}{Q' \omega L_1 + R} = Q''' \omega L_1 \quad .. \quad .. \quad .. \quad (1)$$

If Q is the quality factor of the coil L at f, then $Q'' \omega L$ is equal to the resultant of $Q \omega L$, $Q' \omega L_1$ and R, all three in parallel (Fig. 2).

By equation (1), $Q''' \omega L_1$ is the resultant of $Q' \omega L_1$ and R in parallel.

$$\therefore Q'' \omega L_1 = \frac{Q Q''' \omega^2 L L_1}{Q \omega L + Q''' \omega L_1}$$

$$\therefore Q = \frac{Q''' - Q''}{Q''' Q''} \cdot \frac{L_1}{L} \quad .. \quad .. \quad (2)$$

Since Q' does not appear in the final equation (2), its actual measurement (in step 2) need not be made. It is included only to illustrate the theory.

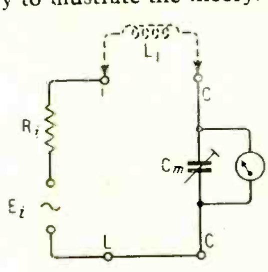


Fig. 1. Basic form of Q meter.

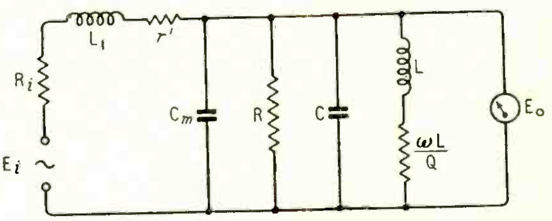


Fig. 2. Q meter arranged with additional coil L as described in the text.

* E.K. Cole, Ltd.
[1] "Radio Designer's Handbook". 4th Edition. p. 150.

In the above calculations, the measured values of Q′, Q′′ and Q′′′ may be corrected[2] for the effect of the self-capacitance of L_1 and so the true Q values can be used in the final equation. Step (4) may be dropped in most cases (and the derivation modified) if C has very high shunt resistance. It is desirable for C to have negligible self-inductance, and this is not difficult to ensure.

The highest Q measured is Q′ for which set of conditions the effective series resistance (r') of L_1 is equal to $\omega L_1/Q'$; hence no correction need be applied for the effect of the injection resistor (R_i) on the true Q values if $r' \gg R_i$. The frequency accuracy of the Q-meter itself need not be of the highest order; nor need the measurements be conducted at *exactly* the same frequency at which the Q of L is desired to be determined, since the Q of a coil is substantially constant over a small range of frequency and since f (or ω) does not appear in the final equation. Absolute accuracy of calibration of C_m is again not vital; it need only be ensured that the C_m setting for resonance (in step 2) is not affected by the connection of the LC combination (in step 3). A fair order of accuracy is essential only in the determination of the individual inductance values of L_1 and L, as well as in the Q indications of the Q-meter itself.

[2] "Radio Designer's Handbook" 4th Edition. p. 451.

Sensitive Three-Valve T.R.F. Receiver

Incorporating Amplified A.G.C. and Negative Feedback Volume Control

By H. E. STYLES, B.Sc.

IN an article published in the *Wireless World* of November, 1951, S. W. Amos and G. G. Johnstone described a three-valve t.r.f. receiver in which amplified automatic gain control was achieved by applying to the r.f. pentode suppressor grid the negative potential changes produced at the anode of an anode-bend detector by rectification of the input signals.

A modified version of this receiver was subsequently described in an article by J. L. Osbourne published in the April, 1954, issue of *Wireless World*. Special features of this modified circuit included the employment of an aperiodic aerial coupling and a diode detector which provided means of incorporating automatically variable negative feedback in the a.f. amplifier.

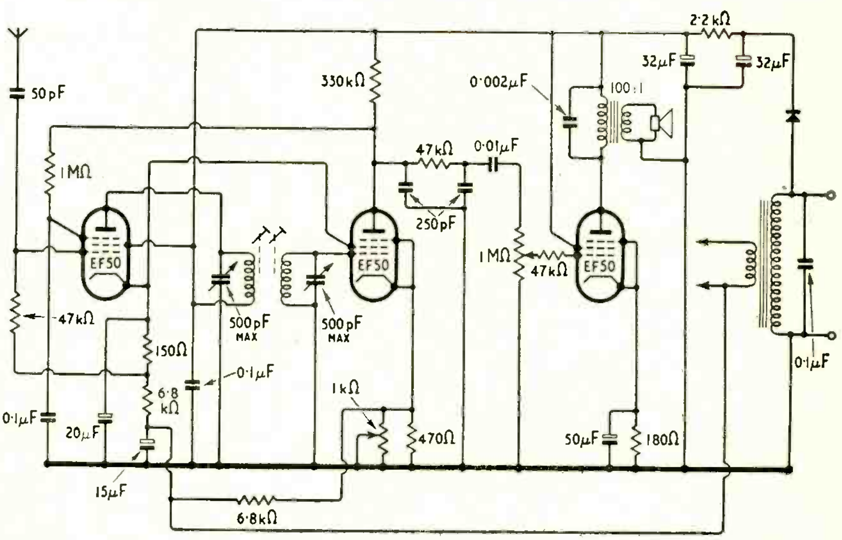
The writer decided that a circuit incorporating the special features of each of these two receivers might be worthy of investigation and, as an outcome, it has been found possible to introduce modifications leading to greatly enhanced sensitivity and a number of other novel features which it is believed may be of general interest.

Preliminary Considerations:—It was decided that the aperiodic aerial coupling used by Osbourne was undoubtedly worth retaining, not only for the reasons given in his article, but also because it should be virtually independent of the particular characteristics of the aerial employed. On the other hand the anode-bend detector employed by Amos and Johnstone was regarded as preferable to a diode on the grounds that the former would obviate unwanted damping of the detector circuit.

As a preliminary, therefore, the circuit shown in Fig. 1 was assembled using Litz-wound coils with dust-iron cores for the intervalve bandpass coupling, the required degree of coupling being obtained by spacing them about 1¼in apart. The 0.1-μF capacitor across the mains input was found necessary in order to eliminate an otherwise rather pronounced modulation hum.

Very satisfactory results were obtained with this circuit which, in particular, was found to be entirely free from any tendency towards instability over the whole tuning range. This fact prompted an attempt to determine whether reaction could usefully be em-

Fig. 1. Initial circuit which formed the basis for the experiments described in the text.



ployed as a means of increasing the sensitivity and selectivity obtainable.

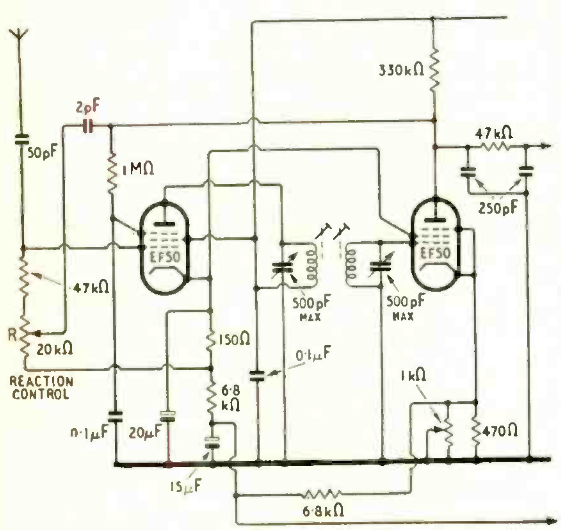
With a view to avoiding distortion of the response curve of the bandpass coupling, and possible mistuning effects which might arise from application of reaction to one circuit only of the inter-valve coupling, it was decided to endeavour to obtain reaction by feedback of r.f. from the detector output to the input of the r.f. amplifier. This was successfully achieved by means of the circuit shown in Fig. 2, a smooth control of regeneration being obtainable by variation of the potentiometer R. An alternative circuit giving equally satisfactory reaction control is shown in Fig. 3 where it should be noted that reaction is increased by reducing the value of the variable capacitor C.

For the foregoing circuits to function properly, it is necessary for the r.f. at the anode of the detector valve to be in phase with the input signal to the r.f. amplifier. Assuming both tuning coils to be wound in the same sense, this requirement can be satisfied by connecting the anode of the r.f. amplifier valve and the grid of the detector valve to corresponding ends of their respective coils.

Reaction so applied caused no significant alteration to the tuning adjustment and produced a truly remarkable increase in sensitivity. With critically adjusted reaction a large number of transmissions were receivable at night, at good volume, in the London area, using no more than six inches of wire as an aerial. This increase in sensitivity, valuable though it was, by no means proved to be the only outcome of incorporating the reaction control. Other interesting and useful effects resulted from the combination of reaction and a high degree of automatic gain control and these are described in the following paragraphs.

Effects Produced by Reaction:—It was observed that increase of reaction to the point of instability immediately produced audible "motor-boating," the frequency of which increased as reaction was further increased. This effect can no doubt be explained by the fact that as soon as r.f. oscillation results from regeneration, the signal thereby produced causes the automatic gain control to come into operation. This, in turn, reduces the amount of feedback as a consequence of which oscillation ceases. The overall gain then increases until oscillation recommences and the sequence of effects repeats indefinitely at a frequency dependent upon the degree of reaction applied and the various circuit constants.

Fig. 2. Reaction was added by controlled feedback from the detector to the grid of the r.f. stage.



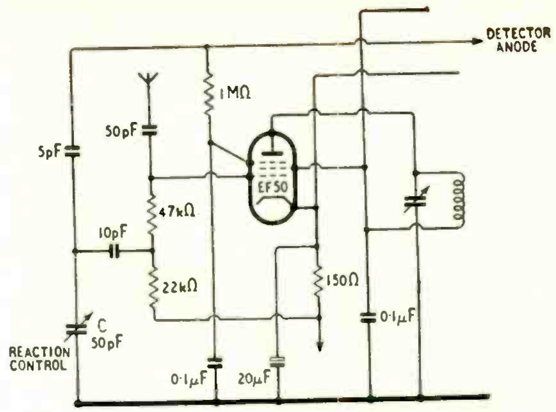


Fig. 3. An alternative method of controlling reaction.

The production of an audible indication of oscillation, together with the fact that the amount of reaction needed to produce such oscillation depends upon the overall gain of the r.f. and detector stages, offered a simple means of adjusting the circuit for optimum performance.

In the first place, critical adjustment of the r.f. valve's suppressor grid potential was easily effected as follows:—With the aerial removed and the receiver tuned so as to avoid pick-up of any strong local signal, the reaction control was adjusted until oscillation was gently maintained. The variable resistor controlling the suppressor grid potential, *i.e.*, the detector cathode resistance, was then adjusted to give maximum frequency of "motor-boating." Reaction was then reduced so as just to maintain oscillation and the suppressor grid potential finally adjusted to the value which enabled oscillation to be just maintained with the least possible amount of reaction. This obviously corresponds to the setting giving maximum gain with no signal input.

Secondly, alignment of the two tuned circuits proved possible in the following manner:—The coils of the bandpass coupling were first separated sufficiently to reduce the coupling to sub-optimum so as to avoid any double hump in their combined response curve. With the aerial removed to prevent signal pick-up, the receiver was first tuned to the low frequency end of its tuning range and the dust cores of the coils adjusted so as to enable oscillation to be obtained with the least possible amount of reaction. This again implies maximum overall gain from the input of the r.f. amplifier to the output of the detector and, with loosely coupled coils, corresponds to correct tuning of the two circuits.

The receiver was next tuned to the high frequency end of its tuning range and the same procedure followed except that alignment was obtained by adjustment of the trimming capacitors and not the cores of the inductors. Having made this adjustment at the high frequency end of the tuning range the whole process was repeated until no further adjustments proved necessary at either end of the tuning range.

Thirdly, optimum coupling for the bandpass circuit was attained, at a chosen frequency within the available tuning range, as follows:—Again with the aerial removed, the receiver was tuned to a frequency somewhere near the centre of the tuning range, and the reaction was set so as to just maintain oscillation. The spacing of the coils was then adjusted to give maximum frequency of "motor-boating," reaction reduced to the minimum necessary for maintenance of oscillation and the coil spacing finally adjusted so that oscillation could be produced with the least possible amount of reaction. This procedure is, of course, based upon the fact that optimum coupling of a bandpass circuit provides the maximum gain obtainable from a pair of coupled coils tuned to the same frequency of resonance.

In the case of the receiver constructed by the author, it was found that reaction effects tended to increase as the receiver was tuned towards the low frequency end of its tuning range. This effect was counteracted by increasing somewhat the coupling between the coils of the bandpass circuit and a compromise setting was established empirically whereby the reaction setting required to just maintain oscillation remained almost constant throughout the major part of the whole tuning range. For many purposes it would thus seem possible to make the reaction control a pre-set one though the author prefers otherwise.

By virtue of the dependence of reaction upon the overall gain of the radio-frequency section of the receiver, it was found that, with the receiver in a just oscillating condition, oscillation ceased whenever a signal sufficiently strong to cause operation of the automatic gain control was accurately tuned in. The stronger the signal, the greater became the freedom from tendency towards incipient oscillation so that, in effect, the receiver not only possessed automatic gain control but also automatic reaction control. In the case of reasonably strong signals, application of reaction produced little or no change in the volume of sound produced from the loudspeaker owing to the functioning of the automatic gain control. Such reaction, however, resulted in a reduction in the level of interference partly by virtue of the increased selectivity brought about by reaction in the usual manner and partly by virtue of the increased strength of the wanted signal causing the automatic gain control to reduce the overall sensitivity of the receiver to unwanted signals.

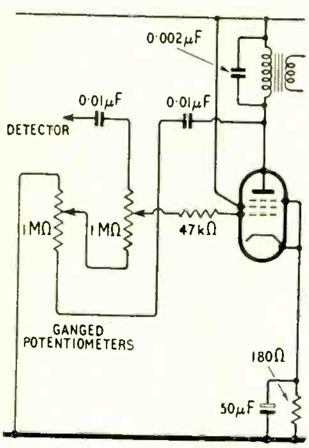
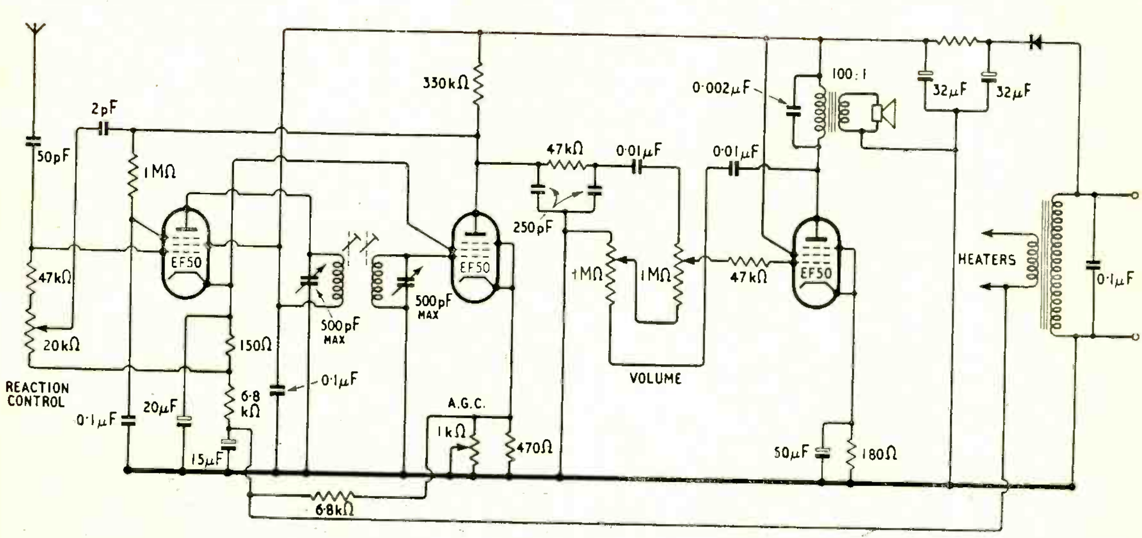


Fig. 4. Negative feedback circuit which provides an adequate range of volume control.

Fig. 5. The final circuit of the receiver incorporating the desirable features described in the text.

Variable Negative Feedback:—Having effected what is regarded as a significant improvement in the r.f. and detector portion of the receiver, attention was next directed to the audio-frequency section. The circuit shown in Fig. 1 makes no provision for negative feedback though, wherever possible, such feedback is regarded as very desirable, particularly in receivers employing the EF50 type valve in conjunction with small-sized output transformers which inevitably possess inadequate primary inductance for the required load impedance of some twenty-thousand ohms.

On the other hand, it is equally desirable that, at maximum setting of the volume control, there should be no appreciable negative feedback in order to avoid unwanted loss of sensitivity when it may be desired to receive unusually weak signals. A method of volume control which automatically increases negative feedback from zero, at the maximum volume setting, to a large value (consistent with freedom from instability) at the minimum volume setting is thus to be regarded as the ideal. Attempts leading to a



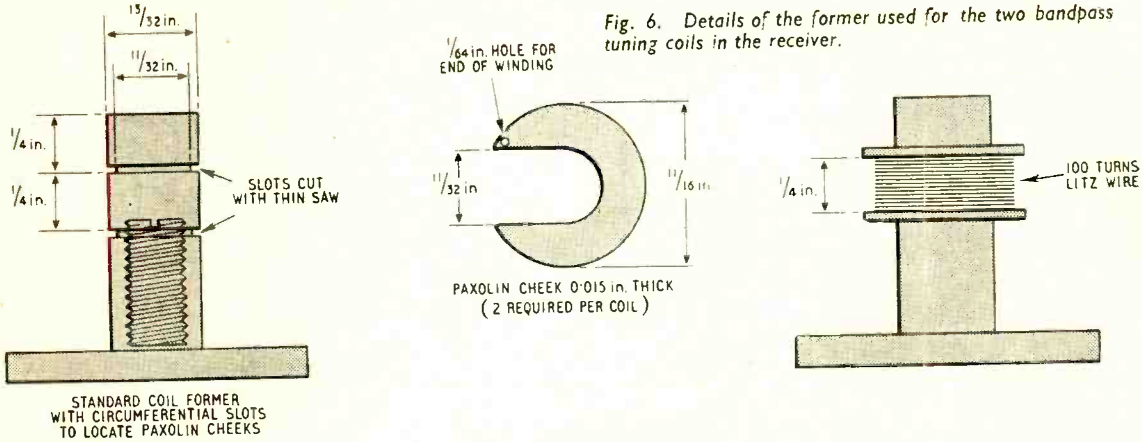


Fig. 6. Details of the former used for the two bandpass tuning coils in the receiver.

successful solution of this problem are described below.

The first possibility investigated involved mechanically coupling the normal output valve volume control potentiometer to a second potentiometer wired into the circuit so as to provide variable feedback from the secondary of the output transformer to the cathode of the detector. This scheme proved to be unsatisfactory for the following reasons: (a) variation of the feedback control potentiometer caused variation in the effective value of the detector cathode resistance and thereby upset the functioning of the amplified a.g.c.; (b) the maximum degree of feedback was limited by onset of instability due to phase changes arising from intervalve coupling and output transformer characteristics; (c) maximum feedback (consistent with stability requirements) was obtained only when the normal volume control was set to its minimum position. This, of course, implied that the effective amplification of the output stage was reduced to a very small value so that full benefit was not obtained from negative feedback; (d) as the normal volume control was within the feedback loop, its effect was largely nullified by virtue of the feedback and control of volume tended to be confined to the minimum end of the control potentiometer. For the reason given in (c), this could not be considered very satisfactory.

In view of these difficulties it was decided to confine feedback to the output stage alone, a certain amount of feedback being in any case provided in the detector circuit by reason of the un-bypassed cathode resistance.

Initially, attempts were made to obtain the desired degree of feedback without employing anything more than a normal volume control potentiometer, but they proved impracticable because volume could not be reduced sufficiently despite the limiting effect of the receiver's automatic gain control.

The problem was eventually solved by means of the circuit shown in Fig. 4 which involved the use of a pair of ganged one-megohm potentiometers. This arrangement automatically varied the feedback from zero to 100 per cent as the volume control was moved from its maximum to minimum positions. Furthermore, at the minimum volume setting attenuation of the signal input to the output stage was limited to 50 per cent so that, within the feedback loop, amplifier gain was maintained at a reasonably high level.

In practice, owing to the limiting effect of a.g.c. upon the detector output, it proved unnecessary ever to reduce the volume control to anything approaching its minimum setting; hence the signal applied to the grid of the output valve was normally not attenuated to any appreciable extent. Control of volume was thus virtually effected by feedback alone, all surplus signal strength thereby being usefully employed in minimizing distortion. It is, of course, possible to apply 100 per cent feedback in this manner to a single valve without risk of instability and the arrangement can thus be regarded as almost perfectly meeting the ideal requirements for a volume control. Certainly, the results obtained, in comparison with the original control without feedback, amply justified the efforts made to gain the desired effects.

Final Circuit:—Fig. 5 shows the complete circuit as finally developed. The previously published articles, to which reference has already been made, should be consulted for details as to the exact mode of functioning of the amplified automatic gain control which, in the present circuit, has been made even more effective by simultaneous automatic control of reaction. A very small aerial is all that is required and its use obviates the likelihood of cross modulation difficulties arising as a result of applying too large an input to the first valve. Even so, a strong local signal causes "swamping" of weaker signals in adjacent channels and it is probable that incorporation of a wave trap, as advocated by Amos and Johnstone, would prove beneficial. This, however, has not so far been attempted.

APPENDIX

Coil Design Data

The two coils of the intervalve bandpass coupling are identical and may be constructed with standard moulded formers of 13/32in external diameter fitted with threaded dust-iron cores. Thin Paxolin cheeks are located on the formers by means of slots as shown in Fig. 6, so as to provide a winding space one quarter of an inch in length. Within this space, 100 turns of Litz wire are pile wound in a random manner so as to approximate to wave-winding. The Litz employed consists of nine strands of No. 45 s.w.g. enamelled copper wire enclosed in an outer covering of silk but alternative forms of a similar kind would no doubt be satisfactory. In fact, in view of the use of reaction, it is probable that solid wire could be employed in place of Litz without detriment to the receiver's performance, though somewhat more reaction might be necessary.

Using tuning capacitors of 0.0005μF maximum capacitance, the coils described should provide a frequency range of 550 to 1,550 kc/s approximately with the dust cores almost fully inserted which should ensure the maximum benefit from the use of dust-iron cores.

Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

Transformer Tester

A TEST SET known as the "Trantesta," designed primarily for testing for short-circuited turns in television line output transformers, but equally applicable to any iron-cored inductor, is obtainable from Farnell Instruments, 15, Park Place, Leeds. Tests can generally be made without removing the component from the set.

"Trantesta" for testing iron-cored transformers for short-circuited turns.

The basis of the tester is an a.f. oscillator with a very sensitive microammeter connected in its grid circuit. The transformer under test is connected across the oscillatory circuit by a pair of probe leads and any disturbance introduced by the presence of the "work" is registered on the meter. A transformer with several short-circuited turns causes serious disturbance in the oscillator and gives a considerable deflection on the meter. For simplicity of operation the meter scale is in two coloured sections only, one marked "good"; the other "replace."

Provision is made also for continuity tests for which a second meter scale, marked also "good" and "replace," is provided.

The "Trantesta" measures 8 × 5 × 4in, weighs 5lb and costs 17 guineas. It operates from the 200-250V a.c. mains.

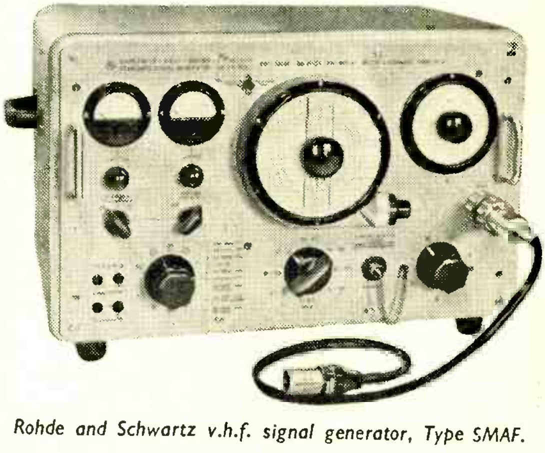
Comprehensive V.H.F. Signal Generator

SHOWN in the illustration is the Type SMAF v.h.f. standard signal generator made by Rohde and Schwarz of Munich and obtainable in this country through Aveley Electric, Ltd., Ayron Road, Aveley Industrial Estate, South Ockendon, Essex. This generator is of laboratory type and the facilities provided are in keeping with this classification.

Eight different modes of modulation can be applied to an r.f. oscillator covering, by means of a six-way coil turret, a frequency band of 4 to 300 Mc/s. A colpitts r.f. oscillator is employed and is frequency stabilized first by means of a voltage-stabilized power supply and secondly by sampling the r.f. output with a crystal rectifier and applying the resulting d.c. to a current-regulating valve in the cathode circuit of the oscillator.

The various types of output provided are: (1) external video up to 5 Mc/s; (2) external a.m., 30 c/s to 100 kc/s; (3) internal a.m. at 1,000 c/s, ±5%; (4) c.w.; (5) internal f.m. at 1,000 c/s, ±5%, with deviations up to 100 kc/s; (6) external f.m., 30 c/s to 20 kc/s with deviations up to 100 kc/s; (7) 1,000-c/s internal a.m. with simultaneous external f.m., 30 to 20 kc/s; (8) simultaneous 1,000-c/s internal a.m. and 100-c/s f.m.; (9) simultaneous external a.m. and f.m. Amplitude modulation and f.m. deviation are internally monitored, adjusted and read off on meters. Amplitude modulation is applied to a buffer amplifier and f.m. only to the oscillator.

Control of the r.f. output is by means of a step attenuator and a variable capacitance voltage divider, the two giving a calibrated output over the range 0.05 μV to 50 mV with an accuracy of ±1 db + 0.1 μV up to 225 Mc/s and ±2 db + 0.1μV from 225 to 300 Mc/s. The output impedance is 60 Ω.



Rohde and Schwartz v.h.f. signal generator, Type SMAF.

The generator is housed in a cast light-alloy case with double screening of the oscillator, employs 11 valves and tubes of one kind or another and several metal and crystal rectifiers. It is a.c. operated, weighs 62 lb and costs about £700.

Electrostatic "Tweeters." It is regretted that the block on page 568 of the November issue, illustrating the LSH75 and LSH100 units was inverted; the square unit on the right is the type LSH75.

American Colour Television

COMMENTS ON ITS TEETHING TROUBLES FROM A B.B.C. ENGINEER

WHAT is wrong with American colour television? Why has it not been as successful as was at first expected? Some months ago D. C. Birkinshaw, superintendent engineer of B.B.C. television, paid a visit to the United States to study television techniques, during which time he obtained some very definite answers to these questions. Giving the results of his observations in a recent Television Society lecture, he began by saying that the situation was not due to any failure of the N.T.S.C. compatible system, in which the American engineers still had great confidence. It arose simply because colour television had been launched too soon, before adequate facilities were available to back it up and make it into a reasonable public service.

Cost of Receivers

To begin with, said Mr. Birkinshaw, the cost of receivers was too high. The average price was in the region of 800 dollars, which was about three times the figure for black-and-white sets. There were some rumours of a drop to 500 dollars but in practice the minimum price was still about 750 dollars. Secondly, the American people apparently did not put much value on the æsthetic advantages offered by colour. They were only concerned with having a picture on all day in the home, which they could look at occasionally in the midst of doing other things. Whether it was in colour or not was immaterial. Arising out of this, the small size of the colour picture (generally 15-in) made it less compelling to the attention than the big 21-inch monochrome pictures to which the Americans were accustomed.

On the transmitting and programme-producing side, Mr. Birkinshaw said the main trouble was that the proportion of television programmes actually transmitted in colour was far too small. The average total of programme time for each network was about 140 hours a week, but of this only one hour was devoted to colour. One reason for this situation was, of course, the enormous cost of producing colour programmes, which was generally too much for the sponsor to pay. In one case an hour of light entertainment had cost 165,000 dollars; of this the sponsor paid only 80,000 dollars while the broadcasting company had to find the rest.

Finally, said Mr. Birkinshaw, there was the poor technical quality of the colour pictures, and for this the receivers were mainly to blame. In his view, nobody in the United States had yet produced a good colour receiver, nor a good three-colour c.r. tube. The colour values on the receiver screen seemed faulty and lacking in subtlety, while tinting occurred on blacks and whites. Registration of luminance and chrominance information was not maintained within the necessary limit, which appeared to be 0.1μsec. Moreover, the luminance bandwidth was deliberately cut to avoid the visible dot pattern caused by the chrominance sub-carrier, and this again resulted in poor definition. (Here Mr. Birkinshaw interpolated that he thought we could do without this bandwidth cutting in Britain and that "notch" filtration of the sub-carrier would be sufficient.) In some viewing tests on a typical American colour receiver it was impossible to find a set of adjustments that was satisfactory for the whole transmission. On the question of servicing, it took about 11 hours to set up a receiver correctly and two hours to change and adjust a three-colour c.r. tube.

The quality of the compatible pictures viewed on black-and-white receivers was better than expected. This impression may have been gained, however, simply because the quality of the ordinary black-and-white pictures was normally so bad! Nevertheless, there were no obvious defects such as sub-carrier dot pattern or noise on the sound.

There were, of course, considerable difficulties at the transmitting end as well. Picture faults were caused by drifts in the cameras, and with three pick-up tubes in each camera this was obviously more serious than in black-and-white television. Very flat lighting was used in the studios (because with "contrasty" illumination the Americans found it difficult to keep their image orthicon pick-up tubes in the linear mode of operation) and this made the colour pictures look inert and lifeless. Mr. Birkinshaw thought that we in Britain would be a long way ahead on this problem by the time colour television arrived here. The great intensity of illumination needed in the colour studios was another difficulty. This was about 400 foot-candles incident* or, in terms of power, 180 watts per square foot of studio space. As an example, the lighting for one studio consumed as much as 1,250 kilowatts!

Vans were available for outside broadcasting, but the Americans had found this type of work extremely difficult. With sunlight outdoors there were bigger contrast ratios to be handled, while with indoor subjects the intensity of illumination was generally not great enough. As a result there had been very few live outside broadcasts in colour—only about one in four months. It had been found better to use colour film.

Colour Recording System

The recording of live colour programmes for future transmission (in colour) had also been quite a problem, and setting up the equipment was not at all easy. There was, however, one new colour recording system on the way which looked rather

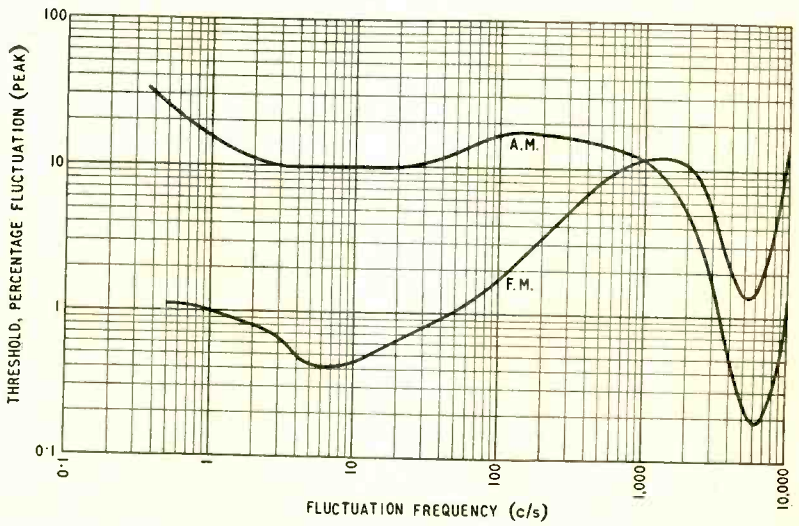
* In black-and-white television the intensity required is normally between 30 and 200 foot-candles, depending on the type of camera used.—ED.

promising. In this, each frame of the recording film was divided into four rectangles, three of which contained images giving (in black-and-white form) the brightness values of the red, green and blue components of the picture, the fourth rectangle being unused. The colour film was reproduced by projecting appropriate coloured lights through the three rectangles and combining the images.

In conclusion, Mr. Birkinshaw said that the lack of success of American colour television, and the particular reasons for it, should provide considerable food for thought for us in Britain at the moment. Choosing a suitable transmission system was one thing, but many other questions apart from the purely technical had to be considered before we could be sure of achieving a successful public service.

Standards of "Wow" and "Flutter"

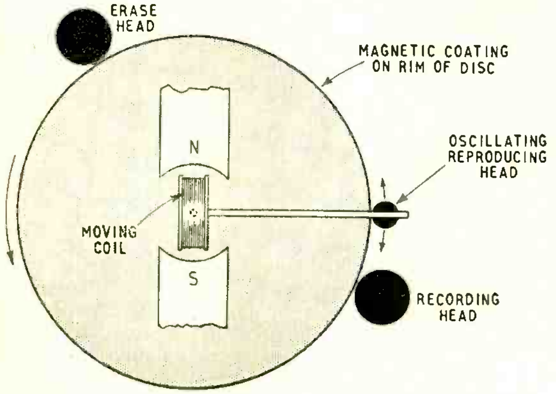
REALISTIC TESTS USING PROGRAMME MATERIAL



Amplitude-modulation and frequency-modulation thresholds for piano programme material.

MOST figures for maximum permissible frequency fluctuation, due to imperfections in sound recording and reproducing equipment, have been derived hitherto from subjective tests using artificially generated simple tones. By an ingenious magnetic drum mechanism these tests have now been extended, by A. Stott and P. E. Axon of the B.B.C. Research Dept., to programme material—particularly the piano—in order that results may be expressed more realistically in relation to actual listening conditions.

The rim of a non-magnetic disc is coated with magnetic oxide after the manner of the storage drum units used in computers. The erase, record and playback heads do not make actual contact but are spaced from the surface by about 0.0005 in, and the peripheral speed of the drum is increased to 100 in/sec to keep the wavelength long and the output from falling at high frequencies. Erase and record heads are fixed, but the playback head is mounted on a radial arm, driven by a moving-coil mechanism, and can be made to oscillate and so increase or decrease the relative speed of the recording medium past the head. The head and other moving parts have been designed for lightness and can be used to apply waveforms other than sinusoidal. This is important because speed changes can, in practice, be random as well as cyclical.



Pitch-fluctuation generator for programme material.

In a paper* published recently details are given of tests on 70 miscellaneous subjects, using the piano as the most critical programme material. Similar tests for the effect of amplitude modulation were also carried out and the results are combined in the curves reproduced here, which are put forward as a basis for permissible standards of performance in recording and reproducing systems. The inverse of these curves might also be used in weighting networks for measuring equipment.

* *Proc. I.E.E.* Vol. 102, Part B, No. 5, September 1955.

1956 DIARY

ONE of the innumerable things affected by the changes in Purchase Tax announced in the Autumn Budget is the *Wireless World* Diary. To the retail prices of 5s leather and 3s 6d rexine must be added 1s and 8½d P.T., respectively.

DECEMBER MEETINGS

LONDON
1st. I.E.E.—"Tridac: a large analogue computing machine" by Lt.-Cdr. F. R. J. Spearman, J. J. Gait, A. V. Hemingway and R. W. Hynes at 5.30 at Savoy Place, W.C.2.

6th. Radar Association.—Mullard technical films at 7.30 at the Bonnington Hotel, Southampton Row, W.C.1.

6th. Society of Instrument Technology.—"Planning a servo-mechanisms laboratory for instructional purposes" by Eric B. Pearson at 7.0 at Manson House, Portland Place, W.1.

7th. I.E.E.—"Some half-tone storage tubes" by R. S. Webley, Dr. H. G. Lubczynski and J. A. Lodge at 5.30 at Savoy Place, W.C.2.

9th. Television Society. — "The secondary emission valve and its applications" by A. H. Atherton at 7.0 at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, W.C.2.

12th. I.E.E.—"The television studio as seen by the producer" by Alvin Rakoff at 5.30 at Savoy Place, W.C.2.

13th. I.E.E. Students.—"Colour television" by L. A. Harris at 6.30 at Savoy Place, W.C.2.

14th. Brit.I.R.E.—"The remote presentation of radar information" by G. J. Dixon and H. H. Thomas at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

14th. Radar Association.—"Guided weapons" by W. H. Stephens (head of the Guided Weapons Department, R.A.E. Farnborough) at 7.30 at the Anatomy Theatre, University College, Gower Street, W.C.1.

16th. B.S.R.A.—"Transistors in audio amplifier design" by L. B. Johnson at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.

16th. Radio Society of Great Britain.—Annual General Meeting and presentation of trophies at 6.30 at the Institution of Electrical Engineers, Savoy Place, W.C.2.

BIRMINGHAM
5th. I.E.E.—"Underwater echo-ranging" by Prof. D. G. Tucker at 6.0 at the James Watt Memorial Institute, Great Charles Street (joint meeting with the Birmingham Centre of the Institution of Post Office Electrical Engineers).

CARDIFF
14th. Brit.I.R.E.—A discussion on the training of radio engineers. Openers, Dr. W. J. Thomas, H. Roberts and A. J. Kenward at 6.30 at the Llandaff Technical College, Western Avenue.

DUBLIN
15th. I.E.E.—"Germanium transistors" by R. McCormick at 6.0 at the Physical Laboratory, Trinity College.

16th. I.E.E.—"Courier to carrier in communications" by T. E. D. Terroni at 8.0 at the Mansion House.

EDINBURGH
6th. I.E.E.—"Electrical energy from the wind" by E. W. Golding at 7.0 at the Carlton Hotel, North Bridge.

20th. I.E.E.—"High-speed electronic analogue computing techniques" by Dr. D. M. MacKay at 7.0 at the Carlton Hotel, North Bridge.

FARNBOROUGH
14th. I.E.E.—"The use of transistors in computor type circuits" by G. B. B. Chaplin at 7.30 at the R.A.E. Technical College.

GLASGOW
7th. I.E.E.—"Electrical energy from the wind" by E. W. Golding at 7.0 at the Institution of Engineers and Shipbuilders, Elmbank Crescent.

8th. Brit.I.R.E.—"Automatic control of machine tools" by H. Ogden at 7.0 at the Institution of Engineers and Shipbuilders, Elmbank Crescent.

LIVERPOOL
5th. I.E.E.—"Transistor power amplifiers" by R. A. Hilbourne and D. D. Jones at 6.30 at the Electrical Engineering Department, Brownlow Hill.

7th. Brit. I.R.E.—"The development of a design for an angle modulation radio link" by H. C. Spencer at 7.0 at the Chamber of Commerce, 1, Old Hall Street.

MANCHESTER
1st. Brit.I.R.E.—"The latest developments in computer design" by J. J. Moore at 6.30 at Reynolds Hall, College of Technology, Sackville Street.

1st. B.S.R.A.—Disc and tape recording competition at 7.30 at the Times Recording Studio, Deansgate.

6th. I.E.E.—"Tridac: a large analogue computing machine" by Lt.-Cdr. F. R. J. Spearman, J. J. Gait, A. V. Hemingway and R. W. Hynes at 6.15 at the Engineers' Club, Albert Square.

7th. I.E.E.—"The recent search for and salvage of the Comet aircraft near Elba" by Commander C. G. Forsberg, R.N. and G. G. MacNeice at 6.45 at the Engineers' Club, Albert Square.

13th. Society of Instrument Technology.—"Electronic developments" by J. E. Fielden at 7.30 at the College of Technology, Sackville Street.

NEWCASTLE-UPON-TYNE
5th. I.E.E.—"Artificial reverberation" by Dr. P. E. Axon, C. L. S. Gilford and D. E. L. Shorter at 6.15 at King's College.

14th. Brit.I.R.E.—"Metal cone loudspeaker" by W. I. Heath at 6.0 at Neville Hall, Westgate Road.

PLYMOUTH
1st. I.E.E.—"Transistors" by R. A. L. Cole at 3.0 at the Electricity Showrooms, New George Street.

SWANSEA
8th. I.E.E.—"Thermionic valves of improved quality for Government and industrial purposes" by E. G. Rowe, P. Welch and W. W. Wright at 6.0 at the South Wales Electricity Board Showrooms, The Kingsway.

TORQUAY
8th. B.S.R.A.—"Three dimensional sound" by F. H. Brittain at 7.45 at Callards Café.

WOLVERHAMPTON
14th. Brit.I.R.E.—"Television aerial design for Band III" by I. A. Davidson at 7.15 at Wolverhampton and Staffordshire Technical College, Wulfruna Street.

RANDOM RADIATIONS

By "DIALLIST"

An Aerial Question

SOMETHING that has been puzzling me for quite a while is that, whereas our aerial manufacturers turn out a special dipole or array for each channel in Band I and Band III, their American opposite numbers advertise "universal" outfits, covering all channels in both bands. Since in some of the bigger towns it may be used for the reception of quite a number of TV transmitters, lying in different directions, the American "antenna array" is often rotatable; but the lengths and the spacings of its elements appear to be as firmly fixed as the laws of the Medes and the Persians. In other words, the Americans seem to have produced satisfactory compromise arrays for both television bands. You switch them, of course; but one array covers the whole of Band I and the other the whole of Band III. Are we, I wonder, over-finicky in preaching that the dipole, reflector and directors must be of precisely the right dimensions and fixed in just the right positions if we're to expect good results? I'm not a bit sure that we aren't; for Devonshire friends of mine, who had been receiving an uncertain picture from Wenvoe, got far better results when they had their sets retuned and their Channel 5 aerials reoriented to the Channel 2 North Hessary Tor.

It's the Picture that Matters

While I entirely agree that, if you have to make the most of a poor metre-wave signal, the receiving array must be made exactly to fit it, I'm pretty sure that no such thing is necessary when a fine "fat" signal is in question. Here's an example. A London friend, owning a 13-channel set, hadn't managed to get his Band III aerial installed when the I.T.A. transmissions started. Just to see what would happen he connected the inner of a co-axial plug to his wireless aerial and its outer to earth. Result: both picture and sound pretty good. Frankly, again, I can't see why the designers of television aerials work in the mid-frequency—the mean of the sound and vision frequencies. The sound seems pretty well able to take care of itself: one seldom hears complaints about it. It's nearly always that there's something wrong with the picture. If it is necessary to have a special aerial, or array, for each channel, I'm not at all sure that designers (particularly when they're working on models intended for fringe-area reception) wouldn't be well advised to base their calculations on the vision frequency only. And this, I expect, is where F. R. W. Strafford (or somebody) ups and smites the neck that I've stuck out.*

* F. R. W. Strafford discusses aerial problems in the present issue.—ED.

Lights Out!

ONE GATHERS that in some towns in this country TV receivers with no mains transformers are giving those responsible for street lighting a considerable spot of bother. So far as one can make out from reports in the lay Press, the switching on or off of these lights is operated by relays, which are actuated by d.c. injected into the service mains. Thus, when John Citizen comes home for the evening and switches on his television set he is apt to produce in the mains a d.c. "kick," which effectively douses the glims near his house. Presumably, when his neighbour returns home and does likewise, all is light (if not sweetness) again—until another fellow turns his switch, when off they go once more. Great brains are reported to be working on the problem. Dare one hope that their solution will be the outlawing of the transformerless set?

405 Lines, Or . . .?

NEW ZEALAND hasn't yet decided what definition standard she's going to adopt when she starts a television service, for although there has been strong support for a 405-line system like our own the Government is now having second thoughts. I'm not quite so sure as once I was that, taking it all round, a 405-line picture with 50 frames a second makes the best possible use of the channel-width available. With the increasing popularity of bigger and bigger screens lininess kept to a minimum might be more attractive than a near-perfect balance between horizontal and vertical definition. We're committed to 405 lines for a long time to come; but New Zealand and a good many other countries with 50 c/s mains supplies aren't.

Technical Hitch

FROM a non-technical friend, living in north Yorkshire, I have received the following account of a narrow escape from a completely unnecessary outlay on his television outfit, which I hope the B.B.C. and the I.T.A. will note, inwardly digest and act upon. It was his very first television receiver. The dealer brought it to his home; went up aloft to fit the aerial and then proceeded to adjust. Try as he would (and did) the said dealer could obtain none but the poorest pale, jittery picture. "Can't understand it," he said at last; "we generally find reception excellent hereabouts. This must be a bad spot and the only thing I can do is to fit a more elaborate aerial array; that'll cost you another £11." Feeling that it was no good spoiling the ship for want of a ha'porth of tar, my friend agreed. The dealer went his way, promising to bring the other aerial next morning. That evening my friend switched on the set just to see what it would do. To his utter astonishment, a perfect picture appeared on the screen as soon as the valves had warmed up. Ringing up a neighbour, he found that owing to one of those technical hitches Holme Moss had been transmitting on much reduced power earlier in the day. He was fortunately able next morning to telephone the dealer in time to prevent him from coming out with the extra £11 worth of aerial equipment.

Letting Them Know

The point is that neither he, nor the dealer (who acted in perfect good faith) knew, or had any means of knowing, that when the receiver was installed the transmitter was working with much reduced power output. One wonders (a) how many needlessly elaborate aerial arrays are installed by honest dealers when such mishaps occur at TV transmitting stations and (b) how much worried knob-twiddling is done by viewers, who fear that the worst, or something very like it, has happened to their sets. My correspondent makes a suggestion which I regard as eminently reasonable and recommend to both the B.B.C. and the I.T.A. for serious consideration. It is this: when for one reason or another the output power is reduced there should be superimposed on the picture some agreed and unmistakable indication that signal strength is below par.* I'm sure that such a system of notification would be warmly welcomed.

* B.B.C. stations which rely on the radiated signal from another station for retransmission do superimpose a white bar on the picture when the received signal is below par.—Ed.

UNBIASED

By FREE GRID

Undebunking Wrotham

I DON'T suppose that the word "undebunking" has the slightest etymological justification but as it exactly suits my purpose, I make no apology for coining it.

As every reader of *Wireless World* knows, the B.B.C. has, in past years, experienced increasing difficulty in providing a reliable broadcasting service throughout the country due to the ever-increasing number of Continental stations struggling for existence in a restricted ether space.

Like the Empire builders of old, the B.B.C. decided to emigrate to the wide open spaces and these they have found up among the higher frequencies. There is plenty of elbow room there and as everybody knows it is *possible* to transmit a wide a.f. band without falling foul of other stations. Now it was, I think, the undue publicity given to this latter fact that led many people to believe in the equation v.h.f./f.m. = Hi-Fi. This belief has, however, been successfully debunked in *Wireless World* and elsewhere. It has been pointed out that the a.f. band is limited by the technical characteristics of the G.P.O. lines which feed the programmes to the transmitter.

Now it has always been my privilege to disagree with my technical betters and I cannot help feeling that this debunking process has been carried a little too far and a little undebunking is necessary. I would make bold to say that Wrotham *does* provide a very real hi-fi service to that section of the community it is intended to serve. To use a simple analogy; to a man born and brought up in a boiler factory a journey in a London tube would seem like Nirvana itself whereas to anybody used to the peace of Juan Fernandez it would be like hell on earth.

My technical betters.

It is all a matter of relativity. I cannot believe that the ardent debunkers, technically correct as they undoubtedly are, realize what the radiations of Wrotham mean to thousands of listeners who, for years past, have had their music mixed up with monkey chatter from the Continent as well as local man-made interference. To a starving man a meal at a coffee stall seems like a Lucullan repast.

All that I have said does not contradict the fact that none of us can have real hi-fi broadcasting in our homes until the limitations of the G.P.O. landlines have been overcome. The Germans have shown us one way out of the difficulty; maybe we can cap this with a better one.

Do You Know?

WHILE browsing through the pages of the November issue of *Wireless World* my attention was caught by a paragraph with the above heading (on page 571). I found that I was stumped by the very first item of the quiz as I couldn't say off-hand what is the correct element length of a Band II aerial. I eagerly read the remaining queries expecting to be directed to another page for the correct answers.

I must confess to a slight feeling of annoyance when I found that I was referred to the 1956 *Wireless World* Diary for the answers. This feeling soon passed, however, and I hurried round to the local stationers to buy my copy. I was glad to find I had scored quite a high percentage of success in my answers. I do think, however, that the Editor might have offered a prize of a diary for an all-correct solution even though I myself would not have won one. I doubt if any of you would have done so either; in fact I feel so strongly about it that I will pay for a diary for any of you who can send the Editor an all-correct solution without looking in the diary or other reference books.

The Televisaphone

THE THREAT of the televisaphone, or in other words the marriage of television with the telephones, draws ever nearer. It is inevitable that one day sight will be added to sound on our telephones and we shall no longer be able to answer the phone in our *negligé*.

The favourite blonde.

I cannot think that this invention is one which is wanted by anybody, but by a slight modification it could be made into a boon and a blessing to man. As at present planned the screen will be switched into circuit at the same time as the mike and earpiece by the lifting of the handset. What is wanted, however, is that the energizing of the bell operates a relay which switches on the television screen so that we can see our caller *before* we answer the phone.

At present when the bell rings we haven't the remotest notion whether the person at the other end is our favourite blonde or our Aunt Maria. In order to find out, we are compelled to say "hallo" and if it happens to be Aunt Maria or somebody equally objectionable there is no escape as our voice will have given us away.

I do admit that my idea is one which could be abused. There would be nothing to stop an unscrupulous person like the local rate collector from ringing me up and hiding his face behind a lifesize photo of a fascinating female. Therefore until this difficulty can be overcome I think it better not to have video added to the audio of our telephones.

Science Fiction

HAVING so much to do with scientific truth in *Wireless World* it is not surprising that science fiction has little appeal for me. However, I have read some of it and I cannot help being struck by the lack of imagination of certain writers. Dealing as they do with marvellous space ships of 1985 or thereabouts they still seem to be using the radio techniques of 1955.

When the commander of one space ship talks to another by radio he still calls out "over" as a signal to his opposite number to switch over from receive to transmit. Even in 1955 we are getting beyond this stage; in 1985 this "over" business will be as remote as the coherer is to-day.