Wireless World

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Objectives in Sound Reproduction

COMPLAINTS are being voiced on both sides of the Atlantic about abuse of the term "high fidelity," which is applied indiscriminately to all sorts and conditions of sound reproducing equipment. There is now a demand for definition and standardization of "high fidelity," in order that those who think they have it may establish a clear advantage over the "have nots."

We have ourselves condemned the term for its inherent (adjectival) redundancy, and would now go further and question the value—even the ethics—of any definition limited to the measurable characteristics of an electro-acousic reproducing system. So many other factors are involved in the establishment of an acceptable standard of sound quality—the mind of the listener, the fact that his binaural faculties are being applied in a different environment to that of the microphone(s), and that someone else has already modified the sound to a form which they think will be acceptable by the time it reaches the hearer.

The importance of modification of the sound at its source was apparent from a lecture given recently to the Acoustics Group of the Physical Society by Dr. F. W. Alexander and T. Somerville on "Acoustic Technique in Broadcasting." The sounds which please listeners to broadcast "swing" music bear little resemblance to what would be heard by an audience in the studio. Muted brass, sub-tone clarinets and other special effects which are practically inaudible in the original blend of sound are brought into prominence by a multiple microphone mixing technique. As many as ten microphones may be used to produce the desired effect—that of "sitting in" with the players. The concert-goer, on the other hand, expects the atmosphere of the hall as a background to the music and a single microphone carefully placed gives the right blend of direct and reverberant sound. But it is not a *faithful* reproduction of the impression which a listener would receive if he took his own ears (and brain) to the same spot.

Binaural and stereophonic systems are capable of producing new and often acceptable experiences for the listener, but they are artificial and even the binaural system cannot hope to give faithful reproduction unless the shape and acoustic characteristics of the artificial head containing the microphones are a replica of those of the listener, who even then must keep as still as a dummy.

A recent demonstration of stereophony by J. Moir at a B.S.R.A. meeting gave support for the view that under favourable conditions a two-channel system with a bandwidth of 7.5 kc/s is capable of giving more acceptable results than a 15-kc/s single-channel system. But equally convincing recorded demonstrations were given by Alexander and Somerville of the realistic quality which can be simulated in a single channel by attention to studio design and the judicious admixture of reverberant sound, either by choice of microphone characteristics and placing, or by a magnetic recording technique using multiple heads to synthesize an "ideal" reverberation characteristic.

We have wandered rather far from our opening theme, far enough perhaps to see that too narrow a preoccupation with the minutiæ of equipment design may prevent us from making bold strides in other directions.

Since fidelity (of any degree) is impossible, let us set about finding the factors which introduce any incongruity into the sound—the factors which proclaim it as "canned." It is not so necessary to be able to hear that a violinist is playing on a Strad or an Amati as that he should not seem to be bowing a banjo; symphony orchestras should not sound as if they were performing either in a seaside bandstand or in Blackwall Tunnel; a lieder singer should not seem to have the physique of the Statue of Liberty.

A prescription for a good sound reproducing system should start with a specification of the listener himself. In what respects is his hearing acute and where is it open to aural illusion? What microphone and transmission technique will most economically preserve illusion, and what characteristics must be *excluded* from the reproducing equipment as being liable to introduce elements which, without reference to the original, will be self-evident incongruities.

RENÉ BARTHÉLÉMY

This appreciation is written by E. Aisberg, Editor of *Toute la Radio*, Paris.

IN René Barthélémy, who died on February 16th, France has lost a pioneer who made no small contribution to the progress of television.

Born in 1889, he qualified as an electrical engineer at the Ecole Supérieure d'Electricité. His choice of wireless as his field led to an association with General Ferrié In 1925 he foresaw the coming of the first mains-operated wireless receiver; but thenceforward his interest was centred on television, at that time in the early stages of its development. His first 30-line, scanning-disc system was completed in 1928. It was at about that time that he forecast the coming of synchronization by the application of pulses to a tuned oscillator in the receiver.

Under Barthélémy's direction, the Compagnie des Compteurs formed its Television Research Centre on the outskirts of Paris. Picture transmissions from this Centre enabled a highly successful public demonstration to be given in the theatre of the Ecole Supérieure d'Electricité on April 14th, 1931.

The Ministère des P.T.T. (which corresponds to the British G.P.O.) then began to take a real interest in television. Regular transmissions were started with equipment designed by Barthélémy, first with 30 lines, then progressively with 60, 90 and (in 1935) 180 lines, leading up to the adoption of 445-line standard in 1937.

In a remarkable demonstration at the Marigny Theatre in Paris in 1939 Barthélémy showed televised pictures on a screen with an area of 4 square metres.

The outbreak of the war put an end to the transmissions, but not to Barthélémy's activities. He went to work on the development of a new type of camera, using a slow-electron tube, and succeeded in producing a system with 1,000-line scanning and big-screen reproduction.

He was elected a Member of the Académie des Sciences in 1947 and on the very day of his death his promotion to the rank of Commander of the Legion of Honour was announced. The painful malady from which he suffered for more than 20 years never succeeded in damping his creative spirit, or in halting his persevering work.

TELEVISION OSCILLATOR RADIATION

AN investigation into the amount of radiation from the local oscillator of superheterodyne-type television receivers has recently been made under the auspices of B.R.E.M.A. As a result of this, the Executive Council of the Association has approved recommendations on limits for the radiation and on standardized methods of measurement.

When the fundamental, or a harmonic, of the frequency of the local oscillator falls in Band I the limits are 20 μV/m for direct radiation, 200 μV for aerial-terminal voltage and 500 μV for mains-borne interference. The same limits are tentatively recommended for Bands II and III. When the fundamental, or a harmonic, of the frequency of the local oscillator falls outside Bands I, II and III, the limit of 50 μV/m is recommended for frequencies up to 100 Mc/s and temporarily for higher frequencies also.

For the radiation test the receiver is connected to 10ft of aerial feeder terminated properly at its remote end. The measurement of field strength is made at a distance of 10 metres. The aerial-terminal voltage is measured across the aerial terminals when terminated by 75 Ω. Mains-borne interference is measured across a standard isolating unit connected in the supply leads.

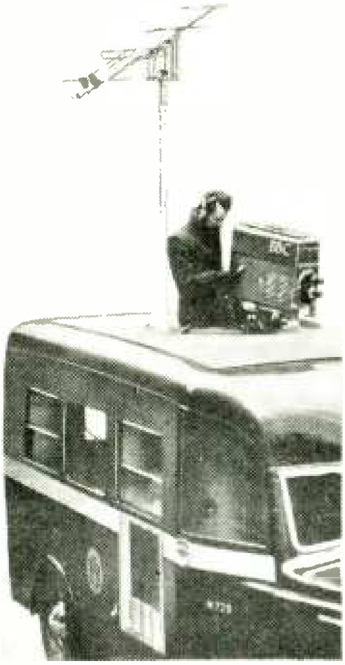
A few only of existing receivers seem to give lower interference figures than the proposed limits and some give much higher figures. Radiation figures as low as 5 μV/m and as high as 890 μV/m were found in the tests. The limit of 20 μV/m thus seems a reasonable one which should result in a considerable reduction of interference.

TECHNICAL WRITERS who, at a recent luncheon, were awarded 25-guinea premiums by the Radio Industry Council for articles published last year. Left to right, A. W. Keen (Coventry Technical College), Alan Brisbane (Enfield Technical College), A. H. Beck (Standard Telecommunication Laboratories), Joyce E. Seaborn (Ministry of Supply), H. M. Davis (Ministry of Supply), J. R. Pollard (Ericsson Telephones) and G. G. Gouriet (B.B.C. Research Deparment).

WORLD OF WIRELESS

P.O. Station Extensions • Set Makers' Problems

V.H.F. Stations • International Conferences



ROVING EYE.—The four-element Yagi array on this mobile B.B.C. television unit is controlled by a gyro-compass ensuring that the aerial is directed towards the receiving point while the van is moving. It operates in the 200-Mc/s band and in central London has a range of about two miles. The camera can be rotated through 360°.

Rugby Extensions

THE POST OFFICE STATION at Rugby was brought into service in 1925 with one long-wave telegraph transmitter, GBR, operating on 16 kc/s (18,750 metres). It now has three long-wave and 20 short-wave transmitters in addition to transmitters for the Standard Frequency Transmission Service (MSF) operated for the Department of Scientific and Industrial Research.

The need for still further services is to be partly met by a major expansion. An additional site of 700 acres (the original was 900 acres) has been acquired and a new building to house a further 28 short-wave transmitters is approaching completion. Twenty of them are expected to be in use by the end of the year. The transmitters are designed for multi-channel independent-sideband operation, which is now generally accepted for international radio-telephone services, and can alternatively be employed as multi-purpose transmitters catering for several types of telegraph service. The transmitters are rated at a peak envelope power of 30 kW and can be remotely controlled from a central control position.

Some 50 rhombic aerials between 600 and 1,000ft along the major diagonal are being erected at heights between 70 and 150ft. To cater for the variations in the optimum directions of transmission to New Zealand, which is nearly antipodal to Rugby, three steel masts 320ft high are being erected to support the aerial arrays for this service.

Set Makers' Report

IN ITS REVIEW of the past year the annual report of the British Radio Equipment Manufacturers' Association, which is of course concerned with the broadcast receiver side of the industry, covers exhaustively both the technical and organizational aspects of the year's work.

Many of the industry's problems have in the past been resolved as a result of the close liaison which has existed with the B.B.C. The proposed setting up of the Independent Television Authority to provide an alternative television programme introduces new problems. Many of the technical problems will be common to both organizations and B.R.E.M.A. has, therefore, submitted to the Government a recommendation that a central body with which the industry can deal be appointed. The Association has set up a Colour Television Sub-Committee to make a broad survey of possible systems, for "better and more practicable colour systems [than N.T.S.C.] are not impossible."

F.M. Transmitters

FIFTY frequency-modulated transmitters (26 Marconi and 24 S.T.C.) have been ordered by the B.B.C. in readiness for the Government's "go ahead" on setting up a v.h.f. chain. No details are officially available regarding the location of the transmitters but the P.M.G. has stated that the first station will be erected at Pontop Pike, Newcastle.

The transmitters, which will operate in parallel pairs, each pair handling one programme, vary in power from 1 to 10 kW. It is understood delivery will begin in about 12 months' time.

Aeronautical Communications

TECHNICAL REPRESENTATIVES of 25 countries are meeting in Montreal for the fifth session of the Communications Division of the International Civil Aviation Organization. Among the various items on the agenda are long-range navigational aids, secondary radar, methods of improving air-to-ground communications and the testing of navigational aids. There will also be a review of frequency and fixed telecommunications problems.

The United Kingdom delegation includes representatives of the Post Office, the Ministry of Transport and Civil Aviation and the radio communication industry. Among the industry's representatives, some of whom are attending as observers and not as official delegates, are K. E. Harris (Cossor), E. R. Bonner (Decca), W. H. Thompson (Ferranti), L. M. Layzell (International Aeradio), Dr. B. J. O'Kane (Marconi's), G. L. Warner (S.T.C.) and H. G. Sturgeon (Ultra). The delegation is led by J. C. Farmer, deputy director of telecommunications in the M.T.C.A.

International Television

DELEGATES from Belgium, Denmark, West Germany, Italy, Netherlands, Switzerland, United Kingdom and Yugoslavia recently met in Cologne as a working party of the European Broadcasting Union to discuss the technical problems relating to international television relays. They were particularly concerned with the series of relays planned for June and July. Decisions were arrived at regarding tolerances, shape of the sync signals and methods of testing. An *ad-hoc* group of engineers under M. J. L. Pulling (B.B.C.) is meeting programme representatives of the various participating countries at Cannes at the end of March to make final arrangements.

The working party concerned with v.h.f. and u.h.f. sound and television broadcasting also met in Cologne with delegates from seven of the countries (the U.K. was not represented).

During the meeting the German authorities demonstrated the prototype of a simple frequency changing television transmitter for use at satellite stations to provide a strong signal in Bands 4 or 5 in towns where reception of Band 3 transmissions is impracticable without a complicated aerial. By utilizing the double superheterodyne principle the received signal is converted into the desired band without demodulation and without separating the sound and vision components. An adaptor for use with standard television receivers was also demonstrated.

R.E.C.M.F. Report

TWO annual radio shows—one public and one industrial—are suggested by the Radio and Electronic Component Manufacturers' Federation in its 21st annual report. The National Radio Show would cater for all domestic equipment, and a "National Electronic Show" would serve the heavy equipment and professional field. The two shows might even be housed under one roof or at least run concurrently.

In its review of the export market the report records that India was again the principal customer for British radio components, followed by Australia and the U.S.A. A feature of the 1953 exports was the volume of sound recording and reproducing equipment sold.

In the section dealing with the technical activities of the Federation it is recorded that the British Standard defining conditions for the climatic and durability testing of components is in the hands of the printers.

Industrial Electronics

SOME 30 PAPERS will be presented at the Industrial Electronics Convention being organized by the British Institution of Radio Engineers from July 8th to 12th in Christ Church, Oxford University. The programme is divided into six sessions:—(1) Industrial Applications of Electronic Computors (chairman L. H. Bedford); (2) Industrial Applications of X-rays and Ultrasonics; (3) Nucleonic Instrumentation and Application (chairman N. C. Robertson); (4) Electronic Sensing Devices—Transducers (Professor E. E. Zepler); (5) Actuators (J. L. Thompson) and (6) discussion on How Electronics Can Increase Production.

Particulars of the programme and registration forms are obtainable from 9, Bedford Square, London, W.C.1. The fee for the convention, exclusive of accommodation, is 9 guineas.

P.A. Show

SOUND REPRODUCING and recording gear will be shown by twenty manufacturers at the two-day exhibition sponsored by the Association of Public Address Engineers which opens at the Horseshoe Hotel, Tottenham Court Road, London, W.1, at 10.0 on April 28th. Admission to the show, which closes at 8.0 on the first day and at 6.0 on the second day, is by ticket, obtainable from the Association, or on the production of this issue of *Wireless World*. The exhibitors include:—Film Industries, G.E.C., Goodmans, Grampian, Leak, Lowther, Lustraphone, M.S.S., Mullard, N.S.R. Manufacturing, Pamphonic, Reosound, Reslosound, Rola Celestion, Trix, Truvox, Vitavox and Whiteley.

Physical Society Show

THE 38TH annual exhibition of scientific instruments and apparatus organized by the Physical Society opens at the Imperial College, Imperial Institute Road, London, S.W.7, on April 8th for five days. It opens daily at 10.0 and will close at 8.0 on the 8th, 9th and 12th, and at 5.0 on the 10th and 13th. Admission is by ticket, valid for a specific session or day, obtainable free from the Society, 1, Lowther Gardens, Prince Consort Road, London, S.W.7. We hope to survey in a forthcoming issue of *Wireless World* the electronic techniques in research and measurement portrayed at the exhibition.

During the show a series of lectures will be given. The Acoustics Group of the Society has arranged a symposium on "Analysis, Synthesis and Recognition of Speech." This will be held in the Imperial College on April 12th under the chairmanship of Dr. Colin Cherry. Copies of the six papers to be delivered during the two sessions (2.0-5.45 and 6.45-8.15) are obtainable beforehand by those applying to the Society for tickets.

PERSONALITIES

J. A. Saxton, D.Sc., Ph.D., M.I.E.E., author of the article in this issue on the propagation of television, graduated in physics in 1935 at the Imperial College of Science and Technology, and in 1938, after serving on the staff of the Physics Department of the College, joined the Department of Scientific and Industrial Research. For the past 16 years he has been mainly concerned with research on various aspects of radio wave propagation, particularly at very high frequencies. Dr. Saxton is now a principal scientific officer in the Radio Research Organization of D.S.I.R. He has twice been seconded to the United Kingdom Scientific Mission, Washington, in 1945 and 1950, to act as radio-physics liaison officer for the Mission.

P. E. Pollard, O.B.E., B.Sc., has been appointed Director (Guided Weapons and Electronics) Technical Services of the British Joint Services Mission in Washington. Trained as a physicist under Professor (now Sir Edward) Appleton at King's College, London, he has been in the Scientific Civil Service throughout his working career and was for six years, from 1947, chief superintendent of the Radar Research and Development Establishment, Malvern. Mr. Pollard was among the 21 successful claimants for awards to radar pioneers made by the Royal Commission on Awards to Inventors two years ago. His claim was in respect of radar ranging systems and radar beacons.

As announced last month, the Royal Commission on Awards to Inventors recommended awards totalling £15,000 to seven claimants in respect of their work on the development of the proximity fuze. **H. Cobden Turner**, M.I.E.E., managing director of Salford Electrical Instruments and its subsidiary, British Ferrocart, Ltd., who shares £11,500 with three other claimants, joined the G.E.C. as an apprentice after gaining a diploma in engineering at the Manchester College of Technology. He subsequently went to Ferranti and later became chief designer with the Electrical Apparatus Company before joining Salford Electrical Instruments.

W. B. H. Lord, M.A., M.Sc., one of the four who share the £11,500 award, was a radio engineer with Salford's, but is now a principal scientific officer at the Atomic Weapons Research Establishment, Aldermaston. During part of the war he was with the Inter-Services Research Bureau. Mr. Lord has held an amateur transmitting licence (G5NU) since 1935.

G. M. Tomlin, M.B.E., and **L. Rollin**, who also share the above award, both received their technical education at the Manchester College of Technology. Mr. Tomlin was employed on radio and television research and development with Ferranti at Moston, from 1932 until 1938, when he joined Salford Electrical Instruments. Mr. Rollin joined the staff of Salford's in 1939 on leaving Philco's. He has recently been in charge of research and development of quartz crystal and magnetic material.

Andrew Stratton, M.Sc., A.M.I.E.E., F.Inst.P., recipient of a £2,000 award from the Royal Commission on Awards to Inventors, graduated from University College, Exeter, in 1939, and has been head of the proximity fuze section of the Armament Department of the Royal Aircraft Establishment, Farnborough, since 1945. He joined the R.A.F. Air Defence Department in 1939 and worked on proximity fuzes under N. Coles and G. A. Whitfield, who each received an award of £750. Mr. Stratton's work on the fuze resulted in the invention of a new form of oscillator detector system for radio fuzes and in 1942-43 he spent six months at the National Bureau of Standards, Washington, introducing this system into American fuzes.

M. M. Macqueen, manager of the Radio and Television Department of the General Electric Company, is on a month's visit to the U.S.A. to examine American electronic developments, including colour television. He has been elected chairman of the Council of the British Radio Equipment Manufacturers' Association for 1954.

J. de Gruchy, contributor of the article on the protection of meters in our September, 1953, issue, has left the Electrical Apparatus Company, of St. Albans, Herts, where he was head of the Instrument Department, and has started his own company. Among the equipment being produced by the new company—the Clare Instrument Company, Rickmansworth, Herts—is the protected moving-coil microammeter described in the September issue.

S. J. Preston, M.A.(Cantab.), A.M.I.E.E., representative of E.M.I. on the Council of the Radio Communication and Electronic Engineering Association, has been elected vice-chairman of the Council for 1954. Mr. Preston is one of the chief executives of the E.M.I. Patent Department.

K. G. Thorne, A.M.I.E.E., A.M.Brit.I.R.E., chief engineer of S. Smith and Sons (Radiomobile), Ltd., since the company commenced marketing operations in 1946, has resigned to take up an electronics appointment with the Canadian Government. He is succeeded by **W. A. Crossland, A.M.I.E.E., A.M.Brit.I.R.E.**, service manager for the past three and a half years. **H. M. Mellor** has been appointed service manager with the company, which is owned jointly by the Gramophone Company and Smiths Motor Accessories.

D. C. Espley, O.B.E., D.Eng., M.I.E.E., chief engineer (telecommunications), G.E.C. Research Laboratories, Wembley, was recently elected a Fellow of the American Institute of Radio Engineers "for his creative contributions to microwave and television techniques in England."

IN BRIEF

The **Three-million Mark** in television licences in the United Kingdom was passed in January; the total at the end of the month being 3,105,644. There was a record increase of 148,798 during the month. The total number of broadcast receiving licences (both for sound and television) at the end of January was 13,315,969, including 221,458 for car radio sets.

Royal Signals Institution.—Readers who have held commissions in the Royal Signals may be interested to know that a Royal Signals Institution has been formed to further the professional and technical interests of the Corps, and maintain contact with those no longer serving. Membership is open to all serving and ex-officers of Royal Signals in the British and Commonwealth forces. The subscription is 15s a year. Full particulars, and application forms for membership, can be obtained from the honorary secretary, Lt.-Col. N. G. Newell, Ministry of Supply, Room 419, Castlewood House, 77/91, New Oxford Street, London, W.C.1.

Colour Television.—Applications for attendance at G. G. Gouriet's Fleming Memorial Lecture on "Colour Television" in February were such that the Television Society has arranged for it to be repeated on April 13th and 15th at the Institute of Education, Senate House, Malet Street, London, W.C.1. Admission to the two meetings, which are complementary, is by ticket costing 5s, obtainable from the Society, 164, Shaftesbury Avenue, London, W.C.2. The lectures will begin at 7.0.

B.R.E.M.A. Council.—The following member firms of the British Radio Equipment Manufacturers' Association have been elected to the executive council for the ensuing year. The names of the companies' representatives are in parentheses:—Balcombe (E. K. Balcombe); Bush (G. Darnley Smith); Cole (G. W. Godfrey); Cossor (J. S. Clark); English Electric (D. C. Spink); Ferguson (L. Bentley-Jones); G.E.C. (M. M. Macqueen, chairman); Gramophone Co. (F. W. Perks); Kolster-Brandes (P. H. Spagnoletti); Philips (A. L. Sutherland); Pilot (H. L. Levy) and Ultra (E. E. Rosen).

R.E.C.M.F. Council.—The member firms and their representatives constituting the Council of the Radio and Electronic Component Manufacturers' Federation for 1954 are: Automatic Coil Winder (R. E. Hill); British Moulded Plastics (J. H. Bridge); Garrard (Hector V. Slade); Hunt (S. H. Brewell); Multicore (R. Arbib); N.S.F. (K. Graham Smith); Painton (C. M. Benham, vice chairman); Reliance Electrical Wire (C. H. Davis); Telegraph Construction & Maintenance (W. F. Randall, chairman).

Semiconductors.—An international conference on semiconductors is to be held in Amsterdam from June 29th to July 3rd by the Netherlands Physical Society. Admittance to the conference, which is being supported by U.N.E.S.C.O. and the International Union of Pure and Applied Physics, is free and applications for participation should be made to Dr. H. J. Vink, Floralaan 142, Eindhoven, Holland. The subjects to be considered include bulk and surface properties, intermetallic compounds, photoconductivity and the application of general physical and chemical laws for the preparation of semiconductors with specific properties.

Radio Heating and industrial electronic measuring instruments are featured in a new film on the application of electrical and electronic aids to industry. Entitled "A New Approach to Production Improvement," it runs for 50 minutes and can be borrowed free of charge by engineering societies, technical colleges, etc., from Philips Industrial Application Centre, 122, Brixton Hill, London, S.W.2.

Radio-Controlled Models.—The annual international contests for radio-controlled models, organized by the International Radio Controlled Models Society, will be held in Birmingham on July 10th and 11th. The first day will be devoted to contests for model boats and the second for model aircraft. Entrance forms and further particulars are obtainable from H. Croucher, 27, St. John's Road, Sparkhill, Birmingham, 11.

Abstracts and References.—Each month some 300 abstracts from and references to articles appearing in the world's technical press are published in our sister journal *Wireless Engineer*. The index to those published in 1953 was included as a supplement to the March issue, which is obtainable from our Publisher price 6s 6d.

"Trader Year Book."—The 1954 edition of this mine of information on radio trade and servicing matters has just been issued by the Trader Publishing Company. In addition to directories of manufacturers, wholesalers and proprietary names, it includes tables of i.f. values of sound receivers marketed since 1947, condensed specifications of some 550 current sound and vision receivers and valve and c.r.t. data. It costs 11s by post.

INDUSTRIAL NEWS

Baird Television, Ltd., has amalgamated with the Hartley group of companies and will now be known as Hartley Baird, Ltd. It will continue to produce Baird television receivers. The Hartley group includes Hartley

Electromotives, Ltd., designers and manufacturers of electronic equipment and instruments, with a factory at Shrewsbury, Shropshire, and Duratube & Wire, Ltd. A. W. M. Hartley, managing director of the Hartley group, will be managing director of Baird's and Sir Charles King will continue as chairman.

Hunt Capacitors (Canada), Ltd., has been formed, with K. A. Jackson, formerly of the Canadian Marconi Company, as general manager and R. A. Grouse, of A. H. Hunt, Ltd., as technical director, to manufacture capacitors for the Canadian market. The products of the new company, which has its works at Ajax, Ontario, will be marketed by the Electronic Tube and Components Division of the Canadian Marconi Company, Toronto.

Transradio, Ltd., claims to be the first British component manufacturer to exhibit at the Radio Engineering Show in New York, which was held this year from March 22nd to 25th. The managing director, B. Zucker, and the sales manager, N. Stephenson, attended the show, where their sub-miniature connectors and high-impedance precision connectors were featured.

Marconi Instruments, Ltd., have added a new wing to their factory at Longacres, St. Albans, Herts. It has more than trebled its size since the company's works were centralized there some seven years ago.

Dollar Order.—B.T-H., Ferranti and G.E.C. share an order for $6.5M worth of electronic equipment and associated test gear from the U.S. Navy Department. The equipment will be installed in ships and ground stations as part of the defence programme of the North Atlantic Treaty Organization.

Trinity House Pilotage Service is being equipped with Pye v.h.f. radio-telephone gear by **Rees Mace Marine** to facilitate boarding and pilotage information being passed to pilot vessels in the Dungeness, Dover and Harwich areas. Shore stations are being installed at Harwich and Dover and six vessels are being equipped.

J. & S. King, of 210, Lillie Road, Fulham, London, S.W.6, point out that they were operating a comprehensive television maintenance scheme in 1948, which was two years earlier than implied in our note on "C.R.T. Insurance" in the December issue.

The Sales Department of **Invicta Radio, Ltd.**, has moved from the head office to 100, Great Portland Street, London, W.1. (Tel.: Langham 5742.)

MEETINGS.—Details of the April meetings will be found on page 201.

BAND III TEST TRANSMITTER

THE B.B.C.'s plans for an alternative television service in the v.h.f.-u.h.f. region have recently taken a more practical turn. The Corporation has ordered from Mullard six low-power transmitters for experimental work (notably field-strength measurements) in Bands III, IV and V, and the first of these, for Band III, has now been completed.

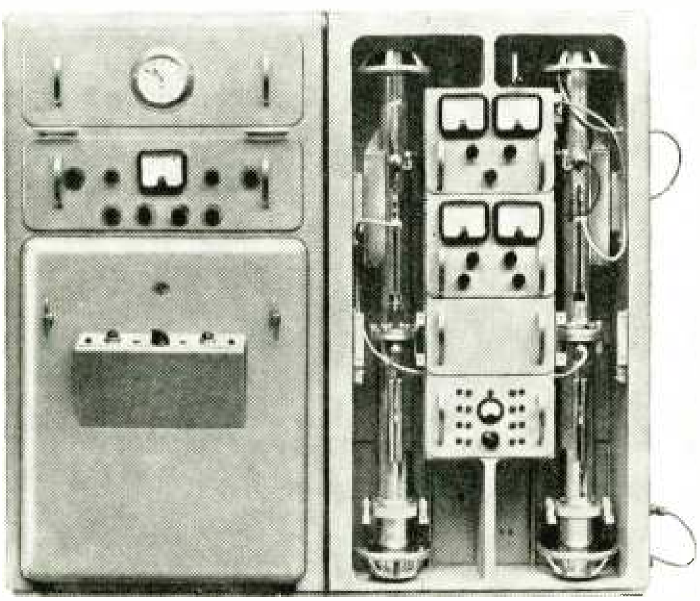
This transmitter, like all the others, is designed to be continuously tunable over the whole of its band—in this case from 174 Mc/s to 216 Mc/s Coaxial resonant lines are used in the last two stages, with the valves inside them, and the tuning is done by winding plungers up and down to vary their effective lengths.

Provision is made for two types of modulation. The first is a square wave of 1,000-c/s repetition frequency, and this gives 100 per cent modulation with a peak power output of 600 watts. (On plain c.w. the r.m.s. power output is 150 watts.) The second type of modulation is a 0.5-μsec pulse, also of 1,000-c/s repetition frequency, which gives a peak power output of 15-18 kW. With these very short pulses it will be possible to investigate the effects of echoes and multi-path transmission. Both sources of modulation are crystal controlled and a quick change-over can be made from one to the other.

On narrow-pulse modulation the output stage (which uses an earthed-grid triode) is operated in a self-oscillating condition. This is obtained by inserting a feedback connection between anode and cathode in the form of a short cylinder round the valve.

The equipment is constructed on the unit principle and is intended to be carried about in a van. It will cope with large variations in mains supply voltage and is designed so that routine measurements at different frequencies can be made by non-technical operators.

The transmitters for Bands IV and V will be similar, but will include additional drive units and the output powers will be lower. On c.w. the outputs will be 100 W and 50 W respectively and when modulated will be proportionately lower than in the Band III model.



Complete v.h.f. transmitter with front cover of the right-hand unit removed. The coaxial lines for the r.f. drive and the amplifier can be seen on the left and right of the panels. The upper parts of the lines can be raised by a hydraulic lift for valve removal.

The Transistor in Hearing Aids

2.—*Design for Use with RC Couplings Throughout*

By S. KELLY*

IN a previous article[1] the writer described experiments with junction transistors. At that time the only transistors available in this country were imported from the United States of America. It was therefore principally a matter of economics to design an amplifier with a maximum possible overall gain using the minimum number of transistors. Recently, British-produced junction transistors have been made available in experimental quantities, and the present dissertation gives the results of some experiments with the Mullard transistors Type OC10, OC11 and OC12. The OC10 transistor is a low-noise *p-n-p* type unit for use in the initial stage, the OC11 is an intermediate amplifying unit, and the OC12 is for use in the output stage. In common with other types of germanium transistors they are temperature sensitive and the parameters are subject to the normal amount of spread. The temperature limitation is 45 deg C and in the writer's experience no germanium transistors, either American or British, currently available for civilian use will withstand temperatures much in excess of 45 deg C at 95-97 per cent humidity for any period of time. The fact that home-produced transistors were available at something less than a king's ransom encouraged the writer to construct a second amplifier which would, as far as possible, eliminate the defects of the original unit.

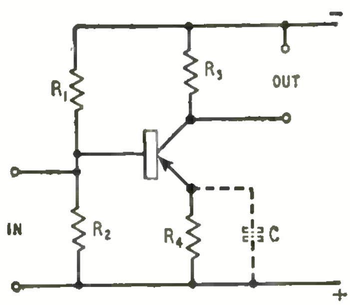


Fig. 1. Basic earthed-emitter circuit.

Cascading Transistors.—Transistors can be used in either earthed base, earthed emitter or earthed collector configurations, and when several stages are connected together the overall power gain will be a function of the individual circuit arrangements. There are nine combinations for two transistors. In practice the most efficient arrangement is earthed-emitter to earthed-emitter, which results in high voltage, current, and power gains. The earthed-base to earthed-emitter is a second best for power gain, but the input impedance is usually fairly low. The third best arrangement is earthed-collector to earthed-emitter; it has good voltage and power gain, and the very high input impedance is advantageous for use with crystal microphones, pickups or other high-impedance devices. The other combinations are seldom used in practice, but when both *n-p-n* and *p-n-p* junction transistors are available, unique circuit arrangements will be possible; by cascading *n-p-n* and *p-n-p* units together complementary symmetry can be obtained. This may be defined as (1) under normal working conditions the current of the *n-p-n* transistor will be negative of the corresponding electrode current of the *p-n-p*, and (2) the polarity of an input signal will be opposite in each transistor with the same increase of output current. Under small signal conditions the equivalent circuits of the two types of transistors are identical; the major advantages to be gained by using these symmetrical circuits is in the biasing arrangements, in that if the first transistor (say *n-p-n*) is stabilized the succeeding stage (*p-n-p*), which is d.c. coupled to it, is also stabilized. This results in a considerable economy of components and at the same time makes for very stable operation.

Circuit Requirements. — The amplifier previously described suffered from two disadvantages:

(1) The miniature transformers used had, of necessity, a poor low-frequency response due to the small amounts of iron and copper. This in itself is not a disadvantage for hearing-aid amplifiers in which bass cut is deliberately introduced, but for other applications it could prove a serious obstacle. The solution is to use (a) larger transformers with their attendant disadvantages of increased weight, volume and cost, or (b) RC coupling which requires more transistors. The final solution will be determined by the ratio of transistor to transformer cost, availability and space considerations, and strictly comes under the heading of Production Engineering.

(2) Variation of individual transistor parameters. This is a serious problem, especially in the output stage. If the base resistor (we are now assuming earthed-emitter circuits) is adjusted to give a collector current of, say, 2 mA with a particular transistor, it will be found that the collector current will vary from about 1.4 to 4 mA with different transistors, due principally to the variation in base current of individual transistors. If steps are not taken to reduce this variation, provision must be made for varying the base resistor for each individual transistor, with all its complications of maintenance and servicing. The same is true of the early stages, although to a lesser extent.

In order to use transistors successfully the maximum effective variation of gain and collector current at a given supply voltage should not exceed 10 per cent for a change of any individual transistor. In other words, taking the top and bottom limits for a particular type of transistor, they should be success-

* Cosmocord, Ltd.
[1] *Wireless World*, Feb., 1954, p. 56.

fully interchanged with a variation of collector current and gain not exceeding ±10 per cent.

Earthed Emitter.—The collector current is almost independent of collector voltage and is determined by the emitter current; the emitter current in turn is determined by the bias applied to the base. The problem then resolves itself in rendering the circuit constants independent of transistor variations, and the simplest way of doing this is the application of negative feedback. This is most easily obtained by fitting a resistance between the emitter and earth[2].

The base voltage in the circuit of Fig. 1 is controlled by the potential divider R_1 and R_2, the emitter current by R_1, output being taken across R_3. The collector current and load impedance will be specified on the transistor data sheet, and the value of R_1 will be determined by the ratio of stabilization required. This has been provisionally set at ±10 per cent.

To meet the above stability specification in the output stage, R_1 should be of such a value that approximately 30 per cent of the available supply voltage is dropped across it, and the value of 680 Ω is about right. R_3 is the d.c. resistance of the load impedance and it is usual for insert telephone receivers to be fed directly from the output transistor rather than from a transformer. These telephone receivers have a polarized connecting plug in order that the magnetizing current will always be in the correct direction, a d.c. resistance of about 300 Ω and a nominal impedance at 1,000 c/s of between 1,000 and 1,250 Ω.

The type OC12 transistor requires a collector current of 2 mA for a collector to emitter voltage

[2] See "Transistors," Part 6, by Thomas Roddam, *Wireless World*, July, 1953.

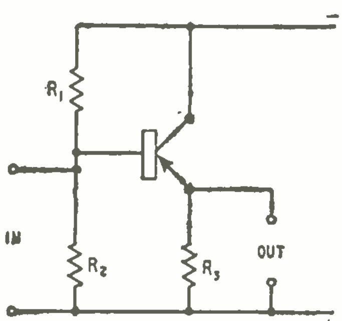
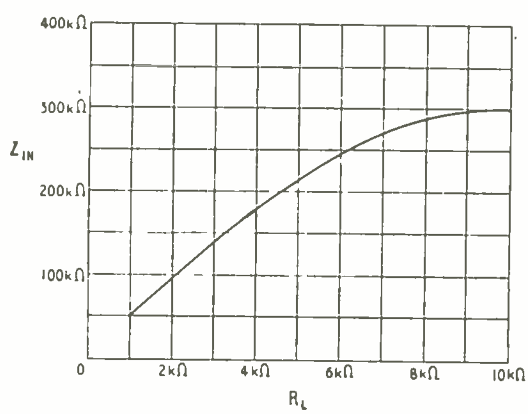


Fig. 2. (Left) Earthed-collector circuit with output taken from emitter, used as an impedance transforming device.

Fig. 3. (Below) Variation of input impedance with output load in the circuit of Fig. 2.



of 2.4. Under these circumstances the power output will be 2 mW. It will be seen that the total battery voltage to provide this will be 4.5, of which 1.5 will be dissipated across R_1. The base potential is obtained by R_1 and R_2 (33 kΩ and 47 kΩ) and they should be so proportioned that the base potential is substantially the same as the emitter potential (this being obtained from R_1 and the emitter current). Ideally, changing current should not affect the base potential, but this would require impossibly low values of resistance, and the increase in current drain is not justified by the slight increase in stability against the values quoted. Additionally, R_1 and R_2 (in parallel) are also in parallel with the a.c. input impedance of the stage and in the interest of maximum gain should be made as high as possible. Because the voltage across R_1 is in phase with the input voltage, severe degeneration will take place and the gain of the stage will be reduced from approximately 26 db to 10 db. R_1 is therefore bypassed to a.c. by means of a condenser C, its value being made so large that the total impedance is negligible over the operating range of frequencies.

In a practical case six OC12 transistors had a nominal collector variation of 1.4 to 4 mA at 3 V emitter-to-collector potential when the base was fed through a 0.5 MΩ resistance; with stabilization the variation in base current was 36-42 μA, and the variation in collector current 1.85 to 2.1 mA. The 1,000 c/s gain was within the limits of 23-26 db with C equal to 6 μF. The input impedance of the stage was 12,000 Ω without the bypass condenser and 4,000 Ω with it.

The treatment for the preceding stages is the same, except that the emitter load resistance is adjusted to a value equal to that of the collector load resistance. If more gain is required for a given battery potential the emitter load resistance can be reduced (this will of course require an alteration in the value of the potential divider R_1 and R_2) but the increased gain will be obtained at the expense of stability. OC11 transistors were used in these stages and their optimum load impedance is 20,000 Ω. It will be seen that the transistors T2 and T3 of Fig. 4 will not be working into their optimum load. Thus the power gain will be reduced below optimum by about 7 db, but, as stated before, this reduction in gain must be balanced against the increased cost of coupling transformers.

Earthed Collector.—The input impedance of a transistor in the earthed-emitter configuration is quite low, usually between 800 and 4,000 Ω. If the amplifier is to be used with a high-impedance input a matching network must be used. A transformer will give optimum power transfer, but a resistance network is more simple and less costly, and also very wasteful in gain. Crystal microphones specifically designed for use with transistor hearing aids have a source capacity of approximately 2,000 pF, and if the a.f. cut-off −3 db point at 750 c/s is accepted the input impedance of the amplifier should be of the order of 100,000 Ω. This value can easily be obtained by feeding the earthed-collector transistor into an earthed-emitter stage. The earthed-collector transistor behaves in a manner somewhat analogous to a cathode follower valve and can be used successfully as an impedance transforming device. Fig. 2 shows the basic circuit, in which degeneration is obtained by means of R_3. R_1 and R_2 are in parallel with the input impedance. Fig. 3 shows the variation of input

Radio Receiver Characteristics

Attempt to Standardize Measurement and Description of Performance

As its title indicates, the new British Standard Glossary* is confined to *electrical* characteristics, and even some electrical characteristics (such as those concerned with hum, and stability with respect to temperature and supply voltages) are excluded. But within these limits the description "glossary" hardly does justice to it. Not only are more than one hundred terms defined, but there are copious explanatory notes, especially on the theory of noise. The scope of the work, its general terminology, and the conditions assumed, are explained at some length in an introduction. There, with the help of a diagram representing a whole receiver or any section thereof as a four-terminal network connected to a source and load, definite meanings are given to such terms as "output circuit" and "response."

It is much to be hoped that universal adoption, wherever practicable, of standard terms and characteristics will enable results obtained in different laboratories to be fairly compared, and will lead to more definite assessment of receiver performance. Looking at the long lists of receiver properties with such names as "modulation-frequency intermodulation distortion characteristic," however, one cannot but feel the need for a "preferred list." Admittedly receivers of all kinds do between them have a great many characteristics in which somebody, sometime, might be interested, and this Standard tries not to leave any out; but the first impact is rather overwhelming.

New Definitions

A number of the new definitions anticipate the revision of BS.204:1943 (Glossary of Terms used in Telecommunications), which did not everywhere provide a satisfactory basis for the quantitative definitions of the newer work. It is good to see that the misguided effort in BS.204 to displace the commonly-used "frequency distortion" by "attenuation distortion" has now been reversed. "Non-linearity distortion" is now admitted as an alternative to "non-linear distortion"; perhaps in time the latter will be put where it belongs, in the "deprecated" class.

Some inconsistency and uncertainty in the use of terms is noticeable. There is nothing to show that "modulation factor" and "degree of modulation" are not the same thing; but if they are, why not stick to one or other? The same might be said of "change of frequency," "frequency change" and "frequency conversion." In the notes on distortion it is not clear whether a "linear system" does or does not include an ideal detector. In one sense such a detector can be described as linear and in another it cannot. In the definitions of various distortion characteristics it would have been helpful if the measure of the "component magnitudes" had been standardized as either voltage or power and not left ambiguous.

Confusion has for some time existed in the use of the symbol μ; officially it denotes the "amplification factor" of a valve, but some authorities very regrettably use it to mean "voltage amplification" of an amplifier. What could be more calculated to make confusion worse confounded, then, than the introduction, in this new Standard, of "voltage amplification factor"!

In four definitions, harmonic distortion is reckoned in terms of the ratio of the harmonic content to the "response" (i.e., total output) instead of to the fundamental component of the response. As a general principle it is desirable that the unwanted quantity should be compared with the wanted, not with the sum of the wanted and unwanted. On this point BS.2065 is not only in disagreement with the corresponding American standard, but is inconsistent with itself, for in its definition of amplitude distortion the measure of the response is its fundamental component.

Intermodulation Distortion

Although the declared aim of this Standard is generality, it defines intermodulation distortion factor in such a way as to take account only of the second-order (i.e., simple sum and difference) products, thereby encouraging design for small second-order products, regardless of the more objectionable higher-order products. (Incidentally, it would have been helpful if a standard method of numbering all intermodulation products had been given.) Harmonic distortion factor on the other hand, although harmonic distortion can be regarded as a particular case of intermodulation, is defined on a basis of total harmonic content. On the question of distortion, this Standard seems to fall between two stools, neither boldly tackling the problem of differing objectionableness of distortion products nor leaving the matter quite general and open.

The intermodulation definitions, by making the basis of comparison the geometric mean of the input component magnitudes, imply that for a given geometric mean the distortion is independent of the individual component amplitudes. This is dangerously far from the truth. It is quite possible for the distortion to be slight with equal components, and intolerable with widely unequal components having the same geometric mean, owing in the latter case to the larger amplitude running into grid current or "bottom bend." These factors so defined are therefore valueless unless the conditions are more closely specified, and the need for this is not mentioned.

In spite of the many years this Standard has been germinating, therefore, it does not reveal itself as a completely mature growth. Many of its definitions are so general as to be of little value, for they still leave it to individual workers to specify important conditions in their own separate ways. And where a lead is given, as in distortion measurement, it is not always in directions that provide a sound measure of electrical performance.

M. G. S.

*British Standard Glossary of Terms for the Electrical Characteristics of Radio Receivers (BS2065:1954). British Standards Institution, 2, Park Street, London, W.1. Price 6s.

prises both physical gauging and electrical comparison. Printed circuits, resistors, and capacitors are compared with their ordinary prototype equivalents both before and after assembly. This is accomplished by the use of electronic computers, bridge circuits, and other comparison devices. The inspection "code" is carried on the punched cards which were prepared by the design engineer and have accompanied the wafers all through the production process. After the final assembly of each "module" its whole circuit is again tested to see that it meets specifications within set tolerances (Fig. 3).

The new automatic production system should prove of great strategic importance in the event of a national emergency, since the costs for conventional production and maintenance would be formidable in view of the quantities and varieties of equipment needed. The development of the system makes possible a rapid change over from civilian to military products (and back again) at short notice and at the same time allows a greatly expanded production capacity. Most of the operating "know-how" is stored in mechanical fingers and electro-mechanical control mechanisms, and even electronic equipment designs may be stored, ready for production, in the form of punched cards and circuit stencil screens.

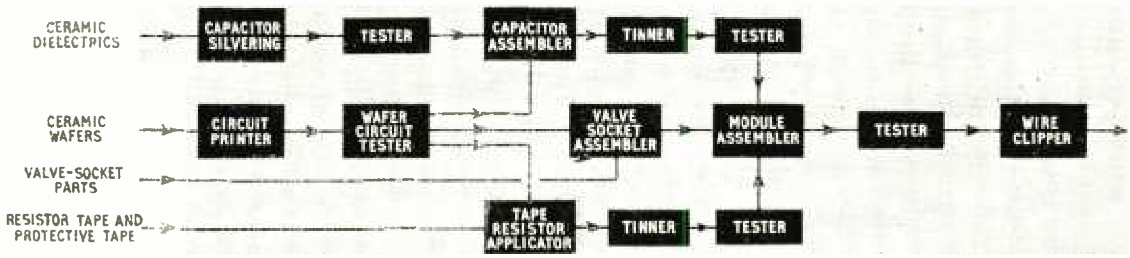
COMPONENTS SHOW

WITHIN a few days of the publication of this issue the eleventh Components Show opens at Grosvenor House, Park Lane, London, W.1. This annual private exhibition organized by the Radio and Electronic Component Manufacturers' Federation opens at 10.0 on April 6th for three days. Admission is by invitation ticket obtainable from the R.E.C.M.F., 22, Surrey Street, Strand, London, W.C.2, by bona-fide users of components in design, manufacture or research. A list of the 130 exhibitors, including a number who have not previously participated in the show, is given below. It is hoped to include in our next issue a review of the trends in component design and manufacture as portrayed at the show.

	Stand No.
A.B. Metal Products	33
Advance Components	11
Aerialite	118
Allan Radio	114
Antiference	52
Associated Electronic Engineers	1
Associated Technical Mftrs.	29
Automatic Coil Winder Co.	111
B.I. Callender's Cables	68
Bakelite	122
Belling & Lee	55
Bird, Sydney S., & Sons	53
Bray, Geo., & Co.	93
British Electric Resistance Co.	28
British Mechanical Productions	62
British Moulded Plastics	113
Bulgin & Co.	46
Bullers	4
Carr Fastener Co.	21
Clarke, H., & Co.	92
Collaro	82
Colvern	38
Connollys	60
Cosmocord	76
Creators	100
Daly	105
Dawe Instruments	73
De La Rue & Co. (Plastics)	80
Diamond "H" Switches	3
Dubilier Condenser Co.	69
Duratube and Wire	24
Edison Swan Electric Co.	63
Egen Electric	20
Electro Acoustic Industries	40
Electronic Components	98
Electronic Engineering	128
Electrothermal Engineering	88
English Electric Co.	101
Enthoven Solders	43
Erg Industrial Corporation	119
Erie Resistor	15
Ever Ready Co.	124
Ferranti	16
Fine Wires	91

	Stand No.
Garrard Engineering Co.	37
General Electric Co.	129
Goldring Manufacturing Co.	74
Goodmans Industries	12
Gresham Transformers	30
Guest, Keen & Nettlefold	107
Hallam, Sleigh & Cheston	90
Hassett & Harper	117
Hellermann	81
Henley's Telegraph Works Co.	2
Hunt, A. H.	44
Igranic Electric Co.	7
Imhof	57
Jackson Bros.	51
Langley London	126
London Electric Wire Co.	14
London Electrical Manufacturing	42
Long & Hambly	31
Magnetic & Electrical Alloys	39
Marconi Instruments	103
Marrison & Catherall	110
McMurdo Instrument Co.	64
Micanite & Insulators Co.	59
Morganite Resistors	23
Mullard	65, 108, 109
Multicore Solders	66
Murex	5
Mycalex Co.	86
Neill, James, & Co.	123
N.S.F.	61
Painton & Co.	27
Parmeko	48
Partridge Transformers	22
Plessey	49, 67
Pye	130
Radio Instruments	106
Reliance Electrical Wire Co.	47
Reproducers & Amplifiers	75
Reslosound	45
Rola Celestion	35

	Stand No.
Ross Courtney & Co.	102
Salford Electrical Instruments	36
Scott, Geo. L., & Co.	89
Simmonds Aerocessories	116
Simon Equipment	83
Spear Engineering	127
Stability Radio Components	72
Standard Telephones & Cables	32, 79
Static Condenser Co.	94
Steatite & Porcelain Products	54
Stocko (Metal Works)	99
Stratton & Co.	10
Suflex	77
Supply, Ministry of	112
Swift, Levick & Sons	125
Symons, H. D., & Co.	97
Taylor Electrical Instruments	18
Telcon-Magnetic Cores	95
Telegraph Condenser Co.	17
Telegraph Construction & Maintenance Co.	78
Telephone Manufacturing Co.	26
Thermo-Plastics	9
Transradio	120
Truvox	71
Tucker Eyelet Co.	6
Tufnol	87
United Insulator Co.	8
Vactite Wire Co.	13
Vitavox	41
Walter Instruments	85
Wego Condenser Co.	25
Welwyn Electrical Laboratories	58
Westinghouse Brake & Signal Co.	34
Weymouth Radio Manufacturing	115
Whiteley Electrical Radio Co.	19
Wimbledon Engineering Co.	84
Wingrove & Rogers	56
Wireless Telephone Co.	70
Wireless World and *Wireless Engineer*	104
Woden Transformer Co.	50
Wolsey Television	96
Wright & Weaire	121



Flow diagram showing the main processes in the automatic production line.

the same manner as the ceramic wafers. The dielectric is non-porous ceramic composed usually of magnesium, barium, calcium and strontium titanates of high purity, organic binders and water. After firing it is about ½in square and 1/50in thick. Capacitances may be varied from 7 pF to 0.01μF by changing the relative proportions of the constituent minerals.

The materials required for the manufacture of the tape resistors are a heat-resistant asbestos paper in tape form, polyethylene tape, carbon black or graphite, resin, and a solvent. The resistor material, a mixture of the carbon, resin and solvent, is ground to a fine adhesive powder. The compound is then sprayed on a loop of the asbestos paper tape and a protective coating of polyethylene tape is applied. A 75ft roll of tape will produce over 10,000 resistors. The tape resistors produced range from 10 ohms to 10 megohms. They will hold their rated resistance within ±10 per cent up to temperatures of about 200°F, and are capable of dissipating ¼ watt.

In another series of operations, appropriate sections of the wafers or capacitor dielectrics are silvered. Circuits are printed on the wafers (Fig. 2), notches are coated, plates and leads are applied to capacitors, furnace-curing takes place and the circuits are inspected. Finally, all silvered surfaces receive a thin coating of solder.

Automatic Orientation

During these metallizing operations the keying notch pressed into each wafer first comes into use. The wafers are loaded into vibratory bowl feeders provided with spiral escape channels, which have a series of four exit ports followed by steps set into them. A small screw is inserted into each exit port, and this permits only those wafers to pass which have their keying notch aligned with it. If a wafer is incorrectly oriented it is turned through 90 degrees as it falls down the channel step following the exit port. A grooved channel inverts it if it has failed to pass through the other four ports and the keying procedure is repeated. As a consequence, all wafers passing from the feeders are oriented in the same direction and have the same surface turned upwards.

Tape resistors, titanate capacitors, valve sockets, and other components are mounted on the wafers between the appropriate silvered conducting patterns. Rolls of resistor tape are placed on a machine that automatically cuts the tape into half-inch lengths, presses the resistors between the printed contacts on the wafer, applies pressure, and ejects the completed resistor-mounted wafer. A single machine is used to mount up to two capacitors on each surface of a wafer. Each capacitor is automatically oriented and the silvered circuit on both surfaces is electrically tested before mounting. In the valve-socket assembler, silvered valve pins are mechanically placed into their proper holes in the socket, a wafer is placed on top, and a rivet binds the two pieces together.

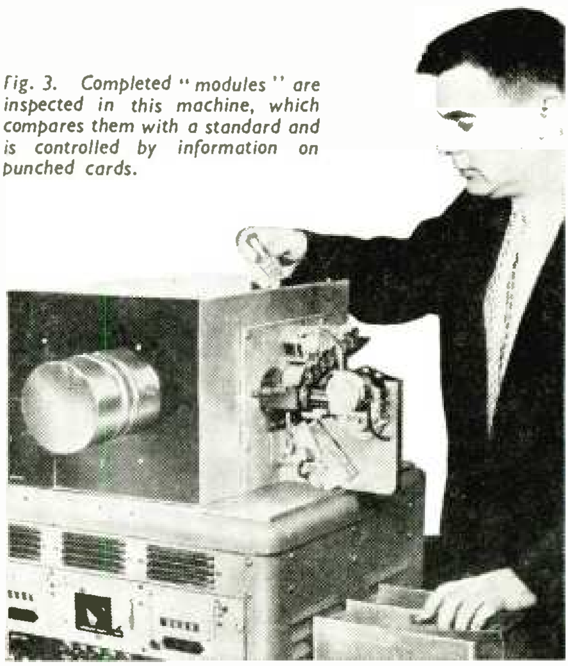
Assembling Operation

After the various parts have been mounted on the wafers the notches in the ceramic are tinned with solder. The machine that performs this operation automatically grips each wafer and dips one side after another into flux and solder.

The wafers with their components mounted on them are now ready for assembly and this operation is accomplished by a single machine. Six vibratory feeders issue the wafers to a loading device that holds the wafers in an upright position between jaws. A chain drive carries this jig to a soldering position, where six more wires are bonded to it. Sections of wire between the wafers are cut out as required by the circuit connections.

During each stage in the production, provision is made for complete automatic inspection. This com-

Fig. 3. Completed "modules" are inspected in this machine, which compares them with a standard and is controlled by information on punched cards.



"AUTOMATION" By LEON G. DAVIS

Mass Production of Electronic Sub-assemblies by Automatic Plant

IT is perhaps logical that the development of a new system of electronic construction should find its first important application in an automatic production line for the manufacture of electronic equipment. The system that makes this possible is described by its developers at the U.S. National Bureau of Standards as "modular design of electronics for mechanized production of electronics." It utilizes mechanically standardized sub-assemblies or "modules" (see Fig. 1), which can be produced with a wide range of different circuit configurations.

Starting from raw or semi-processed materials, machines automatically manufacture ceramic components and adhesive carbon resistors, print circuits and mount resistors, capacitors, and other miniaturized components on standard ceramic wafers $\frac{7}{8}$in square by $\frac{1}{16}$in thick. Special components not suitable for printing techniques can also be incorporated. The wafers are then stacked up to form the "modules." Automatic inspection machines, controlled by information on punched cards, check the physical and electrical characteristics of the wafer circuits at numerous points along the production line.

The completed "module" combines all the requirements of an electronic circuit with ruggedness, reliability and extreme compactness. In general, it comprises about four to six wafers. A number of individual "modules" can be combined to form a major sub-assembly, and this operation can also be done by machines. The pilot plant, now being operated under contract by the Kaiser Electronics Division of Willys Motor Company, is designed for a production goal of 1,000 "modules" per hour.

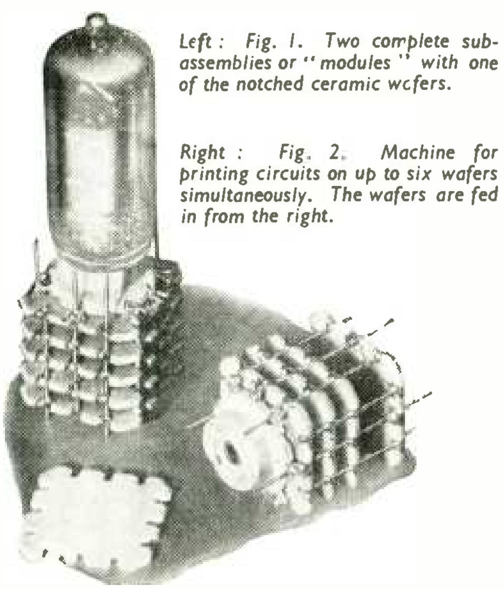
The system dispenses with the conventional circuit diagram of the tested electronic prototype and places all necessary production programming information on a work sheet. Each work sheet contains the front and back outlines of six wafers with appropriate numbering to identify each notch in the wafer, each vertical connecting wire, and the component that is to be placed on the wafer. The engineer translates his conventional wiring diagram to this type of diagram. He indicates the position of the component and its proper value and tolerances, and lines are drawn to indicate how the circuits between wafers are to be connected.

In addition, the work sheet is used to establish the inspection procedure. The current paths on each wafer are recorded on punched cards and these accompany the wafers through all the manufacturing processes. The work sheet is also used in the construction of standard "modules" or counterparts which are employed in the final testing and inspection.

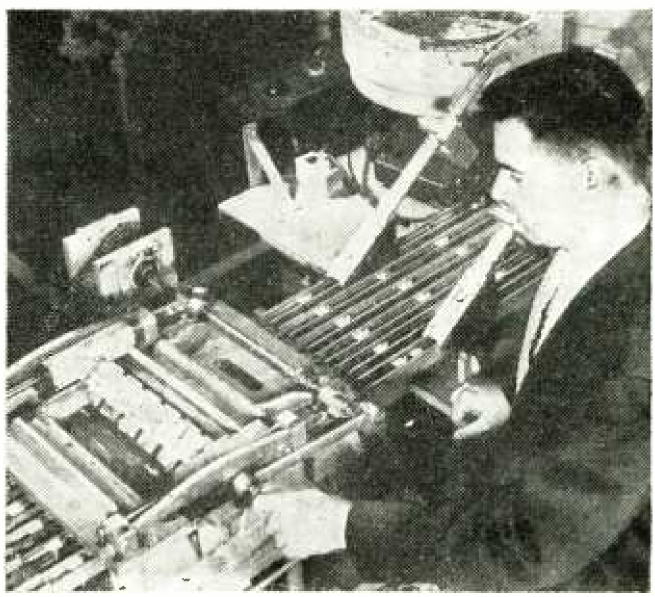
Producing the Ceramic Parts

The wafers and valve sockets are produced from raw materials and are stamped out at a rate of about 2,800 pieces per hour. They are then cured at 2,300°F in a tunnel kiln. The wafers are mechanically gauged, and all pieces which do not fit within close tolerances are rejected. They are pressed with twelve peripheral notches (three on a side) and a keying notch on one side. In the final assembly, wires are mechanically soldered into these notches to serve as physical supports and electrical connectors.

Capacitor dielectrics are manufactured in very much



Left: Fig. 1. Two complete sub-assemblies or "modules" with one of the notched ceramic wafers.



Right: Fig. 2. Machine for printing circuits on up to six wafers simultaneously. The wafers are fed in from the right.

economically worth while when signal strength is low, and our better knowledge of aerial measurement techniques, coupled with more accurate apparatus, indicates that the optimized "H" averages about 3 to 4 db better than a dipole.

A problem which faces the designer is that of accommodating these additional aerials, or stacks of aerials, on the typical dwellings of this country, bearing in mind particularly the semi-detached suburban dwellings with one small chimney stack per two or more families. It may be necessary to erect masts on a ridge-tile fitting and support them by sets of guy wires.

The siting of Band III aerials will call also for closer attention than hitherto. U.S.A. installers have found it necessary to "probe" the space above a building for a position of maximum field strength. The greater reflectivity of surrounding buildings gives rise to stronger standing-wave patterns than on Band I so that the accidental location of the aerial in a deep minima may have a serious effect.

The possibility of increased "ghosting" may exist, but greater use of multi-element arrays, with their sharper directivity, may offset this.

Combined Aerials

The author may be getting into deep water by descending from the technical to the psychological, but when an alternative TV service is established, it seems obvious that if it is properly planned it will be as necessary to the viewer as the Light and Home programme is to the listener. This seems to be reasonable because no one would think of purchasing a broadcast receiver capable of receiving the Home programme but not the Light, or vice versa.

If this reasoning is sound the potential viewers for alternative TV must be about equal to the number of existing viewers with only the £ *s d* problem to solve.

Based on Band I experience there will always be a large number of fringe viewers, and because of range limitations on Band III they will now be located on the outskirts of the densely populated areas, thereby increasing the fringe viewer density. The problem of connecting Band III aerials to existing Band I installations calls for considerable thought on technical and economic grounds. Aerials connected to transmission lines cannot be paralleled in the manner of extension loudspeakers or doorbells, and the average installer would not possess the skill nor the apparatus for determining the correct points of attachment.

If the aerials are in close proximity the Band III feeder may be cut to a length x (Fig. 5a) such that its impedance-transforming properties will provide substantially independent matching of either aerial on its particular frequency. This length x can only be deduced from a knowledge of the impedance at the dipole terminals of the Band III aerial, and is best determined experimentally.

But the main feeder to the receiver may be unduly lossy for efficient Band III signal transfer because it will be doubled in any event due to the 4/1 increase in frequency. In this case a separate feeder of low inherent loss must be run to the receiver, and if the latter is equipped with but a single input socket some form of matching filter (Fig. 5b) must be used to maintain mutually exclusive performance of the two aerials. The two receiving aerials may be widely separated; for example Band I in the loft and Band III on the chimney—again the matching filter (Fig. 5c) is needed. A generic circuit for such a filter is shown in Fig. 6 and is clearly a combined high-pass and low-pass network.

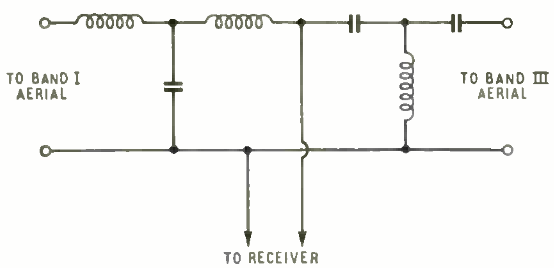


Fig. 6. Generic circuit for a matching filter.

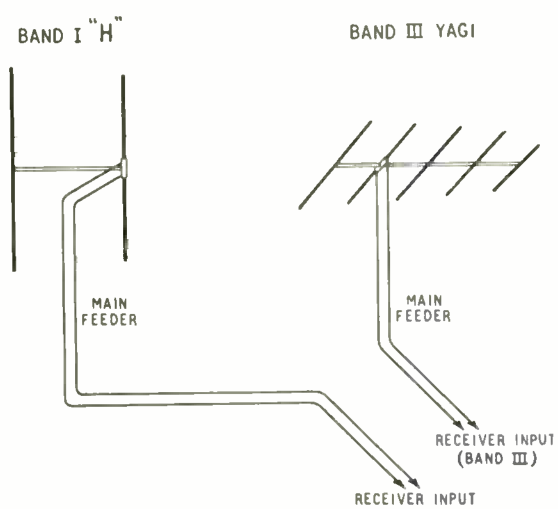


Fig. 7. Band I and III aerials with entirely separate feeders.

The more flexible arrangement, whereby complete independence of operation on either band is assured, makes use of separate feeders for the aerials (Fig. 7) but requires separate input sockets on the receiver. While it is technically sound there is the difficulty of adding extension aerial sockets in other rooms and the cost of installing the extra feeder, where, in many cases, a matching filter might be branched-in much closer to the aerial.

The technical and economic problems involved cannot be solved without statistical assistance based on an established service, but they will assuredly be tackled and solved with minimum delay when the time arrives, and because this is the age of miracles some of them may be solved earlier.

The author wishes to acknowledge with thanks the assistance of a colleague, I. A. Davidson, in carrying out the computational work involved in preparing the graph of Fig. 2.

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[3] "*Broadcast News*" published by R.C.A. October 1953.
[4] H. Yagi, Beam transmission of ultra-short waves. *Proc. I R.E.* (N.Y.) Vol. 16, p. 715 (1928).
[5] R. A. Smith. "Aerials for Metre and Decimetre Wavelengths." Cambridge University Press, p. 145 (1949).

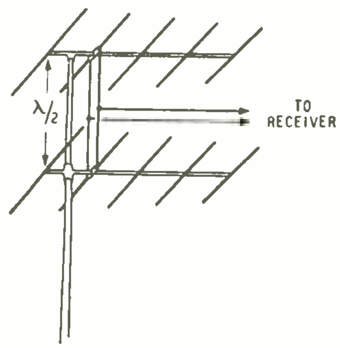


Fig. 4. Stacked Yagis have a gain of 3db over a single unit.

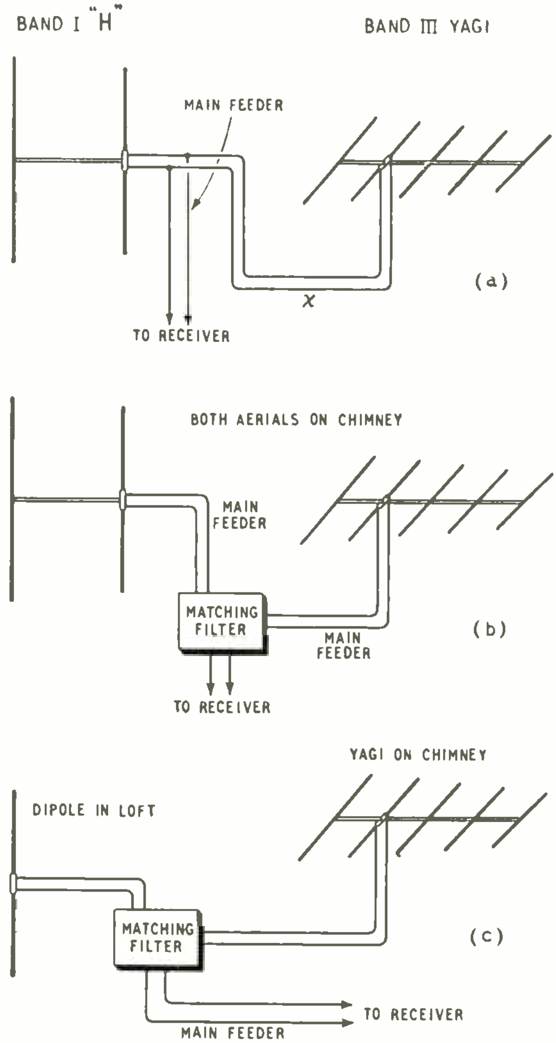


Fig. 5. (a) Two dissimilar aerials connected to common feeder via matching section x, (b) by means of a matching filter located near receiver, (c) by a filter adjacent to one of the aerials.

The simplest multi-element arrays for TV reception are based upon the Yagi system named after its discoverer[1] in 1928 (note the very early date). Essentially it is a simple half-wave dipole backed by a reflector element placed at from 0.15–0.25 wavelength behind it, and with one or more director elements placed in front at spacings of about 0.1 wavelength (Fig. 3).

This arrangement provides the basis for at least 90% of the multi-element TV aerials used throughout the world to-day. Notice that the reflector is slightly longer than the dipole, whereas the directors become progressively shorter. It is essential to follow this technique if a good directional characteristic with optimum gain is to be achieved along the direction of the arrow.

It is erroneously thought that the number of elements determine, uniquely, the gain of such a system. The total length is a major contributory factor, and it can be shown that, for a given length, l, of the array there is an optimum number of directors beyond which no improvement will result. Thus a Band III array with an overall length of, say, five feet comprising a reflector, dipole, and twelve directors, may be inefficient compared with an array having a length of ten feet with a reduced number of directors. Additional reflectors, incidentally, contribute inappreciably to the performance.

According to R. A. Smith[5] it is suggested that the forward gain of a Yagi aerial of total length l is approximately $3l/\lambda$ greater than a half-wave dipole. This only holds for arrays longer than one wavelength which, at 190 Mc/s, is approximately five feet and an array of four feet in length comprising one reflector, a dipole, and three directors should provide a matched gain of about 7 db over a dipole, which brings the reader back to the earlier suggestion that if a dipole gives good reception at the horizon on Band I a five-element Yagi should provide the same result on Band III, assuming the transmission and reception conditions are as originally outlined.

Band III Aerials

This may be a slight exaggeration of what will happen in practice because the sharp directivity of the Band-III Yagi compared with the omnidirectional Band I dipole will improve the signal-to-noise ratio of the former in the presence of ambient man-made and terrestrial interference fields such that a more efficient performance will result. It is more likely that a Band III Yagi array about three feet in length and with one director will be a satisfactory substitute for the Band-I dipole under these receiving conditions.

It has been stated that a gain of 7 db is possible with a four-foot Yagi. If higher gains are required it may not be wise to increase the length (l) of the array and add additional elements, because the bandwidth decreases and may impair picture definition. Experience is needed under field conditions to determine how far one may extend the Yagi array without impairing picture quality.

By stacking two identical arrays (Fig. 4) at a spacing of not less than half a wavelength (2 ft 6 in) and connecting their outputs in phase, an improvement of 3 db in gain may be effected. This 3 db does not seem to be a very useful increase—it is only $\times\sqrt{2}$—but it must be clearly remembered that when receiver threshold noise is present 3 db represents the difference between an acceptable and useless picture.) This has been proved because long experience on Band I has taught the installer that the advantage to be gained by using an " H " aerial over a dipole is definite and

By substituting equation 4 into equations 1, 2 and 3 we obtain the following for the signal e.m.f. developed in a simple half-wave dipole, which is an excellent standard of reference.

Up to the horizon :—

$$e_1 = \frac{0.0016\sqrt{W}\, h_T\, h_R\, f_1\, \lambda_1}{d^2} \quad \text{Band I } \mu V \ldots (5)$$

$$e_3 = \frac{0.0016\sqrt{W}\, h_T\, h_R\, f_3\, \lambda_3}{d^2} \quad \text{Band III } \mu V \ldots (6)$$

Beyond the horizon :—

$$e'_1 = \frac{0.0016\sqrt{W}\, h_T\, h_R\, f_1\, \lambda_1\, D_h^{\,2}}{d^4} \quad \text{Band I } \mu V \quad (7)$$

$$e'_3 = \frac{0.0016\sqrt{W}\, h_T\, h_R\, f_3\, \lambda_3\, D_h^{\,1\cdot 8}}{d^{6\cdot 8}} \quad \text{Band III } \mu V \ (8)$$

Now the product $f\lambda$ is a constant since one is inversely proportional to the other, so that up to the horizon the signal e.m.f. induced in a half-wave receiving dipole is identical for Bands I and III, providing all the other parameters are unvaried. Beyond the horizon the diffraction effects take control *and attenuate the Band III signal very much more rapidly than Band I.*

Curves are plotted in Fig. 2 on the following basis:

Height (h_T) of transmitting aerial ..	625 ft.
Height (h_R) of receiving aerial	30 ft.
Band I frequency (f_1)	55 Mc/s.
Band III frequency (f_3)	190 Mc/s.

As expected, the Band I and III curves are coincident up to the horizon but split thereafter with rapid falling off on Band III. From this one immediately realizes why increasingly high frequencies seriously restrict the useful range. The curve for Band IV propagation, although not under general discussion, shows why transmissions at these frequencies are almost confined to line-of-sight conditions. Field reports from the United States of America are already confirming this.

According to a report by R.C.A.[3] their Band IV station KPTV at Portland, Oregon, with an aerial located at about 1,000 ft above average terrain and operating on channel 27 (548–554 Mc/s), strongly suggests that first-class reception is confined to those receiving installations where the aerial is in optical view of the transmitting aerial! This naturally excludes sites which are close but obscured from view by neighbouring buildings because "swamp" field intensities obviously exist. Another interesting point to be gleaned from Fig. 2 and equation 8 is that, since the horizon distance is proportional to the square-root of the height of the transmitting aerial, doubling the latter will *double* the normal service area within the horizon.

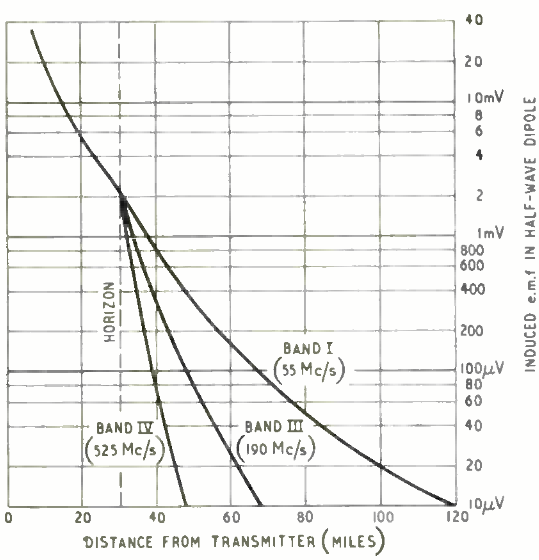


Fig. 2. Induced voltage in a simple half-wave dipole.

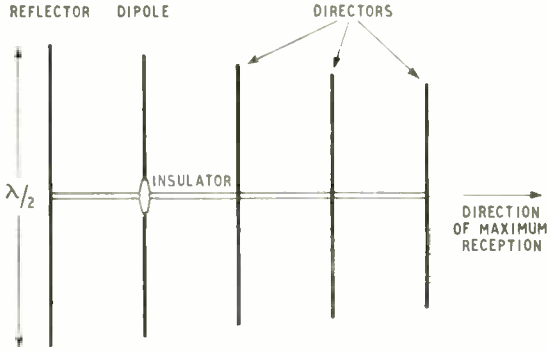


Fig. 3. Details of the Yagi aerial.

On the other hand, doubling the transmitter power will only extend the service area by a few per cent because of the rapid attenuation beyond the radio horizon.

The recipe for good transmitter coverage on Band III is "large helpings of mast height with power added to taste."

Aerial Requirements

Returning to the essential problem of Band I and III transmissions, it would appear that a simple half-wave dipole at a range of 30 miles from the transmitter would provide excellent reception if the conditions specified for W, h_T and h_R were met. Bearing in mind the increased attenuation, with frequency, of obstacles such as buildings, it might be fair to estimate that, within 20 miles of a station as described, a well exposed Band III dipole would be as effective as a similarly erected Band I dipole at about 30 miles. Indeed, U.S.A. surveys seem to suggest this.

Making allowance for this probable 30% reduction in distance due to practical receiving conditions it would appear that recovery of the lost signal at a given range within the horizon will require a receiving aerial gain of 7 db, and this can only be achieved by an economical combination of increased height and multi-element aerials.

Thus, at limit distance for Band I (B.B.C. high power) with simple outdoor dipoles a multi-element array may be essential for equally satisfactory reception on Band III.

Since this condition exists at about horizon distance it is very obvious from the curves of Fig. 2 that, beyond the horizon, at distances where multi-element aerials are required for Band I, little or nothing will be received on Band III unless very elaborate aerials are used and are erected at abnormal heights.

Band III Television Aerials

Evaluation of Requirements from Available Data

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

THE Postmaster-General has already announced the frequencies for the alternative transmissions in Band III. Provisionally two channels will be available within the Band III spectrum of 174–216 Mc/s. These will be designated as follows: channel 8 186–191 Mc/s. (Midlands), channel 9, 191–196 Mc/s. (London and South Lancs).

There is no information as yet regarding the siting, power, or mode of polarization for the transmitters, and without this fundamental data it is impossible to relate Band III aerial requirements to Band I unless certain assumptions can be made.

A realistic approach may be based on the assumption that both transmitters are radiating the same amount of power from the same site. It is then a reasonably simple matter to decide how much more efficient a Band III aerial must be relative to a Band I aerial in order that the develped e.m.fs be equal.

The theory of propagation of u.h.f. waves over a smooth but curved earth is very complicated.† The field intensity at a receiving site is related to the respective heights of the transmitting and receiving aerials, their distance apart, and the dielectric constant and conductivity of the earth. No matter how these parameters are disposed the field intensity is always proportional to the square root of the power, W, radiated from the transmitting aerial.

If one considers a separation between transmitting and receiving sites which is considerably greater than the respective heights of their aerials (Fig. 1), so that the grazing angle, θ, of the reflected wave is a few degrees only, a useful approximate expression for the field intensity, up to, but not beyond, the horizon is :—

$$E = \frac{0.01\sqrt{W}\, h_T\, h_R\, f}{d^2} \text{ microvolts/metre} \quad (1)$$

where h_T and h_R are the respective height of the transmitting and receiving aerials in feet, d is distance in miles, and W is watts in a *half-wave* transmitting dipole. f is in Mc/s. One often sees the expression e.r.p. (effective radiated power) for a transmitting aerial which takes into account the increased radiated power, in useful directions, obtained by stacking a number of radiators into an array.

For a given output power from the final stage of the transmitter, and a given volume into which an array can be packed, it is clear that more half-wave dipoles can be "phased up" on Band III than on Band I because individual dipoles are only one quarter the size (the frequencies are approximately in the ratio 4/1). Thus, a greater e.r.p. is possible from Band III from the aerial viewpoint, but it must be remembered that serious limitations may restrict the amount of power available for feeding the aerial since a considerable increase in frequency is involved and all sorts of limitations in transmitter output valve performance will creep in.

Equation (1) is useful for computing average field strengths up to the horizon but is quite useless beyond it. It is here that one encounters diffraction phenomena which have the net effect of reducing, very rapidly, the field intensity, and of having a *far greater adverse effect on Band III than on Band I.* Useful empirical formulæ[1] for field intensity beyond the horizon for Bands I and III respectively are :—

$$E_1 \text{ (Band I)} = \frac{0.01\sqrt{W}\, h_T\, h_R\, f_1\, D_h^{\,2}}{d^4} \ \mu V/m \quad (2)$$

and

$$E_3 \text{ (Band III)} = \frac{0.01\sqrt{W}\, h_T\, h_R\, f_3\, D_h^{\,4.8}}{d^{6.8}} \ \mu V/m \quad (3)$$

A new term D_h appears in these two equations and is the distance from the elevated transmitting aerial to the horizon, and is equal to $1.25\sqrt{h_T}$ at the latitude of London (not critical for U.K.).

It is important to recognize that these equations are largely empirical and cannot take into account the normal departure from a smooth curved earth. Buildings, trees, and the general undulation of the countryside must produce irregularities so that at a given distance the field strength may be considerably above or below the calculated values. Nevertheless the smooth curves of field intensity, as a function of distance, are likely to represent average values.

The field strengths calculated for Band I and Band III from these formulæ are not very helpful unless they can be related to the amount of signal they will induce in a receiving aerial. Now, the e.m.f. generated across the centre connections of a half-wave dipole whose radiation resistance is matched to the receiver input impedance is well known to be[2] :—

$$e = \frac{E\lambda}{2\pi} \quad (4)$$

where E is the incident field strength and λ is the desired wavelength.

Let λ_1 = Band I wavelength (metres)
f_1 = Band I frequency (M/cs)
λ_3 = Band III wavelength
f_3 = Band III frequency.

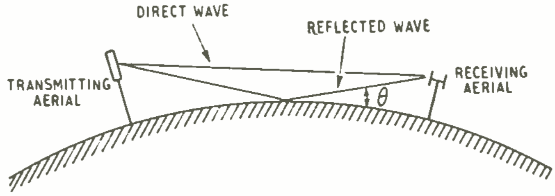


Fig. 1. Propagation conditions known as "grazing incidence," where θ is a very small angle.

* Belling and Lee Ltd.
† Propagation over radio line-of-sight paths is discussed elsewhere in this issue.—ED.

The performance obtained with the well-type *p-n-p* junction transistor is not easily compared with the performance of the surface barrier transistor. At 455 kc/s, however, matching both input and output, and neutralizing the feedback due to the base resistance, a gain of about 35 db is obtained. Using rather simpler circuits, without feedback neutralization, gains of 22.25 db at 1 Mc/s, and of 8-13 db at 10Mc/s have been obtained. At 1 Mc/s the noise factor is only about 4-8 db, which is not likely to cause any embarrassment in the design of a broadcast receiver.

No details are given of the method adopted for producing the pit. It is therefore impossible to form any estimate of the relative ease of manufacture of these two new ways of manufacturing high frequency transistors.

Just after this note was written further information about the Philco system became available. In a letter in the February 1954 issue of *Proc. I.R.E.* the production by the electrolytic jet etching process of a surface-barrier transistor using silicon instead of germanium is announced. Silicon presents the advantage that it is not so temperature dependent, and the appearance of a junction transistor with $\alpha > 0.95$ and $f_c\alpha > 10$ Mc/s opens up new possibilities.

Acknowledgments. Fig. 1 is based on Fig. 4, and Fig. 2 on Fig. 3 of "A *p-n-p* Triode Alloy Junction Transistor for R.F. Amplification" by C. W. Mueller and J. I. Pankove, *RCA Review*, Dec. 1953, p.586.

Calculation of Coupling

By FRANCIS OAKES* M.Inst.E.

Mutual Inductance and Coupling Coefficient on the Slide Rule

EVALUATION of the well-known formula $M = k\sqrt{L_1L_2}$ which applies to the primary and secondary inductances, the mutual inductance, and the coefficient of coupling of a transformer, is frequently required for circuit design and in everyday laboratory practice. A rapid numerical solution can be found on the slide rule, provided that in addition to the ordinary and square scales the slide carries also a reciprocal scale.

As shown in the accompanying diagram, the inductances L_1 and L_2 are set on the square scales, the mutual inductance M on the normal scale, and the coefficient of coupling *k* on the reciprocal scale. For example, the self and mutual inductances of a short-wave aerial coil were measured, and found to be 0.62, 3.7 and 0.41 μH respectively. As shown in the illustration, the coefficient of coupling *k* is 0.27.

It is important that the inductances L_1 and L_2 should be set in the left section of the square scale if the position of the decimal point involves an even power of ten, in the right if an odd power. Thus, 3.7 is set in the left section, because 3 corresponds to 10^0 (in this context 0 is regarded as an even number); 0.62 is set in the right section, because the position of 6 corresponds to 10^{-1}, an odd power of ten.

It can be seen from the diagram that not only can *k* be evaluated from M, L_1 and L_2, but that any one of the four parameters can be found by this method when the other three are given. Thus, for instance, the primary inductance L_1 can be found for given values of L_2, *k*, M, by bringing *k* on the reciprocal scale to coincide with L_2 on the square scale of the stock, and finding the required value L_1 on the square scale of the slide, without further movement of the slide, by setting the cursor to M on the normal scale of the stock, as shown in the illustration.

Proof: The linear distance between L_1 and L_2 is equal to the linear distance between *k* and M, but since L_1 and L_2 are set on logarithmic scales of half the length unit and *k* of the same unit but opposite direction than the normal scale on which the setting of M is effected, the following equation holds good:

$$\tfrac{1}{2}\log L_1 - \log\frac{1}{k} = \log M - \tfrac{1}{2}\log L_2$$

The left side of this equation relates to the slide, and the right to the stock.

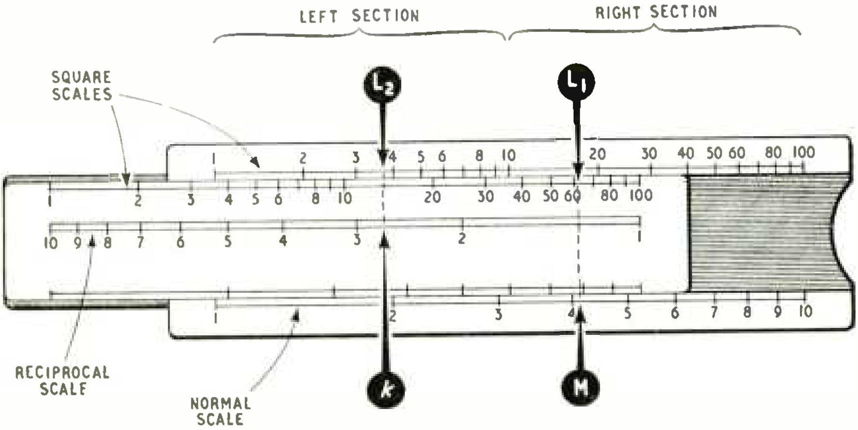
$$\tfrac{1}{2}\log L_1 + \tfrac{1}{2}\log L_2 - \log\frac{1}{k} = \log M$$

$$\tfrac{1}{2}\log L_1L_2 + \log k = \log M$$

$$\log\sqrt{L_1L_2} + \log k = \log M$$

$$\log k\sqrt{L_1L_2} = \log M$$

$$\therefore k\sqrt{L_1L_2} = M.$$



Inductances are registered on the fixed and sliding square scales, mutual inductance on the fixed normal scale, and coefficient of coupling on the reciprocal scale.

* Ferguson Radio Corporation.

Transistors for High Frequencies

Importance of Reducing Base Layer Thickness

A NOTE on p. 119 of the previous issue described the new Philco junction transistor, which has an alpha cut-off in the region of 40 Mc/s and which depends for its success upon the production by electrolytic etching of a working region only 0.0002in thick. A new junction transistor has also been announced by the Radio Corporation of America (*RCA Review*, Vol. XIV, No. 4, p.586, Dec. 1953), with an alpha cut-off frequency of about 10 Mc/s.

The RCA transistor appears to have been designed with the broadcast receiver in mind, so that gain at 455 kc/s is of paramount importance, and no advantage is to be gained by spending money on extending the response above about 2 Mc/s. In their approach to the problem, Mueller and Pankove have considered two effects. The first of these is associated with the fact that in the base region the minority carriers diffuse through from the emitter to the collector without very much encouragement from any electric field. As the input to the emitter is varied the number of carriers must vary too, and so the actual number in transit will vary. There is a sort of space charge in the base, and the need to drive this space charge provides a rather large emitter-base capacitance term in the equivalent network. For the RCA TA-153 *p-n-p* audio transistor the capacitance is about 0.01 μF.

Diffusion Technique

Since the number of carriers in transit increases as the base is made thicker, this capacitance increases with base thickness, and in fact is proportional to the square of base thickness. It does not depend on the junction area, but it is proportional to the direct current. RCA have aimed at a spacing between the collector and emitter junctions of 0.0005in, which is 2½ times the Philco spacing. They stress the advantage of having the electrodes as nearly flat as possible, but they make their junctions by the indium alloying process. Each junction is internal, and is produced by diffusing indium into a germanium wafer. Small discs of a germanium-indium alloy are applied to the wafer and the assembly is heated: the indium soaks in until the two doped regions are separated by the required distance.

Having decided to use a thin wafer so that the junctions will be flat rather than hemispherical, a new difficulty arises. The emitter diameter will be about 0.01 in, and even if a base contact could be arranged round the emitter with a radius of 0.010 in, the series base resistance would be 70 ohms. Moving out to 0.040 in would increase this to 200 ohms. In the equivalent circuit shown in Fig. 1, this resistance is $r_{bb'}$ and in combination with $C_{b'e}$ is obviously of vital importance in determining high frequency response. To make $C_{b'e}$ small, the wafer thickness must be small: to make the wafer thickness small is to increase $r_{bb'}$.

Surface Recombination

There is yet another difficulty. It is not possible to apply the base connection too near to the emitter junction, as such an ohmic connection to the germanium surface provides a region in which the surface recombination of holes and electrons can take place very easily. The solution adopted by RCA is to drill a small pit in a thick germanium wafer, to give a structure of the form shown in Fig. 2. Round the junctions there is only germanium, so that no recombination troubles are encountered: away from the actual junction region the germanium is thick, and the value of $r_{bb'}$ is kept down to about 50-100 ohms. The actual junctions are 0.015 in and 0.010 in diameter, compared with the 0.004 in and 0.002 in of the Philco transistor.

The larger size of the junctions in the RCA transistor is reflected in the choice of working point. Where Philco operate at $I_c = -0.06$mA, $V_c = -0.5$V, the figures for the RCA transistor are quoted at $I_c = -1$mA, $V_c = -6$V, so that we should expect to see a factor of 16 to the advantage of Philco so far as $C_{b'e}$ is concerned. On the other hand, the RCA unit will have a lower value of $r_{bb'}$, which will offset this to some extent.

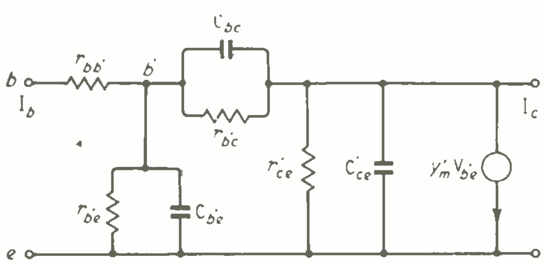


Fig. 1. Base-input single-generator π-equivalent circuit of transistor.

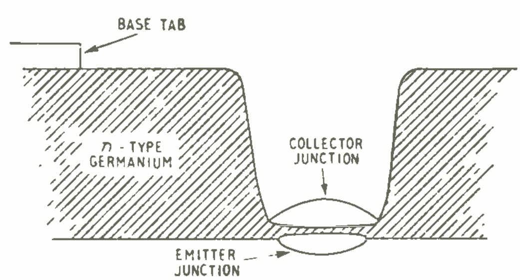


Fig. 2. Cross-section of junction in the RCA high-frequency transistors.

socket is to convey electric current from one point to another. The *contacts* perform this function *regardless* of the type of moulding in which they are mounted, therefore I submit that the type of contact should be the identifying factor. Furthermore, much confusion can be avoided by using the word "pole" instead of "pin" as in the following table:—

N pole plug.—One portion of a plug and socket having N male metallic contacts. Intended for use as a cable attachment or as a rigidly mounted unit.

N pole socket.—One portion of a plug and socket having N female metallic contacts. Intended for use as a cable attachment or as a rigidly mounted unit.

The use of the word "free" for a cable-attached device and "fixed" for a rigidly mounted unit is also to be recommended.

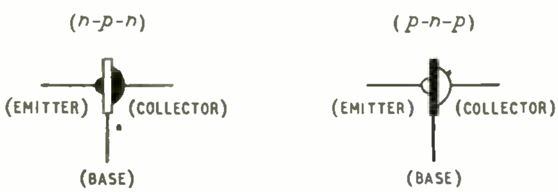
Therefore, my description of the plugs and sockets in Fig. 1 (Mr. Lister's article) would be:—

A: 3-pole plug. 5 amp. Free.
B: 3-pole socket. 5 amp. Fixed.
C: 3-pole socket. ? amp. Free. (Male moulding.)
D: 3-pole plug. ? amp. Fixed (Female moulding.)

London, N.4. P. BROWN.

Transistor Symbols

I DIFFER from F. Oakes (p. 127 March issue) in thinking that the original transistor symbol, introduced at the time of the point transistor, is no longer adequate. By all means retain it in its original context, but let us have a new symbol for junction transistors, and one which will give the maximum information with the least work for the printer and drawing office. Here is my suggestion:—



The lettering would appear only in a glossary of symbols. Useful mnemonics might be "black—dense with electrons—negative—n-type" and "white—full of holes—positive—p-type"; "collector—more power—larger electrode."

Hindhead. HENRY MORGAN.

Ignition Interference

RECENTLY, in your excellent publication, you published letters (M. S. Morse in October, R. Oster in February) that would lead your readers to believe that television viewing in the U.S.A. is completely free from automobile ignition interference. This is definitely not true. Messrs. Morse and Oster are very fortunate if they have never experienced it. We not only enjoy this distraction at times in some fairly high-signal-level areas, but we can be and are occasionally bothered by interference from household appliances. Contrary to Mr. Oster's statement, all appliances are not filtered by the manufacturer. A partial list of interference sources would include electric shavers, oil-burner ignition systems, defective neon signs, thermostatic devices and fluorescent-light starters.

Although older cars seem to be the major source of interference, brand-new cars have no ignition-noise suppression built in unless they are sold with radio. A few non-radio cars may have suppressor-type spark plugs, however. Motor trucks seem to be a greater source of interference than passenger cars, possibly because the spark is "hotter" and the leads are longer.

The American Radio Relay League, the national organization of radio amateurs, has organized a demonstration of most TV reception complaints (which includes the sources mentioned above plus others like FM and TV receiver oscillator radiation, diathermy, and short-wave transmitters associated with other services, etc.) and has presented it to TV servicemen in most of the leading cities throughout the country. (An article describing the demonstration can be found on page 16 of the October, 1953, issue of *QST*.) The demonstration is conducted by Lewis G. McCoy, who has also appeared on a number of TV programmes to tell local audiences the "whys" and "wherefores" of some of their troubles.

I do not wish to leave you with the impression that we do not enjoy good TV viewing in this country—we do—but I would like to correct any notions that we have *no* intereference problems (including automobile ignition). Some of our interference can be traced to poor receiver design—we have some excellent receivers and some poor ones, but we trust that, in time, the poor ones will disappear from the market. But even the best designs do not have a built-in brain that will respond to radio energy that is part of a TV signal and yet not respond to r.f. energy of the same frequency and comparable magnitude that comes from a source other than a TV transmitter.

West Hartford, Conn., U.S.A. BYRON GOODMAN, W1DX. Assistant Technical Editor, *QST*.

Tribute

IN view of the number of times that the opposite side of the picture has been presented, I think that your readers would appreciate the following tribute which appears in the March, 1954, issue of the U.S. publication *Radio Electronics*.

"Recently Britain, which has sent us so many excellent high-fidelity products and circuits, has produced a tone-compensating circuit (introduced by Baxendall*) which for a combination of virtue and simplicity is little short of fabulous."

Incidentally the writer of this article, Mr. Joseph Marshall, has some very excellent ideas himself on high-fidelity amplifiers which I hope you will acknowledge as graciously should you decide to pass them on to your readers.

Montreal, Canada. C. M. WELLS.

* *Wireless World*, October, 1952.

World Television

TELEVISION development and/or future plans in some 50 countries are reviewed in "Television: A World Survey," one of a series of reports on the facilities of mass communication issued by U.N.E.S.C.O. Although based on information available a year ago it will be found of inestimable value to manufacturers interested in the export of television gear.

While it reviews closely the financial and administrative organization of television in each country and gives a brief history of its development, there is a considerable amount of information of interest to the radio engineer. Details are given of the standards adopted, frequencies employed, transmitter power, type of aerial and approximate service area, and on the method of linking stations.

The book surveys the plans made by 52 countries to provide or extend their television networks. Brazil, for instance, which at present operates three stations on the 525-line standard, plans to establish 290 transmitters.

"Television: A World Survey" is obtainable from H.M.S.O. price 9s 6d.

LETTERS TO THE EDITOR

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

Aircraft Flutter

THERE was an unfortunate error in the report of the Television Society's Exhibition (February issue) in connection with my method of simulating aeroplane flutter. I agree that a flutter produced by "an input attenuator" would be "somewhat artificial," and it was for this reason that I did not use it. The simulator in fact operated by preparing a delayed signal of controllable amplitude, passing it through a continuously variable 360 deg phase shifter (at 45 Mc/s) and adding it back on to the main signal. One revolution of the phase shifter therefore produced one cycle of flutter.

The time delay was obtained by about 100 yards of coaxial cable. The phase shifter consisted of four stator sets of quadrantal condenser plates with a quadrantal rotor set revolving inside, and was constructed from two standard 50-pF air dielectric trimmers. The four stators were fed with voltages having successive 90 deg phase shifts (obtained by three lengths of cable cut to one-quarter-wavelength each at 45 Mc/s), and the output was taken from the rotor with a capacitive load adjusted to minimize the incidental small-amplitude fluctuations of the phase-shifted signal. The rotor was driven at a controllable speed via a 30:1 reduction gear box, a small shunt motor, and a Variac transformer from the mains.

In the interests of accuracy, it would perhaps be better to say that frequencies up to some 10 c/s are passed, rather than "in the region of 10 c/s," as the frequency of minimum voltage loss through the coupling circuit is about 0.5 c/s.

A further small point is that in your diagram (page 73 of *W.W.*, Feb., 1954) the third valve shown, the video output valve, should of course be labelled "V.F." and not "A.F." H. B. S. BRABHAM.

G.E.C. Research Laboratories,
Wembley, Middlesex.

Technical Qualifications

IF your correspondent "Engineer Abroad" (January issue) would enter upon the British scene he would find a revelation awaiting him. There he would find technologists, technicians, boffins, applied scientists, etc., all working together as a team to form a radio industry second to none in the world.

Your correspondent pours scorn on radio engineering education in Britain and predicts its effect upon the efficiency of the radio industry. By what yardstick does he measure efficiency? Quality, output or the "professional status" of the members of the industry? If it is quality and output, the present radio engineering education system is certainly justified. The men who enjoy the titles of technicians, boffins, technocrats, designers, research workers and others so revolting to "Engineer Abroad" are radio engineers in their own right; men who have learned theory and practice and how to combine the two to produce results of a high order.

"Engineer Abroad" would eliminate all those titles and would like to do away with all or most of the engineering qualifications and associations as well. This is a strange contradiction in his plea for increasing "professional status." It is all the more so since there is no suggestion as to what the qualifications would be for his "radio engineer." He is indulging in over-simplication if he considers that an academic training such as bestows professional status for example, in the older branches of engineering would be adequate in the vast and increasingly complicated field of electronics. It might satisfy the student and the public but hardly the industry which depends on output for its existence. As the field of electronics widens more associations and qualifications will be required to keep members in touch with the intricate details of their particular branch and as a proof of status in a particular branch.

In conclusion, one wonders what qualifications your correspondent would demand for a "radio engineer." Would the boffins and applied scientists who conceived and developed radar be eligible, or would a university degree in any engineering subject be the hall-mark?

RADIO ENGINEER.

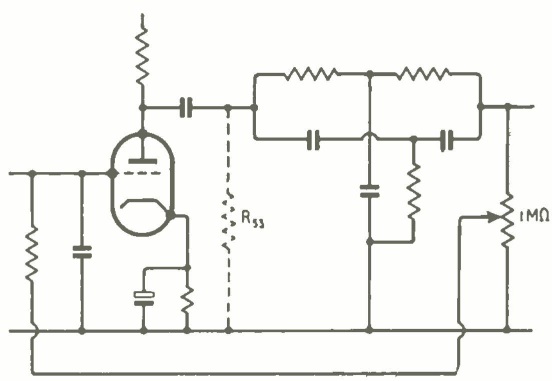
Legal Posers

HERE is a thought, prompted by a letter from one of your correspondents on the subject of television set oscillator radiation. My neighbour's television set (within 100ft) re-radiates the TV programmes at excellent strength from its intermediate frequency amplifier (16 and 19.5 Mc/s for vision and sound respectively). If, by broadbanding my short-wave receiver, I now use these spurious radiations to operate my own television set, do I require a vision licence? And does a "sound" licence cover the "sound" half of the television signal also?

Liverpool, 20. W. BLANCHARD, G3JKV.

Williamson Tone Compensating Unit

IN the switched low-pass filter shown in Fig. 19 of the article High Quality Amplifier (*W.W.*, Vol. LV, No. 11, pp. 426-7, Nov., 1949), it would appear at first sight that by moving R53 to the output end of the parallel-T network, and by using a 1 MΩ potentiometer instead of the fixed resistor specified, control of the loop gain would be possible, thus providing a variable slope feature.



Having no equipment to check results, I would welcome any comments that readers who may have tried this arrangement have to make. JOHN J. CLARK.

Chippenham.

"Plug and Socketry"

C. LISTER'S excellent article (February issue) throws welcome light on this vexed problem of "when is a plug not a plug." But, in my opinion, his suggested table of definitions does not quite meet our requirements as it shows a device having "holes" to be at one instant a socket and, later in the table, a plug.

I suggest that a plug or socket should be defined by function. As everyone knows, the function of a plug and really high—well above nearby surrounding objects—but this might often be neither practicable nor desirable, quite apart from the additional losses introduced by the necessarily longer cable.

The comparison of efficiency of reception at 50 and 500 Mc/s has so far been in terms of median field strengths; i.e., those exceeded for only 50% of the receiving locations at a given distance. If for example it were desired to ensure that 90% of the receiving locations should have a similar service at 500 Mc/s to that at 50 Mc/s an additional discrepancy of 7 or 8 db would have to be made up either at the transmitter or at the receiver. It seems unlikely that the e.r.p. could be increased to approach 10,000 kW at 500 Mc/s: an aerial of 30 db gain with a uniform horizontal radiation pattern is hardly feasible, and 100 kW of radio-frequency power seems out of the question for a considerable time. Also, in view of the arguments advanced above, it would be extremely difficult to find an extra 7 or 8 db at the receiving end.

We have considered in some detail the relative broadcast coverage to be obtained at 50 and 500 Mc/s. It will be clear that most of the difficulties encountered at 500 Mc/s will be accentuated at, say, 900 Mc/s towards the top end of Band V. Smaller transmitter powers will be available, there will be greater feeder losses (both at the transmitter and the receiver), it will not be advisable to use much greater aerial gains (transmitting or receiving) than those already envisaged above for 500 Mc/s, and the disadvantageous effects of rough terrain are greater at 900 Mc/s than at 500 Mc/s. On the other hand, in Band III, at frequencies near to 200 Mc/s, the situation is considerably easier than in Band IV; and it should be possible to provide a coverage more nearly comparable with that of Band I without undue difficulty. Here (in Band III), for the same e.r.p. as in Band I, it would be necessary to make up no more than about 12 db at the receiving end, assuming receivers of similar noise figure. It should in fact be possible to obtain greater e.r.ps (by several db) in Band III than in Band I without the use of unnecessarily complicated transmitting aerials, thus leaving a degree of gain to be achieved by the receiving aerial which is within the bounds of a reasonable design. It might be added that the spread of field strengths occurring at a given distance from the transmitter in Band III will be intermediate between that for Bands I and IV.

Conclusions:—Even taking the most optimistic view of the e.r.ps likely to be available in the television Bands IV and V, and of the noise figures likely to be achieved for receivers in these bands, it is clearly going to be difficult to provide an efficiency of reception at any given distance similar to that obtainable in Bands I and III over terrain of the kind found in the midlands and south-east of England; the problem will be even greater in very hilly country where more intense shadows are cast.

It may be, of course, that the policy to be adopted envisages the use of a large number of u.h.f. stations—since more channels will be available in Bands IV and V than in Bands I and III—each serving a relatively restricted area. (It is beyond the scope of this article to discuss the economics of such a scheme, but it would obviously be a very important matter.) With this in mind it is instructive to compare the v.h.f. and u.h.f. bands taking a rather less optimistic, and perhaps more realistic, view of what may be possible in the near future. If in the early stages of development it is found that the overall signal to noise ratio achievable in Band IV, say, is 15 db worse at a given distance than is at present obtained in Band I—which is not unlikely—the kind of service provided, for example, at 30 miles in Band I could only be provided at about 15 miles in Band IV. No account has been taken of the effects of man-made or extra-terrestrial noise in these arguments. Evidence is to some extent conflicting, but the amount by which it seems possible that these effects will decrease in the u.h.f. as compared with the v.h.f. bands will not seriously change the arguments advanced in this article.

It is in the nature of things that rough terrain should produce wider variations of field strength at u.h.f. than at v.h.f., and whilst some of the effects of variations occurring locally at a receiving site may be eliminated by the use of a suitable directive aerial, little can be done in this way to change significantly the median field strengths. This statistical aspect of broadcast coverage cannot be avoided, and must form the basis upon which plans are made for serving any given area.

Short-wave Conditions

Predictions for April

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 April.

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

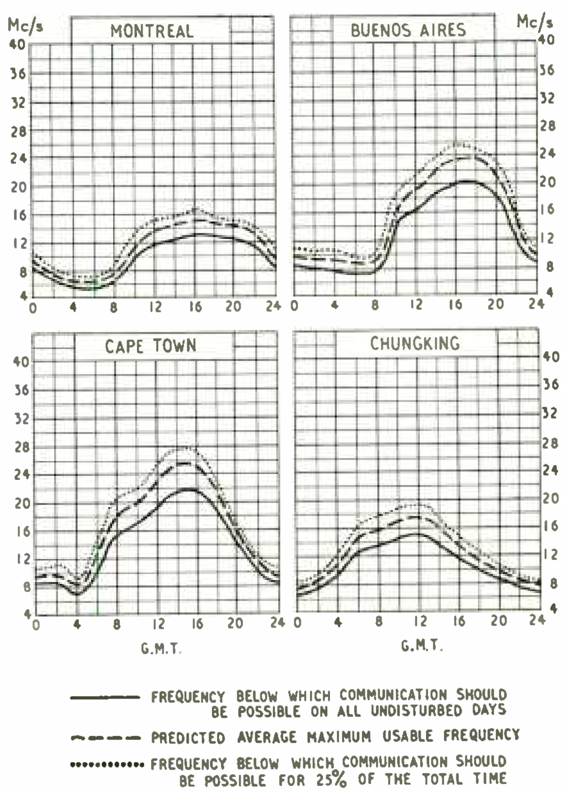
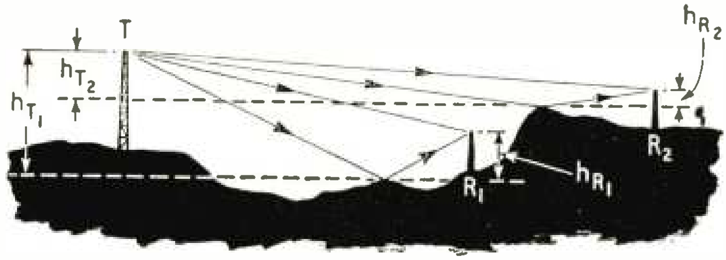


Fig. 2. Transmission over rough terrain, showing relationship between true and effective heights of aerials.



about 10 db, and it ranges from about 15 db at the bottom of Band IV to over 20 db at the top of Band V. The somewhat surprising final result is that, within close limits, the same median field strength is obtained throughout Bands I to V for a given e.r.p., and the same transmitting and receiving aerial heights; at least up to the probable limiting extent of the service area of a u.h.f. station, say out to 30 miles, or so, depending of course on the e.r.p. and the transmitting aerial height.

Before going on to examine further the significance of the constancy of field strength as a function of frequency, we may note the range of variation of the general signal level found on various azimuths around the transmitter at a given distance. In Band I 10% of the receiving locations will have a level some 7 or 8 db greater than the median value, whilst a further 10% of sites will have a level some 7 or 8 db less. In Band III the variation from the median value will be of the order of 12 db for the most favoured and least favoured 10% of receiving locations, whilst at 600 Mc/s (at the cross-over from Band IV to Band V) the corresponding variation will be 15 db. It would perhaps be as well to emphasize that the measurements from which these characteristics have been deduced were taken under a wide variety of conditions—on level ground, in front of, on top of and behind hills, amongst houses and other buildings and in open or wooded country. Further, the receiving aerial height was 30 feet, and the conditions were thus typical of what would be expected with practical television receiving installations for domestic use.

Reception at Various Frequencies:—Consider first reception by a half-wavelength dipole at various frequencies within the Bands I to V. The effective length of such an aerial is λ/π, and the input voltage to a receiver correctly matched to the aerial, neglecting any feeder loss, is $V = E\lambda/2\pi$ when the field strength at the aerial is E volts/metre. For constant E, therefore, $V \propto 1/f$. Thus, by way of example, in going from 50 to 500 Mc/s (Band I to Band IV) the input voltage decreases 10 times (20 db). At present noise figures of receivers at u.h.f. are of the order of 6 db, or more, worse than those obtainable at v.h.f., so that for the same signal to noise ratio at the two frequencies (with a given e.r.p.) a total discrepancy of about 26 db has to be made up.

The e.r.p. of the existing high-power Band I stations in the United Kingdom is about 100 kW. Within the next few years it is unlikely that actual powers exceeding some 10 kW will become available in Bands IV and V; indeed at the present time a figure of 1 kW might be nearer the mark. For the purpose of this argument, however, we shall assume the availability of 10 kW transmitters in Bands IV and V. It would be relatively easy to provide a suitable transmitting aerial with a gain of 10 db, thus achieving the same e.r.p. as obtains in Band I; in fact it would not be unreasonable to envisage transmitting aerials with gains approaching 20 db, or e.r.ps of 1,000 kW, even after allowing for the somewhat greater feeder losses which may exist in the u.h.f. bands. Taking this optimistic view we should be left with a factor of only 16 db to recover at the receiving end to give the same performance at 500 Mc/s as at 50 Mc/s—when using a simple half-wavelength aerial at the Band I frequency. In practice, beyond the immediate vicinity of the transmitter it is common in Band I to use receiving arrays of one form or another having gains of perhaps 2 to 3 db. It may well be, however, that progress in the design of u.h.f. receivers in the near future will lead to a betterment of noise figures by 3 or 4 db, leaving finally a factor of 15 db to be found from receiving aerial gain at 500 Mc/s, though this ignores the fact that cable losses will almost certainly be significantly greater in the u.h.f. than in the v.h.f. bands.

A simple 10-element Yagi array of overall length about 4 feet (and therefore not inconveniently large) can be made to give a gain of 12 db relative to a half-wavelength dipole at 500 Mc/s, so that it might appear not to be impracticable to achieve the 15 db gain required to give comparable performance at 500 and 50 Mc/s.

There are, however, still several important points to be considered. In the first place an aerial of the Yagi type having a gain as much as 15 db will be a relatively narrow band device, and this degree of gain is likely only to be realized in the one u.h.f. channel for which it has been designed. To obtain an aerial of broader band characteristics it would be necessary to go to a type involving a reflector of the parabolic type; and for a gain of 15 db a reflector 8 ft in diameter would be required (at 500 Mc/s), which would hardly be practicable. Thus, if it is essential that a high receiving-aerial gain should be achieved, the problem of designing a practical aerial to cover more than one u.h.f. channel would seem difficult to solve, to say the least. A further hindrance to obtaining high gain with a receiving aerial is brought out by the figures in the table. If there are large fluctuations of field strength over a small area, then it is obvious that the field structure is very complicated, and under such circumstances a highly directive aerial may well have an effective gain appreciably less than it would have in a uniform field, for which it will normally have been designed. This may be a serious problem in towns, for not only is the field strength in the u.h.f. bands some 15 db below the median value obtained in more open country for any given distance from the transmitter (i.e. with $h = 30$ ft), but large fluctuations generally occur in the vicinity of the receiving site. Some improvement in performance may be obtained by putting the receiving aerial return to the main theme of this article, namely the propagation problems encountered within the normal service areas of v.h.f. and u.h.f. stations.

Ground-Wave Propagation at V.H.F. and U.H.F.:—When the transmitting and receiving aerials are at heights h_T, h_R, each at least a few wavelengths above the ground, and spaced a distance d apart over a smooth earth such that $d \gg (h_T + h_R)$, the field strength at the receiving point is given by the expression :

$$E = \frac{90\sqrt{W}\, h_T\, h_R}{\lambda\, d^2} F \text{ volts/metre} \quad .. \quad .. \quad (1)$$

where all lengths are in metres, λ is the wavelength, and W is the effective radiated power (e.r.p.), i.e. the actual power multiplied by the gain of the transmitting aerial relative to a half-wave length dipole. The factor F, which is less than unity, takes account of the curvature of the earth : it is independent of the frequency but decreases as the distance increases. (For a flat earth F = 1). The expression (1) applies for both horizontally and vertically polarized waves at the frequencies with which we are concerned ; and it results from the vector addition of the fields due to the direct wave TR and ground-reflected wave TOR as illustrated in Fig. 1.

Thus, when comparing field strengths at different frequencies at a given distance, and for the same e.r.p., h_T and h_R, we should expect on this simple model based on a smooth spherical earth to find that $E \propto 1/\lambda$, or $E \propto$ frequency (f). Experimental observations have shown, however, that this conclusion is far from borne out in practice when transmission occurs over rough terrain, as is nearly always the case for overland propagation. Consider, for example, an experiment in which the field strength is measured at various distances along a path such as that shown in Fig. 2. (The height scale is here very much exaggerated in comparison with the distance.) It is assumed for simplicity that for each of the receiving positions R_1, R_2 only one reflected ray is possible. The actual height of the receiving aerial above ground level is the same at R_1 and R_2, but for transmission between T and R_1 the effective transmitting and receiving aerial heights are h_{T1} and h_{R1}—very different from h_{T2} and h_{R2}, the corresponding values for transmission between T and R_2. It is clear, therefore, that in general field strength measurements at all points along an irregular path cannot be described in terms of equation (1) with unique values of h_T and h_R. The situation becomes more complicated when it is realized that there are ground configurations which can give rise to more than one reflected ray between T and R —quite apart from the fact that some receiving points will be in shadow regions. Furthermore, such multipath transmission is increasingly likely as the frequency is raised since relatively smaller areas of ground (or of any reflecting object) are required to give effective reflection.

Experimental Field Strength Surveys:—In view of the difficulties of interpretation outlined above it has been found essential to analyse the results of experimental field strength surveys on a statistical basis. It is then found that the measurements of field strength made over the whole of the service area of a v.h.f. or u.h.f. station conform statistically with a law of the form given by equation (1). A word of caution is needed here, for the surveys amenable to this kind of analysis, both in this country and in the U.S.A., refer mainly to terrain which is not mountainous in character, for example such as is found in the regions around London and Sutton Coldfield. It should also be added that, particularly at u.h.f., greater attenuation is observed in densely built-up areas (like London and Birmingham) than in more open country.

Experimental observations of field strength are conveniently analysed in the following manner. First, in the immediate neighbourhood of a receiving site there is nearly always some variation of field strength as the receiving aerial is displaced a few yards ; the range of this variation is found to increase with the frequency, and its order of magnitude is indicated in the table for frequencies of 100 and 600 Mc/s.

LOCAL VARIATIONS ON A RECEIVING SITE

Frequency (Mc/s)	Minimum Range of Field Strength Variation (db)		
	10% of sites	50% of sites	90% of sites
100	8	5	2
600	17	7	3

These figures refer to a typical receiving aerial height of 30 feet, and as far as can be ascertained they are not very dependent upon (i) transmitting aerial height over a wide range, or (ii) distance from the transmitter.

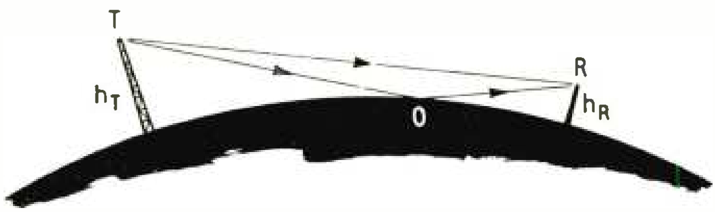


Fig. 1. Transmission over smooth earth. One reflected ray only is shown and aerial heights are exaggerated.

Secondly it is found that the general level of the signal at sites at the same distance from the transmitter, but on a representative selection of azimuths all round the transmitter, varies very considerably. The interesting fact emerges, however, that the median field strength varies with distance according to a law of the form derived for a smooth spherical earth [equation (1)], though the degree of absolute agreement with equation (1) depends upon the frequency. (The median field strength at any given distance is the value exceeded at 50% of the receiving sites at that distance.) In Band I the median field strength agrees very closely with the value $90\sqrt{W}h_T h_R F/\lambda d^2$ (i.e. within 1 or 2 db), with h_T and h_R the actual values of the respective aerials above ground level at the terminal points ; but as the frequency increases the measured median field strength falls progressively below the theoretical value, though the departure seems, to a first approximation, to be the same at all distances, at least up to 40 or 50 miles. Thus in Band III the discrepancy is

Television Coverage

Assessing the Service Areas of Transmitters at V.H.F. and U.H.F.

By J. A. SAXTON, D.Sc., Ph.D., M.I.E.E.*

Variations of field strength caused by rough terrain at v.h.f. and u.h.f. are discussed in this article; and an estimate is made of the part played by these variations in determining the coverage of broadcasting transmitters operating at such frequencies, with particular reference to television transmission in Bands I, III, IV, and V.

FREQUENCY bands at present allocated for television are 41-68 Mc/s (Band 1), 174-216 Mc/s (Band III, though all the channels are in fact, as things stand not available), 470-585 Mc/s (Band IV) and 610-960 Mc/s (Band V). Band II (87.5-100 Mc/s) is to be used for v.h.f. sound broadcasting only. Of the four television bands it is only the first which is generally in use in the United Kingdom at this time. Band III is widely used in the U.S.A., as well as Band I, and there are also some Band III stations in Western Europe: so far the only exploitation of the u.h.f. bands for television has been in America. As the plans for more stations in this country develop, it is certain that use will have to be made of Bands III, IV and V (Band III stations are already projected) since, for reasons outlined below, there is a limit to the number of stations which can be operated on any one frequency in a given area without serious mutual interference—and this limit has already been reached for Band I in the United Kingdom with the stations, high and low power, now existing, and the further low power stations shortly to be put into commission.

The successful allocation of frequencies for, and the siting of, transmitters in the v.h.f. and u.h.f. bands depend upon an accurate knowledge of radio wave propagation characteristics at these frequencies. A considerable amount of information concerning v.h.f. propagation has existed for some time, but, although experimental u.h.f. field strength surveys have been made over the past few years in the U.S.A., it is only recently that any comprehensive investigations in the u.h.f. band have been carried out in this country†. This work has borne out the conclusions drawn from the American experiments for propagation over similar kinds of terrain.

At frequencies less than about 30 Mc/s radio wave propagation is influenced mainly by the electrical properties of the ground and by the ionosphere, the relative importance of these factors depending upon the frequency and upon the distance of transmission; but refraction in the troposphere and the ground profile over the transmission path are of little significance, particularly as the frequency becomes progressively lower. On the other hand, as the frequency increases above 30 Mc/s the situation is reversed; the electrical properties of the ground are no longer of any great importance, ionospheric influences disappear, and the dominant factors are refraction in the troposphere and surface irregularities of the ground, both on a small and on a large scale.

For distances up to, say, 50 or 60 miles variations in signal strength at v.h.f. and u.h.f. arising from changes in atmospheric refraction (brought about by changes in the weather) are normally not of great significance, though they undoubtedly occur at times; and thus the variation of field strength with the nature of the terrain is the most important propagation problem to be considered within what may be regarded as the normal service area of a television or other broadcasting station operating on these frequencies.

In certain kinds of weather—under settled anticyclonic conditions, for example—it is possible, as is now well known, for relatively strong signals to be received with Band I transmissions at distances well beyond the horizon, up to several times the normally expected service range in fact. Similar behaviour is found with Band III transmissions: thus on occasions signals on a frequency near to 200 Mc/s from France have been received quite strongly in the south of England at a distance of about 170 miles. There is no doubt that abnormal ranges will also occur at times with transmissions in Bands IV and V. It must be stressed that these increased field strengths at long range, arising from super-refraction and reflection processes in the troposphere, cannot be relied upon to provide any worthwhile extension of the service area of a v.h.f. or u.h.f. station beyond that obtaining under what are known as standard conditions of refraction—such as exist in the well-mixed atmosphere associated with unsettled weather. Long-range tropospheric transmissions are troublesome, however, since they accentuate the problem of interference between common-frequency stations; and as a consequence it is necessary to put such stations at much greater distances apart than would otherwise have been necessary. It is for this reason that the limit of common frequency working for each of the five channels of Band I has now been reached for the area of Great Britain with the existing and projected stations. It might be added that the problem is obviously aggravated by the close proximity of Western Europe. With these few comments on the influence of atmospheric refraction on frequency allocation and the siting of transmitters we may now

*D.S.I.R. Radio Research Station, Slough.

†"Ground-Wave Field Strength Surveys at 100 and 600 Mc/s" by J. A. Saxton and B. N. Harden; and "Basic Ground-Wave Propagation Characteristics in the Frequency Band 50-800 Mc/s" by J. A. Saxton. These papers are to be published in *Proc. I.E.E.* 1954, Vol. 101, Part III.

feedback and not reduced as we expected. The simplest way of looking at this effect is a "swings and roundabouts" way: if you use feedback up in flattening a poor frequency response, it is not available for reducing the distortion. Here it is not really the harmonic distortion which causes the trouble, but the intermodulation of high frequencies and general mud-production.

At low frequencies a somewhat similar effect is observed in some closely designed amplifiers. If the signal fed back is not in the opposing sense to the input signal, it may be enough to overload one of the early valves in the amplifier. As a result, this valve is driven into the gross distortion region and although the feedback would be available at the harmonic frequencies if the fundamental were not present, the fundamental itself prevents the amplifier having its proper amplification for harmonic reduction. Here, then, is another detail which must be watched if you want to be able to predict the performance of an amplifier with negative feedback.

This survey of the problem of distortion in feedback amplifiers is not rigorous, not exact and probably not complete. It does, however, give some explanation of why the simplest calculation of distortion reduction breaks down, and the method suggested for calculating the distortion appears to provide reasonably good quantitative results without an excess of labour. The construction of an effective mutual conductance characteristic is seen to give a rather simple way of determining a good working point and predicting the resulting distortion. Band edge effects require much more calculation and are outside the scope of this article. In this field, at any rate, if your measurements don't agree with the theory, check them and be sure you have used the right theory.

CLUB NEWS

Brighton.—A series of talks on radio mathematics is being given to members of the Brighton and District Radio Club by E. Bannister. The club meets each Tuesday at 7.30 at the Eagle Inn, Gloucester Road, Brighton, 1. Sec.: T. J. Huggett, 15, Waverley Crescent, Brighton.

Cleckheaton.—Both meetings of the Spen Valley and District Radio and Television Society in April will be devoted to transmitting topics. On the 7th H. Clegg (G3FX) will speak on the use of valves in transmitters and on the 21st A. Smith, B.Sc. (G2BOO), will deal with transmitter design. Meetings are held at 7.30 on alternate Wednesdays at the Temperance Hall, Cleckheaton. Sec.: N. Pride, 100, Raikes Lane, Birstall, Nr. Leeds.

QRP.—The council of the QRP Society (the word "Research" has been dropped from the title) has, in view of its growing overseas membership and the increasing use of v.h.f., amended its rules regarding power limitations. For v.h.f. work the maximum power has been doubled—10 watts to the final stage of transmitters and a total h.t. consumption of 3 watts in receivers. Overseas transmitters will be permitted to use a maximum of 20 watts. Sec.: J. Whitehead, 92, Ryden's Avenue, Walton-on-Thames, Surrey.

Wellingborough.—The Wellingborough and District Radio and Television Society is providing and manning a stand at the Hobbies and Careers Exhibition which is being held at the Drill Hall, Wellingborough from April 20th to 23rd. Sec.: R. J. Henty, 6B, Silver Street, Wellingborough.

Wolverhampton Amateur Radio Society has moved to new headquarters at Stockwell End, Tettenhall, where the club transmitter (G87A) is installed. The club meets on alternate Mondays. Sec.: H. Porter (G2YM), 221, Park Lane, Wolverhampton.

BOOKS RECEIVED

Art and Science in Sound Reproduction, by F. H. Brittain, D.F.H. Acoustic and psychological principles involved in sound reproduction, leading to a series of designs for high-quality amplifiers pre-amplifiers and radio feeder units. Pp. 55; Figs. 35. Price 2s 6d. General Electric Company, Magnet House, Kingsway, London, W.C.2.

Magnitude of the Radio Interference in the Television Band from Ignition Systems of Motor Vehicles, by A. H. Ball and W. Nethercot. Results of field strength measurements on a wide range of vehicles to determine the effect of suppressors in meeting the B.S.833 level of tolerable interference. Pp. 7; Figs. 4. Price 6s. The Electrical Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey.

Information Theory, by Stanford Goldman. Survey of current knowledge written at a mathematical level suitable for first-year university students in electrical engineering. Pp. 385+xiii; Figs. 68. Price 50s. Constable and Company, 10, Orange Street, London, W.C.2.

The Electronic Musical Instrument Manual, by Alan Douglas. Revised and enlarged edition giving up-to-date information on principles, with descriptions of representative commercially produced instruments. Pp. 221; Figs. 187. Price 30s. Sir Isaac Pitman and Sons, Parker Street, London, W.C.2.

Commercial Literature

Nickel Alloy Spring Materials with resistance to corrosion and non-magnetic properties. Descriptions of various alloys and tables of characteristics in a booklet from Henry Wiggin & Company, Wiggin Street, Birmingham, 16.

Heavy-duty Relay, type C.03, for operating from a.c. or d.c. up to 500V, and fitted with two 15-A and two 5-A changeover contacts. Leaflet from Besson & Robinson, 6, Government Buildings, Kidbrooke Park Road, London, S.E.3.

Complete Transmitters (and associated equipment) of various powers for broadcasting and communications, mobile and beacon use and unattended operation. A handsome, well bound and illustrated catalogue of 240 pages giving descriptions and specifications of the major products of The Gates Radio Company, 123, Hampshire Street, Quincy, Illinois, U.S.A.

Sequence Timer for controlling a sequence of switching operations on mains circuits. It consists of a series of switches operated by cams (up to 120) geared to a synchronous motor. Leaflet from the Electrical Remote Control Company, Elremco Works, East Industrial Estate, Harlow New Town, Essex.

Solenoids for industrial use with maximum strokes from ⅜in to 1½in and pulls from 1 oz to 26 lb. Performance data and dimensions in a brochure from Oliver Pell Control, Cambridge Row, Burrage Road, Woolwich, S.E.18.

Tape Recorder in suitcase form with slide-out chassis on steel frame. Leaflet from Tape Recorders (Electronic), 3 Fitzroy Street, London. W.1.

Oscilloscopes, designed to accommodate modifications to customers' special requirements. Basic equipments described in a brochure from A. E. Cawkell, 6-7, Victory Arcade, The Broadway, Southall, Middlesex. Also a leaflet on a **Wide-Band Amplifier** for pulse amplification with a frequency response of 15 c/s to 10 Mc/s (to the −3db points) and a gain of 40.

Variable Tuning Capacitors, air dielectric; an illustrated catalogue giving specifications, law curves and mechanical drawings from The Plessey Company, Ilford, Essex.

Scintillation Phosphors for use in scintillation counters. Various materials in different forms for detecting alpha, beta and gamma rays, neutrons, protons and x-rays. Characteristics on a leaflet from Isotope Developments, Finsbury Pavement House, 120, Moorgate, London, E.C.2.

Retractable Instrument Cord in coiled spring form for use in telephones, test gear, etc. Leaflet from Aerialite, Castle Works, Stalybridge, Cheshire.

occurs beyond about − 6 volts. Let us say that it is the behaviour around − 6.75 volts which settles the distortion. Here the mutual conductance was 4.5mA/volt, and feedback has reduced it to 0.8mA/volt. We have, indeed, only 15db of feedback in this region, and the distortion has gone down 13–15db. Considering that I chose − 6.75 volts because it was a thick line on the graph paper, with no faking, no trial calculations to find a " good " example, this agreement is remarkably close.

We see from this example that the reduction of petty distortion is indeed equal to the gain reduction, provided that we consider the gain reduction in the distortion region. We have, perhaps, trespassed slightly into the region of gross distortion in our example, but the limits of this are much more clearly defined in Fig. 3 than they are in Fig. 2.

This example was worked out for a single distorting valve, preceded by an unspecified number of absolutely linear stages. It is perfectly practicable to build up a composite $g_m - e_g$ curve for a number of stages by multiplying the appropriate values of g_m derived from a set of valve characteristics for the various types used. This would be especially useful in the particular case of a small triode driving something like a 50L6 and operating on 110 volts. The driving down of the triode grid, which lowers the mutual conductance, drives up the 50L6 grid and raises the mutual conductance here. With care, and luck, the two slopes can be balanced to give a reduction of the second harmonic. The effect of feedback on such a composite characteristic can be worked out by the use of a fictional cathode resistor.

Screen Distortion

Having now particularly described and ascertained the effect of feedback on distortion, I must add that this is not nearly the whole story. We have shown that the theory, if correctly applied, gives the right answer, but are we sure the circuit is designed to enable the theory to be applied ? One difficulty which often arises is the result of a weakness in the cathode feedback circuit. It is very attractive to take feedback from the cathode of an output tetrode back to the cathode of the first valve of a three-stage amplifier. It is very tempting to return the screen directly to the positive supply, so that we can get the most output for the least supply voltage. When we do this, however, the screen current flows through the cathode resistance, so that what we feed back is not a voltage proportional to the current in the load, but a voltage proportional to the sum of the load current and the screen current. The screen current may be extremely distorted if the valve is being driven hard, and normally we shouldn't mind, because the screen current does not flow through the load in most normal amplifiers. In the circuit of Fig. 4 we feed back this distortion current and thus introduce the screen distortion into the control grid circuit. Then we complain that feedback is not helping all it should. The remedy is, if we want this kind of feedback, to decouple the screen back to cathode as shown in Fig. 5. Then the signal current in the screen circuit is excluded from the cathode resistance.

This decoupling is often inconvenient, so we decide to take our feedback from the valve anode, back to the preceding cathode perhaps. A new difficulty is sometimes encountered here, though it is apparent only in amplifiers of the highest quality. The swing at

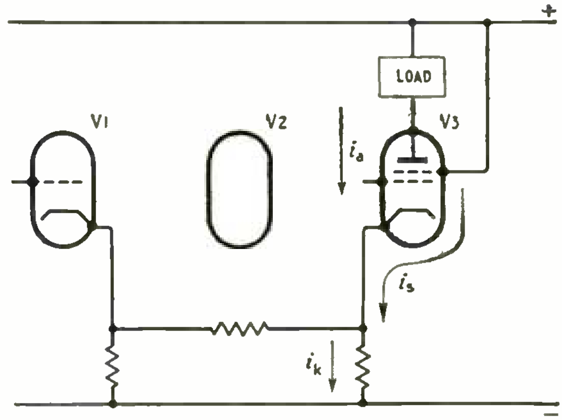


Fig. 4. With this sort of circuit the voltage fed into the cathode of V1 depends on ($i_a + i_s$), not upon i_a alone.

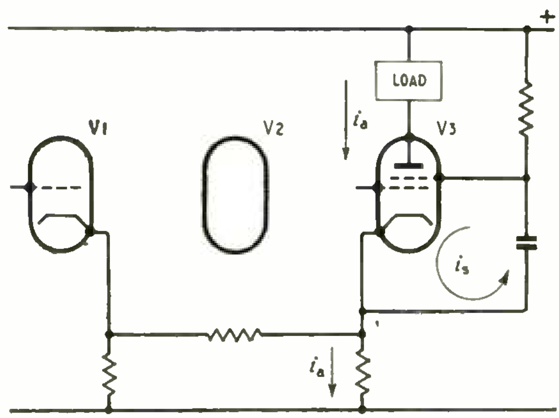


Fig. 5. By decoupling screen to cathode, i_s does not flow through the feedback resistor. The voltage fed back depends only on i_a.

the output anode is usually of the order of 100-200 volts, and almost the whole of this appears across the feedback resistor. For cheapness and convenience a carbon resistor is used here : all heedless of their fate the little victims play. Carbon resistors are not absolutely constant in value, but depend slightly on the applied voltage. This voltage effect is sufficient to produce some distortion in some particularly high-grade circuits. Obviously, in an ideal feedback amplifier, with the gain equal to $1/\beta$, any distortion in the feedback path becomes the limiting factor, and although I have never encountered this trouble myself, some American papers have recorded it.

Are there any more gaps ? One, usually trivial, is the additional feedback path through the power supply impedance. Another, the only one which comes to mind at the moment, is particularly important at the edges of the working band. We write down, very happily, the equation $m = A/(1 + A\beta)$, the equation $d'_o = d_o/(1 + A\beta)$. But what do we mean by A ? Pretty obviously we must mean the gain at the harmonic frequency, which will certainly not be the same as the gain at the fundamental when we are dealing, in an audio-frequency amplifier, with frequencies above a few thousand cycles per second. Furthermore, there will be a phase angle associated with A, and the value of $|1 + A\beta|$ may be quite small. The harmonics will then actually be amplified by the equally at both peaks by an overloaded amplifier. When feedback is applied, the effect is to produce the rather clean flat-topped characteristic shown in Fig. 1, curve (b). It is not very difficult to calculate the way in which the total distortion increases with amplitude : all you need to do is to work out the area under the cap of the sine wave, because that is the actual " distortion signal " generated in the amplifier. If the amplifier clips one side only you can use the expression given on p. 303 of *Reference Data for Radio Engineers* (3rd edition) to calculate the individual harmonics. The diagram in Fig. 1 does illustrate, I hope, the way in which so long as the signal is below the knee of the characteristic the feedback keeps it sinusoidal, and then, well it just can't go any further.

Those readers who have some experience of speech clipping circuits may wonder why we should concern ourselves overmuch about this effect, because on speech a characteristic of this kind has little influence, at any rate if we think mainly of intelligibility. I have discussed this in these columns previously, but I must just remind you that if a second much higher frequency is present at a lower level it will be suppressed during the " flat." The double bass will modulate the ocarina, and instead of the pure, and very dull, tone of the latter we shall have a muddy product tone.

The effect of feedback on gross distortion is seen to be small, and if distortion is plotted as a function of output level, which it always should be, the distortion rises so quickly, because the output can hardly rise at all, that measurement errors play a very great part in fixing the shape of the curve. Moreover, the distortion should be divided by the predicted sine wave output, which you cannot measure anyway.

Calculating Distortion

The reader is no doubt exclaiming, to himself I hope, that he never overloads amplifiers, but that even in his safely underloaded amplifier the theory is not exact. We must, therefore, turn our attention to the petty distortion. I shall assume first of all that all the distortion originates in the last valve of the amplifier and that this valve is a 6AG7. The choice of this valve is dictated by the fact that it is the only large valve for which I can find curves of mutual conductance as a function of bias. From the curve shown in Fig. 2 we can estimate that gross distortion is likely to occur beyond about — 7.5 volts, so that we might choose — 3.75 volts, the point marked on the curve, as our working point. We can calculate the distortion which this valve will produce, by a method which has already been described in *Wireless World* (June 1951). The second harmonic distortion depends on the average slope of the $g_m - e_g$ characteristic, and for the curve shown the level of second harmonic below the fundamental will be

$$20 \log \frac{9}{12} + 18 = 15.5 \text{ db.}$$

The third harmonic depends on the amount of " sag " at the working point, and is

$$20 \log \frac{9}{1.5} + 22 = 26.4\text{db.}$$

It may seem that the distortion, which is well over 10 per cent, hardly merits the name of petty distortion, but this distortion is due solely to the smooth curvature of the valve characteristic, and I have taken the extreme values just in order to make the errors in reading the curve less.

Let us now apply some feedback to the amplifier containing this valve. Since the rest of the amplifier was assumed to be linear, the grid voltage axis, with a suitable change of scale, could be the signal axis at any point in the amplifier. So we need not worry too much about scales. The easiest way in which the feedback can be applied, for calculation purposes anyway, is as current feedback. This will reduce the effective mutual conductance by an amount depending on the feedback applied. If the feedback is simulated by, or even produced by, a resistance in the cathode, the effective mutual conductance g'_m is

$$1/(R_k + 1/g_m)$$

At the selected working point we have $g_m = 9$ mA/V: let us assume that g'_m is to be 0.9 mA, giving us 20 db gain reduction. Then R_k must be 1,000 ohms. In Fig. 3 I have constructed a curve of $g'_m - e_g$, using the equation above. From this curve we can calculate the distortion, with feedback applied. The result is that we have

second harmonic

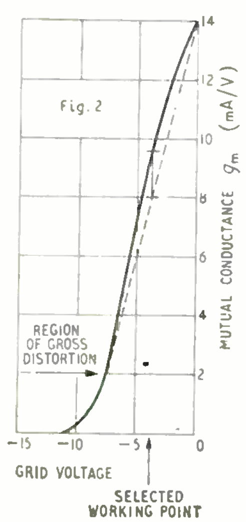
$$20 \log \frac{0.9}{0.27} + 18 = 28.4 \text{ db down,}$$

third harmonic

$$20 \log \frac{0.9}{0.1} + 22 = 41 \text{ db down.}$$

From these results we see that the gain reduction of 20db is accompanied by only 13db of second harmonic reduction and 14.6db of third harmonic reduction. Also, though I don't intend to calculate this, the characteristic shown in Fig. 3 indicates quite clearly that higher-order harmonic terms will be fairly pronounced.

We have thus proved triumphantly exactly what you have always said : negative feedback is a bit of a swindle. Well, if you look at Fig. 3 you can see where we have gone astray. The valve maker tells us to work the valve at — 3 volts bias, and most of the distortion is contributed by the drop in g'_m which



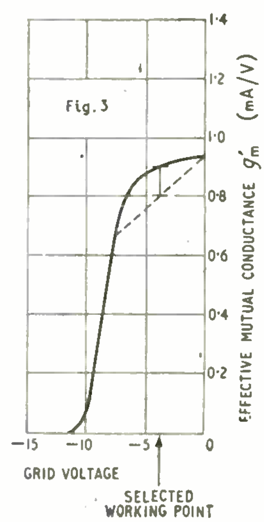


Fig. 2. Mutual conductance of 6AG7 valve as a function of grid bias. $E_a = 330V$. $E_s = 150V$.

Fig. 3. Effective mutual conductance g'_m with 20 db gain reduction due to feedback.

Distortion in Negative Feedback Amplifiers

Points at Which Simple Theory Breaks Down

By THOMAS RODDAM

MOST amplifier designers will have encountered the unfortunate man who has applied, say 20db of feedback to an amplifier which was producing 5 per cent distortion and finds the distortion is still 2 per cent. It is tempting, when asked what we can do about it, to reply in the words of Michael Finsbury "nothing but sympathize." A rather more constructive attitude was adopted by R. O. Rowlands, in *Wireless Engineer* of June, 1953, who analysed the reduction of distortion by negative feedback in a moderately rigorous way. This analysis, however, still omits some significant factors and does not, in my view, lend itself to extension. In this article I propose to examine what the elementary theory of distortion reduction is; why it goes wrong, if it does go wrong, and how we can predict what will happen to the distortion in a particular amplifier when feedback is applied. I do not propose that you should sit down and calculate for days instead of carrying out a few measurements: on the other hand it is always useful to have calculated something similar in the past when you come to assessing the results of a particular experiment. We might follow Mahan and introduce the concept of a "calculation in being."

Before we go any further we must see just what the elementary theory of negative feedback predicts about the distortion. The amplifier, with a gain of A, has its gain reduced to $A/(1+A\beta)$ by feeding back a fraction $1/\beta$ of the output to the input. At any point inside the amplifier the signal level is the same, for a given output, whether feedback is connected or not, so that the distortion signal generated inside the amplifier is unaltered by feedback. Without feedback we find this signal, which we can call d_o in the output. With feedback connected we shall find a new value of distortion, say d'_o, in the output. We feed back $\beta d'_o$ to the amplifier input, where it is then amplified, and appears as a term $A\beta d'_o$. Then d'_o (the actual distortion) $= d_o$ (the intrinsic distortion) $+ A\beta d'_o$ (the distortion returned round the loop) and so $d'_o = d_o/(1+A\beta)$.

The factor $(1+A\beta)$ is the gain reduction factor, and so we should expect to get an improvement of 10 times for every 20db of gain that we sacrifice. Now we know that this does not happen in practice.

Let us divide up the distortion we obtain in an amplifier into gross distortion and petty distortion. Gross distortion is the distortion produced by some discontinuity in a characteristic, a sharp change of some sort which we usually, though not necessarily, associate with overloading. Driving to cut-off, driving a pentode into the "bottoming" region, driving into grid current without special circuit arrangements, at the peaks of the signal something different happens and the low level conditions no longer apply. Grid current or cut-off need not produce a discontinuity, as we know from experience with push-pull Class B circuits, but the system must be designed to work into these special regions if no ill effects are to be obtained. Gross distortion is not necessarily associated with overloading, because a failure to fit the characteristics of a push-pull Class B pair will result in "cross-over" distortion, where there is a momentary "flat" on the characteristic as we swing through the centre. This particular form of distortion is much more disturbing than overload limiting.

Gross distortion obeys the elementary theory for feedback amplifiers quite well, provided that you apply the theory correctly. The distortion is produced during short intervals of time when, shall we say, the grid of the output valve is positive with respect to cathode, grid current is flowing and the input impedance of the valve is, perhaps, 1,000 ohms. The preceding stage gives only a very small gain into such a load, so that the value of A which we must put into our equation is not the 1,000 (60db) we so blithely assume, but shall we say, about 10. For these quite arbitrary figures, and an assumed β of 1/100, the quantity $(1+A\beta)$ is not 11, but 1.1. While the distortion is being produced there is virtually no feedback effect, because the amplifier is blocked off and the distortion sent back through the feedback network cannot get round to produce the expected cancellation.

If we examine an amplifier working under these conditions by using an oscilloscope we can see fairly easily just what is happening. I have sketched it out in Fig. 1, which shows the simple sine wave limited

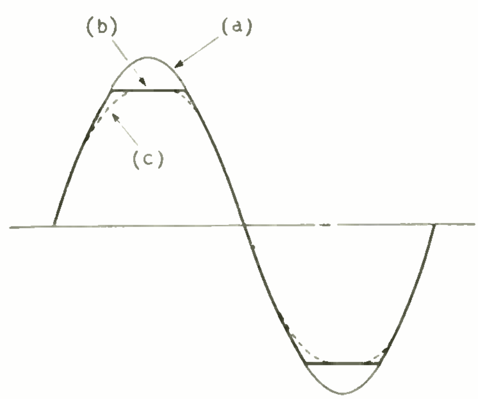


Fig. 1. Gross distortion. The sine wave (a) is distorted by the amplifier into the form (c) if there is no feedback, and into the form (b), which has a sharply defined flat top, if feedback is used.

supply. The value of the smoothing resistor is chosen to give a smoothed h.t. supply of approximately 250 volts. For compactness, the two 32-μF smoothing capacitors are in a single can.

Alignment of the receiver is extremely simple. It is necessary only to adjust C_6 and C_7 for maximum output with the tuning capacitor at minimum and an input at 1.7 Mc/s. The inductance of L_1 and L_2 should be adjusted for maximum output when the tuning capacitor is at maximum and the imput at 550 kc/s, after which the high-frequency adjustment should be repeated.

The potentiometer R_3 should be adjusted in the following way. Set R_3 to that end of its travel which gives minimum V2 screen potential and, with gain control at a maximum, tune the receiver to a very weak signal or to a "quiet" spot on the band where only receiver hiss can be heard. Now advance R_3 slowly until the signal or hiss disappears. Leave R_3 at a setting just below that which causes the signal to vanish.

The receiver is intended for use in the London area, where the Light programme is available on medium waves, and has no long-wave band. The use of a single waveband leads to a simple circuit with no complications due to waveband switching and duplication of trimmers. It is hoped, however, in a note to be published later to indicate how a long waveband could be added to the receiver. This addition is by no means a simple matter. If the long-wave coils are coupled by the method employed between the medium-wave coils, the primary and secondary windings of the long-wave coupling transformer require inductances of the order of 70 μH. It is difficult to wind two coils of this inductance value by hand on a small former of the type used for medium waves, and an alternative method of coupling is preferable.

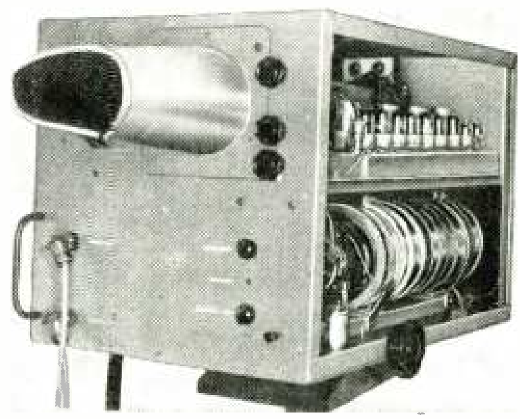
AMATEUR COLOUR TELEVISION

IN our February issue we reported that C. Grant Dixon, using home-constructed equipment, had succeeded in transmitting colour television pictures over a closed circuit. We have now received more information on the technical details of the apparatus. As already stated, it works on the frame-sequential system, with rotating colour discs in front of the camera and receiving screen, and the scanning rate is 100 colour frames per second or 33⅓ complete pictures per second. The standard adopted is 150 lines, sequentially scanned.

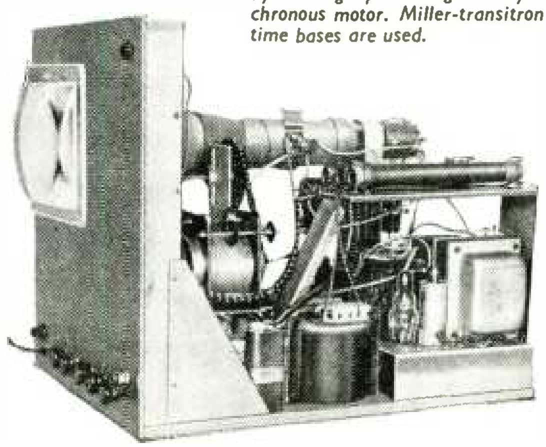
As the frame frequency is locked to the mains the two rotating colour discs are kept in synchronism with it by being driven by synchronous motors. The one at the transmitting end, which has 12 colour sectors, is run at 500 r.p.m. while the one at the receiving end, with six sectors, is run at 1,000 r.p.m. The transmitting motor can be made to slip out of synchronism temporarily for the purpose of phasing the colours correctly. There is also an arrangement for altering the phase of the frame synchronization with respect to the mains and hence to the transmitting colour disc. This enables the camera to be adjusted correctly so that each division between colour sectors on the disc always follows the scanning spot of the pick-up tube; the mosaic is then exposed to the next colour for the whole of the time between successive dischargings of the screen elements.

Apart from the camera and monitor shown in the photographs, the apparatus includes a control rack which carries a timing unit, sync and blanking pulse generators, a unit for mixing these pulses with the video signal, a c.r.t. waveform monitor and a power supply unit. The timing unit produces pulses at 15 kc/s and 100 c/s which trigger the line and frame sync and blanking pulse generators respectively. As already mentioned, it is locked to the mains in frequency, but can be varied with respect to the mains in phase.

Mr. Grant Dixon is the Chairman of the British Amateur Television Club.



In addition to a pick-up tube and rotating colour disc, the colour camera houses a time-base chassis, a video amplifier and a c.r.t. view-finder. An anastigmatic camera lens (f.4.5) is mounted in the camera casing and optical focusing is controlled by moving the pick-up tube backwards and forwards on a pair of rails by a rack and pinion arrangement. Power supplies are in a separate unit. The receiving monitor unit (below) has a 5-inch electrostatic tube working at 3.3 kV. The six-sector colour disc is driven at 1,000 r.p.m. by a Magslip running as a synchronous motor. Miller-transitron time bases are used.



ment; the crystal should be so connected that the anode potential of V2 falls when a carrier is tuned in.

V2 functions as first a.f. and a.g.c. amplifier; to obtain high d.c. gain it is essential to keep the d.c. resistances in the cathode and screen-grid circuit low. The cathode resistor R_8 has a value of only 220 ohms, which causes very little degeneration, but a suitable value of cathode bias is obtained, as in the sensitive t.r.f. receiver described by S. W. Amos and G. G. Johnstone in the November 1951 issue of *Wireless World*, by passing the cathode current of V1 through R_8. The screen circuit resistance is low because it is fed from the cathode circuit of V1, the grid of which is connected to a resistive potential divider R_1, R_2 across the h.t. supply. Thus V1 behaves as a d.c. cathode follower in addition to an r.f. amplifier. The cathode of V1 behaves as a d.c. source with an internal resistance of $1/g_m$ (approximately 250 ohms), but V2 screen is fed from a 10-kΩ potentiometer R_3, connected in the cathode circuit and thus the screen resistance for V2 screen varies somewhat with the setting of R_3, rising to a maximum of approximately 2.5 kΩ when R_3 is at its mid-point. This value of resistance is unlikely to reduce the d.c. gain of V2 to any marked extent. The potentiometer R_3 is included to provide a means of adjusting the anode potential of V2 to the value giving correct a.g.c. performance. The adjustment should be such that the anode potential of V2 equals the cathode potential of V1 when there is no signal input to the receiver. The range of screen potential provided (approximately 50 volts) should be sufficient to enable the correct performance to be obtained in spite of the differences in valve parameters likely to be encountered when V2 is replaced by another valve of a similar type.

It is common practice to have a small fixed degree of voltage feedback in the a.f. section of small receivers of this type. This improves frequency response and decreases harmonic distortion at the cost of decreased gain, but to avoid a serious loss in sensitivity the feedback has usually to be limited to perhaps 6 db. This limitation is unfortunate, because there is a considerable margin of gain in hand during local-station reception when feedback is most required. The ideal solution to this problem is, of course, to have a variable degree of feedback which can be set to maximum on strong signals and a minimum (or zero if desired) on weak ones. A separate control for this is undesirable, however, and in this receiver feedback and a.f. gain are simultaneously adjusted by the gain control. As shown in the circuit diagram the gain control R_6 is returned via C_{10} not to earth but to a fixed potential divider R_{12}, R_{13} across the secondary winding of the output transformer. When the gain setting is low, the slider of R_6 is near the junction with C_{10} and nearly the whole of the voltage developed across R_{13} is applied to V2 grid to give feedback. On the other hand, when the slider of R_6 is near the junction with the crystal, a.f. gain is high and very little of the voltage across R_{13} reaches V2 grid, implying very little feedback.

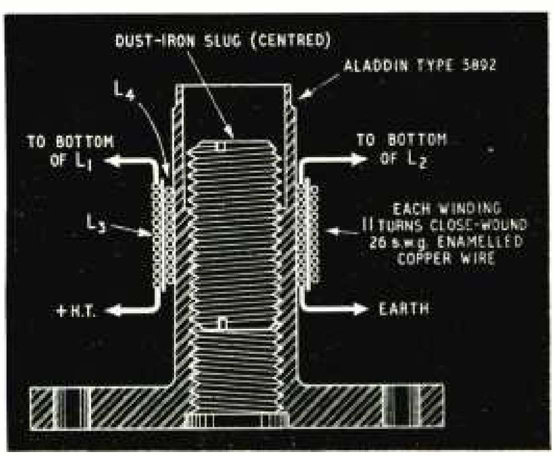


Fig 3. Winding details of coupling transformers (L_3, L_4).

Feedback Adjustment

The degree of feedback which remains when R_6 is set to maximum gain depends on the effective resistance of the crystal at audio frequencies. As the crystal is switched between conduction and non-conduction at radio frequency this resistance is somewhat difficult to assess but it is certainly small compared with R_6 (1 MΩ), and very little feedback remains when the gain control is at maximum. This can easily be demonstrated by short-circuiting R_{13} (to remove feedback entirely) when a weak signal is tuned in and R_6 is at maximum; there is practically no change in audible output. The values of R_{12} and R_{13} must be found by experiment; they are chosen to give the largest degree of feedback compatible with stability at low settings of the gain control. The values used by the author were 470 ohms (R_{12}) and 37 ohms (R_{13}), but these depend on the constants of the output transformer.

The transformer used by the author was a Goodmans Type 74 243. The values of R_{12} and R_{13} can easily be determined by replacing these resistors by a potentiometer and adjusting this, with the gain control at minimum, until instability occurs. Although instability usually takes the form of a supersonic oscillation, the onset is generally indicated by an audible "plonk." The potentiometer should be left a few degrees below the setting giving instability and the two "halves" measured. From the ratio of these two readings the values of R_{12} and R_{13} can be calculated; their sum should be at least 10 times the loudspeaker resistance.

R.f. decoupling is carried out in the a.f. amplifier by capacitors C_{11} and C_{13}. C_{11} presents V2 with a very small load at r.f. frequencies (only 160Ω at 1 Mc/s) and C_{13} is connected between V3 anode and V2 cathode to give negative feedback which is negligible at audio frequencies but considerable at radio frequencies. The values of the two capacitors are so chosen that there is no obvious change in the high audio-frequency response of the receiver when the feedback is removed by operating the gain control to maximum.

The output stage and mains unit are quite conventional. The ratio of the output transformer should be chosen to present V3 with an anode load of approximately 20 kΩ. The mains transformer is a small type measuring 3 inches by 2½ inches by 2½ inches and having a single 6.3-volt winding. For rectification an EZ41 was chosen because of its small size and because it can withstand a high heater-cathode voltage. Thus all valves are operated from a common l.t.

tuning capacitor being considered too large for a midget receiver) and they are employed as a bandpass filter coupling the r.f. stage to the detector. The voltage gain normally obtained between aerial and r.f. grid is, of course, lost, but this is made good by the high gain now available from the r.f. stage. The only disadvantage of the untuned input circuit is the possibility of cross-modulation at the grid of the r.f. stage. Because of the absence of any voltage step up between aerial and r.f. grid this danger is not so serious as might be imagined. Most r.f. pentodes will accept inputs of an appreciable fraction of a volt without serious non-linearity, and it is unlikely that inputs larger than this will be obtained unless the receiver is situated very near a high-power transmitter. In such localities it is advisable to include a resistor (of say 470 ohms) between the cathode of V1 and the junction of C_3 and R_3 to improve linearity by current feedback. Normally, however, this resistor is unnecessary and it is omitted from Fig. 1.

A 6F33 was chosen as r.f. amplifier because it has a very short suppressor-grid base (approximately 7 volts for a screen-cathode potential of 150 volts) and a reasonably high mutual conductance (4·35 mA/V) permitting high stage gain. The operating conditions for the valve must be chosen with care to avoid exceeding the maximum safe screen dissipation (0·8 watt) when the receiver is tuned to a strong signal and the cathode current goes wholly to the screen grid. It was decided to operate the valve with 150 volts between screen and cathode and at 5 mA cathode current. These conditions are obtained by choosing the values of R_1 and R_2 to give 100 volts positive on V1 grid. The cathode potential automatically takes up a potential slightly in excess of this value and, since the total external cathode resistance is 20 kΩ, the cathode current is approximately 5 mA. The cathode potential of approximately 100 volts is a suitable maximum value for application to V2 screen. The r.f. input is applied to V1 grid via C_1, the value of which is chosen to give good r.f. transfer but to give great attenuation to 50 c/s signals from the aerial; such signals would be transferred to V2 screen by cathode follower action to give hum in the receiver output.

L_1 and L_2 are the two tuning inductors; to obtain high gain these must have a high dynamic resistance. Dust-iron cores of the fully-shrouded type (Fig. 2) are used (Neosid Type 10D) and are wound with 57 turns of 9/45 Litz wire to give an inductance of 160 μH. This gives a dynamic resistance of nearly 300 kΩ at 1 Mc/s, corresponding to a Q value of approximately 300. There is, of course, no reason why commercial coils of suitable inductance and Q value should not be used instead.

Bandpass Coupling

A number of experiments were carried out to determine a suitable method of coupling the two tuning inductors. "Top-end" and "bottom-end" capacitance coupling were both tried and rejected because of considerable variation in gain over the waveband. Mutual-inductance coupling was found to give substantially constant gain and was adopted in spite of some variation in passband over the waveband. Attempts were made to obtain the necessary coupling by placing the coils in close proximity, and although it was found possible to obtain greater than optimum coupling in this way, the method had to be abandoned because the coupling was found to be largely capacitive (the dust-iron shrouds, being non-conductive, do not screen the coils against this form of coupling). Thus it was necessary to use additional inductors connected in series with each tuned winding to provide the required inductive coupling. It is necessary to place the tuning inductors some distance apart or to employ some form of electrostatic screening between them to minimize capacitive coupling.

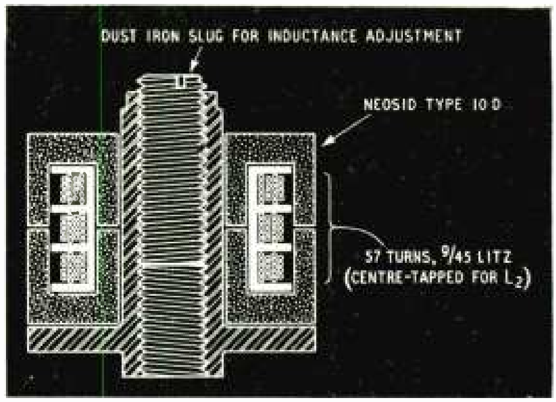


Fig. 2. Winding details of tuning inductors (L_1, L_2).

The coupling transformer consists of two windings each of 11 turns of 26 s.w.g. enamelled copper wire, one wound on top of the other and separated from it by two thicknesses of paper. The former is an Aladdin Type 5892 with a dust-iron slug suitable for medium-wave working. The slug is not intended for adjusting the degree of coupling in the bandpass filter but is left in the centre of the two windings L_3 and L_4 to give maximum coupling between them, as shown in Fig. 3.

The detector is a crystal diode and to keep the damping of the second tuned circuit at a minimum it is series connected to the load circuit. Even so it was found necessary to tap the crystal at the mid-point of inductor L_2 to maintain adequate selectivity. At first a 1-MΩ load resistance was used in parallel with C_9, but this was later omitted because it was found that the reverse resistance of the crystal provides an adequate discharge path for C_9 during negative half-cycles of the r.f. input. Needless to say the type of crystal should be chosen with care and preference should be given to those with a back resistance greater than 100 kΩ. The author used a B.T.H. Type CG1C. The output of the detector is applied to the grid of V2 via the coupling capacitor C_{10} and the gain control R_6 but C_{10} is connected in the low-potential end of R_6. This arrangement does not affect control of gain and is adopted to ensure that the d.c. output of the detector is always applied in full to V2 grid, irrespective of the gain control setting.

The crystal must be connected in circuit in the correct sense, i.e., so that the d.c. output biases V2 positively. Unfortunately, there does not appear to be any agreement amongst the manufacturers about coding the connections of crystals; it is usual practice to mark one end + or to colour it red, but for some crystals this indicates the end which goes positive when the crystal conducts and for others it indicates the polarity of the e.m.f. which must be applied to the crystal to make it conduct. It is best to determine the correct connections by experi-

Midget Sensitive T.R.F. Receiver

By J. L. OSBOURNE

Three-Valve Circuit with Amplified A.G.C.

THIS article describes a small t.r.f. receiver with a number of unusual features. It has high sensitivity, giving the standard output of 50 mW for an input of 70 μV modulated at 400 c/s to a depth of 30 per cent. This and the selectivity are adequate for the interference-free reception of a number of Continental stations in the London area in daylight. The set has an effective amplified a.g.c. circuit, and for a given gain-control setting the output volume from Hilversum on 402 metres is almost equal to that from the London Home Service transmitter. The volume control adjusts the input to the audio amplifier stages in the conventional manner, but in addition controls the degree of negative feedback, removing it entirely at the maximum setting.

Three B7G-based valves are used, a 6F33 as r.f. amplifier, a 6F12 as audio voltage amplifier and a second 6F12 as output valve. The detector is a crystal diode, the d.c. output of which is amplified by the first audio amplifier, and is then applied to the suppressor-grid of the r.f. amplifier to give a.g.c. The circuit was described by S. W. Amos and G. G. Johnstone on p. 417 of *Wireless World* for October, 1951.

One disadvantage of conventional r.f. amplifiers with grid and anode circuits resonating at approximately the same frequency is that the maximum gain available without instability is limited by the anode-grid capacitance of the valve and, in fact, it is often impossible to take full advantage of the high mutual conductances of valves and high dynamic impedances of tuned circuits for this reason. A numerical calculation will make this clear. The 6F33 has a mutual conductance of 4·3 mA/V and the dynamic impedance of the tuned circuits used in this receiver is approximately 300 kΩ at 1 Mc/s. The gain of a 6F33 with such a value of anode load is given approximately by $A = g_m R_d = 4{\cdot}3 \times 10^{-3} \times 300 \times 10^3 = 1300$ approximately. The maximum gain available from the valve without instability is given by

$$\frac{2}{\omega C_{ag} R_d}$$

in which C_{ag} is the anode-grid capacitance of the valve. This expression applies when the valve has identical tuned circuits in anode and grid circuits. For the 6F33 the anode-grid capacitance is 0·01 pF. Substituting for C_{ag} and R_d, the maximum gain available without instability at 1 Mc/s is given by

$$\frac{2}{6{\cdot}284 \times 10^6 \times 0{\cdot}01 \times 10^{-12} \times 300 \times 10^3}$$

$$= 100 \text{ times approximately.}$$

Thus the valve is capable of more than 10 times the maximum gain which the anode-grid capacitance will allow. The full gain cannot be realized in practice, and since C_{ag} may possibly exceed 0·01 pF in a practical layout, it may be impossible even to achieve the calculated gain of 100 times without encountering sideband cutting due to regeneration if not actual oscillation.

This difficulty can be avoided and the maximum gain of 1,000 times realized with complete stability by the use of an aperiodic input circuit such as that shown in Fig. 1. The omission of the tuned circuit normally used in the grid circuit does not, in this instance, result in loss of selectivity because it was intended to use only two tuned circuits (a 3-gang

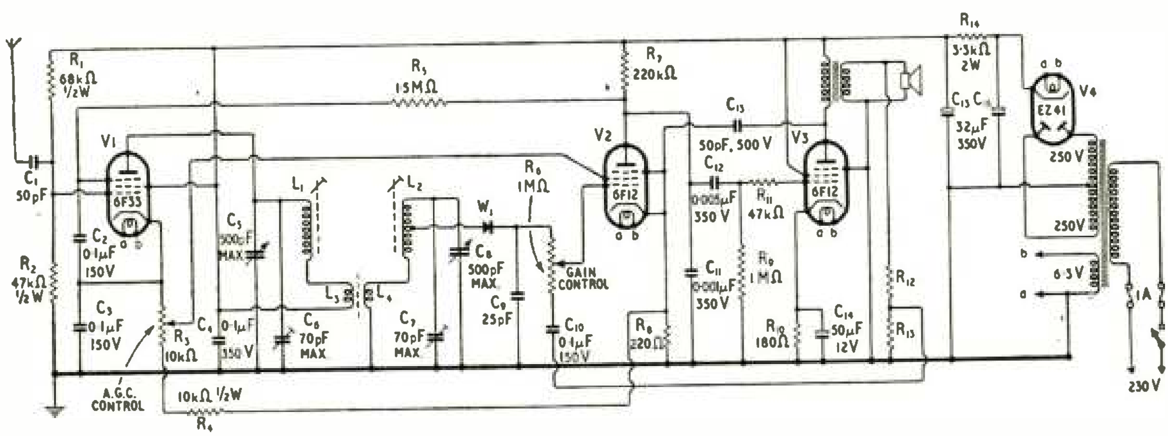


Fig. 1. Complete circuit diagram of t.r.f. receiver with bandpass r.f. coupling and amplified a.g.c. Unless otherwise stated, resistors are rated at ¼ W. Alternative valves to the 6F12 are 6AM6, Z77, EF91 and 8D3.

quency circuits, for they are flat enough to cover two channels.

The signal circuits are heavily damped by the valves and must, in any case, be wideband. The attainment of low losses is not a matter of great importance, therefore, and ordinary switch wafers are used. In the oscillator, however, losses are much more important and here a ceramic switch wafer is employed, and the coils are of a more robust design.

The unit is extraordinarily compact and the basic box measures only $4\frac{1}{16}$ in. deep × 3 in. high × $2\frac{11}{16}$ in. wide. Overall, the behind panel space need not exceed 5 in. deep × 6 in. high × $2\frac{5}{16}$ in. wide.

It is being fitted to the current Pye sets, as a unit separate from the main chassis. It is fixed to the side of the cabinet with the concentric controls coming out through the side. The rest of the receiver is conventional save that it starts with the r.f. amplifier and includes no r.f. or oscillator circuits.

The tuner can be fitted to certain existing Pye receivers—in the main, models for some two years back. This entails certain alterations, because the r.f. and frequency-changer circuits must be rendered inoperative.

The form of aerial necessary for two-band operation cannot, of course, be settled until a good deal more information is available about the siting of the stations, their power, and whether their radiation will be polarized vertically or horizontally. Probably several different forms will be needed to suit different receiving conditions. In the design of this tuner, it has been envisaged that whatever the form of the aerials and their feeder systems, they will be junctioned to a common feeder before the input so that the input will come in on a single cable. In some cases, quite separate aerials may be used for the two bands with separate feeders joining in a junction box near the set. In others, a combined aerial with a single feeder may be enough. This lies in the future and the most suitable form of aerial can hardly be settled until considerable experience has been gained under operating conditions. It is not, however, a matter which affects the tuner. The design which has been adopted enables any form of aerial system to be employed.

British Valve Bases

ON looking through the latest edition of the British Standard on valve bases (B.S. 448 : 1953) it comes as something of a shock to discover that there are at least 25 different types of bases in existence in this country, all with standard B.V.A. numbers like B5A and B7G.

From a purely superficial point of view, the Standard is worth studying, if only to discover what exactly are the rare birds that go under such unfamiliar names as B4F, B5D and B11A. It has a more serious purpose, however, which is given by the B.S.I. as "to schedule the agreed physical requirements for valve bases, caps and holders necessary to ensure both a good mechanical fit and a satisfactory electrical contact between mating parts." Drawings and tables of dimensions are given for each base type.

B.S. 448 : 1953 ("Electronic-Valve Bases, Caps and Holders") brings up to date the 1947 version of the Standard. It is issued in loose-leaf form in a binder so that new additions and amendments can be put in as they are published. It can be obtained from the British Standards Institution, British Standards House, 2, Park Street, London, W 1, price £1 2s 6d.

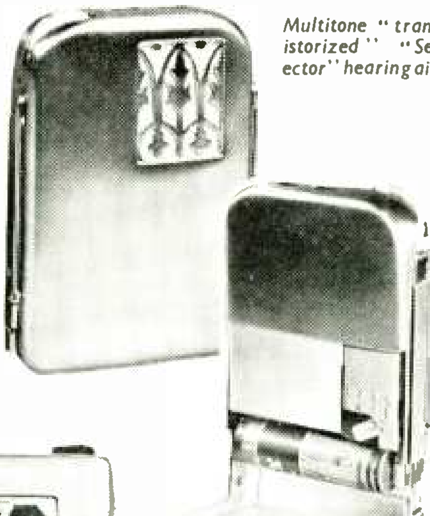
ALL-TRANSISTOR HEARING AIDS

FOUR stages with resistance coupling are used in the transistor version of the Multitone "Selector" hearing aid. The transistors are of the glass-sealed junction type, and a sensitivity comparable with a valve hearing aid is provided with a crystal microphone and a magnetic earpiece wound to match the output impedance.

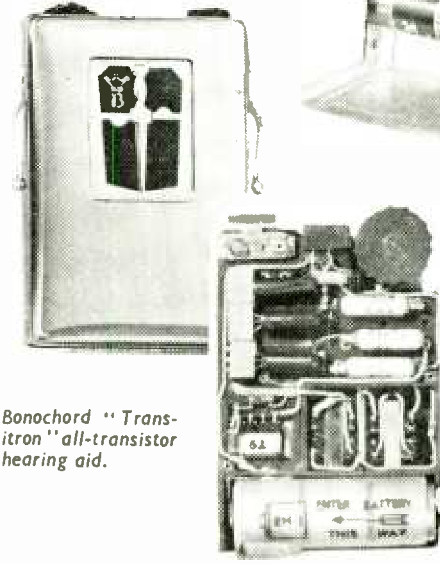
The total current consumption is 2.5mA from a single 1.5-V dry cell. Maximum power output is ample for the majority of cases, though less than with some valve hearing aids. Consequently, overload distortion must be guarded against, and to this end automatic volume control is incorporated, with three degrees of control and an "off" position. This arrangement gives complete freedom from irritating percussive effects, together with quality of reproduction which is better than that which one expects from a valve hearing aid.

Deliveries in the home market will increase as more of the glass-sealed junction transistors become available.

In the "Transitron" hearing aid, made by Bonochord, 48, Welbeck Street, London, W.1, there are three transformer-coupled transistor stages. The power output is variable, according to the number of battery cells used. Total current consumption is 2mA for 1.5V and 7.6mA for 4.5V, and according to the maker's figures the maximum air-to-air gain is 70db. Separate on-off and volume controls are provided and the polished stainless steel case measures $3\frac{1}{4}$in × $2\frac{1}{4}$in × $\frac{7}{8}$in. The weight including battery is $4\frac{3}{4}$oz.



Multitone "transistorized" "Selector" hearing aid.



Bonochord "Transitron" all-transistor hearing aid.

with the switch knob, is provided in the oscillator circuit.

A simplified circuit diagram of the tuner is shown in Fig. 1. A double-triode cascode r.f. stage is used with a PCC84 valve. This is well known to be advantageous from the point of view of signal/noise ratio, because valve noise is inherently less with a triode than with a pentode, other things being equal.

The first section V_1 is used as a neutralized earthed-cathode stage. The valve capacitances c_{ga} and c_{gk} (supplemented by the adjustable C_3) form two bridge arms and C_1 and C_2 form the other two. The switched coil L_1 is across one diagonal of the bridge, and the anode-cathode path of the valve is across the other, so that the two are quite effectively isolated.

The input signal from the aerial is brought in by a coaxial feeder to the transformer T_1 which functions on all bands. Its secondary is connected across the tuning coil which is switched for channel selection. Actually, all coils are connected in series and the selector-switch arm short-circuits the unwanted coils. The arrangement for the input tuned circuit is shown in detail in Fig. 2; the numbers against the switch contacts are the channel numbers.

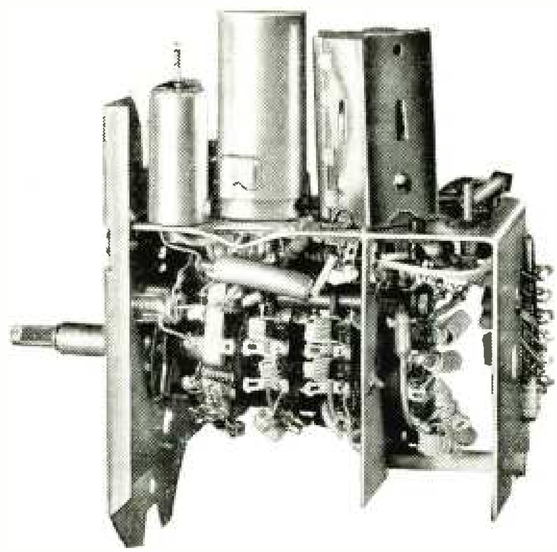
On channel 12, the coil L′ is the only one in circuit. It actually is a coil, for it has some five turns of wire and is nearly three-quarters of an inch long and a bit over one-eighth of an inch diameter. It tunes to around 200 Mc/s with the circuit stray capacitance.

For channel 11, 5 Mc/s lower in frequency, the switch is in position 11 and the inductance L″ is added. This is only an incremental inductance to shift the frequency a matter of 5 parts in 200; the required change of inductance is of the order of 1 part in 80 and is exceedingly small. The inductance of a piece of wire joining adjacent switch contacts is too great! L″ is provided by such a short-circuit between contacts with an additional parallel loop of wire, movement of which acts as a pre-set inductance control. The other incremental "coils" for channels 6-10 are similar, since each has to shift the resonance frequency by 5 Mc/s.

Loading coils are used for the lower frequencies of Band I and are relatively very large, especially the one between contacts 5 and 6 which has to lower the frequency from some 180 Mc/s to 66 Mc/s. The remaining Band I coils are smaller than this for, again, they must shift frequency in 5-Mc/s steps, but they are a good deal bigger than on Band III and increase as the frequency gets lower. They are, in fact, actually coils. The resistor R_1 is the d.c. grid-return path of the valve and R_2 provides damping for channel 1 only.

Returning to Fig. 1, the anode of V_1 is connected to the cathode of V_2 which functions as a triode earthed grid stage. This is the valve which provides the r.f. gain. It has a very low input impedance, being fed at the cathode, and so the first valve gives about unity gain only. The first valve is more an impedance converter for feeding the second valve than an amplifier. V_1 and V_2 must be considered together as forming a single amplifier stage.

The coupling to the frequency changer comprises a top-end capacitance-coupled pair of tuned circuits L_2 and L_3. The physical arrangement of this circuit is basically the same as in the case of L_1. There are basic inductances for channel 12 and the switches add incremental inductance for the lower-frequency channels. There are differences of detail, however; the damping resistors are not the same, additional



Tuner with cover removed showing Band I coils.

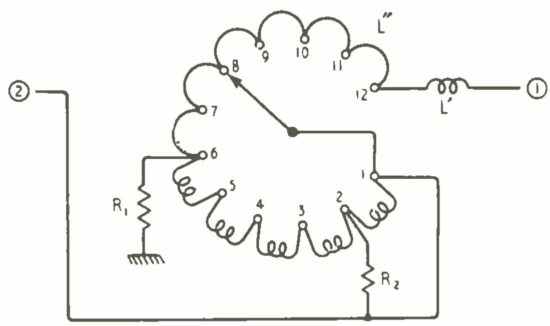


Fig. 2. Coil switching details of the aerial coil L_1 of Fig. 1.

coupling capacitance is brought in for Band I and certain individual sections of inductance are short-circuited to prevent unwanted absorption.

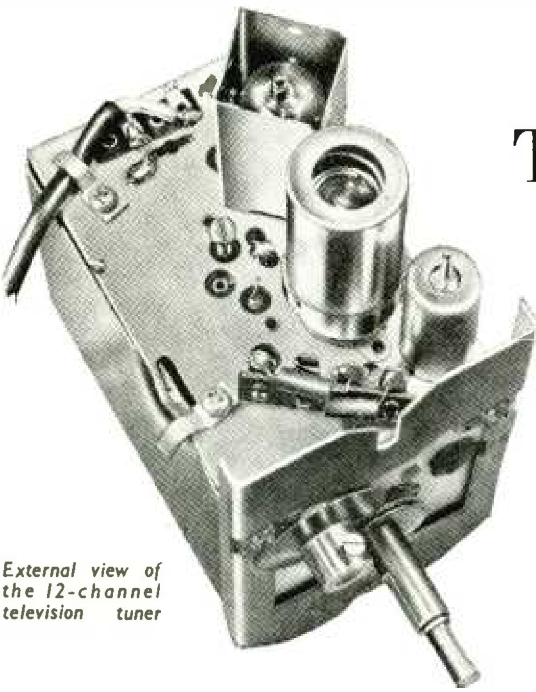
The mixer V_3 is the pentode section of a triode-pentode PCF80, the oscillator voltage being fed to the grid through C_5. Its anode coil is tuned to the intermediate frequency; it acts as step-down auto-transformer to match a coaxial cable which carries the i.f. signal to the i.f. amplifier on another chassis.

The oscillator is a triode V_4 operating above the signal frequency. The same basic switching arrangement is used for L_5, but the basic inductance L_4 for channel 12 is slightly different. It is tapped for the connection of a trimmer, which is a user control, and it has an adjustable slug by which the inductance can be readily adjusted by a screwdriver from outside the tuner.

This is done in order to permit a change to be made in the precise channels selected on Band III. By the adjustment of L_1, the oscillator can be shifted in frequency by 5 Mc/s—one channel—so that the top channel can be made 12 or 13 as required. On Band III all channels are similarly affected and so, according to how L_1 is set, the Band III channels are 6-12 or 7-13. The change is not enough to affect Band I appreciably. No change is made to the signal-fresoldered directly into the circuit and manufacturers state that a thermal shunt must be used if this is done.

After the writer had wrecked two transistors, due presumably to an imperfect shunt, it was decided to use miniature valve sockets instead, the length of the transistor leads being cut to approximately ½in. This is a much more satisfactory proposition, because the transistors can be quickly plugged in and out for test purposes, and there is no danger of the transistor being damaged when circuit modifications are made. Occasionally a transistor was plugged in the wrong way round. This was immediately apparent by loss of gain, but no irreparable damage seems to have been done to them, both noise figures and overall gain being normal when the transistor was reconnected correctly.

Since these experiments were completed we have been informed that the transistors OC10, OC11 and OC12 will be superseded in the near future by glass-encased, hermetically sealed transistors, types OC70 and OC71. These are germanium-type *p-n-p* transistors, and whilst the temperature limitation of 45 deg C will still apply, they should be proof against humidity, and give satisfactory service under tropical conditions. Additionally, the signal-to-noise factor has been considerably improved. The design parameters are somewhat different from those of the previous types and may call for modifications in the values of components shown in Fig. 4.



External view of the 12-channel television tuner

12-Channel Television Tuner

Covering Bands I and III

THIS tuner, which is being fitted to the current production Pye sets, gives 12 channels with switch selection. It comprises a signal-frequency amplifier and a frequency changer and provides an output at intermediate frequency. Five of the 12 switch positions are for Band I and seven for Band III. There is actually room in Band III for eight channels and provision is made for the missing channel to be at either end; that is, by an adjustment, the tuner can be made to cover channels 1-12 inclusive or 1-5 and 7-13. A trimmer, with its control knob mounted concentrically

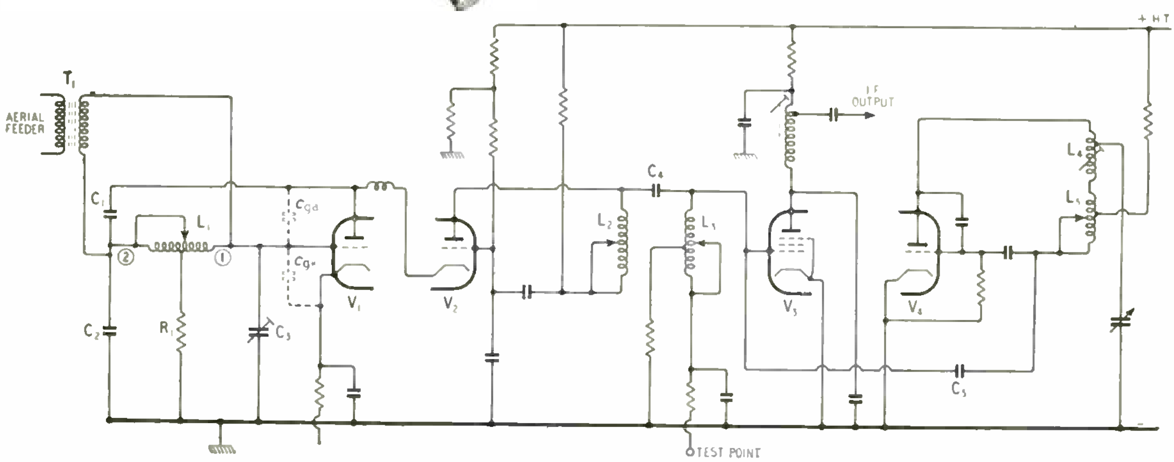


Fig. 1. Simplified circuit diagram of the Pye two-band television tuner.

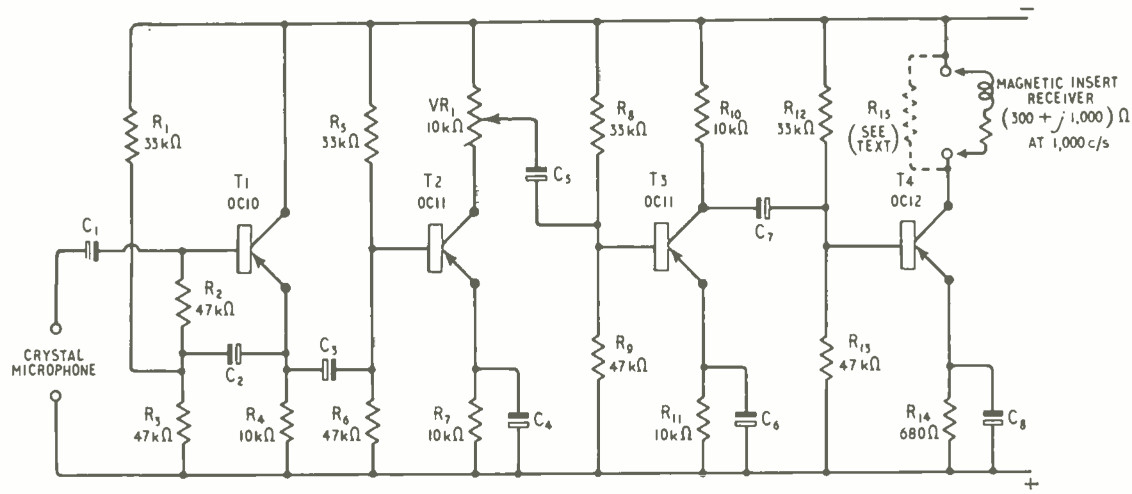


Fig. 4. Experimental four-stage transistor hearing aid with RC coupling throughout. C_1–C_8 inclusive are miniature 8 μF, 6–V d.c. working capacitors.

impedance against load impedance of this network, the effects of R_1 and R_2 being neglected.

In the practical circuit (T1 of Fig. 4) direct-current stabilization is employed as in earthed-emitter circuits. The voltage gain is very near unity, particularly when the supply voltage is made fairly high (8-10 V). Feedback is applied from the emitter to the base voltage divider to decrease the shunting effect of the divider. With selected transistors, an input impedance of 0.75 mΩ has been obtained in the audio range, although this input impedance is a function of frequency, decreasing with increasing frequency. Decreasing the load resistance will decrease the voltage gain, the internal transistor feedback, and also the external feedback of the voltage divider via C_2 of Fig. 4, and with the output short-circuited the input resistance is of the order of 200 Ω.

Practical Considerations.—Fig. 4 shows an experimental amplifier made in accordance with the above philosophy. It consists of one earthed-collector and three earthed-emitter stages. D.C. stabilization is obtained by means of resistances in the emitter circuits R_3, R_7, R_{11} and R_{14}. The overall gain was measured on the set-up shown in Fig. 5. With a supply of 4.5 V, the gain figures obtained are plotted in Fig. 6, curve A being the power gain when the amplifier was fed from a source resistance of 100,000 Ω (R of Fig. 5) and fed into a 1,000-Ω insert telephone receiver. Curve C used the same input conditions as A, but with a 10-henry choke (d.c.R=300 Ω) shunted with a 1,000 Ω resistance. Curve B was with the amplifier fed from a condenser of 2,000 pF (C of Fig. 5). When used as a hearing aid with a crystal microphone the overall air-to-air gain of D, Fig. 6, was obtained. This compares quite favourably with equivalent valve units.

If further treble cut is required it is best to apply it by means of a condenser across VR_1 and extra bass cut can be obtained by reducing the values of C_3, C_5 and C_7. The overall noise of the amplifier was not measured, but when listened to against a standard valve hearing-aid unit of comparable gain, the noise was of the order of 8-10 db worse, and was equivalent to an ambient noise at the microphone face of about 40 phons.

Desirable additions to the amplifier for hearing-aid use would be automatic gain control. The overall gain is a function of the supply voltage and reducing this to 3 V reduces the gain by approximately 8 db, and increasing it to 8 V increases the gain by approximately 12 db.

The circuit is completely stable and no undue precautions were necessary in the layout, the system being laid on a small tag board almost identical in form to the circuit shown in Fig. 4. The transistors are provided with long leads to enable them to be

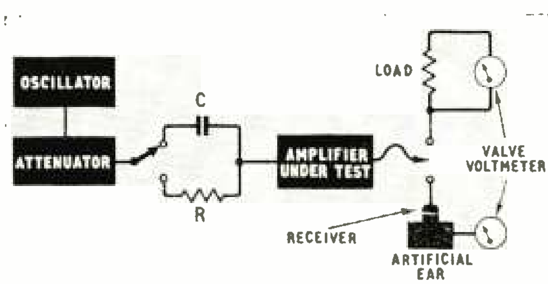


Fig. 5. Schematic diagram of apparatus for measuring circuit gain.

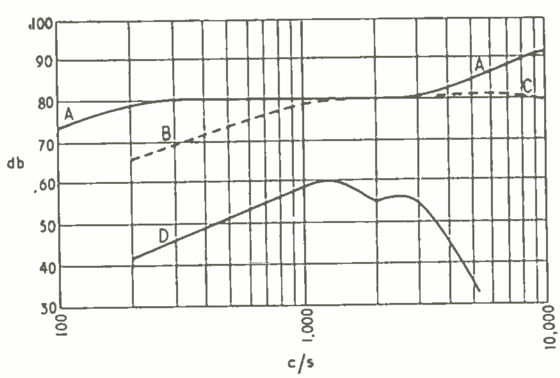


Fig. 6. Results of gain measurements made under conditions described in the text.

Two-Band Television Receivers

Choice of Intermediate Frequency

By G. H. RUSSELL

IT has been made clear by the First Report of the Television Advisory Committee[1] and subsequent discussion that the adoption of Band III for television broadcasting is about to take place. Although only channels 8 and 9 will be available for some time, nevertheless we must look forward to the time when the whole band will be available for television. This will necessitate the construction of receivers to cover both Bands I and III. Some thought must therefore be given to the choice of a suitable intermediate frequency, and the consequences arising out of its adoption. The choice of an intermediate frequency which would be supported by the manufacturers' organizations, the B.B.C., the Post Office and other interested parties, could be a matter of some urgency if we do not wish to find ourselves in the same state with television as we are with radio at the present time.

Possibly one of the greatest single nuisances that can cause interference with a receiver is that of a transmitter operating on or near the intermediate frequency of the receiver. With a view to minimizing this trouble, the Radio Manufacturers' Association of America has recently decided on a standard vision i.f. of 45.75 Mc/s.[2] The Americans have been able to do this because their lowest transmitting channel (2), is 54–60 Mc/s. The European frequency allocations prevent us from adopting the same frequency. Nevertheless, it would be advantageous for us to secure an agreement on a European basis if only to avoid trouble occurring under unusual propagating conditions—a situation with which we are already familiar.

European Conditions

Unfortunately, the position is already somewhat bedevilled by the fact that countries are already making unilateral decisions on this matter. In Italy, for example, an i.f. band of 40–47 Mc/s has been declared protected by government decree.[3] This decision is based on their choice of 61–68 Mc/s as their lowest transmitting channel. Although a protected i.f. band is a step in the right direction, its being a purely national decision makes one wonder whether the decree will offer any protection against sporadic-E activity, and whether, under conditions of such activity, their viewers may not find themselves the recipients of alternative programmes from Alexandra Palace or the Eiffel Tower! We in this country could not adopt channel 1 as an i.f. band as it would put about 50 per cent of our receivers out of action. The foregoing only serves to illustrate how complicated the situation can become when events are allowed to take their natural course. There is only one certain way of dealing with this form of interference, and that is the suppression of all transmitting within a protected band over a wide geographical area, and this can only be made effective by international agreement. But first the band which requires protection must be decided upon.

Before proceeding further, an examination of the frequency allocations in the v.h.f. and u.h.f. bands, and in the bands which might possibly be selected for intermediate frequency, will be necessary. The present allocations for the frequencies from 29.7 Mc/s to 585 Mc/s are shown in Table 1.

I.F. Harmonics

The next most important source of interference is that of i.f. harmonics. These are much more serious in television receivers than in ordinary radio receivers because of the large bandwidth and the high level at which the detector operates. With the high intermediate frequencies involved, sufficient attenuation of the radiation of these harmonics from the detector is a difficult and costly process, if indeed any measure of success can be attained at all. It is generally agreed that it is necessary to take into consideration harmonics up to and including the fourth. This means that the i.f. cannot fall between:

20.5 and 34 Mc/s (41/2 to 68/2)
13.7 and 22.7 Mc/s (41/3 to 68/3)
10.25 and 17 Mc/s (41/4 to 68/4)

A relatively wide frequency clearance must be maintained between the lowest signal frequency and the high-frequency edge of the i.f. pass-band, if instability is to be avoided. Our choice, then, bears a close resemblance to that of Hobson's. Assuming that we are concerned only with the British standard of vestigial-sideband transmission, the i.f.

TABLE 1

Band (Mc/s)	Allocation
29.7-41	Public Services.
41-68	Television Broadcasting (Band 1).
67-87.5	Public Services.
87.5-100	Sound Broadcasting (Band 2).
100-108	Public Services.
108-144	Aeronautical Services.
144-146	Amateur Transmitting.
146-174	Public Services.
174-216	Television Broadcasting (Band 3).
216-235	Aeronautical and Navigational.
235-420	Public Services.
420-470	Aeronautical, Navigational and Amateur.
470-585	Broadcasting.

[1] First Report of the Television Advisory Committee, 1952, H.M Stationery Office, 1953.
[2] *Electronics*, Nov. 1950, Vol. 23, No. 11, p. 99.
[3] Gazzetta Ufficiale della Repubblica Italiana, (Part 1), 3rd April, 1952.

vision carrier would fall at 35.25 Mc/s, the pass-band would be 34-38.5 Mc/s, allowing 2.5 Mc/s clearance between it and the lowest signal frequency. Some authorities believe that the fifth i.f. harmonic can be troublesome,[4] and it is interesting to note that the fifth harmonic of the band given above falls in Band III, and the situation becomes impossible. Adequate precautions will have to be taken in the receiver design to reduce fifth-harmonic radiation to negligible proportions.

[4] K. R. Sturley, "Radio Receiver Design," Part 2, Chapman and Hall, 1947, pp. 391/2.

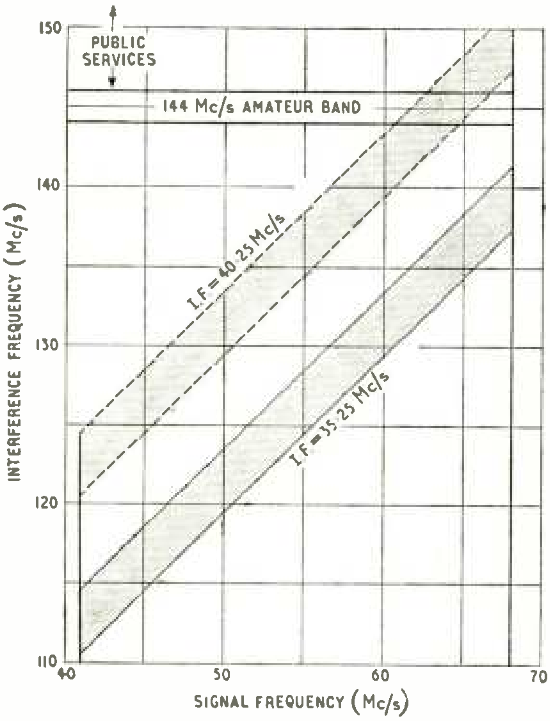


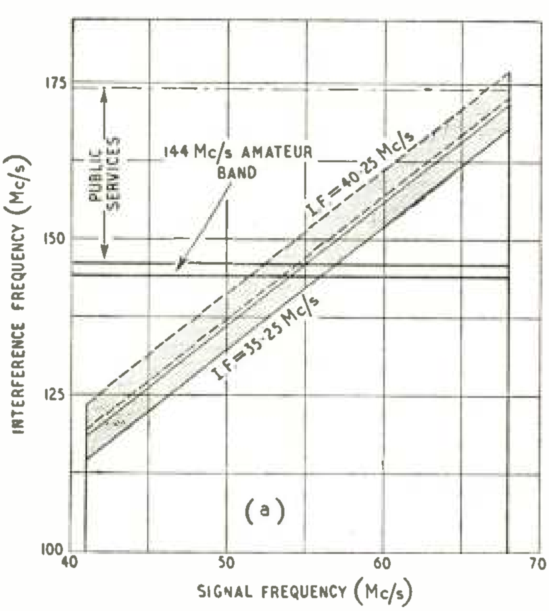
Fig. 1. Second-channel interference, Band I.

Although the intermediate frequency has already been determined, the matter, clearly, cannot be allowed to rest there. It is necessary to investigate other forms of interference which may be expected to arise out of the use of this particular frequency, although it can only be a matter of academic interest to the receiver designer, in so far as it involves factors over which he has little or no control. The remaining important forms of interference are due to, (a) second channel, (b) oscillator second harmonic, (c) the local oscillator of a neighbouring receiver. The last of these can be dealt with first. On Band I, the oscillator covers from 80.25 to 102 Mc/s, and on Band III, from 215.5 to 250 Mc/s. As can be seen, the oscillator of a receiver tuned to the lowest channel of Band III could cause interference to a neighbouring receiver tuned to the highest-frequency channel in that band. This can only be avoided with certainty by ensuring that these two channels do not serve the same area. Similarly, only by careful adjustment between the television channels on Band I, and the sound-broadcasting channels on Band II, will a lot of heart burning be avoided in the future.

Interference Charts

Graphs are used to illustrate the second-channel and oscillator-second-harmonic interference position, and these are shown in Figs. 1, 2, 3 and 4. For the purposes of this analysis, it is assumed that severe interference could be caused by broadcast, amateur and public-service transmitters. Fig. 1 shows that no interference may be expected on Band I from these sources due to the second channel. In Figs. 2 and 3 two sets of possibilities occur because there are two responses to the oscillator-second-harmonic. If the oscillator frequency is f_o, then interference can occur

Fig. 2. Oscillator second-harmonic interference (a) Band I ($2 f_o$ — i.f.); (b) Band I ($2 f_o$ + i.f.)



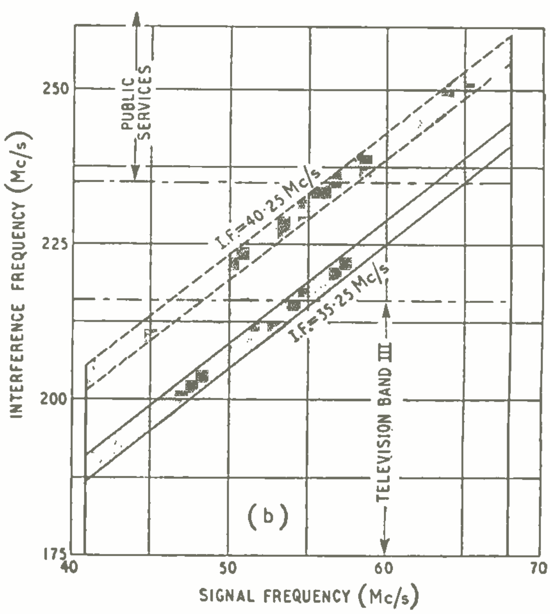
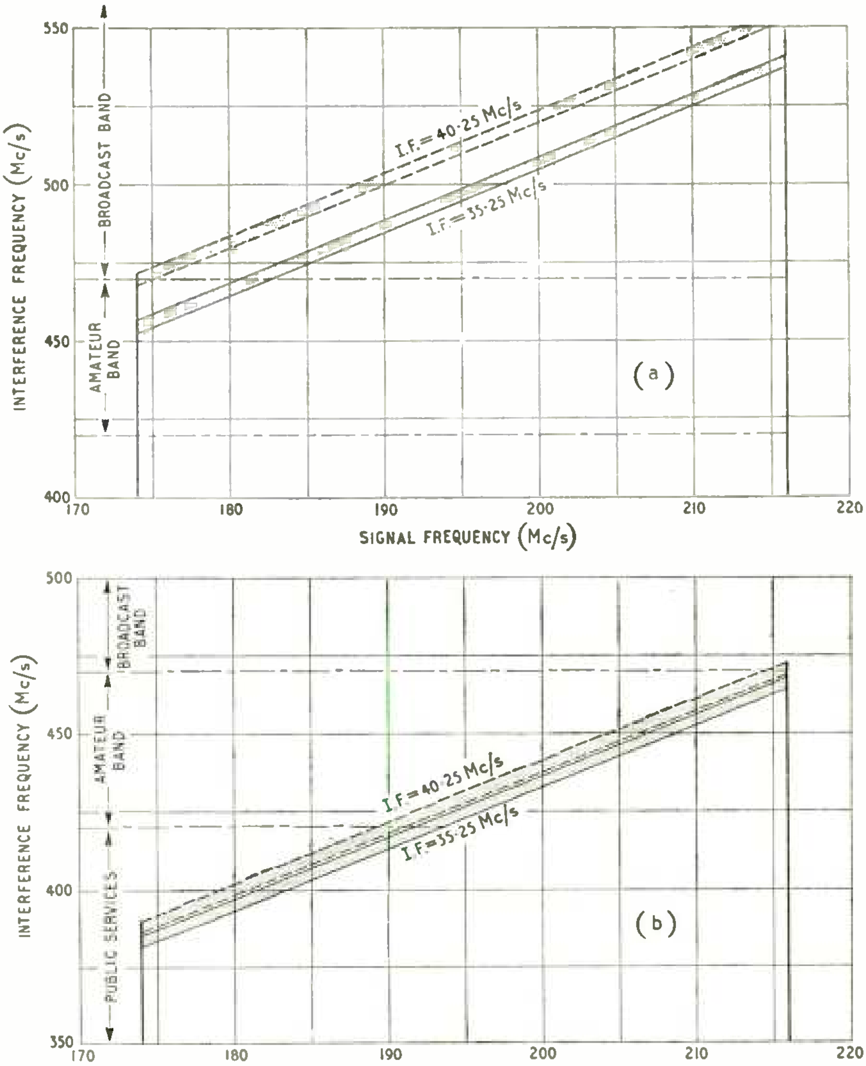


Fig. 3. Oscillator-second-harmonic interference, (a) Band III ($2f_o$ + i.f.) ; (b) Band III ($2f_o$ − i.f.)

from $2f_o \pm$ i.f., the more important of these being $2f_o -$ i.f., as this is nearer the signal frequency where the selectivity of the signal circuits may be expected to be poorer. On Band III, however, the position is less satisfactory, as, owing to the severe damping of the signal-frequency circuits caused by valve input impedance, the selectivity may prove to be inadequate for dealing with interference from strong signals on $2f_o +$ i.f. The graphs are constructed on the basis of vestigial-sideband working, and assume that, for interference purposes, the bandwidth is 4 Mc/s wide; i.e., from 34.25 to 38.25 Mc/s. A rule placed vertically against any carrier frequency on the signal-frequency scale, will give the interference band on the interference frequency scale, where the signal frequency cuts the two "curves" for the particular value of intermediate frequency. Conversely, a ruler placed horizontally against any interference frequency, will show the position and extent of that interference on the signal-frequency scale.

A summary of the results obtained from the graphs, is given in Table 2 on the following page. From this it can be seen that the prospect of interference-free television is none too bright. However, in practice, the position may not be as bad as it might be. Some of the interference possibilities listed, such as those arising from $2f_o +$ i.f. on Band I, should produce little trouble in any self-respecting receiver. As to the other forms of interference, the designer can do little to alleviate the position, and the matter becomes the responsibility



Above : Fig. 3.

Below : Fig. 4.

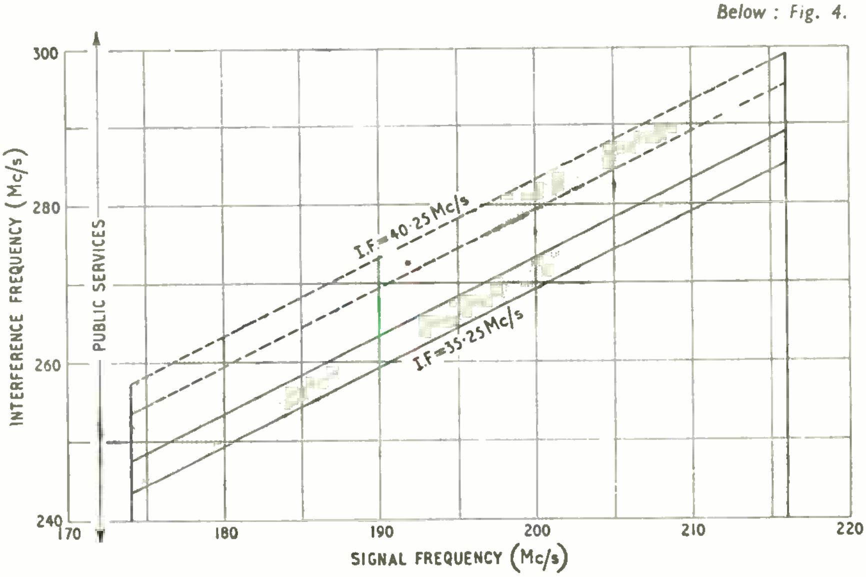


Fig. 4. Second-channel interference, Band III

of the authority who allocates frequencies to stations.

For the purpose of comparison, curves have been drawn for an i.f. of 40.25 Mc/s, in order to ascertain whether relief could be obtained by using a higher intermediate frequency at the expense of losing Channel 1. The results are quoted beside those for 35.25 Mc/s, and they show that nothing worthwhile would be gained by such a change. It would appear therefore, that we shall have to do the best we can with 35.25 Mc/s. If it is agreed that this is, in fact, the most favourable i.f. to select, then it is suggested that the first step that should be taken is to standardize on this frequency, and then to suppress all broadcasting in the band 34.25 to 38.25 Mc/s. The next step should be to evolve a sensible frequency plan, if such a thing is possible. Viewing the past history of frequency planning, one cannot help entertaining serious doubts about such a possibility.

TABLE 2
Table of Interference Possibilities

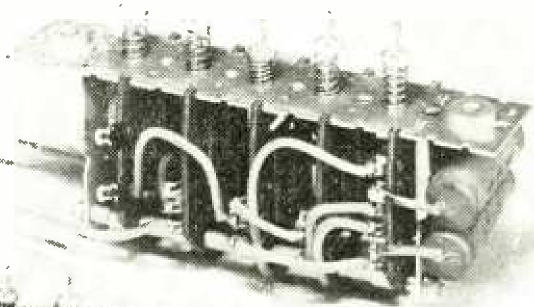
i.f. 35.25 Mc/s			i.f. 40.25 Mc/s	
Frequencies affected (Mc/s)	**Interference source** (Mc/s)	**Cause**	**Frequencies affected** (Mc/s)	**Interference source** (Mc/s)
41—55.6	186.5—216	$2f_o$ + i.f.		
54—56.9	144—146	$2f_o$ − i.f.	51.4—54.5	144—146
55—68	146—172	$2f_o$ − i.f.	52.3—68	146—174
—	—	2nd Ch.	60.5—66.5	144—146
—	—	2nd Ch.	62.5—68	146—151.5
63—68	235—245	$2f_o$ + i.f.	56—68	235—259
—	—	$2f_o$ − i.f.	66.5—68	174—177
174—182.8	452.5—470	$2f_o$ + i.f.	174—175.2	467.5—470
174—193.7	381—420	$2f_o$ − i.f.	174—191.4	386—420
174—216	243.5—289.5	2nd Ch.	174—216	253.5—299.5
180.8—216	470—540.5	$2f_o$ + i.f.	174—216	470—555.5
191.9—216	420—468	$2f_o$ − i.f.	189.5—216	420—470
—	—	$2f_o$ − i.f.	214.7—216	470—472.5

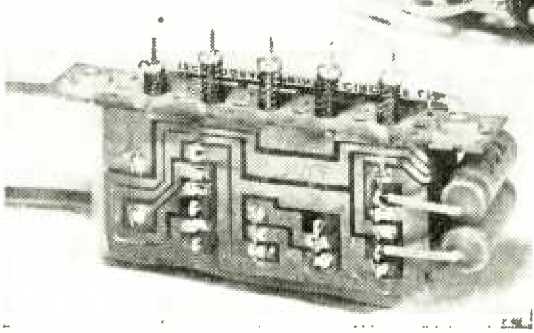
SIMPLIFIED WIRING

THE illustration shows the original wiring of a push-button switch used on a tape deck and the same unit now fitted with a printed circuit strip. The change to this more up-to-date system was adopted after an examination of the wiring had shown that three-quarters of the connections to the switch were made between points located on the actual switch unit. The strip is merely wrapped round the switch with the tags projecting where required and soldered to the adjacent metallizing.

The printed circuit is of the etched variety in which the connections required are printed on a metal-foil-covered plastic insulating base and the unwanted metal etched away in an acid bath.

Apart from other advantages, wiring mistakes are avoided, inspection time is reduced and rejects minimized. The assembly shown is embodied in the latest tape deck produced by Truvox, who say that though printed circuitry is at present a little more costly than older methods, savings in other directions about balances the increase.





The old (top) and the new (left) method of assembling the control switch in the Truvox Mark 3 tape deck.

Relaxation Oscillators

"CATHODE RAY" Explains

How They Differ from Ordinary Oscillators

NO American film is really typical unless every now and then somebody says "Take it easy!" or "Relax!" Whether this is because life in the U.S.A. tends to make everyone naturally tense, or whether it is because the script writer wants to make the audience believe the situation is tense, I am not quite sure. But I am told that the connection between what is commonly understood by relaxing and the sort of relaxing that presumably goes on in what are called relaxation oscillators is not obvious to all. What are relaxation oscillators, and how does one distinguish them from any other kind?

Most people who have heard of them at all, I believe, have an impression that they are quite recent—possibly a development of the second world war. It is true that they were greatly developed during the war, but the name actually appears at least as early as 1926.* And the things themselves appeared earlier still; perhaps the most celebrated date is April, 1918, when Abraham and Bloch described their famous multivibrator. I am confining the discussion to valve oscillators, of course; if one were to include mechanical relaxation oscillators there would hardly be any limit to their antiquity.

Electrical Transients

Not to beat about the bush any longer, relaxation oscillators are those that do not rely on inductance-capacitance tuning circuits. But it is hardly satisfactory to define something by what it is not. In any case, dictionary definitions, even when perfectly correct, often fail to make matters clear to the uninitiated; and in this case unfortunately *Roget's Dictionary of Electrical Terms* confuses relaxation oscillators with intermittent oscillators (better known as squeggers). To understand exactly what relaxation oscillators are, one should go right to the beginning and consider electrical transients. That may sound rather formidable, because the orthodox way is by differential equations; but fortunately a very good picture can be built up by considering some familiar mechanical analogies.

If we puncture a tyre there is a mechanical transient. The air, which up till then had been resting quietly inside the tyre, hisses out. Its speed of exit is greatest at the start, and gradually eases off as the pressure relaxes. This fact can be shown as in Fig. 1. The electrical analogy, of course, is connecting a resistance across the terminals of a charged capacitor. The electrical pressure or voltage of the charge drives current through the resistance, and as this loss of charge causes the voltage to decline the current gets less and less, as shown in Fig. 2. The curves in both of these diagrams can be called relaxation curves, because they show the way in which tension (mechanical or electrical) is relaxing. Their shapes are similar because the mass of air coming out of the tyre is small compared with the resistance offered by the small hole it has to come out through, and the inductance of the circuit (which corresponds to mass or inertia in a mechanical analogy) is small compared with its resistance.

Another mechanical analogy is a released spring, but here the situation is complicated by the mass of the spring generally being far from negligible in comparison with the friction or mechanical damping or resistance. The result is that the spring oscillates to and fro several times before coming to rest. The outline or "envelope," shown dotted in Fig. 3(c) is similar to the curves in Figs. 1 and 2. The same kind of damped

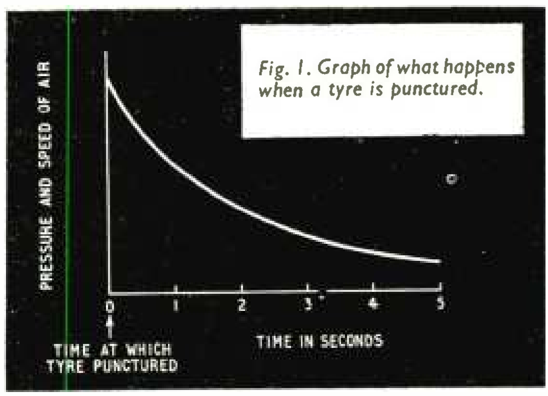


Fig. 1. Graph of what happens when a tyre is punctured.

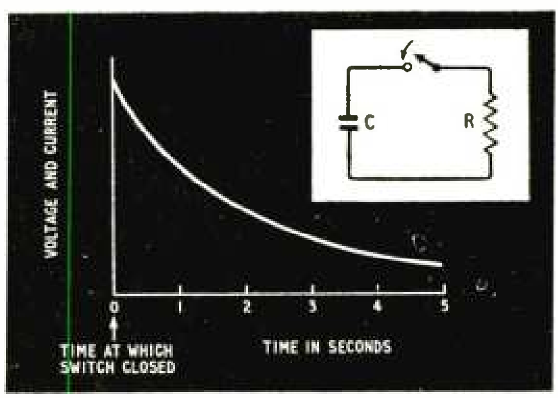


Fig. 2. Electrical analogy of the punctured tyre.

* "Relaxation Oscillators." B. van der Pol, *Philosophical Magazine*, Nov. 1926, p. 978.

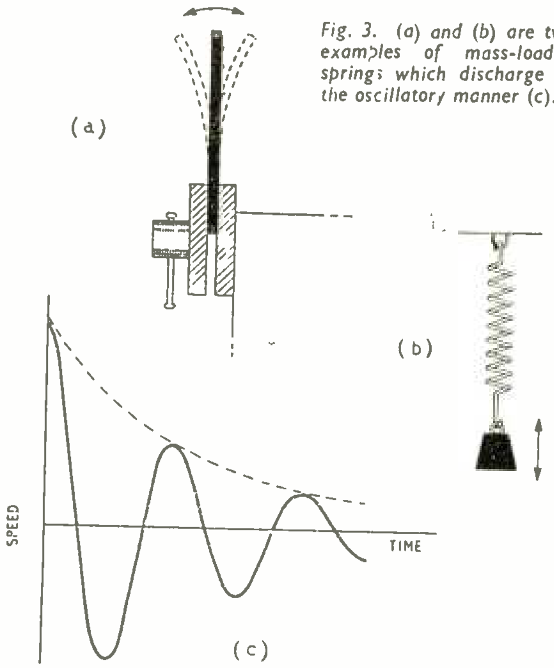


Fig. 3. (a) and (b) are two examples of mass-loaded springs which discharge in the oscillatory manner (c).

oscillation is obtained when the inductance of a discharge circuit (Fig. 4) is sufficiently large compared with the resistance. The amount of inductance needed to make a discharging circuit oscillatory (that is to say, overshoot the final level at least once) must be greater than $R^2C/4$. (If R and C are in ohms and microfarads, L will be in microhenries.) Even if the discharge circuit of a capacitor is highly inductive, the current can be prevented from oscillating by arranging that there is enough resistance to make $R^2C/4$ at least as great as L. A very familiar practical analogy is the springing of cars. If nothing were done to increase the mechanical resistance, every time a car went over a bump or pot-hole it would bob up and down like Fig. 3, which might almost be worse than having no springing at all, for if the bumps happened to occur about once per cycle of oscillation the bouncing would soon become violent. That is why dampers or so-called shock-absorbers are fitted.

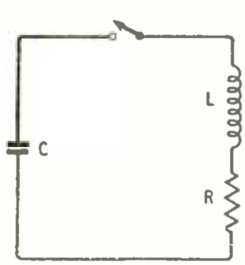
In radio, on the other hand, oscillations are the stuff of life, and one of the main objects of the game is to prevent them from dying out at all but to keep them going at constant amplitude just as long as one wants. Theoretically it can be accomplished by reducing the resistance to zero. This can't be done literally, in the circuit itself, and even if it could it would be of no practical use, for there would be no spare power to do a job of work. That is where the valve comes in, for it can be arranged to neutralize resistance by feeding in power from the h.t. supply at the right moments to keep the current in a tuned circuit oscillating, even when oscillatory power is drawn off. The best mechanical analogy, I think, is the balance-wheel of a watch. If you have let the mainspring run down, or it is broken, a push on the balance wheel will only make it oscillate to and fro several times, in the Fig. 3 manner. But when the force of the mainspring is brought to bear on it twice per cycle by means of the escapement mechanism, the wheel keeps going continuously.

Negative Resistance

The sort of oscillator in which the resistance of a tuned or naturally oscillatory circuit is neutralized by a valve is sometimes (if it has to be distinguished) called a harmonic oscillator. That is not because it is notable for generating harmonics—quite the reverse—but because it performs "simple harmonic motion." In practice it does also generate some harmonics, but that is usually an undesired incidental consequence of the fact that it is impossible to bring the net resistance of the system *exactly* to zero and keep it there. To make quite sure that the net resistance is not positive (which would make oscillation die away) one has to make it at least slightly negative. When that happens, oscillation builds up, as in Fig. 5, theoretically without limit. In practice, of course, the valve that provides the negative resistance very soon reaches its own limits; owing to grid current, cut-off, and one thing or another, its characteristics change, and in the end such changes always reduce the negative-resistance contribution of the valve. So when the amplitude of oscillation reaches the point at which the net resistance of the whole outfit is zero it stops growing. It is this limiting action that causes harmonic distortion.

Most often a stable balance is achieved quite automatically, so that when the balance point has been reached the oscillator carries on indefinitely at a more or less steady amplitude. But many experimenters will have found for themselves that some valve oscillators fail to do this; the growth of amplitude causes a change in circuit conditions that makes the net

Fig. 4. Inductance-loaded discharge circuit analogous to Fig. 3.



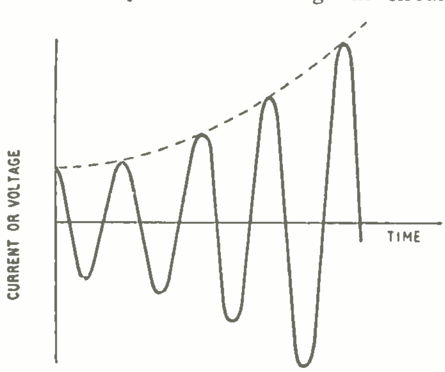
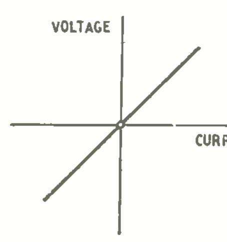


Fig. 5. If the total resistance in Fig. 4 is made negative, its oscillations grow like this.

Fig. 6. Voltage current graph of a linear resistor, in which its resistance is indicated by the slope, constant and positive in this case.



resistance positive, causing the oscillations to die away, and it is only when they have ceased that the net resistance again becomes negative and oscillations start building up again. The result is that oscillation keeps on stopping and starting. A common example is a tightly coupled r.f. oscillator, having in series with its grid a capacitor shunted by a very high resistance. This arrangement—the well-known squegger—usually stops and starts at some audible frequency, as can be discovered by putting a pair of phones in the anode circuit.

The thing to concentrate on just now, however, is not the squegger but more precisely how it is that valves can reverse the natural tendency depicted in Fig. 3, converting it into Fig. 5. In other words, how comes this "negative resistance"?

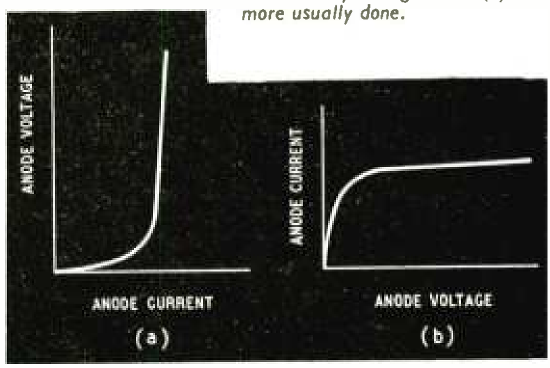
But first, what is the nature of positive resistance? So far as the kind of resistance that was studied by Ohm is concerned, one of its basic features is that the current flowing through it is directly proportional to the voltage applied to it, as shown in a graph such as Fig. 6. When the voltage is reckoned upwards, as here, the resistance (being V/I) is represented by the *slope* of the graph. Since Ohm's day we have extended the idea of resistance to include circuit elements such as valves, which have voltage/current graphs that are not simple straight lines passing through the origin. Fig. 7(a) is an example in which the resistance starts off quite small, as shown by the gentleness of the slope, and then rapidly becomes very large as the voltage increases. Drawn this way, the curve may not be easy to recognize, but when plotted the other way round, Fig. 7 (b), there is no difficulty in identifying it as the anode characteristic of a pentode or tetrode. Either way, in spite of having a large range of values, the resistance is always *positive*. An increase of voltage never makes the current less, or vice versa. An exception is the old-fashioned tetrode with its kink, shown in Fig. 8. Between A and B an increase in voltage does reduce the current, so the slope resistance is negative. And if one connects a tuned circuit in parallel between anode and cathode, as in Fig. 9, it oscillates without more ado, provided that the dynamic resistance of the tuned circuit is greater than the negative resistance of the valve, so that the parallel combination is negative.†

Elusive Working Point

This type of oscillator, by the way, is called the dynatron, and has the quite exceptional feature of providing negative resistance to d.c. Most valve oscillator circuits depend on inductive or capacitive couplings so can only function with a.c. But, you may say, oscillations *are* a.c., so what possible significance can "d.c. negative resistance" have? Well, as it happens, this brings us to a crucial stage in the approach to relaxation oscillators. Suppose we replace the tuned circuit in Fig. 9 by a plain resistance, equal perhaps to the dynamic resistance of the tuned circuit. Obviously it cannot oscillate; yet the resistance of the system as a whole is negative, so what does it do? Suppose the anode voltage V_b (Fig. 10) is applied through the resistance represented by the slope of the load line SPQ, with the intention of working at the point P. On paper this seems quite sound, because the current flowing through both resistance and valve is I_1, and the voltage $V_b—V_1$ is dropped in the resistance, leaving V_1 between anode and cathode of the valve; and the current through the valve when voltage V_1 is applied to it certainly is I_1. Yet if you were to

† If you are sceptical about the sign of a parallel combination of positive and negative resistances being the same as that of the *smaller* of the two, try using the formula $\frac{R_1R_2}{R_1+R_2}$ to find the resistance when R_1 is, say, −15 kΩ and R_2 is +20 kΩ. (The answer should be −60 kΩ.)

Fig. 7. Anode voltage current graph of a pentode, (a) plotted in same way as Fig. 6 and (b) as more usually done.



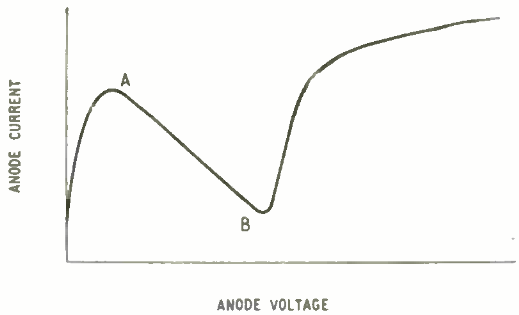


Fig. 8. (Above) Anode characteristic of early type of tetrode, showing negative-resistance portion AB.

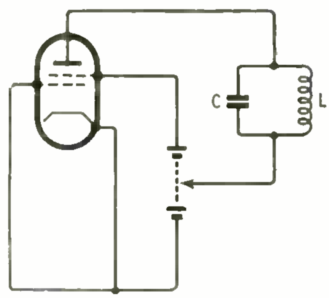


Fig. 9. (Right) Dynatron oscillator circuit.

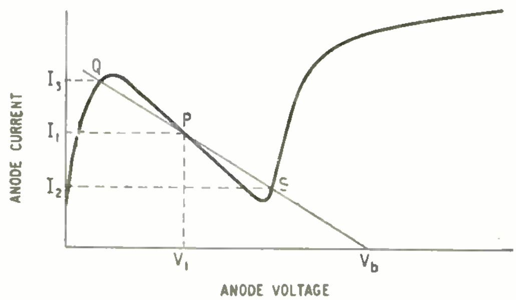


Fig. 10. QPS is the load-line of a resistor substituted for L and C in Fig. 9, and V_b is the anode supply voltage applied to it and the valve in series. (The load resistance is positive because voltage across it is reckoned to the left from V_b.) All three working points, Q, P and S look possible, but P is unstable.

try it you would find point P strangely elusive. Why?

Suppose the anode current and voltage did manage to be I_1 and V_1. Then the slightest fall in current would cause the voltage across the resistor to fall more than it rose across the valve, so there would be some spare voltage across the valve which would reduce the current more, causing the voltage across the resistor to fall still more, and so on. The current would keep on falling until a fundamental change in the situation occurred, and this would not occur until the net resistance of the system ceased to be negative. What happens is that the working point shifts as quick as a flash to S, where the current is less than at P but the total voltage, V_b, is again correct. But so it is at point Q, where the current is more than at P, and like S this is a point where the resistance of the valve is positive. Since Q and S are both possible positions, which one would be the actual working point? Would the current be I_2 or I_3? Well, it all depends on what was done at the start. If the voltage V_b were switched on after the cathode had warmed up, the anode current would probably be found to correspond to point Q. But if now the resistance were reduced (indicated on the diagram by raising the slope of the load line attached to V_b sufficiently to make Q and P coincide, the working point would slide instantaneously down the negative slope until it got to S. Increasing the resistance until S and P coincided would reverse the process. We have probably experienced mechanical analogies of this; such as the tin lid that caves in with a bang when we press it on top, and then springs back with another bang when we push it from underneath.

Slowing Down the Transitions

These changes from one stable shape of the tin lid to the other, quick though they may be, are not in the same speed class as the slide down the slippery slope of the negative resistance of a dynatron. But we can slow down the process by connecting a large capacitance across the valve from anode to cathode. If it is, say, 20μF, with a resistance of 0.3MΩ, the charging is slow enough to follow on a milliammeter. Instead of gradually tailing off like Fig. 2 it tends to accelerate, until stopped suddenly by the bend in the characteristic curve. If one starts off with infinite resistance, the capacitor being uncharged, the slide is started by gradually reducing the resistance until point Q is passed; once started, it carries on automatically until a point somewhere near S is reached. There it stops, and to get a repeat performance one has to push it back to the top of the hill, say by short-circuiting the capacitor.

Obviously this is nothing like continuous oscillation, the reason being the absence of anything automatic to give the push back to the starting point. In the LC oscillator it is the energy stored in the tuned circuit that gives the reverse push, just as the energy stored in a child on a swing by a push brings it back again to the pusher. It would be possible to modify the dynatron circuit by providing a relay to short-circuit the capacitor momentarily every time the anode current fell below a certain level, such as I_2 in Fig. 10. Then the thing would generate a continuous succession of saw-tooth waves, sliding steadily down the negative-resistor slope, back to the start instantaneously, sliding down again, and so on. It would be a relaxation oscillator—but a very clumsy one. There are much better ways of keeping the oscillation going. The simplest is the ordinary neon-tube oscillator, Fig. 11.

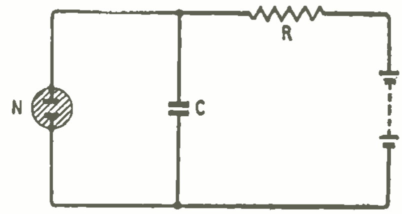


Fig. 11. Simple capacitive relaxation oscillator.

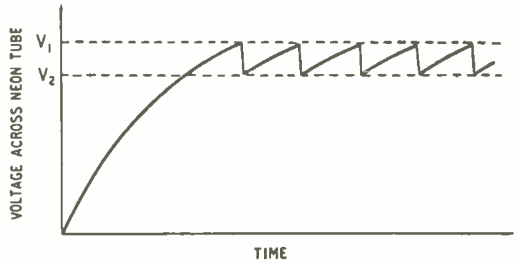


Fig. 12. Voltage waveform obtained with Fig. 11.

The peculiarity of neon tubes, such as the small lamps used to remind housewives that their electric ovens are still on, is that practically no current at all passes until the voltage reaches something like 180; then it goes up with a bump, and unless there is some resistance in series to limit the current to a reasonable amount the life of the device is likely to be only a fraction of a second. Reasonable current once having been started, however, it continues to flow until the voltage across the tube is reduced well below the "striking" voltage; probably about 20 volts lower. So what happens when the voltage is switched on in Fig. 11 is that C charges through R, the voltage across C rises, and N does nothing until its striking voltage is reached; when it strikes it is equivalent to a resistance of only a few hundred ohms, which compared with R is almost a dead short, so C very rapidly begins to discharge. It gets only as far as the extinguishing voltage of N, however, for then N cuts out, and C starts charging again, slowly compared with the discharge because it takes place through the comparatively high resistance R. At the higher voltage N strikes, and so on continually, as in Fig. 12, where V_1 is the striking voltage and V_2 the extinguishing voltage. The duration of each cycle, and hence the frequency, depends on CR (the time-constant of the circuit) and on V_1, V_2 and the applied voltage.

From a practical point of view this type of relaxation oscillator has little in its favour except its extreme simplicity and cheapness. But it is a very good illustration of the British Standard definition of a relaxation oscillator‡, which I think this is the right moment to quote:

> *A generator of oscillations characterized by cycles, each consisting of a period during which energy is stored in a reactive element followed by a period of transition, or relaxation, during which the reactance discharges. These processes usually occur at very different rates.*

Note "reactive element"; not "capacitor." The reason is that the definition is intended to include oscillators in which the energy is stored magnetically in an inductor. We shall take a look at an example of this in a moment, but just now you may be able to see

‡ B.S. 204: 1943, *Glossary of Terms Used in Telecommunication*, Definition No. 1924.

why I have gone rather fully into the principles before giving the definition. Except for the comment at the end, which, as Americans say, is not mandatory, there is nothing very obvious to exclude ordinary tuned oscillators from this definition. Their cycles of oscillation certainly each consist of two periods during which a reactive element alternately charges and discharges. The essential thing about this definition is what it *doesn't* say. It doesn't say anything about the second reactive element that is necessary to a tuned or LC oscillator, in which the energy discharged from the first reactive element is stored, and from which the first is then recharged. Since things that are not mentioned in a definition are not necessarily absent from everything covered by it, this definition fails to distinguish clearly between relaxation oscillators and others. It is only the added comment that gives one a hint that LC oscillators are not meant to be included. Personally I would alter the words "reactance discharges" to "energy is dissipated," because the essential distinction is that in an LC oscillator energy is tossed to and fro between two reactors, whereas in a relaxation oscillator a new lot is used up every cycle.

Mechanical Analogies

We seem to have been getting rather behind with our mechanical analogies, but it is not difficult to think of plenty of mechanical relaxation oscillators; some of them, operating from the galleries of the cheaper variety theatres to denote contempt or disapproval, being less polite than others. Of the others, a good example is the creaking of a rusty hinge. What happens when the door suspended on it is slowly pushed is that the tension builds up against the stiff friction, until suddenly it gives way and one surface slips over the other, relieving the tension and causing the friction to take charge once more. If "Pressure on the hinge" were substituted for "Voltage across neon tube," Fig. 12 would apply fairly well. To some extent a violin is a relaxation oscillator working on the same principle. Rosin is used to increase the friction between bow and strings, causing the string alternately to be pushed forward and to slip back; but since the string itself has both mechanical inductance and capacitance, and is attached to a wooden resonator, the tone is modified in such a respect as to be more generally acceptable than that of a creaking hinge.

At one time the most important kind of relaxation oscillator was the multivibrator, which generates waves with such steep rise and fall that hundreds of harmonics are strong enough to be detected, and this is very useful in frequency measurement. But with the popularization of oscilloscopes, and still more of television receivers, the multivibrator class has been vastly outnumbered by saw-tooth generators of many kinds. There are whole books devoted mainly to these things, so I don't propose to embark on descriptions of them all, but will finish with the promised example of an inductive relaxation oscillator.

As it turned out, it was rather a rash promise, and if I'd known the bother it was going to give me, well . . . ! The trouble was that all the inductive relaxation oscillators circuits I could find included capacitors, which would inevitably have confused the issue. So I hooked up the simple—deceptively simple—circuit shown (appropriately enough) as Fig. 13, consisting of an ordinary medium triode and a 1 : 1 output transformer. Connected in this way, it has a negative-resistance characteristic, for when voltage across the anode winding of the transformer makes the anode more positive its tendency to increase the anode current is more than neutralized by the grid being made negative.

It certainly worked. With as little as 20V "h.t." it produced peaks of over 1,000V across each of the transformer coils. Fig. 14 shows two cycles of this output as seen on the oscilloscope. This waveform was not unexpected, but to think up a convincing explanation of the cycle of operation that could be reconciled both with it and with the current waveform in the anode circuit was a different matter. Oscillograms of this class of circuit, using iron-cored coils in unconventional ways, always look very different from the tidied-up versions one sees in books. Fig. 15 shows, at the top, the anode current and transformer voltage waveforms after the period of the voltage pulse has been very much broadened out to show the details. To make sense of them, even in this modified form, it is necessary to add the grid current waveform and to fill in the zero-current levels (shown dotted) and to realize that the parts shown shaded are currents forced through stray capacitance by the fierce voltage peak. The effective flux-producing current in the transformer is $I_a - I_g$, shown at the foot of Fig. 15; and the voltage V_t across either transformer coil does now clearly look as if it were proportional to the rate of decrease of net current, which according to theory is what it ought to look like. It would have been so embarrassing if it hadn't! If one considered the anode current alone it certainly couldn't; the important thing is that the close-coupled transformer forces the flow

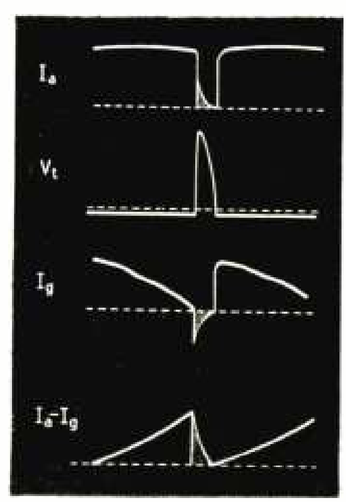


Fig. 15. (Right). Current and voltage waveforms of Fig. 14, with voltage-peak period greatly broadened out.

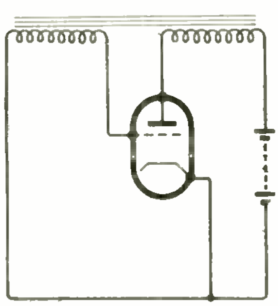


Fig. 13. Simple inductive relaxation oscillator.

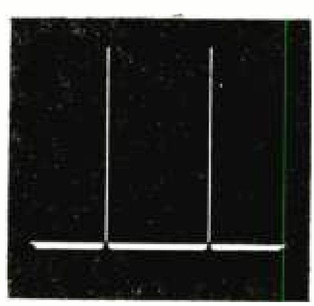


Fig. 14. Voltage waveform obtained with Fig. 13.

of grid current that makes the resultant current waveform a saw-tooth. During about 99 per cent of each cycle, magnetic energy is being slowly and steadily built up by the growth of net current; during the remaining 1 per cent it is "discharged" by the sudden convulsive cut-off of current when grid current ceases to load the secondary, and this sudden relaxation is the cause of the relatively enormous voltage peak.

Summing Up

To describe the operation of this "simple" circuit in full detail would take an awful lot of time, and would spoil your enjoyment of working it out for yourselves, so I finish with a quick summary of the whole subject. Single reactive elements—capacitors or inductors—discharge their voltage or current in the manner shown in Fig. 2. Combinations of both capacitor and inductor discharge in the manner in Fig. 3, provided there is not much resistance. When the resistance is reduced below zero these oscillations, instead of dying away, build up as in Fig. 5, but this growth comes to a "ceiling" when the valve providing the negative resistance becomes overloaded. If negative resistance is applied to a single reactor it charges up, usually like the reverse of Fig. 2, and here too the process is halted by the valve characteristics. What happens next is either that the system sticks in a stable position, from which it has to be "triggered" to repeat the operation, or the valve causes a discharge that automatically obtains continuous repetition, as in a machine-gun. It is arrangements of this last type that are called relaxation oscillators. Squeggers are combinations of harmonic and relaxation oscillators.

Although the tendency is for relaxation oscillators to produce very angular waveforms, this is not an essential feature; in the familiar RC audio oscillator the resistances and capacitances are so arranged that negative resistance sufficient to maintain continuous oscillation is confined to a band of frequency that includes the fundamental but excludes the harmonics, so a very pure waveform is obtainable from a relaxation oscillator.

CRYSTAL SET AMPLIFIER

Avoiding a Possible Pitfall

IT is often the simple things that cause most trouble; a case in point is the connection of the crystal set described some two years ago in *Wireless World** to a valve amplifier.

The simplest way perhaps is to use an intervalve transformer as one can then hardly go wrong; a 3 or 5 to 1 step-up will suffice. Two changes in the original circuit are, however, advised; one is to drop the 0.002 μF 'phone bypass capacitor to from 100 to 500 pF, the other is to connect a 47-kΩ resistor across the primary winding. The latter addition will damp out any transformer resonances.

Resistance-capacitance coupling can, of course, be used in place of a transformer, but there is at least one pitfall which may or may not affect the performance of the valve amplifier; it depends on the actual working conditions. If the amplifier has a grid input capacitor and grid leak (the latter often being a volume control) then it only remains to connect a resistor of about 47 kΩ across the 'phone terminals of the crystal set. However, it would be advisable in this case also to drop the original 'phone bypass capacitor (0.002 μF) to about 100 pF.

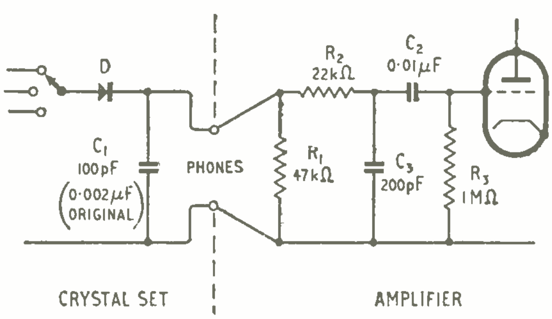
If, however, the amplifier is not fitted with a grid coupling capacitor and leak; or perhaps a single-stage amplifier is being added to boost the output, not necessarily for loudspeaker reproduction, but to give more comfortable volume in two or more 'phones; then in addition to a diode load resistor of 47 kΩ, as already mentioned, a grid coupling capacitor and leak must be included, as shown in the accompanying circuit.

The reason for the blocking capacitor C_2, diode load R_1 and grid leak R_3 is, of course, to keep the d.c. voltage developed across R_1 by the rectifying action of the crystal diode from reaching the grid of the following valve. This voltage may have either a positive or a negative sign at the grid end of R_1—it depends on the way round the crystal diode, D, is connected—and were C_2 not there this voltage would either add to or subtract from the grid bias on the valve.

With weak signals this d.c. component might not matter, but with strong input signals—the condition when a crystal set works best—several volts could be developed across R_1. Under such conditions the grid bias on the following valve could be anything from zero to several times the optimum. The resistor R_2 and capacitor C_3 give additional r.f. filtering, should it be required.

H. B. D.

* "A Modern Crystal Set," *Wireless World*, September, 1951.



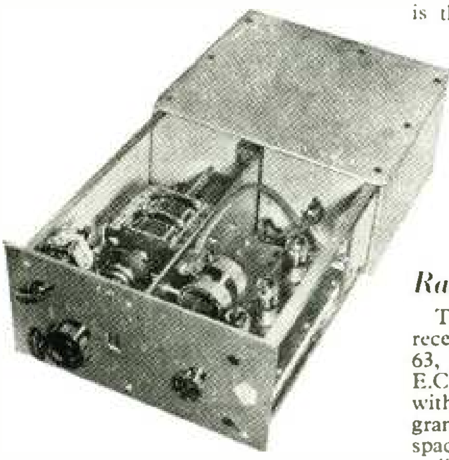
Circuit arrangement for connecting crystal set to amplifier

Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

Transmitter Drive Oscillator

A HIGH-STABILITY variable frequency drive oscillator has been developed by Mullard for use in commercial radio transmitters required to operate on any frequency in the band 4 to 30 Mc/s. By international agreement transmitters using these frequencies must keep within



High-stability variable frequency transmitter drive unit made by Mullard.

±0.003 % of the nominal frequency over periods of at least 24 hours.

The very high stability is achieved by the employment of the Mullard precision variable capacitor, by the choice of inductors and temperature compensating capacitors and by enclosing the frequency determining elements in a temperature-controlled oven.

The oscillator output is variable over the limited range of 1.0 to 1.7 Mc/s and is passed through a tuned buffer stage to a frequency multiplier giving an r.f. output on either the second (2 to 3.4 Mc/s) or the third (3 to 5.1 Mc/s) harmonic as required. A final wide-band amplifier delivers 0.5 W of r.f. at 70 Ω output impedance. Further stages of frequency multiplication are, of course, needed to provide the actual working frequency, but these will be either in the drive unit or in the main transmitter.

The oscillator is made by Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

Television Aerials

AN unusual method of securing the sections of a television aerial is used in the "Lightweight Two" model made by J-Beam Aerials, Ltd., Cleveland Works, Weedon Road Industrial Estate, Northampton. The system takes advantage of the fact that two aluminium surfaces forced into close contact tend to adhere.

By providing wedge-shaped contact surfaces in the die-cast fittings a solid joint of good mechanical and electrical qualities is obtained merely by giving the parts concerned a few sharp taps with a hammer.

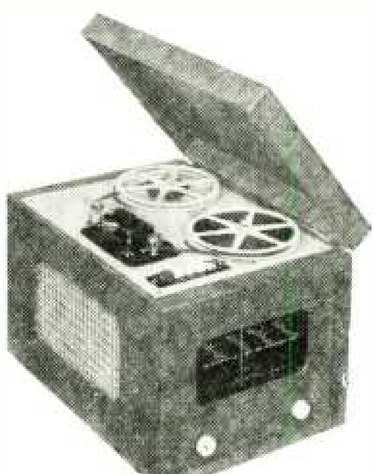
Another feature of J-Beam aerials is that the lower half of the aerial dipole is integral with the supporting mast and forms the outer section of a coaxial matching section for the feeder.

The price of the "Lightweight Two" is dependent on the channel required, but complete with mast and lashings is under £5.

Radio-Recorder

THE "Impressario" instrument recently developed by Lee Products, 63, Great Eastern Street, London, E.C.2., is a magnetic tape recorder with normal inputs for microphone, gramophone, etc, and in addition, space for a built-in high-quality radio receiver unit. Power supplies for the feeder unit are taken from the main amplifier, which can be used separately as a straight amplifier (output 4W).

Internal switching is arranged to change over to radio recording, but this is overridden by muting contacts on the microphone and gramophone input jacks. The tuner unit, which is purchased as a separate item, fits into a special compartment at the side. It is a modified version of the RF/716 three-waveband superhet, with low - distortion detector.



Lee Products "Impressario" tape recorder and radio feeder unit.

The tape mechanism is by Truvox and gives speeds of 3¾ and 7½in/sec with interlocking push-button concontrols.

The price of the recorder is £51 19s 6d and of the radio unit, £14 14s.

Push-button Track Changing

TWIN track recording without the necessity for changing spools is a notable feature of the new TK9 tape recorder by Grundig (Great Britain), Kidbrooke Park Road, London, S.E.3. The recording is made in either direction, and the change from one track to the other is made automatically by pressing a button.

Using 850-ft tape reels, a playing time of 2 × 45 minutes is provided at the tape speed of 3¾ in/sec. An automatic stop functions at the end of a reel, and a geared indicator marks the progress of the recording or playback, enabling any item to be located quickly.

Frequency response is stated to be 50-9,000 c/s ± 3 db and a tone control is provided for playback. A "magic

Grundig Type TK9 tape recorder.

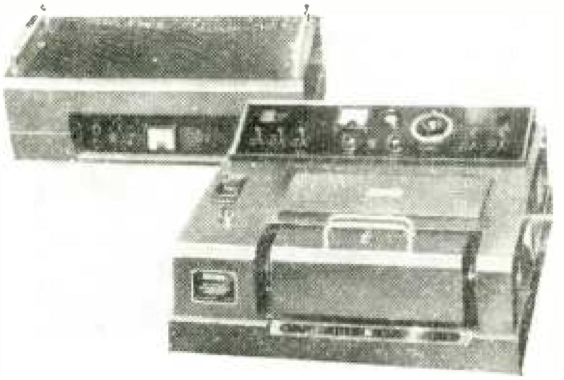
eye" level indicator functions on both recording and playback.

The overall dimensions are 13¾ × 12½ in × 8 in and the weight is approximately 28 lb. The price is £68 5s excluding microphone; alternative moving-coil or crystal microphones are available at £6 6s and £4 14s 6d respectively.

Compact Facsimile Receiver

ALTHOUGH portable picture transmitters have been available for some time, the receiving equipment installed at newspaper offices has usually been of the rack-mounted type and has occupied considerable floor space.

A compact bench-mounting photographic receiver (D-700) has now been developed by Muirhead and Company, Beckenham, Kent, which measures only 21 in × 19 in × 11 in, and weighs, together with its power



Muirhead Type D-700 photographic facsimile receiver.

supply unit of comparable size, only about 100 lb.

Positive or negative prints on paper or film up to 10½ in × 10 in can be recorded. Drum speeds of either 1 or 2 r.p.m. are provided and the scanning pitch is 100 lines/inch. The bandwidth required is 2 kc/s centred on a carrier of 1.3 kc/s. For line operation the signal is amplitude modulated, but for radio transmission f.m. can be used with a conversion unit. There is provision for a speech channel and for the use of a synchronized "Mufax" monitor which enables the picture to be seen on electrosensitive paper as it is received.

The price of the D-700 photographic receiver is £950.

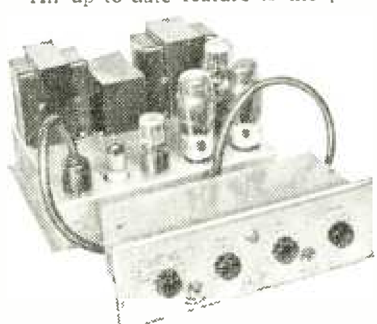
Ten-watt Amplifier

FIRST introduced for export, the Leak TL/10 amplifier and "Point One" pre-amplifier are now available for the home market.

Like the TL/12, the new amplifier uses a triple loop feedback circuit with 26db in the main loop. Harmonic distortion is claimed to be 0.1 per cent at 7.5 W and 1,000 c/s, and frequency response ±1 db between 20 c/s and 20 kc/s. Damping factor is 25 and hum −80 db referred to 10 W.

The pre-amplifier, in addition to four fixed compensating channels providing basic correction for most British and foreign record characteristics, is fitted with continuously variable bass and treble tone controls. The main volume control is supplemented by an attenuator at the back of the set, for accommodating the variations in sensitivity of crystal, moving coil and other types of pickup.

An up-to-date feature is the provision of jacks enabling the amplifier to be used in conjunction with tape recorders for both recording and reproduction.

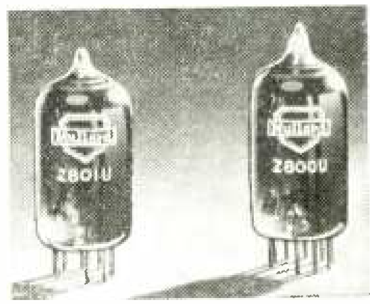


Leak TL 10 amplifier and "Point One" pre-amplifier.

The price of the two units is £28 7s and the makers are H. J. Leak and Company, Brunel Road, Westway Factory Estate, London, W.3.

Cold Cathode Tubes

TWO cold-cathode trigger tubes, the Z800U and Z801U, have been introduced by Mullard for use as



Mullard Z801U and Z800U cold-cathode trigger tubes.

low-current stabilizers and counters with Geiger-Muller tubes. Particular features of the Z800U is said to be its very stable trigger breakdown voltage and freedom from photo-electric effects, while one of the main characteristics of the Z801U is its very high charge sensitivity; an energy input of only 45 μcoulombs is required to initiate the main discharge. Triggering is effected by applying a negative pulse to the auxiliary cathode via a small capacitor of about 10 pF.

The makers' address is Century House, Shaftesbury Avenue, London, W.C.2.

"Hall Mark" for Die Casting Alloy

DIE castings, particularly in zinc alloy, are finding many applications in the radio and electronic industries and it is, therefore, of interest that the British Standards Institution and the Zinc Alloy Die Casters Association have together drawn up a certification mark scheme for this type of casting. It means that users of zinc alloy castings carrying the B.S.I. "Kite" mark can be assured that the quality of the material complies with the very exacting requirements of BS1,004:42.

Zinc alloy die casting probably provides the quickest transition from raw material to the finished product; the castings are strong and durable provided the alloy is free of certain impurities. The presence of lead, tin and cadmium, even in such minute quantities as a few parts in 100,000, can result in a casting that would otherwise be almost as strong as cast iron becoming as brittle as a biscuit. BS1,004 specifies that the content of these and other "poisonous" elements shall not exceed 0.012%. A little aluminium, copper and a trace of magnesium and iron are beneficial.

A.R.R.L. Handbook 1954

COMPILED by the technical staff of the American Radio Relay League, the Radio Amateur's Handbook has come to be regarded as a textbook of amateur radio. It provides the novice with much of the theoretical and practical knowledge he needs for the design, construction and efficient operation of an amateur radio station.

The "old hand" is equally well served, and the current issue has been carefully revised to include the latest developments of the past year. V.H.F. and u.h.f. chapters have accordingly been considerably expanded and there are many useful designs of equipment for mobile operation. These should be of great interest to members of the newly formed U.K. Radio Amateur Emergency Network, since amateur radio communications of this kind are well established in the U.S.A.

Copies of the Handbook are obtainable in this country from The Modern Book Co., 19-23, Praed Street, London, W.2, or they can be ordered for direct delivery from the U.S.A. through the Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.1; the price is 30s (31s by post).

APRIL MEETINGS

Institution of Electrical Engineers

Kelvin Lecture: "The Physics of the Ionosphere" by J. A. Ratcliffe, O.B.E., M.A., F.R.S., on April 29th.

Informal discussion on "Safety Measures for Radio and Television Equipment," opener E. P. Wethey, on April 12th.

Radio Section.—Discussion on "Technical Problems involved in Receiving Alternative Television Programmes" on April 5th.

"A Versatile Transistor Circuit" by E. H. Cooke-Yarborough, M.A., "The Measurement of the Small-Signal Characteristics of Transistors" by E. H. Cooke-Yarborough, M.A., C. D. Florida and J. H. Stephen, Ph.D., "A Bridge for Measuring the A.C. Parameters of Type 'A' Transistors" by A. R. Boothroyd, Ph.D., and L. K. Datta, M.Sc., and "The Transistor as a Regenerative Amplifier with some Application to Computing Circuits" by G. B. B. Chaplin, M.Sc., on April 7th.

"The Experimental Synthesis of Speech" by W. Lawrence on April 26th.

All the above meetings will be held at 5.30 at Savoy Place, London, W.C.2.

Mersey and North Wales Centre.—"Technical Arrangements for the Sound and Television Broadcasts of the Coronation Ceremonies" by W. S. Proctor, M. J. L. Pulling, M.A., and F. Williams, B.Sc., at 6.30 on April 5th at the Liverpool Royal Institution, Colquitt Street, Liverpool.

North Midland Centre.—Faraday Lecture "Electro-Heat and Prosperity" by O. W. Humphreys, B.Sc., at 7.0 on April 12th at the Town Hall, Leeds.

Sheffield Sub-Centre.—Faraday Lecture "Electro-Heat and Prosperity" by O. W. Humphreys, B.Sc., at 7.30 on April 14th at the City Hall, Sheffield.

Northern Ireland Centre.—"Special Effects for Television Studio Productions" by A. M. Spooner, B.Sc.(Eng.), and T. Worswick, M.Sc., at 6.15 on April 13th at the Presbyterian Hostel, Howard Street, Belfast.

South Midland Radio Group.—"The Theory and Application of Transistors" by F. F. Roberts, B.Sc., and H. G. Bassett, B.Sc., at 6.0 on April 26th at the James Watt Memorial Institute, Great Charles Street, Birmingham.

North Staffordshire Sub-Centre.—"Technical Colleges and Education for the Electrical Industry" by H. L. Haslegrave, M.A., Ph.D., M.Sc. (Eng.), at 7.0 on April 5th at the Technical College, Stafford.

London Students' Section.—Address by the president, H. Bishop, C.B.E., B.Sc.(Eng.), at 6.30 on April 13th at Savoy Place, London, W.C.2.

British Institution of Radio Engineers

London Section.—"Crystal Valves in Radio and Electronics" by B. R. Bettridge (G.E.C.) at 6.30 on April 21st at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.

Scottish Section.—Members' papers at 7.0 on April 1st at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2.

North-Western Section.—Programme of technical films at 7.0 on April 1st at the College of Technology, Sackville Street, Manchester.

North-Eastern Section.—"Electro-encephalography" by Prof. Alexander Kennedy, F.R.C.P., and J. W. Osselton, B.Sc., at 6.0 on April 14th at the Neville Hall, Westgate Road, Newcastle-upon-Tyne.

Merseyside Section.—"Logic, Algebra and Relays" by Prof. E. Williams, B.A., B.Eng., at 7.0 on April 1st at the Electricity Service Centre, Whitechapel, Liverpool, 1.

West Midlands Section.—"Radio Telephone Equipment" by T. C. Howell at 7.15 on April 27th at the Technical College, Wulfruna Street, Wolverhampton.

South Wales Section.—"The Manufacture of Radio Receiving Valves" by G. P. Thwaites, B.Sc. (Brimar), at 6.30 on April 7th at Glamorgan Technical College, Treforest.

British Sound Recording Association

London.—"The Design of Tone Correction Circuits" by E. W. Berth-Jones, B.Sc., and H. J. Houlgate at 7.0 on April 9th at the Royal Society of Arts, John Adam Street, London, W.C.2.

Television Society

London.—Fleming Memorial Lecture "Colour Television" by G. G. Gouriet, B.Sc., at 7.0 on April 13th and 15th at the Institute of Education, Senate House, Malet Street, London, W.C.1.

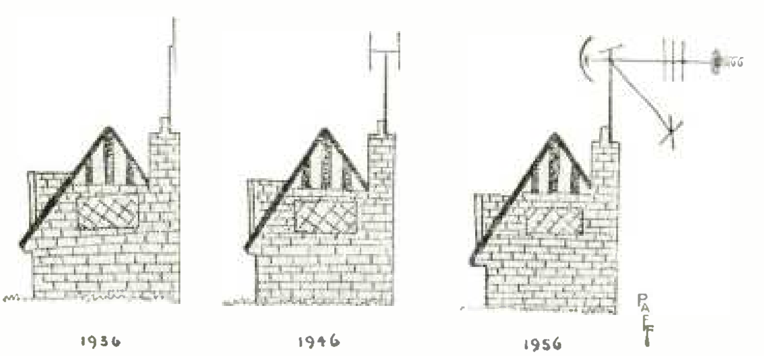
"Valves for U.H.F. and V.H.F. Television" by D. N. Corfield (S.T.C.) at 7.0 on April 22nd at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

Radar Association

"Radar and the Weather" by P. A. L. Harris (Mullard) at 7.30 on April 7th in the Anatomy Theatre, University College, Gower Street, London, W.C.1.

Institution of Production Engineers

Nottingham Section.—"The Electron Microscope" by W. J. Lloyd at 7.0 on April 7th at the Victoria Station Hotel, Milton Street, Nottingham.



RANDOM RADIATIONS

By "DIALLIST"

Any Suggestions?

THERE'S ONE fault that shows up with quite remarkable frequency in television receivers, though it is not unknown in sound-only sets. Here is a typical example: the television receiver has been working as it should for maybe an hour or more. Then the picture shrinks, or fades, or does both together and in a few moments the screen is blank. None of the outside-the-cabinet controls has the slightest effect. Then somebody happens to turn a lighting switch and, hey presto! all is well with the picture. There must, I imagine, be a hidden fault in the set, due to a dry joint, or to a break in a lead or something of that kind. When the receiver is cold a connection, though a pretty chancy one, exists. But when it is thoroughly warmed up expansion of the metal causes a movement to take place which results in a "dis." The little "kick" in the mains voltage due to the use of the lighting switch may cause an arc to occur at the "dis" and result in some kind of a weld between the very slightly separated members of the joint. Any such weld would consist of very thin filaments of metal between the two parts. It would be likely to break down rather soon—and that is just what does happen. Can any readers offer other explanations?

EVAW

LIFE IS FULL of little problems. I was confronted by one of them when I found that some rather highly technical stuff that I'd been asked to put into French contained the term "backward-wave oscillators." The French seem so to dislike inventing technical terms of their own that they're usually content to borrow them from us. "*Un wobbulateur*" and "*un oscillateur grid-dip*" are, for instance, perfectly good French. By all the rules, then, it seemed that I wouldn't be taking much of a chance if in this case I simply wrote "*un oscillateur backward-wave*." Luckily I didn't. Except that it was probably a micro-wave device concerned with travelling waves, I had, frankly, no idea of what the thing was. Nor had the first four radio addicts whom I consulted on the telephone. The fifth, however, had a hazy recollection that a paper had been read on something of the sort at an I.E.E. meeting. A search in my files of the *Proceedings of the I.E.E.* showed that such a paper had indeed been read; and what's more, read by the French inventors of the oscillator, Warnecke and Guenard! Not only that: they'd given it the name by which it is known in France, the *carcinotron*. I can't help thinking that EDNO (*onde* backwards) would have been neater and less of a mouthful. And why not an English name EVAW on the same lines?

The Hydraulic Light Bulb

AN EDGWARE READER records one of those electrical adventures which all too seldom brighten our humdrum lives. On his return home one evening he found the kitchen floor awash and soon traced the cause to a running tap and a stopped waste pipe in the bathroom above. The water had made its way down by way of the ceiling rose and the flex of the pendant lamp below. When he switched on, the lamp gave full brilliance, accompanied by "a nasty vibrational burning noise." Subsequent investigation, he tells me, disclosed a pinhole in one of the lamp's contacts, through which water had made its way into the hollow glass "foot" inside the bulb. When the bulb was connected up again the water quickly boiled away and all was (and is still reported to be) well. Actually I described some years ago my own efforts* to use this effect for the cheap production of constantly changing coloured lights to delight the little ones at Christmas. The basic idea was to introduce a succession of aniline dyes into the water fed to deliberately pinholed bulbs *via* their flex leads. I had reluctantly to abandon my experiments owing to the difficulty of obtaining sufficient supplies of the dehydrated water necessary if "shorts" were to be avoided.

Not So Funny

IT'S ALL VERY WELL to talk about our having a television service that covers eighty-something per cent of the homes in this country; but that takes no account of the homes in alleged service areas in which anything approaching even tolerable reception is impossible at most times. I'm not thinking now of houses standing on roads which carry an endless stream of (mostly unsuppressed) motor traffic. Some of those that I have in mind are near one or other of the pylons of our grid system; and their occupants learn the hard way something about brush discharges. People who live near busy aerodromes have as bad a time as any.

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* "Autochromatomorphic Illumination," D. I. List, F.R.G.S.; *Tiny Tots*, Nov. 31, 1938.

Well-designed a.g.c. may take charge to some extent of aircraft flutter; but nothing much can be done about interference at short range from radar and other such things. Perhaps most of all to be pitied are those living close to radio-equipped police- and fire-stations; or those who have certain kinds of ray-treatment clinics almost next door to them.

Let's Know the Price!

A LETTER in a recent issue of *Wireless World* asked why those who advertise wireless gear, laboratory equipment and so on so often say nothing about prices. That is something which has long puzzled me. If other people's reactions to such advertisements are like mine, I don't think that they can be a very paying form of publicity. Consciously or unconsciously, I argue that as the price isn't mentioned it must be pretty stiff. Not much use, then, writing for the full particulars as suggested in the advertisement, and so I just don't do anything more about it. When, on the other hand, I see an attractive something-or-other advertised *with* its price I'm at once attracted. It may be rather a lot of money for me, but I do send for the further particulars. I'm, in fact, already what I believe salesmen call "a prospect"; and, if the state of my overdraft permits, it doesn't take much high-pressure work to make me a buyer.

"Bib"

AS YOU KNOW, I'm always on the lookout for tools which make things easier and save time and bad language in the wireless workshop, amateur or professional. One that is definitely good enough to mention in these notes is "Bib," the wire-stripper recently brought out by the Multicore people. It's the simplest thing, as ingenious tools often are: just two flat blades of very hard steel, pinned together to form what looks like a thin pair of pliers. At the business end there is a sharp-edged V-shaped notch in each blade. Close the handles and the Vs come together to form a diamond-shaped cutter. Just put the flex, V.I.R. or what-not into the cutter, squeeze the handles and pull. Off comes the insulation as clean as a whistle and not a strand is so much as nicked. The stripper is easily adjusted to deal with wires of various diameters. The tool also contains cutters which snip wire cleanly and a simple device for separating the leads of twin, plastic-covered flex without damaging the insulation.

UNBIASED

By FREE GRID

Silent Sound

MODERN MOTHERS are well acquainted with the baby alarm consisting of a microphone over the child's cot feeding into the domestic wireless receiver so that the petulant pulings of the child are superimposed on the radio programmes. *Wireless World* gave this idea to the world nearly 30 years ago in reply to an anxious parent in the then popular Readers' Problems, or Questions and Answers, section of the journal.

No doubt many of you with sensitive musical natures have often had your nerves stretched to breaking point by the mewling and puling of the animated piece of protoplasm upstairs marring a pianissimo passage from a Chopin nocturne. All this can be a thing of the past if modern mothers will be really modern and insist on a television set being adapted for fitting a baby alarm so that the child's cries appear not as an irritating over-riding sound from the loudspeaker but as an interference pattern on the screen. The programme would not be unduly marred by this visual baby bawling as it is by the present sonic system.

There is another very great advantage of this idea. Experienced mothers are supposed to be able to apply the principle of differential diagnosis to a child's cries and tell instantly whether the baby's bellowings indicate a crying need for nourishment or nappies. In practice, however, it is not at all easy to do this when there is a background of Sousa in full blast. But if the child's caterwaulings were made to appear as a visual interference pattern I feel sure this difficulty would not arise. It is, therefore, up to the manufacturers of television sets to let us have the necessary P.U. terminals and circuitry.

Great Minds Think Alike

IT IS EXTRAORDINARY how frequently I find myself in tune with the minds of the mighty or, at any rate, only a semitone or so out of resonance. Two years ago I suggested in these columns that wireless ought to have a patron saint and put forward the claims of St. Michael for that office. On the very same morning that the editor read my suggestion the Pope put forward the same idea; we differed only on the question of personnel and Gabriel was, as you know, appointed.

Now I find that once again a somewhat similar thing has happened. This time it is the Oldham Borough Council with whom I am in accord. I see that it has decided to use plastic plumbing in its houses, a thing which I decided on and told you about in the February issue.

This time the semitone difference between my thought and that of my fellow *magna meus* is not a matter of personnel but of the reason for the use of plastic pipes. In my case I suggested it as a means of curing the cross-modulation chatter caused by corroded and, therefore, high-resistance joints in pipes and guttering in an area close to two powerful B.B.C. transmitters, whereas Oldham's reason for adopting the idea was to stop burst pipes as it has been found that plastic plumbing stretches.

Carping Criticisms

THERE ARE MANY THINGS which I have vainly pleaded with wireless manufacturers to give us. One of them is a remote-control unit whereby we could not only switch the set off from our armchairs but could tune it and adjust the volume control also. Such a unit should preferably be a radio-controlled one and not have a trailing cable over which everybody would be bound to trip up. One manufacturer did make such a device once—in fact I believe there was more than one—but, like the pale hands beside the Shalimar where are they now? Another thing for which I have asked in the past is a valve which heats up quickly and makes it snappy like an electric light bulb.

It is interesting to note that both these requests have now been granted simultaneously, but not quite in the form which I had in mind. The common answer to my two requests is the mains/battery portable. Obviously, as you can have this by your armchair and can adjust it in comfort, it does after a fashion answer my request for a remote-control unit. My request for snappy cathode heating has been answered also by this type of set, for obviously it must use battery-type valves.

Now although my double request has thus been answered I am not at all happy about it. These little sets are getting more and more popular and threaten to become ubiquitous. I have no complaint against them if used within reason and in situations where a more ambitious set cannot be put into action. But nobody can deny that these receivers have a less satisfactory output than those using pukka mains valves and it is clear that the manufacturer of at least one of them realizes it as, apart from his mains/battery portable, he markets a "mains only" one using indirectly-heated valves. When I wrote to him about it he quite frankly admitted that the reason was that the "mains only" portable gave a more satisfactory output.

The other reason why I prefer not to use one of these small portables if a more ambitious set is available is that, because of their use of a small built-in aerial, they are more susceptible to interference from such things as unsilenced electric sewing machines and other disturbers of the etheric peace. A good outdoor aerial will always win the day unless somebody comes along with a drastic new invention.

1914 Amateurs and Coherers

I SHOULD LIKE to convey my very sincere and hearty thanks to all those kindly readers who wrote to me about coherers as a result of the photograph I published in the January issue. I should have liked to have replied to them all individually but for various reasons this was quite impossible.

I was quite wrong in supposing that coherers had disappeared by 1908. Whatever may have been the case in professional circles they were still in use in non-professional circles right up to the outbreak of the 1914-18 war. I have used the expression "non-professional circles" deliberately rather than "amateur circles" for I have no mind to have my bowler bashed in by any of those serious amateurs of 1914 vintage who swore by (and also at) the crystal. It is quite evident from information which has been so kindly sent to me that these coherer outfits were offered for sale merely as scientific toys.

Reprisals