Wireless World

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The Licence Muddle

UNTIL recently the all-powerful Post Office control of radio has not come under serious or widespread criticism. With a few minor exceptions, the ruling of our activities has been beneficent, and progress has been helped rather than hindered by exercise of the sweeping powers enjoyed by the Postmaster-General. But now there is growing support for the idea that some at least of these powers should be transferred to other hands.

To understand the monopolistic nature of the Government's control of radio, we have to go back about 100 years, when Benjamin Disraeli "nationalized" (as we should now say) the electric telegraph by making it a monopoly of the Post Office. Wired telephony and then wireless telegraphy and wireless telephony were successively added to that monopoly by subsequent legislation. Finally, by the Act of 1949, the P.M.G. was virtually given control of all "radiation of electromagnetic energy of a frequency not exceeding three hundred million megacycles a second"—and not only for purposes of communication. That sounds wide enough!

Growing resentment against the monopoly has been brought to a head by a recent test case in the High Court, started by the firm of Davey Paxman, who are members of the Mobile Radio Users' Association. The Post Office agreed to refund the charges collected from the firm for licences; these had been levied without proper authority, as the P.M.G. had failed to make the necessary regulation. The firm did not press another (and perhaps more interesting) part of their suit for a declaration that the Post Office had no right to impose conditions in the licence regarding change of frequencies.

The Mobile Radio Users' Association said, in a statement issued after the test case, that it was brought to focus attention on the "unsatisfactory administration" of mobile radio services. In particular, they stressed that certain channels allocated exclusively to land mobile radio are now to be transferred to commercial television. Members of M.R.U.A. are thus put to inconvenience and expense, and suitable alternative channels have not been made available. M.R.U.A. is pressing for compensation, security of tenure and adequate spectrum space. They contend the new regulations contain "preposterous anomalies" and express the view that there is in this country no satisfactory machinery for resolving frequency allocation problems.

Others beside M.R.U.A. are dissatisfied with recent Post Office actions. We recently drew attention to the foolishly conceived hotels broadcasting licence, which seems virtually to have become a dead letter almost as soon as it was framed. Then there is the muddle over the air-sea rescue device SARAH, which was apparently given a channel in Band III after it had been decided to clear that band for commercial television.

Perhaps the most serious shortcoming of the Post Office is the failure to implement that part of the Wireless Telegraphy Act, 1949, which gives power to make regulations for curbing interference. The Act was passed five years ago, but, so far, all that has been done is to control interference from petrol engines. In the meanwhile, the manufacture of electrical devices capable of causing trouble is increasing at a frightening rate, and nothing can be done about it except to invoke the maker's goodwill. For example, a 100-kW r.f. heater, radiating at any frequency the maker chooses, may be legally operated next-door to an important receiving station or, more realistically, in the middle of a densely populated area that does not happen to enjoy a strong television signal.

It has been said from time to time that the Post Office is basically unsuited to the task of controlling radio because, being itself a user of that medium of communication, it is in competition (especially in the matter of channel allocation) with its own licensees. That argument now applies with even greater force, in view of the growing demands of conflicting interests. But nowadays the vital factor is that broadcasting—especially television—has unfortunately become one of the most controversial of political issues. Under the present system the impartiality that is so essential in a controlling body cannot easily be maintained.

Television Intermediate Frequencies

B.R.E.M.A. RECOMMENDATION

THE British Radio Equipment Manufacturers' Association has recently recommended that a frequency of 34.65 Mc/s be adopted for the vision intermediate frequency in television receivers. The recommendation has been made with the aim of minimizing not only any interference to which a television receiver may itself be subject but also any which a television receiver may cause to other receivers. It comes after a lengthy investigation into the technical problems involved.

In the past, the choice of intermediate frequency has been made chiefly with a view to avoiding i.f. harmonic interference. The advent of Band III, however, now makes it impossible to avoid it in this way; all that can be done is to choose the frequency to minimize it and to avoid the possibility of low-order harmonics being involved. In the future, the main remedy for it must lie in proper screening.

The major object in the choice of frequency to-day is so to place it that neither the intermediate frequency itself nor the second-channel and kindred frequencies, which are influenced by it, fall in places where strong signals from other stations are likely in residential areas. Also, so that the local oscillator of the television set will not interfere with other nearby receivers, whether television or not.

Choice of frequency and the liability to interference depend very much on whether the local oscillator is higher or lower in frequency than the incoming signal. The lower beat has often been chosen in the past, mainly because it is easier to obtain good oscillator stability. Interference problems are considerably more severe with it, however, and so the use of the higher frequency is recommended.

With this frequency, the main interference possibilities are as shown on the chart. From this, it is at once evident that the best choice is around 35 Mc/s. The precise figure of 34.65 Mc/s is selected to minimize i.f. harmonic feedback on Band III; the fifth harmonic then falls midway between channels 8 and 9 and only on channel 12 is there likely to be any trouble. If there is, it is from a sixth harmonic which is likely to be relatively weak.

With the oscillator above the signal, the sound i.f. falls 3.5 Mc/s higher than the vision i.f.—at 38.15 Mc/s. This is not very far from the sound signal of channel 1, 41.5 Mc/s, and any appreciably higher intermediate frequency would clearly be impracticable. The sound i.f. is not so well placed as the vision in regard to interference, but it is not so important because, with its much narrower bandwidth, interference is more readily avoided by a slight change of tuning.

Amateur transmitters can be a major source of interference because they are commonly operated in residential areas. The 34.65-Mc/s frequency should result in the disappearance of such interference, since it avoids the amateur bands, both for the i.f. itself and for the second-channel.

Oscillator radiation is just as troublesome as the other forms of interference, but to others than the owner of the set concerned. Viewers in the Brighton area have known this for some time, since the oscillators of some older sets tuned to channel 1 fall in channel 3. It is impracticable completely to suppress oscillator radiation and all that can be done is to put it where it will do least harm. With the 34.65-Mc/s

Interference level		
1	Amateur transmitters	Direct breakthrough 144-146 Mc/s amateur band in 2nd channel of Band I Direct breakthrough second harmonic 21.0-21.45 Mc/s
2	Fundamental oscillator radiation in television bands from other television receivers	Oscillator in Band I Oscillator in Band III
3	2nd channel interference due to transmitters in Bands I, II and III	Band II in 2nd channel of Band I receiver Band I in 2nd channel of Band I receiver Band III in 2nd channel of Band III receiver
4	Fixed and Land Mobile in 2nd channel of Band I receiver	Interfering signal in Band 71.5-72.8 Mc/s Band 76.7-78.0 Mc/s Band 80.0-84.0 Mc/s Band 85.0-88.0 Mc/s Band 95.0-100 Mc/s Band 146-148 Mc/s
5	Direct breakthrough due to I.S.M.	Interfering signal 13.56 Mc/s 27.12 Mc/s 40.68 Mc/s
6	Second harmonic of i.f. sound and vision carriers appearing in r.f. pass-band of receiver	
7	Direct breakthrough of International Broadcast Bands	Interfering signal in Band 11.7-11.975 Mc/s Band 15.1-15.45 Mc/s Band 17.7-17.9 Mc/s Band 21.45-21.75 Mc/s Band 25.6-26.1 Mc/s
8	Direct breakthrough of S.B.A. beacons	Interfering signal in Band 31.7-34.5 Mc/s Band 36.5-39.0 Mc/s
–	Television oscillator radiation from Band I receivers interfering with other services	Interfering with Band II Interfering with Fixed and Land Mobile Band 71.5-72.8 Mc/s Band 76.7-78.0 Mc/s Band 80.0-84.0 Mc/s Band 85.0-88.0 Mc/s Band 95.0-100.0 Mc/s

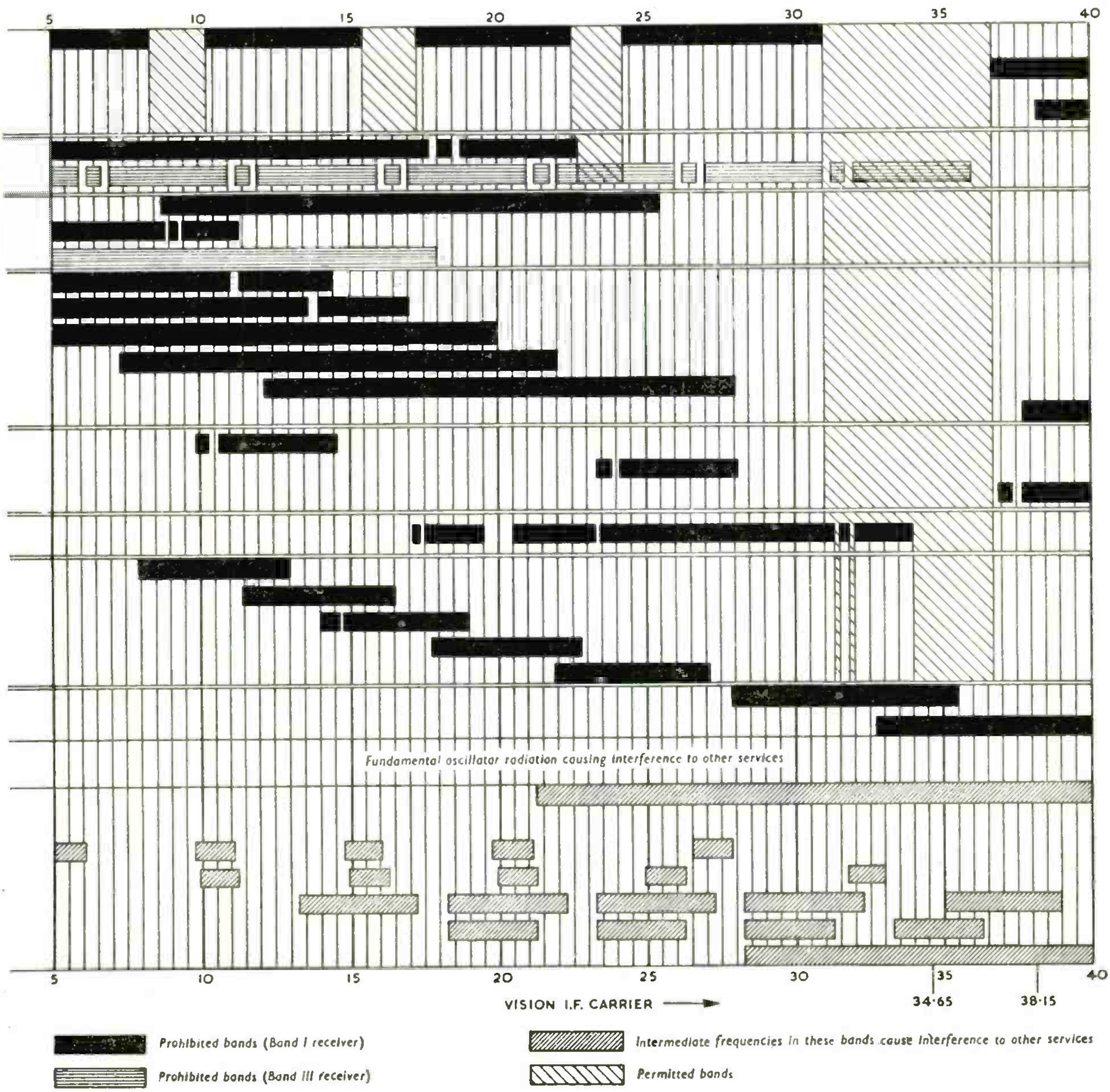
Chart showing the forms of interference that are possible with various intermediate frequencies, the local oscillator being above the signal frequency.

i.f., any oscillator radiation will affect broadcasting mainly in Band II but, although the chart does not show it, there are distinct possibilities of avoiding it by a suitable allocation of the television and f.m. frequencies on an area basis. This would mean so allocating frequencies that in any area the oscillators of Band I television receivers did not fall on the Band II frequencies used for that same area.

Generally speaking, nearly everything is in favour of a high intermediate frequency. The only important drawback is that it makes it rather more difficult to obtain adequate adjacent-channel selectivity. That adequate selectivity can be obtained is evidenced, however, by the fact that some firms have successfully used frequencies quite near to 34.65 Mc/s for some years; and, of course, the older straight sets worked at a still higher frequency.

The frequency of 34.65 Mc/s is not a critical one. In selecting it, allowance has been made for the inevitable drift of the local oscillator and for variations from the nominal intermediate frequency. The last are small in new sets, since precision equipment can be used in the factory. Signal generators employed by dealers, however, may not be more accurate than 1 per cent in frequency, so that when a set is realigned its i.f. may depart from the nominal value by this amount. The allowance for all causes of drift has been taken as ± 500 kc/s.

The use of the 34.65-Mc/s frequency will not, in itself, necessarily remedy interference in particular cases. The full benefit will be obtained only when all manufacturers adopt it and, even then, not until existing sets with other frequencies have fallen into disuse. Its use should, in time, reduce much of the existing interference and should certainly prevent chaotic conditions from arising in the future.



WORLD OF WIRELESS

More TV Stations

◆

Interfering Receivers

◆

Components & Instruments Shows

Extending TV Coverage

IT WAS originally planned to close down the temporary transmitter on Truleigh Hill, near Brighton, when the Rowridge, Isle of Wight, transmitter was brought into service on November 12th. The temporary mast at the Isle of Wight station has, however, limited the range so some of those who were getting a signal from Truleigh Hill are at present outside the service area of the Rowridge station. As a result of pressure from W. Sussex viewers, the Brighton transmitter is to continue in service for the present.

It has, of course, been necessary for the frequencies of Truleigh Hill to be changed to avoid mutual interference, and it is now operating in Channel 2, which it shares with Holme Moss and S. Devon.

Test transmissions from the North Hessary Tor, Devon, and Redmoss, Aberdeen, stations began a few days ago in channels 2 and 4 respectively. The Scottish station goes into regular service on December 14th and the south Devon station on December 17th.

With the continued operation of the Truleigh Hill mobile transmitter which was to have been transferred to Norwich, other arrangements have had to be made for East Anglia. A low-power transmitter is, however, to be installed in a temporary building and will be brought into service next February. The site will be at Tacolneston, 10 miles south-west of Norwich, but the city will come within the temporary station's service area (approx. 10 miles radius).

P.M.G.'s Powers

THE RECENT correspondence in *Wireless World* and last month's note by "Diallist" prompted us to enquire if the P.M.G. has, in fact, used his powers, under clauses 6 and 7 in the sound and television licences, to prohibit the use of receivers causing interference.

We understand that there have been two cases where the owners of sound receivers causing interference were notified that unless their sets were modified the licences would be withdrawn. One of the owners refused to modify his set and his licence was, therefore, withdrawn.

Scientific Instruments

THE annual exhibition of scientific instruments and apparatus, organized by the Physical Society, will be held next year in the Royal Horticultural Society's New Hall, London, S.W.1. The change of venue will not alter the character of the exhibition, but it will make the 140 stands more readily accessible.

Fortunately the dates of the Physical Society exhibition (April 25th to 28th) will not clash with those of the components show as has so often happened in the past.

PICTURESQUE setting for the television aerial erected by Pye for the 625-line demonstration transmissions radiated during the recent British Trade Fair in Baghdad

Components Show

A RECORD number of 142 stands will be included in the 12th Radio Components Show which will be held in Grosvenor House, Park Lane, London, W.1, from April 19th to 21st next year. As in former years this private show, which is organized by the Radio and Electronic Component Manufacturers' Federation, will also include valves and test gear.

Instead of circulating admission tickets, as has been done in the past, application cards will be issued and will have to be filled in and forwarded by each intending visitor, who will then receive a ticket "if his application is approved." Prospective overseas visitors, however, will receive their tickets as in previous years without application.

Permanent Magnet Research

TO accommodate the widening front of research into the fundamentals of magnetism and their application in the manufacture of permanent magnets, a new extension has been added to the Central Research Laboratory of the Permanent Magnet Association in Sheffield.

In addition to their principal concern with the development of new alloys, this team of physicists, metallurgists and chemists is, amongst other things, investigating in detail the effects of ambient temperature, over a wide range, on the performance and stability of magnets. The low-temperature range is of particular importance as it influences the accuracy of electrical instruments in high-flying aircraft.

Radio Engineers' Training

DESPITE a deplorably low percentage of success in the graduateship examination of the Brit.I.R.E., the membership of the Institution continues to increase, and at the end of March was 4,750.

Stress is laid in the annual report of the Institution on education and training, especially in relation to the low percentage of passes in the graduateship exam. Of last year's 1,149 candidates, which was a 10 per cent increase on the 1952 figure, only 72 were successful in the entire examination (approximately 6 per cent). The Institution's education committee has, therefore, recommended that a regulation be introduced requiring candidates entering for the examination to provide evidence of supervised practical work.

SIR PHILIP CLARKE

In his inaugural address, the new president, Rear-Admiral Sir Philip Clarke, laid emphasis on the need for close co-operation between radio engineers in the Services, in industry and in Government departments. He also touched on the menace of over-complexity in electronic equipment and urged the need for constant awareness of the possibilities of "neat solutions and brilliant simplifications."

PERSONALITIES

Brigadier E. J. H. Moppett, M.I.E.E., has been on a two-months' tour of Burma, India and Pakistan on behalf of Pye Telecommunications, Ltd., of which he became a director in 1952. His tour was mainly concerned with the introduction of the Pye transmitter-receiver C12, which is the modern counterpart of the wartime maid-of-all-work No. 19 set. He also spent some time with the radio survey team on the company's contract to supply, in conjunction with Redifon, Ltd., and Etelco, Ltd., a complete telecommunications v.h.f. system for the new 350-mile pipeline being laid by the Sui Gas Transmission Company from Sui to Karachi.

F. C. McLean, C.B.E., B.Sc., M.I.E.E., deputy chief engineer of the B.B.C., has gone to Karachi for five weeks to advise the Pakistan government on the development of the country's broadcasting service. The request for assistance in assessing the needs, and the ways in which they can best be met, was made to the British Government under the technical co-operation scheme of the Colombo Plan.

Martin Ryle, F.R.S., M.A., lecturer in physics at the Cavendish Laboratory, Cambridge, is to receive the Hughes Medal of the Royal Society "for his distinguished and original experimental researches in radio astronomy" at the anniversary meeting of the society on November 30th. Martin Ryle left Oxford in 1939 with an M.A. degree and joined T.R.E., where he worked on radar applications until the end of the war. He then went to Cambridge, where he is undertaking radio astronomical research.

R. J. H. Branthwaite, B.A., A.M.I.E.E., formerly chief engineer of Furzehill Laboratories, Ltd., has been appointed by R. B. Pullin & Company, Ltd., of Great West Road, Brentford, Middx, as superintendent of the new electronic division of their Development Laboratories.

H. M. Dowsett, M.I.E.E., F.Inst.P., who retired some years ago from the Marconi Company, which he joined in 1899 as assistant to Marconi, has been elected president of the Association of Retired Engineers. The association was formed in 1951 for retired professional engineers living in the neighbourhood of Worthing, Sussex. Mr. Dowsett was editor of the *Marconi Review* from 1928 to 1939 and for the latter four years was also principal of the Marconi School of Wireless Communication.

Dr. E. Duncan-Smith, D.Sc., M.I.E.E., M.Brit.I.R.E., has been appointed United Nations radio adviser for the Middle East and has relinquished his appointment as radio adviser to the Government of Jordan under the United Nations Technical Assistance Administration. He was formerly at the Admiralty Signal Research Establishment for some six years, where he served in the technical secretariat and the Shore Station Division, in which he assisted in planning high-power communication schemes for the Middle and Far East. After resigning from the Royal Naval Scientific Service and before joining U.N.T.A.A., Dr. Duncan-Smith was with Air Service Training, Hamble, and International Aeradio, Ltd., organizing radio technical training.

G. R. Scott-Farnie, general manager of International Aeradio, Ltd., was invited to attend the annual electronics conference of the American Institute of Radio Engineers held in Kansas City in November and to be principal speaker at the banquet. His subject was "Some International Aspects of Radio Engineering," in which he reviewed the problems facing electronic engineers with the growing demands of civil aviation.

F. Livingston Hogg, M.Brit.I.R.E., A.M.I.E.E., director of Livingston Laboratories, Ltd., specialists in electronic instruments for industry, went to America early in November for an extended tour to study developments in the U.S.A.

E. Green, M.Sc., who for many years has been well known in the transmitter engineering world, having joined the Marconi Company in 1913, has retired from the position as head of the Transmitter Advanced Development Group. He is, however, continuing his work for the company as a full-time consultant engineer. From 1919 to 1929 he assisted C. S. Franklin in the development of the Marconi short-wave beam system. In 1929 he was appointed chief of the group concerned with developing high-power short-wave transmitters and was responsible for the development of many of the well-known S.W.B. series of short-wave transmitters. In more recent years, as head of the Transmitter Advanced Development Group, he has been concerned with the

E. GREEN

V. J. COOPER

development of vision transmitters. Mr. Green is succeeded by **V. J. Cooper,** B.Sc., M.I.E.E., M.Brit.I.R.E., who has been appointed chief engineer (advanced development). The scope of the group, of which Mr.

Green was in charge, has been enlarged and the organization is now known as Advanced Development. Mr. Cooper joined the company in 1936 and, like his predecessor, has been concerned with the development of transmitters, including those for the Holme Moss television station.

Dr. V. K. Zworykin, the well-known television pioneer and inventor of the iconoscope camera tube, has retired from the vice-presidency of the R.C.A. Laboratories, which he has held since 1947. He is continuing as technical consultant and has been elected honorary vice-president of the parent organization, Radio Corporation of America. Dr. Zworykin, who served in the Russian Signal Corps in the first world war and afterwards became an American citizen, received the degree of Doctor of Philosophy at Pittsburgh University in 1926. He joined R.C.A. in 1930 after working on the research staff of Westinghouse Electric Corporation.

Colin H. Gardner, past president of the Incorporated Practical Radio Engineers, has completed 25 years' service with Mullard, Ltd., where he is concerned with technical/commercial liaison with dealers. **Leonard A. Sawtell**, Comp.Brit.I.R.E., has also recently completed 25 years' service with the company, where he has been commercial manager of the Entertainment Valve Department since 1945.

B. H. Douthwaite, A.M.I.E.E., has joined British Physical Laboratories, of Houseboat Works, Radlett, Herts, as sales manager. During the war he was engaged on radio counter measures as a member of the scientific staff of the General Electric Company and has subsequently had considerable experience as a technical executive in the electrical industry.

H. Priest has joined the car radio sales division of E. K. Cole, Ltd., as technical representative and will be responsible for liaison with car manufacturers and dealers.

Douglas A. Lyons, of the Trix Electrical Company, is on an eight-weeks' tour of North and South America, during which he is meeting Trix distributors.

OBITUARY

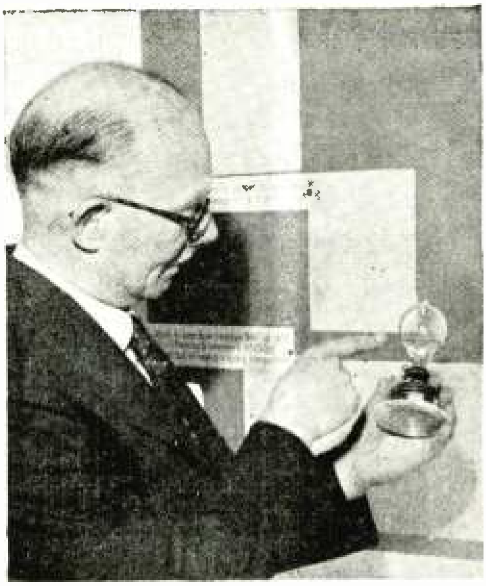
A. H. Ginman, for over 15 years president of the Canadian Marconi Company, died in Canada on November 7th at the age of 79. He joined the Marconi Company, Chelmsford, in 1901, where he worked with Marconi himself, and a year later transferred to the American Marconi Company. He also represented the parent company in the Far East and on returning to England became general manager at Chelmsford for two years before going to Canada in 1935. He retired in 1951.

IN BRIEF

The many readers who were unable to obtain tickets for the recent Festival Hall **Sound Reproduction** demonstration by G. A. Briggs (managing director, Wharfedale Wireless)—reported elsewhere in this issue—will be glad to learn that a similar demonstration will be given on Saturday, May 21st, 1955, in the Royal Festival Hall. Details of admission and prices, which, we understand, will have to be increased to cover the costs, will be announced later.

TV By Wire.—Figures quoted at the annual luncheon of the Relay Services Association show that in addition to the million listeners served by the various relay companies throughout the U.K. some 300,000 receive television by wire.

I.S.W.C.—The International Short Wave Club celebrated its 25th anniversary on October 4th. Founded in the United States, the administration was transferred to London during the war, the present secretary being Arthur E. Bear, 100, Adams Gardens Estate, London, S.E.16.



VALVE JUBILEE.—The 50th anniversary of Sir Ambrose Fleming's first valve patent was celebrated on November 16th at University College, London, and by the I.E.E. In 1884 Edison discovered the rectifying properties of a lamp with a sealed-in anode; Fleming's great contribution lay in the practical application of this device to radio-frequency detection. The photograph shows Dr. H. M. Barlow, professor of electrical engineering at University College, with one of the first Fleming diodes.

Comet Investigation.—Strain gauge equipment, specially developed and manufactured for the Royal Aircraft Establishment, Farnborough, by McMichael Radio, was used in the recent technical investigation into the loss of the Comet airliners. This equipment comprises a multi-channel amplifier of high gain and stability and a 2,000-c/s carrier oscillator.

Proc.I.E.E.—Changes in the publications issued by the Institution of Electrical Engineers are being introduced in January. The *Journal* will continue to be issued monthly but will in future be available to non-members. It will include some of the material at present appearing in Part I of the *Proceedings*. There will be, in future, only three parts of the *Proceedings* (A, B and C), part "B" being that covering light current engineering. This will be published in alternate months.

Radio Facility Charts.—Six maps showing the aeronautical radio facilities available in the U.K., and tabulated lists of radio communication stations and navigational services, are given in the latest edition (4th) of "Radio Facility Charts" (C.A.P. 111). It is available from H.M.S.O., price 5s.

F.B.I. Register.—The 1955 edition of the "F.B.I. Register of British Manufacturers," issued by the Federation of British Industries, includes, in addition to the usual buyers' guide and directories of trade names and associations, glossaries in French, German and Spanish. Each glossary gives a translation of all the 5,000 or more names of commodities and services under which the 6,800 member-firms are classified. The register is obtainable from our Publishers, price 2 guineas, post free.

The 80 or more technical papers presented at the tenth **National Electronics Conference** held in Chicago, Ill., from October 4th to 6th will be published in Vol. 10 of the *Proceedings* of the conference which will be available (price $5.00) from the N.E.C. Inc., 84, East Randolph Street, Chicago, Ill., early in 1955.

Many radio and electronic concerns are included in the list of donors to the **Electrical Industries Benevolent Association** given in its 1954 Year Book, which also incorporates the annual report and accounts for 1953. The collections at the Radio Industries Club luncheons in London are given to the E.I.B.A. and last year totalled £487.

An explanation of modern **Costing Techniques** and their application to production engineering is given in "Cost Accounting and the Engineer," by Kenneth B. Mitchell. Published by Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1, for *Machine Shop Magazine*, the 126-page book costs 10s 6d.

The American **Audio Engineering Society** has elected as its new president Albert A. Pulley, manager (general recording) of the R.C.A. Victor Records Division of the Radio Corporation of America.

BUSINESS NOTES

An industrial television camera has been set up by **Pye, Ltd.**, in the experimental workshop of Smith Meters, Ltd., of Streatham, to improve the liaison between the experimental workshop and the design engineer's office where a receiver has been installed. With this closed-circuit equipment the piece of apparatus or diagram on which a question has arisen is placed before the camera and with the aid of the internal telephone the query is settled without the designer having to leave his office.

Wafer switches in small quantities, made to one's own specification are obtainable from **Specialist Switches.** They are the well-known Type "H," made from parts manufactured by A. B. Metal Products to whom orders for bulk supplies should be sent. Enquiries for Specialist Switches—by post only—should be addressed to 24, Cranbourn Street, London, W.C.2.

Two 650-ton trawlers now being built in a German shipyard for Grimsby fishing companies are to be fitted with **Redifon** marine radio-communication and d.f. equipment.

Twelve tankers now in course of construction for the Shell fleet—five of them of 31,000 tons—are to be fitted with **Marconi** radar equipment.

A mobile radio installation has been supplied by the **General Electric Company** for the transport section at the Coryton, Essex, oil refinery.

The name of Rees Mace Marine, Ltd., the Pye marine radio subsidiary, has been changed to **Pye Marine, Ltd.** Administration, production and sales departments are now at the new factory at Oulton Works, Lowestoft, Suffolk (Tel.: Oulton Broad 425).

The Duke of Edinburgh recently opened Ferranti's new electronics research laboratories at Crewe Toll, Edinburgh. He is seen here being shown an electronically controlled milling machine by D. T. N. "Amplifier" Williamson, who is now senior development engineer in the Industrial Application Laboratory. On the left is the Minister of Supply.

Four **Nera** projection television receivers (4×3ft) have been installed by the B.B.C. in the television theatre at Shepherds Bush so that studio audiences can see the transmitted picture as well as the stage show. Two of the receivers are suspended from the ceiling, the other two, using a folded optical path, are installed in the circle boxes. The pictures are remotely controlled from a vantage point in the theatre.

We are informed that the **Ampex Corporation,** of California, U.S.A., whose tape duplication system was referred to in our last issue (p. 530), is represented in this country by Rocke International, Ltd., 59, Union Street, London, S.E.1 (Tel.: Hop 4567).

Midland Silicones, Ltd., of 19, Upper Brook Street, London, W.1, are the distributors of the silicone products of Albright and Wilson, Ltd., who have brought into service a new silicone plant at Barry, Glamorgan. One use of silicones in the radio industry is as a coating for resistors to improve their resistance to moisture.

Lasky's Radio have opened new premises at 42, Tottenham Court Road, London, W.1 (Tel.: Langham 1151). Post orders are still dealt with at 370, Harrow Road, London, W.9.

Arrell Electrical Accessories, Ltd., is the new name under which R. Lowther, Ltd., manufacturers of television aerials, of Vincent Works, New Islington, Manchester, 4, will in future operate.

A new servicing depot and research laboratory at Wallisdown, Bournemouth, has been opened by **Good Listening, Ltd.,** who provide a radio and television rental service from their 12 branches.

The Bedford depot of **British Insulated Callender's Cables, Ltd.,** has been closed and a new depot opened at 81, Dumfries Street, Luton, Beds (Tel.: Luton 6866).

Standard Telephones and Cables, Ltd., have moved their Leeds branch office and cable depot (rubber, plastic and textile insulated) to 6-8, York Place, Leeds, 1 (Tel.: Leeds 22900).

EXPORTS

A research centre has been opened by **Export Packing Service, Ltd.,** of Sittingbourne, Kent, to study the packing of equipment for export. Manufacturers of electronic components and equipment are invited to submit prototypes for advice on packing. This new research and development establishment, which covers 16,000 square feet, includes physics and chemical laboratories and a test section with humidity chambers, vibration and "drop" tests and an immersion tank.

Pye, Ltd., of Cambridge, have received a contract from the Thailand police for over £100,000 worth of telecommunications equipment, including a large quantity of new 60-watt h.f. sets.

Components.—Quotations from U.K. manufacturers for the supply of a quantity of fixed and variable capacitors and resistors, and i.f. transformers (455 kc/s) are required by the Director of Industries, Department of Industrial Development, Khairpur Mirs, Khairpur State, West Pakistan. Details of values and quantities are obtainable from the Export Services Branch, B.o.T., Lacon House, Theobalds Road, London, W.C.1 (Ref. ESB/25652/54).

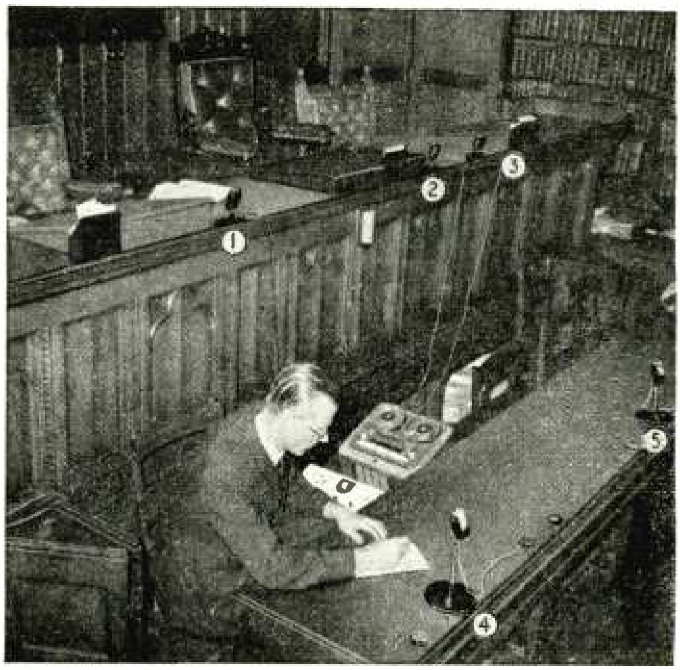
Tape Recorders.—Frank Loasby, of the Raytheon Television and Radio Corporation, 5921, W. Dickens Avenue, Chicago, 39, Illinois, U.S.A., would like to get in touch with United Kingdom manufacturers of tape recorders. The Corporation is contemplating developing several new receivers which will incorporate tape recorders and is, therefore, interested in contacting manufacturers who would be willing to supply the basic tape recording chassis without the loudspeaker and other sound reproducing equipment.

Californian Agency.—The Clyde Allen Company, of 1355, Market Street, San Francisco, California, U.S.A., would like to act as agents for manufacturers of tape and wire recorders, portable gramophones and valves.

LEGAL REPORTING

Use of Tape Recorders in the Courts

By T. D. CONWAY
B.Sc.(Eng.), A.C.G.I., A.M.I.E.E.*



Arrangement of the recording unit and the five microphones in No. 1 Appeals Court.

THE recording of court proceedings is now being seriously considered and, in order to examine some of the problems involved and study the techniques necessary, a prototype equipment has been built and installed in the No. 1 Appeals Court at the Law Courts. This was arranged by the Association of Official Shorthand Writers. In this article we shall discuss the special requirements which had to be met in the design of the equipment, and detail how these facilities were provided for.

Basic Requirements.—In the court where the installation was to be made the whole proceedings are taken down in shorthand, and this, after transcription, is the official record of the court. Tape recording was introduced to provide a simultaneous recording of the shorthand version with a view to determining whether the possibility exists of eventually replacing the shorthand version by a taped one. In practice, the recording equipment had to come under the control of the shorthand writer and be arranged in such a fashion that he had complete charge of it. It further followed that the maximum simplicity of controls must be provided so that the minimum of attention would be required to operate the equipment.

The space available for the recording equipment was not great, but provision had to be made for up to three hours of recording without reel change; additionally, reliability demanded that a minimum of two machines were employed in order to allow for possible breakdowns. The total available floor area was 1ft 6in by 2ft, and the overall equipment height could not exceed that of the writer's desk (2ft 4in) since the keynote of the installation was to be its unobtrusiveness. The accompanying photograph shows the general layout of the court, the judges' microphones being marked Nos. 1, 2 and 3, and those of the counsel 4 and 5: the shorthand writer's position is shown with the recording equipment beside him.

Technical Problems.—The technical problems involved were twofold. First, that of satisfactorily recording the inputs from five different microphones at levels varying from a murmur to loud conversations, and, secondly, recording court proceedings up to three hours continuously without the necessity for changing of tape reels. In normal tape recording continuous monitoring of the recording level is necessary to ensure that the recording stays within the dynamic range of the instrument; thus it must not be so low that it sinks into the noise and hum level, nor so high that it exceeds the maximum allowable distortion on the tape. In this case any form of monitoring was completely out of the question.

For the microphone inputs a special mixer unit was developed having a separate pre-amplifier chain with automatic gain control for each microphone: by the use of a.g.c. the recording level of the tape recorder can be kept within a relatively narrow dynamic range. A two-position sensitivity control was provided on each channel, the low sensitivity being for the judges, who would be close to their microphones, and the high sensitivity for the counsel, who would be from 5-15 feet from the microphones. Details of this mixer unit and a circuit diagram follow in the next section.

For the actual recording it was decided to employ a Grundig TK9 machine since it is compact (15in by 13in by 8½in) and has the facility of recording on both tracks of the tape without reversing the reels: the economics of the situation make half-track recording imperative. This machine operates at 3¾in per second and although there is no doubt that perfectly satisfactory speech recording can be made at 1⅞in per second, it was decided to use a standard machine in the interests of simplicity and economy. The 850-foot tape provides 45 minutes of recording in each track, a total of 1½ hours, and hence two machines provide a virtually continuous three hours

* Grundig (Great Britain) Ltd.

of recording, besides giving provision against breakdown, when one machine may be used alone by changing the tape after 1½ hours.

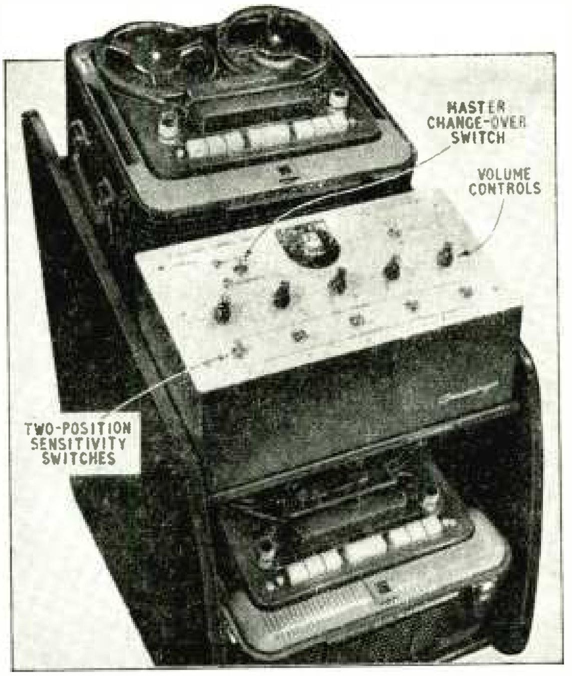
A master change-over switch from the first recorder to the second was provided, and this changes over the input as well as stopping and starting the respective machines. Owing to the switching complexity involved it was decided to employ a relay operated by a simple toggle switch.

Mixer Unit.—The circuit of one microphone channel of the mixer unit is shown in the figure. The microphones are all of 200 ohms balanced impedance, which has been found to be a good compromise level for the minimum pick-up of hum and signal attenuation on long leads. Each microphone is connected to its own input transformer which feeds into the grid of an EF86. The EF86 has switchable alternative anode loads of 230 kΩ and 30 kΩ, which act as the two-position sensitivity control.

Conventional coupling is made to the grid of the EBF80 *via* the volume control, which in practice has to be varied very little, and it will probably be dispensed with in later designs The diodes of the EBF80 are fed directly from its anode output into a 10-MΩ load, and the a.g.c. voltage is passed *via* a filter network to the grid of the EF86; a.g.c. delay is provided by a cathode auto bias voltage. The time-constant of the a.g.c. feed is fairly critical in practice, as it must not produce too serious distortion by rapid compression, nor must it be too slow to follow the intensity variations of speech which may be emphasized by the speakers' movements to and fro. It first appeared that it would be advantageous to use the variable-mu characteristic of the EBF80 for a.g.c. purposes, but experiments showed that in this arrangement the ratio of a.g.c. feed of the two valves becomes quite critical and unstable operation may easily result as the setting of the volume control is changed.

Each channel develops approximately 3 volts of r.m.s. signal and since half a volt is adequate for the 500-kΩ input of the TK9, a 1-MΩ isolator was added in series with the output to prevent interaction of the individual a.g.c. circuits.

The general appearance of the mixer unit may be seen in the second photograph, where are shown the five two-position sensitivity switches and their respective volume controls. The master change-over switch for the two recorders, on the top left-hand side of the panel, controls the relay which simultaneously changes over the input from the first recorder to the second, and controls their operation through their respective remote control sockets; indicator lights are provided to show which of the two recorders is in operation.



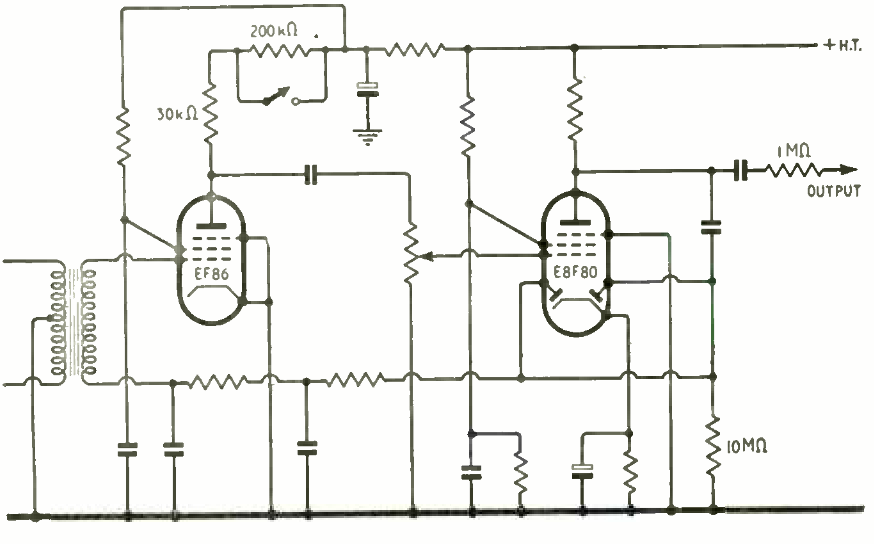
Mounting of recorders and mixer unit.

General Arrangements.—The two tape recorders and the mixer unit were mounted on to a trolley designed to fit into the limited space available. All microphones plug directly into the back of the mixer unit and interconnecting cables are run from the input and remote control sockets of the tape recorders into the mixer unit.

Space limitations made it impossible to locate the power supply for the mixer inside the case, and hence a separate unit was located at the back of the trolley, providing h.t., l.t. and a d.c. supply for the change-over relay: this had the added advantage of eliminating cooling problems in the mixer, which is only ventilated by small bottom and back louvres.

Operation.—To operate the equipment both machines are first loaded with tape. The mixer and the two recorders are then switched on, and their

Circuit of one of the five amplifiers in mixer unit.



respective recording buttons are depressed. The sensitivity switches on the five microphones are next set according to the nearness of the various speakers, and trial speeches are used to set the volume controls of the five channels in accordance with the "magic eye" programme level meters of the TK9s. Overall control of each recorder is provided by the built-in recording level control, and this is set in accordance with the "magic eye" of each machine to limit the distortion on the loudest passages of speech. Owing to the a.g.c., the setting of all channel controls is very uncritical and once settings have been decided upon the equipment may be left untouched. Generally speaking, the output of the mixer unit only varies between very close limits and most adjustments are made on the master recording level controls of the recorders.

To commence recording the track button of the No. 1 machine is depressed, the change-over switch being in the No. 1 position, and continuous recording then ensues for ¾-hour. At the end of this period Track 2 button is depressed to give a further ¾-hour.

Whilst machine No. 1 is in operation the Track 1 button of No. 2 machine is pre-set, so that this machine is ready to start immediately after Track 2 becomes full on the No. 1 machine, by operating the change-over switch. If a particularly long session has to be recorded, a second tape is fitted to the No. 1 machine whilst No. 2 is in operation and the change-over carried out as before.

Finally, it should be noted that both machines are fitted with automatic stop foils at either end of the tape, so that, in the event of tracks or machines not being switched over, the machine in use switches itself off automatically. A third TK9 was provided with the installation so that transcription could commence immediately one tape is full. This machine is provided with stethoscope earphones and a foot-operated remote control having "back-space" facilities.

Conclusion: Other Applications.—The equipment has now been in use for several months and has proved itself extremely simple to operate and reliable in its performance.

Equipment of this kind is capable of wider applications than court recording and is particularly convenient for all forms of conference recording. Since the mixer is designed on a unit channel basis, there is no limit to the number of microphones which can be incorporated. For this application, push-to-speak buttons would be employed to reduce the general background noise normally emphasized by the a.g.c. and signal lamps would be needed on the microphones to indicate that they are live.

Velocity of Radio Waves

An Internationally Agreed Value

By R. L. SMITH-ROSE* C.B.E. D.Sc., M.I.E.E.

AT the 11th General Assembly of the International Scientific Radio Union (U.R.S.I.) held at the Hague in August-September, 1954, the following resolution, first formulated two years earlier, was confirmed:—

> "As a result of investigations made in recent years by several different methods, it is recommended that the following value of the velocity of electromagnetic waves in vacuum be adopted for all scientific work: 299,792 ± 2 km/sec."

As this is a matter of far-reaching importance to many scientists and engineers engaged in the radio field, it will be interesting to review briefly the circumstances which have led to this resolution.

From the earliest days of the discovery of the existence of electromagnetic waves in what is now known as the radio part of the spectrum, it was appreciated that their properties were similar to those of light waves, except, of course, that their frequency or wavelength was different. Prior to about 1940, it was also usually assumed that the velocity of light, and therefore of radio waves, was approximately equal to the nice round number of 3×10^5 km/sec (or nearly 186,000 miles per second). This was extremely convenient for the conversion of frequency into wavelength; but what was not always appreciated in those days was that, whereas frequency could be measured and expressed to a precision of better than one part in ten million, the wavelength derived by the above arithmetical process had nothing like this accuracy. This fact was not of much consequence for many applications, and it was not until the early years of the war that the need for a careful study of this matter became apparent.

A review[1] made in 1942, of the latest available measurements of the velocity of light in a vacuum showed that the mean value was 299,775 km/sec, and also that the accuracy of these measurements was not better than 50 parts in a million. It was also clear that the velocity of radio waves under practically useful conditions could not be stated more precisely than about one part in a thousand. Considering that at that time radar techniques for navigational aids and bombing purposes were being developed with a precision of indication very much better than this, there was obviously a need for more research into the true value of the velocity of electromagnetic waves in general.

In the following decade several investigations were carried out, notably by L. Essen[2], who, in 1947, des-

* Vice-President. International Scientific Radio Union.

[1] R. L. Smith-Rose: *Journal I.E.E.*. 1943, Vol. 90, Part I, p. 31.

[2] L. Essen: *Nature*, 1947, Vol. 159, p. 611, and *Proc. Royal Society*, 1950, Vol. 204, p. 260.

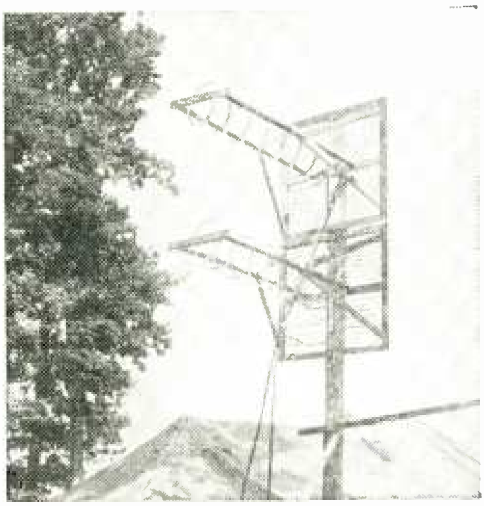
cribed a method of deriving the value of the velocity of radio waves from the resonant frequencies of a cylindrical cavity. Using the resources of the National Physical Laboratory for the measurement of the dimensions of the cavity in the Metrology Division and the frequency in the Electricity Division, he obtained a value about 17 km/sec greater than the hitherto generally accepted value for the velocity of light referred to above. This result was soon confirmed by other workers. Concurrently, the apparent discrepancy between the values applicable to the velocity of light and of radio waves was later resolved by E. Bergstrand[3] in Sweden, who applied modern techniques to the classical methods of measuring the velocity of light.

At the General Assembly of U.R.S.I. held in Sydney in August, 1952, a paper by L. Essen contained the following summary of the latest results obtained for the measured velocity of electromagnetic waves in a vacuum:

Date	Author	Method	Result—km/sec
1950	Essen	Cavity Resonator	299,792.5 $\pm$ 1
1950	Bergstrand	Optical	793.1 $\pm$ 0.25
1950	Bol	Cavity Resonator	789.3 $\pm$ 0.4
1951	Aslakson	Radar	794.2 $\pm$ 1.4
1952	Froome	Interferometer	792.6 $\pm$ 0.7

The arithmetic mean of these results gives the value 299,792 km/sec with a probable error of $\pm$2 km/sec. Further measurements by other investigators have since confirmed this value, which is thus recommended for adoption in accordance with the resolution quoted at the beginning of this article. When applied to practical radio conditions, this velocity will usually be modified by the dielectric constant of the atmosphere or by the conductivity of the earth's surface, depending upon the actual frequency and mode of transmission used. Recent research, which is still in progress, has provided a knowledge of the appropriate corrections to be applied for various typical conditions.

[3] E. Bergstrand: *Nature*, 1950, Vol. 165, p. 405.



The illustration shows the helical aerials and their reflectors used for a multi-channel telephone system for a summer camp in a somewhat isolated part of Yugoslavia. It was obtained by A. O. Milne, president of the R.S.G.B., while attending the Congress of the Yugoslav Amateur Radio Society this year.

Television Safety Precautions

By E. G. GOODHEW* M.I.E.E.

THERE are, of course, possible hazards—such as electric shock and fire—involved in the use of a television receiver, as with any high-voltage equipment. There is, however, the additional danger of physical injury due to the implosion of the c.r. tube and the remote possibility of X-radiation. In this country the drafting of safety precautions for television receivers is the concern of one of the British Standards' Committees (TLE 2/2) which is drafting the ninth, and, it is hoped, the final revision of B.S.415.

On the international level such matters are the concern of a sub-committee of the International Electrotechnical Commission (I.E.C.) which, in September, held its jubilee congress in Philadelphia. The main item on the agenda of this committee (telecommunications safety, 12-2) was the consideration of a draft of "safety requirements for electric mains-operated television receivers."

During the post-war years, the meetings of this I.E.C. Committee have been held in Europe, and as a result, the recent meeting was the first at which the U.S.A. had been adequately represented. The United States delegation included engineers from the Underwriters' Laboratories Inc., whose approval must be obtained for domestic and other equipment offered for sale in the U.S.A. They have therefore tested for safety many more television receivers than any other laboratory, and their experience was invaluable to the Committee.

The television safety precautions considered at the Philadelphia meeting will be a supplement to I.E.C. publication 65, "Safety Requirements for Electric Mains-Operated Radio Receiving Apparatus," issued in 1952. In this document a safe condition is specified for the receiver in its normal operating condition and under abnormal conditions when short-circuits are applied to certain spacings which are smaller than those considered sufficient to ensure safety in themselves. This principle is also followed in the revision of B.S.415.

The new problems not already contained in publication 65 are those relating to the higher voltages involved. Acceptable spacings for voltages up to 4,500 have been determined experimentally, but above this value the shape of electrodes and conductors has an increasing effect, and while the present method of specifying breakdown voltages is deemed to be satisfactory, it is to be expected that further experience will indicate more satisfactory methods.

Even when the mains supply has been disconnected, removal of the back-plate may involve a hazard due to the charge on the capacitor of the high-voltage source. It had been intended to specify

* Philips Mitcham Works, Ltd. [The author was a member of the British delegation to the I.E.C. Congress, Philadelphia.]

a limit for the charge, but experiments being conducted in the U.S.A. tend to show that the hazard is more accurately specified by the energy than the charge. Until more is known, the I.E.C. has adopted a method of limiting the capacitance, used successfully by the Underwriters' Laboratory for some time. This specifies that the capacitance shall not exceed 3,000$\mu\mu$F and that the sum of the total capacitance in $\mu\mu$F plus 300 times the voltage in kV shall not exceed 7,500.

Metal cabinets are appearing on the American market particularly for use in hotels. The majority of receivers in the U.S.A. are transformer fed, and therefore no particular hazard is involved when the cabinet is connected to the negative of the high-voltage supply. Receivers having a series heater chain and the chassis connected to one pole of the mains, must have the cabinet insulated from the chassis by a material appropriate to the voltage of the mains supply. Should the insulation break down, one pole of the mains supply would be connected to the cabinet.

Circuits have been designed to overcome this difficulty. They will be studied in the light of the prevailing conditions in Europe (e.g., higher mains voltages).

With minor changes, the requirements regarding fire hazard specified in publication 65 were considered satisfactory.

Experience has shown that the probability of a cathode-ray tube imploding is not very high. Nevertheless it is necessary to be certain that the enclosure, and in particular the protective screen, are strong enough to ensure safety should a tube implode. Attempts in the United Kingdom to find a satisfactory impact test have not been entirely successful, and it is therefore necessary to cause a tube to implode in order to test its enclosure. Of the various methods which have been used, that of driving a steel pin into the tube seemed to be the easiest to carry out, and as the Underwriters' Laboratory had already carried out about 1,000 tests, the standards which they have adopted were accepted by the Committee. Through a hole drilled in the cabinet housing the tube, a steel pin 1in in diameter is driven into the tube at a point on the rim of the face by a weight, which varies according to the diameter of the tube, falling from a height of five feet.

At the voltages in use on direct-viewing cathode-ray tubes, X-radiation is a hazard which need give no concern. Even using projection-type tubes operating at 25kV, it is very difficult to measure any X-radiation outside the optical system assembly. The limit of 0.6 micro rontgens/second accepted by the International Electrotechnical Commission agrees with that included in the draft of B.S.415 and is one-third of the value given by the International Commission for Radiological Protection as a safe dose for eight hours' continuous exposure.

EUROPEAN BROADCASTING

Technical Work of the E.B.U.

THE General Assembly of the European Broadcasting Union and the statutory autumn meeting of its Administrative Council, which are held in a different country each year, were this year held in London. The opportunity was taken also to hold meetings of the Legal, Technical and Programme Committees. At the meeting of the Technical Committee, at which E. L. E. Pawley (B.B.C.) was chairman, there were representatives from 18 member-countries, 3 extra-European associate-member countries, the C.C.I.R. and the I.F.R.B.*

The technical work undertaken by the E.B.U. falls roughly into two categories—(i) routine and special studies undertaken by the Technical Centre in Belgium and (ii) studies delegated by the Technical Committee to individual Working Parties of experts, specially nominated for that purpose.

At the London meeting, the Technical Committee first of all worked out a plan extending over the next five years for completing and improving the technical equipment of the Union's receiving and measuring station at Jurbise-Masnuy, Belgium, which was officially opened in July, 1953. Routine operations are to continue on approximately the same lines as hitherto, except that more attention is to be given to observations in the v.h.f. bands. After studying the present situation on long and medium waves, the committee recommended the use of Band II by its members for local and regional transmissions.

The reports of the Working Parties presented at the meeting covered:—A long-term study of indirect-ray propagation on medium waves that should prove of great value when these bands are reallocated; unattended sound and vision transmitting stations; magnetic recording, including the standardization of sound-recording in television and the recording of television picture signals; v.h.f. and u.h.f. sound and television broadcasting (incidentally, the programme of propagation experiments in Band IV has been deferred until more members have the necessary equipment); and the transmission of television over long circuits including the exchanges of television programmes in Europe.

It was decided to reconstitute the ad-hoc Committee which has been co-ordinating the recent European television exchanges as a Working Party, with M. J. L. Pulling (B.B.C.) as chairman, and to include representatives of the television services of Luxembourg and Sweden. The terms of reference of the new Working Party are the planning, direction and technical supervision of international television relays.

The Technical Centre was instructed to issue as soon as possible a draft Code of Practice relating to international television relays. The question of the provision of a permanent international television co-ordination centre to replace the temporary arrangement at Lille was discussed at length. It was decided that, in the present state of development, it was too early to say whether such a centre would always be necessary, but that the E.B.U. should accept responsibility for the co-ordination.

* International Radio Consultative Committee and International Frequency Registration Board permanent organs of the International Telecommunication Union.

LETTERS TO THE EDITOR

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

Quality on V.H.F.

MAY I comment very briefly on the editorial about v.h.f. in your November issue. I said in my talk to the Radio Industries Club that the new v.h.f. stations would give improved quality because of reduced background noise, but I also said that the B.B.C. did not intend to transmit an audio-band up to 15 kc/s because the frequency characteristics of the Post Office music circuits would not permit it.

But, of course, I agree with you, and I hope this was clear from what I said, that the absence of background noise will bring out the difference in quality of reproduction between v.h.f. and what is possible at the present time on medium waves. The serious irritation of "monkey chatter," which is heard if the frequency characteristics of a medium-wave receiver goes much above 5 kc/s, will be overcome, and the new service will permit a substantial improvement in receiver performance which will we hope be very welcome to the vast majority of listeners and certainly to the B.B.C.

Director of Technical Service, B.B.C. H. BISHOP
London, W.1.

Output Stage Performance

MR. WOODVILLE is correct in his statement that "ultra-linear" operation can produce considerably less distortion than either tetrode or triode operation.

I drew attention to the advantages of this circuit as long ago as 1943. Since then, however, the principle has had to travel across the Atlantic and back again before becoming generally popular with designers. During this process it has been incorporated in many amplifier designs with both good and bad results. Much depends on how the principle is applied; there are several alternatives.

For example, having a percentage of the output winding common to screen and anode, part or all that percentage can be placed in the cathode circuit (*Wireless World*, September, 1950). This gives greater freedom to the designer in integrating the output stage with the requirements of the amplifier design as a whole.

The Acoustical Manufacturing Co. P. J. WALKER
Huntingdon.

GRAHAM WOODVILLE, in your November issue (p. 555), makes out a convincing case for the adoption of distributed-load tetrodes in the circuit under discussion, but a few comments may not be out of place.

Would it not be more reasonable to assume a maximum output of six watts per pair for the N709 when triode-connected, if the sharp increase in the curve at this point can be taken to indicate the onset of grid current? The distortion is then 1 per cent. Mr. Woodville's figures show 100 per cent increase in distortion for an increase of only 0.5 watt. The more gradual rise in the curve for the distributed-load condition is a characteristic of the circuit, and I think it is possible that grid current does not start until the maximum output of 14 watts is reached, with a distortion figure of 1.5 per cent. The advantage of the circuit would then appear to be chiefly in increased power efficiency. This criticism is, perhaps, unfair, and is invalid if Mr. Woodville's curves apply strictly to the Class A condition.

The application of negative feedback produces a different state of affairs, and a direct comparison is available in the published distortion-percentage/wattage output curves of such amplifiers as the Williamson and the Acoustical Quad II, the latter amplifier, of course, having the load distributed between anodes and cathodes.

The subject is discussed at some length in the article "Amplifiers and Superlatives," by D. T. N. Williamson and P. J. Walker (*Wireless World*, Sept., 1952). The figures given in that article, of relative distortion just below onset of grid current, are 1.0 and 1.5 for triode-connected tetrodes and tetrodes with load distributed between anode and screen, respectively, which would appear to bear out my observations on the N709 case.

The term "ultra-linear," which is meaningless, can have no justification, and should be abandoned on this side of the Atlantic, unless "Free Grid" can think of a use for it.

Birmingham. NORMAN F. BUTLER

"Inexpensive 10-watt Amplifier"

I THINK E. F. Good is raising a mare's nest in his letter in your October issue. Whilst the form of coupling shown in the Mullard circuit does not go down to d.c., it is fairly satisfactory for 10 c/s or so, which is quite a good limit for an inexpensive amplifier.

Mr. Good's point concerning the tertiary winding calls for some comment. In point of fact I was quoted six guineas for a Baxandall transformer, which is about the price of the classical Williamson output transformer. Hence there seems no saving in money by using the tertiary winding. I would not be dogmatic about it, but I think the high price may be due to patent royalties accruing to the holder of the patent cited in Baxandall's references.

The other aspect in Mr. Good's letter is valid: viz., instability with capacity loads. I knew one Williamson enthusiast build a Baxandall amplifier because a cross-over network made his Williamson unstable.

London, N.W.11. F. B. WHITE

A.C./D.C. Dangers

"DIALLIST" (November issue, p. 579), would have us believe that a chassis of the a.c./d.c. type cannot be of any danger when operating on d.c. mains. Nothing could be further from the truth and I sincerely hope none of your readers discover this the unpleasant way.

Your contributor must surely be aware that most public d.c. supplies are distributed by the three-wire system; consisting of an "inner" (neutral) at earth potential and two "outers" (lives) at potentials equal to normal mains voltage, above and *below* earth respectively. The voltage across the two "outers" is twice the normal domestic supply. The service to domestic premises consists of connections to the "inner" and *one* of the outers." The point is, of course, that it is a fifty-fifty chance that any particular house is using the "negative" outer. When this is the case the positive side of all wiring therein will be virtually at earth potential and the negative side at mains voltage *below* earth and accordingly alive. Under these conditions, in order to operate at all, an a.c./d.c. type sound or television set *must* have its chassis connected to this *live* side of the mains and all the usual hazards will be present.

Like "Diallist," I do not like the growth of the a.c./d.c. technique in the receivers of to-day. I do not, however, think the solution lies in making the dealer responsible for the correct fitting of a 3-pin plug; for the simple reason there would be no guarantee, that immediately the dealer left his customer's house, the plug would not get changed, the flex extended, or some other modification carried out to meet the exigencies of the household concerned. In any case, the conditions regarding d.c. mains, discussed above, might exist and he would, in fact, be faced with an impossible task because the set just could not work at all when connected the safe ("correct") way.

Most manufacturers ensure that a.c./d.c. sets bearing their name are adequately insulated and users need have no fear of danger, provided the back of the set and/or control knobs, etc., are not removed without first completely disconnecting from the mains. My own personal view is that *all* mains radio and TV receivers of the domestic type should be fitted with small "gate-switches," similar to those usually found on commercial and service transmitters (also on burglar alarms). This would ensure that the back of the set be firmly and properly affixed when in use. Also, any screws, control spindles, etc., projecting from the cabinet should be completely insulated from the main chassis.

It is true almost all set makers see that chassis bolts are suitably covered and control-knob grub screws recessed and wax covered when a set leaves the works. But how many dealers see that the same state of affairs exists after a set has been serviced? Very few.

King's Lynn, Norfolk. A. B. GRIEF.

Band III Television Interference

WHILST appreciating that F. R. W. Strafford's article in your October issue is of a tentative nature, I feel he has painted too gloomy a picture of the problems of suppression at Band III frequencies so far as domestic appliances and other small commutator motors are concerned. This is to be regretted at this stage as it may cause unnecessary discouragement to the large number of manufacturers, dealers and members of the general public who are now fitting Band I suppressors to appliances, and they may be tempted to discontinue the good work until Band III problems are resolved.

The dominant note of the article is set by the photograph of electric shaver interference on Band III. Now unless the test was made with true transmission on Band III frequency and reception on a *Band III aerial system* (and the text does not imply this), it can be most misleading. Band III aerial systems are highly directional and interference from sources other than those situated on the line from receiver to transmitter will have less effect at the receiver than in corresponding circumstances on Band I. It seems, therefore, that higher interference noise levels may be tolerable on Band III than on Band I. Incidentally the electric shaver is not typical of small motors generally. It does not figure in the 1953 list of most frequent causes of TV interference compiled by the Post Office, and is not likely to be frequently in use during peak viewing hours. Furthermore, most shavers are of the impulse motor type in which the interference derives from the pulse waveform in the contact circuit of the order of 2 kV peak having a frequency spectrum quite different from that of a normal commutator motor.

Mr. Strafford has described how self-resonant inductors fitted in the mains lead to an appliance are ineffective at Band III frequencies. This is, of course, to be expected since suppressors so used are not working to their maximum efficiency, even on Band I. Such limited measurements as we have made to date show that Band I suppressors efficiently fitted *within* the appliance give in many cases a good measure of suppression at Band III frequencies and are expected to prove adequate at these frequencies when other factors appertaining to Band III (e.g., aerial characteristics) are taken into account. Since many motor manufacturers are already fitting such suppression within the motor the outlook on Band III is reasonably encouraging. For special cases not responding to Band I techniques and available components, development work now in hand will, I believe, provide the answer.

Dubilier Condenser Company. R. DAVIDSON.
London, W.3.

Tape Machines

COULD not some enterprising manufacturer of tape recorders let us have a twin-track machine which automatically reversed itself at the end of each track, preferably taking spools up to 1,000 metres? As so very much has been done to give the disc user long duration surely a much simpler device would prolong the unattended playing time of tapes, and without any sacrifice of quality.

Even with the much improved Continental spools, loading and threading takes time. Again we must hand it to the Continentals for at least making the tape switch off the motor, although a little more thought in locating the metal foils might have left the tape still threaded after fast spooling, instead of over-shooting as at present.

Another bee in my bonnet is against the current craze for more than one tape speed from a single instrument. This increases costs more than would either of the suggestions made in my opening sentence, besides tending to jeopardize performance and reliability, to say nothing of the intricacies imposed on design by the ganged and interlocked switching of at least four different equalizer circuits. The net result of all these complications is simply a compromise between quality and duration.

Since permanent recordings can be made more cheaply on l.p. lacquer discs than on tape (given access to a disc recorder) the overall cost becomes virtually independent of the speed of the tape medium, which is erasable and can be regarded as part of the capital equipment.

Surely what is now wanted is a high-quality twin track recorder of fixed speed (say 7½in/sec) but capable of taking standard 11½-in spools. Although the lid may not be closed whilst playing it should at least be possible to close it afterwards without having to wind off the tape and remove the spools—even the present professional equipment does not always provide for this.

It is admitted that a delay of about 2 seconds would be needed every 90 minutes when reversing the tape, but this would present little difficulty to competent designers and still less to the user whose only alternative is a delay of eight seconds after every single side. Moreover, the best that can now be achieved in really long disc programmes is the indefinite repeat of the last side only, whereas a self-reversing tape machine would repeat the entire programme *ad lib*.

The prime factors of the tape medium would seem to be erasability and unlimited continuity, yet far from increasing spool diameters and tape speeds the manufacturers are in many cases reducing them as if portability were the prime consideration. I am surprised that the other (and comparatively inexpensive) desiderata have not been embodied in at least some current designs, and can only express my willingness to be customer number one when they are.

Grimsby, Lincs. HARRY CRAMPIN.

Dry Battery Life

"DIALLIST" is incorrect in implying (your November issue) that *all* mains/battery broadcast receivers are fitted with combined h.t.-l.t. batteries. The "Ultra Twin," uses separate batteries and has done so for some years.

Ultra Electric, Ltd. C. A. QUARRINGTON.
London, W.3.

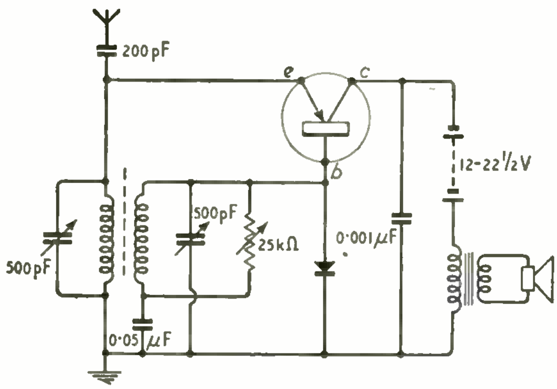
Очен Жан

I AM in complete agreement with Dr. Hague on the question of standardizing wherever possible: I am flattered by his great interest. But we are not all librarians and linguists, and we must not alarm the more timid readers. The spellings Tchebysheff and Chebyshev are both used in the literature: there are, I think, one or two more. I have used the spelling which is used by Guillemin, van der Pol and Darlington, because I think the reader is likely to turn to these writers before he turns to Green, or hunts through *Science Abstracts*. (And *Science Abstracts* does not correct the spelling of authors who write Tchebycheff). I remember that the B.B.C. attempted to make us spell Tchaikovsky as Chaikovski, but gave up in despair. For the advanced work, the convenience of Green's A, B(utterworth) and C(hebyshev) responses are great, though, as Dr. Hague's last paragraph points out, irrelevant. For us, though, Tony Weller had the answer: "Spell it with a Wee, me lord, spell it with a Wee."

THOMAS RODDAM.

Transistor Circuit

AS junction transistors of various types are now generally available, many of your readers will no doubt be trying them in receiver circuits, still an open field of modest experiment for those who have the patience and means to indulge their curiosity. The price of a good transistor is not yet as convenient as its insignificant size; a superheterodyne circuit will be beyond most of us; but a great diversity of circuits can be tried with a single transistor and germanium diode in different combinations. The circuit herewith, on a fair outside aerial, gives good loudspeaker performance at all times for our local stations (West and Welsh Regionals) and brings in Third Pro-



gramme and Continentals in adequate volume after dark. It is highly selective, especially if the transistor can be brought into oscillation, which is not the case with all types or with all samples of the same designation. The one used here is a Standard Telephones & Cables LS/828, which gives 2-3 mA with 12-22½ volts on a local signal, cut off to 100 µA on no signal—a convenient feature for standby or relay operation as the miniature hearing-aid battery will survive being left on for long waiting periods. We have not tested an LS/828 to destruction but the collector-emitter voltage can be as high as 24 V and, in that condition, with a 45-V battery, over 100 mW can be developed in the output transformer. The coils used are basket-wound on a miniature former with adjustable ferrite core.

Those interested in transistor circuitry in general will note that the signal drive is on the emitter and the rectified signal is derived from the coil in the base. The 25-K variable resistance is used as a volume control to limit oscillation.

A note of warning. A good transistor will oscillate vigorously on the medium waveband and can cause widespread interference. In the words of P. P. Eckersley, Please don't do it!

Bristol, 9.

W. GREY WALTER.
KARL WALTER.

"*Neon Timers*"

THE letter from J. R. Barnard in the November issue of *Wireless World* describes a simplified version of one of the timers in my article in the October number and this illustrates a principle of design. Almost any piece of semi-automatic equipment can be simplified behind the panel provided that extra manual controls are added to the front. In the case of the simplified timer, there is an additional operation; it has to be reset manually. In the original, relay "B" is, in effect, an automatic reset. This is a small point, but in practice it will be found that the elimination of this added manual operation is well worth while.

Actually, the simplified circuit is ideally suited for another purpose in the dark-room, namely, the timing of the exposure of a contact printer. Switch S2 would then become a change-over micro-switch actuated by the closing of the pad which presses the printing paper to the negative. This would switch on the lamp and the pad would be kept closed until it was seen through the small observation port that the timer had switched it off. Releasing the pad would then reset the timer. In this case the values of R1, C1 would have to be modified as the exposure range would be from about one-tenth of a second to five seconds.

For reasonably accurate timing from one exposure to another a voltage regulator tube must be considered necessary and this becomes increasingly important should the timer be moved to a district having a different value of mains voltage and also if it is to be used in an area where there is the possibility of considerable mains variations.

One point relating to both timers which was not mentioned in the original article is that they are suitable for both a.c. and d.c. operation.

Totland, I.o.W. B. T. GILLING.

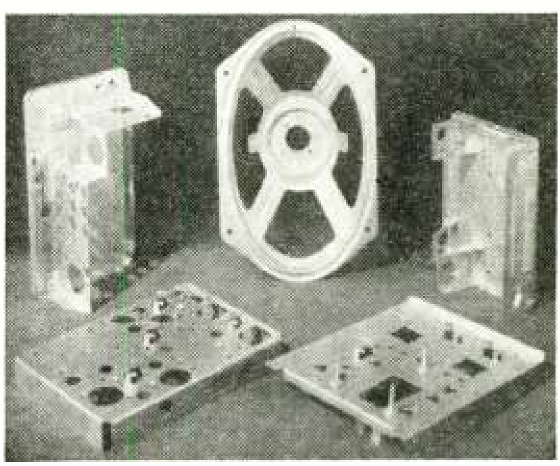
TIN-ZINC PLATING

IN the course of a year a large quantity of steel parts are used in the radio industry, and, while several different protective finishes are in current use, none appears to be entirely satisfactory.

A new process, demonstrated recently by the Tin Research Institute, employs a tin-zinc alloy and it is said to possess all the intrinsic advantages of these two metals but has none of their disadvantages. Zinc is a good rust preventer, but notoriously difficult to solder and prone to corrode, so a thick coating is generally required; tin is good in most respects and takes solder well but is costly. The new coating solders very easily.

It is not restricted to use on ferrous metals, although this is probably its most profitable field, and it has been applied advantageously to brass and other high-copper-content alloys. It cannot, however, be deposited direct on aluminium or, curiously enough, on zinc-based alloys. Its silver-like appearance is extremely pleasing and it will take a polish if required.

Full technical details of the process, together with advice on installation and operation of plant, are obtainable from the Tin Research Institute, Fraser Road, Greenford, Middlesex.



Examples of steel parts with the new tin-zinc finish

Extended-Range

By L. F. SINFIELD

THE usual coverage of 20-20,000 c/s for an audio oscillator is now regarded as sufficient for the exhaustive testing of high-fidelity amplifiers and for general experimental purposes. Also with the increasing use of magnetic recording it is desirable that the range should be sufficiently high to cover the bias and erase frequencies in general use for checking bias filters, etc. The low-frequency end can also be usefully extended, for the purpose of testing industrial electronic equipment. If possible the unit should be small and easily portable.

The optimum coverage of the instrument to be described was set at 6-70,000 c/s, as this would adequately fulfil the above requirements.

The obvious choice was for an oscillator of the Wien bridge type, using a relatively low impedance bridge network. The variable capacitance method would give precise setting accuracy, but against this it is prone to hum pick-up, and at low frequencies the resistors for the required time constant would become far too high. Also the necessary four-gang condenser is too large for compact construction. Ganged potentiometers were therefore used, with fixed capacitors for range switching. At the high frequencies, in order to obtain accurate calibration, it is necessary to have the capacity large enough to swamp any strays so that on the highest range the range condensers are 0.001 μF with the lower ranges covered by 0.01, 0.1, and 1.0 μF. This gives a required value for the ganged variable resistances of 25 kΩ (with a fixed series limit resistor of 2.2 kΩ) which is a very convenient value in that it enables a preferred value to be used and also makes it possible to obtain smaller sizes of this value in semi-log form. Thus it is possible to build a cheaper, smaller unit; but of slightly less setting accuracy than one using the larger component sizes.

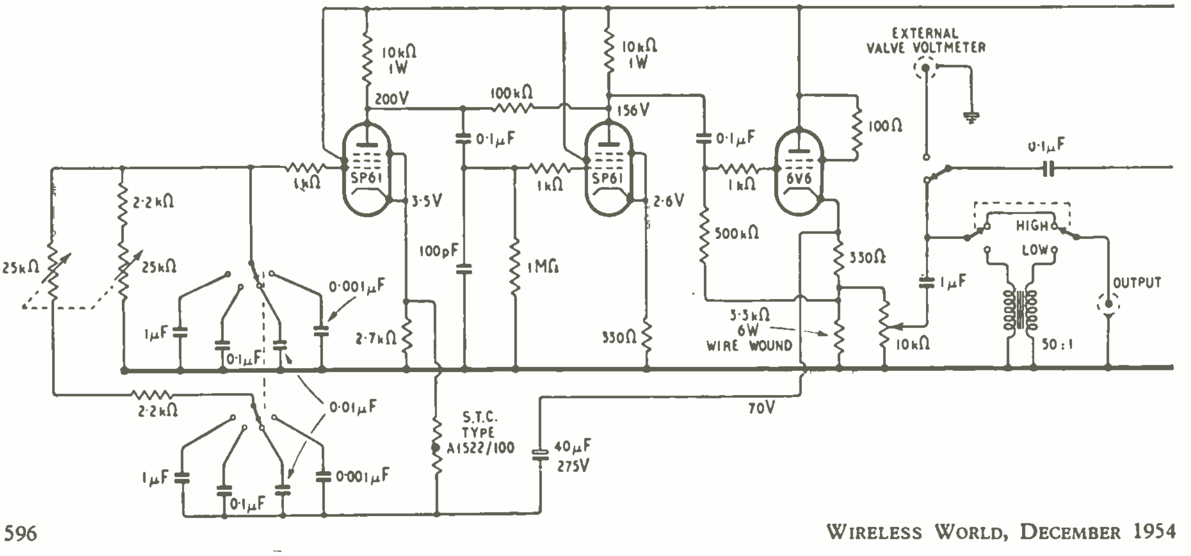
The use of a low-impedance network means that in this case the overall impedance of the network, at the lowest setting is only around 3,000 ohms. To ensure that the amplifier gain remains constant over the frequency range it is necessary that the output impedance of the amplifier be made very small, so that the varying shunt effect of the network on the output load is reduced. This is achieved by inserting a cathode follower. The almost constant gain over the entire range means also that only a small degree of control is necessary to maintain constant amplitude and good waveform, so that the inclusion of the thermistor makes the unit extremely good on these points.

The amplifier itself is quite simple and although SP61s were used there is no reason why other high-slope pentodes such as EF50s or EF91s should not be used. Low-value anode loads are used to extend the top response, and there is no decoupling whatsoever. A small 100-pF capacitor shunts the grid of the second valve, and this was used to suppress parasitics which at first occurred. This only happened on an experimental set-up, but as the capacitor does not seem to have any detrimental effect it was left in.

A 6V6 output valve is used for the cathode follower, and again this could be changed for other high-slope output valves, with any necessary change in the self-bias resistor. Although the SP61 type was tried in this position it was not possible to obtain sufficient voltage swing in a small load. In this respect it must be remembered that initially, on switching on, it is necessary that the swing should exceed the peak of the thermistor curve in order to operate it at the correct point of its characteristic. Unless the thermistor is taken past this peak it will not assume a negative coefficient.

Alternative Outputs

As the unit was intended for feeding into comparatively high impedances the output is simply taken from a potential divider across the cathode load with a step-down transformer for matching into inputs



L.F. Sine Wave Oscillator

A Compact Source for Audio, Sub- and Super-Sonic Testing

such as those intended for moving coil or ribbon microphones. This arrangement is satisfactory for general use, but if required for working into loads which would appreciably shunt the output, and so upset the oscillator, it would be better either to take the output via an attenuator and sacrifice output level for isolation, or to feed the output via a further cathode follower. The reason for using a potentiometer shunted by a resistor is simply that it allows a standard potentiometer value, and also the resistor carries most of the current.

With several miniature Mumetal microphone transformers that were tried as output transformer a lowest frequency of between 15 and 40 c/s was obtained (depending on the particular primary inductance) before the waveform distortion became noticeable. The high frequencies were maintained up to maximum frequency as the low source impedance heavily damps the transformer.

To extend the low-frequency limit at low impedance it would be necessary to use a transformer of larger dimensions with the required high primary inductance, or an alternative more complex output coupling arrangement. It is doubtful, however, if the input transformers into which the unit would feed under these conditions would have such an extended low-frequency response, so that a miniature type was fitted with a 20-c/s lower limit and it was considered that this would be satisfactory for general use. If then the extended low response was required at any time it is always possible to feed out at high impedance and match with an external transformer of better quality.

The feedback capacitor must obviously be of high value to feed back into such a low impedance bridge so that an electrolytic type is used. This is a high-voltage type, *not* bias type, so that leakage current is negligible, as any leakage would upset the correct working of the thermistor. The d.c. voltage at the 6V6 cathode is considerably higher than that of the input valve, so that the condenser is always correctly polarized. In practice the component chosen was a 16-24 μF, 275-V d.c. working, with both sections in parallel. The container must, of course, be isolated from chassis.

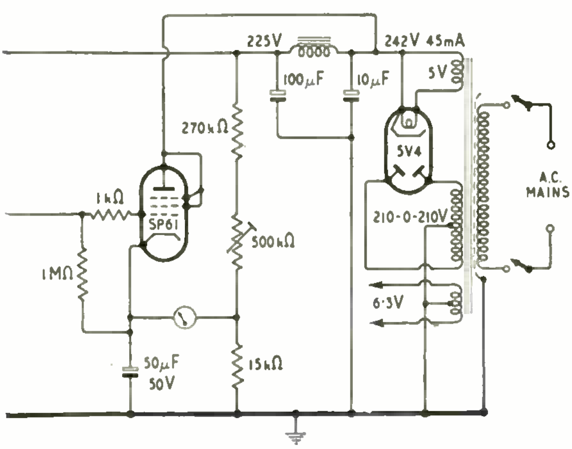


Fig. 1. Circuit diagram with values for an overall range of 6 c/s to 70 kc/s. The two-gang resistors recommended are Reliance TW or PIW, semi-log wirewound.

A valve voltmeter is incorporated to monitor the output level and is switched so that it can also measure external signals in the same range. This consisted of a small ex-Government meter scaled 0-20 V with a full-scale deflection of slightly less than 2 mA. It is not recommended that this current be exceeded as the current pulses of the valve at low frequencies, below about 12 c/s, cause motor-boating via the h.t. line if greatly exceeded. This f.s.d. current is about the maximum possible and it is advisable to use a more sensitive meter. There are ex-Government meters of 0-15 V scale 0-500 μA which would be ideal. The cathode resistor controls calibration and so would have to be changed to suit other meters. Also the bleeder chain to h.t. would have to be increased proportionately to obtain the correct zero setting of the meter. The anode of the voltmeter valve is returned to the reservoir to obtain better isolation from the oscillator h.t. supply as smoothing is relatively unimportant at this stage. Separate decoupling could be provided, but it introduces extra components.

Extra H.T. Smoothing

Power supply is quite conventional except that the h.t. smoothing is rather large in order to cope with the by-pass of the very low frequencies. However, although the condenser is a 10 + 100-μF this is quite standard and is both small and cheap. The mains transformer was of 210-0-210 V but any type with an output of between 200-0-200 and 250-0-250 would be suitable.

The whole unit is housed in a cabinet 13in × 6in × 6in, but this is by no means cramped and it would be possible to reduce the size considerably, if desired.

A maximum output of 15 V, r.m.s. is obtained and both the amplitude variation and the harmonic distortion remain negligible over the whole of the frequency range.

To calibrate, selected 1%, 0.01-μF condensers are fitted in the appropriate position and the 600-7000 c/s range marked on the scale, but actually calibrated 6-70 c/s (1/100 of the actual frequency). This is because 1%, 0.01-μF condensers are relatively easy to obtain and the range 600-7000 c/s probably the easiest to calibrate. By actually marking the scale 6-70 c/s it enables the range control to be calibrated as × 1, × 10, × 100, and × 1000. The two lower ranges and the high range are then matched by selecting condensers of slightly low capacity and padding with small parallel condensers to make the scale accurate on each range; only one check point is needed on each range.

PAN-CLIMATIC TESTING

Reassessment of Requirements for Service Equipment

By G. W. A. DUMMER,* M.B.E., M.I.E.E. S. C. SCHULER,* Assoc.I.E.E., and J. E. GREEN*

EVEN in the short period since World War II, conditions under which Service airborne electronic equipment is operated have changed considerably. The increased speeds of modern aircraft have resulted in more frictional heat being generated on the aircraft skin, which may raise the internal ambient temperature considerably. Aircraft flying at heights of the order of 40,000 feet cannot use normal air-cooling methods to cool the electronic equipment, as the density of the air is so low that normal cooling fan systems have low efficiency. The development of guided weapons has also revealed new types of Service hazards for which testing is necessary.

During the compilation of testing schedules covering all Service equipments, climatic conditions and hazards likely to be encountered were the subject of considerable study, which was the result of joint effort by all the major Service establishments. The findings are presented in the Joint-Service Test Specification K.114 issued by the Radio Components Standardization Committee (Ministry of Supply).

The summaries contained in Tables I and II give information from the K 114 Specification on the climatic extremes and environments experienced in different parts of the world, and also conditions of mechanical shock, vibration and handling. These conditions represent Service hazards and the tests cover combinations of these conditions depending on the intended use of the equipment—shipborne, airborne, ground equipment, etc.

It is mandatory that all equipment for the services should be tested by one of the Service research and development establishments, and the K.114 series of test schedules have been designed to cover nine types of conditions which are summarized in Table III.

The value of initial testing before design approval is given to a Service equipment has been proved beyond doubt. During the past eight or nine years in which equipments have been tested to these stringent schedules, many faults have been exposed which would otherwise have occurred in service. "Pre-testing" results in improved reliability of equipments by exposing weaknesses and faults when there is still time to make modifications.

Testing equipment designed and installed at the various Service establishments is considerable, and ranges from simple dry heat ovens to large stratosphere chambers capable of testing complete equipments under all airborne conditions (low pressure, low temperature, etc.). A stratosphere chamber which is being installed at the Radar Research Establishment will have a working volume of 550 cu ft, and will cover the range +80°C to −75°C and altitudes up to 70,000 ft. At the same establishment a large precision vibration testing machine (up to 120 c/s) is in use, capable of dealing with equipments up to 500 lb in weight. The machine is mounted on a 55-ton block of concrete, which in turn is freely suspended on springs. This is done to preserve the sinusoidal vibration waveform.

Many attempts have been made to correlate the artificial test conditions with those experienced in various parts of the world, and recently an investigation was made into the drop in insulation resistance of components of various types exposed at the Tropical Testing Establishment in West Africa and in the humidity chambers at T.R.E. (now R.R.E.). Whilst it was difficult to assess the ratio in time between the two sets of conditions, it was obvious that the humidity chambers produced worse deterioration of components than actual conditions. This is illustrated by the graph (Fig. 1) showing insulation

Table I

SERVICE CONDITIONS

CLIMATIC EXTREMES	
DESERT	Dry heat, intense sunlight, sand, dust, destructive insects. High day temperature { Air +60° C. / Ground exposed +75° C. Relative humidity 5% Low night temperature −10° C. Large daily variation in temperature, average 40° C.
TROPICAL	Damp heat, high relative humidity, heavy seasonal rainfall, mould growth, destructive insects. + 40° C. during day. + 25° C. during night. Exposed surfaces +70° C. Humidity can approach saturation.
ARCTIC	Low temperature, driving snow, icedust. Exposed Arctic −70° C. extreme. −40° C. common. Sub-arctic −25° C. common.
HIGH ALTITUDE	Low temperature, low pressure, condensation due to rapid changes in temperature. 30,000ft. 225 mm Hg −60° C. minimum. 60,000ft. 55 mm Hg −90° C. minimum. Allowances: 10° C. for fuselage protection. Above 30,000ft. 15° C. for adiabatic heating.
SEA	Sea spray, immersion. Air temperature extreme +52° C., −40° C in harbour. +38° C., −32° C. at sea. Sea temperature extreme +29° C.

* Radar Research Establishment. Ministry of Supply.

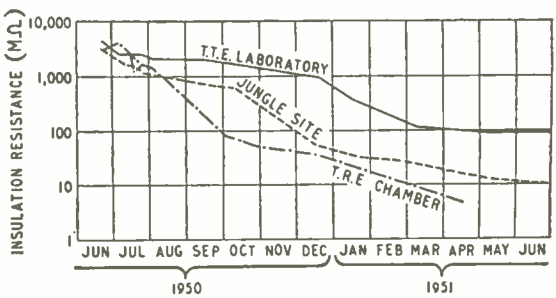


Fig. 1. Comparison of insulation resistance tests of sealed potentiometers under tropical and laboratory test conditions.

Table II

SERVICE CONDITIONS

MECHANICAL SHOCK, VIBRATION AND HANDLING

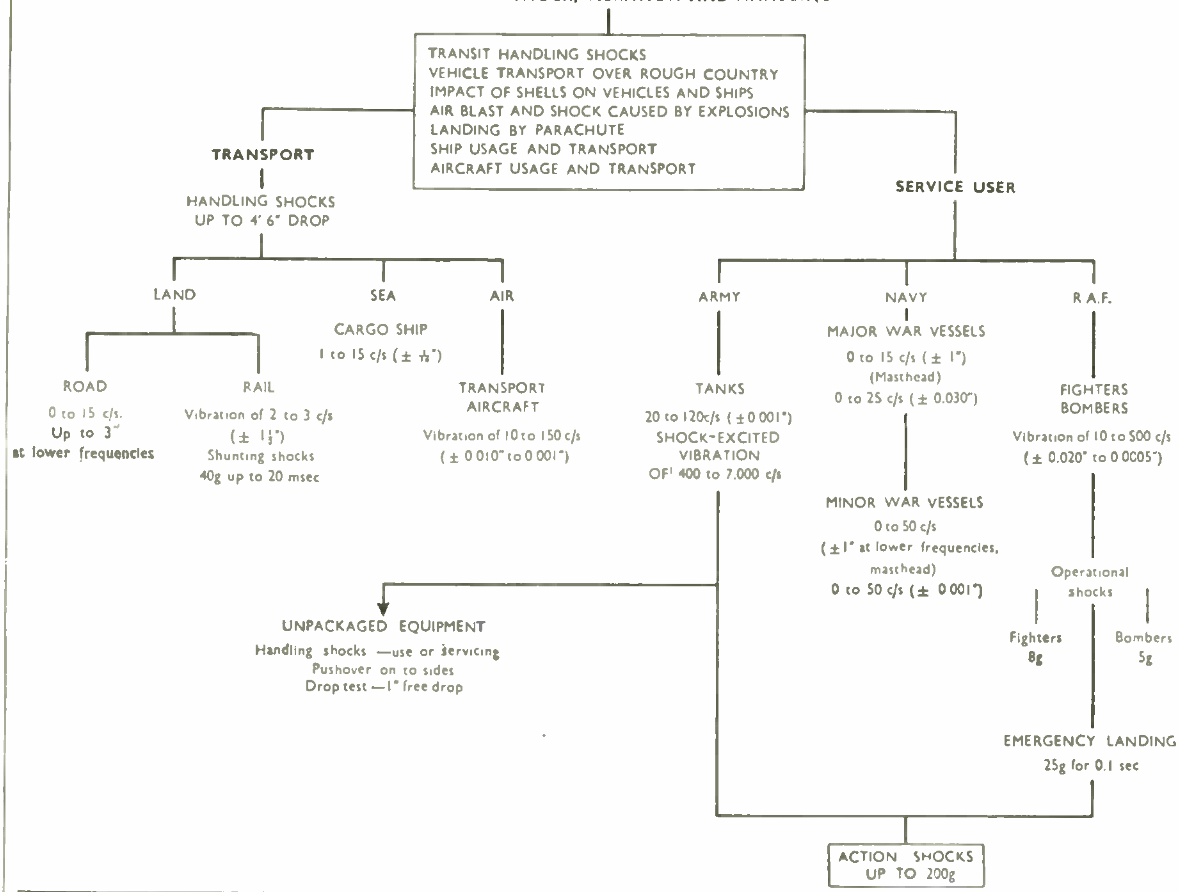
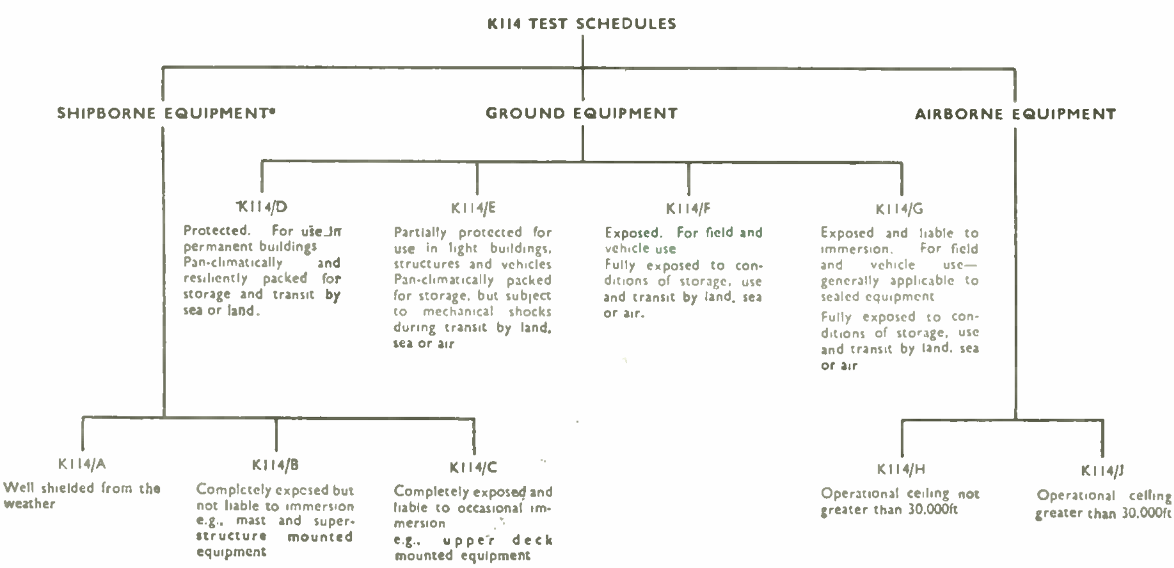


Table III

DESIGN ACCEPTANCE TESTS FOR SERVICE TELECOMMUNICATION EQUIPMENTS



*Includes equipment suitable for transport by air

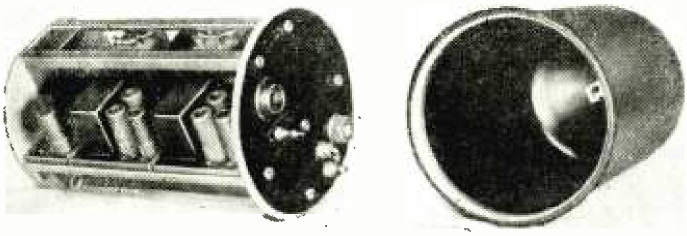


Fig. 2. Airborne electronic equipment totally enclosed in a sealed container.

resistance measurements on a sealed type of potentiometer at T.R.E., at T.T.E. under laboratory conditions (warehouse storage) and at T.T.E. exposed to jungle conditions.

The faults which occur under K.114 tests cover a wide range, and in a short article there is only space to list some of the common faults which are found in electronic equipment submitted to the tests. The reliability of equipment could be greatly increased if it were designed to avoid:—

1. Weak supports for component group boards and inadequate stiffness in structures, which result in resonances within the vibration test range.

2. Mounting of large condensers and resistors by connecting wires without further support.

3. Inadequate protection of cables and leads passing through metal partitions.

4. Use of small bolts in mounting heavy transformers, components, block condensers, etc.

5. Excessive heating of components mounted too close to vitreous-enamelled wirewound resistors.

6. Operation of components at levels in excess of the R.C.S. ratings.

7. Inadequate locking on screws, bolts and nuts.

8. Seizure of rotating mechanical devices at low temperature due to differential contraction of materials or stiffening of lubricants.

9. Poor finishes of metal parts. On unsealed equipments, most cadmium-plated nuts and bolts corrode under the damp heat cycling, unless very heavily plated, and the greater use of stainless steel nuts and bolts is encouraged.

10. Flashover at high altitudes in unsealed equipments due to insufficient spacing of high-voltage terminations.

11. Poor accessibility. Extra time and effort are required for servicing, and often part dismantling is necessary to gain access to some components. This aspect of Service electronic equipment still leaves much to be desired.

Steps which are being taken to reduce component faults fall under the broad headings of (1) improvement in the components themselves, (2) protection of components by sealing.

Sealing may be either by rubber gasket or by the recently developed plastic resin potting techniques. An airborne sealed unit is illustrated in Fig. 2, and a typical experimental potted sub-unit assembly is shown in Fig. 3. It has withstood the K.114J airborne test schedule without developing a fault.

A marked improvement in components has been achieved by better sealing methods, and fully sealed transformers, chokes, capacitors, relays and potentiometers are now available. If the equipment itself is sealed, it is not always necessary to use these fully sealed components, although, in the interests of reliability, many Service designers employ a combination of both methods.

It can be seen from this review that the value of extensive testing in the early stages has been established, and it should be emphasized that the cost of "pre-testing" equipments on the ground is far less than that of flying them in aircraft or in guided missiles. Complete surveillance is possible and the development of faults can be seen under far less arduous conditions than those experienced in the field.

A great deal of experience is being built up at the testing establishments on all aspects of electronic equipment and component design, and it is important to remember that this accumulated experience is available to the designers and manufacturers of new Service equipments. Pan-climatic testing has undoubtedly led to marked improvements in the reliability of Service electronic equipments, and will continue to do so in the future.

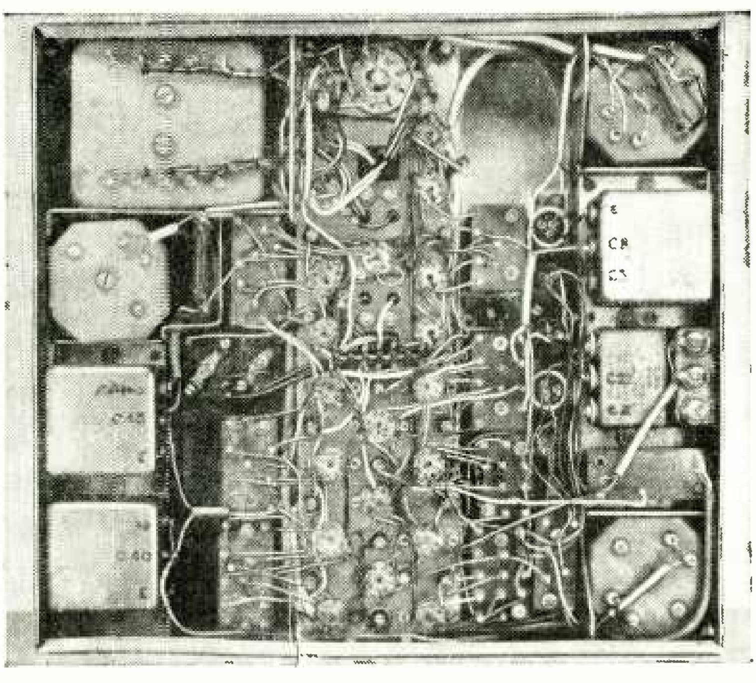
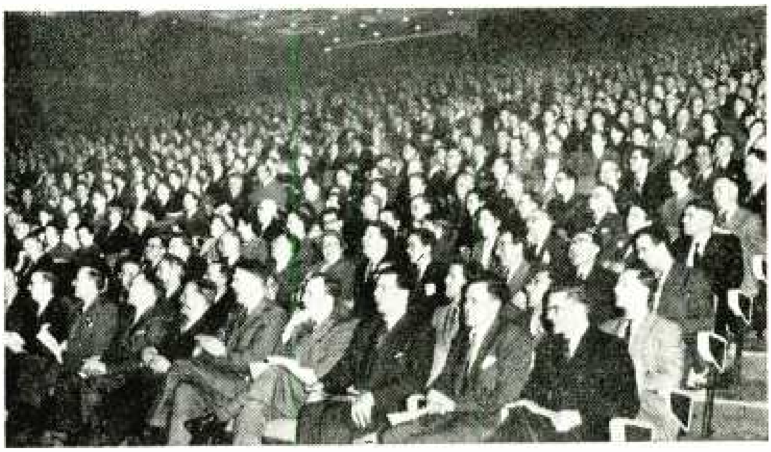


Fig. 3. Underside of chassis employing the technique of sealed sub-assemblies.

FESTIVAL OF SOUND

A Bold Experiment Succeeds



The trenchant commentary by G. A. Briggs was as much enjoyed by the audience of 3,000 as were the demonstrations of good sound reproduction and the "live" performances by well-known musicians.

WHEN G. A. Briggs announced his intention of taking the Royal Festival Hall in London for a lecture-demonstration on sound reproduction there was much shaking of heads. Could he hope to fill a hall with a seating capacity of 3,000? Would the vast size and acoustic clarity of the Hall prove too searching a test for equipment designed primarily to give an illusion of reality in domestic surroundings?

The first question was unambiguously answered when it was announced that all tickets—including those for standing room—had been sold within four days. Any misgivings on the second were quickly dispelled on the night, when, after listening critically and perhaps a little anxiously to the opening items, we were able to sit back and enjoy ourselves—as Mr. Briggs intended that we should.

For many of the items a single Wharfedale "3-speaker" system was used; two of these units, in parallel, were used for organ and orchestral pieces demanding a greater power output. A third unit, reinforced with extra high-frequency units, was reserved for demonstrations of effects which were primarily dependent on good h.f. response; in a hall of this size atmospheric absorption is a significant factor—at least for those in the back seats.

Pilot lamps showed the audience which loudspeaker(s) were in operation, and a visual power level indicator enabled all to see what was going in at any given moment. This instrument, devised by E. M. Price, M.Sc., consisted of a row of neon lamps arranged to strike in ascending order as the power increased from 3 to 60 watts. Viewing this meter from a seat in the stalls, one gained the impression that levels in excess of 15 watts were extremely rare. The whole of one organ piece (Allegro-Voluntary in D, by John Stanley) was accomplished within the 3-watt level. On the other hand, there were occasions, usually when one least expected it, when the power flicked up to the 60-watt level. To take care of the peaks, four of the Acoustical Manufacturing Company's "Quad II" amplifiers were connected in parallel.

Records were played on a Garrard Model 301 transcription turntable in which the speed control enabled exact equality of pitch to be found with the "live" performances with which comparisons were made. The pickup was a Ferranti ribbon type.

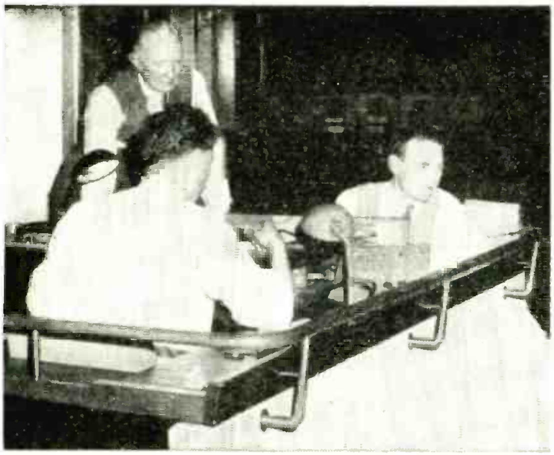
Tape records were made and reproduced by an E.M.I. Type BTR/2 professional machine.

All seats and standing room were filled long before 8 p.m.; thus, even before the proceedings were opened by the genial chairman, J. R. Tobin, B. Mus., we were already in debt to Mr. Briggs for showing us the strength of the public interest in good sound reproduction. With a disarming pretence of being non-technical, and with many bold sallies at the pundits Mr. Briggs quickly cut through the undergrowth of "hi fi" to get at the roots of good sound reproduction where art is more important than science; in particular the importance of microphone and studio technique to create the exact degree of "atmosphere," "ambience"—call it what you will—when replayed in given surroundings. It followed that his choice of orchestral recordings for demonstration in the Festival Hall carried a higher ratio of direct to reverberant sound than would be chosen for playback in a small room.

The acoustic level of reproduction relative to that of the original has a profound influence on balance and quality and must obviously be exact when direct comparisons with the original are made. For some of the items this yardstick was not available, but in all cases one felt that judgment in the choice of level was well informed.

The most courageous of Mr. Briggs' experiments—the immediate comparison of live performances by Stanislav Heller (harpsichord), Ralph Downes (organ) and Denis Matthews (pianoforte) with disc and tape recordings—proved to be the highlights of the evening. The delicacy and precision of the harpsichord playing, with every gradation of tone crystal clear in the recording made by C. E. Watts, were exactly matched in the impeccable playing of Stanislav Heller. The background noises in the Hall, which fell to a level creditable for an audience of three in a country cottage rather than 3,000 in the heart of London, was an even more eloquent comment than the applause which followed.

In the Bach organ Toccata in D we were able to compare an E.M.I. tape recording, made in the Festival Hall by Ralph Downes, with a live repetition of the same piece by the same player. In volume and quality the original and the reproduction were again exactly matched. By listening carefully the slightly



A study in concentration at one of the rehearsals. Facing the camera are G. A. Briggs (left) and P. J. Walker, who was responsible for the operation of the amplifier controls.

longer reverberation time of the recording was perceptible—proof that the Festival Hall really has got a hangover of sorts, if you go looking for it by successive recordings. This effect was absent in the harpsichord recording, which was made in accordance with the principle advocated by Watts of "no ambience" for solo instruments other than that of the space in which they are reproduced.

Unfortunately the piano available for Denis Matthews' playing of the Beethoven D minor sonata was not the one he used for the E.M.I. recording, so comparative analysis was given a holiday while we sat back and enjoyed two similarly realistic and virile examples of the pianist's art.

No live orchestra was available for comparison with the Decca l.p. recording (LXT2872) of the Beethoven 6th Symphony by the Concertgebouw orchestra under Erich Kleiber; but none was needed, for the inherent clarity and definition of all the parts was self-evident. The sight of an empty stage was the only incongruity. The string tone—wiry in some early l.p.s—was as near the real thing as the tone of one violin is to another.

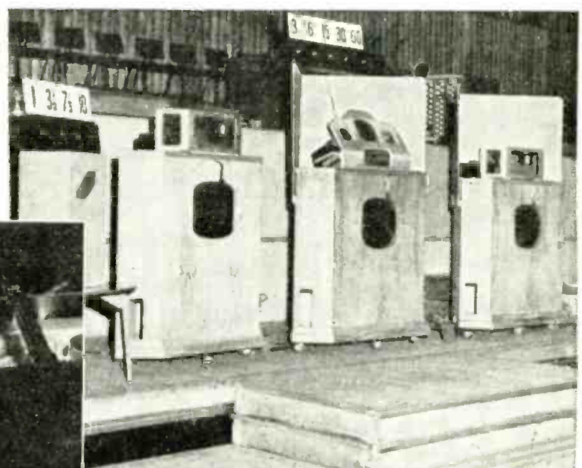
Those whose appetite for the classics is insatiable would have liked longer excerpts from many of the works, but that would have deprived others in the audience of a hearing of some remarkable sound effects, the records of which are themselves classics in their sphere. There was R. Bradford's recording of breaking glass, the B.B.C. recording of awe-inspiring reverberation effects in the Hamilton Mausoleum, the incisive tugboat engine-room noises captured by Mercury Sound Recordings, Ltd. and the W. S. Barrell collection of percussion instruments, with and without high frequencies (E.M.I. JGS74).

Mr. Briggs made some pithy comments on exaggerated claims for frequency response, particularly in the bass, and proved his point by having 32-c/s and 16-c/s notes played on the organ. The 32-c/s pure tone sounded useful, but most people would have needed a barometer to detect the 16-c/s. A 32-c/s reed pipe gave a plausible imitation of a loudspeaker with the coil off-centre.

The last item on the programme was the Vaughan Williams Sea Symphony (Decca LXT2907). A suggestion from Mr. Briggs that Ralph Downes should double the organ part was received in shocked silence by the musical purists, until Mr. Briggs fired a characteristic parting shot: "Well, if he plays as loudly as all the rest put together, we shall be only 3 db up—and what's 3 db among friends?"

On this note ended a most successful evening. The sound reproduction community owe a great debt to Mr. Briggs for his courage, vision and drive in staging this event. He in turn paid tribute to the help received from firms collaborating in the assembly of the equipment, to P. J. Walker for his sure handling of the amplifier controls, and to the recording companies for putting on disc and tape the high standard of quality which he was able to reproduce.

There was still much shaking of heads as the crowds left the Festival Hall, but it was noticeable that whereas six months ago the polarization was horizontal it had now changed to vertical.—F. L. D.



Original and reproduction. Denis Matthews alternates with the loudspeakers in a performance of a Beethoven piano sonata.

Filters Without Fears

4—*Make Your Mathematics Multi-purpose*

By THOMAS RODDAM

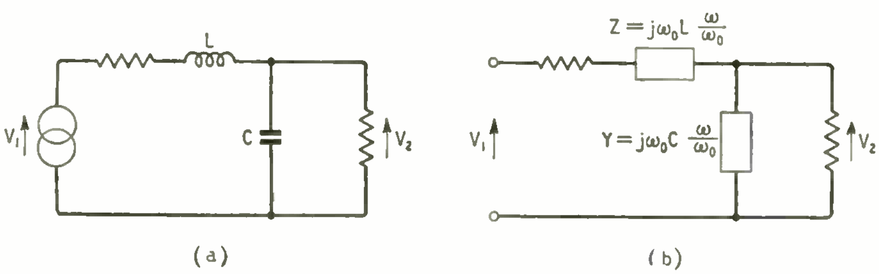
ONE of the main defects of formal education is that everything has to be made up into neat packets. This is history, that is geography and that rather grubby subject is science: if someone invents a steam engine on an island, it isn't anyone's business to point out that what has really happened is a sharp change in the movement of history. In our own special field we begin by making the same mistake: we chop up telecommunications into a number of special plots, and these we then subdivide again. If you look in the textbooks you will see a a chapter on low-pass filters, a chapter on high-pass filters; a chapter on band-pass filters and a quick mention of band-stop filters. This arrangement is both unnecessary and unwise.

The three previous articles have been concerned with the algebraic design of low-pass filters. For the forgetful, the procedure has been to take a simple network made up of series inductance and shunt capacitance elements connected between a resistive generator and a resistive load, to calculate by means of Kirchhoff's laws, or any other method, the ratio of generator voltage to load voltage, and then to do some simple algebra. We find that $V_{in}/V_{out}=A+jB$, we convert to $|V_{in}/V_{out}|^2=A^2+B^2$ and for the networks we have considered $|V_{in}/V_{out}|=a+b\omega^2+c\omega^4$. This is the frequency response of the network, and we have then considered two special forms that this polynomial can take. The result is to give us a number of equations which can be solved to provide, in the end, the values of inductance and capacitance needed for a specified frequency response. The more complicated the response (for example a Tchebycheff response with ripples instead of a smooth Butterworth response) the more complicated the equations.

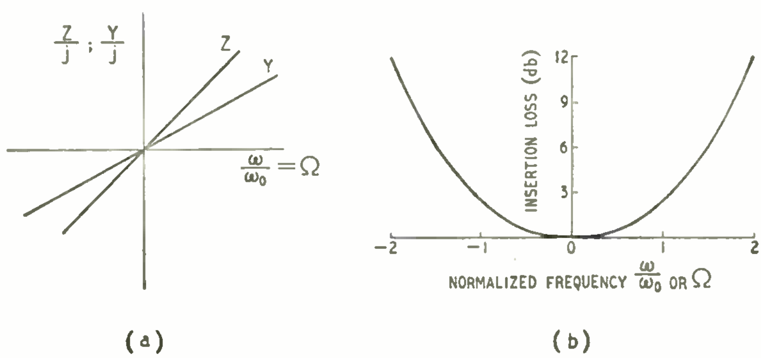
We could now start off again, and repeat the whole process for high-pass and band-pass filters. This method is possible, it is tedious and it is completely unnecessary.

Let us look at a second-order low-pass filter, shown in Fig. 1(a). We can draw this in a rather more general way by using the form shown in Fig. 1(b), in which the series arm is now a box mounted with its impedance, $Z=j\omega_0L.\ \omega/\omega_0$, and the shunt arm is a box marked with its admittance, $Y=j\omega_0C.\omega/\omega_0$. There are two points to notice here. The first is the choice of impedance for the series arm and admittance for the shunt arm: this is to enable us to draw graphs of these functions easily. It is a general rule that if you can choose your relationships to make your graphs straight lines you should. The second point is that instead of writing $j\omega L$, I have written $j\omega_0L.\omega/\omega_0$: this is the usual normalizing process, the process of making one graph do the work of many. All the responses we have seen in the previous articles have been normalized responses.

Fig. 2(a) shows the impedance and admittance functions, $j\omega_0L.\ \omega/\omega_0$ and $j\omega_0C.\omega/\omega_0$ plotted as functions of ω/ω_0. If you don't ask what is meant by a negative frequency there is no reason why the two straight lines in the top right-hand quadrant should not be projected back through the origin into the bottom left-hand quadrant. Similarly we can draw Fig. 2(b), the insertion loss characteristic, but this time on a linear scale including negative frequencies. I've

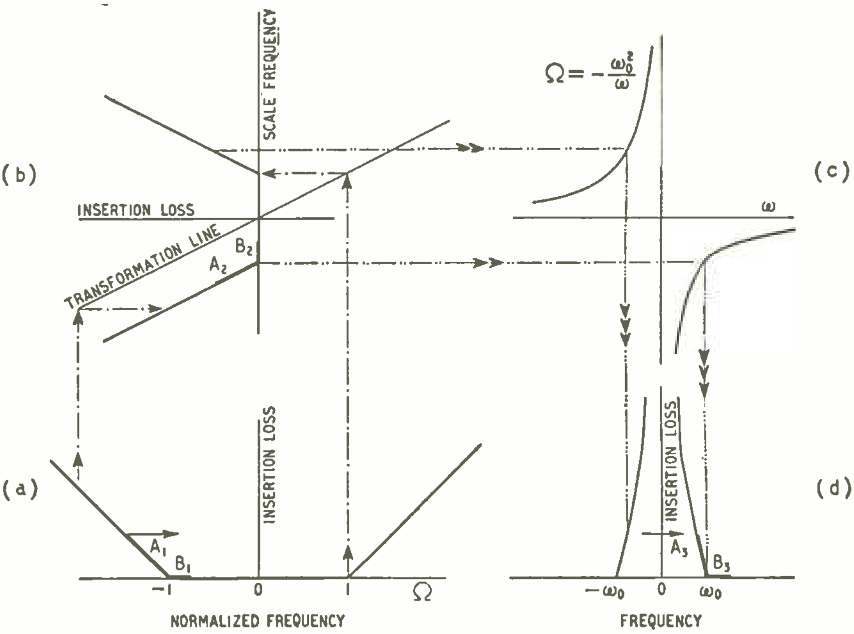


Above: Fig 1. The second-order low-pass filter (a) can be drawn in a more formal way by inserting impedance and admittance "boxes" as in (b).

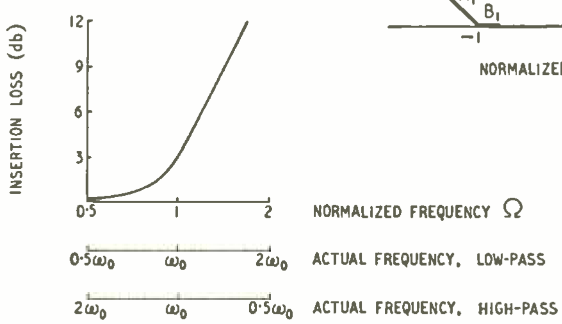


Right: Fig. 2. The impedance and admittance characteristics of (a) lead to the insertion loss characteristic (b). Note that a linear frequency scale is used here.

Fig. 3. The transformation of low-pass to high-pass takes us from A_1 (a), up to the transformation line and then along to A_2 (b). Then we go across to the transformation curve (c), and down to (d). The transformation is of frequency only: the insertion loss just goes straight across.



Below: Fig. 4. For the high-pass case, we need only reverse the scales in a logarithmic frequency plot.



chosen the Butterworth shape because it is easier to draw, and since we have

$$\text{Insertion loss} = 10 \log \left[1 + \left(\frac{\omega}{\omega_o}\right)^4\right]$$

the insertion loss at any negative frequency $-\omega$ is exactly the same as at the corresponding positive frequency ω, and the response is symmetrical about the insertion loss axis. Similarly symmetrical Tchebycheff responses were given in Fig. 2 on p. 446, September, 1954 issue.

We got from the circuits of Fig. 1(b) to the insertion loss characteristics of Fig. 2(b) by a series of mathematical manœuvres. There is a very difficult mathematical step, so difficult that most of us take it on trust and never really question it. This is the abstract truth of a mathematical equation. We start off quite happily with the idea that 2 apples + 3 apples = 5 apples. This is followed up by a series of confidence tricks which convince us that $2+3=5$, always, and then that $2\times3=6$, and $(x+1)(x-1)=x^2-1$. It's a good job we started off with apples, because with rabbits we should find that $1+1=1+\epsilon^{kt}$ was a reasonable approximation. The only trouble is that very often the apples still lurk in our minds, the equations are held too firmly to physical reality, and then we give ourselves a lot of unnecessary trouble. Let us write in our discussions above $\Omega=\omega/\omega_o$. Then we know that if we have a series impedance $jA\Omega$ and a shunt admittance $jB\Omega$, provided that A and B are properly related to the circuit resistances the insertion loss will be small for $-1<\Omega<1$ and large for $|\Omega|>1$.

Note that Ω does not have to be any particular kind of thing: since it had, at its first appearance, the dimensions (frequency/frequency) there is no dimensional limitation. So long as Z and Y are proportional to Ω we get the filter type insertion loss characteristic.

As a special case, we can take $\Omega=\omega/\omega_o$. Then, as we know, we get a low-pass filter. Suppose, however, we take $\Omega=-\omega_o/\omega$. If we look at some special values of Ω, $\Omega=0$, ±1 and $\pm\infty$ we see that

$\Omega=-\infty$	-1	0	$+1$	$+\infty$
$\omega=\ \ 0$	ω_o	$\pm\infty$	$-\omega_o$	0

The stop band of the insertion loss characteristic, which we can take as roughly the region $|\Omega|>1$ (the transistion region can be forgotten for the moment) now becomes the region $-\omega_o<\omega<\omega_o$.

The pass band, in the positive frequency region, begins at ω_o and extends up to infinity: the filter is a high-pass filter. The elements of this filter are: series arm, $Z=-j\omega_o L.\omega_o/\omega$, and shunt arm, $Y=-j\omega_o C.\omega_o/\omega$. Thus we have $Z=-\dfrac{j\omega_o^2 L}{\omega}=\dfrac{\omega_o^2 L}{j\omega}$ and $Y=-\dfrac{j\omega_o^2 C}{\omega}=\dfrac{\omega_o^2 C}{j\omega}$. The series arm is therefore a capacitance, $1/\omega_o^2 L$, and the shunt arm is an inductance $1/\omega_o^2 C$, where L and C are the values we calculated from our basic low-pass theory. If the low-pass filter has a Tchebycheff type of insertion loss characteristic, so has the high-pass filter: if the low-pass filter has a Butterworth type of insertion loss characteristic, so will high-pass filter.

Notice how useful that negative frequency region has become. We must use $\Omega=-\omega_o/\omega$ to get the signs right in Z and Y, and it is the negative frequency region of the low-pass characteristic which is transformed into the positive region of the high-pass.

For those readers who like a geometrical picture, Fig. 3 has been constructed. The bottom left-hand diagram (a) is a simplified filter characteristic, showing insertion loss as a function of the normalized frequency Ω. First of all we do a scale transformation, to give us the response shown in (b). The scale transformation is just a way of altering the size of the diagram, and twisting it through a right angle. From each point on the characteristic in (a) we move vertically until we hit the transformation line, giving us our position on the "scale frequency" axis. Then we mark off the same insertion loss as we have in (a), to get a diagram of insertion loss against scale frequency. If we make the slope of the transformation line 45° the scale frequency will be the same as the normalized frequency: any other slope opens out or closes up the frequency scale. Now we move across from points in the characteristics in (b) to the main transformation curve (c). This, which is the form used for the low-pass to high-pass transformation, must be of the kind $\Omega=k/\omega$, where k includes ω_o and the slope of the transformation line. You need not worry about that k, because it is really put in just to enable us to write the actual frequency in our final characteristic. We go across from (b) to (c), and then down to (d). To make it easier to draw, I have not traced out the path of a single point, but you can, if you wish, follow the section A_1B_1 to A_2B_2 and then on to A_3B_3. The corner of this section, which is at $\Omega=-1$ in (a), is at $\omega=\omega_o$ in (d) (that's what we use the k for).

I have drawn this transformation process for a rather simple and unreal filter characteristic. Obviously it can be done for any complicated real characteristic, and point by point you can build up the high-pass filter obtained by changing all the inductances to capacitances of size $1/\omega_o{}^2L$ and all the capacitances to inductances of size $1/\omega_o{}^2C$. To do this, of course, you must use a linear scale for Ω.

You may think this is a long way round for the high-pass filter. It is. As you can see from Fig. 4, if we have our response plotted on a logarithmic scale we need only number it from right to left instead of left to right to obtain the corresponding high-pass response. Why, then, all this complication of Fig. 3?

The answer is, of course, that this is a general process of very much wider application. Instead of taking $\Omega=-\omega_o/\omega$, let us now take $\Omega=\frac{\omega_m}{\omega_o}\left(\frac{\omega}{\omega_m}-\frac{\omega_m}{\omega}\right)$

This function is plotted in Fig. 5(c), and the transformation construction is carried through again. To save effort, the transformation line in Fig. 5(b) is at 45°, so that Fig. 5(b) is the same as Fig. 5(a), but sideways. The transformation curve of Fig. 5(c) has two branches, both of which must be used. The result is the response shown in Fig. 5(d), a band-pass characteristic. Notice here that the single pass-band of the low-pass filter from $-\omega_o$ to $+\omega_o$ has been transformed into two pass-bands, one centred on ω_m and one centred on $-\omega_m$. Normally, of course, we only worry about one of these, the one centred on $+\omega_m$ but the existence of the other is of some theoretical importance. It accounts for certain oddities of behaviour, such as the lack of symmetry of the band-pass characteristic.

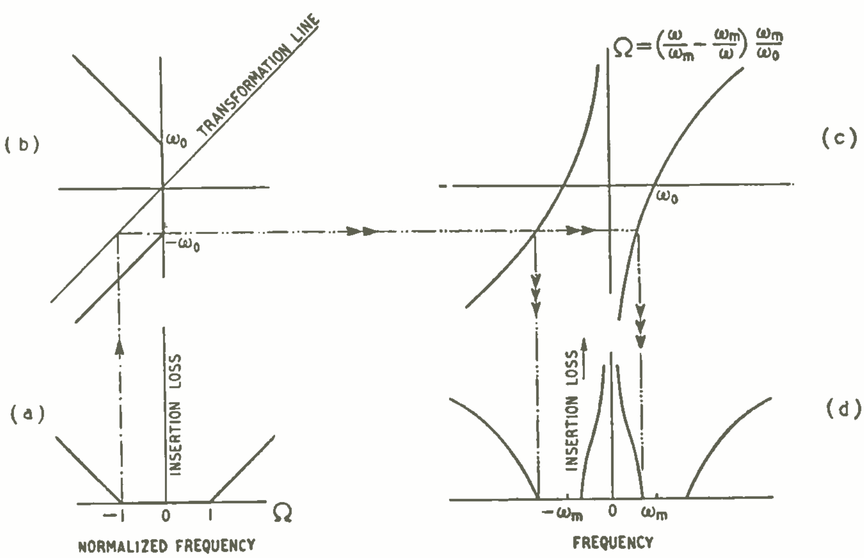


Fig. 5. With the curve shown in (c), the low-pass filter transforms into a band-pass filter.

Geometrical exercises are all very well, but what use are they? Here we have written $\Omega=\frac{\omega_m}{\omega_o}\left(\frac{\omega}{\omega_m}-\frac{\omega_m}{\omega}.\right)$ The series arm of the filter, then, is an impedance

$$Z=j\omega_oL.\Omega=j\omega_oL.\frac{\omega_m}{\omega_o}\left(\frac{\omega}{\omega_m}-\frac{\omega_m}{\omega}\right)=j\omega_mL.\frac{\omega^2/\omega_m{}^2-1}{\omega/\omega_m}$$

This impedance can be recognised as the impedance of an inductance L_1 and a capacitance C_1 in series, with $\omega_m{}^2L_1C_1=1$. The change from L, C, to L_1, C_1 is made, so that we shall not get confused with the capacitance in the shunt arm.

$$Z=j\omega L_1+\frac{1}{j\omega C_1}=\frac{1-\omega^2L_1C_1}{j\omega C_1}=j\omega\ L_1\frac{\omega^2L_1C_1-1}{\omega^2L_1C_1}$$
$$=j\omega_mL_1\frac{\omega^2/\omega_m{}^2-1}{\omega/\omega_m}.$$

In the same way, the admittance of the shunt arm, $Y=j\omega_oC.\Omega$ is the admittance of a capacitance C_2 tuned to ω_m by a parallel inductance L_2.

We have made the transformation $\Omega=\frac{\omega_m}{\omega_o}\left(\frac{\omega}{\omega_m}-\frac{\omega_m}{\omega}\right)$ and we want to know more about this. We have

$$\Omega=\frac{\omega_m}{\omega_o}\ .\ \frac{\omega^2-\omega_m{}^2}{\omega\omega_m}=\frac{\omega^2-\omega_m{}^2}{\omega\omega_o}=\frac{(\omega+\omega_m)(\omega-\omega_m)}{\omega\omega_o}$$

The band edges, as we can see from Fig. 5, correspond to $\Omega=\pm1$. What does this mean in terms of ω? Suppose we have a narrow-band filter, first of all. Then $\omega\approx\omega_m$ in the band, and we can write $(\omega+\omega_m)\approx2\omega$. This makes

$$\Omega=\frac{2\omega(\omega-\omega_m)}{\omega\omega_o}=\frac{2}{\omega_o}.(\omega-\omega_m).$$

For $\Omega=\pm1$ this means that $\omega=\omega_m\pm\omega_o/2$. The band-width of the band-pass filter is ω_o, the band-width (in the positive frequency direction) of the low-pass filter from which we started. The reason why we get this halving is that there is a second pass-band in the negative frequency region: the total pass-band width is the same for the low-pass and band-pass filters if we watch all the pass-bands.

It may not be immediately obvious what has happened. Suppose we want to design a band-pass filter of band-width B, centred on some frequency F. First we design the low-pass filter which has a cut-off at a frequency B, then we tune all the inductances with series capacitances to the centre frequency F, and all the capacitances with parallel inductances to the same centre frequency F. Provided that B/F is small, the filter will have the wanted response, and according to our choice of shape for the low-pass circuit, so the band-pass filter will be Tchebycheff or Butterworth or what you will.

When B/F is not small, we must determine ω_o, the design characteristic for the low-pass filter, more carefully. We know that $\Omega = \pm 1$ represent the values of the transformation function at $\omega = \pm\omega_o$ in the low-pass circuit. Let us call the upper characteristic frequency of the band-pass filter ω_{c2}, and the lower characteristic ω_{c1}. We can then write

$$\Omega = 1 \text{ at } \frac{\omega_m}{\omega_o} \cdot \frac{\omega_{c2}^2 - \omega_m^2}{\omega_{c2}\omega_m}$$

and

$$\Omega = -1 \text{ at } \frac{\omega_m}{\omega_o} \cdot \frac{\omega_{c1}^2 - \omega_m^2}{\omega_{c1}\omega_m}$$

This leads us to

$$\frac{\omega_{c2}^2 - \omega_m^2}{\omega_{c2}\omega_m} = \frac{\omega_m^2 - \omega_{c1}^2}{\omega_{c1}\omega_m}$$

$$\omega_{c1}\omega_{c2}^2 - \omega_{c1}\omega_m^2 = \omega_{c2}\omega_m^2 - \omega_{c2}\omega_{c1}^2$$

or

$$(\omega_{c1} + \omega_{c2})\omega_{c1}\omega_{c2} = (\omega_{c1} + \omega_{c2})\omega_m^2$$

$$\omega_{c1}\omega_{c2} = \omega_m^2$$

Thus ω_m is the geometric band centre.

Now we can work the geometrical construction backwards, because we know what ω_m is to be. Alternatively, we know that from the equation $\Omega = 1$,

$$\omega_o = \frac{\omega_{c2}^2 - \omega_m^2}{\omega_{c2}} = \frac{\omega_{c2}^2 - \omega_{c1}\omega_{c2}}{\omega_{c2}} = \omega_{c2} - \omega_{c1}$$

Much to our surprise, this complicated transformation leaves the band-width completely unaltered. Thus for any ratio of band-width to centre frequency, the primary elements—by which I mean those we calculate from the low-pass theory—depend only on the band-width.

Let us look at a slightly synthetic but fairly typical example of the problems we can solve by this method. We want a transformer to connect a valve to a feeder and to give a response which is 3 db down at 2 Mc/s and at 8 Mc/s. The valve output capacitance is 10pF and the feeder impedance is 100 ohms.

Then
$$\omega_{c1} = 2\pi.2.10^6$$
$$\omega_{c2} = 2\pi.8.10^6$$
$$\omega_m = 2\pi.4.10^6$$

We start off with the low-pass filter of Fig. 6, and we assume that we want a Butterworth response with the 3 db point at $\omega_o = 2\pi.6.10^6$. If we turn back to the first article and take $k' = 1$ on page 369, we find that

$$C_{(2)} = \sqrt{2}/\omega_o R_2 \text{ so that } R_2 = \sqrt{2}/\omega_o C$$

This gives us $R_2 = \sqrt{2}/2\pi.6.10^6.10.10^{-12}$ putting in the values for C_2 and ω_o already chosen. Thus R_2=4,100 ohms.

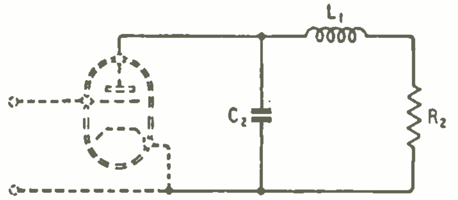
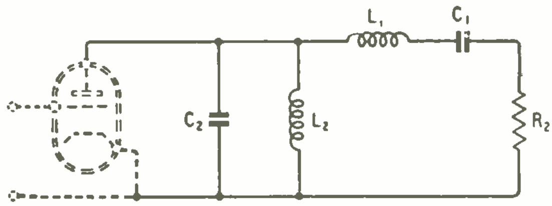
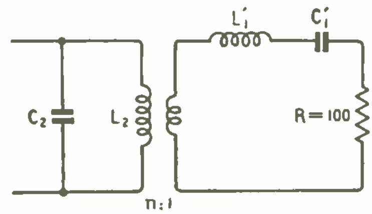


Fig. 6. In designing an output transformer we begin with this low-pass circuit.



(a)



(b)

Fig. 7. The conversion to band-pass leaves C_2 and L_1 unaltered from Fig. 6 (a), but we introduce the transformer as shown in (b).

L_1 we could calculate from the equation $\omega_o^2LC = 1$. We shall not do this, though, because we can avoid one step by adopting a different order. We convert Fig. 6 to a band-pass filter by adding L_2 and C_1, producing two tuned circuits, both tuned to 4 Mc/s. We want to work into an impedance of 100 ohms, so now we convert to the circuit shown in Fig. 7(b), in which L_2 is the primary of a transformer, the ratio of which must clearly be $(4{,}100/100)^{\frac{1}{2}}:1$ or 6.4 : 1. We put L_1 on the secondary side, and from the first article we know that

$$L_1' = R2/\sqrt{2}\omega_o = 100/\sqrt{2}.2\pi.6.10^6 = 1.87\mu H.$$

C_1', is the capacitance which tunes 1.87 μH to 4 Mc/s. The output transformer, then, has a primary inductance which resonates at 4 Mc/s with 10pF, a ratio of 6.4 : 1 and a leakage inductance of 1.87μH. The remaining numbers are easily calculated. With such a transformer we present a load of 4,100 ohms to the valve at band centre.

If we want to know any other characteristics of the circuit, we can work them out for the low-frequency case, plot the result as a function of Ω and then transform by the geometric method of Fig. 5. For example, the impedance presented to the valve at any frequency is obtained by calculating, for the low-pass case,

$$Z = \left(j\omega C + \frac{1}{j\omega L + R_2}\right)^{-1}$$
$$= \frac{j\omega L + R_2}{1 - \omega^2 LC + j\omega CR_2} = R_2 \frac{\frac{1}{1 + j\Omega\sqrt{2}}}{1 - \Omega^2 + j\Omega\sqrt{2}}$$

Then we can plot the impedance as a function of Ω, and transform the resulting curves by the method of Fig. 5.

We really need no more transformations, for our simple analysis, because if we first convert from low-pass to high-pass, and then carry out the transformation which gave us the band-pass filter, we shall obtain a band-stop filter. Only rarely do we want a band-stop filter, however, and I do not think we should trouble too much about it.

Having come to this point, let us look back and see what we have managed to do. We have seen that filters can be designed without any special concepts, such as image attenuation constants or characteristic impedance: we have seen how exact responses can be selected and the choice which is presented to us. All this, using ordinary simple algebra, we work out in terms of low-pass filters. Now we have shown that the whole of the low-pass analysis can be used, lock, stock and barrel, to solve our high-pass and band-pass problems. By two successive operations, the band-stop filter can be handled without introducing a new transformation. Similarly, if the band-pass filter is re-passed through the transformation of Fig. 5, we shall have designed a filter with two pass-bands. It is, of course, the ordinary band-pass case which is of the greatest importance, and it is here that the method is of special value, because a direct approach involves such very cumbersome algebraic expressions.

An interesting example of the power of this method of attacking the band-pass filter will serve as a tail-piece. When we make the system of Fig. 7(b), what happens if the two circuits are not tuned to the same frequency? If we transform the impedance and admittance of Fig. 2(a) to the band-pass form, we see that they should both look like the curve of Fig. 8(a). Suppose, however, that one is tuned slightly above f_m, and the other slightly below. The result is shown in Fig. 8(b) as an approximation; when we transform this back to the low-pass case, we have $\frac{Z}{j}=(\omega+\delta\omega)L$ and $\frac{Y}{j}=(\omega-\delta\omega)C$, assuming that the two circuits are detuned by equal amounts above and below the correct value (this may imply a new definition of ω_m).

The insertion loss coefficient can be obtained by writing $j(\omega+\delta\omega)L$ in place of $j\omega L$ and $j(\omega-\delta\omega)C$ in place of $j\omega C$ in the equations previously derived. We had

$$N=1+j\omega\left(CR_p+\frac{L}{R_s}\right)-\omega^2LC_k$$

for the special case of $R_1=\infty$, $k'=1$ and $R_s=\infty$ so that $N=1+j\omega CR_2-\omega^2LC$

Now we put in the modified forms, to get

$$N'=1+j(\omega-\delta\omega)CR_2-(\omega+\delta\omega)(\omega-\delta\omega)LC.$$

$$=1-\omega^2LC+j(\omega-\delta\omega)CR_2 \text{ if } (\delta\omega)^2 \text{ can be neglected.}$$

$$|N'|^2=1+\omega^2(C^2R_2^2-2LC)+\omega^4L^2C^2-2\omega\delta\omega CR_2$$

For a Butterworth response we put $(C^2R_2^2-2LC)=0$ and this now gives us

$$|N'|^2=1+\omega^4L^2C^2-2\omega\delta\omega CR_2$$

Now $CR_2=\sqrt{2}/\omega_o$, so that

$$|N'|^2=1+\omega^4L^2C^2-2\sqrt{2}\delta\omega.\frac{\omega}{\omega_o}$$

$$=(1+\Omega^4)-2\sqrt{2}\delta\omega.\Omega$$

The term $(1+\Omega^4)$ is just the usual Butterworth response, while $-2\sqrt{2}.\delta\omega.\Omega$ is the perturbation due to the mistuning. As you can see, with the approximations and assumptions we have made, the perturbation is proportional to Ω.

The whole response has thus acquired a tilt, something on the lines of Fig. 9, and across the full band our approximations have led us to a uniform slope to be added to the Butterworth curve. When we transform to the band-pass case, the whole positive and negative low-pass response is used, and now it is important to remember this, because it is no longer symmetrical.

How large is the effect? Let us now look back at the example we discussed earlier of a band-pass output transformer where we could expect the valve capacitance, nominally 10pF, to have a tolerance of $\pm$1pF. Suppose that it is actually 10pF$-$1pF. The series tuned circuit is unaffected, so that if we want to use our simple approximation above we must first shift our reference frequency up a little, so that the two circuits are equally detuned on either side of the reference frequency. The capacitance error at the valve anode will then be halved, to 0.5pF. From this, the value of $\delta\omega$ in the normalized low-pass case will be about 1/40, so that at the band edges, where $\Omega=\pm1$, the response will be

$$10\log 2\pm2\sqrt{2}/40\text{db}$$
$$=10\log 2\pm0.07\text{db}$$
$$=3.15\text{db and } 2.85\text{db.}$$

There is nothing to prevent our carrying out the same calculation for a third-order Tchebycheff filter: nothing, that is, except laziness. All the processes we have considered in this article are applicable over a very much wider field than that I have tried to cover. There is still a trace of the original apple in our analysis. But this set of articles, now at an end, has been intended only to describe the methods which you can use to understand filters.

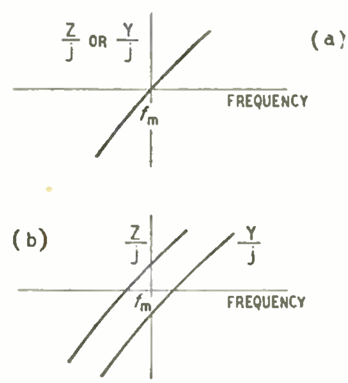


Fig. 8. (a) For a band-pass filter, both circuits should tune to f_m. Errors in alignment may cause one to be slightly low, and one slightly high (b).

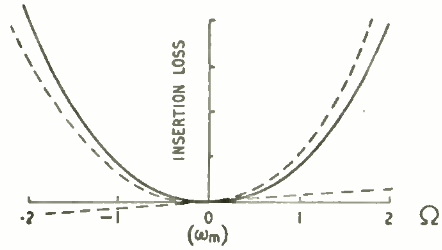


Fig. 9. The effect of mistuning is to put a linear tilt on the curve, as well as shifting it sideways.

COLOUR COMPLICATIONS

Additional Circuitry Required for Television Receivers

THE diagram below gives some idea of the type of receiver circuitry we would have to cope with if colour television came to Britain—that is, colour television based on the N.T.S.C. compatible system. It shows not a complete receiver, but simply the additional circuits required to enable colour information to be received and displayed. The receiver in question is actually the first commercial colour set to be produced by R.C.A.—the model CT-100. It uses 37 valves, two metal rectifiers and three crystal diodes. Just over half of these are in the standard parts of the circuit, which are much the same as an ordinary black-and-white receiver. The front end consists of a u.h.f.-v.h.f. turret tuner, while the pictures are displayed on a tri-colour c.r. tube (type 15GP22)* with a diagonal of about 12½ inches.

Separation of colour information from the complete video signal is done by a pentode band-pass amplifier with a pass band of 2.4-5 Mc/s. In the absence of colour information (a normal black-and-white transmission) this amplifier is cut off automatically by a triode gating circuit operated from the colour sync signal. The separated colour signal is passed to two synchronous detector stages (heptodes), and these demodulate the two colour-difference signals (which, at the transmitting end, are modulated on to two components of a sub-carrier displaced 90° in phase).

The synchronous detection is achieved by heterodyning the incoming colour signal with two components, displaced 90° in phase, of a local oscillation having the same frequency as the colour sub-carrier (3.58 Mc/s). This is produced by a quartz crystal oscillator (followed by pentode amplifier) which is automatically kept at the right frequency and phase by a control system worked from the incoming colour sync signal. The control system has a double-triode phase detector which compares the phases of the incoming sync signal and the local oscillation and produces an error signal proportional to their difference. This error signal controls a reactance valve which in turn varies the frequency of the local oscillator until the error is reduced to zero. A triode gating circuit is used to select the colour sync signal from the rest of the video waveform.

Returning to the two demodulated colour-difference signals, each of these is now passed to a triode phase-splitter and this produces positive and negative outputs suitable for the adding circuits, which come next. The adding circuits consist of three resistance networks, each followed by a triode. Here, suitable proportions of the colour-difference signals and the brightness signal (from the black-and-white section) are combined to produce three outputs corresponding to the red, blue and green components of the original picture. These are amplified by three output triodes, then d.c. restored by three diodes and finally applied to the three grids of the tri-colour tube.

There is also a double-triode circuit directly associated with the tri-colour tube itself. This modulates the d.c. potentials on the focus and convergence electrodes so that the electron beams are always kept properly converged and focused on the perforated mask wherever they are moved across it by the scanning system. Without this the beams would not pass through all the holes in the mask correctly and fall on the appropriate coloured phosphor dots on the screen.

* *Wireless World*, May, 1954, p. 242.

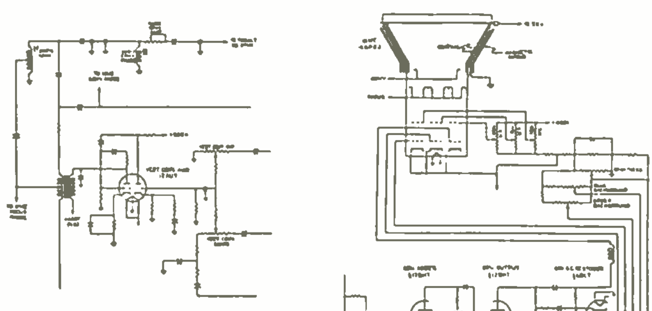
Colour Television Valves

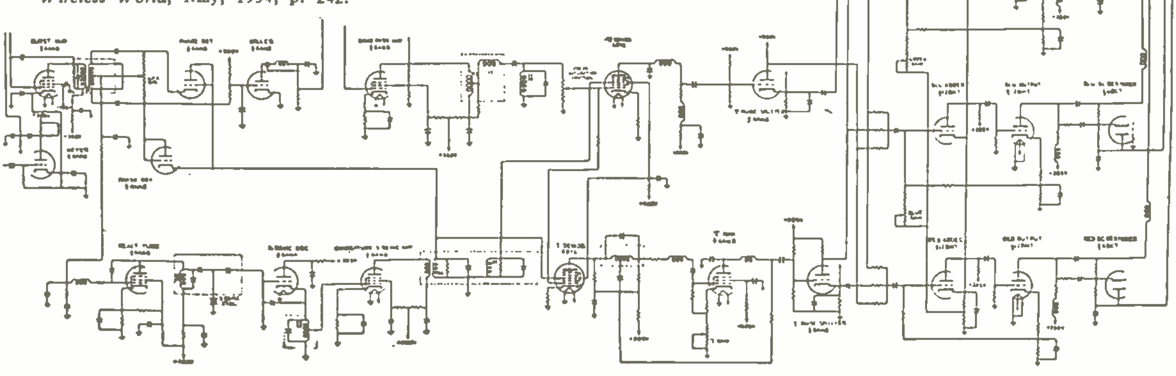
THREE new valves, specially designed for colour television, are used in the colour channel of the CT-100.

6AN8, a miniature pentode plus triode. The pentode section is used as a video amplifier or as a reactance valve while the triode performs variously as a phase detector, gating valve, oscillator and phase splitter.

6BY6, a miniature heptode. This is used as a synchronous detector, and the local oscillation from a separate source is applied to g_3 (the second control grid).

6BC7, a miniature triple diode. This provides the three d.c. restorers used on the red, blue and green colour-component signals immediately before they are applied to the tri-colour c.r. tube.





(Courtesy *RCA Review*)

Feedback I.F. Amplifiers for Television

By H. S. JEWITT,* B.Sc. (Eng.)

Experimental Design Offering Simplicity of Alignment

LAST February this journal published an article† giving details of a feedback technique for obtaining wide bandwidths in i.f. amplifiers. No specific application was discussed, but, in view of the simplification claimed to result from the use of this technique, the possibility of its application to television receivers has now been investigated. The present article is concerned with current television receivers of about 3 Mc/s bandwidth, but, as was clear from the previous article, the technique is likely to be of even greater value if wide-band colour television comes into use some time in the future (see page 625).

The television receiver presents a special problem for study, with requirements not met in other design fields. The first of these is the need for adequate sound rejection, which demands a trough in the response curve at sound frequency giving about 30-40 db of attenuation. This rejection may be provided by sound traps, or by designing the vision amplifier so that the response curve falls so sharply on the sound side that, although the highest vision frequency is passed satisfactorily, the sound carrier 0.5 Mc/s from this frequency is attenuated by the required 30-40 db.

The second special requirement has been introduced by the opening of new transmitters to give national coverage. This has filled the allocated television band of frequencies (in Band I) and created a number of areas where two or more transmitters can be received, possibly on adjacent channels within the band. It has become necessary to ensure that receivers will reject signals from the channels on either side of the one to which the receiver is tuned: thus, on the sound side the attenuation must be maintained, and on the vision side the response curve must fall away sufficiently sharply to give adjacent-channel rejection. The same methods as were noted for sound rejection apply in this case.

In commercial receivers both methods have been used. Traps tend to be simpler to fit and adjust but involve a loss of receiver performance, which may necessitate fitting an extra stage of amplification; the steep-sided selectivity curve can be obtained by using complicated coupling networks, which tend to be difficult to design and align. Amateur-built receivers have used traps almost exclusively since they are simple and the cost of an extra amplifying stage is of little importance to the amateur.

Current methods of obtaining the wide bandwidth necessary for the vision channel are the use of transformers, or frequency staggering, or a combination of both. The complications inherent in these methods were indicated in the previous article and they can be summarized here as: (a) transformers are not easy to design or manufacture but are relatively non-critical once correctly made; (b) frequency staggering uses simpler circuits but requires a complicated alignment procedure and is very dependent on capacitance and damping resistor values. The advantages to be expected from the use of feedback are: (1) the use of simple, single-tuned circuits; (2) a simple adjustment procedure; (3) insensitivity to small capacitance and resistance value changes.

The foregoing remarks consider the use of feedback to broaden an isochronous amplifier (i.e., tuned to a single frequency): feedback can also be used with transformers or staggering, and improves both at

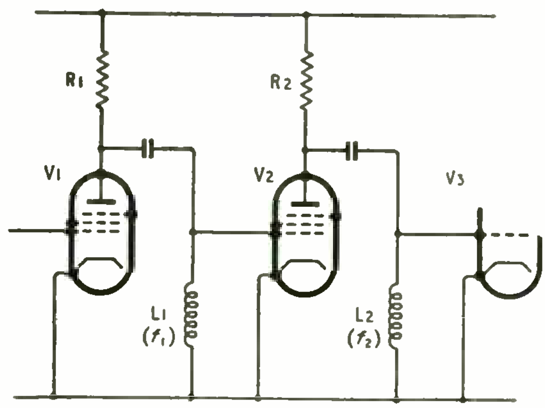


Fig. 1. Two stages of a conventional staggered i.f. amplifier. The first circuit is tuned to f_1 and the second to f_2.

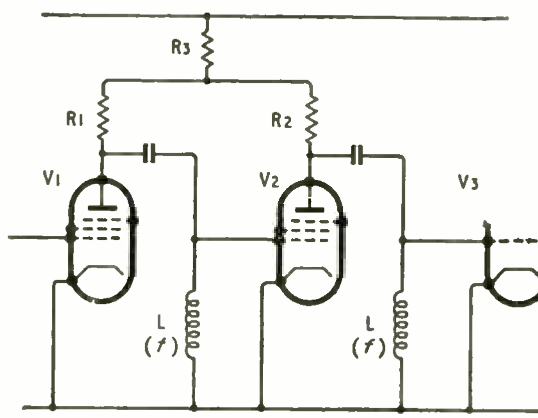


Fig. 2. Feedback amplifier with both circuits tuned to the same frequency (f).

* Decca Radar.
† "Wide-band I.F. Amplifiers" by H. S. Jewitt, *Wireless World*, February, 1954.

a sacrifice of simplicity. From one aspect, however, feedback presents a difficulty not met with in either of the other schemes—that of certain inevitable circuit capacitances. Consider Fig. 1, which is the circuit of two stages of a staggered amplifier. If R_1 and R_2 possess capacitance—as, being practical resistors, they do—it can be absorbed in the tuning capacitance and the coil made slightly smaller to maintain the tuning. Similarly, the effect of anode-grid capacitance may be allowed for. If, now, Fig. 2, the circuit of a feedback amplifier, be examined, a different state of affairs is seen to exist. Capacitances across the resistors R_1, R_2 and R_3 cannot now be absorbed in the tuning capacitance, and they will, in fact, affect the feedback both in magnitude and in phase. Again, the anode-grid capacitance of V2 has the effect of tilting the response curve, and, if it is sufficiently large, may produce a tilt which cannot be corrected. Both of these effects will become worse as the bandwidth decreases (and consequently the gain per stage increases): as R_1 and R_2 increase the effect of their self-capacitance will become more obvious, and the same holds for the effect of the anode-grid capacitance of V2.

It is apt here to consider one point of view on television receiver bandwidth—that of the radar receiver designer who considers television receivers as being of narrow bandwidth. This may be rather startling unless it is appreciated that the radar designer is usually concerned with "wide" bandwidths of 20 Mc/s or more and that, to him, a bandwidth of less than 5 Mc/s is narrow. Consequently, a circuit configuration that is ideal for radar wide bandwidths may present difficulties at television "wide" bandwidths. This is so in the case under discussion. The values of R_1 and R_2 (Fig. 2) needed for 3 Mc/s bandwidth are so high as to lead to difficulties with their stray capacitances. Similarly, the resultant gain per stage of approximately 26 db is higher than any normally used in radar practice with feedback amplifiers, and leads to tilt trouble with the anode-grid capacitance.

Circuit Configuration

With the foregoing difficulties in mind, an experimental design of a vision i.f. amplifier was attempted. One primary parameter to be chosen was the i.f. itself: this is preferably low to reduce the troubles associated with stray capacitance effects. An arbitrary choice of 16 Mc/s for the vision carrier and 19.5 Mc/s for the sound carrier was made. The circuit configuration was considered, and, bearing in mind the experimental nature of the work and the requirement for simplicity, it was decided to use two flat feedback pairs. This choice was also conditioned by the stray capacitance problem, for other feedback circuits generally use higher resistor values. A quick computation of the gain to be expected from two pairs yielded a result of approximately 100 db, assuming the Mullard EF91 valve to be used. If the first of the four valves be made the mixer and detection losses are taken into account, an overall gain figure from mixer grid to detector output of 75 to 80 db is to be expected, and this appears to be a reasonable value. The flat pairs were initially designed using the data

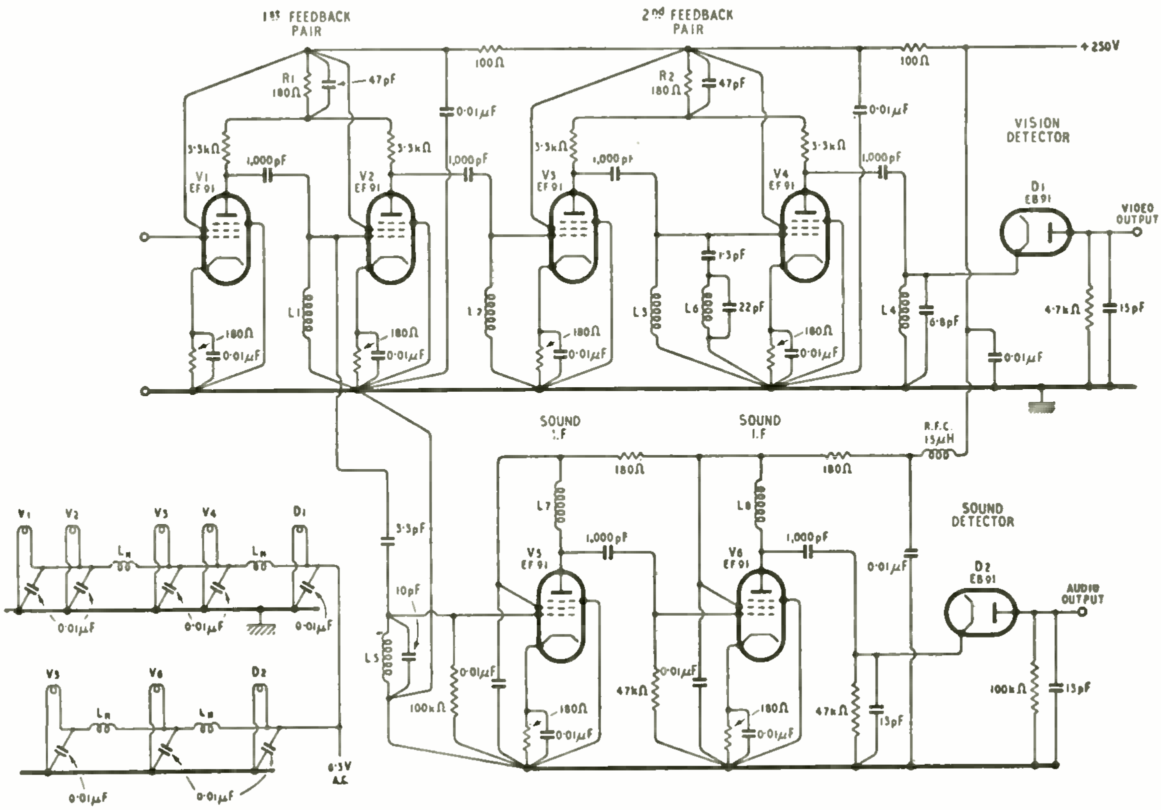


Fig. 3. Complete circuit diagram of i.f. section of a receiver with diode detectors. Coils L_1 to L_8 are wound on Aladdin formers, dust-core tuned and screened. No other screening is used. L_1, L_2, L_3, and L_4 : 27 turns of 30 s.w.g. close-wound. L_5, L_6, L_7, and L_8 : 20 turns of 30 s.w.g. close wound. L_H : about 15μH (type of coil not important).

given in the previous article and the resulting i.f. amplifier was constructed.

As had been anticipated, stray capacitances modified the response curve considerably and some modification of resistor values had to be made. This is normally regarded as most unusual at wider bandwidths, but was not unexpected in this case. Due again to the capacitance problem, a very large value of tilt-compensating capacitance was necessary to overcome the falling-off on the high frequency side of resonance. Traps were fitted to the completed vision amplifier for sound rejection and these produced some modification of the response curve. It had been hoped that much of this change could be corrected, using the tilt compensator, but as this had already been raised to its limit value, it was not possible. The aligning frequency was therefore raised from 17.5 to 18 Mc/s. Finally, a sound amplifier was added, taking its input from the first sound trap.

Fig. 3 is the circuit diagram of the complete i.f. section for a receiver. V1 would be the mixer, possibly preceded by an r.f. stage (certainly for Band III use), and the only requirement on this valve is that its output capacitance should be very close to that of the EF91s used throughout the amplifier. V1 and V2 form the first pair, and V3 and V4 the second. Contrast control may be applied to the mixer and to V3, but V2 and V4 cannot be so controlled since variation of the gain of these stages affects the feedback factor and hence the bandwidth. The sound i.f. amplifier comprises V5 and V6 in a conventional narrow-band circuit. The two detectors D1 and D2 may be either thermionic diodes as shown or germanium crystal diodes (the Mullard OA73 for example).

The alignment procedure for this amplifier consists in short-circuiting R_1, and adjusting L_1 and L_2 to resonate at 18 Mc/s. This short-circuit is then removed, R_2 is short-circuited and L_3 and L_4 are made resonate at the same frequency. With the signal generator set at 19.5 Mc/s, L_5 and L_6 are adjusted for minimum signal at the vision detector and L_7 and L_8 for maximum signal at the sound detector.

The response curve obtained in this fashion is shown in Fig. 4. This is not ideal for television reception but indicates that a usable response curve can be obtained with such a simple amplifier. It should be noted that the response is not −6 db at 16 Mc/s, the vision carrier frequency, but approximately −4.5 db: this allows for the effect of the mixer and r.f.-stage tuned circuits. The dotted curve on Fig. 4 shows the result of changing all four valves in the vision amplifier, without any re-alignment, and indicates the lack of sensitivity of the circuit to valve changes. The replacement valves were chosen at random from batches other than those of the original four.

Performance Figures

The amplifier measurements made (apart from the vision response curve) give the following results:—

Vision gain, V1 grid to D1 output	:	92 db
Sound gain, V1 grid to D2 output	:	97 db
Sound channel bandwith to −3 db points	:	210 kc/s
Sound rejection on vision channel	:	−35 db
Vision rejection on sound channel	:	−57 db
Adjacent sound channel rejection on vision	:	−35 db

The principal effect of the valve change was to reduce the sound rejection to −28 db.

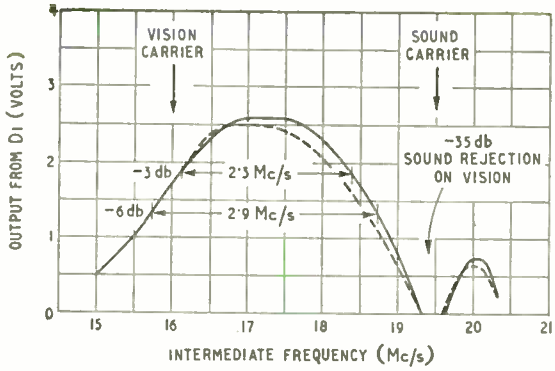


Fig. 4. Response curve obtained from the vision circuit in Fig. 3. The dotted curve shows the effect of changing the valves.

This experimental circuit indicates the possibilities for television of the negative feedback i.f. amplifier. It cannot be expected to show to best advantage at the rather narrow 3 Mc/s bandwidth of the present British television system, but, even at this bandwidth, may well be used where simplicity of construction (the absence of transformers) and of alignment (no frequency staggering) is important.

The author would like to thank Mr. S. H. Knight for much helpful advice and assistance in the experimental work.

Medium Power Television Transmitter

New B.B.C. Station in the Isle of Wight

THE first of the B.B.C.'s medium-power television transmitters came into service on November 12th. It operates on Channel 3, 56.75 Mc/s vision and 53.25 Mc/s sound, with vertical polarization and a power of 5 kW peak-white for vision and 2 kW carrier for sound.

The station is at Rowridge in the Isle of Wight 470 ft above sea level and is at present operating with a temporary 200-ft mast. The permanent mast will be 500 ft high and will carry a higher gain aerial; it is expected that it will come into service during the autumn of 1955.

The vision signal for modulating the transmitter is brought in by a radio link. A Post Office receiving station at Alton in Hampshire receives the London signal on Channel 1 and transmits it to Rowridge on a microwave link. The receiving aerial is a paraboloid on the 60-ft level of the mast. The sound signal comes in by line, a submarine cable being used between the island and the mainland.

The vision transmitter employs low-level modulation, actually at a 500-W level, the subsequent amplifier comprising two wideband linear r.f. stages in cascade. Each stage has two forced air-cooled triodes operating in class B. An unusual feature is the omission of a special vestigial-sideband filter, the appropriate shaping of the sidebands being obtained

View of the vision and sound transmitters at Rowbridge with the control desk in the foreground.

instead by the design and adjustment of the tuned circuits of the amplifier.

The transmitter is crystal controlled with a long-term stability better than 0.002%. Frequency multipliers and amplifiers bring the r.f. power to a level of 50 W to drive the push-pull tetrode modulated amplifier. This is grid modulated.

The video circuits, which amplify the received signal, to drive the modulator include sync-pulse stretching and picture-amplitude shaping circuits.

The transmitter has been manufactured by Marconi's Wireless Telegraph Co., Ltd., who have also made the sound transmitter. This is of the class B modulated type rated for 2 kW output. It will normally be used to deliver 1.25 kW in order to maintain the standard ratio of vision to sound power; that is, equality of peak power.

The station includes a stand-by 500-W vision and 125-W sound transmitter made by Standard Telephones & Cables, Ltd.

The power supply comes from the grid at 11 kV and is transformed to 415-V 3-phase on the site. A local supply from a diesel-driven generator is available for emergency use and permits low power operation.

No studio or camera facilities are provided but this does not prevent the origination of programmes in the island. The usual O.B. vans can be used and the station can accept the signals from them and transmit them to the main television network.

H.F. CABLES AND CONNECTORS

Preferred Impedances Agreed by I.E.C.

ONE of the sub-committees to the International Electrotechnical Commission, which met in Philadelphia during the recent jubilee congress, is concerned with h.f. cables and connectors. There were three British representatives on this sub-committee and we are indebted to one of them—R. W. Kersey of Mullard, Ltd.—for this brief report.

The main object of the meetings of the sub-committee was the reconsideration in the presence of American specialists of the work done at the first meeting held at Lugano last April. Twelve nations were represented on the committee at Philadelphia by over thirty delegates, nearly half of whom were Americans.

For two days discussions were mainly concerned with preferred impedances and diameters for h.f. cables. A British document was submitted in answer to the German plea for the selection of 60 ohms rather than the preferred values of 50 ohms and 75 ohms which are in accordance with British, American and French practice, both as regards Services and industry applications, and moreover had been accepted at Lugano.

Other matters that were dealt with included coaxial aerial connectors for television (based upon a British proposal) and a general requirements specification for h.f. cables.

It may be said that the interchange of ideas had proved valuable and that in general the experience of U.S. Services and industry supported the conclusions that had previously been arrived at in Europe. The American delegates were evidently impressed by the technical level of work already done by the sub-committee and there is, therefore, every reason to suppose that the keen American co-operation that was so evident at Philadelphia will be maintained at future I.E.C. meetings in Europe and, in particular, at the next meetings of the sub-committee to be held in London during the summer of 1955.

PUBLICATION DATE

We regret that owing to the Christmas holidays it will be necessary to postpone publication of the January issue of *Wireless World* from December 27th to January 3rd.

Signal-Operated Switching

Fault-warning System Using a Thyratron Valve

By R. SELBY*

THERE are a number of occasions when it is necessary to arrange for a certain switching operation to be performed automatically by the starting or cessation of an audio signal. These may include voice-operated send-receive switching for radio communication and intercom systems, start and stop arrangements for tape recording, and fault-warning systems for radio relay services. The last mentioned case is the one which concerns the writer, and as in some ways it presents the most difficulties, a description of a simple practical scheme is given. A similar unit would probably be useful to radio servicemen when "soak-testing" receivers having obscure intermittent faults.

In all these applications time is an essential element. Generally it is required that operation of the switching relay should occur as quickly as possible after commencement of a signal, but that there should be a controllable delay after cessation of the signal before the relay changes over. For communication purposes this delay will require to be long enough only to avoid false switching during normal pauses in speech, but in the case of a programme-failure alarm it must extend to a period slightly longer than the expected maximum interval in the programme. This may vary between 20 or 30 seconds for the Light Programme and 3 or 4 minutes for the Third Programme.

A system incorporating a conventional negative feedback time delay circuit has been described elsewhere† and has been used with fair success for some two or three years. The basic circuit is shown in Fig. 1. The audio signal is rectified by the diode and charges C (4 μF) negatively so that the triode is cut off. Upon cessation of the signal, C discharges slowly through R, R_k, and the relay winding. Approximate resistances are 5 MΩ, 5 kΩ and 1,000 Ω respectively. The triode grid slowly rises to the same potential as the cathode, allowing anode current to pass and the relay to operate, but the action is prolonged by the feedback effect of the high resistance in the cathode circuit. This system suffers from several disadvantages. One is the fact that some valves are unsatisfactory with such a high value grid resistor. Another is the very slow rate of change of anode current, which does not allow the relay to operate smartly, resulting in "dithering" of the contacts and difficulty in setting and maintaining a definite delay period. The latter varies considerably with the adjustment and spring load of the relay. A further complication which arises when it is desired to feed several such units from a common power supply is the necessity for voltage stabilization.

Fig. 2 shows the basic circuit of a system which is considerably simpler, has fewer variable factors, and which gives positive operation of the relay. The triode is replaced by a thyratron, thus ensuring that the relay is either fully energized or completely non-energized, so that precise adjustment is unnecessary and a full spring load may be carried.

Since the thyratron current is either zero or a maximum determined by other circuit elements, a negative feedback circuit cannot be used, and the required delay can only be obtained by the simple discharge of a capacitor through a resistor. For-

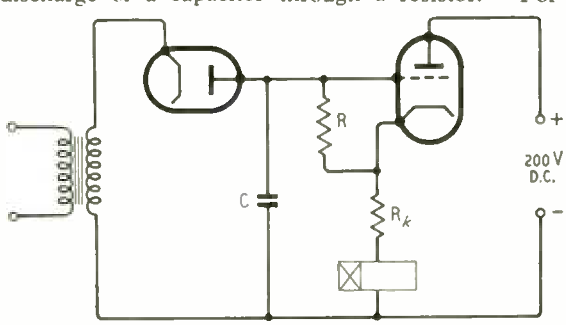


Fig. 1. Basic circuit of signal-operated switching system described in the text.

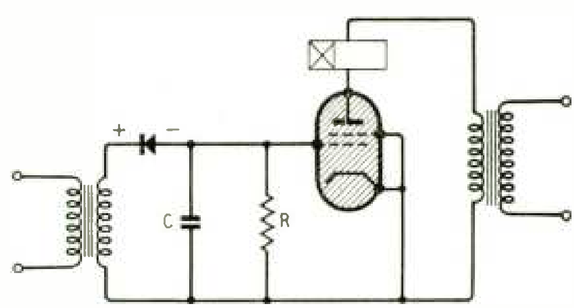
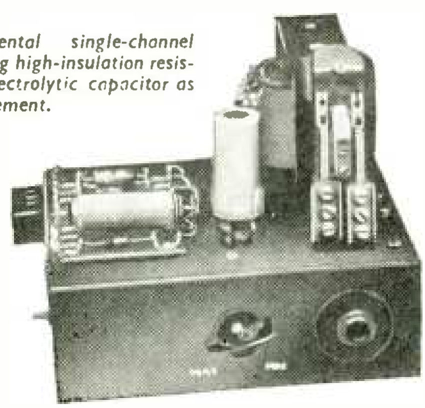


Fig. 2. Modified circuit using a thyratron valve.

* Metropolitan Relays, Ltd.
† *Relay Association Journal* March 1951

Experimental single-channel unit using high-insulation resistance electrolytic capacitor as delay element.



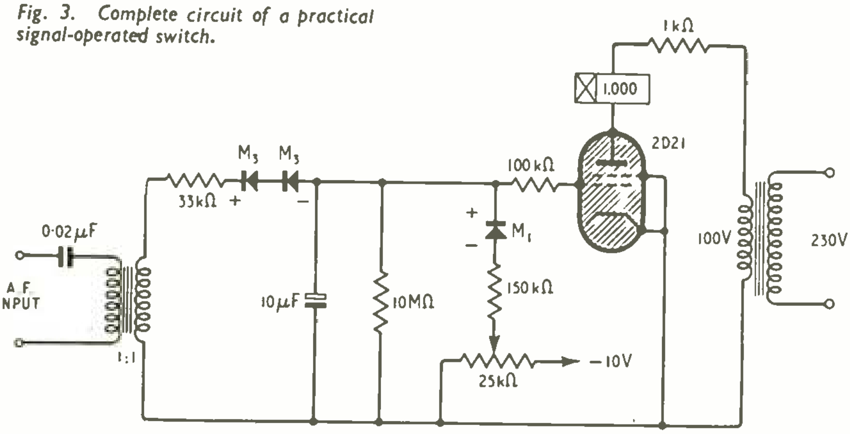


Fig. 3. Complete circuit of a practical signal-operated switch.

tunately the rule of thumb formula for such a time constant, T=CR, where T is in seconds, C in μF and R in MΩ, is not strictly correct, otherwise impossibly high values of C and R would be needed. It was found quite practicable to take advantage of the latter part of the exponential voltage decay curve for a CR combination, where the voltage is dropping at a progressively slower rate. This, combined with the small range of critical grid voltage required to strike the thyratron, enables delays of several minutes to be obtained, providing the initial voltage is reasonably high.

The anode of the thyratron is supplied with a.c., so that the grid has the opportunity of regaining control at every half-cycle. When the negative grid potential is below the critical value the thyratron is conductive and behaves as a half-wave rectifier with the relay as the load. Under these conditions it is necessary to prevent the relay buzzing and also to prevent a high back-e.m.f. being generated by the cessation of current in the inductive winding of the relay. Such a back-e.m.f. would be injurious to the thyratron. The simplest method is to employ a slugged relay, and a P.O. Type 3,000 having a 1,000 Ω winding and a ½-in slug at the armature end has been found quite effective. Alternatively a plain winding may be used if shunted by a capacitor. The additional operate and release lag introduced by the slug does not exceed 200 millisec under the most unfavourable conditions, and is therefore unlikely to cause difficulty.

Practical Circuit Details

The opportunity was taken when designing this simplified unit to explore the possibility of replacing the thermionic diode (Fig. 1) by a metal rectifier in order to reduce space and wiring. Germanium and copper-oxide types are unsuitable, as their comparatively low reverse resistance allows C to discharge far too quickly for most purposes. The miniature selenium Types M1 and M3 recently introduced by Standard Telephones and Cables proved quite satisfactory however. The M3 is the more suitable on account of its higher current rating. Its reverse resistance varies considerably with the applied voltage, representative nominal figures being 45 MΩ at 5 V and 25 MΩ at 15 V. These values are not low enough in relation to the maximum permissible grid-cathode resistance of the thyratron (10 MΩ for Type 2D21) to affect the time constant greatly, and in any case it will frequently be necessary for other reasons to employ two or more rectifiers in series, when the total reverse resistance becomes high enough to be ignored. Moreover, it is over the useful working range of lower voltages that the resistance rises.

The practical circuit is shown in Fig. 3. The 0.02-μF capacitor in series with the a.f. input serves no essential purpose, but was fitted in a particular instance to reduce the response to hum frequencies. The ratio of the transformer depends on several factors, including the voltage and impedance of the a.f. source, the time delay desired, and the required speed of response on resumption of the input signal. The resistor of 100 kΩ at the grid is a probably unnecessary precaution to protect the thyratron from excessive grid current in the event of failure of any other component, or accidental reverse connection of the rectifier. The resistor (1 kΩ) in the anode circuit limits the current to a figure well below the maximum rating of the 2D21. It might need to be reduced slightly if an unusually heavy spring load is required on the relay. In order to operate the thyratron at a low critical grid voltage point the anode supply is of the order of 100 V only. It should be noted that it is not possible to employ a higher voltage transformer winding in conjunction with a series voltage-dropping resistor, since, until the thyratron fires, there is no current and therefore no voltage drop.

The primary elements in determining the time delay are, of course, the grid capacitor and leak resistor, and the values shown are the maximum likely to be required for most purposes. Where delays of up to one minute only are required, C could often be reduced to about 4 μF. It must naturally have a high and stable insulation resistance.

The delay period is also a function of the voltage existing across the capacitor at the moment when the input signal ceases. In other words the delay is affected by the level of the final signal. Where a fairly constant signal level is maintained, as might be the case for communication purposes, this point may not cause difficulty, but where, as in the writer's case, the system is to operate from broadcast programmes, some means of compensating for wide variations in signal level is necessary. A d.c.-limiter with adjustable bias is therefore incorporated, and this uses also a miniature selenium rectifier. It is very unlikely that the bias will require to be adjusted to a figure approaching the maximum d.c. reverse voltage rating (20 V), and a single M1 rectifier should suffice. The maximum current rating of this type is, however, only 250 μA, and it is therefore necessary to restrict the current on peak signals by inserting a 150-kΩ series resistor. This has the effect of slowing up the limiting action somewhat, so that there is a few seconds variation in the delay between maximum and small signal voltages. If closer timing is essential, the series resistor may be much reduced and the single M1 rectifier replaced by two or three Type M3 in series. This is necessary to maintain sufficiently high reverse resistance.

A bias supply of about −10 V will usually be sufficient and may be obtained by any convenient means, such as by a shunt diode rectifier circuit fed through a capacitor from the 100-V winding on the transformer. If an additional low-voltage winding is available for pilot bulbs, alarm bell, etc, this may be connected in series-aiding with the 6.3-V heater winding to supply a small metal rectifier. A single 25-μF capacitor provides sufficient smoothing.

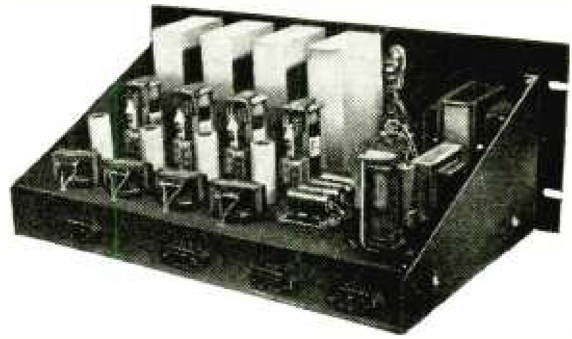
The potentiometer (25 kΩ) for adjusting the bias, automatically provides a very effective means of adjusting the time delay because its setting determines the starting point of the effective CR discharge curve, assuming that a signal greater than the bias voltage has been received recently. If a prolonged low signal is being fed in, and then ceases, the charge on C may initially be lower than the bias voltage, and the delay will be shortened. A numerical example may make this clearer. Assume a delay of three minutes is required and that this can be obtained when the potential across C is 9 V. The limiter bias will therefore be adjusted to 9 V, and a final signal of 9 V or more will offer the correct delay period. But if for the past three minutes or longer a signal at only 5 V has been received, and is then interrupted, C commences its discharge with an initial voltage of only 5 V, and a period of less than three minutes elapses before the thyratron fires. Fortunately, in practice it would be uncommon to find a programme containing such a relatively low signal lasting for such a period without a single peak, and then followed by a further period of complete absence of signal. It will usually be satisfactory to set up the adjustments at a signal level corresponding to quiet speech. Greatest constancy of time delay is obviously achieved if the unit is fed with an adequately high signal, so that even on quiet passages, C is charged to the maximum potential permitted by the setting of the limiter bias.

It will be clear also that with given values of C and R, the lower settings of bias voltage give correspondingly shorter time delays, but greater constancy. The following table shows the time in seconds taken for the relay to operate after the input signal is reduced to zero from the value given in the first column. Figures are given for three settings of bias voltage, the test frequency being 1,000 c/s and the component values those given in Fig. 3.

Signal Volts (r.m.s.)	Bias Voltage			Release time
	—5	—7.5	—10	
4	87	73	62	3
5	115	105	110	2
10	125	170	197	1
20	130	172	203	—
50	133	174	210	—

With the limiter circuit disconnected, a delay of 310 sec is obtained following a signal of 25 V r.m.s.

The column headed "release time" refers to the period taken for the relay to open after re-application of the signal. This time may be decreased by reducing the value of the series resistance in the rectifier circuit. It is not essential for the signal to fall completely to zero for operation, and the relay will close if the input falls to approximately 2 V. The minimum signal required to release the relay is 3.75 V. There is thus some degree of backlash between the two conditions.



Four-channel unit transmitting d.c. warning signals over P.O. lines in event of programme failure at a substation.

The 33-kΩ resistor in series with the signal rectifiers is for the purpose of limiting the current to a figure within the maker's rating of 1 mA average. No figures are quoted for maximum peak current. This series resistance increases the charging time of C to some extent and therefore slows up the release time of the relay. It should therefore in most cases be kept to the minimum safe value, which will depend principally on the maximum a.f. voltage to be applied. All the component values given in Fig. 3 refer to a unit designed to operate from an a.f. source having a maximum level of 100 V r.m.s.

Precautions

Care must be taken not to exceed the peak inverse voltage rating of 68 V for the rectifiers, and it may often be necessary to use two or three in series. Where no d.c. voltage limiter is used, the load resistance is very high, and the p.i.v. is almost twice the peak value of the signal voltage. When a limiter is used, the effective load resistance is much reduced and must be considered in relation to the total series resistance (including the source resistance) in arriving at the p.i.v., which will be lower in this case. When operating from a 100-V signal with the circuit values of Fig. 3, a minimum of three rectifiers is required. Whether the comparatively short duration and infrequent occurrence of peak signals in practice would permit a reduction in the number remains to be seen. A unit using two only has run without breakdown for a few hundred hours so far.

One small point to bear in mind is the maker's recommendation to allow 20 sec cathode heating time for the 2D21 before allowing anode current to flow. In some circumstances this might call for delayed switching of the anode supply.

This circuit (Fig. 3) enables a very simple and compact unit to be built, which gives positive operation of the switching relay. Where timing requirements are particularly stringent, the limited current ratings of the miniature selenium rectifiers might make it desirable to revert to the use of thermionic diodes.

If the relay is required to remain operated after the signal has been re-established, this can easily be arranged by providing an extra contact which breaks the input circuit when the relay closes. Manual resetting may then be performed by breaking the anode circuit momentarily.

Pith Balls and Grid Current

Traditional Electrostatics In Modern Valve Design

By "CATHODE RAY"

WHEN we are beginning to learn about electricity, all concerned are naturally in a hurry to get on to something interesting and practical. So the least time is devoted to the nature of electric currents as will just about give us the impression that we know about them. The rest of our lives are spent in discovering that we didn't really know. If our elementary course had tried to tell us, we would have stuck there the whole time. Which would have been discouraging. Most of us need all the encouragement we can get, and it consists mainly of looking back down the hill and seeing how far we have climbed. Perhaps fortunately we do not yet see the altitudes hidden behind the peak close above. To scale these it is often necessary to descend once more to levels we thought we had left for good.

Take this matter of electric current, for instance. In order to work out all those examples of series and parallel circuits, we needed only to know that an electric current was something like water flowing through a pipe, or (if we were very up to date) like a mob of people surging through a street full of stationary obstructions. This concept did us quite well until we came to capacitors; and even then the resourceful instructor or author got us by with the aid of a slight extension of the original idea. On reaching the chapter on valves, however, the water-pipe idea begins to get into serious difficulties, and the advantages of the electronic approach become manifest. At this stage I fancy most of us were informed that the vacuum inside a valve is a clear space across which the electrons leap, provided that the jumping-off place (the cathode) is heated in order to release them into the space, and a sufficient inducement is provided, in the shape of a positive potential, at the place of arrival (the anode). Since the strength of an electric current is proportional to the number of electrons passing a given point per second, the current in the wire joining the anode to the source of positive potential is proportional to (we may perhaps even say, consists of) the electrons arriving at the anode from across the vacuum.

This picture gets us quite a long way. But when we come to valves for frequencies higher than about 30Mc/s, we are again in difficulties. We find that there are currents in the anode or grid circuits even when electrons don't arrive at all. And so we have to go back to the beginning again and revise our ideas about electric currents. Why weren't we given these ideas at the start and so save a lot of trouble? Well, just as I said—if we had been given them at the start we would probably have decided to become chartered accountants or fishmongers. And in any case, even our re-revised ideas will no doubt have to be re-re-revised some day.

In the meantime, we won't get very far towards understanding valves at v.h.f., u.h.f., s.h.f., e.h.f., and the rest of the series to infinity, on the basis of counting arrivals at the anode or any other electrode; that is to say, on a mere extension of the idea of the number of electrons passing any point in the circuit per second. The really old boys, who went to school in the days of pith balls and catskins, may be able to teach us a thing or two, because they did at least learn something about induced charges. But in those days the idea of charges going about entirely by themselves was too highly theoretical and imaginary, perhaps, to take root firmly, and the teaching on the subject soon congealed into Leyden jars and, much later, silvered ceramic capacitors. But the principle is really the same.

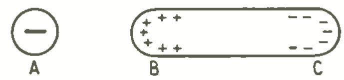


Fig. 1. Typical illustration from old-style book on electricity, showing the effect of a negatively charged body A on a previously uncharged conductor BC when brought near.

Fig. 1 is typical of what we see in the older books. A represents a negatively charged body (they were always bodies or conductors) brought near a sausage-shaped uncharged conductor BC. It was then demonstrated by means of gold-leaf electroscopes, etc., that B became charged positively and C negatively. Before A had come on the scene, these opposite charges were uniformly distributed throughout BC, so neutralized one another. Now the positive (unlike) charges have been attracted by A, and the negative (like) charges repelled. The next step was usually to earth C, allowing the negative charges to get still farther from A by leaving BC altogether. C was then disconnected from earth, leaving BC with a positive excess. When A was taken away, BC as a whole retained a positive charge, because the neutralizing negative charges that had gone to earth had no means of returning.

If this kind of experiment is still demonstrated, I suppose it is much the same except that the negative charges are called electrons and the positive charges are explained as the molecules deserted by the electrons and therefore electron-deficient or positive.

At a later stage in our education the situation would be described in terms of field and potential. A, being negatively charged, is surrounded by an electric field, and if BC were not a conductor, the locality B (being nearer to A) would be at a more negative or lower potential than C (Fig. 2 (a)). But as it *is* a conductor this potential difference immediately causes a current to flow to the end having lower potential; i.e., from C to B, which is really a negative current (of electrons) from B to C. When sufficient charge has been moved to neutralize the p.d., the current obviously ceases. Under static conditions, and with no e.m.f., a conductor must all be at the same potential. It therefore distorts the field around a charged body such as A by setting up a counter-field of its own. As shown in Fig. 2 (b) the positive charges at the B end raise the potential there from its previous −15 V to −10 V, while the negative charges at the C end lower it from −7½ V to −10 V.

If a sensitive galvanometer were inserted between the two halves of the conductor BC, it would show a current in one direction so long as A was moving towards it, and in the opposite direction when it was moving away. The same thing would apply if the galvanometer were connected between BC as a whole and earth—or any other conductor, at any potential. In every case the current would be necessary to shift some charges in order to neutralize the difference of potential that would otherwise be set up by the electric field from A.

It is the same if A is not a "body" at all but just one or more electrons, and BC an electrode in a valve. Fig. 3 shows an enlarged section of a valve with cathode K, grid G, and anode A. As usual, the grid consists of a spiral of wire coaxial with the cathode; the turns are all shorted together by connecting wires. The external circuit part of the diagram shows that relative to the cathode the anode is fairly highly positive, while the grid is slightly negative. The electrons that have boiled off from the surface of the cathode are therefore repelled by the grid but attracted by the anode, and they stream between the grid wires somewhat as shown. The reason they thin out as they approach the anode doesn't mean that some of them are disappearing on the way; it is because they are accelerating. If you were to empty a sack of lead shot from the top of a high tower, the shot would be a compact mass as it left the sack, but by the time it reached the ground would have thinned out considerably—fortunately for anyone who might happen to be passing.

Even with ordinary receiver voltages the electrons are quite mobile by the time they hit the anode; with 200 V, about 18,000,000 m.p.h. (Of course in a vacuum there is no sound barrier, so they can hardly be described as supersonic.) When these widely spaced electrons reach the anode they find that it, being a conductor, is already densely crowded with electrons. So an extremely slow movement of this

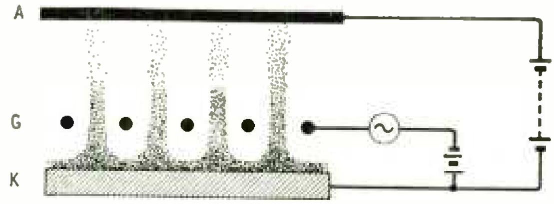


Fig. 3. Enlarged section of a valve, showing electrons streaming between the grid wires to the anode.

crowd along the external circuit towards the cathode is sufficient to make room for the new arrivals and so preserve the electrical balance of the circuit. As I mentioned in "How Fast is Electricity?" (Jan. 1954 issue), the contrast in speed is quite astonishing. The 18,000,000 miles per hour becomes something more like one *inch* per hour. Yet because of their relatively enormous numbers in metal as compared with the vacuum, there are just as many passing a given point in the wire per second as in the vacuum where they are going so fantastically fast. That is because under steady-current conditions the current is the same number of milliamps everywhere around the circuit.

Traffic Census

The foregoing is the usual picture one gets when first studying valves. But note the proviso—"steady-current conditions." If we enquire into what happens when the anode voltage is first switched on, and remember our old-fashioned electrostatic experiments, we will realize that here is a negative charge (but without its "body") being brought near a conductor (the anode) and that therefore movements of electrons must take place on the anode directly the electrons start moving towards it from the cathode. In other words, there is a brief moment, before the leading cathode electrons have reached the anode, when a traffic census officer stationed in space close to the anode would see no electrons at all passing him and would therefore report zero electric current; yet at the same moment electrons have begun to move away from the surface of the anode towards + h.t., under the advance influence of the approaching electron field, and these constitute an anode current.

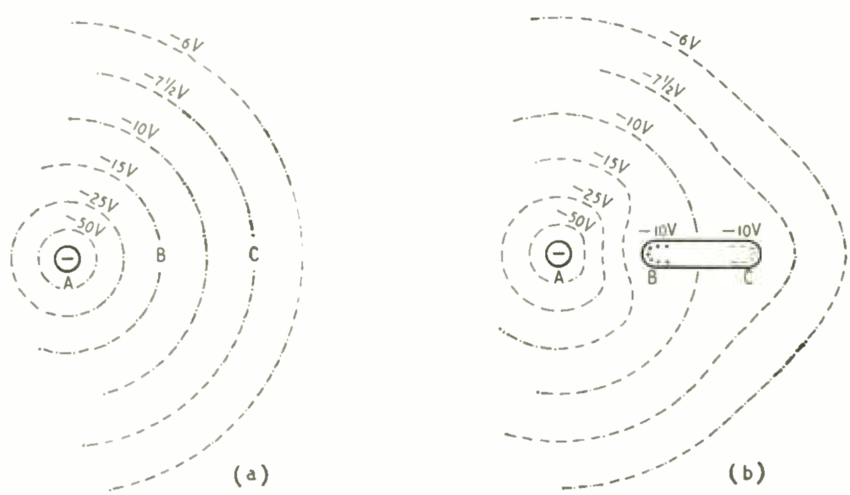


Fig. 2. If there were no conductor near A, equipotential lines would form a concentric pattern around it as at (a). Under static conditions a conductor must all be at the same potential, so when BC is present it must set up in itself a charge pattern that will distort the resultant field as shown at (b).

"Brief moment" is right, for he will have only about one thousand millionth of a second to note the facts of this situation before the leading electrons sweep past. Unless he is an exceptionally alert and conscientious observer, he may even fail altogether to notice this time delay between the start of current in the anode circuit and the start of current in the space near the anode. Even when the anode current is so far from steady that it is varying at the rate of a good many megacycles per second, this discrepancy is too small to matter in practice. But it is there, and at really high frequencies it does matter. In fact, in microwave valves such as magnetrons, it is everything. So for these valves our elementary ideas about electric currents may be a handicap. According to those ideas, it seems quite wrong and incomprehensible for current to be flowing in one part of a series circuit and not in another—even for 10^{-9} sec. But I hope the old electrostatic experiments are still performed, because they show quite clearly that this microwave phenomenon is in accordance with the classical electricity of the nineteenth century. Some teachers are now saying that when considering valves we should regard the circuit currents as primarily due, not to so many electrons arriving at an electrode, but to electrons moving towards or away from it. As Stevenson said, "To travel hopefully is a better thing than to arrive." When those electrons arrive, their speed is slowed down so much that they might be excused for supposing that they had come to a standstill.

Signal Conditions

At the now much discussed frequencies of Band I, Band II, or even Band III (of the order of 50, 100 and 200 Mc/s respectively) it doesn't make very much practical difference which way one regards the anode current. Looking again at Fig. 3 we see in the grid circuit, in addition to the bias source, the symbol for an alternating generator, which in practice would usually be a tuned circuit across which r.f. signal voltages are induced by coupling to an aerial or to another valve. Provided that this voltage is only a small fraction of a volt (as it normally would be) and the bias is adequate, the voltage of the grid never becomes so un-negative as to allow electrons actually to land on it. The generator varies its negativeness and thereby acts as a throttle, controlling the numbers of electrons squeezing past the grid to the anode.

Let us suppose it is now alternating gently. So the streams of electrons vary, sometimes (at the positive peaks of the grid voltage) being more than average; sometimes (at the negative peaks) less. In other words, the current flowing past the grid varies in phase with the grid voltage. And consequently the current in the anode circuit varies similarly. One complete cycle at 100 Mc/s, of course, takes one hundred millionth of a second. If the time the electrons take to cross from cathode to anode—the transit time—is about one thousand millionth, then according to our traffic officer, with his elementary idea of valve currents, the anode current is slightly delayed in phase as compared with the grid voltage. According to our more enlightened view it will start flowing practically in phase with the grid voltage; but since it is only when the electrons are travelling really fast and close to the anode that they have anything like their maximum effect, there is not really much difference between the two views. And what does it matter, anyway? A little transit-time phase shift in the anode circuit can easily get lost among other phase shifts, notably as a result of tuning or mistuning that circuit.

Induced Grid Currents

But it is now time to regard the grid as our "conductor BC," with negative charges being brought towards and away from it, faster by far than we could ever manage with our traditional laboratory "body." They, the charges, in the form of bunches of electrons, are sweeping past. Suppose for the moment that the generator is not generating, so there is no signal voltage, and the grid is at the steady bias voltage. The stream of electrons is consequently flowing steadily. So far as the grid is concerned they might just as well be standing still, for although the individual electrons are very much on the move there are always almost exactly the same number occupying any given part of the space in the valve. And every electron contributes exactly the same electric field, no matter whether its name is George or Harry. The "induced charge" effect of some of them moving away is counterbalanced by others moving towards. So there is no tendency for electrons to move either on or off the grid; i.e., no grid current.

Now switch on the signal. This makes the grid voltage vary as shown in Fig. 4 (a), alternately less and more negative than before. If the signal voltage were made to "hold it" at its positive peak, the flow of electrons past the grid would be greater than before, but it would be constant, so again no induced grid current. At a held negative peak there would be fewer electrons flowing past, but again no flow actually in the grid. But now consider the period between positive and negative peaks. The stream of electrons past the grid is thereby being checked. So there are fewer moving towards it than are moving away. In effect, a negative charge is being moved farther from a conductor. Some of the electrons that had previously been repelled from the grid by the larger negative space charge near it begin to return. In other words, there is a negative grid current. If a grid current were caused by the grid being joined to the cathode through a resistor, it would flow most strongly when the signal voltage was at its negative

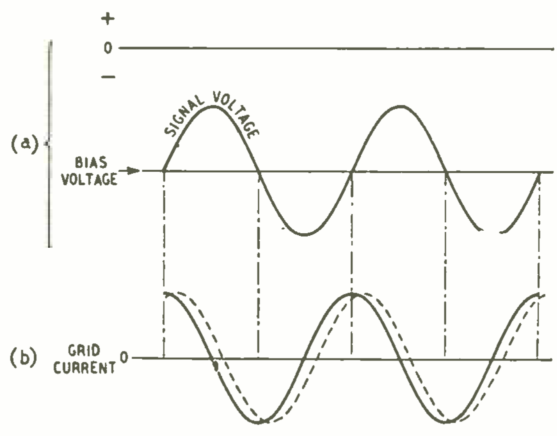


Fig. 4. (a) Voltage and (b) current diagram for the grid. The dotted current curve shows the effect of the time taken by electrons to move across the valve space.

peak. It would then be in phase with the signal voltage. But this negative grid current is flowing most strongly when the negative charge near the grid is becoming less negative most rapidly, that is to say, when the signal voltage is going negative most rapidly, which is when it is quarter of a cycle (90°) earlier than its peak negative, as shown by the full line in Fig. 4 (b).

Now a 90° leading current is what would flow in the grid circuit if the grid were joined to cathode through a capacitor. As a matter of fact such a capacitor is already there, because the grid and cathode, with the space between, form a capacitor of one or two pF, and a leading current would flow in the grid circuit because of that, even if there were no electrons flowing past at all—perhaps because someone had forgotten to switch on the heater. But we are ignoring that current at present. What we have found is that when at length the heater is turned on, so that electrons stream from it, there is more capacitive current between grid and cathode than there was before, and therefore, in effect, more capacitance.

This is serious, because at very high frequencies the grid capacitance forms a large part of the total tuning capacitance of the input circuit, and if in addition to what is there when the heater is off ("cold capacitance") there is some extra that varies according to electron space current—which is nearly the same thing as the anode current—then when this is varied by bias voltage, as in manual or automatic gain control, the capacitance varies and the tuning is altered. Now let's get this quite straight; this extra capacitance is not proportional to the space current. If you have followed the explanation you will see that it is proportional to the amount of *change* in space current brought about by a given change in grid voltage. In other words, it is proportional to the mutual conductance of the valve. But mutual conductance is precisely what one seeks to alter by gain control. So if the "extra" capacitance is an appreciable proportion of the total tuning capacitance, here is a possible snag. In practice it often *is* appreciable, and designers are aware of this snag and have to do something about it.

Power Loss

Although I mentioned very high frequencies as being particularly liable to be badly affected, and although the "extra" grid current is proportional to the rate at which the grid voltage plunges from a positive peak to a negative, or vice versa, and is therefore proportional to the frequency, this does not, of course, mean that the extra capacitance increases with frequency. The current through an ordinary fixed capacitance increases in proportion to frequency, so in this respect this peculiar electron-generated capacitance is like the real capacitance made up of grid and cathode acting as capacitor plates. The startling way it differs is in being proportional to the valve's mutual conductance.

Ever since we turned from the anode to consider what effect the varying grid voltage has on the grid itself, we have been making no allowance for the time delay that the traffic officer (if he were really on top of his job) would have reported. So far as the grid is concerned, this time taken by electrons to move from one place to another between cathode and anode means that when the grid voltage has ceased

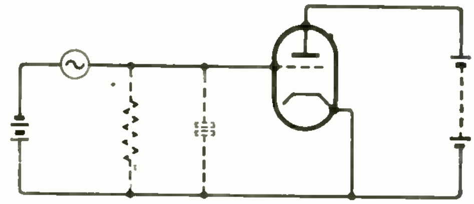


Fig. 5. The movements of electrons past the grid induce currents in the grid circuit equivalent to an extra capacitance and an extra conductance (dotted).

to become less negative and is pausing on its positive peak, the electron stream is still adjusting itself to this condition and there are still rather more electrons approaching the grid from the cathode than are departing for the anode. Consequently the extra grid current is not quite zero at the positive voltage peak; it is still slightly positive. Similarly at other stages of the cycle, as shown dotted in Fig. 4 (b). The general effect is to retard the phase of the grid current—to bring it more into phase with the voltage. It is the same as if part of the grid current flowing through the imaginary capacitor at the input of the valve were diverted through a resistor (Fig. 5).

This may be more serious than the extra capacitance. Provided that that is kept constant by keeping the mutual conductance constant, it can be allowed for by a slight reduction in tuning capacitance or inductance. But resistance means loss of power, which it may not be practicable to make good.

However, let us see how this resistance depends on frequency. First, let us suppose that the phase delay is a fixed proportion of the signal cycle. That means that of the total grid current caused by variation of space charge, a fixed proportion goes through the imaginary resistor and the rest through the imaginary capacitor. Keeping the signal voltage constant, let us increase its frequency. This increases the grid current in proportion. It is natural for this to happen when the impedance is a fixed capacitance. But so far as the in-phase part of the current is concerned, the effect can only be imitated by making the imaginary resistance decrease in proportion to the rise in frequency. So obviously the power loss gets worse at higher frequencies. But that is not all. The time delay is *not* a fixed proportion of the signal cycle; it is a certain fixed fraction of a second—say, one thousand millionth—regardless of frequency. So the higher the frequency the greater the fraction of a cycle this time becomes. At 100 Mc/s it is 10%; at 200 Mc/s it is 20%. So on this count, too, the imaginary resistance is inversely proportional to frequency. Taking the two effects together, it is inversely proportional to the square of the frequency. Doubling the frequency quarters the imaginary resistance and quadruples the power loss.

This line of argument holds good only for fairly small phase delays. To go to extremes, a phase delay of 360° would—disregarding other effects—bring things back to what they were at negligibly low frequencies. But even small phase delays are bad enough and account for a good deal of the difficulty in making valves amplify above about 30 Mc/s. At 300 Mc/s we would expect this part of the difficulty to be a hundred times as great. Certainly measurements of the imaginary valve input resistance confirm that it varies inversely as the square of the frequency, but whereas at one time all or most of this was blamed on transit time it was later found that the blame had to be shared with something quite different —the inductance of the cathode lead. Valves for v.h.f. are therefore arranged so that this lead is as short as possible. Transit time can be reduced by increasing the speed of the electrons, by increasing the anode voltage; but it is not practical to carry that policy very far. A better line of attack is to reduce the distance the electrons have to go. At the same time this increases the mutual conductance, which increases the undesired grid current, but also increases the amplification. The whole thing becomes quite complicated, and anyway I am not a valve designer and this is not a treatise on valve design, so let us leave them to it. The point that is meant to emerge is that by pondering on the simple experiments performed by Faraday with glass rods and suchlike, one can explain the apparently obscure snags that affect the design of the valves and sets we shall need for our Band II f.m. and Band III TV.

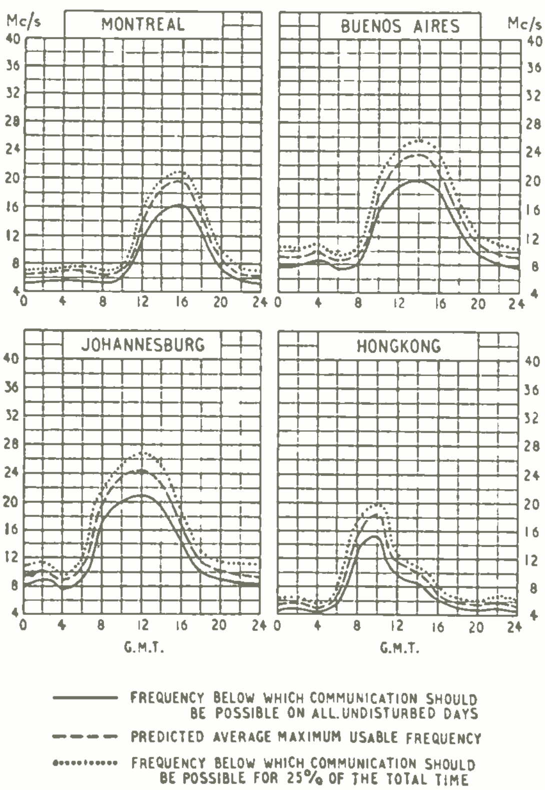
I have applied this early Victorian line of thought to only one phenomenon in modern valves, but clearly it is something to remember all the way through.

Short-wave Conditions

Predictions for December

THE full-line curves given here indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during December.

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



Fifty Years of Wireless Telephony

THIS is the title of an article by Professor F. Benz in the *Archiv der Elektrischen Ubertragung*, 1954, p. 369, describing the celebration at Graz in Austria of the jubilee of a demonstration of radio-telephony given on June 15th, 1904, by Otto Nussbaumer in the Institute of Physics of the Graz Technical College. For this celebration the original apparatus was borrowed from the Vienna Museum and the experiments were repeated. The transmitter was in one room and the receiver in another room, some distance away.

As a detector Nussbaumer used a coherer in which the filings were replaced by granulated iron oxide; this was inserted in an aerial and a battery and telephone receiver connected across it. He used several different transmitting arrangements; in some he used a Duddell arc to generate an alternating current, which was then stepped up by an induction coil with a 2-cm spark-gap. The distant receiver reproduced the audio-frequency noise made by the arc. For the transmission of music and speech, in some cases he used a similar arrangement but with a microphone coupled to the oscillatory circuit of the arc, while in other cases he dispensed with the arc and inserted the microphone, suitably shunted, in series with a battery and the primary of the induction coil. In this way music and speech were transmitted, but naturally not of high quality.

A few people who had been at the original demonstration were also present at the jubilee demonstration. Unfortunately, Nussbaumer left only rather brief records of his work,* which he does not appear to have followed up. He died in 1930 at the age of 53, but in the previous year the 25th anniversary of his historical experiments had been marked by the presentation to him of the golden Badge of Honour by the President of Austria.

* O. Nussbaumer, "Kurzer Bericht über Versuche zur Ubertragung von Tönen mittels elektrischer Wellen." *Phys. Zeitschrift*, 1904, p. 796; also *E.T.Z.*, 1904, p. 1096. See also "Wireless Telephony," by Ernst Ruhmer, trans. by Erskine-Murray, p. 98.

Commercial Literature

Television Aerials for Band 1. Ten different arrays constructed on unit principle to permit variation of fixing and interchangeability of parts. Catalogue (giving also details of dealer service facilities) from Belcher (Radio Services), 59 Windsor Road, Slough, Bucks.

Precision Vernier Potentiometer with overall range of 1μV to 1.9V in two ranges. Accuracy is of the order of 1 part in 100,000 of the 1 volt setting. Also a **Portable Thermocouple Potentiometer** for temperature measurement, with two ranges, 0-21mV and 0-105mV. Leaflets from the Croydon Precision Instrument Company, 116 Windmill Road, Croydon, Surrey.

Printed I.F. Transformer is one of the American products described in the latest "Auri-News," a bulletin issued by Ad. Auriema, Inc., who are export agents for a large number of American firms. From 89 Broad Street, New York 4, N.Y., U.S.A.

Transfers for Control Panels. Set No. 1, for receivers and amplifiers, contains one tuning scale, twelve graduated scales for control knobs and associated wording with symbols. Set No. 2 is similar for test instruments. Price 3s 6d per set. From Data Publications, 57 Maida Vale, London, W.9.

Sound Reproducer, consisting of 15-watt amplifier and 12-in speaker in cabinet, with frequency response of 35 c/s-16 kc/s. Bass and treble tone controls are included and power supplies are provided for a tuner. Leaflet from Shirley Laboratories, 125 Tarring Road, Worthing, Sussex.

Flywheel Synchronizing

3.—Balanced A.F.C. Systems

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

IT was said in Part 2 that phase discriminators could be divided into two broad classes—the balanced and the unbalanced. A rather brief description was given of one form of the latter. The balanced types are probably the more widely used, however, and there are good reasons for this to which we shall return later.

The commonest form of balanced phase discriminator is shown in Fig. 1. It comprises a pair of diodes fed in push-pull with one signal and in parallel with the other, so that one diode operates on the sum of the signals and the other upon their difference. The usual practice is to feed the sync signal in push-pull and the local signal in parallel; there are theoretical advantages, but practical disadvantages, in reversing this arrangement and making the local signal the push-pull one.

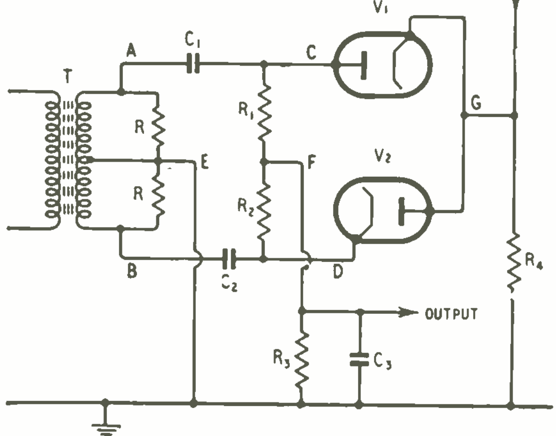
The usual arrangement of push-pull sync pulses is adopted in Fig. 1. The transformer T is connected in the anode circuit of the sync separator and is fed with the sync pulses as a current waveform. The secondary is centre-tapped to provide a push-pull output and is loaded by the two resistances R. The transformer is designed to act in conjunction with these resistances as a differentiating circuit and so differentiated sync pulses appear as a voltage waveform across the secondary. The transformer and the resistances R are commonly used in commercial practice, but they are not necessary, for they can be replaced by an RC circuit and a phase-splitting valve and this is often more convenient in that it does not call for any special component.

A saw-tooth voltage waveform which is obtained from the time-base and which is positive-going on the flyback and negative-going on the scan is applied across R_4 in Fig. 1. This wave has no d.c. component so that it passes through zero twice per cycle, once during the flyback and once during the scan.

When a sync pulse occurs, A becomes positive to E and B negative to E by equal amounts. If it so happens that at this instant the saw-tooth is passing through zero, point G is at the same potential as E. Then V_1 conducts on the voltage provided by the upper half of T and V_2 conducts on the voltage provided by the lower half. The charging current for C_1 flows round the path C A E G C for V_1 and round the path G E B D G for V_2. The currents in R_4 are equal and opposite and so cancel. When the diodes cease to conduct, C_1 discharges by the path C F E A C and C_2 by the path D F E B D. In practice, C_1 and C_2 are made of the same value and R_1 and R_2 are also alike. Therefore, C_1 and C_2 become charged to equal voltages and so the discharge currents in R_3 are equal and opposite and cancel. No voltage is developed across R_3 and the output is zero.

If the instantaneous value of the saw-tooth at G is not zero when the sync pulse occurs, but is at some positive potential so that G is positive to E, then when the diodes conduct this voltage opposes the input to

Fig. 1. Basic circuit of balanced diode phase discriminator.



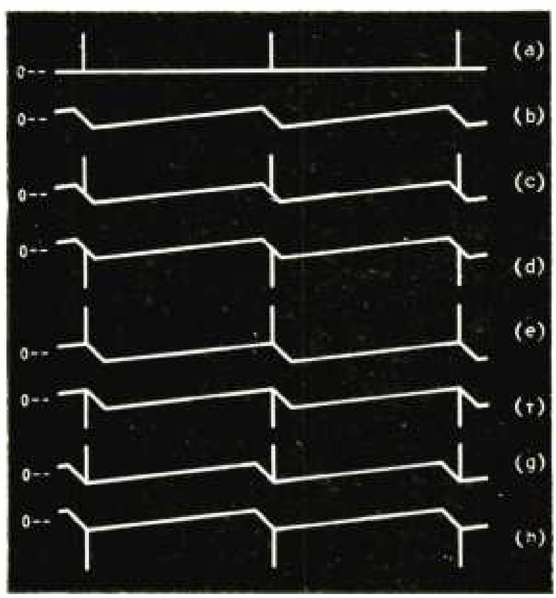


Fig. 2. Idealized waveforms for the circuit of Fig. 1. The sync pulses (a) and the waveform (b) are summed in (c) and (d) to show their combined effect on the two diodes when the relative phase difference is zero. The two extremes of phase difference are indicated in (e) and (f) on the one hand and (g) and (h) on the other.

V_1 but assists the input to V_2. Therefore, C_1 is charged less and C_2 more than when G is at zero potential. The subsequent discharge current of C_2 round D F E B D therefore exceeds the discharge current of C_1 round C F E A C. The difference between the currents produces a voltage drop across R_3, making F positive to earth. Similarly, if G is negative when the valves conduct, V_1 passes a greater current than V_2. The discharge current of C_1 then predominates over that of C_2 and the potential of F becomes negative to earth.

In practice, the input at G is a saw-tooth without a d.c. component. Ideally, it would pass through zero at the mid-point of its flyback. No output is obtained if the sync pulses coincide with this zero of the waveform, but a positive output is obtained if they occur at a time when the saw-tooth is positive or a negative output if they occur at some other time when it is negative.

Phase Relations

The conditions are illustrated in a simplified manner in Fig. 2. It should be noted that the saw-tooth is shown here reversed in phase compared with Fig. 1 because, for simplicity, it is drawn as if it were applied to the transformer centre-tap instead of to the junction of the valves. The line pulses are indicated at (a) by the thin vertical lines and the saw-tooth is shown at (b), the two being at the correct position of zero relative phase. At (c) and (d) are the sum and difference of (a) and (b). The sync pulses coincide with the moments when the saw-tooth passes through zero and so the saw-tooth adds nothing to them. Both (c) and (d), therefore, show waves of the same peak value, one positive and the other negative. Both detectors pass the same current and the output is zero.

The conditions in (e) and (f) are for the case when the saw-tooth is of different phase so that the sync pulses just coincide with the start of its flyback. If we reckon the peak-to-peak saw-tooth amplitude as one unit, so that the pulse amplitude is 2 units, then in (e) the peak value of the wave is $+2\frac{1}{2}$ units and in (f) it is $-1\frac{1}{2}$ units.

The other extreme condition is shown in (g) and (h) with the saw-tooth so phased that the sync pulses occur at the end of its flyback. Here the peak values are $+1\frac{1}{2}$ units and $-2\frac{1}{2}$ units respectively.

Over the extremes of phase shown, the input to one detector varies from $+2\frac{1}{2}$ units to $+1\frac{1}{2}$ units while the other varies from $-1\frac{1}{2}$ units to $-2\frac{1}{2}$. The combined output is proportional to the difference between them and so varies from +1 to −1. The magnitude of the output varies with the peak-to-peak amplitude of the saw-tooth and is, to a first approximation at least, independent of the amplitude of the sync pulses, provided that they are the greater.

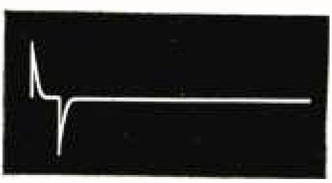


Fig. 3. Waveform of differentiated line sync pulse.

In practice, the sync pulses will be wider than is shown in Fig. 2 and they will normally be accompanied by reverse pulses 10 μsec later, corresponding to the ends of the original pulses. The greater width is not very important as long as the pulses are of a good deal shorter duration than the flyback of the saw-tooth. The reverse pulses are quite unimportant for, when they occur, the diodes are non-conductive and they are in the wrong sense to make them conduct again. The fact that the sync pulses are rather like Fig. 3 actually makes very little difference.

In the circuit of Fig. 1, it is the usual practice to make $C_1 = C_2 = 0.001\,\mu F$, $R_1 = R_2 = 100\,k\Omega$ and $R_3 = 2\,M\Omega$, while the other resistors are of relatively low value. When the diodes are conductive on the pulses, the charging time-constants of C_1 and C_2 are quite small. They are governed by the values of R and the diode resistance, which may total 5–10 kΩ only. The charging time-constants are thus of the order of 10 μsec or less. There are two different discharging time-constants. The first governs the rate of discharge of C_1 and C_2 and so the voltage changes at C and D of Fig. 1 relative to earth when the diodes are non-conductive. This is approximately C_1R_1 and is 100 μsec—the line period. The time-constant for the output voltage is much longer, even if the effect of C_3 is ignored, and it approximates to $2C_1R_3$. It is about 4,000 μsec in practice and, taking C_3 into account, it is considerably greater.

The waveform at C of Fig. 1 relative to earth is of the kind sketched roughly in Fig. 4 and that at D is its inverse. This diagram is not to the same scale as the others.

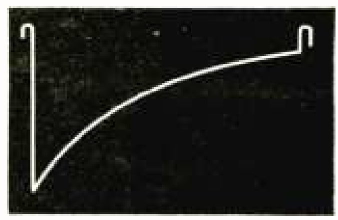


Fig. 4. Waveform at point C of Fig. 2.

It will be seen that the sync pulses act as a kind of gating waveform to make the diodes conduct when they occur. The actual output of the circuit depends on the instantaneous value of the saw-tooth at the instant when the pulses occur.

It is possible to imagine the circuit as being a kind of switching device which joins G and F whenever a sync pulse occurs. The output voltage, therefore, is brought to whatever is the instantaneous value of the saw-tooth at the moment the sync pulse occurs. Because of the time-constant C_1R_3, the voltage remains substantially at this value until the next pulse comes along; it then changes or not according to whether the saw-tooth has a different value or not at this instant.

When the sync pulses have, as they must have, a finite duration which is small compared with the flyback period, the voltage at G must vary during the pulse. Assuming a rectangular pulse and a linear flyback, it will be the mean value corresponding to the middle of the pulse that matters. Noise and interference will, in the manner explained in Part 1, alter the width of the sync pulse. The main effect will, therefore, be to alter the precise timing of the differentiated pulses applied to the diodes. There may also be some change in their width, but this is likely to be less than the change of timing.

Noise and interference, therefore, alter the effective instant of switching and make it occur for an incorrect value of the saw-tooth voltage at G. The output is thus affected and it is upon the time-constant that reliance is placed for reducing the effect of noise and interference.

In one particular case, however, the balance of the circuit gives immunity. If the conditions are adjusted to be of mean phase, so that the saw-tooth passes through zero when the sync pulse occurs the discriminator output is zero. If then a burst of severe interference comes along which obliterates the sync pulse completely, the diodes do not operate, the output remains zero and the time-base remains quite unaffected. With less severe interference, which produces a delayed pulse, the diodes conduct later than they should do and an unwanted output appears.

One defect of the circuit is obvious. Spurious pulses occurring at almost any time can cause diode conduction and so affect the output. Such pulses can be due to noise and interference and will certainly occur at half-line intervals during the frame pulses.

It appears to be wrong in principle, therefore, to use as the gating waveform one which is subject to irregularities and it would seem much better to use the local waveform for gating. This can be done in Fig. 1 by reversing the signals; that is, by applying the local waveform in push-pull by T and the sync pulses in parallel across R_1. The practical difficulty is that it is not so easy to develop the required waveforms but, if it can be done, the circuit becomes quite immune to any interference except that which occurs while the diodes are made conductive by the local gating pulses.

The question now arises as to what are the best waveforms for this kind of operation. The gating pulses should obviously be narrow and should occur at some little time after the time-base flyback has started. The flyback pulse clearly suggests itself as a possibility since it occurs at about the right time and is available with ample amplitude. It is, however, inclined to be on the wide side.

The sync pulse waveform is more difficult. It should have a sloping part of more or less regular slope with equal positive and negative values and would, ideally, be like Fig. 5 with its start and finish corresponding to the beginning and end of a line sync pulse. It cannot be generated by making use of the two ends of the pulse, however, otherwise there will be a change of waveform during the frame pulse period; it is only the leading edges of the line pulses that recur regularly.

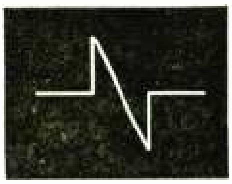


Fig. 5. Sync-pulse waveform required for ideal operation.

It is not at all easy to design a simple circuit which will produce the required waveform and it is probably because of this that it is usual to employ the sync pulses as the gating waveform. Returning to this system, therefore, the saw-tooth input to R_1 in Fig. 1 is usually obtained by integrating the voltage pulse which occurs on the anode of the line output valve during flyback, or a related pulse obtained from a tapping on the scan transformer. This pulse is positive-going and of large amplitude, so that the integration is simple and cheap and rarely involves more than a couple of resistors and capacitors.

The precise form of the phase detector has an effect upon the degree of immunity to interference and noise and upon whether or not the change of sync-pulse waveform during the frame flyback distorts the upper part of the picture. It also affects the pull-in range; that is, the range of free-running frequencies of the time-base over which the circuit will lock in, when sync pulses are applied. Generally speaking, the balanced type of detector is to be preferred to the unbalanced. When the time-base happens to be correctly adjusted it gives no output, so if the sync pulses cease the time-base frequency is not altered. An unbalanced detector, when correctly adjusted to the mean condition, gives quite a large output, so that if the sync pulses cease the time-base changes frequency by quite a large amount and it may not pull into step again when the pulses re-appear. It may be necessary to adopt special means for making it lock-in again.

In any case, however, a time-base can pull into synchronism only over a limited range of frequency difference—the lock-in range. Once locked, however, it may hold in over a much wider range of control settings. One can have the condition, therefore, that the time-base will remain locked as long as the sync pulses persist, but lose synchronism and refuse to lock again (without manual adjustment of the hold control) if they are interrupted for a short interval.

Stability

The lock-in range depends mainly upon the time-constant of the circuit. If this is made large to secure good noise reduction the lock-in range becomes small. This is fairly obvious because the circuit is a low-pass filter. When a difference of frequency exists between the sync pulses and the time base, this difference frequency must be passed by the filter if there is to be any control voltage acting on the time-base. The larger the time constant is made, the lower is the difference frequency which is passed with any effectiveness.

Once the time-base is in synchronism, however, it can remain locked for quite large changes of the values provided that they occur slowly, for slow changes are passed by the filter.

Because of these effects it is often necessary to take special precautions in the design of the time-base to ensure that its free-running frequency remains within quite narrow limits. In the ordinary directly-locked time-base the free-running frequency is normally several kilocycles below the locked frequency and quite large variations are permissible. It is quite normal for a receiver to operate for months without the hold control being adjusted.

The tuned-circuit type of flywheel-sync system described in Part 1 behaves in the same way as the directly locked time-base in this respect. In fact, the time-base is locked in the ordinary way by pulses. The flywheel circuit acts to generate noise-free pulses. With flywheel sync of the a.f.c. type, however, the permissible variation of frequency is relatively very small and may be a few hundred cycles only, if the time-base is to lock-in reliably without manual adjustment. Apart from effects due to the ageing of valves and components, the chief causes of frequency changes are temperature and supply voltage. Some form of stabilization is usually needed and it is common to include a tuned circuit in the time-base as an aid to frequency stability.

It has already been mentioned that all forms of a.f.c. systems are negative-feedback circuits. In the closed loop formed by the phase detector, the filter and the time-base, there are several time-constant circuits in cascade and there is gain around the loop. It is possible, therefore, for the system to go into oscillation at some frequency. The trouble arises through the time delay around the loop. If some change occurs, the response of the circuit, which should act to correct it, does not occur straight away but is delayed by the time-constants of the circuits. The change remains for a time uncorrected and a large correction voltage is built up. When this does start acting it may be excessive for the change existing at that moment and cause over-correction.

It is almost invariably necessary to include a stabilizing circuit which acts to reduce the phase-shift around the feedback loop. In servo nomenclature, it is an anti-hunt circuit and it results in the output of the filter containing a component proportional to the rate of change of phase as well as to the phase difference between the sync pulses and time-base voltage.

Typical Circuit

One form of this is shown in Fig. 6. This diagram shows a complete a.f.c. circuit of the balanced diode type and should be compared with Fig. 1; similar components in the two diagrams bear the same reference letters. In Fig. 6, differentiation of the sync pulses is carried out by C_7R_7 and the push-pull input to the diodes is obtained from the phase-splitter V_3. This is an alternative to the transformer of Fig. 1.

The saw-tooth is obtained by integrating the pulse on the line output circuit by R_6, R_1 and C_1 in combination, C_6 being merely a d.c. blocking capacitor. The components R_5C_3 form the main filter for interference reduction and C_5 is for stabilizing the circuit. An alternative arrangement is to omit R_5C_5 and make C_3 rather larger and then to connect in shunt with C_3 the series combination of a resistor and a capacitor for stabilizing.

A drawback of having to include these stabilizing components is that since, of necessity, they make the filter respond more quickly to a change of input they do also reduce the effectiveness of the filter against noise and interference. They do not do so in quite the same way as a simple reduction of the time-constant would do, of course.

In all flywheel sync circuits, whether of the tuned circuit or the a.f.c. type, the noise and interference reduction is obtained by means of high selectivity in some form, so that the time-base is affected only by the cumulative effect of many sync pulses. It would appear to be ideal to make the selectivity so high (that is, the time-constants so long) that the integration effect persisted over several frames. Any break-up of the picture or displacement of the lines would then be impossible and noise or interference could affect things only by causing a small and very slow sideways movement of the picture as a whole. This would be hardly noticeable.

Unfortunately, it is found in practice that this is not always practicable because the sync pulses themselves do not recur sufficiently regularly. This is especially the case with outside broadcasts and, if the time-constant is made too great, the picture may have curved sides. In practice, it is often necessary to restrict the integration period to quite a few lines only. As a result, a certain amount of line displacement can occur. It is, however, of a less troublesome character than with direct-locking. Lines do not tear out in an irregular manner, but a group of lines may move slightly sideways in a smooth fashion so that a vertical line in the picture may develop a small bulge.

When only a moderate time-constant is used, trouble may be experienced from the half-line pulses which occur during the frame pulse. These will inevitably cause a change of output unless the phase discriminator is of a type which does not respond to them or unless the integrating time constant is so great that the output cannot change appreciably. In other cases, the time-constant must be small enough to enable the output to recover after the change before the picture modulation starts.

In view of the drawbacks of flywheel sync (namely, its greater complexity, the need for a more stable time-base, the movement of the picture as a whole with any change, and the limited noise immunity imposed by transmitter effects) the writer's view is that its use is not worth while under normal receiving conditions, in which receiver noise is negligible and external interference is small. There is, however, no doubt at all that it is very much worth while in poor locations where interference is serious or where the signal is so weak that receiver noise is important.

It is quite important not to be misled by foreign practice. The fact that flywheel sync is universal in the U.S.A. and is widely used on the Continent is quite irrelevant, because their television systems employ negative modulation whereas the British practice is to use positive modulation.

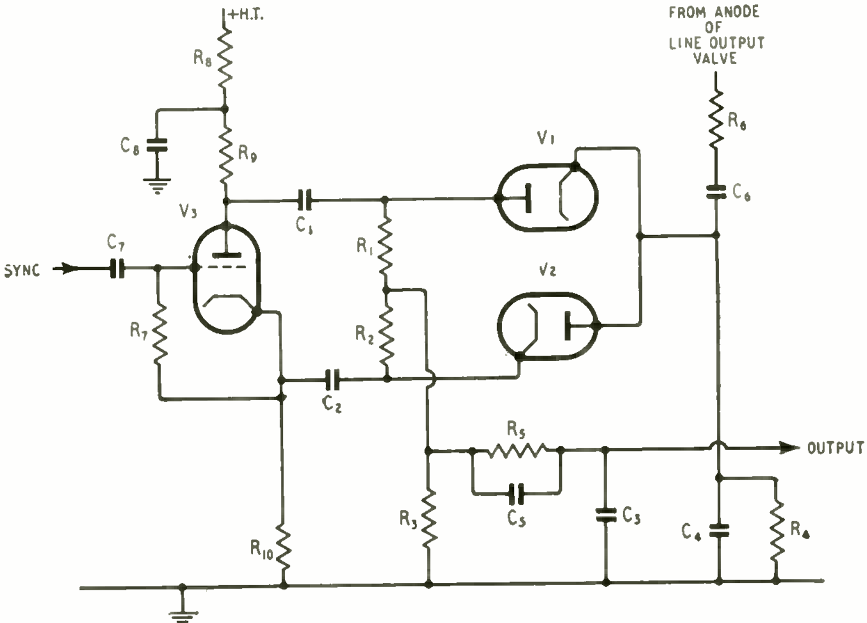


Fig. 6. Complete a.f.c. circuit using a phase-splitting input valve and showing the anti-hunt capacitor C_5.

Must We Have Compatibility?

I.E.E. Discuss the Future of Colour Television in Britain

NOT very long ago any mention of the word "non-compatible" in connection with colour television was considered almost indecent. In America the C.B.S. non-compatible frame sequential system had been tried and had proved a miserable failure, and everybody was pouring scorn on the F.C.C. for bringing it into operation. The wonderful new N.T.S.C. compatible system was introduced shortly afterwards and we all (or, at least, most of us) felt that this compatibility—a fascinating new idea—was the only sensible thing to have.

Since then it appears that radio technical people in Britain have been pondering rather deeply over compatibility and all it implies, and as a result there has been quite a strong reaction against it. The main objections seem to be that when you shackle a new system (colour) to an existing old one (the present 405-line monochrome system) you are not only making things difficult for future generations of receiver designers, but putting a stop to the development of new colour systems. Moreover, the compatible system which has now been tried out in America has not proved quite so successful as was at first hoped, and it appears to have one or two technical disadvantages, such as "buzz" on sound and dot patterns on the screen, which would not be very acceptable in this country.

At the moment, then, there is quite a division of opinion on compatibility, and it was probably this that gave rise to the recent discussion at the I.E.E. on "whether compatibility is necessary for a colour television system in Great Britain." Most of the contributions to this discussion were naturally concerned with engineering matters. It is doubtful, however, whether these helped to clear the air, for the whole issue of compatibility versus non-compatibility is really bound up with economic and political considerations. For example, in commercial television, whether here or in America, the programmes have to reach the largest possible number of people, so compatibility is almost an essential. With an organization like the B.B.C., however, there is no pressure from commercial interests and they can afford to develop a non-compatible service, with quality as the main criterion, even if there are very few people capable of receiving it at first.

Systems and Apparatus

But what exactly are the engineering considerations? What do "compatibility" and "non-compatibility" really mean in terms of systems and apparatus? At the moment a compatible system for Britain is generally taken to mean an adaptation of the American N.T.S.C. system,* and, according to opinions expressed at the I.E.E. meeting, no other compatible system is likely to be developed. As is well known (and was admitted at the meeting), the N.T.S.C. system has a degrading effect on the vision and sound of black-and-white receivers because of interference from the colour sub-carrier. There is a general opinion, too, that this would be worse in Britain than in America owing to the superior video response of our receivers and the fact that the lower frame repetition frequency would not allow such effective cancellation of the sub-carrier dot pattern by the viewer's eye. A partial solution would be to degrade the bandwidth of our receivers to just over 2 Mc/s. Another problem mentioned at the meeting was that the N.T.S.C. system requires asynchronous operation (not locked to the mains), which would produce a visible beat effect on the screen as a result of interaction between the mains and the frame frequency.

"Adjacent-channel" Scheme

Most of the drawbacks of the ordinary N.T.S.C. system can be overcome by transmitting the troublesome colour information in an adjacent channel—an expedient which has already been demonstrated on a 405-line closed-circuit system.† This could still be considered as a compatible system suitable for Bands I and III, but it would be necessary for the "adjacent-channel" colour signals to overlap the monochrome signals of another station. Thus there would still be a risk of interference. However, the idea has not yet been proved impracticable (at least in this country), so it remains an interesting possibility.

By moving the "adjacent-channel" system into Band IV and occupying a channel width of 7-8 Mc/s to avoid overlapping, the problem of interference could be overcome completely. This would then provide a compatible colour service in the u.h.f. region—as was advocated by one speaker at the discussion. Existing Band-I monochrome receivers would not be able to receive the programmes (except with the addition of converters), but all new monochrome sets could be designed from the beginning for Band IV reception.

There is a general feeling, however, that any colour system put into Band IV would probably take full advantage of the wider channels available (the T.A.C. have suggested 7.5-Mc/s channel widths) and work on a higher definition—possibly 625 lines. The proposal was, in fact, put forward at the I.E.E. discussion by the opener, E. P. Wethey, who envisaged a 625-line non-compatible system with "adjacent channel" colour operating in Band IV. Mr. Wethey pointed out that this could, in a sense, be made compatible by using a standards converter to change the 625-line pictures to 405-line pictures, so that they could be transmitted in Bands I and III and received by existing monochrome receivers. An incidental advantage of the 625-line standard, also mentioned at the meeting, was that it would facilitate programme exchanges with the Continent. A speaker who had had wide experience of compatible colour television in the U.S.A., however, maintained that the cost of

* *Wireless World*, November, 1953, p. 524.

† *Wireless World*, June, 1954, p. 256.

introducing a non-compatible 625-line system in Band IV would be prohibitive.

When talking of non-compatible colour systems, then, it appears that engineers are concerned mainly with the use of wider channels in Bands IV and V, possibly higher definition, and probably "adjacent-channel" colour signals. Thus one important principle of the American compatible system has not been thrown overboard—the idea of transmitting the brightness information and the colour information separately. This is now generally felt to be a good thing. If it comes to be regarded as an essential there is no hope for the old frame-sequential system, which is still considered a possibility for non-compatible colour transmissions. (This does not necessarily mean rotating colour filters at the receiver; tricolour c.r. tubes can be used equally well.) The frame-sequential system gives good colour pictures and is simple in operation, but, unfortunately, is rather wasteful of bandwidth as it transmits a certain amount of redundant information.

The question of bandwidth is, indeed, one of the main problems with non-compatible systems, and it came in for a good deal of discussion at the I.E.E. meeting. There is some difference of opinion on whether receivers with wide bandwidths are expensive to manufacture. It was, however, agreed at the discussion that signals occupying a band of 7-8 Mc/s would increase the cost of programme distribution by cable and radio link. A more important problem is that radio transmission systems with wide bandwidths are more susceptible to the effects of multi-path propagation, and this would no doubt have a bad effect on colour phasing in the television pictures. It could be argued, too, against non-compatible colour systems, that they would take up valuable space in the ether, while compatible systems would make use of the existing television frequency allocations. (The general reaction of television engineers to this is: if *we* don't take the available space then somebody else will!)

Finally, there are the general problems of transmission and reception in Bands IV and V. At the moment there is very little data available on the coverage obtainable from transmissions at these frequencies and Band IV receivers are only in the experimental stage. However, it was suggested at the discussion that by the time we are ready for colour television most of these difficulties will have been overcome.

INTERNATIONAL RADIO RESEARCH

Summary of the Recent U.R.S.I. Meetings

SOME 300 delegates from twenty-one countries attended the 11th General Assembly of the International Scientific Radio Union (U.R.S.I.), which was held in The Hague from 23rd August to 2nd September. The two main functions of the Union are: (1) to promote and organize research requiring international co-operation and (2) to promote the setting up of common methods of measurement and the standardization of measuring equipment. The work of the Union is carried on by eight commissions, each concerned with a specific aspect of radio research.

Reference is made on p. 590 to a resolution on the velocity of radio waves made by Commission I (measurements and standards) which met under the chairmanship of Dr. R. L. Smith-Rose, who is also vice-president of the Union. This commission also decided to arrange for the international comparison of standards for measuring power at frequencies of 3,000 and 10,000 Mc/s, and to assist the International Radio Consultative Committee (C.C.I.R.) in observations of the reception of standard frequency transmissions from various countries.

Dr. C. R. Burrows (U.S.A.) was chairman of Commission II, which is concerned with the propagation of waves through the troposphere. Here the importance was stressed of studying propagation conditions in the v.h.f. and u.h.f. bands, in several parts of the world and under various meteorological conditions. Detailed knowledge is required as to the manner in which the received field strength is dependent upon the season, geographical location and the length of path and nature of the terrain over which the signal travels.

The meetings of Commission III were presided over by Sir Edward Appleton, and they dealt with various problems associated with the propagation of radio waves through the ionosphere. An important part of the proceedings and the associated resolutions, was concerned with the detailed arrangements being made for world-wide observations to be undertaken during the International Geophysical Year of 1957-58. On certain days of each month during that year, all nations in a position to do so will carry out an intensive series of measurements of various atmospheric and terrestrial phenomena. A corresponding programme was also recommended by Commission IV, which, under the chairmanship of J. A. Ratcliffe, deals with atmospherics of terrestrial origin. The discussions at the meetings of this commission ranged over the subjects of the waveforms of atmospherics, "whistlers" and the measurement of the noise level which prevails in various parts of the world.

Radio waves which arise from sources external to the earth's atmosphere are the concern of Commission V (Radio Astronomy), which held meetings under the chairmanship of Dr. M. Laffineur (France). Here the radio scientist has developed a new field of research since the war, in which a great deal of knowledge has already been obtained on the radiation from the sun and stars at various frequencies above 30 Mc/s. Improved techniques of reception have resulted from work in this country, as well as in Australia, Holland and U.S.A. Members of the commission have been responsible for the recent publication by U.R.S.I. of three special reports in this field. These have considerably enhanced our knowledge of the distribution of radiation from the sun, and also of the distribution of neutral hydrogen atoms, which are identified by their characteristic line radiation at 1420 Mc/s.

The remaining two commissions of the Union held a number of discussions on subjects in the fields of radio waves and circuits (VI) under Professor S. Silver (U.S.A.), and radio electronics (VII) under Professor G. A. Woonton (Canada). A wide range of subjects was dealt with including information theory, and various aspects of circuits, aerials and wave-guides.

The Proceedings of the Hague meetings will be published by the General Secretariat of U.R.S.I., 42 rue des Minimes, Brussels, from whom previous publications, including the special reports mentioned above, can also be obtained. The next meeting of the Assembly will be held in 1957 in Boulder, Colorado, U.S.A. R. L. S.-R.

DECEMBER MEETINGS

Institution of Electrical Engineers

London.—December 1st. "The Vertical Radiation Patterns of Medium-Wave Broadcasting Aerials" by H. Page and G. D. Monteath.

December 6th. Discussion on "The Applications and Limitations of Electronic and other Computors" opened by Dr. L. G. Brazier.

December 13th. Discussion on "Practical and Economic Problems in the Maintenance of Domestic Television Receivers" opened by W. L. Greenwood.

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

East Midland Centre. — December 16th. Faraday lecture "Courier to Carrier in Communications" by T. B. D. Terroni at 6.30 at the Albert Hall, Nottingham.

Cambridge Radio Group.—December 7th. "Transistor Circuits" by E. H. Cooke-Yarborough at 6.0 at the Cambridgeshire Technical College.

Mersey and North Wales Centre.—December 6th. Faraday lecture "Courier to Carrier in Communications" by T. B. D. Terroni at 6.45 at the Philharmonic Hall, Liverpool.

North-Eastern Radio and Measurements Group.—December 2nd. "Radio Stars" by R. Hanbury Brown at 7.0 at King's College, Newcastle-upon-Tyne. (Joint meeting with Newcastle-upon-Tyne Astronomical Society.)

December 6th. "An Investigation of the Characteristics of Cylindrical Surface Waves" by Prof. H. E. M. Barlow and A. E. Karbowiak, and "Surface Waves" by Prof. H. E. M. Barlow and Dr. A. L. Cullen at 6.15 at King's College, Newcastle-upon-Tyne.

South-East Scotland Sub-Centre.—December 7th. "Technical Arrangements for the Sound and Television Broadcasts of the Coronation Ceremonies" by W. S. Proctor, M. J. L. Pulling and F. Williams at 7.0 at the Carlton Hotel, North Bridge, Edinburgh.

South Midland Centre.—December 6th. "Technical Arrangements for the Sound and Television Broadcasts of the Coronation Ceremonies" by W. S. Proctor, M. J. L. Pulling and F. Williams at 6.0 at the James Watt Memorial Institute, Great Charles Street, Birmingham.

Rugby Sub-Centre.—December 10th. Faraday lecture "Courier to Carrier in Communications" by T. B. D. Terroni at 7.0 at the Temple Speech Room, Rugby.

Hatfield District.—December 8th. "Magnetic Amplifiers" by J. F. Coales at 7.0 at the Hatfield Technical College.

British Institution of Radio Engineers

London.—December 29th. Discussion on "Education and Training of Radio Engineers" at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1.

West Midlands Section.—December 8th. "Industrial Applications of Electronic Control" by J. A. Sargrove (Sargrove Electronics) at 7.15 at the Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.

North-Eastern Section. — December 8th. "Logic, Algebra and Relays" by Prof. Emrys Williams at 6.0 at Neville Hall, Westgate Road, Newcastle-upon-Tyne.

Merseyside Section.—December 2nd. "Electronics in Materials Handling" by L. Landon Goodman (British Electrical Development Assn.) at 7.15 at the College of Technology, Byrom Street, Liverpool, 3.

Scottish Section.—December 2nd. "Some Interesting Applications of Electronics to Photography" by D. M. Neale (Ilford, Ltd.) at 7.0 at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2.

British Sound Recording Association

London.—December 10th. "Magnetic Sound Stripe Recording on 16mm Film" by W. C. C. Ball at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.

Manchester Centre.—December 13th. "Balance and Control and Acoustics" by M. R. G. Garrard at 7.30 at the Engineers' Club, Albert Square, Manchester.

Television Society

London.—December 10th. "Television Circuit Refinements" by C. H. Banthorpe (Derwent Radio) at 7.0 at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, W.C.2.

Royal Society of Arts

Commonwealth Section. — December 2nd. "Broadcasting in the Colonies" by J. Grenfell Williams (B.B.C. Colonial Service) at 5.15 at John Adam Street, London, W.C.2.

Institution of Production Engineers

Manchester.—December 2nd. "The Electronic Control of Machine Tools" by E. Heys at 7.15 at Reynolds Hall, College of Technology, Sackville Street, Manchester.

Incorporated Practical Radio Engineers

South Coast Section.—December 9th. "Television Servicing Equipment" by a member of the staff of Marconi Instruments at 7.30 at the Kings Arms Hotel, Castle Street, Christchurch.

North-West Section.—December 6th. "Aerials for Commercial Television" by P. Jones (Aerialite) at 7.30 at the Barley Mow Hotel, Turner Street, High Street, Manchester, 4.

CLUB NEWS

Birmingham.—At the meeting of the Slade Radio Society at 7.45 on December 10th at the Church House, High Street, Erdington, B. V. Somes-Charlton, of Pye, Ltd., will give a survey of television camera developments and demonstrate the Pye miniature industrial camera.

Cleckheaton.—T.R.F. receivers will be dealt with by J. E. Church (G2BMC) at the meeting of the Spen Valley and District Radio and Television Society on December 1st. Members of the Bradford Radio Society will be the club's guests on the 15th, and on the 29th F. Jowett (G2FIS) will speak on superhets. Meetings are held at 7.30 at the Temperance Hall, Cleckheaton.

Newark.—At the meeting of the Newark and District Amateur Radio Society at 7.0 on December 5th at the Northern Hotel, Newark, A. Hall will talk about valve-voltmeters.

RANDOM RADIATIONS

By "DIALLIST"

TV Extensions

MANY people like to be able to use the television receiver in either of two rooms at will. It is simple enough to make such an arrangement; but it's surprising that one should so often find the job wrongly done. "Can't understand what's amiss with my TV set," said a friend not long ago; "In the drawing room, which is right under the aerial, it gives a poor and rather jittery picture; but in my own sitting room it's as good as one could wish. Funny thing is that when it's working in my room there's about an extra 30ft of aerial cable in use: surely that shouldn't cause reception to be *better*?" You'll guess at once what I found. The feeder had been connected so that the whole of it was always in circuit. Thus, when the set was used in the drawing room the portion running to the other room formed a 30ft dead end. The proper method, which avoids all dead ends, is to connect the dipole direct to the nearer skirting-board socket, and to it alone. The far end of the extension feeder goes direct to the distant socket, its near end being fitted with a plug and clipped to the skirting board near socket No. 1. In this way the extension is out of circuit until the set is needed in the distant room, when it is connected to socket No. 1.

Suppressors Again

THE Assistant Postmaster-General is not, I fear, a reader of *Wireless World*. Had he been, he might have given a better answer to the question recently put to him in the House about the possibility of introducing legislation to make the fitting of ignition interference suppressors compulsory for *all* cars, as had been done for rear reflectors. He suggested it would "entail recruiting a corps of inspectors to go round looking at every motor car." I would remind him that it was pointed out months ago in *W.W.*, when a similar answer was given in the House, that enforcement could be effected without adding a single man to the police force. Every police car is radio-equipped, as are many police motor cycles. Any such vehicle has only to switch its v.h.f. receiver to a.m. to become an admirable detector of ignition interference. No need to take the motor patrol officers off their more important duties; all that they need to do is to turn their attention to interference detection for occasional spells. Any offending car owner would receive a notice to put things right within, say, seven days and a warning that if he doesn't do so he'll be fined next time he's caught. As no motorist could tell whether a police vehicle was or was not "detecting," I'm sure that this system would be as effective as are the P.O. detector vans against TV licence-dodgers.

A Disclaimer

Let me say at once that I don't hold shares in any of the concerns that make ignition or other suppressors. I only wish I did! Nor am I personally much of a sufferer from ignition interference. My home in the country is not near a main road and on the average the number of cars passing it during the television programmes is not more than five or six an hour. More than that, my aerial, 45 feet above the level of the road and over 100 feet from the nearest point on its surface, cannot "see" passing cars since a good solid chunk of house intervenes. More even than *that*, my aerial is 550 feet above sea level and brings in such a whacking signal from Alexandra Palace that no small amount of attenuation is required. In other words, the signal/noise ratio is pretty good. Again, though I'm keenly interested in television theory, the programmes are a very minor source of entertainment to me. With these things in mind, you'll see that so far as the effects of ignition interference on TV reception are concerned, I have few axes of my own in need of grinding. But I am deeply concerned about its adverse effects on the progress of television. Some of my friends who live on or near main roads now make little use of their television receivers. Others are not renewing their licences as they fall due. Every reader of *W.W.* who owns or drives a car has important issues at stake. If television is not his livelihood it is a major interest. I just can't and won't believe that the man who owns any sort of motor vehicle is unable to afford the shilling or two needed to prevent the slowing down of television development which must be a consequence of the prevalence of ignition interference.

Why Not Uniformity?

IT'S a mystery to me why the manufacturers of domestic television receivers can't, or at any rate don't, agree to use the same set of names for the "user" control knobs; those, I mean, that are outside the cabinet. When the completely non-technical man-in-the-street buys a new set, he may have to accustom himself to controls differently arranged, and with a fresh set of names for them. "Height," he understood easily enough; but what is "frame amplitude"? Is "horizontal form" the same thing as his old "line linearity"? There doesn't seem to be a knob labelled "contrast"; can "picture control" be the same thing? I needn't give further examples. Yes, I know that the dealer who installs the new set should explain the knobs and their uses. But not all dealers bother to do so. I know, too, that the buyer of a set should read the "book of words" that accompanies it. But some who start to do so don't get very far, especially if they are confronted by puzzling new names. I hope that manufacturers will get together and produce a single set of names for the controls.

Robbing Peter to Pay Paul?

FROM the Television Act, 1954, one gathered that the Independent Television Authority's annual subsidy was to be found out of the receipts from general taxation, for Section 11 of the Act reads:

"The Postmaster-General may, with the consent of the Treasury, pay to the Authority out of moneys provided by Parliament, such sums, not exceeding seven hundred and fifty thousand pounds in any one financial year, as he may with the consent of the Treasury determine."

But the section of the B.B.C.'s annual report for 1953-54 devoted to finance makes one think a bit, for it throws a rather startling light on the intended source of those "moneys provided by Parliament." Here is what it says:

"The Exchequer will retain £2,000,000 from licence revenue in each of the three years [from March, 1954] and the Post Office will receive a proportion estimated at £1,600,000 a year to cover the cost of collecting fees and dealing with interference. *In addition, £750,000 per annum will be given to the Independent Television Authority in each of its first two years of operation.* The remainder will come to the B.B.C." (The italics are mine.)

If the B.B.C. statement is correct then it is not only contrary to the Act but also to the statement made by Mr. Gammans earlier this year when announcing the increased licence fee. He then stated that by stabilizing the amount taken by the Exchequer from licence fees at £2 million it would be possible to provide the subsidy for the I.T.A. "without reducing the amount that would otherwise accrue to the B.B.C." Them's my sentiments, too!

UNBIASED

By FREE GRID

The First Wireless Patent

ONE OFTEN HEARS elderly people talk glibly of the good old times but we have only to examine these allegedly happy days to realize that we have good cause to be thankful that we live in this present day and age. Let us, for instance, cast our minds back from 1954 to 1854 and instantly we are reminded that just a hundred years ago we went to war with Russia, whereas in 1954 all is peace between us and that great country, the giant strides of science since the carnage of the Crimea having made the very idea of war between civilized nations unthinkable.

Now all this has not the remotest connection with wireless and electronics except that when delving into the history of 1854 I came across what seemed superficially to be the first British wireless patent. It was granted to James Bowman Lindsay on June 5th, 1854, but although a "wireless" link was used there was no question of electro-magnetic waves, communication being by conduction between metal plates immersed at the opposite sides of a river.

But this patent of a hundred years ago has, at any rate, as close a link with modern wireless as has the first radar patent—granted to Hulsmeyer just fifty years ago in 1904—with modern radar technique. The real interest in Lindsay's century-old "wireless" patent is that the inventor's claims were investigated by Mr. (later Sir) William Preece, who performed the same office for Marconi nearly half a century later.

Preece didn't see any future in Lindsay's invention and pointed out to him that Morse had accomplished the same thing in the U.S.A. twelve years earlier. Contrary to popular supposition, Sir William Preece wasn't over-enthusiastic with regard to Marconi's pioneer work although he did help him considerably. On the whole I think we had better continue to celebrate June 2nd, 1896, as the date of the first British wireless patent rather than June 5th, 1854; after all, conduction and electromagnetic wave propagation are two very different things.

Points of View

FROM up North, where life is grim and earnest and not as it is in London—filled with the luxury that ruined ancient Rome, a correspondent has written to me criticizing certain aspects of the National Radio Show which displeased his practical Northern mind. He suggests that the organizers might have done worse than to visit the Manchester Business Efficiency Exhibition to see how a show should be organized and staffed.

I cannot altogether agree with him for surely the radio show—or at least that part devoted to domestic listening and viewing—should suggest joy rather than soul-destroying commerce. I, for one, like my listening and viewing to be associated with carpet slippers and an armchair and have no wish to be compelled to enjoy myself efficiently. I am also rather partial to the restful atmosphere of the radio exhibition where some of the stands, as at the Motor Show, are staffed by delightfully languid young men—real matinee idols—who couldn't care less whether I bought their firm's products or not. I prefer that to the high-pressure salesmanship horror which the phrase "business efficiency" suggests to my mind. Quite frankly I'm not efficient and have no wish to be. In the words of dear old Omar, "A jug of wine, a loaf of bread—and thou . . ."

"—and thou . . ."

A Plea for Myriacycles

SPEAKING as one who was brought up on metres I found it as difficult to change over to kilocycles and megacycles as those brought up on feet did to change over to metres. This latter change was made, I believe, after the Berlin Radio Conference of 1903. It was, of course, all right to deal in metres in the days when wireless wavelengths ranged from about 200 metres upwards, but in these microwave days it would mean dabbling in decimals and much use of what a certain V.I.P. anathematized as "those damned dots."

Unfortunately the changeover to frequencies instead of wavelengths hasn't killed the wretched dots which cannot always be seen at a glance by those like myself who have to use glasses. Personally, I found it very irritating to study the list of frequencies of the B.B.C.'s proposed f.m. stations in the September issue of *W.W.* Not one out of the whole 27 of them was a whole number. Surely it is a mistake to use megacycles at all? The word has no numerical value in its mother tongue, whereas the word myriacycle would really mean 100,000 cycles or, in other words, 100 kc/s. The list of frequencies to which I refer above would thus range from 881 mc/s to 945 mc/s; I use the abbreviation mc/s to distinguish it from the existing Mc/s.

Apart from the foregoing argument, the word miriacycle is more euphonious than megacycles, an important point to bear in mind as we technical people surely don't want to be regarded as more uncouth and uncivilized by poets, artists and men of letters than we are at present.

Watson-Watt's Bloomer

A KINDLY correspondent has sent me a newspaper cutting recording that Sir Robert Watson-Watt the radar pioneer had been fined in Ontario, Canada, for speeding after being caught in a special police trap in which use was made of the principles of radar. The *Star*, in a praiseworthy poem, compares his fate with that of Dr. Guillotine, the French physician who invented the instrument of execution which bears his name and by which he himself later suffered the extreme penalty.

I think, however, that a more homely instance of this sort of thing—although by no means so exact a parallel—is provided by the story of the late Mrs. Bloomer who, with modesty as her sole motive, invented the cycling garment which I cannot, of course, discuss in detail in the austere pages of *W.W.* She reckoned without the prejudice and prudery of the "refained" and the coarse jests of the vulgar, and so on her first outing awheel a blushing young constable was forced to escort her to the police station for her own protection. There was, in his opinion, a risk of "a breach of the peace being occasioned." It appeared that certain young bloods in the crowd with a boat-race-night mentality threatened to "debag" her, to use the jargon of a later age.

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—— ——, Wide-Band, H. S. Jewitt, 86 Feb.
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